Project group Number	**10**
Project Acronym	**SMART**
Project title	**Facilitate the Use of Innovative Strategies to Improve Air Quality and Reduce Carbon Footprint of Cities**
Name of Students	ATMAYA Haifa Fawwaz DORISMOND Jean Joseph FUENZALIDA NAVARRETE Jose Ignacio FUQOHA Iqlima UPRETI Gaurav
Coordinator:	atmoterra 80 impasse des Nympheas, 44300 Nantes http://www.atmoterra.com

Source: *getyourguide.com*

TABLE OF CONTENT

1. EXECUTIVE SUMMARY

Cities are facing many issues that are prone to affect human health, well-being (Bolunda & Hunhammar, 1999). The use of fossil fuel-based transportation system and increasing settlement of human in cities (with the use of residential or district heating) contribute to the degradation of cities air quality due to considerable emission of sulfur oxide (SO_x), nitrogen oxide (NOx), Carbon dioxide (CO_2), Carbon monoxide (CO), volatile organic compounds (VOCs), and particulate matter (PM10/2.5) into the atmosphere and the surrounding environment. By establishing pollution-control technologies for diesel vehicles and fuels, effective urban planning strategies that privilege sustainable transport, clean energy, energy-efficient buildings and homes, and public green areas which are able to filter air pollutants this issue can be addressed (UNEP, 2014). The following report aims to identify and review current innovative strategies and cost effective options to improve Air Quality and reduce Carbon Footprint in urban areas; identify relevant themes and pollutants targeted by these measures; identify and synthesize key qualitative and quantitative elements (benefits and limits) for each strategy or option and finally develop a simple tool (web-based or xls) to support and facilitate shared decision making for policy makers and urban planners. The results are the reduction percentage of each strategy application: 0.000015% % PM_{10}/bike user/year and 0.000103% % NO_2/bike user/year for bicycle, 0.40% %NOx/area covered/year and 0.47% %PM_{10}/area covered/year, for Urban Access Regulation (UAR), 0.04 Ton O_3/ha of forest/year and 0.073 ton PM_{10}/ha of forest/year for Urban Green Infrastructure, and 5.488 Ton CO_2/person/year for energy efficient planning. This values were used to develop a simple tool that will statistically give the amount of pollutants reduced. Adding more data to the database and constructing therefore more robust parameters can do further work. Nevertheless, strategies in all directions should be all be implemented in order achieve good results in air quality.

2. CONTEXT, POSITION AND OBJECTIVES OF THE PROJECT

2.1. CONTEXT, SCIENTIFIC, SOCIAL AND ECONOMIC ISSUES

The use of fossil fuel-based transportation system and increasing settlement of human in cities (mainly from residential or district heating) contribute to the degradation of cities air quality in many countries in the world from these activities emit considerable amount of sulfur oxide (SOx), nitrogen oxide (NOx), Carbon dioxide ($CO_{2)}$, Carbon monoxide (CO), methane (CH_4), volatile organic compounds (VOCs), and particulate matter ($PM_{10/2.5}$) into the atmosphere and the surrounding environment. Moreover, other factors as the increasing production of energy from fossil fuel due to a higher energy demand, industrial activities, and agriculture, have also emitted significant air pollutants and greenhouse gas emissions. Such emissions have worsened the issue of air pollution and carbon footprint in urban areas as well as contributing to the global warming climate change and climate change (EPA, 2011).

What's more, the European Environment Agency (EEA) reveals that during 2010 and 2012 respectively that 21–30% and 64–83% of the European urban citizens were exposed to a level of particulate matter that exceeds the EU daily limit values standards (50 $\mu g/m^3$) and the World Health Organization (WHO) annual reference level (20 $\mu g/m^3$) (European Environment Agency, 2016). As a result, several studies have shown a stronger link between air pollution exposure and premature death, life expectancy, respiratory and cardiovascular diseases (Brunekreef & Holgate, 2002)

To exemplify that, the World Health Organization (WHO) has revealed that, in 2015, around 7 million people die prematurely in the world due to air pollution related diseases, among them, 3.7 million as a result of outdoor air pollution exposure. Besides that, between 2005 and 2010, the death rate rose by 4% worldwide, by 5% in China and by 12% in India. According to (UNEP, 2014) this also causes 4.3 million premature deaths every year. Only for 2011, fine particulate matter ($PM_{2.5}$) concentrations have caused about 458 000 premature deaths in Europe (European Environment Agency, 2016). By 2050, it could be 6.6 million premature deaths every year worldwide, a new study predicts. Thus, human's health is at risk due to the exposure of air pollution.

Air pollution contribute have many side effects on the environment and public health. They contribute to air pollution and climate change. Pollutants or greenhouse gases like carbon monoxide ($CO_{2)}$, methane (CH_4), and nitrous oxide (N_2O) are the main and respective agents of global warming and climate change. Atmospheric greenhouse gases (GHGs) may trap the energy radiated from the sun to the earth and prevent the heat from escaping (EPA, 2011).

Talking about climate change, it is estimated that global losses to soybean, maize and wheat crops due to ground-level ozone pollution could be estimated to $17-35 billion per year by

2030. The cost of air pollution of the world's richest economies plus India and China are estimated to be $3.5 trillion per year in terms of loss of life and illness. To give an example of the severity of the issue, in OECD countries the monetary impact of death and illness due to outdoor air pollution in 2010 is estimated to have been $1.7 trillion (UNEP, 2014).

As a result of adverse impacts of air pollution and climate change, many efforts to reduce gas emissions, and public exposure to air pollutants in urban areas have been undertaken. In other words, to improve cities 'air quality as well as to slow down the global warming phenomenon by cutting down CO_2 emission. Public and private transport, district heating, commercial and residential building, and the energy sector are the main targets for air pollutants and carbon footprint reduction in cities. The green cities movement (trends) has helped city planners, policy makers, and central and local government to cut significantly CO_2 emission and toxic air pollutants emission in urban areas.

Actually, more than half of the world's people live in cities, this figure will rise to more than two-thirds by 2050, according to United Nations forecast (The Green City Index, Siemens). The death toll and climate change effect have raised the awareness to improve air quality and living standard in cities. In point of fact, this can be achieved by establishing pollution-control technologies for diesel vehicles and fuels, effective urban planning strategies that privilege sustainable transport, clean energy, energy-efficient buildings and homes, and public green areas which are able to filter air pollutants (UNEP, 2014).

Referring to the World Health Organization (WHO) air quality policy and guidelines along with regional policy of EU such as Directive2001/80/EC for limit value of some pollutants, many cities are moving forward to a green and sustainable city. As a result of that, many of cities of developed countries, are designed and/or renovated with consideration of environmental impacts, inhabited by people dedicated to minimize the inputs of energy, water and food, minimizing waste generation and heat consumption, reduction of side effects from human-made activities that results in emission of air pollutants the main driver of the urban air pollution.
Thus, several cities government bodies take various and ambitious actions to cut down the emission of CO_2, and other pollutants as SOx, NOx emissions, particulate matters and volatile organic compound in an attempt to minimize the concentration of these pollutants in ambient air to an acceptable level as well as to increase the living standard, the quality of life of inhabitants and safeguard the environment.

2.2. POSITION OF THE PROJECT

Cities are facing many issues that are prone to affect human health, well-being and climate change (Bolunda & Hunhammar, 1999). They hold the majority of human activities and the associated air pollution emissions with significant adverse health and environmental effects. However, despite the fact that government bodies, agencies and city planners have made considerable efforts to reduce air pollutant emissions and improve air quality, city dwellers are still exposed to high levels of pollutant concentrations that exceed the World Health Organization (WHO), European Union Standard (EU) and American Protection Agency (USEPA) standards to protect public health.
Various initiatives such as green and public transportation, law enforcement and regulation, green space construction, among other examples have been taken and set by cities in the world to reduce air pollutants emission and enhance air quality in cities since years. For

instance, the European Union has proposed a reduction of several pollutants such as SOx, NOx, and $PM_{2.5}$ by 81%, 69%, and 51% respectively as improving strategies (European Commission, 2013). The EU air quality health-based standard for the exposure to such pollutants are summarized in the table below.

These strategies are mainly revolving in good public transportation, promotion of bicycle usage, green building, and low zero emission area has been conducted in several European countries. Nevertheless, those ambitious and promising actions implemented in large cities are not quite widespread. The main cause of this dissemination, is a lack of awareness from city planners owing to an absence of key qualitative and quantitative data.

This project is carried out with the aim to develop a simple tool that can support and facilitate global shared-decision making for urban planners and policy makers of cities. As they can be aware of existing innovative strategies that are being applied worldwide to achieving air pollution reduction targets and carbon footprint in cities. In general, the tool will help urban planners to getting access and apply various strategies that are able to minimize the impact of air pollutants emission on public health, the environment and climate change.

2.3. STATE OF THE ART

Improving Air quality and CO_2 reduction are currently one of the most prioritized issues in the world. The development of the project emphasis on what strategies that can be implemented in a city to improve the air quality in the city. The innovative solutions in the strategies provided collectively, eliminates the possible contaminants in the air. The technologies which are considered to put forward innovative solutions to be implemented by city planners and to facilitate enough information to formulate the environmental policies of the particular cities by administrative government respectively.

This project also explains the type of strategies that can be implemented for the better urban planning of infrastructure for the people and thereby improving their standard of living. The provided information in the project focuses on the target areas of sources of pollution, and the methodology for the elimination of contaminants and the benefits after the application.

The concept and approach of the project is intended for providing a quantified database that has the feasibility for the information provided for the sustainable solutions in the particular city. The development of the database has been up to a level where it can also provide information about the phase of planning of strategy applied for the particular number of inhabitants and year of its application in the city. The database information focuses on the case studies conducted on cities which were under the influence of heavy air pollution.

The structure of the database are in references of various database like IPCC, AIR4EU where various parameters has been highlighted like the name of city and in which country it is situated, the area and number of inhabitants in the city, the strategy which was implemented in the city, what were the pollutants which were mitigated through that particular strategy, the percentage/values change in the amount of the air pollutant, what were the finances involved in the total project like the operational, cost per inhabitant and investment cost and change in social standard of the people living in the city.

It is a complete overview developed to make it adaptable to the global level where it can be accessed to easily understand that how the strategy can be operational to various cost effective options. This kind of the quality and quantitative data in the database will provide a better evaluation to city planners who can propose to the concerned authorities to get a better image and approachability of the type of strategies.

2.4. OBJECTIVES, ORIGINALITY AND INNOVATIVE NATURE OF THE PROJECT

To carry out this work and meet the objectives of this project, we have first identified and reviewed the existing innovative strategies that have been implemented worldwide with the aim of reduce air pollution and carbon footprint in urban areas. The European cities are the most represented herein, following by some cities in Latin America, then come Asia and North America. We have chosen those cities owing to the fact that they have been implemented solid environmental policies and environmental laws enforcement.

In addition, the focuses were on countries that have an economical growth and at the meantime are facing many issues related to air pollution and carbon footprint while they are trying to tackle these issues. Our scope of investigation has been an approach to concentrate on strategies which are implemented for the reduction of the major contaminants in the air for example $PM_{2.5}$, PM_{10}, NO_x, SO_x, CO_2. These are the pollutants which are emitted from sources like power plant industries, transports, residential heating, etc. which has its functions of operations by consuming fossil fuels or biomass. Thus, the objective, scope and innovative nature of our project can be summarized as follow:

- Identifying the existing innovative strategies that are being applied in cities to improve air quality and carbon footprint reduction.
- Assessing the main focuses in terms of emission reduction target for the energy sector, transportation, district heating and carbon footprint that are imparted per technologies or tools that are implemented.
- Identifying and synthesizing key qualitative and quantitative parameters (benefits and limits) for each strategy or option.
- Creating a tool that can support and facilitate shared decision making for policy makers and urban planners worldwide.

As for the scope of this project, there are twenty-two (22) considerable green cities in the world, spread over four (4) continents, for which some quantitative and qualitative data are available. Moreover, the solutions mentioned in this project are the current strategies which are applied to reduce gas emissions, particulates matters, volatile organic compounds in such a way that the technology remains as the innovative approach for the enhancement of utilization of the non-conventional sources for electricity, transport etc. thereby reducing the overall cost for the services provided.

Regarding the innovative nature of this project, it integrates the current strategies into a simple and straightforward database where urban planners and policy makers for cities can get access to and be aware of the existing innovative that are applied in the selected cities and also it provides some mathematical formula to estimate the level of certain pollutant reduction to achieving air pollution and carbon footprint abatement with respect of the number of inhabitants, land areas, and energy production.

3. METHODOLOGY

3.1. SCIENTIFIC METHODOLOGY

In order to develop a simple tool to support and facilitate city planners regarding air quality improvement strategies, literature review is used as the main information source for methodology. There are three main tasks that have to be performed:

1. Literature review

   After the concept, objectives and position of project have been defined, the first process is data collection. The approach to collect the data is based main in three ways:

   - Online Engine Searchers: A few key words used in order to search for air pollutant reduction strategies: “Air pollution strategies”, “Green cities” and “Smart cities”. Most of these keywords went towards governmental and city council websites were documents and presentations about this topic could be obtained. Scientific libraries were also consulted under the same key words.
   - Specific Organizations – European Project: There is one European organization called “Clean Air Europe”, which rejoins nine NGO who are making efforts and taking different actions on this topic. A project called “Air4EU” establishes case studies in European cities to review and examine a range of quality assessments and methods.
   - Meeting with Nantes Metropole: A meting with Nantes Metropole occurred in order to obtain information about the French city, discuss about the approach of this project and get feedback. The minutes is attached in the Appendix D.

   Afterwards identification, review, and synthesis of the implemented strategies have to be performed. The identification of each strategies needs to address the objectives, the context, the implemented measures and how they have been implemented and by whom, and also the time frame. It is necessary to review all the related key parameters of the strategies including the criteria, advantages and disadvantages, and cost that have to be clearly explained in the result chapter. A qualitative scale measurement can be applied if there is a lack of any quantitative information.

2. Data interpretation

   The data interpretation task consists in organizing the information in a table where it can be properly analyzed and then sorted by the quality and quantity of the information available. The columns of this table are: city, country, population of the city, area of the city, strategy name, details of the strategy, timeline, pollutant reduced/targeted, benefits and total cost.

   The information collected in the table needs to be validated in order to construct key parameters which are going to be used to compare and analyze the strategies in each city. The validation of the information consists in ensuring the maximum information can be collected for each case. (see Table 1)

Table 1. The Key Parameter in Data Interpretation

Main Aspects of the Database	
Information	Country; City; Population of the city; Area of the city; Strategy; Benefit; Target Pollutant; Total Cost; Details

Strategies	Parameters Proposed
Bicycle	% reduction of pollutant/year/person
Transportation	% reduction of pollutant/year/area
Urban Access Regulation	total pollutant reduction/year/person/area
Urban Green Infrastructure	total pollutant reduction/year/area of forest
Renewables Energy	total pollutant reduction/year/person/GWh
Efficient Planning	total pollutant reduction/year/person

3. Sensitivity analysis

After all the results have been obtained, the analysis of data robustness has to be done by characterizing each related references in order to construct the graphs and charts which summarizes the information collected. Once analyzed the next step is to compare the effectiveness and efficiency of all the strategies by equalizing the units of all the collected data in every strategy as mentioned in Table 1. The key parameters then were selected in the averaged values when data robustness allows, which means enough quantity of data (more than 2 values) and not extreme values.

4. Tool Development

Once the parameters are selected the construction can be done, by entering in a chart its values and automatizing the excel sheet. It has to be considered the maximum, minimum and average of the selected information in order to know what is the extent of this tool. (see **Figure 1**)

Figure 1. Tool Development Method

Figure 2. The methodology flow diagram

3.2. PROJECT MANAGEMENT

This report is conducted to execute the Integrated Engineering Project (IEP) course in the 2nd Semester of Project Management (PM3E) program at École des Mines de Nantes (EMN). The project is an initiative partnership between EMN and an environment consultant company named ATMOTERRA where the director, Adrien Bouzonville supervises this project.

The project started in March 2016 and ended by July 2016. According to the kick-off meeting, progress meeting with the supervisor was held regularly in face to face and by phone, and also the minutes were sent to all members and supervisor after the meeting. A detailed project schedule was created in order to keep in check with progress and deadlines. An intermediate report has been submitted on May 13th 2016. After Interim, the supervisor has delivered a feedback for the final report continuation. A scientific poster along with the final report has to be submitted on July 4th 2016. Further detailed and timeline of the project are available in Appendix E.

4. EXPLOITATION OF RESULTS

4.1. BICYCLE

Bicycle share schemes have arisen as an innovative approach in several cities in Europe, Asia and North America, with over 700 programs in operation around the world (Meddin and DeMaio, 2014 in European Cyclists' Federation file). Cycling is considered also as an effective method for improving a healthy lifestyle (Steinbach et al., 2011; Press-Kristensen, 2014 in European Cyclists' Federation file). The first bicycle share program was implemented in Amsterdam in 1965 and Copenhagen in 1995.

Figure 3. Cyclist in Copenhagen, Denmark (source: compass.ptvgroup.com)

The main benefits of bike sharing are mainly to the reduction of pollutants and GHG emissions due to the replacement of trips made by cars. The reduction of pollutants and GHGs emission such as PM_{10} and NO_2 by applying bicycle as a transportation is remarkable. The data shows a significance reduction of those pollutants in five cities, which are Antwerp (Belgium), London (England), Nantes (France), Seville (Spain), and Thessaloniki (Greece). Those city has been chosen due to its continuous support of cycling movement and its geographical location (European Cyclists' Federation, 2014).

Table 2. Selected city cycling information (European Cyclists' Federation, 2014)

City	Strategy Name	Lane (km)	Mode share (2010)	Bike users	Total cost (Euro)
Antwerp	Velo Antwerp	100	23%	115721.74	60,000,000
London	Barclays Cycle Hire	-	3%	168338.7	1,100,000,000
Nantes	Bicloo	373	4.5%	43656.65	40,000,000
Seville	Bici Sevilla	110	7%	49211.47	421,000,000
Thessaloniki	ThessBike	-	10%	32224	unknown

The reduction of PM_{10} and NO_2 by using bicycle as a mode transport in certain cities are shown in graph below.

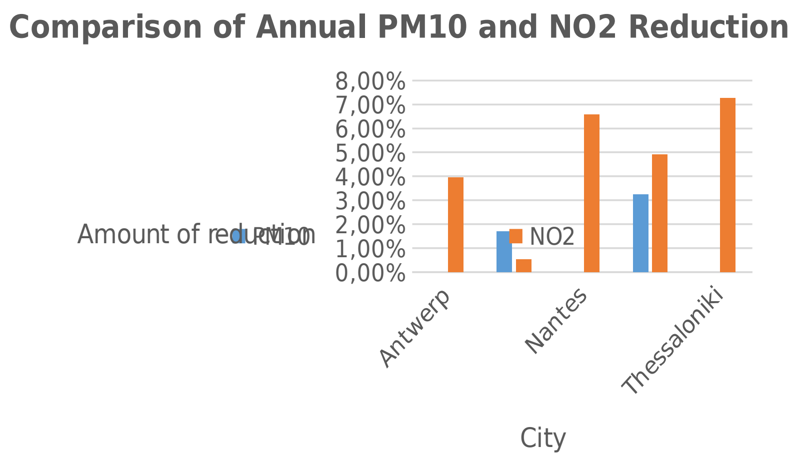


Figure 4. PM_{10} and NO_2 Reduction in cities annually of bicycle

According to the figure above, Thessaloniki in Greece has the highest reduction rate of NO_2 per year which is 7.26% (2.83 µg/m^3/year), while London has reduced only 0.53% of NO_2 (0.27 µg/m^3/year). However, Seville outdid Thessaloniki of PM_{10} reduction about 3.25% per year (1.5 µg/m^3/year). The PM_{10} reduction in the selected cities were not significantly reduced.

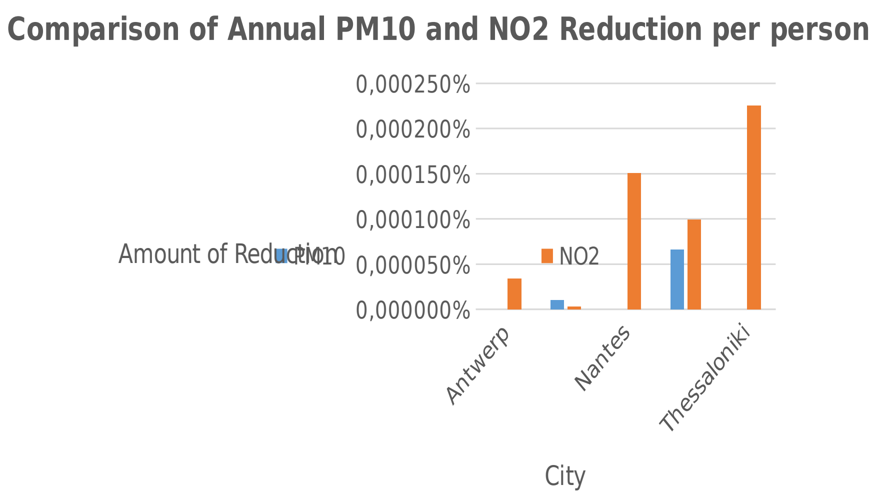


Figure 5. PM_{10} and NO_2 Reduction in cities per year per person of bicycle

The graph above shows the annual reduction of PM_{10} and NO_2 of each bike users. Referring to the graph, Thessaloniki has the highest amount of NO_2 reduction per year 0.000225% reduction/person/year (8.79×10^{-5} µg/m^3/person/year) while London has the least the reduction rate of NO_2 for about 0.000003% reduction/person/year (1.62×10^{-6} µg/m^3/person/year). Meanwhile, Seville has the highest percentage of PM10 reduction for 0.000066% /person/year).
Several cities in Europe does not rely on bicycle share scheme. Münster is the national bicycle capital of Germany and 37% of all journeys are traveled by bicycle. According to reliable estimates, there are more than 500,000 bicycles used by the 280,000 citizens of Münster or

two bicycles per capita (City of Munster). Bicycle efficiency according to the modal share in European countries are shown in the **Figure 6** below.

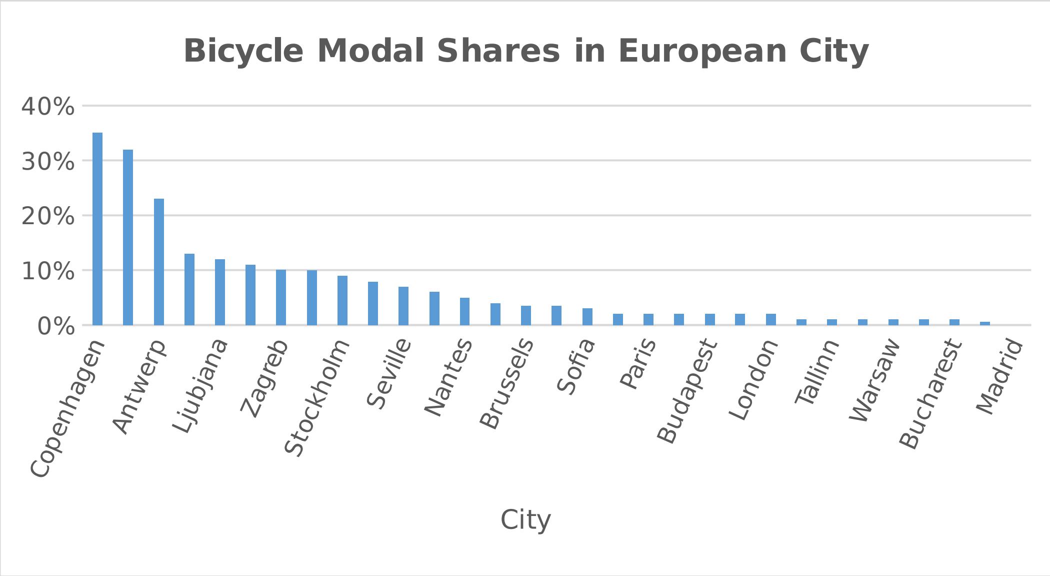


Figure 6. Bicycle modal shares in European city (European Cyclists' Federation, 2014)

Copenhagen has the highest modal share among European countries which is 35%. Amsterdam and Antwerp are included in the top three with percentage of modal shares of 32% and 25% consecutively. However, there is no data for the detailed pollution reduction in most of the cities because the bicycle is run privately.

4.2. TRANSPORTATION

The improvement of public transportation may help reduce the impact of pollutants and GHGs emission. Copenhagen (Denmark) has reduced the private vehicle usage by adapting integrated transport system: online journey planner, easy transfer between transport modes, one ticket for metro, train, and bus, and available place for bicycle in metro and trains (City of Copenhagen, 2014). For Helsinki (Finland), improving the rail infrastructure and congestion charging, will reduce 29,200 ton CO_2/year and 126,000 ton CO_2/year (Siemens AG, 2013). Bogota (Columbia) has started to implement new strategies as using bus rapid transit systems (BRT), e-taxi, car-free Sundays, double parking fee, and renovation of streets for pedestrian. While Paris (France) applied “Autolib” which is public electric cars available to be rented by citizens (Autolib' Paris, 2016).

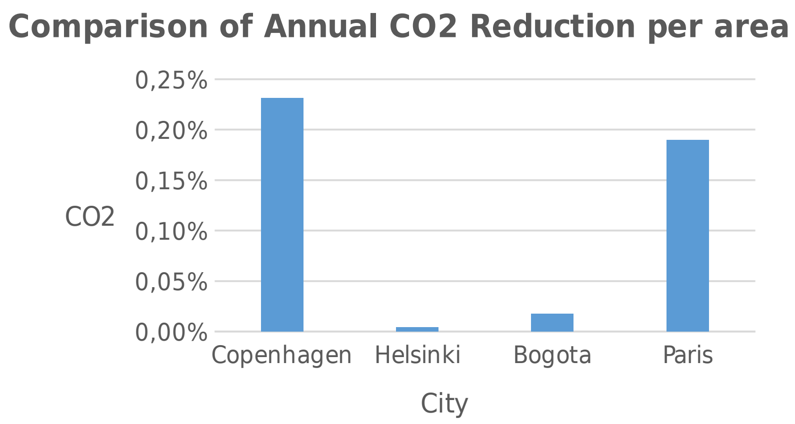


Figure 7. Annual CO_2 reduction per area of transportation

From the graph above, Copenhagen has the highest percentage of CO_2 reduction for 0.23% per area per year. While Paris has can reduce 0.19% of CO_2 per area every year. Even though Helsinki has the lowest percentage of CO_2 reduction.
However, Berlin (Germany) has the scheme of transportation by applying clean vehicle to reduce PM_{10} and NO_x. This scheme may reduce 0.24% of PM10 and 1.40% of NO_2 annually.

4.3. URBAN ACCESS REGULATION

European cities are now striving in implementing measurement in urban access regulation sector to maintain the EU standard limits. The first strategy is Low Emission Zone (LEZ) that is an area where access to certain vehicles is restricted due to their emissions. In most of European cities, the vehicles allowed to enter corresponds as minimum EURO 4 or EURO 3 standard completed with particle filter for diesel vehicles and EURO 1 with a catalytic converter for petrol vehicles. The European vehicles standard can be found in Appendix B. Congestion charge (CC) or road pricing is originally introduced to finance road construction, public transport or consolidating the public budget. Since it reduces traffic, consequently the emission pollution also goes down. To comply with those regulatory measures, the government is also taking into account the technical abatement strategies which is retrofitting vehicles with denitrification systems (Bund für Umwelt und Naturschutz Deutschland (BUND) e.V., 2012). Five big cities in Europe have been chosen in order to discover the efficient way to improve air quality in urban access. The percentage of NOx and PM_{10} concentration reduction per year and the area covered have been collected from European Commission webpage "Urban Access Regulation in Europe", the calculation to get the benefit in annual reduction per area covered was carried out afterward (European Comission, 2015).

Firstly, LEZ in Berlin was introduced on January 2008 covering the city center area of 85 km^2. It resulted reduction per year per km^2 area covered of particulates (PM_{10}) by 0.45% and NOx by 0.21%. Berlin municipality has financed 2 Million Euros to retrofit about 200 buses with Selective Catalytic Reduction Technique (SCRT) from 2013 until 2014. The predicted result is quite interesting as it lowers NOx by 55% per year or 0.06% per year per km^2. The other strategies implemented in Berlin are retrofitting diesel vehicles to meet EURO 4 standard and promoting EURO 6 standard for all vehicles aiming to reduce particulates (PM_{10}) by

12.1% per year or 0.14% per year per km^2 and 1.5% per year or 0.02% per year per km^2 consecutively (Senate Department for Urban Development and the Environment of Berlin, 2014). After all the implementation of urban access strategies in Berlin, it can be seen from **Figure 8** that Berlin reduced 0.29% of NOx per km^2 and 0.61% of PM_{10} per km^2 each year.

In London case, the CC zone with 84.9 Million pounds' investment in 2003 annually reduced by 0.57% per km^2 for both PM_{10} and NOx. In the next five years, London was launched LEZ covering Greater London (Mayor of London, 2015). The combination of these two strategies decreased NOx by 0.63% and PM_{10} by 0.58% per km^2 per year as expressed in Figure 7. The same scheme has been executed also in Milan and Stockholm (European Cyclists' Federation, 2014). The 4 years operational LEZ and CC with 8 km^2 area covered in Milan has a quite massive effect proven by reducing 0.56% of PM_{10} and 0.31% of NOx per year per km^2. Thus, by operating both LEZ and CC corresponds with minimum EURO 4 standard for diesel vehicles and EURO 1 standard for petrol vehicles, it can be defined the annual average reduction of NOx and PM_{10} per km^2 area covered are 0.4% and 0.47% respectively. Overall, London succeeded more to improve its air quality, followed by Berlin, Milan, Stockholm, and Rome.

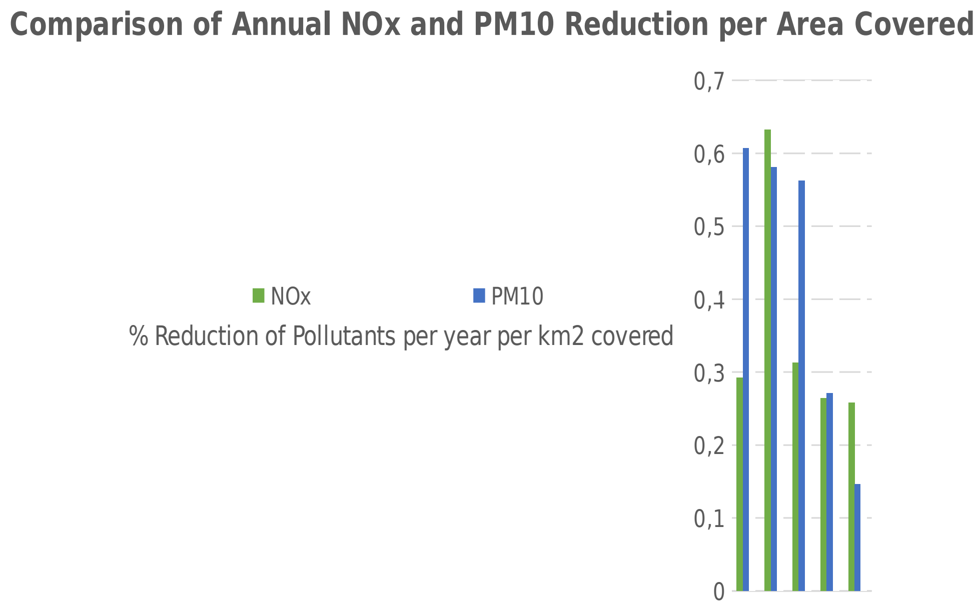


Figure 8. Annual NOx and PM_{10} reduction of urban access regulation

More studies have been carried out to know which strategy reduces more PM_{10} and NOx, the charts presenting these studies can be found in Appendix C. By comparing cities that have the same scheme, London and Stockholm cases, it can be concluded that CC is more effective in terms of NOx and PM_{10} removal strategies. Apart from it, Berlin shows that LEZ has greater effects in reducing both NOx and PM_{10} than some retrofit and promotion strategies with 72% and 74% proportion consecutively.

4.4. RENEWABLE ENERGY (WIND FARM)

As the data available regarding air quality improvement in renewable energy sector is only about wind farm, there are only 3 cities that have been studied, Copenhagen, Hawaii and Colorado. The key parameter that were taken into consideration are the percentage reduction of air pollutants, in this case are SO_2 and NOx, CO_2 emission, and the number of people who get the benefit from the electricity produced.

The offshore wind farm in Copenhagen located at Middelgrunden operates 20 turbines with 40 MW (2 MW each) of total capacity. It generates 89 GWh electricity and distributed to 8,650 members of local community (City of Copenhagen, 2014). Thereby, the annual reduction of SO_2 is 2.61 tons/GWh or 0.0003 tons/GWh per capita, NOx is 2.34 tons/GWh or 0.0003 tons/GWh per capita and CO_2 is 764 tons/GWh or 0.088 tons/GWh per capita. As seen in **Figure 9** and **Figure 10** below, comparing to other wind farms in USA, the one in Copenhagen is much more effective to contribute in improving the air quality.

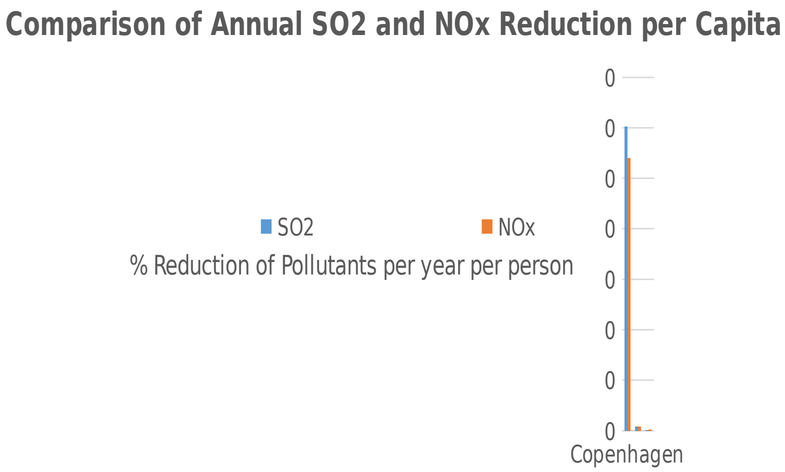


Figure 9. Annual NOx and SO_2 reduction of wind farm sector

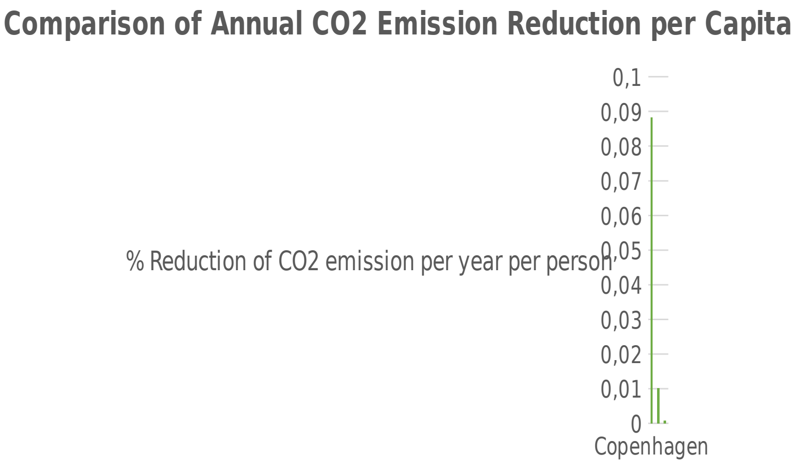


Figure 10. Annual CO_2 Emission reduction of wind farm sector

4.5. ENERGY EFFICIENT PLANNING

The results were compared with each other in the cities according to the type of pollutant reduced by the strategy for Energy Efficient Planning.

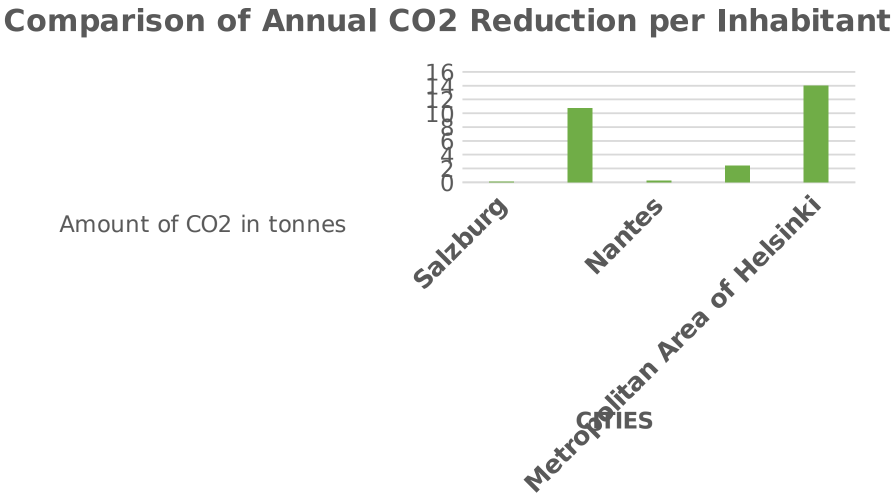


Figure 11. Annual CO_2 reduction of energy efficient planning

The graph shows the analysis of amount CO_2 reduced per inhabitant annually among the cities Salzburg, Apeldoorn, Nantes, Helsinki and metropolitan area of Helsinki. The highest reduction of the CO_2 per inhabitant annually is in metropolitan area of Helsinki with 13.99 tons annually followed by the strategy implemented in Apeldoorn with reduction of 10.772 tons per year.

Figure 12. District heating unit in Austria
(source: www.crossborderbioenergy.eu)

4.6. URBAN GREEN INFRASTRUCTURE

The results were compared with each other in the cities according to the type of pollutant reduced by the strategy for urban infrastructure planning.

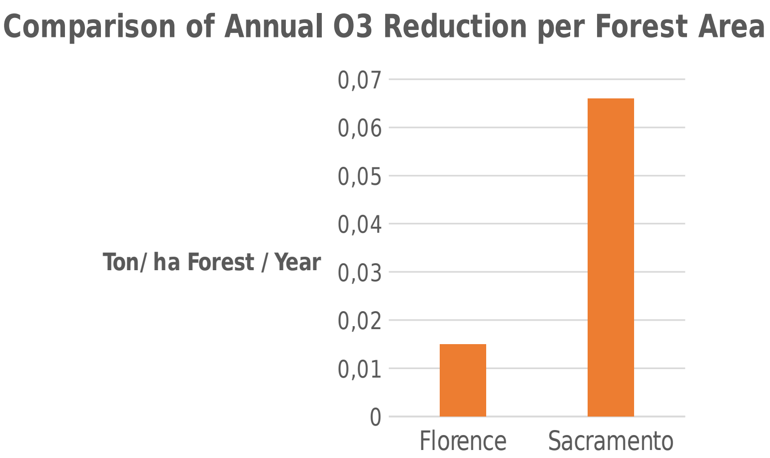


Figure 13. Annual O_3 level reduction of urban green infrastructure

The above graph is in comparison for reduction of O_3 in Sacramento and Florence. It was found in the analysis that Sacramento succeeded Florence in the reduction of O_3. The amount of reduction by Florence was 0.015 ton/ha forest/year and Sacramento was 0.066 ton/ha forest/year. Sacramento reduced the O_3 level by 77.27% than Florence.

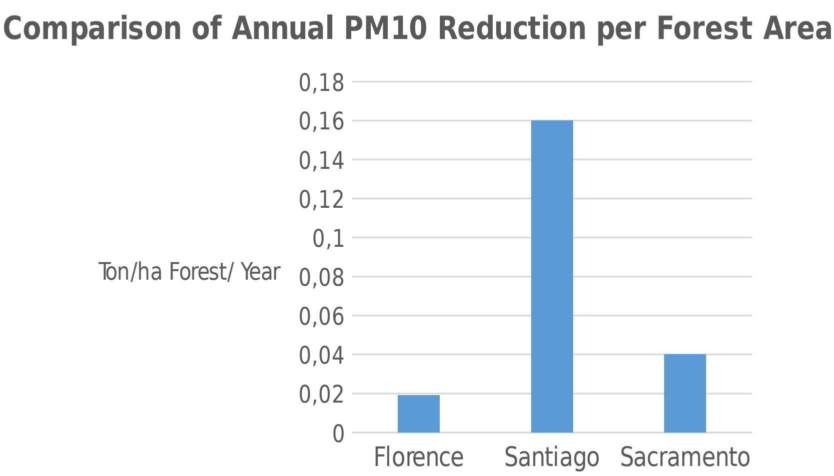


Figure 14. Annual O_3 level reduction of urban green infrastructure

The above graph is in comparison for reduction of PM_{10} in the cities Florence, Santiago and Sacramento. The highest reduction of PM_{10} was done by the strategy implemented in Santiago city with reduction of 0.16 ton/ha forest/year followed by Sacramento at reduction level and 0.04 ton/ha forest/year and Florence at the end at the level 0.019 ton/ha forest/year.

5. DISCUSSION

5.1. BICYCLE

The cycling movement throughout Europe has been contributing in reducing the pollutants such as PM10, NOx, and GHGs emission. Five selected cities: Antwerp (Belgium), London (England), Nantes (France), Seville (Spain), and Thessaloniki (Greece) have been involved in bike share scheme.

Seville has the most effective pollution reduction of PM_{10} for 3.25% per year (1.5 µg/m^3/year) or 0.000066% /person/year) followed by London. However other cities still could not reduce the PM_{10} significantly. Thessaloniki has the best NO_2 reduction cities for 0.000225% reduction/person/year (8.79 x 10-5 µg/m^3/person/year) followed by Nantes, Seville, Antwerp, and London consecutively. Those percentage number will be relevance for 1 million inhabitants or more. The difference of rate of reduction is due to by the number of population, percentage of bicycle used and bike users (mode share), reduction of vehicle, and other detailed explained as follow:

- Antwerp: It has a medium rate of reduction of NO_2 because the mode share is the highest amongst the selected cities for 23% and succeeded reduce car mode share significantly from 61% to 41% in 2 years (2008-2010).
- Nantes: The percent reduction of NO_2 is quite high (the second highest) for about 6.58% due to the initial emission is already low in the cities. NO_2 daily exposure is almost zero. The cycling movement and green public transportation has been well-developed.
- London: It has the highest percentage of population for about 8 million but low bicycle mode shares (only 2 %). In general, the mean air quality levels of NO2 in London have not changed significantly between 2000 and 2012.
- Seville: This city has the most balanced PM_{10} and NO_2 rate of reduction. It invested a lot and has a lot of expanding activity of cycling infrastructure and dropping car usage.
- Thessaloniki: Cycling has a 10% of the mode share. Despite the fact that Thessaloniki does not have an extensive cycling infrastructure, but it created many important efforts by the local authorities to create a cycling culture such as hosting cycling schools and events (the cycling carnival) (European Cyclists' Federation, 2014)

The reduction of NO_2 is quite efficient by introducing bicycle and it is contradictive with PM10. In order to reduce PM_{10}, other strategies scheme has to be conducted. By having only bicycle scheme, it will not enough to reduce NO_2 and PM_{10} because it needs other scheme i.e. LEZ and congestion charge. The lower bicycle mode share over car or vehicle will not make a significant reduction to pollutant. The vehicle neither to be reduced nor changed into clean vehicle. The number of population and bike users influences the reduction of pollutant. Cycling has to be socialized to every people in order to get the top benefit it can offer.

The percent reduction of NO_2 and PM_{10} can be used as parameters to find the estimated reduction for other cities. Key finding in the bicycle for tools are:

Table 3. Key parameter of bicycle

Pollutant	**% Reduction/person/year**	**Data source**
NOx	0.000066%	Average
PM10	0.000103%	Average

5.2. TRANSPORTATION

Transportation has an ability to reduce pollutants and GHGs emission by creating an integrated system. It has been done in cities such as Copenhagen (Denmark), Helsinki (Finland), Bogota (Columbia), and Paris (France). The result of annual CO_2 reduction per area shows that Copenhagen has the highest CO_2 rate of reduction, followed by Paris in the second position, and other cities.
As for Copenhagen, it reduces CO_2 effectively by only improving the system of public transportation (online journey planner, easy ticket for every public transportation) and also supported by the high rate of bicycle users (35% bicycle mode share, the best in Europe). It reduces the CO_2 by 0.23% annually. Paris may reduce the CO_2 emission with a very high rate by introducing environmentally-friendly electric cars by 0.19% every year. However, it is not sufficient enough to reduce the CO_2 emission by improving rail infrastructure and congestion charge as seen in Helsinki.
From the result, the best scheme in transportation is the establishment of integrated system and eco-friendly vehicle (low emission vehicle). The key findings are different related to each scheme as seen in table below:

Table 4. Key parameter of transportation

City	Strategy	% CO_2 Reduction/person/year
Copenhagen	Integrated System	0.23
Paris	Eco-friendly vehicle	0.0041
Bogota	Eco-friendly & new system	0.02
Helsinki	Infrastructure renovation & congestion charge	0.19

As the values are too distant from each order, it is considered that take into account an average value cannot be possible, also as for the variety for the sub-strategies.

5.3. URBAN ACCESS REGULATION

The key findings in urban access regulation for the tool are:

Table 5. Key parameter of UAR

Cities	% Reduction per year per km^2 area covered	
	NOx	PM_{10}
London	0.63	0.58
Milan	0.31	0.56
Stockholm	0.26	0.27
Average value =	**0.40**	**0.47**

The different values retained from LEZ with CC in 3 cities might be caused by:

1. The different traffic access reduction due to different mode of transport shifting or the reduction of cars entering the zone:

a. In London, it went down by 15% with up to 60% motorists changing to public transport. That is the reason why London is the most successful case in this particular sector (European Cyclists' Federation, 2014)
b. In Milan, the traffic access reduced by 30% along with the number of cars entering decreased by 33% (European Comission, 2015)
c. In Stockholm, the traffic access went down by 18% (Eliasson, 2014)

According to Air4EU London case studies, the light good vehicles such as cars and minivan release the biggest amount of pollutants, hence the fewer cars entering the zone, the faster the zone to lower the pollutants emission (Nutthida Kitwiroon, 2007)

2. The different scheme operation. All the cities started with different scheme of LEZ. Stockholm and London provide a very good information so the annual reduction can be calculated as the actual data given. However, in Milan case, the new scheme that was only taken into consideration since the old scheme is not very well explained in terms of the vehicles standard.

Comparing to Clean Air Europe project, this study concluded almost the same order in urban access sector, however there are some different points

a. Berlin is supposed to be ranked before London, but because of the retrofitting strategies are still ongoing therefore the amount of pollutant reduction taken into account is only the estimation. This condition makes the comparison between strategies in Berlin is not that well represented. Based on this project result, CC is suggested to be implemented along with LEZ in Berlin in order to decrease more NOx emission generated by any kind of vehicles.
b. Milan is supposed to be ranked after Stockholm, as the Clean Air Project also considered the reduction of traffic access each year. However, in this study the traffic access was only counted as the additional benefit.

5.4. RENEWABLE ENERGY (WIND FARM)

The wind farm in Copenhagen is considered to be the best one comparing to two others. However, as seen in **Figure 9** and **10**, there is a huge gap between wind farm in Copenhagen and the others. Moreover, since the information explained about the wind farm operation is not very well and also there is no precise information regarding the electricity consumption from each wind farms in Hawaii and Colorado, the conclusion in this strategy cannot be decided. Hence, this renewable strategy is not taken into account in the developed tool.

5.5. ENERGY EFFICIENT PLANNING

This planning is an integrated approach in order to maximize the resource planning for sufficing the energy demands. The approach includes the maximum utilization of the resources such as waste, renewables etc. The cities that are selected for the energy efficient planning are Salzburg, Apeldoorn, Nantes, Helsinki and metropolitan area of Helsinki (European Comission, DG Energy, 2014).

In the analysis, the results showed that the highest reduction of CO_2 per inhabitant annually was achieved by Metropolitan area of Helsinki. Landfill gas to energy was the planning they implanted for the energy supply. It also reduces the benefit of reduction of CO_2 achieved by this strategy was 13.99 tons annually followed by the Apeldoorn which uses district with CHP plant.

From the results, the most effective strategy is from metropolitan area of Helsinki as the amount of Total reduction in CO_2 annually and benefit reduction per inhabitant is highest.

Table 6. Key parameter of energy efficient planning

Cities	% CO_2 Reduction/person/year
Salzburg	0.087
Apeldoorn	10.722
Nantes	0.238
Helsinki	2.398
Metropolitan Area of Helsinki	13.995

5.6. URBAN GREEN INFRASTRUCTURE

Urban Green Infrastructure is the planning for planting various types of trees in order to improve air quality. Trees have the tendency to absorb various pollutants like the GHG emissions. The cities that have been taken in concern for the selection of analysis are Florence, Santiago, and Sacramento.

In terms of the reduction of O_3, it was found in the analysis that Sacramento succeeded in achieving the highest reduction of O_3. Sacramento reduces 0.066 tons/ha forest/year. For the reduction of the PM_{10}, Santiago achieves the highest value that is 0.16 tons/ha forest/year.

- **Sacramento**: It has the highest reduction value for the O_3 but the lowest value in terms of reduction of PM_{10}. They use the planning for planting 50,000 trees annually. The planning included 13 different types of trees (McPherson, Scott, & Simpson, 1997).
- **Santiago:** It has the highest value in terms of reduction of PM_{10}. The planning they used was the methodology for planting trees according to their cost effective methods. They allocated the area according to the socio-economic data.
- **Florence:** Florence has the lowest values for the reduction of PM_{10} and O_3. Probably, the area that is covered by the urban forestry is very less.

Table 7. Key parameter of urban green forestry

Cities	PM_{10}(ton/ha forest/year)	O_3(ton/ha forest/year)
Florence	0.019	0.015
Santiago	0.16	
Sacramento	0.04	0.066

5.7. TOOL DEVELOPMENT

The tool development as explained in the methodology consists calculating the average values for each strategy and parameter considered. The values are shown in table below.

Table 8. Key parameter of all strategies

Strategies	Parameter	Value
Bicycle	% PM_{10}/bike user/year	0.000015%
	% NO_2/bike user/year	0.000103%
Transportation	-	-
Urban Access Regulation	%NO_X/area covered/year	0.40%

(UAR)	$\%PM_{10}$/area covered/year	0.47%
Urban Green Infrastructure (UGI)	Ton O_3/ha of forest/year	0.04
	Ton PM_{10}/ha of forest/year	0.073
Renewables Energy	-	-
Efficient Planning	Ton CO_2/person/year	5.488

The range of values where they were calculated and the extent of where these values should be used are. Nevertheless, an extrapolation can also be considered.

Table 9. Tools' Input

Range of Values			
Input	Min	Max	Average
Bike Users	30,000	170,000	40,000
Area Covered for UAR	5	35	28
Area of Forest for UGI (ha)	25,000	100,000	44,290
Timeframe	2	15	8

Finally, an example is brought up, a city that aims to have 50000 bike users, 20 square kilometers for urban access regulations and 48000 hectares of city forest will achieve in average the results shown in table x.

Table 10. The Developed Tools

TOOLS		
Inputs		
Bike Users	50,000	habitants
Area Covered for UAR	20	km^2 for UAR
Area of Forest for UGI	48,000	ha of forest
Benefits		
Bicycle	1%	% PM_{10} reduced per year
	5%	% NO_2 reduced per year
Urban Access Regulation	8%	% NOx reduced per year
	9%	% PM_{10} reduced per year
Urban Green Infrastructure	1,920	Ton O_3 per year
	3,504	Ton PM_{10} per year
Efficient Planning	274,400	Ton CO_2 per year

6. CONCLUSION

It can be stated that most of all the objectives were achieved. A wide literature was realized, joining in one database strategies for 22 cities around the world. Several strategies were found and comment in detail; these strategies also were quantified with key parameters, which helped to construct the urban planner tool.

The urban planner tool shows that:

- Bicycle strategy is substantial in average for over 100,000 users for PM_{10} and 10,000 for NOx,

- Regarding urban access regulation covering areas in average over than 10 km can be determinant for these two pollutants,
- In Urban green infrastructure and energy efficient planning only total amount of pollutant can be calculated therefore city planners will need the initial amount of concentration in order to have the percentage reduction,
- Transportation and renewable energy were not considered into the tool because both strategies showed variability and different approaches. City planner should review the example of Copenhagen for this scheme.

The difficulties were to search and found the cost in detail, for that reason, it was only mention in certain cases as it can be found in the database but because of lack of information it was not considered for the tool. A great update can be done in this direction as well as increasing the numbers of cities reviewed.

As discussed with Nantes Metropole, one very important parameter should not be avoided which is people awareness and education. For example, a city could have great public transport system with a reliable bicycle share system but if the citizens prefer anyway to mobilize themselves in cars, few changes can be made. In the end, this tool gives assistance to urban city planners for what kind of strategies should be implemented and also quantify the impact of them in order achieve good results in air quality standards.

7. REFERENCES

Autolib' Paris. (2016). Retrieved June 2016, from https://www.autolib.eu/en/

Bolunda, P., & Hunhammar, S. (1999). Ecosystem services in urban areas. *ELSEVIER, Ecological Economics*, Pages 293–301.

Brunekreef, B., & Holgate, S. T. (2002). Air pollution and health. The Lancet. *SienceDirect*, 1233–1242.

Bund für Umwelt und Naturschutz Deutschland (BUND) e.V. (2012, January). *Soot Free Cities.* Retrieved from Clean Air Europe: http://www.cleanair-europe.org/fileadmin/user_upload/redaktion/downloads/Clean_Air_Publikationen/LIFE_soofree_cities_measures_2012.pdf

City of Copenhagen. (2014). *Copenhagen: Solution for Sustainable Cities.* Retrieved April 2016, from http://kk.sites.itera.dk/apps/kk_pub2/pdf/1353_58936BnEKE.pdf

City of Munster. (s.d.). *The Munster Application for European Green Capital Cities.* Retrieved by May 2016, sur http://www.muenster.de/stadt/greencapital/muenster-application.pdf

Eliasson, J. (2014). *The Stockholm congestion charges: an overview.* KTH Royal Institute of Technology. Stockholm: Centre for Transport Studies. Retrieved June 2016, from http://www.transportportal.se/swopec/CTS2014-7.pdf

EPA. (2011). Retrieved April 2016, from https://www3.epa.gov/airquality/airtrends/2011/report/climatechange.pdf

European Comission. (2015). *Impact of Low Emission Zones*. Retrieved June 2016, from http://urbanaccessregulations.eu/low-emission-zones-main/impact-of-low-emission-zones

European Comission, DG Energy. (2014). *Energy Solutions for Smart Cities and Communities: Lessons learnt from the 58 pilot cities of the CONCERTO initiative.* Retrieved June 2016, from http://www.concertoplus.eu/concerto1_lrage.pdf

European Commission. (2013). Retrieved April 2016, from http://www.europarl.europa.eu/EPRS/EPRS-Briefing-565910-Reducing-air-pollution-v3-FINAL.pdf

European Cyclists' Federation. (2014, November). *Cycling and Urban Air Quality: A Study of European Experiences.* Retrieved April 2016, from https://ecf.com/files/150119-Cycling-and-Urban-Air-Quality-A-study-of-European-Experiences_web.pdf

European Environment Agency. (2016, April 21). Retrieved from http://www.eea.europa.eu/publications/air-quality-in-europe-2014

Mayor of London. (2015). *Transport for London: Congestion Charging & Low Emission Zone Key Fact Sheet*. Retrieved June 2016, from http://content.tfl.gov.uk/congestion-charge-low-emission-factsheet.pdf

McPherson, E., Scott, K., & Simpson, J. (1997, October). Estimating Cost Effectiveness of Residential Yard Trees for Improving Air Quality in Sacramento, California, Using Existing Models.

Nutthida Kitwiroon, Y. Y. (2007). *Air4EU Case Studies - Individual case study report: 8 Traffic Management impact in London, using OSCAR.* Air4EU.

Senate Department for Urban Development and the Environment of Berlin. (2014, December). *Air Quality Plan for Berlin 2011-2017.* Retrieved April 2016, from http://www.stadtentwicklung.berlin.de/umwelt/luftqualitaet/de/luftreinhalteplan/download/lrp_150310_en.pdf

Siemens AG. (2013). *Sustainable Urban Infrastructure: A view to 2030.* Retrieved April 2016, from http://innovatiivinenkaupunki.aalto.fi/en/current/news/helsinki_study_2013_eng_final_copy.pdf

UNEP. (2014). Retrieved April 2016, from http://www.unep.org/ccac/Media/PartnersInFocus/WorldHealthAssemblyPassesLandmarkResolution/tabid/1060210/Default.aspx

UNEP. (2014). Retrieved April 2016, from http://www.unep.org/yearbook/2014/PDF/chapt7.pdf

8. APPENDIXES

A. Air quality health-based standards for exposure to some air pollutants in ambient air.

Title	Metric	Averaging period	Legal nature	Permitted exceedances each year
PM_{10}	50 µg/m³	24 hours	Limit value entered into force 1.1.2005**	35
Fine particles ($PM_{2.5}$)	25 µg/m³	1 year	Target value entered into force 1.1.2010 Limit value enters into force 1.1.2015	n/a

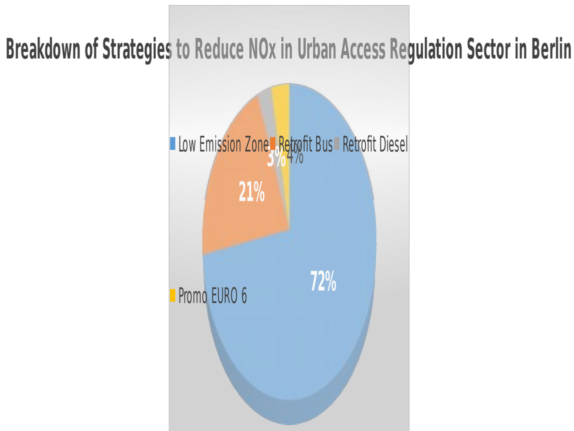
Sulphur dioxide (SO_2)	125 µg/m³	24 hours	Limit value entered into force 1.1.2005	3
Nitrogen dioxide (NO_2)	200 µg/m³	1 hour	Limit value entered into force 1.1.2010	18

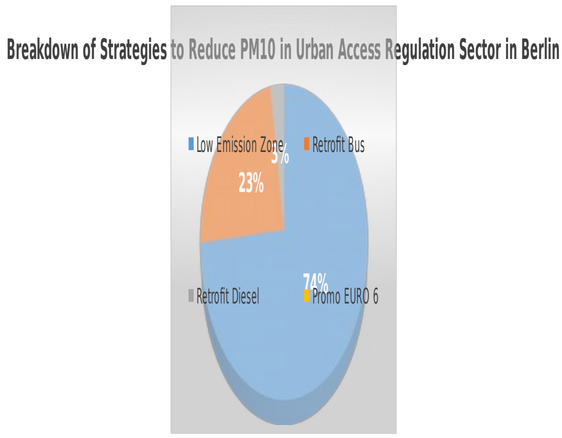
B. Euro Standard Vehicles

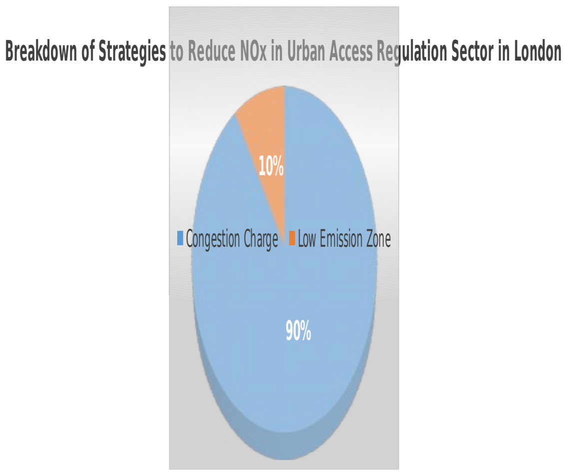
Standard	Starting Year	Fuel Type Used	Emission Limits (g/km)					Purpose
			CO	HC + NOx	HC	NOx	PM	
EURO 1	Jul-92	Petrol	2.72	0.97				Euro 1 required the switch to unleaded petrol and the universal fitting of catalytic converters to petrol cars to reduce carbon monoxide (CO) emissions
		Diesel	2.72	0.97			0.14	
EURO 2	Jan-96	Petrol	2.2	0.5			No limit	Euro 2 reduced the combined limit for unburned hydrocarbons and oxides of nitrogen for both petrol and diesel vehicles
		Diesel	1	0.7			0.08	
EURO 3	Jan-00	Petrol	2.3		0.2	0.15	No limit	Euro 3 modified the test procedure to eliminate the engine warm-up period and further reduced permitted carbon monoxide and diesel particulate limits
		Diesel	0.64	0.56		0.5	0.05	
EURO 4	Jan-05	Petrol	1.0		0.1	0.08	No limit	Euro 4 concentrated on cleaning up emissions from diesel cars, especially reducing particulate matter(PM) and oxides of nitrogen (NOx). Some Euro 4 diesel cars were fitted with particulate filters
		Diesel	0.5	0.3		0.25	0.025	

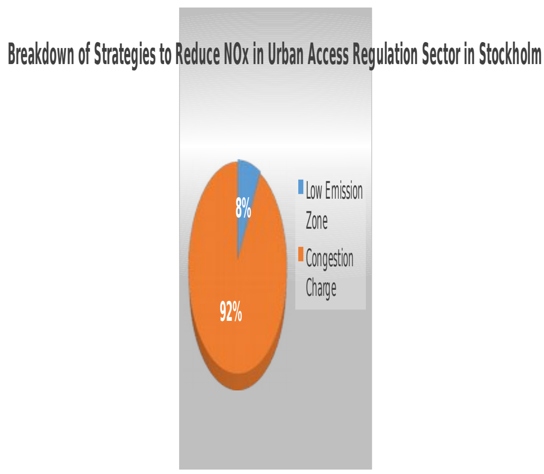
EURO 5	Sep-09	Petrol	1.0		0.1	0.06	0.005	Euro 5 further tightened the limits on particulate emissions from diesel engines and all diesel cars needed particulate filters to meet the new requirements
		Diesel	0.5	0.23		0.18	0.005	
EURO 6	Sep-14	Petrol	1.0		0.1	0.06	0.005	The Euro 6 standard imposes a further, a 67% reduction in NOx emissions from diesel engines compared to Euro 5 and establishes similar standards for petrol and diesel
		Diesel	0.5	0.17		0.08	0.005	

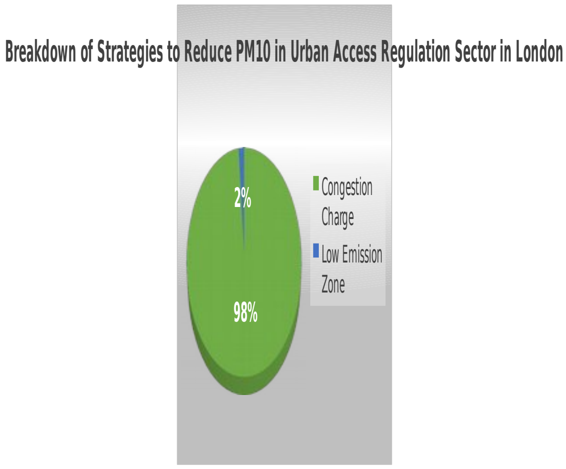
C. Urban Access Regulation Further Study Results

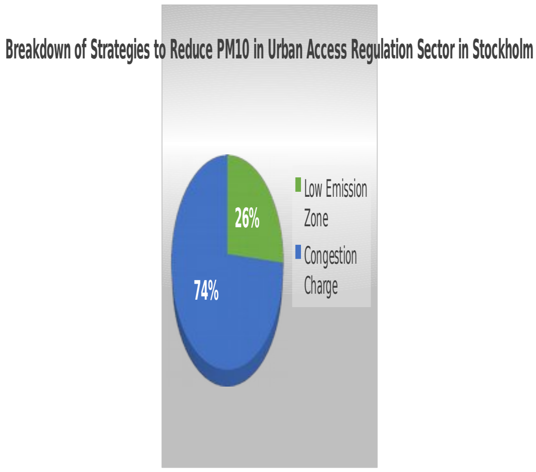












D. Minutes of Meetings

MINUTES OF MEETING

"Innovative Strategies for Reducing Carbon Footprints and Air Treatment in Urban Areas"

Place: Ecole des Mines de Nantes, Salle de Travail Bibliotheque
Date: Tuesday, June 21st 2016
Time: 16.30 – 17.30
Attendees:

- Supervisor: Adrien BOUZONVILLE
- Team Member:
    - Jose Ignacio FUENZALIDA NAVARRETE
    - Iqlima FUQOHA
    - Gaurav UPRETI
    - Haifa Fawwaz ATMAYA
    - Jean-Joseph Dorismond

Agenda:
Discussion feedback of the report, collected data and table, and sensitivity analysis.

Discussion Points:

- The content of state of the art will be:
    - Description of the problem/current issues
    - The methodology followed/referred to solve the problem
    - Specific detail of drawbacks
    - Database/references/case study/parameters reviewed
- The summary table:
    - 25 cities currently
    - Mention the CAPEX and OPEX
    - Do a qualitative assessment for CAPEX, OPEX in a range of medium, high, low rate
    - Standardize the units:
      Transportation: reduction/km/year
      Efficiency: GWh/year
      Building: reduction/concrete/year
- Review the AIR4EU case study
    - Find two strategy regarding the reduction of pollutants (PM_{10}, NO_x, and So_x) and CO_2
- Formulating questions for Nantes Metropole
- Sensitivity analysis:
    - Use the standard emission value that are comparable to every city in the same scheme
    - Compare the value and determine the best performance of city in reducing pollutant

MINES OF MEETING

"Innovative Strategies for Reducing Carbon Footprints and Air Treatment in Urban Areas"

Place: At Nantes Metropole office
Date: Friday, June24th 2016
Time: 14:45 – 15:45
Attendees:

- Responsible of Nantes Metropole: Tatiana LECOSSAIS
- Team Member:
  - Jose Ignacio FUENZALIDA NAVARRETE
  - Iqlima FUQOHA
  - Gaurav UPRETI
  - Haifa Fawwaz ATMAYA

Discussion Points:

- The current strategies being implemented in Nantes to abate air pollution and carbon footprint in the city [Transportation, bike, energy building, energy efficiency].
- Type and level of pollutants they are targeting and removing
- The investment cost and operating cost of in technologies/projects to improve air quality and carbon footprint reduction.
- Advantages and disadvantages of the applied strategies (financial benefit, social welfare index)
- Current emissions due to the current politic and future trends in Nantes.
- Hurdles and future plan to make Nantes a greener city.

General idea from the discussion points.

- The air quality in Nantes Metropole has not exceeded the limit value. The air quality in Nantes is favored by its geographical location, the wind, and considerable vegetation that the city has.
- On the other hand, the city doesn't have an integrated climate and air pollution abatement plan. They have two separate plan for and climate change. Nevertheless, they are pushing forward to get one integrated plan.
- Nantes Metropole has achieved significant air pollution and carbon footprint reduction by improving the construction of the building in terms of insulation, used of district heating and renewables materials as fuels. On the hand, when it comes to improving urban air quality, the city aims to reduce CO_2, SO_x, and NO_x emissions.

MINITES OF MEETING

"Innovative Strategies for Reducing Carbon Footprints and Air Treatment in Urban Areas"

- The city has a climate plan with the main target: a reduction of greenhouse gasses by 30% per inhabitants for 2020-2030, for these three (3) sectors (Transportation, energy production, commercial and residential building.
- As a future plan to make Nantes a greener city, the responsible has reported that many projects are under study or even started to implement. For instance, making Nantes a city of short distance by improving mobility. They plan to construct highways for bicycles, putting more parking for bikes, a plan to buy electrical bicycle and rent them. Moreover, pushing for cleaner and energy efficiency as they aim to double the production of electricity from renewables energies (mainly from solar and wind). Lastly, they want not only to conserve, also increase a number of existing greener spaces and parks. It should go without saying, they have a politic for district heating by using biomass.
- As an issue, not enough data is available regarding the implemented strategies, for instance, the cost. And also there is a lack of reliability in the methodology they used to set the indicators to asses carbon footprint reduction or other air pollutants.
- The responsible of Nantes Metropole, has made the following point: When it turn to improve air quality in cities, a very important parameter should not be avoided which is people awareness and education. By way of example, a city could have great public transport system with a reliable bicycle share system but if the citizens prefer anyway to mobilize themselves in cars, few changes can be made. Strategies in all directions should be all be considered in order achieve good results in air quality standards.

E. Project Schedule

Month	March	April				May				June				July	
Week	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II
Date	1	8	15	22	29	6	13	20	27	3	10	17	24	1	4
TASK 1 - Literature Review															
- Kick off Meeting															
- Collecting cities strategies and related key parameters			Phase 1					Phase 2							
- Progress Meeting															
- Writing chapter 1															
- Writing chapter 2															
- Writing chapter 3				Phase 1				Phase 2							
- Validation for Interim															
TASK 2 - Data Interpretation in XLS Format															
- Classifying and selecting key parameters				Phase 1				Phase 2							
- Validation for Interim															
- Interim Report Submission															
- Progress Meeting															
- Meeting with Nantes Metropole															
TASK 3 - Sensitivity Analysis															
- Characterizing references															
- Validating the robustness															
- Progress Meeting															
Final Report															
- Compiling final draft report and poster															
- Validation of final draft															
- Submission of final report and poster															
End of Project															

Phase 1 : Interim report
Phase 2 : Further report