



Assessing Traffic and Air Quality in Central Copenhagen

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Interactive Qualifying Project (IQP) Final Report
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Executive Summary

The Problem

Copenhagen is the capital city of Denmark, a small Scandinavian country in Northern Europe. With an increasing population, the city has been plagued by problems of traffic congestion and air pollution. These problems are particularly present on H.C. Andersens Boulevard, a main arterial road that goes through the central neighborhood of Indre By and connects mainland Copenhagen with the island of Amager. According to the public, the congestion on H.C. Andersens is heaviest in the morning at 9:00 and in the evening at 16:00. Furthermore, based on direct observations of the area, it is evident that the majority of cars are travelling through Indre By and there is little cross traffic. This indicates that the road is mainly being used to commute between the outer neighborhoods

of Copenhagen and Amager. With the increasing traffic congestion in the area, comes increasing air pollution. H.C. Andersens is the most polluted road in Copenhagen with almost 70% of its pollution originating from the road traffic (Press-Kristensen, 2014). The average NO_2 emission on H.C. Andersens Boulevard is $44.5 \mu\text{g}/\text{m}^3$ which exceeds the European Union's limit of $40 \mu\text{g}/\text{m}^3$ as seen in Figure 1. Similar to the traffic, there are several patterns for NO_2 with emissions on the road peaking in the morning and the evening rush hours.

The traffic congestion and air pollution on H.C. Andersens impact the quality of life experience for those working, living, and commuting on the road. The traffic causes delays for bus and personal vehicle users due to the long waiting times at several

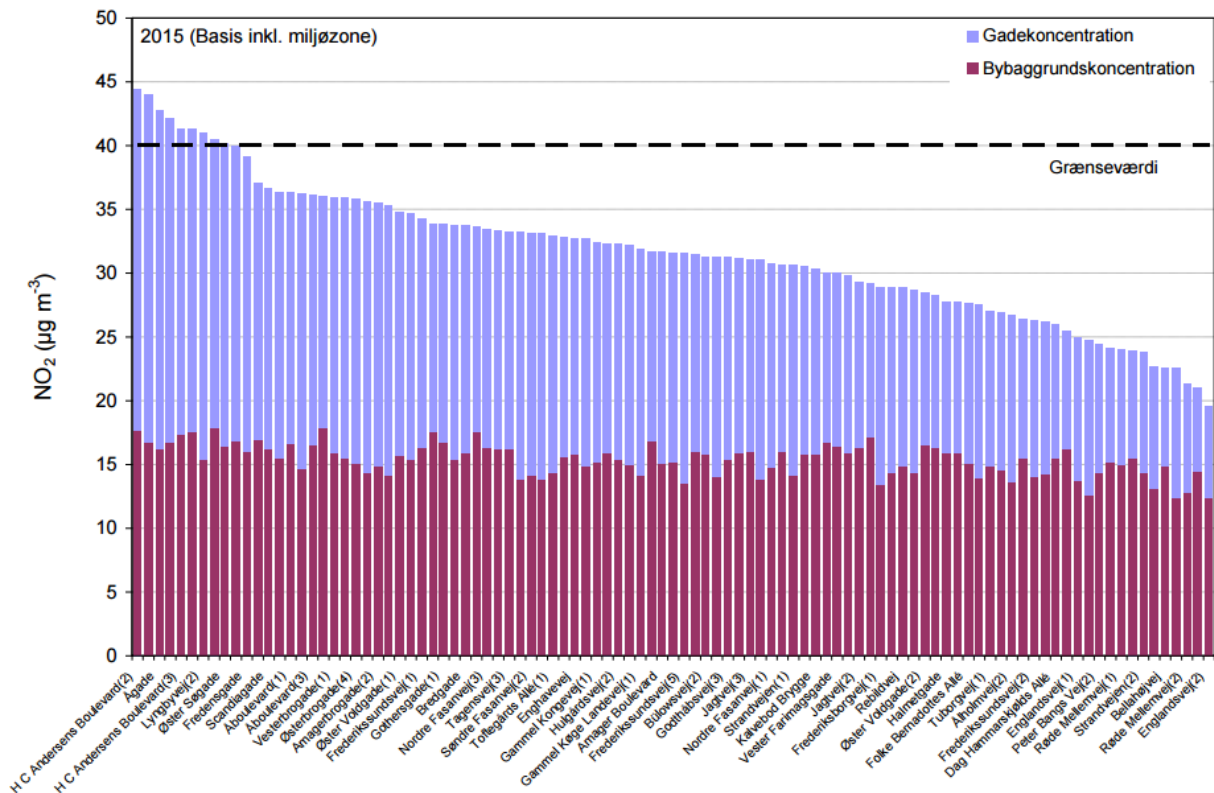


Figure 1. Average NO_2 Concentrations on main roads in Copenhagen compared to the EU's limit, with H.C. Andersens on the far left. The blue represents traffic emissions and the purple represents background emissions.

Source: Luftkvalitetsvurdering Af RenLuftzone I København

intersections. Also, the high density nature of the area creates barriers for pedestrians and bicyclists. The pollution in the air is a health hazard for people in the area. For example, ultrafine particles such as soot are carcinogenic and cause a variety of illnesses such as cardiovascular disease and chronic lung disease (Personal Comm., Engelbrecht 2015). Furthermore, there could be several negative impacts on the tourism in the area. Copenhagen plays an important role for the Danish tourism industry which contributes approximately DKK 82 billion in revenue and 120,000 full-time-equivalent jobs (The Danish Government, 2014). Recently, Denmark has been experiencing decreased numbers of tourists and the congestion in Copenhagen may be one of the reasons.

The Copenhagen municipality has taken several steps to alleviate congestion and improve air quality in central Copenhagen. For example, the Five Finger plan was created in 1947 when citizens realized the city was developing at an uncontrollable rate (Rahunen, 2015). The goal of the plan was to concentrate the development of Greater Copenhagen in the urban “fingers” created around the railway network with natural green spaces in between. Furthermore, the city of Copenhagen has been developing a Metro system which will be completed in 2019. The Metro will hopefully increase travel efficiency and reduce congestion on the roads. In order to improve air quality, several solutions were proposed, including a law mandating the use of close particulate filters on trucks.

Despite these measures, more steps must be taken in order to reach Copenhagen’s goal of reaching carbon neutrality by 2025. Our sponsoring organization, Miljøpunkt Indre By is working towards bringing people together in order to create optimal solutions for the environment and climate. They aim to help Copenhagen reach its carbon neutrality goal and are focused on improving conditions on H. C. Andersens Boulevard.

Goals, Objectives, and Methodology

In order to address the problem, the goal of our project was to analyze traffic in central Copenhagen and its effect on air quality, and determine the appropriateness of a tunnel for congestion alleviation and air quality improvement. To achieve this goal, we constructed the following objectives:

1. Understand current traffic patterns and identify main causes of congestion in the Indre By and Christianshavn areas.
2. Determine stakeholder opinion on traffic conditions and air quality.
3. Explore the appropriateness of tunnels to alleviate traffic and air quality issues and explore possible alternative solutions.
4. Compile recommendations and suggest the most appropriate course of action.

To accomplish this goal and the subsequent objectives, we conducted research using a variety of sources and methods, including reports, interviews, a questionnaire, and direct observation.

To gain an understanding of the current air quality patterns on H. C. Andersens, we obtained pollution data from reports regarding air pollution in Copenhagen provided by the Danish Ecological Council. Furthermore, we obtained data from Aarhus University’s air quality measuring station on H. C. Andersens Boulevard.

To understand the current traffic patterns, we directly observed seven intersections on H. C. Andersens Boulevard, and compared congestion levels of each intersection to one chosen baseline. The intersections were observed over two days at 9:00 and 16:00. We created maps with our data shown in Figure 2.

Semi-structured interviews were conducted with several experts on traffic and air quality, including members of The Danish Council for Sustainable Traffic, and professors from Roskilde University and the Danish Technical University.

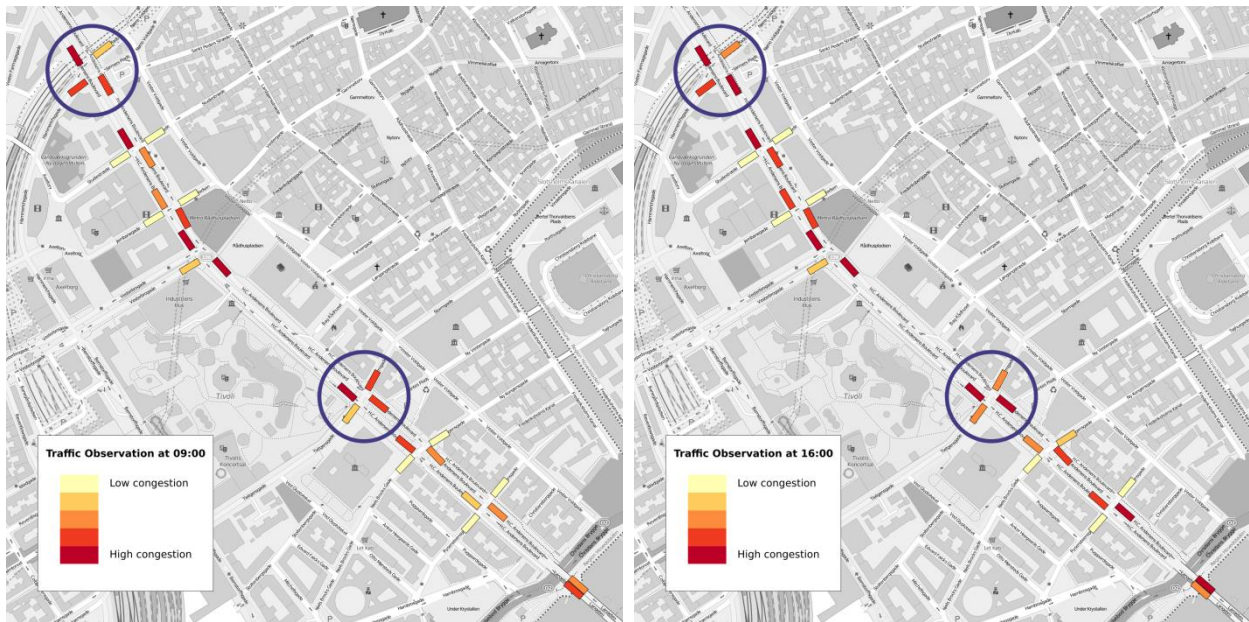


Figure 2. Maps showing traffic congestion on H.C. Andersen Boulevard in Copenhagen at 9:00 and 16:00 with colored blocks representing congestion levels. The circled intersections have high cross traffic.

We also conducted email interviews with a member of Letbaner.DK and the Mayor of Technical and Environmental Affairs of Copenhagen.

A short structured questionnaire was created, in both English and Danish and pedestrians were surveyed near H. C. Andersens Boulevard. A link to the online version of the questionnaire was distributed via Miljøpunkt Indre By's social networking site, their contacts, and by passing out flyers. In total, we received 47 responses. We also explored literature regarding alternative solutions.

Key Findings

A proposal has been made by local organization to implement a tunnel under H.C. Andersens Boulevard and replace the road on the surface with a green space. We found that while a tunnel and a green space has the potential to reduce air and noise pollution, it would not be the most suitable solution for reducing traffic volume. According to our public surveys, 93% of the respondents said that a tunnel would reduce air and noise pollution. Furthermore, implementing a tunnel would eliminate noise pollution and air pollution would collect around the openings

of the tunnel instead of along the road, posing less health hazards to people in the area (Personal Comm., Press-Kristensen 2015). The addition of a green space on the surface would also improve the quality of life by providing a recreational area and improving the aesthetics of H.C. Andersens Boulevard.

Implementing a tunnel would allow continuous flow of traffic and thus alleviate the congestion in the Inner City. However, this solution conflicts with the goal of the city to be carbon neutral by 2025 because it would encourage more car drivers to enter the city and use the tunnel to commute. Currently, almost 70% of the air pollution on H.C. Andersens Boulevard originates from traffic and this number needs to be reduced if the city is to fulfill their climate goals (Press-Kristensen, 2014). The tunnel and green space solution only aims to move the traffic quicker and does not discourage private car use. According to Mr. Ivan Lund Pedersen from the Danish Council for Sustainable Traffic, with the addition of cars, there is a possibility that more traffic congestion would build somewhere else in the Indre By area (Personal Comm., Pedersen 2015). Furthermore, the construction of a tunnel is expensive and the city currently cannot support it (Personal

Comm., Kabell 2015). During construction, the tunnel would also create barriers for pedestrians and bicyclists. Although this solution has the potential to alleviate traffic congestion, it will not reduce the number of private cars in central Copenhagen.

Aside from a tunnel, other alternative solutions were also explored. These solutions aim to encourage public transportation and disincentivize private car use. It is vital that prices for public transportation are reduced because low cost incentives influence ridership more than convenience. The primary solution for improving public transportation is a light rail system. The current proposal connects the outer neighborhoods of Copenhagen. This tram-like system uses electric wiring and can run on different infrastructure like rails, roads, and tunnels. Light rail is a good solution because it will connect the outer neighborhoods to the Inner City and will improve connections among the existing public transportation. The stations are built on the surface making the system cheaper to build and easier to access (Kjaer Jensen, 2014).

There are several possibilities for discouraging car use. Congestion pricing, a fee paid to use a particular road, was a potential solution proposed in 2012 but was rejected by politicians. These politicians were wary of not being reelected as many of their voters are car drivers who feel that taxation on cars is high and no more fees should be paid (Personal Comm., Jespersen 2015). Technically speaking however, congestion pricing is an effective solution that will reduce the traffic volume and encourage public transportation use (Personal Comm., Larsen 2015). It may also be effective to combine the road pricing system with a tunnel, if it was to go through, so that car users are only required to pay a fee for using the tunnel. This was done in Seoul, South Korea and proved to be a success, reducing traffic volume by 25% in the first month (Son & Hwang, 2002). Further solutions for disincentivizing car usage include the reduction of parking spaces or the

increase in parking prices. This may discourage people from bringing cars into the city center however, it may be met with the same opposition that congestion pricing experienced. Yet, if a park and ride styled parking lot was built outside the Inner City, people may have the incentive to park outside and take public transportation into Indre By.

The last alternative proposal is eliminating lanes on major roads (Personal Comm., Jespersen 2015). Although it may initially cause increased congestion, the inability to quickly move through an area will divert car users to other roads or may encourage people to switch to public transport or bicycles. An example of the success of lane removal is the Cheonggyecheon River in Seoul, South Korea shown in Figure 3. The government restored a river and the large arterial road was reverted to a natural green belt in 2005 to combat air pollution and traffic congestion. As a result, traffic volume in the city decreased by 170,000 cars and air pollution decreased by 35% (Rutherford, n.d.). If this principle was applied to H.C. Andersens Boulevard in Copenhagen, similar effects may be observed. Instead of a river restoration, the road would be converted to a green space with plenty of room for pedestrians and bicyclists, and with a lack of lanes for traffic.

Recommendations and Conclusions

There are significant problems with air pollution and congestion on H. C. Andersens Boulevard, and these problems are likely to get worse over time if no actions are taken.

In our opinion, implementing a tunnel would not be the most appropriate solution for H. C. Andersens Boulevard because the disadvantages outweigh the benefits. Though a tunnel will improve the continuous flow of traffic, it will attract more car users to the Inner City which will interfere with the city's goal to reach carbon neutrality. However, there is currently a tunnel proposal that stretches from Nørrebro to Amager. We recognize that this proposal would make the



Figure 3. The before and after of the restoration of the Cheonggyecheon River in Seoul, South Korea

Source: <http://www.nclurbandesign.org/wp-content/uploads/2015/01/Cheonggyecheon-Stream-Before-After1.jpg>

tunnel a preferred solution in order to promote continuity through the three areas. If a tunnel was to be constructed, Miljøpunkt Indre By should advocate congestion pricing as an addition to the tunnel. Congestion pricing will hopefully discourage car usage. Overall, this would decrease the traffic volume on H. C. Andersens Boulevard.

We think that constructing a light rail is a very effective solution, especially if the current proposal in the outer neighborhoods is extended to Indre By. Implementing a light rail system would reduce car lanes and replace bus lines on H. C. Andersens since the system runs on exclusive lanes 90% of the time. Reducing car lanes would discourage car usage. This solution would be especially effective if public transportation prices were lowered and parking spots were reduced. We found that many commuters believed that public transportation was expensive and therefore, lowering prices might encourage more people to utilize the systems. Reducing parking spots on the road and near businesses disincentivizes car usage. Furthermore, bike lanes on roads leading to H.C. Andersens could be extended further, discouraging car usage.

Although we have provided several solutions to Miljøpunkt Indre By, there are

steps that need to be taken before these solutions can be considered.

We recommend that Miljøpunkt Indre By propose their plan with our report as a supplement to the Copenhagen Municipality. The Copenhagen Municipality's budget should be taken into consideration when moving forward with these proposed solutions. Meanwhile, Miljøpunkt Indre By can take other approaches such as informing the public of the traffic situation on H. C. Andersens Boulevard. With the support of the public, the Copenhagen Municipality might be inclined to take further action.

It is clear to us that the actions that are being taken by the Copenhagen Municipality to combat air pollution at this time are not sufficient. We conclude that action must be taken to improve the air quality and traffic congestion on H. C. Andersens Boulevard by incentivizing less private car usage and more public transportation. Hopefully, the solutions we proposed will push the city of Copenhagen one step closer to their goal of carbon neutrality in 2025.