



WPI



Air Pollution on Prinsessegade: A Global Problem on an Ultrafine Level

Interactive Qualifying Project Supplemental Materials

Submitted by:

Emilee Gancarz (EVE)

Yao Long (ME)

Nicole Luiz (ME)

Emily Matsco (ME)

Ian Vossoughi (CS)

Date submitted: 30 April 2017

Submitted to:

V.J. Manzo, PhD., Assistant Professor

Lauren Mathews, PhD., WPI Associate Professor

Authorship

The following table outlines the primary contributors to each section and the individuals responsible for revising each section.

Chapter	First draft by:	Revised by:
Background		
Air pollutants	Emilee	Nicole, Emily
Children and air pollution	Emilee	Yao, Ian
Road traffic as a major contributor to air pollution	Yao, Nicole, Ian	Emilee, Emily
The science behind ultrafine particles	Emilee	Emily, Yao
Euro vehicle standards	Nicole	Yao, Emilee
The problem with air pollution in Copenhagen	Nicole, Emily	Emilee, Ian
The problem in Christianshavn	Nicole, Emilee	Yao, Emily
Strategies to reduce traffic congestion	Ian, Emily, Nicole, Emilee	Yao
Solutions in Christianshavn	Nicole, Yao	Ian, Emily
Detailed Methodology		
Objective 1: Assess the viability of identified air pollution and traffic congestion strategies within the context of Prinsessegade, a major street in Christianshavn.	Nicole, Ian	Emily
Informal observation	Yao, Nicole	Ian
Assessment of strategies	Emilee, Nicole	Yao
Objective 2: Investigate public and expert opinion on strategies deemed viable for the Prinsessegade context.	Emily	Nicole
Semi-structured interviews with experts	Emily	Yao
Semi-structured interviews with business owners	Nicole, Yao	Emilee
Interview analysis	Nicole	Ian
Street surveys with the public	Emily, Yao	Nicole
Survey analysis	Yao	Emilee, Nicole
Objective 3: Obtain collaborative input about traffic strategies among community members in order to evaluate our findings.	Emilee	Nicole, Ian
Open forum	Emilee	Emily, Yao
Detailed Results		

Objective 1: Assess the viability of identified air pollution and traffic congestion strategies within the context of Prinsessegade, a major street in Christianshavn.		
Informal observations	Emilee, Nicole, Yao	Ian, Emily
Assessment of strategies	Emily, Nicole, Yao, Emilee	Ian
Objective 2: Investigate public and expert opinion on solutions deemed viable for the Prinsessegade context.		
Semi-structured interviews with experts	Emilee, Nicole, Emily, Ian	Yao
Semi-structured interviews with business owners	Nicole, Emily	Ian
Street surveys with the public	Yao, Nicole	Ian, Emilee
Objective 3: Engage the Christianshavn community in evaluating our conclusions and recommendations.		
Open forum	Emilee	Nicole, Yao
Evaluation of strategies	Emilee, Nicole	Ian, Emily

Table of Contents

Interactive Qualifying Project	1
Authorship	2
Table of Contents	4
Background	6
Air pollutants	6
Children and air pollution	6
Road traffic as a major contribution to air pollution	7
The science behind ultrafine particles	8
Euro vehicle standards	9
Strategies to reduce traffic congestion	10
The problem with air pollution in Copenhagen	14
The problem in Christianshavn	16
Solutions in Christianshavn	17
Detailed Methodology	19
Objective 1: Assess the viability of identified air pollution and traffic congestion solutions within the context of Prinsessegade, a major street in Christianshavn.	19
Informal observation	20
Infrastructure	20
Traffic	21
Daily life	21
Modes of transportation	21
Assessment of strategies	21
Objective 2: Investigate public and expert opinion on strategies deemed viable for the Prinsessegade context.	23
Semi-structured interviews with experts	23
Semi-structured interviews with business owners	24
Interview analysis	25
Surveys with the public	25
Survey analysis	28
Open forum	30
Assessment of strategies based on informal observation, public and professional opinion	30
Open forum data analysis	34
Final assessment of strategies	34
Detailed Results	36

Objective 1: Assess the viability of identified air pollution and traffic congestion solutions within the context of Prinsessegade, a major street in Christianshavn.	36
Informal observations	36
Infrastructure	36
Traffic	37
Daily life	38
Modes of transportation	38
Assessment of strategies	38
Objective 2: Investigate public and expert opinion on strategies deemed viable for the Prinsessegade context.	40
Semi-structured interviews with experts	40
Erling Ekegren	40
Poul Cohrt	41
Anja Clausen	41
Inge Hopps	42
Kåre Press-Kristensen	43
Thomas Ellermann	44
Steen Solvang Jensen	44
Andreas Massling	44
Francesca Desmarais	45
Movia representative	45
Semi-structured interviews with business owners	47
Surveys with the public	48
Open forum	55
Discussion of Strategies	58
References	63
Appendix	67
Appendix A: Interview Transcripts	67
Appendix B: Open Forum Notes	91

Background

This section includes additional background information that we investigated during the preparation phase of our project. This information helped inform our approaches and may be of interest to readers who seek deeper coverage of the background details relevant to this project.

Air pollutants

Air pollution is a contributing factor to cardiovascular disease, the leading cause of death worldwide, and is considered the world's single biggest health risk (Wichmann et al., 2013). Air pollution is defined as anything emitted into the atmosphere that can potentially cause harm to humans and the environment (Wu et al., 2012). Diesel vehicles are one of the primary contributors to the air pollution that cause these health problems. Particulate matter (PM) and Nitrogen oxides (NO_x) are considered the most harmful pollutants from diesel exhaust and cause major health complications (Reşitoğlu et al., 2015).

The most common harmful pollutants emitted are organic carbon, PM, carbon monoxide, NO_x (Wu et al., 2012), and ozone (Caiazzo, Ashok, Waitz, Yim, & Barrett, 2013). In Europe, air pollution from particulate matter reduce the lifespans of its residents by an average of nine months (Goldstone, 2015). Depending on the type of vehicle, different air pollutants are emitted into the atmosphere. The components of diesel exhaust are nitrogen (N₂), carbon dioxide (CO₂), water (H₂O), oxygen (O₂), and various pollutants. The main pollutants diesel vehicles emit are carbon monoxide (CO), hydrocarbons (HC), PM, and NO_x. From these pollutant types, PM and NO_x are most hazardous to health.

These complications involve both the respiratory and cardiovascular systems. Respiratory effects include the exacerbation and potential cause of asthma, chronic obstructive pulmonary disease (COPD), lung cancer, inflammation of airways, and respiratory infections (Kurt, Zhang, & Pinkerton, 2016). Cardiovascular effects include vasoconstriction and arterial stiffness, increased blood pressure, and cardiovascular disease (Langrish et al., 2012). Mitigating air pollution would spare lives and improve the overall health of people and the environment (Vendelbjerg, 2016).

A 2012 Danish study found that if air pollution is mitigated, incidences of stroke, lung cancer, coronary heart disease, and chronic obstructive pulmonary disease (COPD) will decrease among the population and lead to healthcare savings of 0.1 to 2.6 million Euros annually. (Sætterstrom et al., 2012). A similar study conducted in Portland, Oregon concluded that if NO₂ emissions were lessened, Portland could save between \$34 to \$46 million annually in reduced excess cases of NO₂ asthma exacerbation, fewer asthma emergency room visits, and fewer cases of elderly hospitalization due to NO₂-related respiratory complications (Rao, 2014).

Children and air pollution

A major concern in this area is children's exposure to air pollution, specifically the children that go to school on Prinsessegade. A recent study conducted in Edinburgh, UK, determined that the concentration of the air pollutant NO₂ varies by vertical height from the road. The tailpipes of most

vehicles are located close to the ground, creating a gradient of NO₂ pollution: NO₂ concentration is highest close to the ground and decreases with height. Furthermore, since the concentration of NO₂ is 5 to 15% higher at a child's breathing height of 0.8 meters than at an adult's breathing height of 2.0 meters, young children receive a higher exposure to NO₂ than adults. This is especially problematic considering that the developing lungs of children have a higher sensitivity to air pollution than adult lungs (Kenagy et al., 2016). While this study focused on NO₂, a reasonable assumption can be made that a closer vertical proximity to tailpipes will lead to a higher concentration of any type of air pollution, and small children will therefore receive greater exposure to all kinds of pollutants than adults. Figure 1 below illustrates how air pollution can affect children more severely than adults.

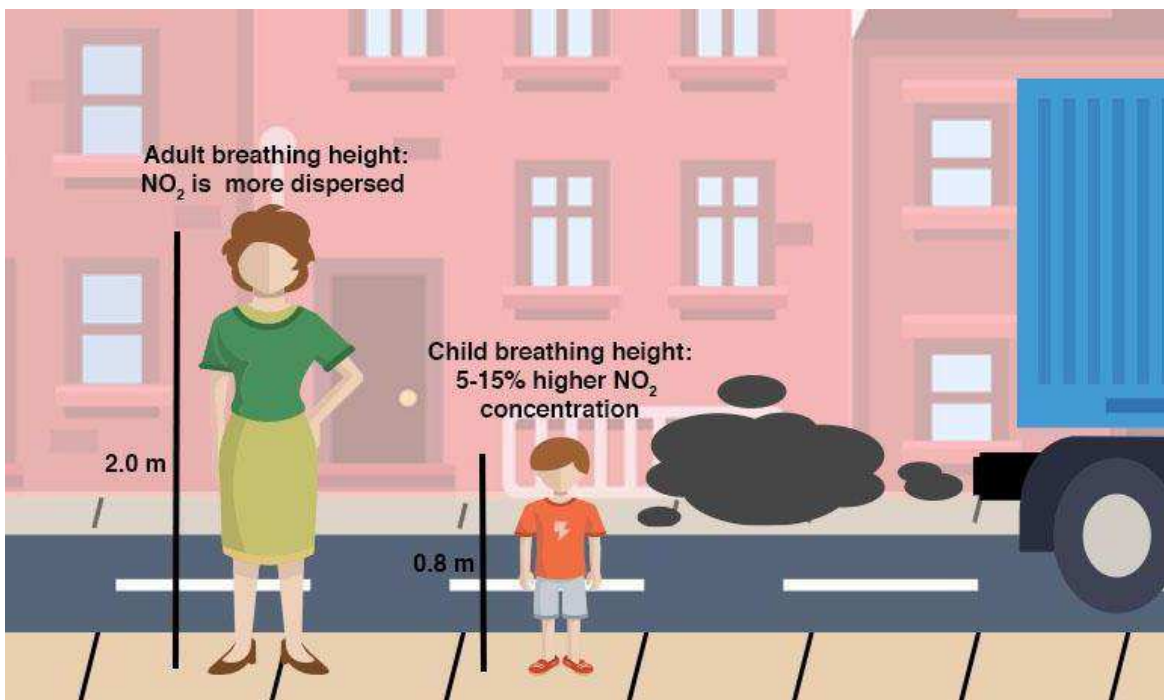


Figure 1: How air pollution impacts children more than adults

Road traffic as a major contribution to air pollution

The most significant contributors of air pollution fell into the category of transportation sources, which account for 25% of the particulate matter associated with urban air pollution (Karagulian et al., 2015). Any type of vehicle that runs on fossil fuels emits harmful air pollution, although different types of vehicles emit different types of pollutants. Diesel vehicles emit PM, which has been linked to causing respiratory and other health problems.

While transportation is the most significant source of air pollution, the various conditions of traffic flow have an influence on the concentration of air pollutants that are produced by vehicle exhaust. Road congestion results in a higher concentration of air pollutants emitted into the atmosphere (Raheem et al., 2015). The lower vehicle speeds associated with high volumes of traffic cause longer travel times for vehicles and thus result in a higher concentration of pollutant emissions in the associated area (Zhang & Batterman, 2013). Such speeds also reduce the airflow that scatters nearby particles, hindering the dispersion of air pollutants in the atmosphere. This reduction in particle

dispersion heavily concentrates air pollutants in high traffic areas on a regular basis (Zhang & Batterman, 2013). Road congestion also disrupts the flow of traffic; the sudden braking and accelerating associated with congestion produces higher emission rates than if a vehicle were traveling without any traffic disruption (Bujak-Pietrek et al., 2016). Several examples have demonstrated that pollutant concentrations drop when urban traffic sharply falls (through voluntary or involuntary means), proving that resolving traffic congestion is vital to combating urban air pollution

One notable instance of sudden air pollution reduction occurred with the 1996 Olympic Games in Atlanta, Georgia, which required sweeping tactics of traffic congestion elimination to manage the 1 million additional guests in the city (Cesaroni et al., 2011, p. 133). Through a combined strategy of 24 hour public transit, 1000 additional buses, downtown closure to private vehicles, and adjustments to delivery truck schedules, Atlanta experienced 17 days of reduced traffic congestion (Friedman et al., 2001). The effects of this period on particulate pollution were significant: in particular, PM_{10} concentrations decreased by 16.1% and NO_2 decreased by 6.8% for the duration of the games, returning to similar pre-Olympic levels after the games concluded on August 4 (Friedman et al., 2001). A similar, albeit more drastic, example comes from Haifa, Israel, which experienced a month-long evacuation of one-third of its population after a missile strike in July 2006 (Yuval et al., 2007). In spite of the industrial plants (contributing to 95% local industrial emissions) continuing operation during this time period, the 40% decline in traffic produced startling decreases in the most critical pollution particles. Across all measuring stations, NO_2 was reduced by 20-55% compared to the control levels and PM_{10} concentrations dropped by 4-18% (Yuval et al., 2007). These examples, demonstrating steep drops in pollutant concentrations when cities experience sharp declines in vehicle volume, prove a strong link between traffic density and air pollution.

The science behind ultrafine particles

Ultrafine particles (UFPs) are the smallest form of particulate matter (PM). As shown in Figure 2, a minimum of 500 UFPs with diameters of 100 nanometers can fit across the 50 to 70 micrometer diameter of a single hair strand (Levin, 2012). The average size of a UFP from diesel engines is 15 to 40 nanometers in diameter (Bujak-Pietrek et al., 2016); when applying this average to the same model, over 3,000 UFPs can fit the diameter of a 50 micrometer strand of hair.

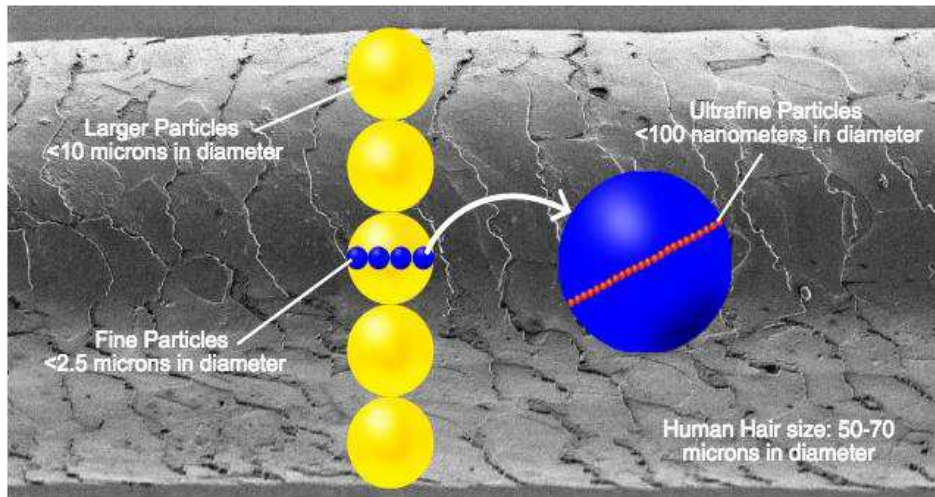


Figure 2: Comparison of Particulate Matter Sizes

UFPs from engines generally have a core of elemental or organic carbon and can absorb lead, platinum, and other trace metals (Bujak-Pietrek et al., 2016), as well as sulfate, ammonium, and volatile and semivolatile compounds due to their large surface area (Li et al., 2016). The particulate emissions from the tailpipes of vehicles discharge directly from the engines or precipitate from condensation of exhaust gas (Bujak-Pietrek et al., 2016). Diesel engines emit six to ten times the amount of PM as gasoline engines, and 90% of PM from diesel engines is less than 1 μm in diameter (Reşitoğlu et al., 2015). As such, diesel vehicles emit the largest amount of UFP of all vehicle types and emit further UFPs during their cold start-up, while running idle, and while transporting cargo below their capacity levels (Bujak-Pietrek et al., 2016). After exiting the tailpipes of vehicles, UFPs quickly agglomerate into $\text{PM}_{2.5}$ and PM_{10} , but they are still found in large concentrations near roadways and pose significant threats to health (Li et al., 2016).

Euro vehicle standards

The EU has organized emission regulations for vehicles into various categories, Euro 1-6, which are arranged in ascending order of strictness. Since 1992 with the introduction of the Euro 1 vehicle category, every car sold in Europe must comply with strict limits on tailpipe emissions. When denoting vehicle standards, light passenger vehicles receive Arabic numerals and heavy duty vehicles receive Roman numerals. As technology improves over the years, the EU releases new corresponding Euro emission standards; a new Euro vehicle category follows for each new technological standard, and all new vehicles made after that year must comply with the new Euro standards. As of April 2017 Europe has adopted Euro 6 and VI vehicle standards (ACEA, 2017).

While each new Euro vehicle category passes every new emission standard during laboratory tests, studies of on-road emission tests reveal that diesel vehicles emit more NO_2 than the Euro standards permit. Furthermore, the number of diesel vehicles on the road in Europe continues to increase (Weiss et al., 2012). Images representing the emission limits for these vehicles compared to real world emission values are shown in Figure 4. Prior to 2010 (and therefore including Euro 3 and Euro 4 vehicles) the EU only had limits on particle mass. Later, with the introduction of Euro 5 and Euro 6

vehicles, limits were established for both particle mass and particle number (Press-Kristensen, 2014). Figure 3 compares the NO_x limits for Euro 3-6 to measured emissions from petrol and diesel vehicles.

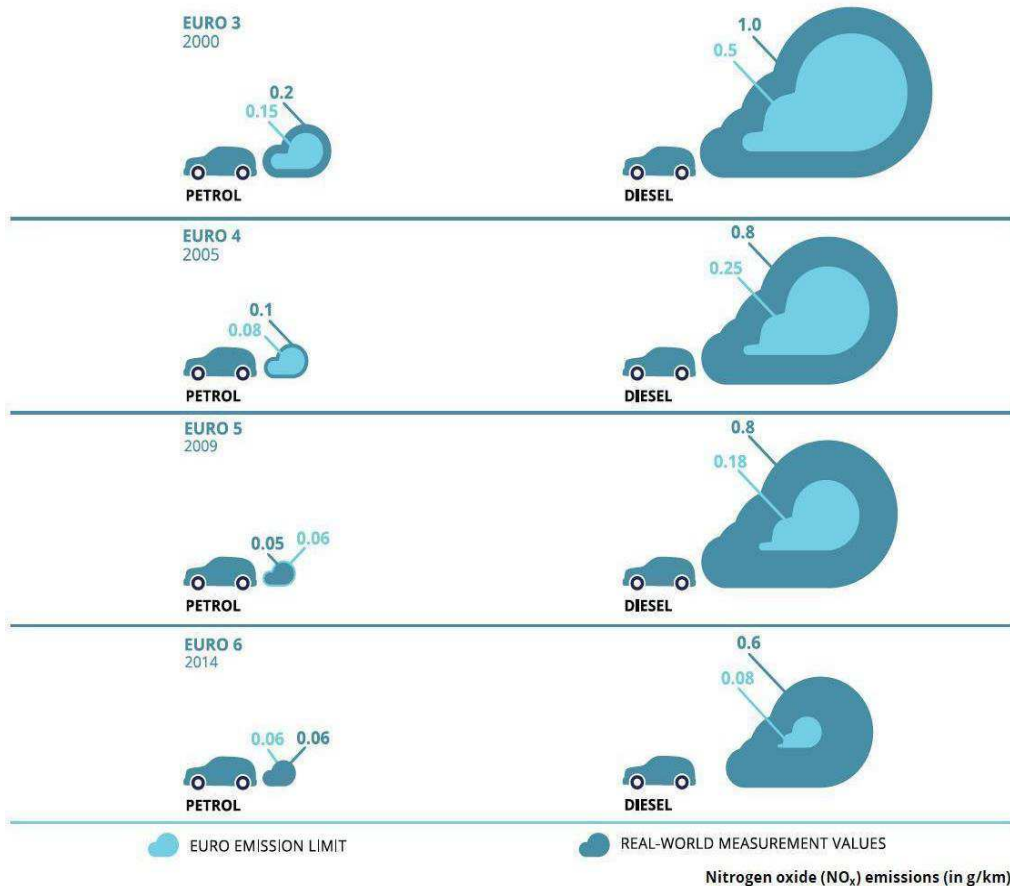


Figure 3: Comparison of NO_x emissions for different Euro class vehicles (European Environmental Agency, 2016)

Strategies to reduce traffic congestion

In this section, we will review the strategies that we have identified through our research. Based on our research of these strategies' logistics and various success other cities have experienced with them, we determined these could feasibly reduce air pollution. Below is a description of each strategy we investigated in our project as well as any relevant examples.

1. Road closure

Research has demonstrated that road closure is an effective method in mitigating traffic congestion, which was exemplified in Paris when the city closed a main road along the Seine and, unexpectedly, the traffic in other locations was minimal, as people adapted to new routes (Gréco, 2016). When the road along the Seine was closed and commuters were forced to seek alternate routes, Mayor Anne Hidalgo announced that "It was thought that it would have been six months to a year before we saw an adaptation of the behavior" (Gréco, 2016), yet the resulting reduced traffic congestion indicates the pedestrianization of this road has had minimal effect on traffic elsewhere (Gréco, 2016). However, this created some backlash from

representatives of the opposing party, who argued that there was not sufficient evidence to prove that road closure will even improve air pollution (Cross, 2016). Paris, in a less extreme measure, has also implemented strict traffic regulations. Not only has the city closed their busiest road, but they also chose one week in December during which the city alternated between banning vehicles with odd numbered license plates and even numbered license plates (Chazan, 2016). In order to implement a strategy such as closing off the road completely, there needs to be parallel streets or alternate routes that can be taken to get to various locations along the road. This is especially necessary for emergency vehicles and police cars.

The University College of London, England researched 60 cases of road closure around the world and found that the vehicles that had once used the closed roads did not reroute to use nearby roads, but instead no longer contributed to traffic at all. The study concluded that vehicular usage decreased by an average factor of one-fifth when a road was closed (Silberstein & Maser, 2014). There are alternative options to closing off the road completely, such as converting the road to bike and pedestrian-only lanes or to block off the road to through traffic. With the latter solution, public buses, residential vehicles and emergency vehicles are still able to pass through. Also, in order to successfully implement a bike and pedestrian-only road, there should be sufficient evidence of existing bike and foot traffic.

2. Improved public transportation options

Public transportation should be sufficient to get commuters where they need to go. Some places lack enough public transportation options to meet the needs of the cities they serve. If public transportation is limited in certain areas, commuters might be more likely to use private cars to reach their destinations. In this case, it would be best for transportation companies to expand their transportation networks to serve more people. However, there should be a heavy enough flow of traffic in an area to justify implementing more public transport options. Updated public transportation options are only worth consideration if a significant need for improvements exists.

3. Incentivized alternative transit

An alternative to adding more public transportation options is to attempt an increase of the use of existing options. However, while utilizing public transport is a straightforward solution in theory, convincing commuters to change their daily habits is considerably more difficult in practice. In a 2008 Copenhagen study, a group of participants received a free month pass to use all forms of public transport (i.e., bus, train, and metro) on their daily commute, with the intent of convincing participants to regularly use public transport in the future. Although this proved successful for the first four months after the experiment, the majority of participants reverted to commuting in private cars after this period (Thøgersen & Møller, 2008).

Another study in Lahore, Pakistan attempted to gain insight on why people choose private vehicles over public transport, concluding that people are more likely to use public transport when alone and without the influence of other people (Javid et al., 2016). They also identified “personal orderliness” (cleanliness and neatness of the transport method) as a reason to use private cars (Javid et. al, 2016). The authors recommended targeting moral obligations to health and the environment to encourage public transport use, and also cited a combination of

improved public transport and fiscal restrictions on car use as effective means to change behavior (Javid et al., 2016).

Incentivizing public transport has been implemented in Sacramento, California, where the city provides bonuses to commuters when they switch from a private vehicle to public transportation. One non-profit organization, YOLO Commute, even provides fiscal incentives to those who walk or ride bikes to work (YOLO Commute, 2017). However, studies have shown that convincing commuters to change their habits is very difficult in practice. In order to implement a solution such as this, some education regarding the importance of using public transportation is necessary. In addition, there needs to be funding for providing fiscal incentives. This can happen by partnering with local businesses and shops in an attempt to offer discounts. Additionally, this strategy requires the support of the municipality and the public transportation company, Movia.

4. **Reversible lanes**

Reversible lanes are lanes that switch direction depending on the heaviest flow of traffic. In order to implement reversible lanes, a higher flow of traffic in one direction must exist. For example, if in the morning rush hour there are significantly more cars travelling north on Prinsessegade (towards the Opera) than there are travelling south (towards Torvegade), then Prinsessegade could become one-way travelling north at that time of day. This traffic strategy requires an alternative route for the small amount of traffic that still needs to travel in the opposite direction. Typically reversible lanes are used on large highways where several lanes can be reversible and still enable access for emergency vehicles to travel against the flow of traffic if need be (Trepanier et al., 2011). While reversible lanes differ in logistics from unvarying one-way roads, the creation of one-way roads has been shown to ease traffic. In particular, the one-way road strategy has proved effective for Fifth Avenue in Manhattan, New York; after Fifth Avenue was converted into a one-way street, travelers experienced improvement in trip times and speeds (Falcocchio, 2016). This shows how one-way streets can alleviate traffic congestion, and this would likely be same for the case of reversible lanes.

5. **Education**

For educational measures to prove effective at mitigating air pollution, there should be an established knowledge gap for the public with regards to traffic congestion and its effect on air pollution. Paris has used this strategy extensively, through online programs that estimates the average number of NO₂ particles emitted by a person's car when they provide information on their daily commute. The same site offers interactive information geared toward children about the severe health effects air pollution has (AirParif, 2010).

6. **Green wave**

In order for signal timing techniques such as the green wave to be considered a potential strategy to reduce traffic congestion, there are certain requirements regarding the existing road infrastructure. The street should have a series of three or more traffic lights in succession, and therefore the green wave is most applicable to roads with higher traffic volumes. The green wave addresses the issue of traffic lights interrupting a constant flow of traffic. Cars that are stopped at red lights emit four times the pollution when compared to cruising (Vos, 2014). The green wave would be applicable when vehicles are unable to travel

through multiple intersections without being stopped at various traffic lights. The green wave has been implemented in the Netherlands (Vos, 2014), in addition to having been tested in Copenhagen with truck drivers of Folehavn (Technical and Environmental Administration, 2014).

7. **Stricter policies regarding air pollution**

Implementation of Limited Traffic Zones (LTZ) and stronger policies on Low Emissions Zones (LEZ) are two strategies to try and decrease the air pollution in an area. A Limited Traffic Zone can specifically forbid any non-local vehicles or those with insufficient filters on a specific road or in a particular region. One example of a successful LTZ implementation that reduced pollutant concentrations comes from Rome. The city implemented sweeping, restrictive measures in the form of Limited Traffic Zones in 2001. In addition, the railroad ring LTZ imposed restrictions on the type of engine permitted in the zone, prohibiting old diesel vehicles in 2002 and all vehicles without catalytic converters in 2003 (Cesaroni et al., 2011). The railroad ring zones produced noticeable results for air pollution reduction: from 2001 to 2005, Rome's average concentration of NO₂ and PM₁₀ respectively decreased by 2% and 1% through the intervention's efforts, while the railroad ring area experienced drops of 23% (NO₂) and 10% (PM₁₀) (Cesaroni et al., 2011). Indeed, Rome's policy has proven effective at reducing the high production of air pollution particles from diesel engines. Furthermore, Rome's LTZ ban on non-residential vehicles is an example of a successful strategy to combat traffic congestion as a whole, which often extends to legal restrictions or financial disincentive policies. A stronger policy on LEZs would involve developing standards for passenger vehicles to have a Euro 4 or higher sticker in the city of Copenhagen. These strategies require the support of the municipality and the Danish Parliament.

8. **Road pricing**

A strategy for reducing road traffic would include road pricing. Not only does road pricing discourage private vehicle usage, but also provides funding that could be used for transport, infrastructure, and environmental projects.

a. **Toll Roads**

Road pricing can be found in many different forms; the most popular form of road pricing is the implementation of toll roads. A general characteristic of toll roads is the existence of alternative routes that motorists can use to circumvent a toll booth and still reach their destination. The toll road would serve as the easiest option of travel at a cost, whereas alternative routes would typically involve longer travel distance to reach the same destination (Santos et. al, 2006). To consider toll roads as a traffic strategy, the existing infrastructure should have sufficient space to construct a toll booth. Trondheim introduced toll roads with variable charges throughout the day in 1991, maximizing during peak traffic hours to provide funding for transport, infrastructure, and environmental projects (Santos et al., 2006).

b. **Congestion pricing**

Another form of road pricing is congestion pricing. Congestion pricing is not associated with any specific road or intersection, instead it encompasses areas with high traffic volume such as the city center. With the use of traffic cameras to record license plates, vehicles would be charged upon entering a specific zone (Wilson, 2010). This has

been implemented in London. The 2003 London Congestion Charging Scheme (CCS) charged citizens for any vehicular road use and decreased the affected area's free public parking spots (Santos et al., 2006). As a result of the London Congestion Charging Scheme, NO_2 and PM_{10} levels in the affected zones decreased respectively by 1.33% and 0.792% (Beevers et al., 2005). While these amounts are statistically minimal, they still indicate a correlation between charging for road use and reduced pollutant concentrations in the area.

The problem with air pollution in Copenhagen

Although Copenhagen is perceived as a global leader in sustainability, the city has battled the European Union (EU) on air pollution regulations for nearly a decade. When the NO_2 limit set by the EU went into effect in 2010, Denmark failed to meet the air quality standards. While the Danish state received an extension to 2015 to reach these standards, Denmark still could not decrease the NO_2 values after five years (Press-Kristensen, 2014). The majority of values exceeding the cut-off originated from the measuring station at H.C. Andersens Boulevard, as shown in Figure 4 via data from Aarhus University studies.

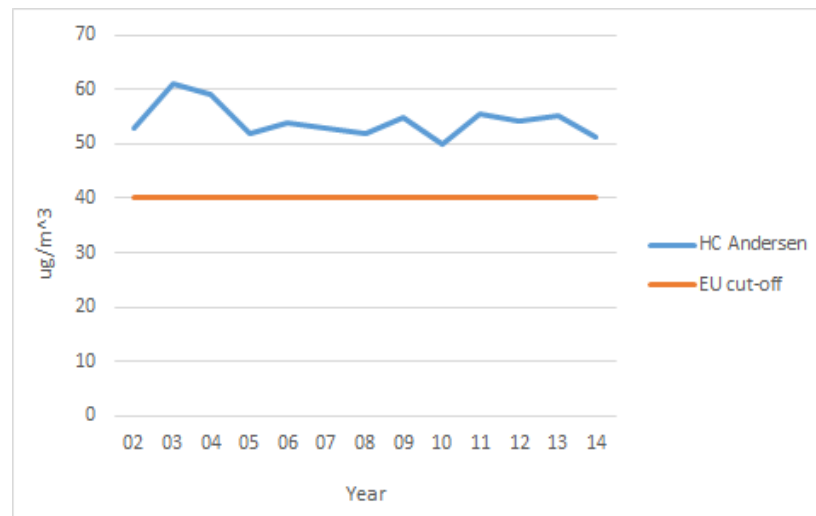


Figure 4: NO_2 levels on H.C. Andersen Boulevard from 2002-2014 (DCE- Danish Center for Environment and Energy at Aarhus University, 2014)

The Danish government attempted to duplicitously solve this problem by moving the measuring station further from the street (Press-Kristensen, 2014). Both the Danish Ecological Council and EU found this plan unacceptable; as a result, the EU drafted a letter to the Danish state in April 2016, reprimanding them for refusing to establish tougher regulations on trucks and diesel vehicles (Weaver, 2016). A timeline of events pertaining to this is illustrated in Figure 5.

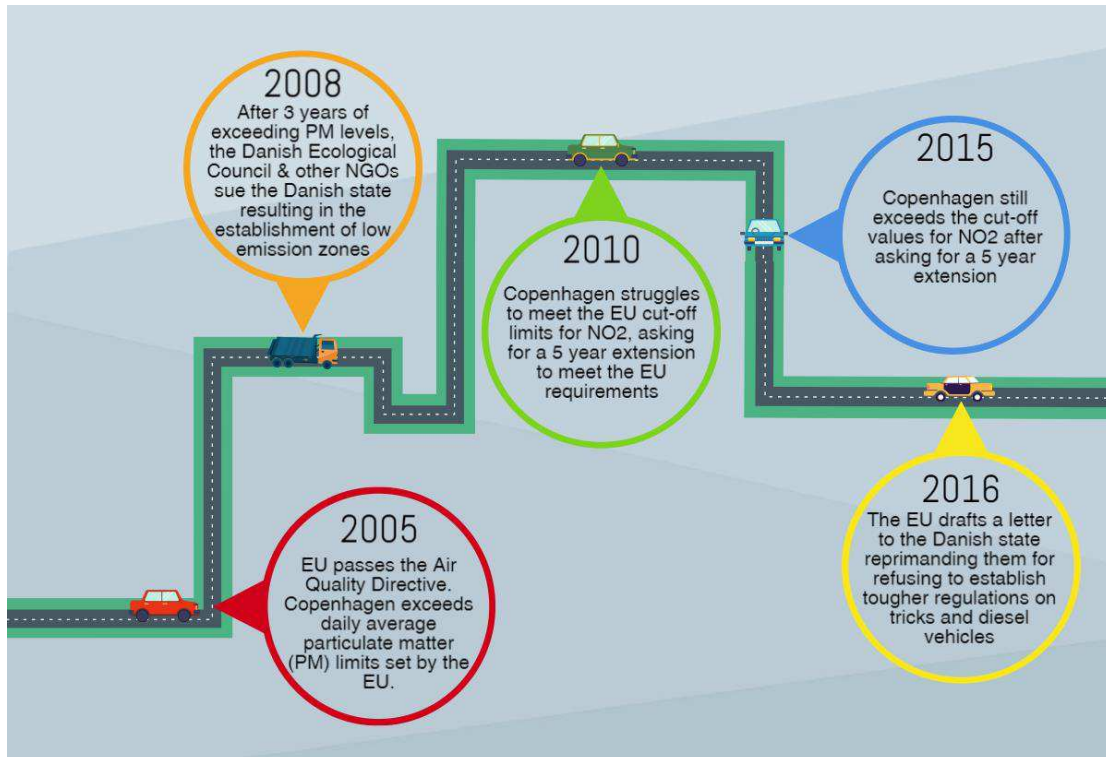


Figure 5: Timeline of Denmark's clash with EU regulations

When the Air Quality Directive was enforced in 2005, Denmark was already over the average daily limits for particle mass. After three years of exceeded limits, the Danish Ecological Council joined several non-governmental organizations (NGOs), including Miljøpunkt Nørrebro, to sue the Danish state. The subsequent political pressure resulted in the implementation of low emission zones in Copenhagen for older, heavier vehicles (Euro 2) in 2008. Today, these zones require all heavy vehicles to meet Euro 4 or later standards or contain an equivalent particulate filter (Ministry of Environment and Food of Denmark, 2014). Vehicles that meet these stipulations are marked with a sticker in their windshield, and drivers without a sticker must provide proof that their vehicle meets all standards to an inspection facility (Ministry of Environment and Food of Denmark, 2014). These policies require particulate filters with a minimum of 80% removal efficiency on all vehicles (Euro 2-6) entering Copenhagen. Denmark currently meets the requirement for larger particulate matter values, but there are no established standards for ultrafine particles. Limits on newer vehicles are insufficiently strict, as certain new heavy vehicles produce up to 500 times as many ultrafine particles as retrofitted older heavy vehicles (Miljøpunkt Indre By-Christianshavn, 2016). Table 1 depicting the EU air quality regulations and the Danish Ecological Council's recommended UFP standards is shown below.

Table 1: Regulations for Air Quality

Regulations for Air Quality - European Union (EU) and Danish Ecological Council (DEC)				
	EU PM _{2.5}	EU PM ₁₀	EU NO ₂	DEC recommended UFP
1 year	25 ug/m ³	40 ug/m ³	40 ug/m ³	7000 particles/cm ³
1 hour	N/A	N/A	200 ug/m ³	20000 particles/cm ³
24 hours	N/A	50 ug/m ³	N/A	N/A

The problem in Christianshavn

Christianshavn is a neighborhood on an island within Copenhagen's inner city. In this region, there are two major roads, Torvegade and Prinsessegade that are used to travel the width and the length of the island (Figure 6). Unfortunately, with these two roads as the primary means of transport, there is often a large buildup of traffic (M. Spang Bech, personal communication, March 13, 2017). Christianshavn has also experienced infrastructure changes and a steady increase in population since the 1960s (Das & Jingzhong, 2011), and these developments add to the congestion, and consequently to air pollution. As a direct result of this congestion, Aarhus University and the Danish Centre for Environment and Energy studies have revealed that Christianshavn is ranked the 35th most polluted location out of 98 Copenhagen measuring stations in NO₂ levels (Ellerman et al., 2016).

There are several reasons people are inclined to travel on Prinsessegade, as illustrated by the points on the map in Figure 6. Popular destinations include a church, schools, Christiania, and the Opera House. For more information about the destinations in Christianshavn, see the Supplemental Materials. Christianshavn has three public transportation options: a metro station, a bus line, and a harbor bus. The metro station is in southern Christianshavn, and the 9A bus takes passengers up Prinsessegade. Copenhagen also currently has three harbor bus routes that sail up and down the main harbor (Havnebusserne, 2015). There are several stops along the way, and one of the stops is the Opera House. The 9A bus and the infrequent harbor bus are the only public transportation to northern Christianshavn, so this area is not as accessible to commuters or residents that are coming from the Inner City or the southern end of Christianshavn. The narrow car and bicycle lanes make both driving and cycling a hassle. If travellers wish to avoid Prinsessegade, they would have to drive through Torvegade to Amager, and then travel on a road around the island to approach Christianshavn's attractions from the north. However, this is an undesirable option, as going the long way around Prinsessegade takes more time and wastes more fuel for cars.

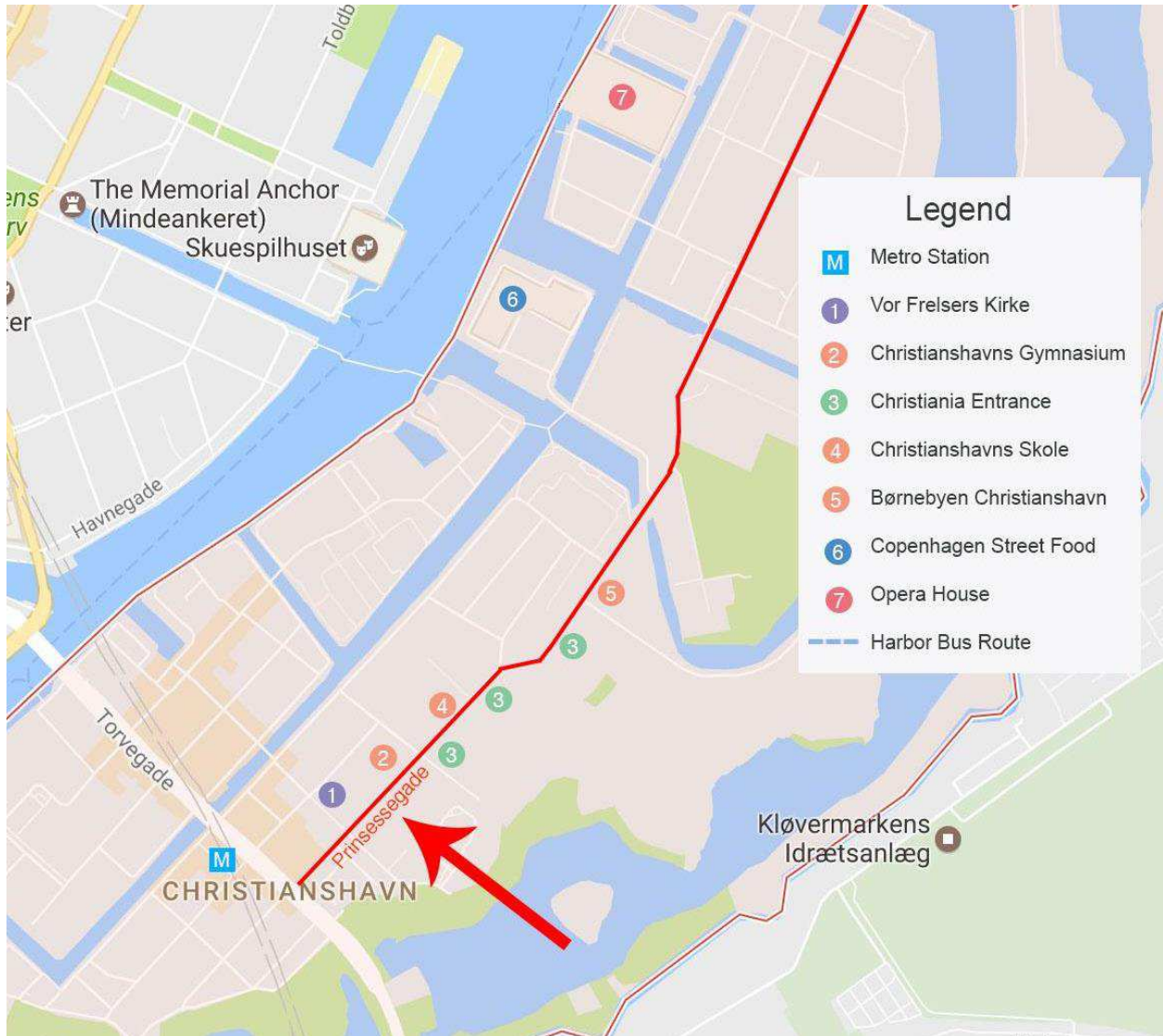


Figure 6: Map of Christianshavn (Google Maps, 2017)

Solutions in Christianshavn

Miljøpunkt has worked to mitigate the air pollution problem in the Inner City and Christianshavn through events such as the Car-Free Sunday. They coordinated with the municipality and combined Car-Free Sunday with the Copenhagen Half Marathon in order to extend the hours during which cars were not allowed to use certain roads (Rychla, 2016). As a result, Copenhagen restricted vehicular access to various main roads in the city center from 15.00 to 21.00, and Miljøpunkt worked to extend this restriction to areas of Christianshavn. The city also offered events and activities throughout

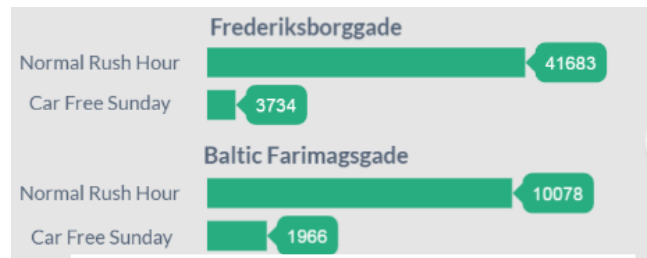


Figure 7: Ultrafine particles per cubic cm on two streets in Copenhagen

its streets to encourage citizens to take advantage of the car-free roads (Rychla, 2016). The results of the UFP counts on this day are illustrated in Figure 7.

Another example of a municipal effort to relieve traffic congestion in Christianshavn occurred with the implementation of the Prinsessegade bus gate. The bus gate, installed in 2003, was designed to

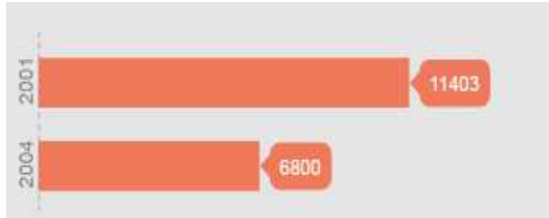


Figure 8: Number of cars passing through Frelsers Kirke before and after installation of the bus gate

restrict traffic along a section of the street using barriers that only residents, buses, emergency vehicles, and larger vehicles with a waiver could pass. The restriction of vehicular travel on the street proved beneficial to the community, whose residents were concerned about the effects of air pollution from traffic congestion on the children that attend school on Prinsessegade (Ravndal, 2016). The changes in traffic after the installation of the bus gate are depicted in Figure 8.

Although the construction of the bus gate addressed the traffic concerns of Christianshavn residents, efforts to remove the bus gate still existed. This opposition consisted of people that had previously used Prinsessegade to travel from Amager to Holmen, a neighborhood in northern Christianshavn (Berg, 2003). The introduction of the bus gate barricaded the quickest route to Holmen, leaving travellers having to take a 1 km detour around Christianshavn in order to reach their destination. In 2016, the bus gate was removed by the city council of Copenhagen. Lord Mayor Frank Jensen provided two arguments for why the road was reopened: 1) it would link Christianshavn to the new developments better and 2) it would reduce the CO2 levels that were higher from passenger cars taking the longer route through Amager (Lund, 2015). There were considerations to make the road a one-lane street, but this received opposition from the police who wanted easy access to Christiania.

Detailed Methodology

The goal of this project was to identify viable solutions to air pollution on Prinsessegade by evaluating the effectiveness of existing solutions in the context of Copenhagen and, more specifically, this street in Christianshavn. In order to achieve this goal, we devised the following objectives:

1. Assess the viability of identified air pollution and traffic congestion strategies within the context of Prinsessegade, a major street in Christianshavn.
2. Explore public and expert opinion on strategies deemed viable for the Prinsessegade context.

The following chapter details our plan to address these objectives and accomplish the goal of the project. We identified various methods that provided vital information to the completion of the project.

Objective 1: Assess the viability of identified air pollution and traffic congestion solutions within the context of Prinsessegade, a major street in Christianshavn.

From our background research, we identified a variety of strategies to mitigate traffic congestion that have been successful in other parts of the world (described in the section titled “Strategies to reduce traffic congestion”). These strategies require certain components in order to be implemented and to be considered successful. We assessed each strategy initially by identifying what factors are necessary for each strategy to be put into effect, and then assessing them within the context of Prinsessegade. Although obtaining public and official approval of these strategies was a vital aspect of determining if a strategy is feasible, we sought to strictly focus on the technical requirements for our initial assessment. To achieve this objective, we performed informal observations to determine if Prinsessegade and the region of Christianshavn demonstrate the necessary characteristics for each potential traffic strategy. Figure 9 details the set of strategies that we included in this initial analysis, all of which are detailed in the Background.

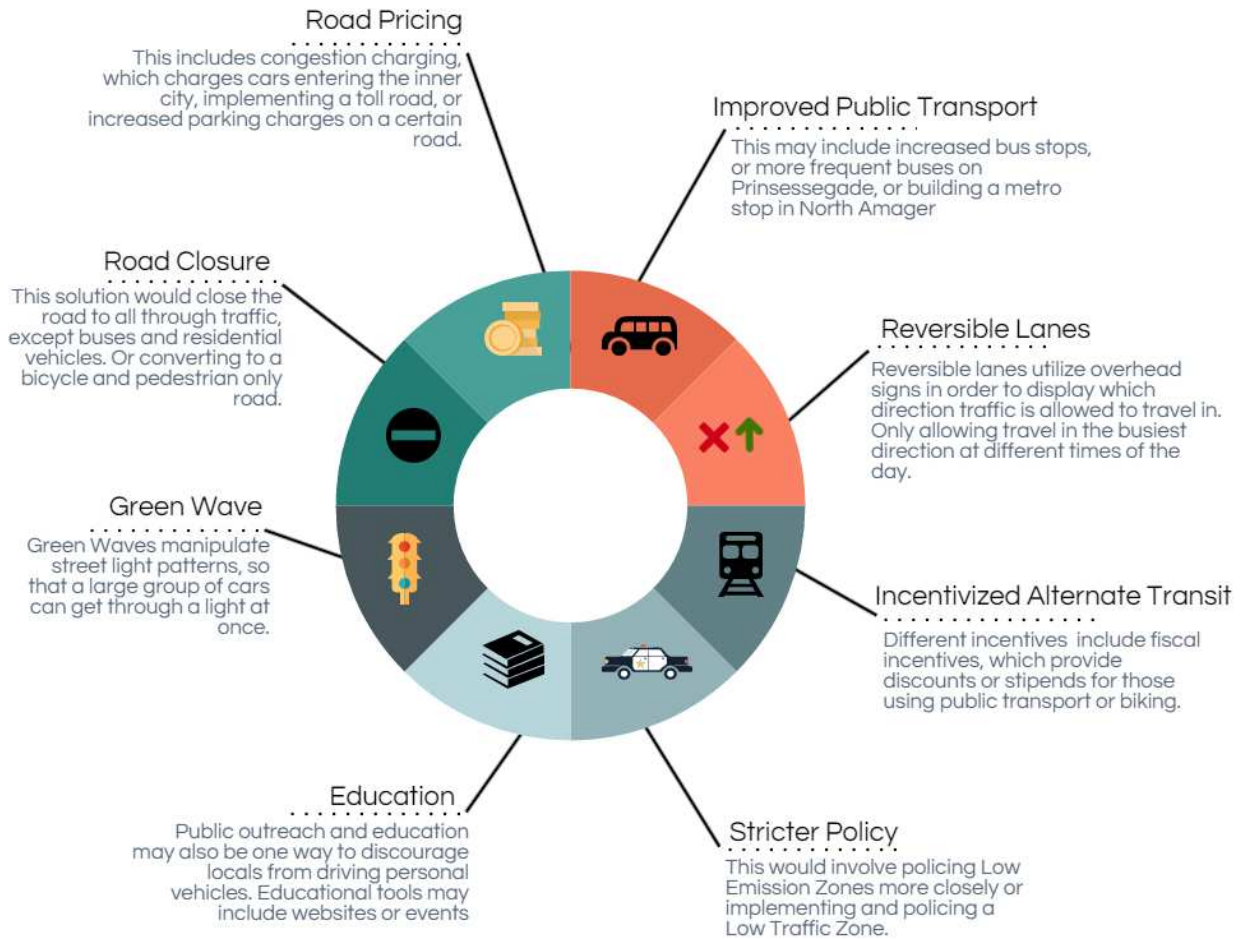


Figure 9: Strategies to Mitigate Traffic Congestion

Informal observation

During the early stages of our project, we conducted informal observations focusing on the variety of requirements established in the previous section. The strategies that we considered all have factors that must be considered prior to implementation on a specific street. We also carried out observations to determine which destinations are contributing to the problem. We took notes on our observations and photographed both the intersections and current traffic. Our variety of observations can be categorized in the following ways: infrastructure, traffic, daily life, and existing modes of transportation.

Infrastructure

Before conducting roadside observations, we utilized Google Maps to gain familiarity with the area. We noted the streets surrounding Prinsessegade and created a map of Christianshavn highlighting what we determined as the most important parts (see Background Figure 7). We also noted parallel streets and alternative routes that can be taken to get from the south end of Christianshavn to the north end and vice versa. Once we finished observing the map of the area, we visited Prinsessegade on

Monday (20 March 2017) at 12.00 to gain further insight about the existing infrastructure. We analyzed the number of lanes, existence of bike lanes and sidewalks, and the traffic lights and intersections.

Traffic

As the second part of our informal observation, we visited Prinsessegade during peak rush hours, 9.00 and 16.00, on Monday (20 March 2017), Wednesday (22 March 2017) and Friday (24 March 2017). These times were determined as peak rush hour times in a public survey of Copenhagen residents conducted in 2015 (Stepanian et al., 2015). We verified these hours by comparing the live Google Traffic congestion rates at these times with other times during the week day. We noted the direction of the traffic flow at these times based on the requirements defined for reversible lanes. We also noted the traffic at the three major intersections (Torvegade, Sankt Annæ Gade, and Bådsmadsstræde) to see if any particular intersection had a noticeably heavier vehicle backup than the others. In order to determine if the Green Wave initiative would prove suitable, we checked if the timing of the lights impacted congestion. We performed this check by noting if any cars were not able to make it through an intersection in one light cycle. In addition to observing road traffic, we noted the foot and bicycle traffic at rush hour, and if congestion also occurred in the bike lanes and sidewalks.

Daily life

Through observing daily life on Prinsessegade, we identified major destinations that individuals used Prinsessegade to reach. By identifying these popular destinations that contribute to traffic on Prinsessegade, we were able to determine if specific strategies could cater to and alleviate traffic heading towards such locations (for example, if there is a need for more public transport options or more frequent bus stops). Prior to our observation, we utilized Google Maps to provide an initial list of locations in the surrounding area that may contribute to the road use on Prinsessegade, including apartment complexes, businesses, schools, and other attractions. We performed these observations at various times of the day (both peak and nonpeak traffic times): 9.00, 12.00, and 16.00 on Monday (20 March 2017), Wednesday (22 March 2017) and Friday (24 March 2017).

Modes of transportation

While performing our informal observation, we noted the various modes of transportation used to travel on Prinsessegade. During each observation time of 9.00, 12.00, and 16.00, we made note of how road users traveled at these times and if certain methods of travel appeared more popular at different times of the day. In a scenario where motorists form the largest population of travelers during a specific time of day, we would determine if a strategy such as incentivizing alternative transport would prove effective at reducing the number of cars on the road. We also observed the frequency of 9A bus arrivals to determine if Prinsessegade's public transportation requires improvements to provide a reliable service to its users.

Assessment of strategies

After identifying traffic strategies and conducting informal observations, we assessed the strategies based on the technical aspects of the road. We gathered the constraints and requirements of each traffic strategy and then compared them with our observations, identifying which strategies appeared technically viable based on our observations. We eliminated strategies whose technical

requirements were incompatible with Prinsessegade and retained the remaining requirements for further assessment through Objective 2. Since physical restrictions do not impact the viability of strategies such as education and stricter emission policies, these strategies are not included in Table 2. We designated the elimination of strategies that did not meet all of the obvious technical requirements with a check in the “No” column of the table.

Table 2: Evaluation of Strategies Based on Observation

Strategy	Requirements	Yes	No
Road closure	Alternative routes (parallel roads or other)		
	Route for emergency vehicles		
	Evidence of existing bike and foot traffic		
Bicycling and pedestrian road	Existing sidewalks and bike lanes		
	Evidence of existing bike and foot traffic		
	Alternate route for cars		
	Route for emergency vehicles		
Improving public transport	Lack of public transport options		
	Infrequent/ unreliable public transport		
	Heavy enough flow of traffic in area		
Incentivizing alternative transport	Bicycling infrastructure		
	Public transport options available		
	Existing local businesses and transport companies to partner with		
Reversible lanes	One direction of traffic should have a higher flow of traffic		
	Parallel lane for opposite flow of traffic to use		
	Route for Emergency vehicles		
Green wave	At least three intersections		
	Back-up of vehicles at intersections (unable to get through in one cycle of the lights)		
Road pricing	Location for toll booth		

Objective 2: Investigate public and expert opinion on strategies deemed viable for the Prinsessegade context.

To evaluate potential traffic mitigation strategies that would be well received by local residents and business owners, we gauged the public's opinion of the remaining strategies to traffic congestion and air pollution. In order to complete this objective, we conducted surveys with residents and semi-structured interviews with local business owners and experts. These experts included, but were not limited to, professors and researchers from Danish universities and members of the Local Borough Council of Christianshavn, the active local committee. The committee's role is to engage the community and ensure that they are informed on local developments, as well as update politicians on conditions and attitudes of the residents of Christianshavn. In addition to the local committee members, we contacted individuals from the municipality, including urban and traffic planners, and representatives from the Christianshavn Skolebestyrelse (school board). Lastly, to receive collective feedback on our potential strategies for traffic congestion from local Christianshavn experts, we held an open forum dedicated to discussing the possibilities and complications of each approach. We completed this objective from March 13 to April 20.

Semi-structured interviews with experts

In this set of semi-structured interviews, we sought experts on the traffic problem in Christianshavn as well as experts on general traffic congestion and air pollution to provide assistance in evaluating potential strategies. This method of obtaining experts is purposive sampling (Berg & Lune, 2012), as we specifically targeted individuals and groups who are educated on air pollution, traffic congestion, and the link between both major problems.

We originally encountered difficulties in convincing some experts to participate in an interview. However, after coordinating with our liaison from Miljøpunkt, we received a list of names from the local committee and municipality. These original interviews then referred us to further contacts who were willing to speak with us.

We conducted these interviews in a one-on-one, semi-structured fashion, prepared with a list of questions that would launch a discussion with the interview subjects. We tailored each interview's questions to apply to the particular interviewee's area of expertise. For each interview we assigned one person to ask the interview questions and another to record the answers. The research questions we hoped to answer through our expert interviews, specifically with local committee members, included the following:

- Which of our considered traffic strategies have already been researched for use in Prinsessegade, what factors have prevented these strategies from entering usage, and to what extent have the previously attempted congestion mitigation strategies reduced Prinsessegade's daily traffic congestion, if at all?
- What do locals believe is the biggest problem regarding the traffic on Prinsessegade?
- What is the best method to evaluate our strategies and make conclusions about the success of our proposed traffic strategies?
- What sort of strategies will the community support to solve this issue?
- What sort of strategies will the government support to solve this issue?
- What challenges exist when trying to recommend strategies to reduce traffic congestion?
- What strategies are most effective to change traffic behavior in Copenhagen?

These broad questions provided more insight into the strategies we have researched and aided our understanding of the local history in the recent years. Prinsessegade's traffic has been an ongoing concern, and our goal was to gather information on strategies that have been previously implemented or discussed, specifically by the local committee (following their role as a liaison between residents and policy makers). This also exposed which approaches proved particularly successful or ineffective when implemented in the area, and we compared our own strategies against any past failures to further narrow down our candidate strategies. We also inquired about the public's general understanding of air pollution's health effects, as the committee members are cognizant of the community's attitude toward this issue. This question was designed to target education and community outreach as a strategy to mitigate traffic congestion.

We also contacted researchers and professors at institutes such as Aarhus University and the Technical University of Denmark (DTU). Originally we intended to gather more data on air pollution and its health effects, as well as any information they could provide on air pollution (ideally specific to Prinsessegade). In addition, we were interested in methods to rank our proposed traffic strategies and predict which would provide the highest chance of success. Not only did we inquire regarding how to rank the methods, but we also asked for input on our strategies in order to weigh professional opinions in our final recommendations.

Semi-structured interviews with business owners

In addition to our expert interviews, we conducted semi-structured interviews with business owners to understand how their establishments are affected by traffic congestion and air pollution. From our informal observations of Prinsessegade, we identified businesses whom we wished to contact. Many of these businesses either reside on Prinsessegade or are located in the surrounding area. Our purpose in interviewing business owners or their representatives was to gather information on how local businesses are impacted by the current traffic and pollution situation, and additionally how they might react to or be impacted by any possible changes in the area. We asked business owners if they were impacted by traffic congestion, and inquired about how the removal of the bus gate on Prinsessegade had an impact on their businesses. In addition, we sought opinions from business owners regarding potential strategies to alleviate road congestion and gauged their willingness to participate in an incentive program to encourage travelers to utilize public transportation. As a result of our observations conducted as part of completing Objective 1, we also identified the companies with delivery vehicles travelling along the street during peak traffic times. By contacting the companies associated with the delivery vehicles, we intended to learn the reasons that they travel on Prinsessegade during peak traffic times.

To obtain the contact information of these businesses, we utilized the Google search engine to find each business's phone number or email address, if either could be found on their websites. We then emailed or called these companies whose contact information appeared on the Internet to answer our questions via a personal interview or phone call with the business owner or manager. For a phone interview, we designated one person to participate in the discussion and take notes on the interview. We utilized the same qualitative content analysis method for expert interviews and interviews with business owners.

Interview analysis

We analyzed each interview separately using a content analysis approach. This approach involved the multiple steps listed below.

1. **Organizing the data**

In this step we reviewed our interview notes to decide which were the most relevant to the problem. Following this criteria, we transcribed the interviews that appeared likely to be most useful and for which the recording was audible. For the other interviews we only transcribed our notes. We kept both the transcriptions and interview notes organized with the date and time that the interview was conducted. We also included the larger research questions that we hoped our interviews would answer in the transcripts and notes.

2. **Organizing ideas and concepts**

In this step, we collectively discussed the themes that were commonly expressed in each interview and whether or not our research questions were sufficiently answered. We kept notes that highlighted the most important topics from each individual interview. We also took note of any unexpected new information and any unanswered questions.

3. **Developing an overall theme**

After organizing the main ideas from each interview, we compared the individual interviews against each other to find trends in the data. For example, if many participants complained about public transport in the area, we inferred that we likely needed to focus our traffic strategies in that direction.

4. **Determining validity in the data analysis**

Next, we verified the data that emerged from the rest in Step 3. If a respondent provided a clashing contrary opinion to common phrases or ideas from the rest of the interviews, we carefully investigated the cause of this difference in opinions to determine its validity.

5. **Creating a visual representation of results**

Lastly, we created a graphic that demonstrates the research questions that each interview answered, complete with the results of these questions. This allowed us to organize our thoughts and graphically represent the larger themes from each interview for clarity. We then identified patterns across the the interviews in order to draw conclusions about our findings.

Surveys with the public

Our surveys focused on discovering how members of the public perceive traffic congestion on Prinsessegade and each of our potential solutions to congestion and air pollution for Prinsessegade. We chose this method as the most direct way to understand the impacts on individuals who live and work in Christianshavn that any strategies might create. It provided us with a better understanding regarding what people know about the relationship between air pollution and traffic congestion. It also allowed us to gauge public knowledge about the impacts of air pollution on human health, which, again, we designed to gauge how useful education would be. Additionally, we used these surveys to evaluate

public opinion on strategies to mitigate traffic congestion. The complete list of survey questions can be found in Figure 10.

While we recognize that those who use Prinsessegade are not experts on the subject matter, they provided us with insight into the impacts of congestion on the daily lives of people who live on or use Prinsessegade. Our final recommendations suggest traffic strategies that directly impact the users of Prinsessegade, and therefore collecting public opinion is an important aspect of this process. Moreover, we have researched past strategies to reduce road traffic in Copenhagen that were not implemented due to a combination of political discord and also public opposition. This is evident in such cases as road pricing, which the local government of Copenhagen was unable to implement due to public resistance (CPH Post, 2013). We decided, because of the previous controversy, that we would categorize negative public opinion towards a potential strategy as a con in our final results and recommendations. While we did consider negative public opinion as a con, we did not assume that it could not be outweighed by pros, which we determined for each strategy through research, past results, and expert interviews.

We utilized Google Forms to create a survey with a list of predetermined questions, leaving space for any additional comments or information provided that were outside the scope of our questions.

1. I understand that when submitting this survey, my answers will be used anonymously in the final report for the students listed above.

- a. Yes b. No

***2. How old are you?**

- a. 18-30 b. 31-50 c. 51-70 d. 71+

***3. Do you live in Christianshavn?**

- a. Yes b. No

***4. Where do you work?**

- a. Inside of Christianshavn b. Outside of Christianshavn
c. Retired d. Other: _____

***5. Do you have children?**

- a. Yes b. No

6. What form of transportation do you most frequently use to move to/from Christianshavn? (Select all that apply)

- a. Private vehicle b. Taxi cab
c. Walking d. Bicycling
e. Public transport (bus, metro, train) f. Other: _____

7. Why do you use this form of public transportation?

8. Have you ever experienced traffic congestion on Prinsessegade?

- a. Yes b. No

9. Where have you experienced the worst traffic congestion?

- a. Intersection of Prinsessegade and Torvegade
b. Intersection of Prinsessegade and Sankt Annae Gade (Spiral Tower)
c. Intersection of Prinsessegade and Badmandsstraede (Christiania)
d. Other: _____

10. What times of day have you experienced the worst traffic congestion? (Check all that apply)

- a. Early morning (07.00 - 9.00) b. Late morning (09.00 - 11.00)
c. Midday (11.00 - 13.00) d. Early afternoon (13.00 - 15.00)
e. Late afternoon (15.00 - 17.00) f. Evening (17.00 - 19.00)
g. After 19.00

- 11. For what purpose do you travel on Prinsessegade? (Check all that apply)**
- a. I live in Christianshavn (I use the street to get to and from my home)
 - b. To visit Christiania
 - c. To drop my child off at school
 - d. To get to the universities in northern Christianshavn
 - e. To go to Opera House
 - f. To get to Northern Amager
 - g. Other _____
- 12. What were your thoughts on the bus gate that was reopened on Prinsessegade last year?**
- 13. Please respond to the following statements with strongly agree, agree, neutral, disagree, or strongly agree**
- I believe that traffic congestion is a major contributor to air pollution
 - I believe that air pollution negatively affects my health
 - Traffic congestion negatively impacts the flow of my daily commute
 - I believe that private vehicles are the most convenient mode of transportation
 - The current government standards on air pollution sufficiently protect me against pollutants
- 14. Please rate the following solutions to traffic congestion on Prinsessegade from 1-5, with 1 being highly undesirable and 5 being highly desirable**
- Close the road (public transport and residents only)
 - Reversible lanes/ one way lanes
 - Bicycling and pedestrian road
 - Improved public transportation options
 - Monetary incentives for alternative transport use (including bicycling or carpooling)
 - Increased policing on low emission zones (stricter enforcements)
 - *Road pricing
- 15. Would you be interested in participating in an open forum to discuss these solutions in more depth?**
- a. If yes, can we have your name and email?
- *this question was added when we posted the survey online*

Figure 10: Survey questions asking the public about traffic congestion on Prinsessegade and their opinion on potential traffic strategies

These surveys took place between March 27 and April 14. On March 27, 28, and 31, we administered surveys in person by having two or three team members interact with locals and commuters along Prinsessegade and neighboring streets. However, in order to supplement our sample size, we also posted the survey to Miljøpunkt's Facebook page where we collected responses from April 5 to April 11.

We generally chose to conduct in-person surveys in the square outside of the Christianshavn Metro station. This presented a challenge because we attracted people who use public transportation in this location, however, it is one of the more populated areas in close proximity to Prinsessegade and is surrounded by businesses with a lot of foot traffic. Upon approaching people and asking them to participate in our survey, one of our initial questions was to ask if they have travelled on Prinsessegade, to ensure we were targeting individuals who understood the context of our questions. We also relocated to Prinsessegade multiple times, which guaranteed that we would encounter users of the road, but this was not successful because many of these people were tourists visiting Christiania or the Spiral Tower.

During the in-person surveys, one person conducted the interview and another team member filled out the Google Form survey on a smartphone. The interview questions included a variety of topics

regarding how traffic congestion impacts the lives of the locals. We asked the participants a set of basic questions in order to categorize the different responses. The questions we addressed in these surveys included what motivates people to use a certain type of transportation over other types. We also wanted to know why exactly people use Prinsessegade so we could think about how different strategies would appeal to the users of different vehicles.

One challenge we faced conducting these interviews was that we were not realistically able to interview people using their cars on Prinsessegade and our in person surveys were therefore limited to mostly pedestrians. To combat this we also posted our survey to Miljøpunkt's Facebook page to try and get a broader range of participants. Posting the survey through our sponsor's page, however, also creates some bias as those interested in Miljøpunkt's work are more likely to exercise environmentally friendly habits such as bicycling or walking. Prior to posting our survey online, additional survey questions were created so that we could further categorize the data. We sought to ask about the participant's age, residence, place of work, and if they have children because we believed that these factors could have an influence on their experience with traffic congestion on Prinsessegade and their opinion on potential mitigation strategies. Additionally, we introduced road pricing as another strategy to rate after speaking with our sponsor and other experts.

In addition to this more demographic based information, we asked our survey participants to rate each of our potential strategies that remained after objective 1 on a pre-defined scale of 1 to 5:

1. Highly undesirable
2. Undesirable
3. Neutral
4. Desirable
5. Highly desirable

In doing this, we could determine which strategies were rated the highest by the largest number of people. We then used these results to conclude whether public opinion was positive or negative for a strategy, in order to determine if public opinion was a pro or con for each strategy. These survey responses, though they provided some insight into how strategies would be received by the public, are limited in their ability to completely represent public reaction to alternative strategies that were not discussed in our survey. Therefore, we asked participants to rate traffic mitigation strategies without providing them much detail about what each strategy would entail, and what costs and benefits would be associated with each one. Moreover, we had a limited spectrum of participants, so the larger community may react differently than we anticipate. This is especially true in Christianshavn, a very strong community that may support more extreme traffic alleviation strategies, that exists within a larger community that still uses Prinsessegade. In this case, the opinions of the residents of Prinsessegade are likely very different from the people who use it as a throughway street. Another consideration is the developing area in northern Amager, which could create a very different demographic in the future, with contradicting opinions to those collected in the survey, which is impossible to predict until the development actually occurs.

Survey analysis

By using a Google Form to host our survey, we were able to automatically record the responses to a spreadsheet for analysis. Using a spreadsheet formula, the participant responses were tallied for each multiple choice question that our survey had. In the case that a participant had responded to a

multiple choice question with an answer that was not defined in the question options, we had categorized them as an “Other” response. To address the survey responses that involved rating potential traffic strategies on our predefined numerical scale, we calculated an average rating for each strategy as well as the standard error. In order to assess whether a potential strategy would be well received by the public, we determined that a positive public opinion would be indicated by an average rating of greater than or equal to 3.1, a negative public opinion would be determined by an average rating of less than or equal to 2.9. If the average rating for a strategy fell between 2.9 and 3.1, then we were not able to determine if public opinion could be a pro or con in our final assessment.

Once we had analyzed the data from the survey as a whole, we chose to further analyze how people with different demographic information answered the questions. We chose to evaluate demographic traits that we believed would potentially have an influence on how participants would answer the survey questions. We compared the difference in responses between participants who had children and those who did not have children (survey question #5), those who lived in Christianshavn and those who lived elsewhere (survey question #3), and those with various methods of primary transportation. We believed that people with children may be more aware of the health impacts of air pollution and the increased risk to children, which may influence their rating on potential traffic strategies. We also believed that residency would impact a participant’s responses to the survey; residents are more likely to experience traffic congestion on a daily basis, and may have different opinions on strategies that directly impact the street infrastructure when compared to individuals that use Prinsessegade as a through-street. Lastly, we believed that a person’s primary method of transportation would influence his or her ratings. For example, converting Prinsessegade into a bicycle-only road would be a more appealing strategy to a bicyclist than a car owner. Once again, we tallied the responses from each demographic group to the multiple choice questions and calculated an average rating for each potential traffic alleviation strategy.

Throughout our analysis, we utilized pie charts, bar graphs, and column graphs to visualize our survey responses. In addition to using visual representation to analyze data, we also performed chi-square tests in order to determine if the responses of two groups were statistically significant. We chose to perform the chi-square test because it is used for analyzing categorical data and tests how likely that an observed distribution is due to chance (Ling, 2017). For the numerical data, we performed an analysis of variance (ANOVA) to determine if the average ratings between two categories were statistically different. First, we generated a column graph that compared the average ratings between two categories (e.g. residents and non-residents) to make a visual assessment to determine if there were specific traffic strategies where the ratings could potentially be significantly different. Afterwards, we performed a single factor ANOVA to determine if the ratings were statistically different.

Our survey responses included some qualitative data. We sought to know why the participant uses a certain mode of transportation and also their feelings regarding the Prinsessegade bus gate removal. To assess the qualitative responses, we constructed an initial list of keywords and topics that we anticipated would be prevalent in the answers to the open response questions: speed, distance, environmental reasons, convenience, exercise, physical ability/limitations, and cost. After conducting the surveys, we reevaluated the list of keywords to reflect any topics that we may not have initially considered. Using this list, we tallied the number of times that a participant had mentioned a particular subject.

Open forum

We took measures to ensure that we involved the Christianshavn community in our discussion of strategies for reducing traffic congestion on Prinsessegade. To do this, we organized an open forum meeting to publicly discuss our proposed strategies.

Assessment of strategies based on informal observation, public and professional opinion

Before we conducted our open forum, we eliminated additional strategies that did not seem viable based on combined expert interviews and survey results. We then created an informational flyer representing the pros and cons of each remaining strategy for use in our open forum, as shown in Figure 11. Some strategies were eliminated prior to the open forum if our observations suggested they would not be successful. In addition, we eliminated strategies if both the infrastructure seemed unsuitable and our interviews supported that observation.

TRAFFIC CONGESTION
ON PRINSESSEGADE

THE PROBLEM: Traffic congestion on Prinsessegade results in increased air pollution levels.

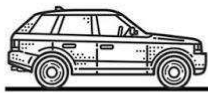
POSSIBLE SOLUTIONS

ROAD CLOSURE		STRICTER POLICY	
Restrict road use to buses and residents only, or convert to a pedestrian and/or bike road		Road pricing, implementing low emission zones, or low traffic zones	
PROS	CONS	PROS	CONS
<ul style="list-style-type: none"> People will be more inclined to use public transit. Through traffic must find alternate route Reduces vehicular emissions, provides safety for schoolchildren 	<ul style="list-style-type: none"> Bus gate has been attempted and removed Lack of political support No sufficient alternate route that could be used for cars or emergency vehicles 	<ul style="list-style-type: none"> Car users will be less likely to travel through these zones due to stricter enforcement and increased costs Studies and researchers have estimated that this could make a noticeable impact 	<ul style="list-style-type: none"> Increased enforcement requires additional personnel to ensure that cars are being checked More money and more resources Parliament does not support it
ALTERNATE TRANSPORT		COMMUNITY OUTREACH	
Improving public transport or providing incentives for alternate transport including biking and public transit		Including planned events with residents as well as distributing information about traffic and air pollution	
PROS	CONS	PROS	CONS
<ul style="list-style-type: none"> Increases easy transportation methods to northern Christianshavn Commuters will be provided with additional benefits to use public transit 	<ul style="list-style-type: none"> No guarantee people will actually abandon private vehicles Creating more public transportation would be costly 	<ul style="list-style-type: none"> People may be motivated by moral obligation More informed individuals may be more likely to realize the environmental consequences of cars 	<ul style="list-style-type: none"> Long term solution Community seems fairly knowledgeable about the problem already

Figure 11: Open forum handout

Our primary aim in hosting an open forum was to present our survey and interview-based pros and cons for each of the traffic strategies diagrammed in Figure 11 to the local attendees, with the intent of discussing and exposing any complications that could arise from pursuing each possibility, further engage with residents of Christianshavn and reveal more ideas about the potential strategies, including political perspectives, as everyone was free to agree or disagree with our findings. We hoped to gauge the Christianshavn community's opinions and ideas of our proposed traffic strategies for Prinsessegade by allowing discussion amongst attendees. We had a variety of attendees in order to allow different parts of the community to engage with each other to see opposing perspectives and gain insight into what other locals think. This would hopefully allow the community to better understand each other to eventually come to a decision about which strategies to employ on Prinsessegade.

To attract attention to the forum, we advertised it with a digital flyer on Miljøpunkt Indre By-Christianshavn's Facebook page (<https://www.facebook.com/MiljopunktIndreByChristianshavn/>) and posted 10 physical copies in various locations in Christianshavn: in the Christianshavn Beboerhus cafe, Christianshavn library, Lakagehuset and Holm's Bager bakeries, Havnens BBQ, Grillen Christianshavn, and Blue House restaurants. The poster (Figure 12) had a QR code, a matrix barcode that smartphone users can scan in order to navigate directly to a webpage, and a bit.ly address (<http://bit.ly/2oBlbNL>) that people could use to take them to the registration page for the forum. We used Eventbrite, a website designed to host events and provide an interface for event registration, for the forum; this allowed us to estimate how many people would show up to the forum and also let us cap the attendee allowance to 35 people. We determined that a maximum of 35 people would be an appropriate limit for the forum because it is the approximate recommended size for an open forum (Francisco and Schultz, 2017). We asked participants of our survey to fill out their name and email if they were interested in participating in our open forum; if they were, we emailed them a link to our Eventbrite registration page. We also emailed the Eventbrite link to the attendees of the Local Borough Council of Christianshavn that expressed interest at the meeting we attended on March 29th. Lastly, we emailed out the link and flyer to experts we interviewed and members of the Copenhagen Municipality Technical and Environment Committee. In total, we personally emailed 25 possible participants. Furthermore, our sponsor posted the registration link on their Facebook page. A few days before the open forum, Eventbrite automatically sent out reminder emails to the people who registered, and on the day of the open forum, we sent out emails ourselves to the people who had registered. The open forum was held on 19 April 2017 from 16.30 to 17.30 in Beboerhus, a community meeting space in Christianshavn. Our team arrived at Beboerhus at 15.30 to set up tables and chairs and prepare our presentation materials. We placed the tables and chairs in a small U-shape to facilitate group discussion. The central location of Beboerhus provided easy access for Prinsessegade residents and users.



TRAFFIC ON



PRINSESSEGADE

JOIN US and

MILJØPUNKT
AGENDA 21 FOR ET BJEREDYGTIGT KØB



INDRE BY
CHRISTIANSHAVN

GET MORE
INFO AND
REGISTER
HERE



<http://bit.ly/2oBlbNL>

IN AN OPEN COMMUNITY
DISCUSSION

WHERE

CHRISTIANSHAVNS BEBOERHUS
Dronningensgade 34, 1420 København K

WHEN

WEDNESDAY, APRIL 19TH
16:30 - 17:30



Christianshavnet

Figure 12: Flyer advertisement for open forum

our report. Two team members gave the presentation, led the forum, and recorded the discussion with a smartphone, two team members took notes, and one took pictures of the proceedings.

Open forum data analysis

After conducting our open forum, we transcribed our notes (since the audio recording was low quality and unintelligible) in order to analyze the results. To do this, we got ideas from a focus group analysis strategy (Hoets, 2017) due to the similarities between our open forum and a focus group. The following list describes each step of the open forum analysis.

- 1. Data grouping**

The transcribed notes were coded according to which traffic strategy they covered. The traffic strategy categories discussed in the forum were road closure, stricter policies, alternate transport, and community outreach, and these four categories were used to highlight the transcription notes with different colors. The open forum notes are available in Appendix B.

- 2. Findings**

Next, we further organized the coded notes of the open forum according to which research question they answered in order to ensure that we got the results we were looking for from the open forum.

- 3. Data representation**

Finally, we organized the notes from the open forum into a table to show the attendees' perceptions of our proposed traffic strategies and to highlight any new ideas that were brought up.

Final assessment of strategies

At our open forum, we presented a variety of pros and cons that we gathered from both Objective 1 and Objective 2. After we conducted the open forum, we took the pros and cons list that we developed for our presentation, and then adapted it based on the opinions and ideas that were presented in the forum. We did not use the open forum to eliminate any strategies; we used it to learn about the strengths and weaknesses of each as seen by the Christianshavn community. Table 3 summarizes the pros and cons of our proposed traffic strategies and Table 4 summarizes the outcomes of whether each strategy passed or failed our objectives.

Table 3: Assessment of pros and cons of each strategy

Strategy		Pros	Cons
Road closure	Bus gate		
	Pedestrian/bike road		
Improving public transport			
Incentivizing alternative transport			
Reversible lane			
Green wave initiative			
Stricter policies			
Road pricing			

Table 4: Summary of Elimination of Strategies

Pass: ✓ Fail: ✗

Strategy	Objective 1: technical evaluation	Objective 2: evaluation of public and expert opinion	Discussion of strategy	Outcome
Green wave				Eliminated
Road closure				Potential solution
Improving public transport				Potential Solution
Incentivizing alternate modes of transport				Potential solution
Reversible lanes				Eliminated
Education				Potential solution
Stricter policies regarding air pollution				Potential solution
Road pricing				Potential solution

Detailed Results

Objective 1: Assess the viability of identified air pollution and traffic congestion solutions within the context of Prinsessegade, a major street in Christianshavn.

Informal observations

The informal observations conducted in the beginning of the term allowed us to evaluate whether there were any logistical or technical reasons to eliminate any of our preliminary strategies for addressing traffic congestion on Prinsessegade before moving on to the public perception component of our project. In the section below we provide summaries of the basic observations we made on Prinsessegade.

Infrastructure

Prinsessegade is a narrow two-way street generally flanked by tall buildings and bicycle lanes on either side of the road. Narrow sidewalks also exist on both sides of the road; however, current construction on certain parts of the sidewalks requires that pedestrians move into the bicycle lanes in the affected areas. The vehicle lanes and bicycle lanes are narrow through the entire length of the street, and the bridges do not contain separate bicycle lanes, forcing cyclists to ride in the street with car traffic.

Prinsessegade is the most direct route to the attractions in northern Christianshavn, which is why it is the most popular route to places such as the Opera House. However, an often ignored alternative route to northern Christianshavn exists in the form of Kløvermarksvej, a northern Amager road. The Prinsessegade route and the alternative Kløvermarksvej route can be seen in Figure 14 below. This route is less popular because it is longer and requires more travel time, as shown in the figure. However, while the alternative route is over two times longer than the Prinsessegade route, it only adds 2 more minutes to the drive from the Christianshavn metro to the Opera House. In addition, the alternative route has far less traffic and minimal traffic lights. The drive also opens with wider streets and more trees than Prinsessegade to minimize air pollution, as compared to the street canyon of Prinsessegade that traps particles among taller buildings and creates more concentrated pollutants.

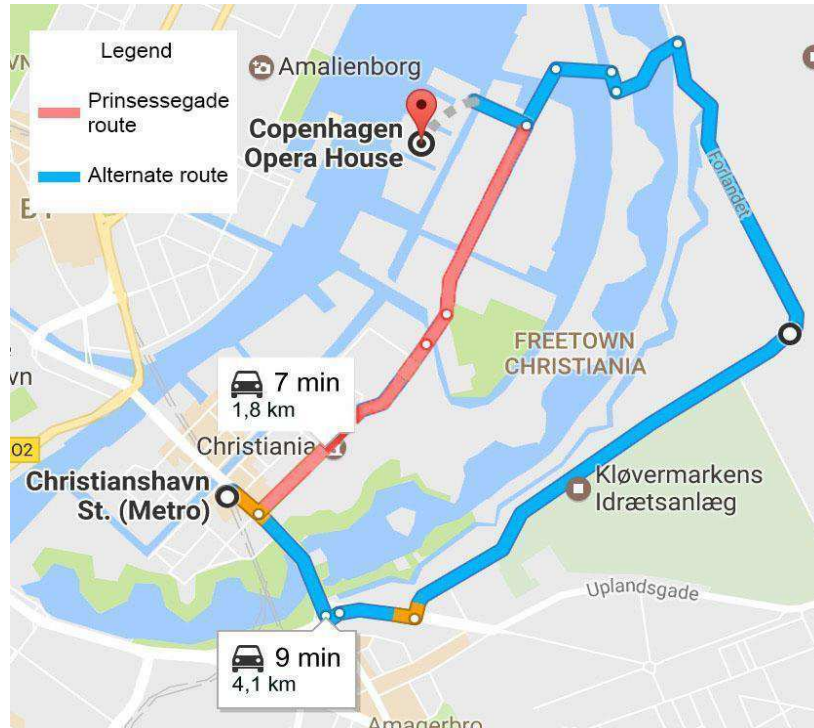


Figure 14: Prinsessegade vs. alternative route (Google Maps, 2017)

Traffic

There are three traffic light intersections on Prinsessegade. The traffic we witnessed on the street during both rush and non-rush hours revealed that there are not enough cars on the street to delay vehicles across multiple traffic light cycles. The lights have proper timing so that vehicles on the road can move through intersections with ease and avoid experiencing excessive stops at multiple lights. Figure 15 is a product of our own traffic observations.



Figure 15: Traffic at the intersection of Prinsessegade and Torvegade

Daily life

During the morning and afternoon rush hours, the excess of pedestrians on the sidewalks spill into the bike lanes, thereby forcing the cyclists into the car lanes. We observed a high volume of pedestrians along the street during the afternoon, largely consisting of tourists visiting the Spiral Tower, Paper Island or Christiania. There was an even larger number of pedestrians from 11.00 to 13.00 due to local high school students standing outside during their lunch break. In the evenings when events are held at the Opera House, we observed a larger volume of overall traffic heading north towards the venue.

Modes of transportation

On Prinsessegade, we noticed a heavy amount of foot and bike traffic around rush hour times. In addition, rush hour conditions contributed to a large amount of car congestion. Bus 9A travels up the road every 10 minutes. Taxis, tour buses and delivery trucks also regularly drive along the road. None of the rush hour observations uncovered a significant imbalance in the volume of traffic for both directions. We did not conduct official counts of cars, but confirmed the variety of transport options used along this street.

Assessment of strategies

This section details how our informal observations of Prinsessegade and Christianshavn led to the elimination of certain traffic strategies that would be unsuitable for use on Prinsessegade based on the current infrastructure of the street. Table 5 shows each traffic strategy's requirements for success; an X under the Yes or No column indicates whether or not each requirement has been met. This is how we eliminated the Green Wave as a potential traffic strategy, as we recognized that there is no need for traffic management and that a strategy that would decrease the number of cars on the road would be more beneficial.

Table 5: Completed Evaluation of Strategies Based on Observation

Strategy	Requirements	Yes	No
Road closure	Alternate routes (parallel roads or other)	X	
	Route for emergency vehicles		X
	Evidence of existing bike and foot traffic	X	
Bicycling and pedestrian road	Existing sidewalks and bike lanes	X	
	Evidence of existing bike and foot traffic	X	
	Alternate route for cars	X	
	Route for emergency vehicles		X
Improving public transport	Lack of public transport options		X
	Infrequent/unreliable public transport		X
	Sufficiently heavy flow of traffic in area		X
Incentivizing alternative transport	Bicycling infrastructure	X	
	Public transport options available	X	
	Existing local businesses and transport companies for partnerships	X	
Reversible lanes	One direction of traffic should have a higher flow of traffic		X
	Parallel lane for opposite flow of traffic to use		X
	Route for emergency vehicles		X
Green wave	At least three intersections	X	
	Back-up of vehicles at intersections (unable to get through in one cycle of the lights)		X
Road pricing	Location for toll booth		X

Objective 2: Investigate public and expert opinion on strategies deemed viable for the Prinsessegade context.

Semi-structured interviews with experts

All transcripts and transcribed notes can be found in Appendix A. We found that five of our interviews were helpful to us in answering our research questions. For those five interviews, we created infographics. For the other interviews, we found that our conversations did not help us to answer our research questions, and thus we provide only brief summaries of the conversations in this section.

Erling Ekegren

We interviewed Erling Ekegren on 22 March 2017. This interview was conducted in person in the Christianshavn Beboerhus (community house). Ekegren is a local Christianshavn resident and member of the Local Borough Council of Christianshavn and has knowledge about the traffic issues on Prinsessegade. We were provided his contact from our sponsor, Marianne Spang Bech. He spoke to us about the problems on Christianshavn and gave us various contacts in the area, mostly those in charge of various Christianshavn committees. Results from the interview can be seen in Figure 16.

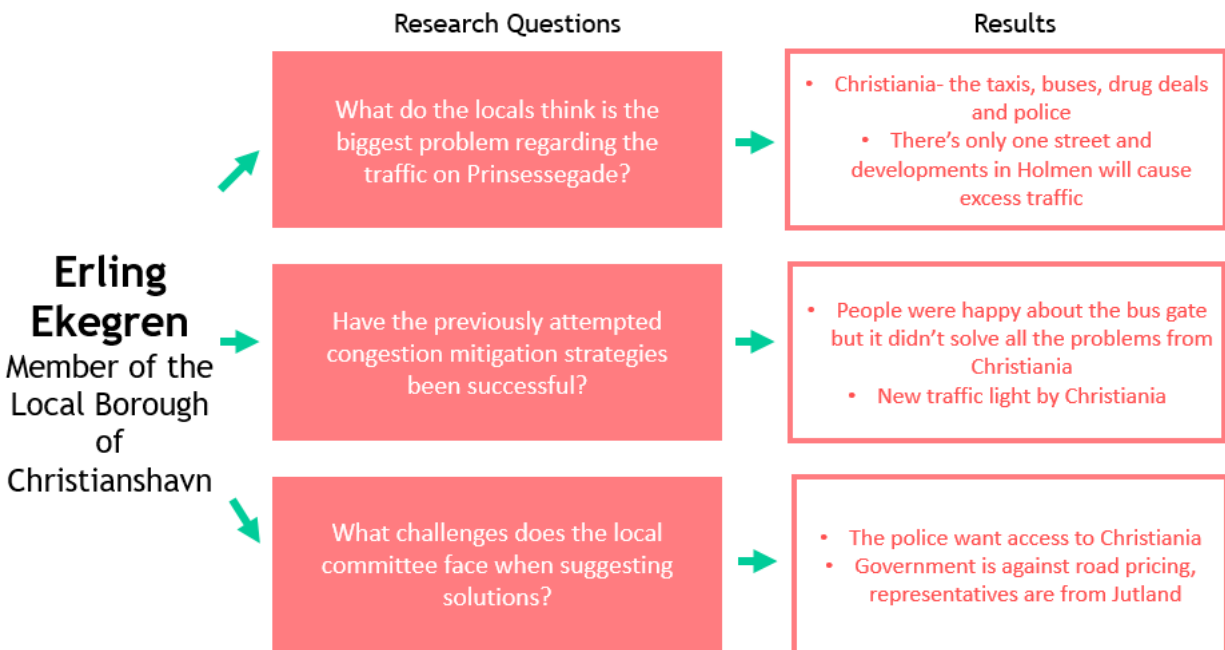


Figure 16: Results from the interview with Erling Ekegren

Poul Cohrt

We interviewed Poul Cohrt on March 24, 2017. This interview was conducted via phone call. Cohrt is the chairman of the Local Borough Council of Christianshavn and explained more about what we had discussed with Ekegren as well as past work that the committee has done in the community. We were provided his contact information from our sponsor, Marianne Spang Bech. Results from the interview can be seen in Figure 17.

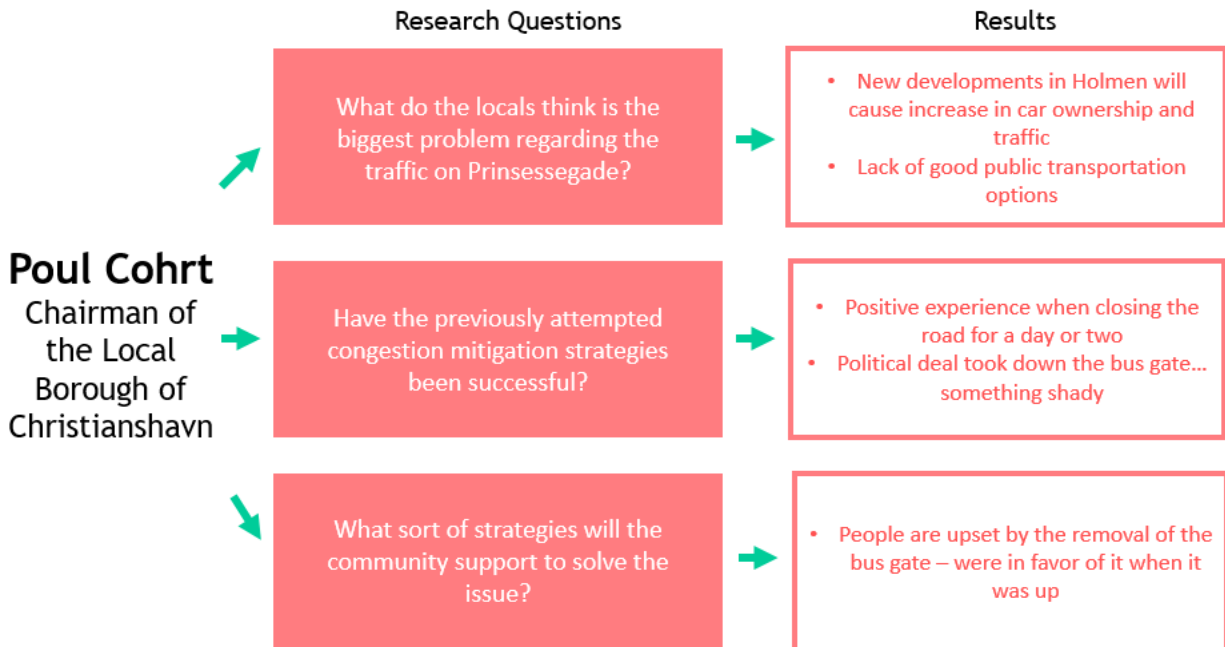


Figure 17: Results from the interview with Poul Cohrt

Anja Clausen

We interviewed Anja Clausen on March 29, 2017. This interview was conducted via phone call. Clausen is the school board chairman of Christianshavns Skole, an elementary school on Prinsessegade. We were provided her contact information by Erling Ekegren. She provided insight into the school's and the parents' perspectives on traffic congestion, emphasizing that the school board is concerned with the safety of children due to traffic congestion and air pollution. Results from the interview can be seen in Figure 18.

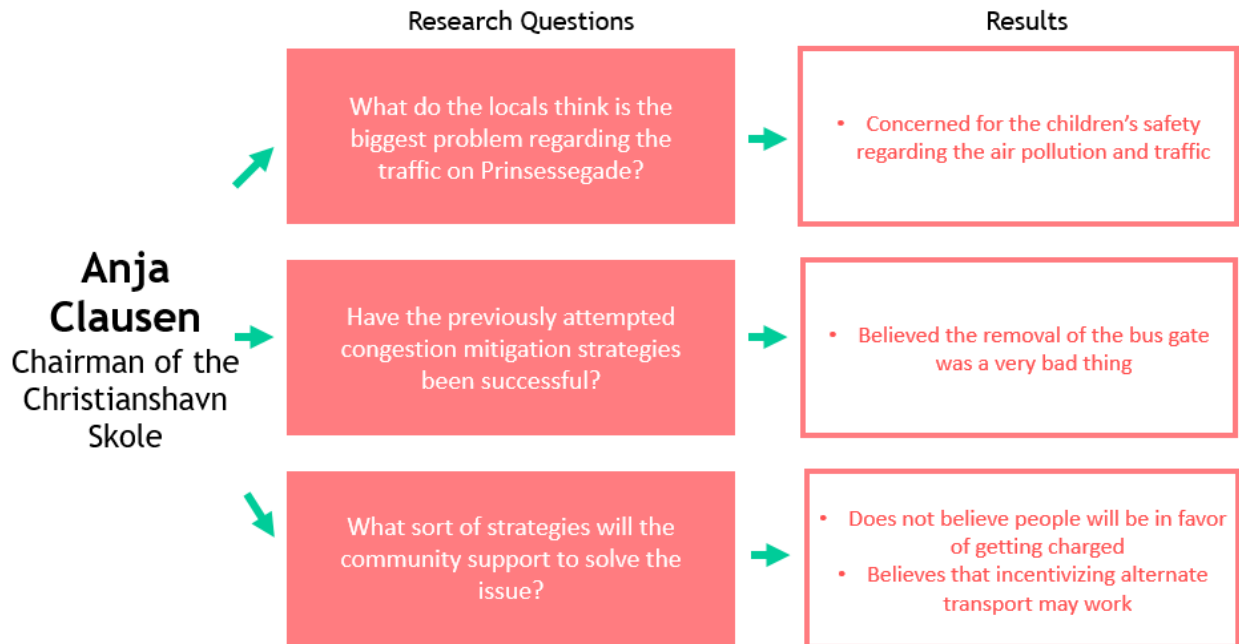


Figure 18: Results from the interview with Anja Clausen

Inge Hopps

We interviewed Inge Hopps, a resident who has lived on Prinsessegade for one and a half years to whom our sponsor introduced us, on 3 April 2017. This interview was conducted in person on Prinsessegade. Hopps is also a landscape architect, allowing her to understand and explain the logistics and infrastructure of the road. Hopps learned about our project via our sponsoring organization, Miljopunkt Indre By- Christianshavn, and reached out to us to provide insight. She identified several major problems with said infrastructure and related her personal account of the bus gate and the noticeable increase in traffic. Results from the interview can be seen in Figure 19.



Figure 19: Results from the interview with Inge Hopps

Kåre Press-Kristensen

We interviewed Kåre Press-Kristensen, a researcher from the Technical University of Denmark who published a report in 2014 entitled “Clean Air Copenhagen,” on 11 April 2017. We utilized this report in our early stages of research, and found Press-Kristensen’s contact information online. This interview was conducted via phone call. He spoke with us regarding his ideas for reducing car traffic in Copenhagen and how he estimated the predicted effectiveness of his proposed strategies. In addition, he provided valuable insight about politics in Denmark and why certain strategies have not already been implemented. Results from the interview can be seen in Figure 20.



Figure 20: Results from the interview with Kåre Press-Kristensen

Thomas Ellermann

We interviewed Thomas Ellermann, a professor and researcher from Aarhus University in the Department of Environmental Science who is involved in air pollution studies, on 24 March 2017. This interview was conducted via phone call. Unfortunately, he did not have the information we wanted regarding air pollution in Christianshavn, and was not very informed about the air pollution modeling that the university developed. He referred us to Steen Solvang Jensen for further questions.

Steen Solvang Jensen

We interviewed Steen Solvang Jensen, a professor and researcher from Aarhus University in the Department of Environmental Science on 3 April 2017. This interview was conducted via phone call. Mr. Jensen provided further information on how to approach air pollution science, measurements, and effects and explained that it would be impractical for us to estimate the air pollution effects of our proposed traffic strategies.

Andreas Massling

We interviewed Andreas Massling, a researcher from Aarhus University on 10 April 2017. This interview was conducted via Skype call. Unfortunately, the Skype connection was poor and he had limited information on the air quality monitoring systems.

Francesca Desmarais

Francesca is a student at the Copenhagen Institute for Interaction Design (CIID) who completed a project entitled 'Quick Fix' in 2014. This interview was conducted in person at CIID on 19 April 2017. This project developed a prototype of a program where cyclists would drop off their damaged bicycles in Metro stations, get a ticket and leave their bicycle to be fixed by a traveling mechanic while they are gone. This project was of interest to us because we would like to recommend more collaboration between the public transport company and bike users.

Movia representative

We spoke with a traffic planner from Movia on 29 March 2017. We were given the representative's name, but were asked to cite his information as "a Movia representative." This interview was conducted in person at the Movia main office. He provided a presentation on public transportation in Christianshavn. We gained valuable information from him about the public transportation in Christianshavn and obtained figures for ridership numbers for various types of transport in the area. Figure 21 shows the routes and stops of the Metro, the buses, and the harbor bus in Christianshavn.

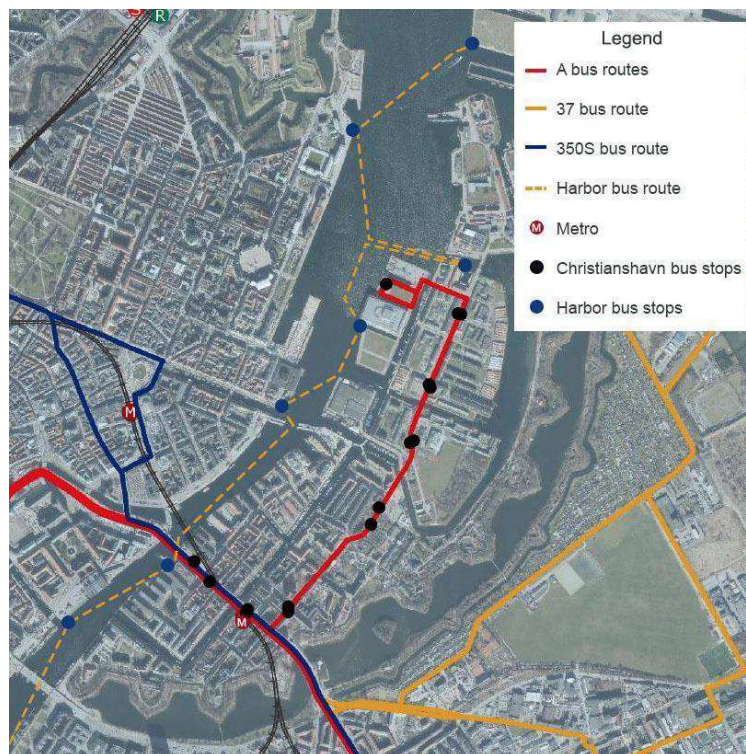


Figure 21: Map of Christianshavn public transportation (Movia, 2017)

In this area, the most and least frequently used modes of public transportation are the Metro and harbor bus, respectively. These usage patterns happen to correlate with the frequency at which each mode of transport runs. Table 6 shows the frequency of each mode of transport and estimates of how many passengers enter and exit each transport option at the Christianshavn stops.

Table 6: Public Transportation Frequencies and Ridership (Public Transport, 2017 and Movia representative, personal communication, 31 March 2017)

Mode of Transportation	Rush Hour Frequency (6-9 AM)	Non-rush Hour Frequency	Passengers per Weekday
Metro	2-4 minutes	3-6 minutes	~19,000
2A bus	3-7 minutes	10 minutes	~1,500
9A bus	3-7 minutes	10 minutes	~1,300
350S bus	5-10 minutes	20 minutes	~1,000
37 bus	5-10 minutes	20 minutes	~250
Harbor bus	40 minutes	40 minutes	~900

The 9A bus and the harbor bus are the only public transportation options to access northern Christianshavn. Of these two, the 9A bus is by far the more popular option. From data collected in November 2016, a high volume of traffic travels north on Prinsessegade during the morning rush hour, and a slightly higher volume travels south during the afternoon rush hour (Table 7) (Movia, 2017). This pattern may be attributable to several different factors; most notably, students attending one of several universities in northern Christianshavn may use the bus to commute to and from school in the morning and afternoon, respectively. Additionally, residents of northern Christianshavn might use the bus more frequently in the afternoon to return home after work (Movia representative, personal communication, 31 March 2017).

Table 7: Bus passenger movements during rush hour on Prinsessegade

Time	Bus passengers moving north up Prinsessegade	Bus passengers moving south down Prinsessegade
Morning (06.00-09.00)	521	275
Afternoon (15.00-18.00)	528	599

The bus lines accommodate expected increases in ridership during large events (such as popular shows at the Opera House) by mobilizing more buses with fewer stops between their starting point and the Opera House. Due to new developments currently under construction in northern Christianshavn, an increase in demand to enter the area is expected within the next five years. For this reason, Movia has extended the 9A bus line's route (which previously stopped at the Opera House as seen in Figure 23) into Amager (Movia representative, personal communication, 2017). The current 9A bus route and its extension are shown in Figure 22.

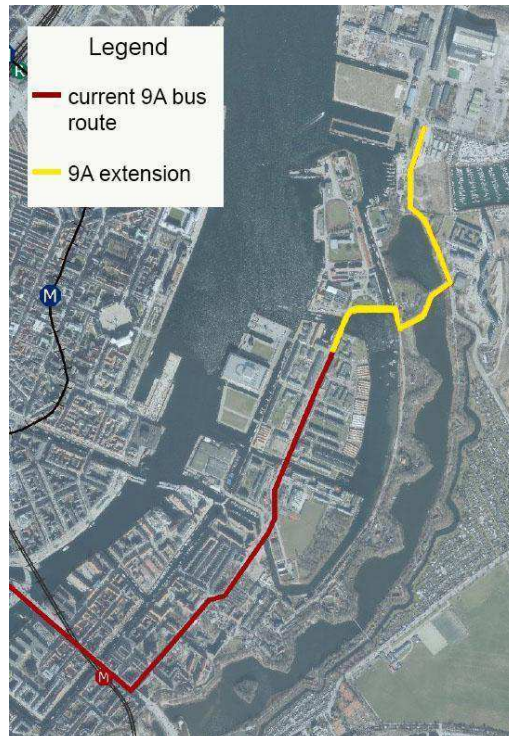


Figure 22: Extension route of 9A bus line

The harbor bus receives infrequent commuter traffic; a Movia representative told us about a previous study that determined that approximately one-third of the harbor bus users travel to work on the boat, while the other two-thirds consist of tourists and Copenhageners riding for leisure. (Movia representative, personal communication, 2017). Even though harbor buses neither contribute to nor suffer from any traffic congestion, they are still the least popular mode of transportation. Harbor buses also have higher purchase prices and operating fees than street buses, causing Movia to limit its fleet of boats to four (Movia representative, personal communication, 2017). Even with only four boats in operation, the harbor buses currently contribute a disproportionate amount of air pollution, emitting 15% of the NO_x and 65% of the particulate matter released by all of Movia's transportation (Wenande, 2017). However, by 2020, these heavily polluting harbor buses will be replaced with clean electric boats to cut harmful emissions (Wenande, 2017). This interview with Movia provided a lot of information in regards to the way that people travel throughout Christianshavn and on Prinsessegade.

Semi-structured interviews with business owners

We intended to conduct interviews with businesses to gauge the varying impacts that strategies could produce upon the establishments, as well as their interest in collaborating on strategies to remove cars from the road. Unfortunately, this approach proved quite unsuccessful. Many smaller, local companies had neither time to speak with us nor any interest in collaboration. Holms Bager, a company whose manager spoke with us briefly, stated that all employees bike to work and that they would be neither interested nor willing to participate in an incentive program. The manager stated that because all employees use bicycles rather than passenger cars, they have no need to improve their personal transportation. Additionally, we attempted to contact larger companies, including the marketing

department of Movia and the Opera House. However, we were unable to reach contacts from either organization.

Surveys with the public

To learn more about the individuals who travel on Prinsessegade and the surrounding area, we conducted surveys with 20 arbitrarily selected pedestrians at the Christianshavn square and along Prinsessegade. We received another 40 responses from the survey that was posted online on Miljøpunkt Indre By-Christianshavn's Facebook page. After organizing the survey responses and assessing the overall data, we analyzed the data with respect to the various demographic categories that would most likely influence a participant's answers to our questions: where he/she lives, if he/she has children, and his/her primary method of transportation. Of the participants who provided a response to Question 3, regarding their location of residence, 77% were residents of Christianshavn and 23% were non-residents (n = 56). In addition, of the respondents who answered question 5, which asked if they had children, 53% had children whereas 47% did not have children (n = 43).

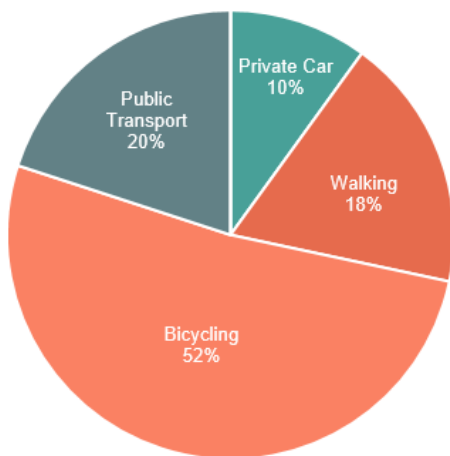


Figure 23: Pie chart of transportation use

We identified bicycling as the primary method of transportation for travelling in Christianshavn, with 52% of the 60 individuals whom we surveyed listing it as the main transport method in their daily lives (Figure 23). A chi-square test revealed that local residents and non-residents reported bicycling or walking as their primary mode of transportation in significantly different proportions (residents: 36 out of 43 respondents; non-residents: 5 out of 13 respondents; $\chi^2=11.7262$, $df=3$, $p=0.008382$).

Prior to conducting the surveys, we hypothesized that a participant with children would be more inclined to use private cars over other modes of transportation. To test this, we looked at the distribution of data relating a participant's primary mode of transportation and whether or not they have children, which can be shown in Figure 24. After performing a chi-square test, we concluded that there was no significant relationship between having children and a participant's primary method of transportation ($\chi^2=1.3317$, $df = 3$, $p=0.7216$).

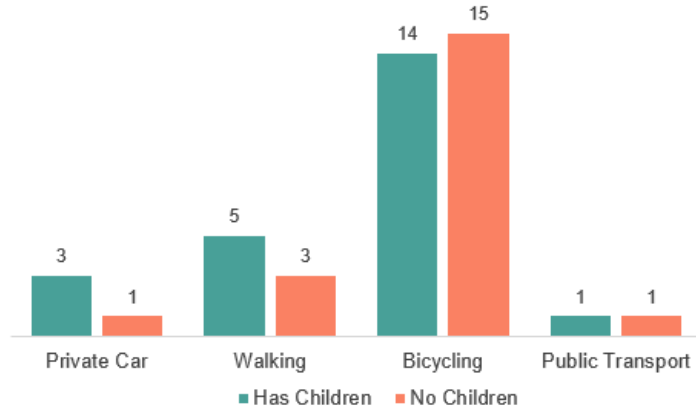


Figure 24: Primary method of transportation while traveling in Christianshavn for participants with children and participants without children

When we prompted individuals to explain (in free response) why they prefer a certain method of transportation, we received a variety of responses. We tallied the number of times that a participant had mentioned a concept from our predefined list (refer to the “Survey analysis” section in the Detailed Methodology) when explaining why they used a certain mode of transportation. The tallied counts for each subject mentioned is shown in Table 8. These counts represent the number of respondents that mentioned each of these concepts in their survey answers. From this data, we identified the top three common factors that influence an individual’s preferred method of travel: travel time, convenience, and cost.

Table 8: Number of survey responses regarding motivation for mode of transport

Why do you use this type of transportation?	
Faster	21
Distance	8
Environmental Reasons	6
Convenience	19
Exercise	9
Physical ability/limitations	2
Cost	12

In addition to asking about which modes of transportation were the most common, we also used the surveys to ask if participants had experienced traffic congestion on Prinsessegade. A total of 50 of the 60 survey participants reported that they had experienced congestion on the street. There were differences in responses depending on residency status, as 41 (95%) residents reported having experienced congestion, but only 7 (54%) non-residents reported having experienced congestion. We found that a majority of walkers and bicyclists had experienced traffic congestion on Prinsessegade: 10 out of 11 walkers and 30 out of 31 bicyclists reported affirmatively. The results of performing a chi-square test established statistical relationship between a participant’s place of residence and having experienced traffic congestion on Prinsessegade (residents: 41 out of 43 respondents, nonresidents: 7 out of 13 respondents, $\chi^2=14.0417$, $df=1$, $p=0.000179$).

For the 50 participants who reported having experienced traffic congestion on Prinsessegade, we examined their responses to Question 9 on our survey, which asked which times of the day that they were most likely to experience congestion: 18 responses had indicated heavy congestion occurred in the early morning (07.00 - 09.00) and 37 responses stated that traffic congestion was the worst in the late afternoon (15.00 - 17.00). These peak traffic times coincided with the rush hour time periods that we had previously identified in our research. When asked about the impact of traffic congestion on their daily commute, 60% of the 60 respondents reported that traffic congestion had a negative impact on their commute.

In order to determine if potential strategies would be well-received by the public, we asked the participants to rate potential strategies for reducing traffic congestion on Prinsessegade on a scale from 1 to 5, where “1” indicates a highly undesirable strategy and “5” indicates a highly desirable strategy . The average rating and its associated standard error for each strategy is shown in the Figure 25.

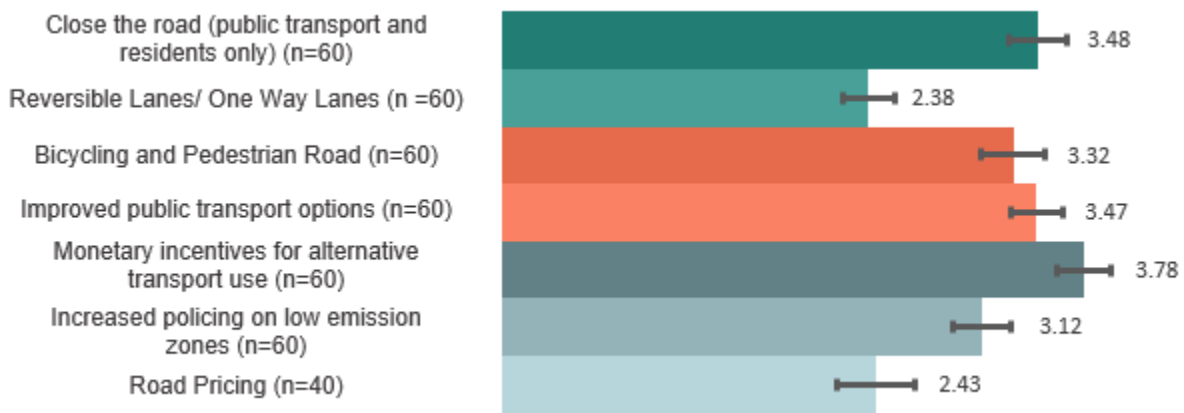


Figure 25: Average ratings for each potential strategy. Error bars indicate standard error.

The responses collected from our surveys identified strategies that might receive a favorable or unfavorable public perception. We asked participants to rate strategies on a Likert scale from 1 to 5 (1 being highly undesirable, 2 being undesirable, 3 being neutral, 4 being desirable, and 5 being highly desirable). In our methods, we had designated a scale to determine if a strategy would be considered to be well-received by the public:

- Negative public opinion - average rating ≤ 2.9
- Public opinion is neutral - $2.9 < \text{average rating} < 3.1$
- Positive public opinion - average rating ≥ 3.1

The highest rated strategy involved providing monetary incentives in order to encourage alternative transport, with an average rating of 3.78 ± 0.18 ($n = 60$). Since this strategy was rated higher than 3.1, we designated it as “likely to be well-received by the public,” along with closing the road to private vehicles, converting the road into a bicycle/pedestrian-only road, improving public transportation, and increased policing in low emission zones. The lowest rated strategy, with an average rating of 2.38 ± 0.17 ($n = 60$), was to convert Prinsessegade into a one-way street or have reversible lanes. Converting the road to have reversible lanes and road pricing, which were the two strategies with average ratings less than 2.9, were considered to have a negative public opinion in our evaluation.

We further analyzed this data by looking to see if the average ratings for each strategy for Christianshavn residents were significantly different than nonresidents. We calculated the average ratings for each strategy in addition to the standard error for both categories, which is shown in Figure 26.

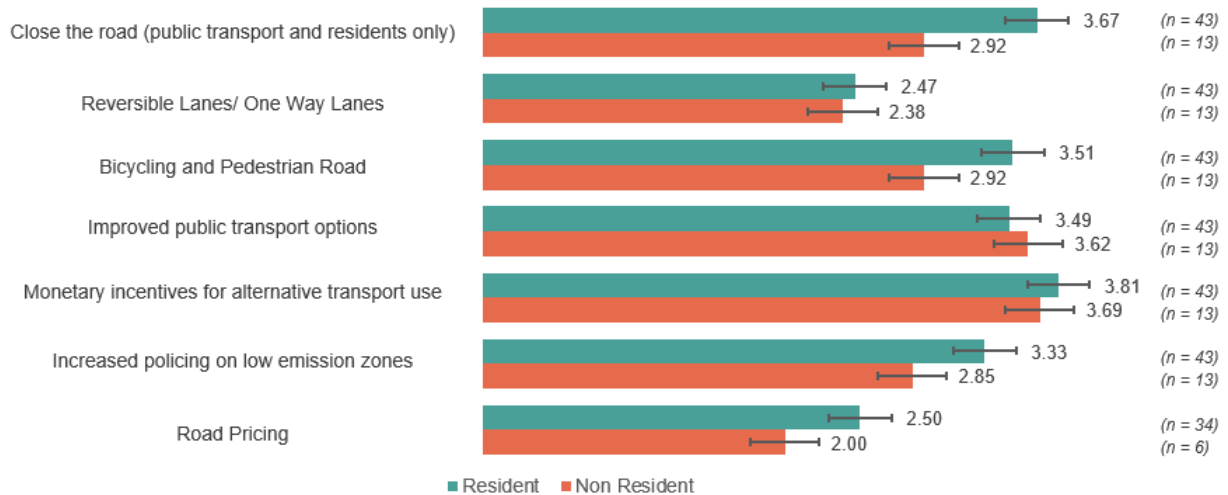


Figure 26: Average ratings of strategies for residents and nonresidents. Error bars indicate standard error bars

For both groups, improving public transport and providing monetary incentives for alternative means of travel were determined to have a positive public opinion. In contrast, both groups showed a negative public opinion for implementing reversible lanes and road pricing. As a whole, residents had a positive opinion regarding the two road closure strategies, either limiting travel to only public buses and residents or making the street only accessible to bicyclists and pedestrians, whereas nonresidents had a neutral opinion to these strategies. Increased policing for low emission zones had contrasting public opinions; residents appeared to favor the strategy whereas non-residents had a negative public opinion. Through our visual assessment of the column chart and seeing that there may be significant differences between ratings from residents and nonresidents, we hypothesized that that a participant’s place of residency had an influence on their opinion of certain strategies. We then performed a single factor

ANOVA for all strategy with the results in Table 9, finding that there was no statistical relationship between a participant’s residency and their opinion on the potential strategies.

Table 9: Results from ANOVA for ratings of all strategies between residents and nonresidents

Strategy	Sample size for residents	Sample size for non-residents	Degrees of Freedom (Df)	Mean Square (MS)	F-value	p-value	Statistically significant at p < 0.05?
Road closure	43	13	1	5.635	2.615	0.112	No
Reversible lanes/one-way road	43	13	1	0.0646	0.037	0.848	No
Bike/pedestrian road	43	13	1	3.458	1.337	0.253	No
Improve public transport	43	13	1	0.161	0.104	0.749	No
Monetary incentives for alternative transport	43	43	1	0.148	0.077	0.782	No
Increased policing	43	13	1	2.294	1.058	0.308	No
Road pricing	34	6	1	1.275	0.513	0.478	No

In addition to residency, we also believed that a participant’s opinion on particular strategies would be affected by whether or not they have children. To test this hypothesis, we separated the data regarding the ratings for strategies into two groups: respondents that had children and respondents that did not have children. After calculating the average ratings and standard error for each group, we constructed another column graph, shown in Figure 28, to perform a visual assessment for strategies that show a potential relationship between having children and how they perceive a particular strategy.

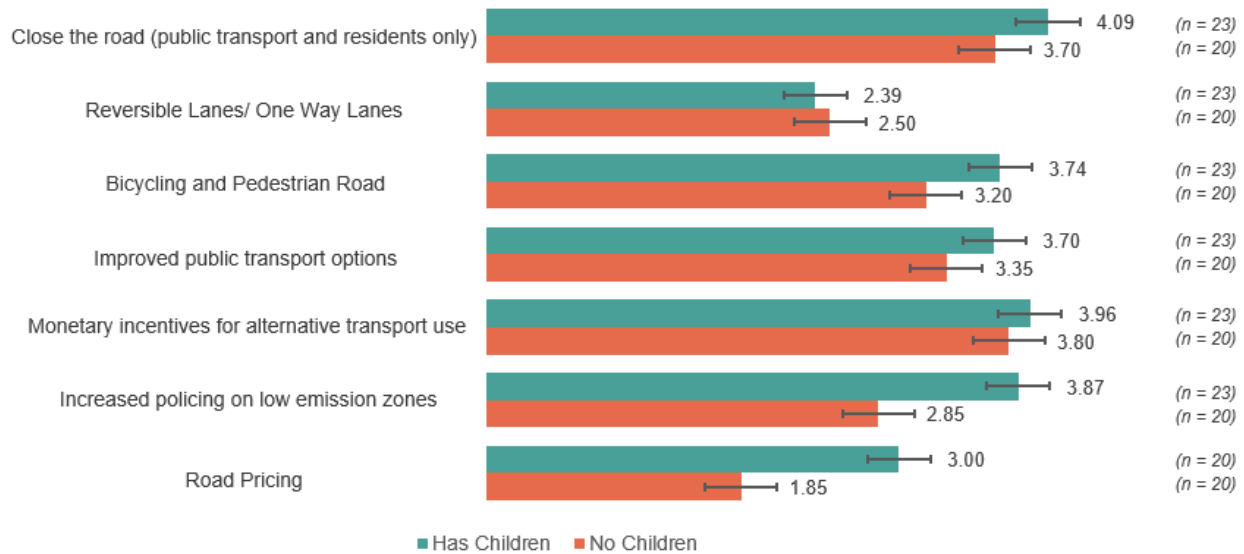


Figure 27: Average ratings of strategies for respondents with children and respondents without children. Error bars indicate standard error.

After calculating the average ratings for each group, we determined which strategies have a positive opinion or a negative opinion. We found that there was a positive opinion in both groups for solutions such as closing the road to allow only public transit and residents, converting the street to a bike-only road, improving public transportation, and providing monetary incentives. Regardless of whether or not a participant had children, the idea of implementing a reversible lane or making the street a one-way road was negatively received. For increased policing on low emission zones and road pricing, there were contrasting opinions; these strategies were well-received by respondents with children but appeared to be unfavorable to individuals without children. After our visual assessment of the column graph, we determined that there may be statistical differences for the rating of strategies between those who have children and those who do not. The results from performing an ANOVA for all strategies is shown in Table 10. Through our data analysis, we found that the data was not statistically different between participants with children and participants without children for the ratings on most strategies. We did, however, find that road pricing and increased policing on low emission zones were more favorable to individuals with children than individuals without children.

Table 10: Results from ANOVA for ratings of all strategies between participants with children and participants without children

Strategy	Sample size for those with children	Sample size for those without children	Degrees of Freedom (Df)	Mean Square (MS)	F-value	p-value	Statistically significant at p < 0.05?
Road closure	23	20	1	1.602	0.965	0.331	No
Reversible lanes/one-way road	23	20	1	0.126	0.080	0.778	No
Bike/pedestrian road	23	20	1	3.109	1.279	0.265	No
Improve public transport	23	20	1	1.278	0.882	0.353	No
Monetary incentives for alternative transport	23	20	1	0.262	0.153	0.698	No
Increased policing	23	20	1	11.120	5.618	0.023	Yes
Road pricing	20	20	1	13.225	6.088	0.018	Yes

In order to gauge whether or not a knowledge gap about air pollution and traffic exists in Christianshavn, we asked survey participants to rate the following statements from 1 (Strongly Disagree) to 5 (Strongly Agree) in our surveys:

1. **I believe that traffic congestion is a major contributor to air pollution.**
2. **Air pollution negatively impacts my health**

Overall, a large majority of respondents answered “strongly agree” or “agree” that air pollution negatively affects their health. Likewise, a large majority of participants answered “strongly agree” or “agree” that traffic congestion is a major contributor to air pollution. The responses for these two survey questions are shown in Figures 28 and 29.

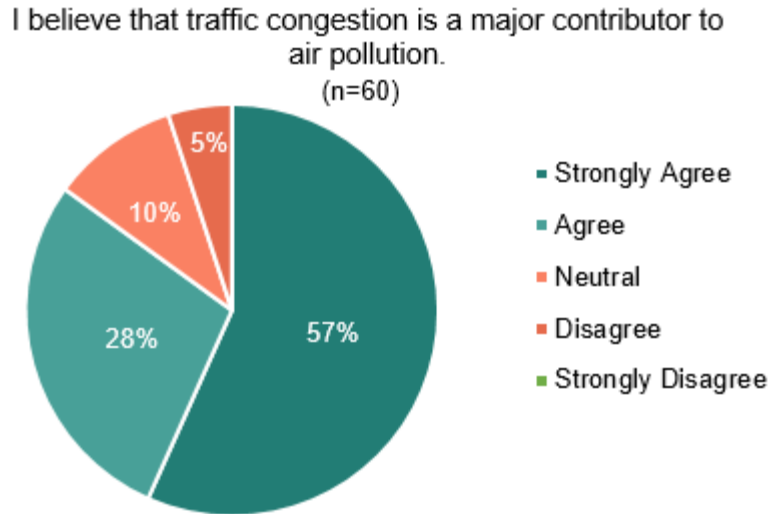


Figure 28: Pie chart representing participants' opinions on air pollution due to traffic congestion

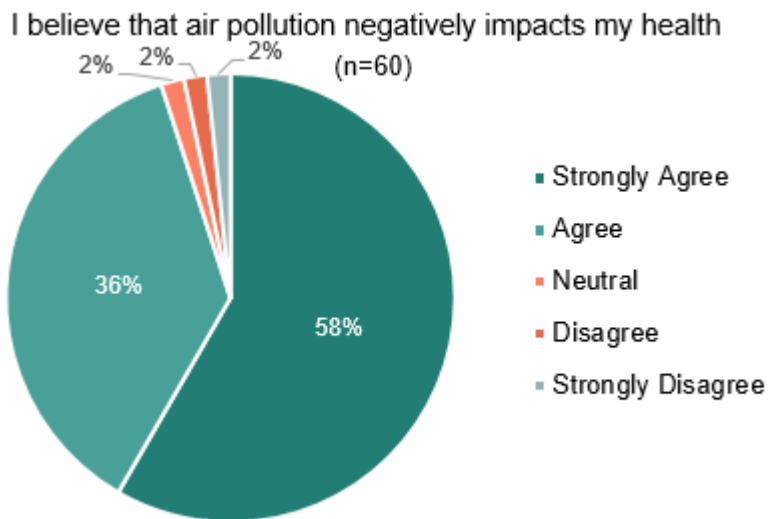


Figure 29: Pie chart representing participants' opinions on air pollution impacting their health

Open forum

A total of seven people attended our open forum, the majority of whom were Christianshavn locals. Our scheduled hour proved sufficient for a complete discussion among the Christianshavn community members. The forum allowed us to engage with the community on which traffic strategies might work most effectively in Christianshavn and which would receive the greatest public support. During the open forum, we received various comments from the attendees about both our proposed traffic strategies and new ideas to further consider. The comments included both pros and cons of each strategy, and attendees discussed the details of their preferred strategies. Figures 30 and 31 respectively show our initial presentation at the open forum and the community discussion.



Figure 30: Presenting the Prezi



Figure 31: Engaging the community through discussion of traffic strategies

Though the seven individuals who participated in our open forum are unlikely to represent a random sample of the neighborhood, the forum provided valuable insight into the thoughts of the Christianshavn community regarding our proposed traffic solutions. The discussion also inspired new ideas of traffic strategies that could potentially prove effective on Prinsessegade. We used this feedback to form our final recommendations about traffic strategies to Miljøpunkt Indre By-Christianshavn. One of the main goals we intended to achieve through our open forum was to gauge a broader community opinion on our proposed strategies after we had narrowed them down. We were only able to achieve this through an open forum, which clearly demonstrated conflicting opinions and encouraged an open

discussion where individuals could naturally stimulate the ideas of their peers. Additionally, we wanted to identify what other strategies the Christianshavn community had considered, as the bus gate is the only strategy we had found significant information on through our other methods. In analyzing our data, we noticed that stricter policy engaged the conversation and provided more feedback than the other three solution groups and that community outreach provided the least amount of feedback. The research question that the open forum answered was “What does the Christianshavn community think of our proposed solutions?” This question was answered by forum’s provided information on road closure, stricter policy, alternate transport, and community outreach. The results of this analysis are exhibited below in Table 11.

Table 11: Summary and analysis of open forum

Road Closure		Stricter Policy	
Positive Feedback	Negative Feedback	Positive Feedback	Negative Feedback
<ul style="list-style-type: none"> ● Introduce the bus gate before the canal ● Would force people to use the alternate route 	<ul style="list-style-type: none"> ● Government removed the bus gate and is not in favor of it ● Closing the road entirely restricts access to residents ● Road closure might result in the need for a bridge to northern Christianshavn 	<ul style="list-style-type: none"> ● Environmental zones should only allow Euro 6 standards ● The environmental zone might work from Torvegade to canal ● Restrict vehicles that are non-electric from the street at various times ● Prevent buses and trucks from idling 	<ul style="list-style-type: none"> ● It might be harder to make more car restrictions due to the new developments ● Low emission zones need to be passed by Parliament
Alternate Transport		Community Outreach	
Positive Feedback	Negative Feedback	Positive Feedback	Negative Feedback
<ul style="list-style-type: none"> ● Focus on green mobility (walking, buses, biking) ● Incentivization for people who let others borrow their car/carshare programs ● Bonus for getting rid of your car and switching to alternate transport 	N/A	<ul style="list-style-type: none"> ● TV ads and public service announcements (PSAs) could be used ● It will work if people have a will to learn about the issue of traffic and air pollution 	<ul style="list-style-type: none"> ● Education might not be the best or easiest way to make people change their behavior

Discussion of Strategies

After we collected data from our observation, surveys, interviews, and open forum, we synthesized the following assessments for each strategy. Table 12 is a summary of our process of assessment for each strategy, including a short discussion of each strategy, which links our above findings with our final recommendations. Following the table is a more detailed analysis of each of our proposed strategies.

Table 12: Summary of Elimination of Strategies

Solution	Objective 1: technical evaluation	Objective 2: evaluation of public and expert opinion	Discussion	Outcome
Green Wave	X	-	There is a lack of need for traffic management.	Eliminated
Road Closure	✓	✓	We observed considerable foot and bike traffic as well as support from residents. We also identified a viable alternate route for through traffic.	Potential solution
Improving public transport	✓	X	Interviewees did not see a necessity and it was not feasible to implement.	Eliminated
Incentivizing alternate modes of transport	✓	✓	Many survey participants expressed interest in cheaper forms of public transit, and the existing bike culture could be encouraged further.	Potential solution
Reversible lanes	✓	X	Interviewees were confused by the concept, and there is a lack of a need for traffic management.	Eliminated
Education	✓	✓	After surveys, shifted more toward campaigning and public outreach. Would complement other strategies to encourage improved habits and less car use.	Potential solution
Stricter policies regarding air pollution	✓	✓	Open forum revealed that there are many possibilities for different forms of policy that could be effective on Prinsessegade, however it will require more support from the Danish government.	Potential solution
Road pricing	✓	✓	Another form of stricter policy, which has seen success in other cities such as London. Researcher Press-Kristensen estimates it would provide a significant drop in road traffic. However, it will also require more support from the government.	Potential solution

1. Green Wave

The Green Wave initiative is used for large volumes of traffic. This initiative times traffic light cycles to allow multiple cars in one direction through several intersections in a row without being stopped by a red light. Prinsessegade has three intersections, but since the traffic on Prinsessegade does not significantly accumulate between multiple traffic lights, the Green Wave would not affect the traffic on the street with a meaningful impact. For this reason, after our observations, we eliminated the Green Wave initiative as a possible traffic strategy for Prinsessegade.

2. Road closure

Closing Prinsessegade to all traffic except bicycles and pedestrians (a bicycle road) or residents and public transportation (a bus gate road) would prove an effective way to remove a large number of private cars from the street. This strategy passed the informal observation method and received consideration in our survey. Once we established the existence of a considerable amount of foot and bike traffic on this road, we felt that it would be reasonable to close it to through traffic or to cars entirely. This strategy gathered the strongest support from parents with children, as fewer cars on the road would provide more safety to their children. However, the majority of survey participants, including parents, bicyclists, and pedestrians, considered closing the road a favorable strategy. However, a road closure strategy for Prinsessegade would have significant drawbacks, specifically regarding the need for an emergency vehicle route and the existence of alternative routes for through traffic to reach the northern end of Christianshavn. Although road closure contained flaws, we continued to survey the community on the strategy and included it in our open forum discussion. In the open forum, our attendees provided more information on where the bus gate was previously located and suggested moving it closer to Torvegade to more properly address the street's traffic buildup, as shown in Figure 32. They also indicated a sufficient alternative route (Kløvermarksvej) around Christianshavn, which would still allow vehicles to easily access northern Amager if Prinsessegade closes.

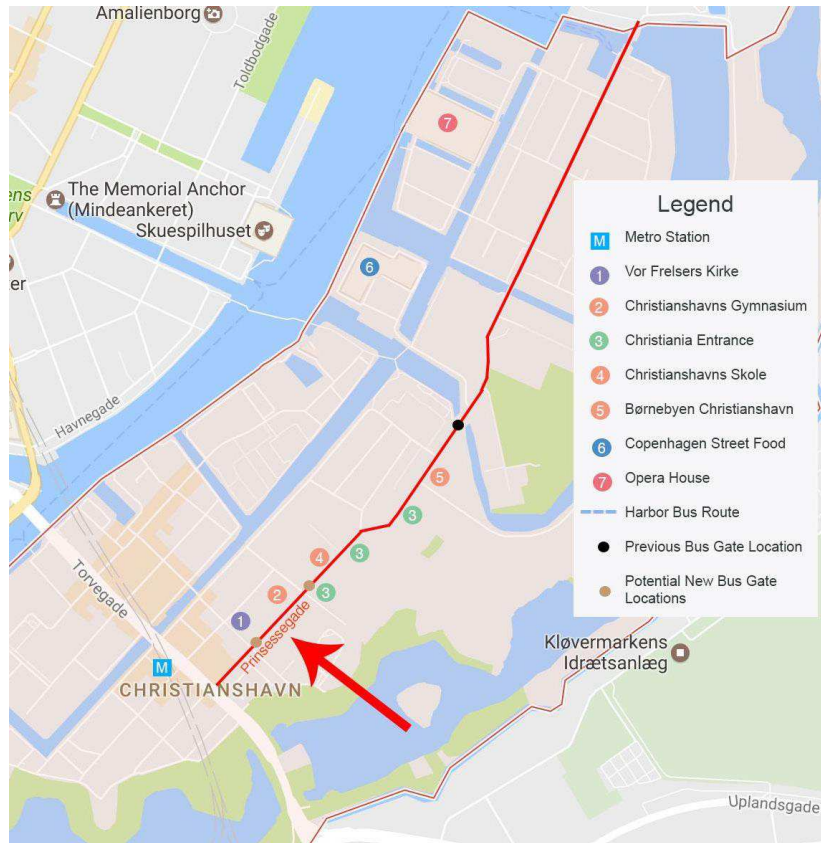


Figure 32: Christianshavn map with bus gate locations (Google Maps, 2017)

3. Improving public transportation options

Based on our observations of Christianshavn, we believed a lack of public transportation to northern Amager contributed to Prinsessegade’s traffic issues, with only the 9A bus and the harbor bus serving as public transportation options to reach the area. Of the two, the 9A bus is more frequently utilized to reach northern Christianshavn. We believed that the idea of a new Metro or train station for northern Christianshavn would pique the interest of the public, so we added this consideration for our public surveys. Interestingly, our survey participants generally reported that they are content with the current public transportation infrastructure. In addition, our interview with a Movia representative revealed that the only current plan to improve public transportation in Christianshavn is an extension of the 9A bus line into northern Amager to account for the new developments in the area; the representative also emphasized the high expense of constructing a new train or Metro station in the area. Based on this feedback, improvements to the public transportation options in Christianshavn are most likely infeasible and unnecessary at this time. However, as we conducted surveys primarily in southern Christianshavn, we could not predict whether commuters travelling to northern Amager would provide contradicting feedback. In addition, we cannot anticipate the degree to which the developments in northern Amager may create an increased need for public transit, and how opinions of transportation options will change as this area becomes more populated. We proceeded to present this information at the open forum. However, the conversation generally focused on creating greener transport options such as electric buses, and as such this topic received limited discussion time and lacked further input.

4. Incentivizing alternative modes of transportation

The focus of our traffic strategies was to reduce the number of cars using Prinsessegade and encourage users of the road to seek alternative modes of transportation, such as public transportation, bicycling, and walking. Our informal observations have exposed an existing bike culture in Christianshavn, especially with the new pedestrian and bicycle bridge that connects Nyhavn and Paper Island. For this reason, we believed that it is possible to encourage more people in the area to use alternative modes of transport. We considered this strategy further in our surveys of local residents of Christianshavn. Additionally, our survey results revealed that many people would like to make public transportation cheaper, and doing so might encourage them to use public transportation more often.

There is also the possibility of incentivizing people who normally bicycle to use public transportation rather than a private car when their bicycle is in the repair shop or if they chose not to use their bicycle for other reasons (e.g weather, distance, etc). For example, bicyclers could receive a free or reduced public transportation pass when their bicycle needs repairs. Another possibility would be to work with businesses, targeting Christianshavn companies who can provide incentives for their employees to bike or take public transport to work. Similar programs exist in Nashville, TN, Seattle, Washington, and Austin, Texas (University of Wisconsin, 2014). We considered this strategy for our open forum but the conversation focused more on other topics rather than incentives for transit.

5. Reversible lanes

In order to mitigate traffic congestion, reversible lanes require a large unidirectional stream of traffic during certain times of the day. The bus traffic data from Movia does not show a significant difference between the number of bus commuters traveling north as compared to south on the road during both rush hours, as detailed in Table 2 in the semi-structured interview section with a Movia representative. While this data is only provided for bus passengers, we have no reason to assume the pattern would deviate for private cars. We also witnessed a roughly equal number of cars travelling in each direction on Prinsessegade during our informal observations. Additionally, the road only has two lanes, one in each direction. This increases the logistical challenge of implementing reversible lanes, which are more often applied to much larger roads with numerous lanes. Although our observations exposed multiple drawbacks to this strategy, we nonetheless included it for our interviews and surveys to gain more information about public opinion and expert insights. From our survey results, many participants deemed a reversible lane road as confusing and likely to cause more accidents without significantly relieving traffic congestion. As such, we eliminated reversible lanes as one of the proposed traffic solutions for our open forum.

6. Public Outreach and Campaigning

We asked interviewees two air pollution and traffic-related questions in order to gauge their knowledge on the dangers of air pollution and measures of preventing it. We believed that better public knowledge about the damaging effects of air pollution could potentially convince and motivate individuals to seek alternative modes of transportation. However, after conducting our surveys, no significant knowledge gap about air pollution and traffic congestion appeared. We still introduced this strategy in our open forum after analyzing our surveys to confirm our initial conclusion, and skepticism

arose during the proceedings regarding the strategy's effectiveness as an independent strategy to traffic congestion. The open forum discussions concluded that community outreach and campaigns would provide a better approach to what we had originally categorized as education. Increasing awareness of the problems caused by traffic congestion as well as any strategies proposed to improve the problem would be the most effective form of engagement with the community.

7. Road pricing

Our research pointed out that toll roads may require sufficient space for a toll booth (Santos et al., 2006) and our observations of the infrastructure revealed the narrow width of Prinsessegade. While the limited space renders the construction of full toll booths impossible, different types of toll roads could potentially work effectively on Prinsessegade, such as the London strategy where cars entering the tolled zones are tracked with cameras and then later charged (Santos et al., 2006). Since methods to implement tolls exist without requiring toll booths, we did not eliminate road pricing as an option and included it in surveys and interviews. However, from expert interviews, we learned that past political backlash against road pricing in Copenhagen will likely increase Parliament's reservations about passing this strategy. Unfortunately, our open forum the conversation largely centered on our "stricter policies" strategy, and road pricing therefore did not receive as much positive feedback as other policing strategies.

8. Stricter policies regarding air pollution

Copenhagen currently only enforces low emission zones for large diesel trucks and buses, requiring all of these vehicles to comply with Euro 4 standards, as described in "The problem with air pollution in Copenhagen" section of the supplemental background. However, passenger vehicles have no such obligations to comply with the same regulations. One potential traffic strategy to mitigate air pollution is to expand the traffic zone regulations to include passenger cars. Adding passenger cars to the regulations would discourage more people from driving into the city center, therefore eliminating the traffic on Prinsessegade. While we could not assess this strategy based exclusively on informal observations, we included this strategy for review in our surveys and interviews. We learned from expert interviews that the Danish Parliament is not in favor of stricter low emission zones and that this type of legislature is unlikely to pass in Copenhagen for the foreseeable future. We also discussed this strategy at our open forum, where the attending citizens responded well to the idea and suggested other, non-traditional versions of the policy to consider. For instance, one proposed alternative involves creating a limited traffic zone specifically for heavy vehicles (e.g., large trucks), allowing only electric delivery trucks on Prinsessegade during certain hours.

References

- ACEA. (2017). Euro standards. Retrieved from <http://www.acea.be/industry-topics/tag/category/euro-standards>
- Airparif. (2010). *Pollution*. Retrieved from <http://www.airparif.asso.fr/>
- Beevers, S. D., & Carslaw, D. C. (2005). The impact of congestion charging on vehicle emissions in London. *Atmospheric Environment*, 39(1), 1-5. doi:10.1016/j.atmosenv.2004.10.001
- Berg, B. L., & Lune, H. (2012). *Qualitative research methods for the social sciences* (8th ed.). Boston: Pearson.
- Berg, J. (2003). Dissatisfaction with the bus gate. Retrieved from <http://jyllands-posten.dk/indland/kbh/ECE3393551/Utilfredshed-med-busslusen/>
- Bujak-Pietrek, S., Mikołajczyk, U., Kamińska, I., Cieślak, M., & Szadkowska-Stańczyk, I. (2016). Exposure to diesel exhaust fumes in the context of exposure to ultrafine particles. *International Journal of Occupational Medicine and Environmental Health*, 29(4), 667-682. doi:10.13075/ijom.1896.00693
- Caiazzo, F., Ashok, A., Waitz, I. A., Yim, S. H. L., & Barrett, S. R. H. (2013). Air pollution and early deaths in the United States. Part I: Quantifying the impact of major sectors in 2005. *Atmospheric Environment*, 79, 198-208. doi:10.1016/j.atmosenv.2013.05.081
- Cesaroni, G., Boogaard, H., Jonkers, S., Porta, D., Badaloni, C., Cattani, G., . . . Hoek, G. (2012). Health benefits of traffic-related air pollution reduction in different socioeconomic groups: The effect of low-emission zoning in Rome. *Occupational and Environmental Medicine*, 69(2), 133-139. doi:10.1136/oem.2010.063750
- Chazan, D. (2016). France announces 'clean sticker' anti-pollution measures as cities choke on smog. *Telegraph.Co.Uk*. Retrieved from <http://search.proquest.com/docview/1847924213>
- CPH Post (2013). Panel wants car owners to pay to drive. *The Copenhagen Post*. Retrieved from <http://cphpost.dk/news/national/panel-wants-car-owners-to-pay-to-drive.html>
- Cross, Tony. (2016). FRANCE - Paris to close seine right bank to traffic despite unfavourable report. Rfi Retrieved from <http://en.rfi.fr/environment/20160824-paris-close-seine-right-bank-traffic-despite-unfavourable-report>
- Das, D., & Jingzhong, Y. (2011). Christianshavn -- history, traditions, culture in Denmark's capital. *Xinhua English.news.cn*. Retrieved from http://news.xinhuanet.com/english2010/culture/2011-07/17/c_13989961.htm
- Ellerman, T., Nygaard, J., Nojgaard, J. K., Nordstrom, C., Brandt, J., Christensen, J., ... Jensen, S. S. (2016). The Danish air quality monitoring program. Aarhus University, Department of Environmental Science. Retrieved from <http://dce2.au.dk/pub/SR201.pdf>
- European Environmental Agency. (2016). *Air quality in Europe*. Luxembourg: Publications Office of the European Union.
- Falocchchio, J. C. (2016). *Road traffic congestion: a concise guide*. Switzerland: Springer International Publishing. doi:10.1007/978-3-319-15165-6
- Francisco, V., & Schultz, J. (2017). Conducting public forums and listening sessions. Retrieved from <http://ctb.ku.edu/en/table-of-contents/assessment/assessing-community-needs->

- and-resources/conduct-public-forums/main
- Friedman, M. S., Powell, K. E., Hutwagner, L., Graham, L. M., & Teague, W. G. (2001). Impact of changes in transportation and commuting behaviors during the 1996 Summer Olympic Games in Atlanta on air quality and childhood asthma. *Jama*, *285*(7), 897-905. doi:10.1001/jama.285.7.897
- Goldstone, M. E. (2015). Review of evidence on health aspects of air pollution - REVIHAAP project. *Air Quality and Climate Change*, *49*(2), 35-41. Retrieved from <http://search.informit.com.au/documentSummary;dn=351123840805252;res=IELNZC>
- Google Maps. (2017). *Prinsessegade, Copenhagen, Denmark*. Retrieved February 17, 2017 from <https://www.google.com/maps/place/Prinsessegade,+K%C3%B8benhavn+K,+Denmark/@55.6724007,12.5942314,17z/data=!4m5!3m4!1s0x4652533bdf7e65cd:0x6c20d1e0adaaf9f8!8m2!3d55.6734038!4d12.5959576>
- Gréco, B. (2016). EXCLUSIVE. Paris: The real impact of the pedestrianization of roads on banks. Retrieved from <http://www.lejdd.fr/JDD-Paris/EXCLUSIF-Paris-l-impact-reel-de-la-pietonnisation-des-voies-sur-berges-812212>
- Havnebusserne. (2015). Retrieved from <http://www.aok.dk/byliv/havnebusserne>
- Hoets, H. (2017). How to analyze focus group results. Retrieved from <http://www.focusgrouptips.com/focus-group-results.html>
- Javid, M.A., Okamura, T., Nakamura, F., Tanaka, S., & Wang, R. (2016). People's behavioral intentions towards public transport in lahore: Role of situational constraints, mobility restrictions and incentives. *KSCE Journal of Civil Engineering*, *20*(1), 401. doi:10.1007/s12205-015-1123-4
- Karagulian, F., Belis, C. A., Dora, C. F. C., Prüss-Ustün, A. M., Bonjour, S., Adair-Rohani, H., & Amann, M. (2015). Contributions to cities' ambient particulate matter (PM): A systematic review of local source contributions at global level. *Atmospheric Environment*, *120*, 475-483. doi:10.1016/j.atmosenv.2015.08.087
- Kenagy, H. S., Lin, C., Wu, H., & Heal, M. R. (2016). Greater nitrogen dioxide concentrations at child versus adult breathing heights close to urban main road kerbside. *Air Quality, Atmosphere & Health*, *9*(6), 589-595. doi:10.1007/s11869-015-0370-3
- Kurt, O., Zhang, J., & Pinkerton, K. (2016). Pulmonary health effects of air pollution. *Current Opinion in Pulmonary Medicine*, *22*(2), 138-143. doi:10.1097/MCP.0000000000000248
- Langrish, J. P., Bosson, J., Unosson, J., Muala, A., Newby, D. E., Mills, N. L., . . . Sandström, T. (2012). Cardiovascular effects of particulate air pollution exposure: Time course and underlying mechanisms. *Journal of Internal Medicine*, *272*(3), 224-239. doi:10.1111/j.1365-2796.2012.02566.
- Levin, D. (2012). Big road blues. Retrieved from <http://now.tufts.edu/articles/big-road-blues-pollution-highways>
- Ling.Tutorial: Pearson's chi-square test for independence. Retrieved from <http://www.ling.upenn.edu/~clight/chisquared.htm>
- Lund, J. (2015). Princess street - the scandal in Christianshavn. Retrieved from <https://www.cityavisen.dk/prinsessegade-skandalen-paa-christianshavn/>
- Miljøpunkt Indre By-Christianshavn. (2016). *Measurements of ultrafine particles at selected*

- locations in the Inner City and Christianshavn*. Retrieved from <http://a21.dk/wp-content/uploads/2016/11/M%C3%A5linger-af-ultrafine-partikler-p%C3%A5-udvalgte-lokaliteter-i-Indre-By-og-p%C3%A5-Christianshavn-2016.pdf>
- Press-Kristensen, K. (2014). *Clean air Copenhagen*. Copenhagen, Denmark: Danish Ecological Society. Retrieved from http://www.cleanair-europe.org/fileadmin/user_upload/redaktion/downloads/The_Danish_Ecocouncil/Clean_air_CP_H_2014_UK.pdf
- Raheem, S. B., Olawoore, W. A., Olagunju, D. P., & Adeokun, E. M. *The cause, effect and possible solution to traffic congestion on Nigeria road (A case study of basorun-akobo road, oyo state)*
- Rao, M., George, L. A., Rosenstiel, T. N., Shandas, V., & Dinno, A. (2014). Assessing the relationship among urban trees, nitrogen dioxide, and respiratory health. *Environmental Pollution*, 194, 96-104. doi:10.1016/j.envpol.2014.07.011
- Ravndal, K. (2016). Notorious bus gate closed down - now you can run directly from Christianshavn holmen. Politiken. Retrieved from <http://politiken.dk/ibyen/byliv/art5615954/Berygtet-bussluse-nedl%C3%A6gges-nu-kan-du-k%C3%B8re-direkte-fra-Christianshavn-til-Holmen>
- Reşitoğlu, İ. A., Altinişik, K., & Keskin, A. (2015). The pollutant emissions from diesel-engine vehicles and exhaust aftertreatment systems. *Clean Technologies and Environmental Policy*, 17(1), 15-27. doi:10.1007/s10098-014-0793-9
- Rychla, L. (2016). *Copenhagen getting ready for car free Sunday*. The Copenhagen Post. Retrieved from <http://cphpost.dk/news/copenhagen-getting-ready-for-car-free-sunday.html>
- Sætterstrom, B., Kruse, M., Brønnum-Hansen, H., Bønløkke, J. H., Meulengracht Flachs, E., & Sørensen, J. (2012). A method to assess the potential effects of air pollution mitigation on healthcare costs. *Journal of Environmental and Public Health*, 2012, 935825-10. doi:10.1155/2012/935825
- Santos, G., Fraser, G., & Newbery, D. (2006). Road pricing: Lessons from London. *Economic Policy*, 21(46), 263-310. doi:10.1111/j.1468-0327.2006.00159.x
- Silberstein, J., & Maser, C. (2014). *Land-use planning for sustainable development* (2. ed.). Boca Raton, Fla. [u.a.]: CRC Press.
- Stepanian, C. M., Ong, F. N., Mendez, L. M., Khurana, S. (2015). *Assessing Traffic and Air Quality in Central Copenhagen*. Worcester, MA: Worcester Polytechnic Institute. Retrieved from https://web.wpi.edu/Pubs/E-project/Available/E-project-050115-163910/unrestricted/Traffic_and_Air_Quality_in_Central_Copenhagen.pdf
- Technical and Environmental Administration. (2014). *Better mobility in Copenhagen*. Copenhagen, Denmark
- Thøgersen, J., & Møller, B. (2008). Breaking car use habits: The effectiveness of a free one-month travelcard. *Transportation*, 35(3), 329-345. doi:10.1007/s11116-008-9160-1
- Trepanier, T., Jones, G., Demidovich, M., Nederveld, L. A., Abbo, T. S., Pillsbury, M., & Acutanza, J. (2011). *Best practices in maximizing traffic flow on existing highway facilities*. Lawrenceville, NJ: Arora and Associates, P.C. Retrieved from http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-68A_08-02.pdf

- University of Wisconsin. (2014). Individual incentives for public transportation. Retrieved from <http://whatworksforhealth.wisc.edu/program.php?t1=109&t2=126&t3=128&id=550>
- Vendelbjerg, R. R. (2016). *Measurement: So pure was the air of Copenhagen to the car-free Sunday*. Retrieved from <http://www.mx.dk/nyheder/kobenhavn/story/27868525>
- Vos, Marieke. (2014). Don't stop for red traffic lights, use green-wave technology. *The Epoch Times*. Retrieved from <http://www.theepochtimes.com/n3/677539-dont-stop-for-red-traffic-lights-use-green-wave-technology/>
- W, C. (2017). Green harbor buses to cleanly connect copenhagen. CPH Post Online. Retrieved from <http://cphpost.dk/news/green-harbour-buses-to-cleanly-connect-copenhagen.html>
- Weaver, R. (2016). *Air quality in Copenhagen slammed in letter from EU*. Retrieved from <http://cphpost.dk/news/air-quality-in-copenhagen-slammed-in-letter-from-eu.html>
- Weiss, M., Bonnel, P., Kühlwein, J., Provenza, A., Lambrecht, U., Alessandrini, S., . . . Sculati, M.(2012). Will euro 6 reduce the NOx emissions of new diesel cars? – insights from on-road tests with portable emissions measurement systems (PEMS). *Atmospheric Environment*, 62, 657-665. doi:10.1016/j.atmosenv.2012.08.056
- Wenande, C. (2017, April 3,). Green harbor buses to cleanly connect copenhagen. CPH Post Online Retrieved from <http://cphpost.dk/news/green-harbour-buses-to-cleanly-connect-copenhagen.html>
- Wichmann, J., Folke, F., Torp-Pedersen, C., Lippert, F., Ketzel, M., Ellermann, T., & Loft, S. (2013). Out-of-hospital cardiac arrests and outdoor air pollution exposure in Copenhagen,Denmark*PLoS ONE*, 8(1), e53684. doi:10.1371/journal.pone.0053684
- Wu, S., Deng, F., Wei, H., Huang, J., Wang, H., Shima, M., . . . Guo, X. (2012). Chemical constituents of ambient particulate air pollution and biomarkers of inflammation, coagulation and homocysteine in healthy adults: A prospective panel study. *Particle and Fibre Toxicology*, 9(1), 49. doi:10.1186/1743-8977-9-49
- Yolo Commute (2017). Retrieved 20 March 2017, from <http://www.yolocommute.org/>
- Yuval, Flicstein, B., & Broday, D. M. (2008). The impact of a forced reduction in traffic volumes on urban air pollution. *Atmospheric Environment*, 42(3), 428-440. doi:10.1016/j.atmosenv.2007.09.066
- Zhang, K., & Batterman, S. (2013). Air pollution and health risks due to vehicle traffic. *Science of the Total Environment*, 450–451, 307-316. doi:10.1016/j.scitotenv.2013.01.074

Appendix

Appendix A: Interview Transcripts

Anja Clausen (A) Interview

April 4, 2017 – 20.00

Attendees: Emily Matsco (E), Yao Long (Y)

Research Questions:

1. What do the locals think is the biggest problem regarding the traffic on Prinsessegade?
2. Have the previously attempted congestion mitigation strategies (bus gate) reduced Prinsessegade's daily traffic congestion?
3. What is the community willing to do to solve this problem/ what would the community be in support of?

A Det' Anja?

E Hi, Ms. Clausen?

A Yes! Hello!

E Hello, this is Emily. I emailed you about our project; we're the students from the U.S.

A Yes.

E So I was just wondering if you had a couple minutes to answer some questions and if you were okay with recording this phone call so we could use some of this information in our final report.

A Yes. I'm not that good at English, but I'll try my best.

E Okay, thank you so much! So, just to go over, our project is on road congestion – too many cars on the same road at the same time – and we're working with Miljøpunkt Indre-By, the environmental group in the area, to try to come up with solutions to mitigate some of this traffic congestion on Prinsessegade specifically.

A Yes.

E So, some of the things we have been researching have been the health effects attached to air pollution and the air pollution that is caused by this type of traffic congestion and so many cars being on the road at the same time. So, just a couple of the questions we have [are] specifically about the school because we have researched that children can be more susceptible to the health effects due to air pollution, and that that can affect them a little bit more. So, is this a concern of the school board and school community, all of the traffic that uses the road?

A Are we concerned about the pollution?

E The pollution and just the traffic in general; how many cars use Prinsessegade.

A Yes, we are concerned about it.

[adjust phone to improve connection and speak more slowly]

E So, for parents dropping off their children at school, do you think they usually use cars or more bikes and walking to get their children to school?

A Yes, they are [biking/walking]. But it's also because it's really hard to find a parking space around the school, so mostly the parents are biking or walking here.

E Okay. And then, do you think that the congestion – the cars – make it unsafe for kids walking around near the school? Is that a concern?

A Yeah, it's a very big concern.

E Okay. And then, we've also been researching some past solution to all of the cars, and we found some information about a bus gate that was removed last March, I believe. And before that, only buses and residents could get through, but that ended. What were your thoughts on the bus gate removal? Did you think it was a good thing or a bad thing?

A Oh, it's a very bad thing!

E [laughs] Any specific reason you thought it was a bad thing?

A Yes, it's a bad thing because there are more cars in Prinsessegade now, so there's more pollution and more traffic. And it's more dangerous for the kids to walk.

E Other things we were wondering [were if] parents or the school board would consider participating in events such as "Bike Your Kids to School Day" or some other event. We know that the organization that we're working with sponsored some Car Free Days, if that is something the school board would be interested in participating in, possibly in the future.

A Yes, yes. Yes we would.

E Okay. And we have researched other solutions, more long-term solutions to how many cars use the street. Some of the things we've come up with [are] incentives for public transport, or just improving public transport in that area. Do you think that would be a good solution/

A Say it again, sorry?

E No worries. Just improved public transport or even providing some rewards for people who use public transportation a lot. Do you think that would be a successful solution in this area to getting people to stop using cars so much?

A That could be a perfectly good solution.

E Yeah. And another thing we researched was converting the road to a pedestrian or bike road, or even possibly charging people to use the road. How do you feel about either of those solutions, having people pay to use Prinsessegade or just having pedestrians and bikes allowed on the road?

A Charging people, I think it would be very difficult to do. That would be a new thing in Denmark and I don't think there would be [much support for it].

E Yeah.

A Yeah, we could try it! [laughs] But I don't think it would be preferable. But it's a good idea!

E Okay. I think those were all of our questions. Do you have any other contacts, possibly within the local community or the school board that you think might be useful for us to reach out to about this?

A Yeah. Can I send you them via email?

E Yes!

A I'll send you the name and the phone number.

E That would be perfect!

A Yup! I will do that.
E Great. Thank you so much!
A Yes. Thanks for calling, and good luck!
E Yeah, we really appreciate your time.
A Okay. Thank you!
E Bye!

Erling Ekegren (EE) Interview

March 22, 2017 – 14.00

Attendees: Nicole Luiz (NL), Emilee Gancarz (EG), Emily Matsco (EM), Yao Long (YL), Ian Vossoughi (IV)

Research Questions:

1. What do the locals think is the biggest problem regarding the traffic on Prinsessegade?
2. Have the previously attempted congestion mitigation strategies (bus gate) been successful?
3. What challenges does the local committee face when suggesting solutions?

NL ...Just to make sure we don't miss anything [laugh]
EM Yup. So, Marianne told us you were a part of the local committee in the area?
EE Sorry?
EM Do you work with the local committee in the area?
EE Yeah.
EM Yeah, and just kind of what your role is in that group, and what you've done in [unintelligible]
EE It's divided in working groups, and we have one working group on the committee working on town planning, traffic, and the harbor.
NL Okay.
EE And I'm chairman of that group.
EM Okay, great. And then, how does the committee work with the community and are the general residents of the area involved a lot in that planning?
EE Yeah, yeah. It's only locals living in Christianshavn.
EM Okay. And then you live in the area?
EE Yeah.
EM Okay. That's good to know. And then, she – Marianne – also talked about a website that might be a good way to get a survey out to people in the area, to gauge how they are using Prinsessegade.
EE Yeah, we do. A panel, you know?
EM Yeah.
EE Yeah. So we make a lot of surveys about different subjects.
EM Okay. Is there any way we would potentially be able post a survey on that website?
EE I'm not sure, I'm not sure. Because you know it costs money.
All Oh.
NL No, okay, that's completely fine.
EE And I'm not quite sure. We don't have that subject at the moment. It's not an issue at the moment, Prinsessegade.

EM Okay.

EE But maybe it will be, you never know, because next week, on this Friday, the Municipality of Copenhagen, will have a big [analysis] about the traffic problems on this part of Christianshavn, on Prinsessegade, and they will congregate on this Friday. So we will gather from Friday and have a meeting on Monday to have a discussion [of] what we will do about it. And maybe we will do something about it involving much more people. Get the answer, so it has to be discussed, I think on this Friday we will ?know it?, on Wednesday next week, not this week but next week, there will be a meeting in the Municipality to have a discussion on that one. But I don't think they will make any decisions; it's just another discussion on the background of it.

NL Right, right. It's just a discussion.

EE So we're quite interested in what will happen, what will be in it.

EM [laugh] Will those be publicly released, or...?

EE Yeah, you can get it.

EM Okay, that would be wonderful.

EE But it is in Danish.

EM Oh yeah, we could translate it.

NL Yeah, we got resources.

EE Oh yeah, very nice. You can do that. You can just ask Marianne where to get it. She will know exactly where to get it on the internet. It will be on the internet on Friday.

EM Okay. Wonderful, that's really good to know.

NL Do you have anything else?

EM No, I think that was it to start.

NL Okay. So, we were also wondering about how, like your opinion on how the traffic congestion is on the street. I know you said you have that meeting, but do you have any thoughts on what the main source of the problem is? We know there's a lot of schools in the areas, also a lot of events that are happening, and what is causing the buildup on the road itself?

EE Really, there's a lot of problems.

NL [laugh]

EE So, everything is wrong. That's something.

NL [laugh]

EE Because also Christiania, and the schools, and the tourists, and the tourist buses, and the taxis, everything! Pollution, too much traffic, and the schools, and the [unintelligible]... everything is wrong.

All [laugh]

EE But we don't know how to make a solution.

NL Right.

EE Because there's only one street, and that's that street going out there. And they're going to develop a lot of new activities out on the side of Christiania, what we call Holmen. That's the next part. That would be in a lot of development in 2021, 22, and we know plans and things are going very fast now. So there will be much more traffic. And what do we have to do? So we had some ideas about shuttling ferries in the harbor.

NL We're interested in that, yeah.

EE We have asked about that. And also, a tunnel, maybe, maybe have some more bridges?

NL Yeah, to the island.

EE From the outside, you know, from the inner part of Copenhagen to this part of

NL Christianshavn.

EE Yeah, yeah. Maybe. But we haven't managed to suggest this yet. Because it will be very important in 4 years from now, but you know the plans.

NL Yes.

EE So we have to work on that stuff.

NL Right. Does it appear that a lot of the people living in this area have a private vehicle?

EE Some have. But there's a lot of bicycles. People go on bicycles and you see it everywhere. Many people have a car ?to spend much more? a smaller car.

NL Right.

EE Maybe they go to... especially families with children. Because they want to take their children to kindergarten, and maybe to schools, and then when they're tired.

NL Mm-hm.

EE Because some of the families are living quite some kilometers away from the inner part of Christianshavn. On the far northern part of the island.

NL Okay.

EE So that's a reason to buy them, because public transportation is really bad to go to the school, go to the theater.

NL Yeah, we noticed that. It's very limited in this area.

EE It's really limited. You can go by Metro, but if you don't live near the Metro station, what to do? Especially when it's cold, and windy, and snow, and you know?

NL Yeah. Do they have any ideas of adding any more public transportation and any plans for that?

EE Yeah, we had some plans for some small buses, you know, instead going different ways. But that's only one bus now. But the responses going from first of April, we managed to get him to go directly to those areas where people live, where the families live. They didn't do that before, they stopped by the Opera before. And know from the first of April, you can go up.

NL This is the 9A, right?

EE 9A, yeah. It could get a new name.

NL Okay. Interesting, interesting.

EE It's so it can go to the kindergarten with the bus, and they can go to the school, and they can go to the Metro station, with the bus.

EM And we did read the road closing

NL Yeah, we know that the road had closed in the past. It was closed to just the buses.

EE Yeah yeah, it was for the buses.

NL Do you have any more information on what happened there and how come it reopened?

EE They reopened it, ?and? there's a lot of rumors, you know.

NL [laugh]

EE But nobody has any...

EM [unintelligible]

EE No, they said that it was [unintelligible]... it was some kind of ... deal.

NL [laugh]

EE Between the politicians. But they don't tell us.

NL Well, when the road was closed, were people in Christianshavn, were they happy about that?

EE They were happy about that. But there were still a lot of problems. It didn't solve ALL their problems.

NL Right.

IV Yeah.

NL What sort of problems did you still face?

EE As I told you, with the buses and people going to buy hashes and they're driving, and parking in front of Christiania. Taxis going there.

NL So even when the road was closed, they could still access that part of it?

EE Yeah yeah, that was no problem. It's the same. It didn't influence that one. But it influenced, you know, we have the schools further out? The architect school for example. A lot of young people they have further out there, in order to have them. And the area with a lot of music and entertainment, called Refshalevej further out. And nobody lives there, it's only for a period, you know, you can use the old buildings for many kinds of activities. And those people and people going to the opera, they had to go in another way by car. But they could go by bus or by bicycle. And people start to go to the opera by bicycle instead of by car.

NL That's good.

EE So, I don't think it would change a lot. But still, we wanted to have it closed again. But you know, we don't know what kind of deal it is.

NL Right.

EM And then, some of the solutions we talked about as a group after researching, we talked about road tolls, congestion charging, things like that. Kind of being stricter with the Low Emission Zones. Also, the green wave, with the traffic lights? I didn't know if there were a lot of traffic lights on Prinsessegade. We were going to go kind of look there afterward also. But if the traffic patterns could somehow allow for more traffic to go through at once so it doesn't get backed up? We don't know if you had any opinions about that, or if the local committee talked about that type of thing before.

EE A lot of times.

EM Yeah. [All laugh] That's what I figured.

EE You know, there's some people more active in this field than I am. For example, the school board. It could be a very good idea to talk to them. And also there is an organization called "The Neighbors of Christiania." And one who's more active is the chairman of the local sports club for Christianshavn's ?middle? school, and he is called Dan Sorensen, he's a very nice guy. And he's very active in that accord, because the sports club is very close to that corner of Christiania, CIK it's called.

EM Yeah, we saw that when Marianne came.

EE So, he could be very nice because they're more active and know all about what they've tried and discussed with the police. And one of the problems is that the police want to go very fast, so they don't want to make too much... what do you call... barriers on the road. Because you know that would be a really strong struggle with the police, or fights with the police about all this money connected to the [unintelligible] blocks.

NL So the police want access to make sure they can get in and out quickly?

EE Quickly, yeah.

NL Okay.

EE That is one of the problems.

NL One of the many. [laughs]

EE Yeah. And then he tried to make the taxis to stop in a special place outside Christiania, so they don't stand in the middle of the road and block the street of Prinsessegade, but they don't do it! No, and we say the police come and give them a bill, but 5 minutes after there will be somebody else. Because there's so much money in this drug dealing, and the taxis get a lot of money for transportation of the drugs. All day long.

EM And do you think the general public understands the severe health effects that traffic creates?

EE Really, they do. They do. They do.

EM They just don't care?

EE And also they're aware of the problem of Torvegade's biggest pollution problem. On the main street. And there's a plan to make a renovation of that street.

NL In what ways?

EE Only to make it more convenient for bicycles and pedestrians and to put the buses in the middle.

NL Hmm.

EE And only have a few cars to go. Very difficult for the cars to go through. We think it was a good idea to take money to drive on Torvegade over from Amager, maybe. Get them out of the way. But there's a long discussion on how we can do that.

All Right.

EE We don't have any talk because the government is against it. They're not allowed to make the car drivers and cars pay for driving in the city. You could make a... what do you call it in English?

NL A "zone?"

EE A zone, and you have to pay to drive into that zone. They do it in Stockholm, they do it in many other places.

IV Yeah, we read about that.

EE But they will not do it, not allowed [in Copenhagen]. We have a very little government, and they will do everything for the cars.

NL They don't want to do any tolls or road pricing?

EE No road pricing.

NL Interesting.

EM That's really good to know.

EE And that's a government decision. It's not the local. It's the nation argument.

IV And the local has no power over that?

EE No no.

NL [laughs]

EE You know, most of the people in government or in Parliament are people elected in Jutland. It's not from Zealand, [it's] from the mainland.

NL Oh.

EE Because we have this kind of system. All parts of the country should elect some mandates to Parliament, so that's the reason that we call it the Party of the Juts – people from Jutland. And they decide they want cars, motorways.

IV Hmm.

NL So do you think that a method that could potentially help is just trying to incentivize people to use public transit more? Or maybe just bike more in this area? How could we convince people not to have a private vehicle?

EE Yeah, I know that. [laughs] You know, they're so interested in going by bicycle. Everybody does, and we'd like very much to make better conditions for biking. As part of the example we also have **problems with parking with the bicycles.** You go out here and see everywhere you can find bicycles in the streets, and **you can't nearly pass because there's bikes everywhere.** Especially if you're handicapped or if you have a child, where can you go? Because there's bicycles everywhere. That's a problem. But you have to find out where to put them. New areas for it. They have done it very well in one of the Metro stations, Nørreport. Maybe you have seen it.

NL Yeah.

EE It's quite nice. But you know, it's a small area here. Maybe we should have plans to do it over there. We would like them to get away from the streets, get away so we can park. Because people just throw them everywhere! People on bicycles can just walk maybe 2 meters, that's enough for them! [laughs] Ask them to walk 50 meters and they get angry.

All [laughs]

EE That's too much!

NL Too funny.

EE It's really, REALLY crazy.

NL Well, we were wondering, I know you said you had some more contacts, maybe some other people we could talk to, even in the local committee, too.

EE Yeah, and also in the local committee, you know, the director of the Cycling Foundation of the whole country, he's also in the local committee.

NL Oh, really? What's his name?

EE And his name is Jens Loft Rasmussen.

NL [laughs]

EE You should talk to him too, that would be nice.

YL Could you repeat that?

NL [laughs] Could you spell his last name?

YL Yeah.

EE [Uncaps pen] I think, as an example, they are good people. [writes "Jens Loft Rasmussen" on paper] Jens. Loft. Rasmussen.

YL Oh!

EE And, Dan Sorensen from the local sports club. Because he's very active. [writes name on paper] For the Neighbors of Christiania... [writes "Julius Lund" on paper]

YL Oh, Julius Lund!

EE Yeah. I think they're good. And also, we have another [administrator]. She has been working on that topic for 20 years, at least!

All Wow.

EE Jane Lythhans. [writes name on paper] [Caps pen] Very good names for you. You can have a talk with them. And they can tell you more specifics and more details about the problems of Prinsessegade.

NL And is there any way, I know we talked potentially about the survey and the website. How else would we figure out more information about how to get questions to the general public of Christianshavn?

EE Just walk in the streets!

All [laughs]

EM Do you think people would respond well?

EE Yeah, they would! They're very nice. Because some students from another university, not a Danish university, made a big survey, "What Do People Want on this Local Community," about development on one of the islands. So they were just taking a wagon, and put it out here. They were standing here and stopping people and made a survey, and they answered them.

NL And it worked well?

EE It worked very well.

NL Okay.

EE People are very open, and a lot of people speak English.

NL Good, good. We were wanting to do some street surveys.

EE You can do very good on streets. It's best to do it on streets, I think. And then, the school board, I didn't mention. I don't know the name of the school board. And also, for the high school board. The high school headmaster; there's no board in the high school. But there's a parent board in the primary school. And they also are a neighbor to Prinsessegade. And you can see all the high school students. They are not allowed to smoke outside, so they are just standing outside, hundreds of them, on their break, and... [motions with an "air cigarette"] having a cigarette in the street.

All [laughs]

EE And you can see all their bikes standing on the fence of the church. It's nearly impossible to walk through, because they put all their bikes there.

NL True.

EE So they go on bike.

NL So they need more bike parking too?

EE Yeah, yeah, we need it also, bike parking.

NL Do you think if Prinsessegade itself were made into a bike/pedestrian road, or something along those lines...?

EE Yeah, someday it will be.

NL [laughs]

EE We have been working for that. Some of those people are still active here. I haven't been living here for so many years, but some of them have been living for more than 20 years, or their whole life. And they have been working on those plans for at least 20, maybe 25 years. And they think nothing will happen. But you know, small steps.

NL Yes, of course.

EE It's not too easy.

NL Absolutely... all right. So do you guys have any thoughts from things we heard; any questions?

All ...no, nothing really.

EE But there's no motorbikes and no scooters. Nearly, nearly! The weather's just too cold.

NL Yes! [laughs] It's cold right now.

EE [laughs] A little warm one day, and then ice!

NL Yeah, the weather changes a lot. It was raining what, 15 minutes ago?

EE Two minutes ago.

NL And now it's sunny again! [laughs] ...Oh, I actually do have—

EE It could be very interesting to see what could be the results of your work, if you have ANY good ideas, it could be very nice.

NL Yeah, we'll have some time to think about it.

EE Yeah, you have to think about it.

NL One other question I had. We found on the website that there was a study/focus group done in 2013 with residents and different ideas about how to calm the traffic on Prinsessegade. And there were some different ideas about potentially closing different side streets. Do you know if anything came of that particular study?

EE You know... that created some ideas. For example on the traffic lights in the middle of the streets now. You know, by the corner of Christiania. That's very new. That was one of the ideas.

NL Okay.

EE And there's also an idea to stop traffic from going past the church. So when you go from here [Torvegade] to Prinsessegade, you're not allowed to go left to go beside the church. Or if you come from outside Christiania, and you want to turn beside the church. One of the reasons we stopped that was because some of the drug dealing, which was happening in Christiania, they were driving very fast from Christiania. Before they get to Torvegade, on Prinsessegade, they turn to the right. And then they went nearly down to what we call Strandgade and then turn to the left. So it was kind of a shock for them, and they were driving fast.

NL And so that has been stopped?

EE That was the reason why it was shut down there. So they're not allowed to drive through there. Now we have to [teach] the people on bicycles not to go out to Torvegade when they go from Prinsessegade. The best for them is really to turn right at the church and then continue over the small bridge and down to the next street called Strandgade, and then turn to the left by the Ministry of Foreign Affairs. That could be a good idea instead of going out here.

NL There is, I saw a bike bridge.

EE That's a horrible place over there.

NL Right, on the bridge.

EE But they don't do it. I don't know why. There should be some sign, "Bicycles, please go to the right here, if you go to the Inner City." That could be a good idea for you, but it's complicated. Small things.

NL Just trying to reroute them, so they're not trying to interrupt?

EE Yeah. And then they will do it, I think. They used to go this direction and I was like, "Okay!"

NL [laughs]

EE You can it's like, red flags. You know, it's just sitting here and are thinking. And I think... for those meetings, there must be some notes somewhere in our [unintelligible] there must be something.

All [laughs]

NL We found part of that study. I believe that's what you're talking about.

EE Yeah, some of the ideas there. It's not too easy to have good ideas.

EM No, it's not!

EE Not so easy. And also we want to put cars into Christiania, make a parking spot. On the farthest corner of Prinsessegade, because it's not owned by Christiania; it's the only place they don't own themselves. It's run by the Municipality of Copenhagen. But they're not interested because some people have moved into the area, built small homes, and now live there. So they had to throw those people away to make a parking spot, to get the cars away from Prinsessegade.

NL Is there any charging for parking on Prinsessegade?

EE All of the town. But if you are a resident and you live in the area, you can have nearly free parking. It's pretty cheap. You pay an amount every year, a small amount. But if you are a customer or guest, you have to pay every hour. It's quite expensive. I think it is!

NL [laughs]

EE Well, maybe. It changes every year.

EM Are there any ride-share or carpool programs in the area where people can carpool together to the schools, or things like that?

EE No, I think the distance is too small for the locals to go local. It's mostly if you want to go 20 km in that direction. NL Right.

EE I haven't heard of anything like that. But there's a lot of cars where you can pay to use it for one hour or two.

NL Like car shares?

EE Not like car shares. It's owned by companies; it's not owned by private. So you pay for the car. And there are special parking plots where they are standing, those cars. And it's only electrical cars.

EM Oh, nice! That's good.

NL And are there a lot of businesses and commuters in the area, or is it mostly residential?

EE I think at the moment we have 12 thousand persons living altogether in the whole area, in the whole part of Copenhagen. And I think we have 14 thousand working places. So the amount must be quite a lot of commuters. But we have just started asking people how many commuters are there and where are they coming from? Maybe 4 thousand of those working places are locals; maybe it's less. But if we have 14 thousand there are a lot of commuters. And they're working on business, banking, and public government.

NL Are a lot of those buildings around here?

EE Yeah, a lot of the buildings around here everywhere. It's a lot of administration.

NL Okay, that's good to know. Because that's probably something we were asking in our surveys, where they're coming from or if they're commuting.

EE Yeah. But you know, the drug dealers and the drug people there, some of them are local, I think.

NL [laughs]

EE And some of them are coming from elsewhere. You could ask them; maybe they would tell you!

[laughs]

NL We'll see! [laughs]

EE You go to Pusher Street, and make an interview there. And then they'll tell you!

All [laughs]
NL Now, I thought private vehicles weren't allowed in Christiania.
EE Yeah, they're not allowed to have private vehicles, but they have a lot of cars and stuff, and they're parked outside in the streets. I don't think they're allowed inside the area, but you can see them everywhere in the streets. They have their own cars.
NL Okay. So they have their cars and they park them out here and they go in?
EE Yeah. They don't want to have cars inside Christiania, but they want to have a car and park it outside. Right outside.
NL Interesting. [laughs]
EE So they will not answer any questions from you.
NL Yeah, they want to keep their cars out!
EE You could make a survey, "How many cars do they own in Christiania?"
NL And how much they're affecting the problem out here? It'd be interesting to know.
All [laughs]
NL Well, you've been very helpful. Thank you so much.
EE I hope you can use some of it.
EM Oh, absolutely! And those contacts will be great.
EE You can continue to have discussions with a lot of people, but you'll have to be fast. And you know, there's Easter next month; people are leaving!
NL Gotta get them before that.
EM We're hoping to start street interviews next week.
EE Really, by the 9th or 10th of April. You will have a problem after that. Maybe a little in the late of April, but best to do it now. The next two weeks are very important
NL Yeah, our plan is to get as many interviews in the next couple of weeks as possible.
EE Yeah, do that. That would be a very good idea.
NL Okay, I think we're good. Thank you very much! It's been a pleasure speaking with you
EE You're welcome! Same, same. I hope you can use it!
NL Absolutely. We'll let you know if we have any followup questions.
EE Just call me.
NL Will do.

Inge Hopps

April 3, 2017

In-person interview on the sidewalk of Prinsessegade

Research Questions:

1. What do the locals think is the biggest problem regarding the traffic on Prinsessegade?
2. Have the previously attempted congestion mitigation strategies (bus gate) reduced Prinsessegade's daily traffic congestion?
3. What is the community willing to do to solve this problem/ what would the community be in support of?
4. Evaluate our strategies to change traffic behavior in Copenhagen

- She has lived here for a year and a half
- Used to live in Amager
- Landscape Architect
- Keeps herself updated
- Does not own a car
 - She bikes because it is easier, faster, and she gets some exercise
 - She beats the buses sometimes
- Weird street- A lot of foot traffic confusion about where one should be on the street
- Taxis line up on weekends which causes problems specifically with the bus
 - Half parked on the road, half parked in the bike lane (general pain in the ass)
 - A lot of comings and goings and tourists
 - Two really poorly designed intersections with weird light placement... poor infrastructure
 - Culmination of people cause traffic
- Worst time is around 16.00 or 17.00 on weekdays and weekends during the evening
- Yao: What about parents dropping kids off?
 - Very local schools, assumes children walk themselves or are dropped off by bike
- Is the community aware of health effects:
 - It's been in the news a lot recently
 - However, not focused on Christianshavn or that community specifically as much
 - It's been focused around the lakes, that is where the most people are aware
- Bus gate
 - Hasn't affected her personally because she rides a bike but it definitely increased car traffic, which she is not a fan of
 - Access to the up and coming area up north. Impossible to get to, and needs the access
 - In general, she doesn't like more car traffic
- Solutions:
 - a. Road closure
 - i. Well received by people in Christianshavn, lots of concern about developments. Sounds tricky for people trying to get home
 - ii. Thinks it's a good idea, but maybe not for people outside Christianshavn
 - b. Bike road or pedestrian road
 - i. Might be really good for the neighborhood, but doesn't know how else the traffic would be dealt with and where it would go if the road was closed
 - c. Road pricing
 - i. Thinks it could work
 - ii. The government tried to implement a city ring, however, the party got a lot of opposition and then they weren't able to and now they have gotten a lot of backlash and it never was put in
 - iii. She supports it, though
 - d. Incentivize public transport

- i. If they were to close the road, it would have to be paired with incentives for public transport.
- ii. People do see it as costly, so a decreased price would help
- iii. In general, businesses might be wary, a lot of people think of public transport as the government's responsibility and they shouldn't have to help

Kåre Press-Kristensen (K) Interview

April 11, 2017 – 14.00

Attendees: Nicole Luiz (N)

Research Questions:

1. What is the best method to evaluate our strategies and make conclusions about the success of our proposed solutions?
2. What challenges exist when trying to propose solutions to air pollution?
3. What are some good strategies to change traffic behavior in Copenhagen?

N First, I want to ask if it's all right if we record the interview just so we can refer back to it, just so we can use it later.

K Yeah, sure!

N Thank you so much! So, we can tell you a little about our solutions, but first do you mind if I ask you just a couple logistic questions about some of the things in your Clean Air Copenhagen?

K Nope!

N Okay! [laughs] So we noticed in the Clean Air Copenhagen report that there had been estimates about how much pollution would be reduced by implementing road pricing or emission zones, and we were curious about how you were able to come up with this data.

K Yeah. Well [as for] the data, there was a table called Table 7 in the Danish version of the publication, where I try to sum up how large a share of the pollution originates from different kinds of vehicles, like heavy duty vehicles, passenger cars, taxis, vans, and so on. And when you introduce congestion charge, it doesn't affect the business traffic very much, like vans and ?dories? and trucks and buses, because they just pass on the costs to their customers. So if I had a company in town and I had a truck going to and from that company, my customers would just pay a little bit more if there were a congestion charge. And some of the customers would probably save the money because there would be more free space for parking, so they wouldn't have to spend so much time finding some place to park my car or my truck. And when I need to deliver something it might be easier to find a place to stop. But in reality it doesn't really affect the business because they will just pass on the cost. So the only category we have left that will have an effect is passenger cars. And then you can say, "Okay! How large a share of the different pollutants like PM10 and PM2.5 and NO2 and ultrafine particles – how large a share of these particles are emitted from passenger cars?" And then, of course, how much the congestion charge reduces the number of passenger cars? It depends on the price. I mean, of course if you put an extremely high price, then nobody will go into the city in a passenger car, but it's probably not possible to create a political majority supporting that idea. So I think in reality, it will be possible to have a political decision reducing the passenger cars between 15 and 30%.

N Okay.

K So it would be around the 20, 22% plus or minus 10. I mean, nobody knows what the charge would be in the congestion charge – would it be 20 Danish kroner? Probably would depend on rush hour or non-rush hour; nobody really knows. So my guess is that it would be between 20 and 25% but then

with a variation of plus/minus 10, so I would say between 15 to 30% you would be able to reduce passenger cars. And then, if you take this reduction and see how high a share of the different pollutants are emitted from passenger cars, and then you reduce this by, let's say, 20%, then you'll have the effect of the congestion charge. More or less, of course; that's an estimate. But it's a best estimate.

N Okay. So, for example, we're trying to rate a variety of different solutions, and how would you assume that 20% of the cars would be reduced? How would you make that assumption?

K Once more?

N Oh. So when you believe that, say, 20% of the cars would be reduced by implementing congestion charges, what is that based off? How do you know that, say, 20% would be reduced?

K Well, no one knows; that's why it's a variation! Nobody really knows how large a congestion would get, because it depends on the price elasticity of this economical turn where you say, "Okay! So if you increase the price on driving your private car, and you know the prices of the alternatives like buses and bicycling, then how many people will change?" Of course, everybody that is just about to take their bicycle, they will change to bicycles. But there will be people that are comparatively inelastic, that will not change no matter what the price is. So 20% is an estimate, and you can go out and make investigations asking people if "[assuming you are charged] the price of 20 kroner every time you drive into this area of the city, would you leave your car at home?"

N Mm hm.

K And some people would say, "Yes!" And some people would say, "No!" And then you always have the problem because certain investigations are usually biased because if you don't want congestion charge, you will always say, "No, I will not leave my car at home." Because then you think, "Okay, then the investigation will show that congestion charging doesn't work." So you will always have some strategic behavior during certain investigations. But it's usually the best way you can do it, but in reality it depends on the charge. **What will be the charge? Will it be 5 kroner or 30 kroner or 50 kroner or 100 kroner? It will make a hell of a difference, and that's why nobody knows.** My guess is that it would be possible to have a political majority accepting a congestion charge around 20 kroner; I guess that would be possible. Maybe even more; maybe even 50 kroner. And I guess that would reduce traffic around 20% plus/minus; nobody really knows.

N Yeah. Do you have any insight or idea as to why the city hasn't implemented such road pricing yet?

K Yes, it's quite strange. In Denmark it's the National Parliament that needs to allow municipalities to introduce congestion charge, and to allow municipalities to have tighter demands or more ambitious demands in their emission zones. **So basically it's Parliament that decides if Copenhagen can introduce a congestion charge. It's Parliament that decides if Copenhagen had forbid old diesel cars. It's a little strange; in many other countries it's the city, the Municipal Parliament. But in Denmark it's the National Parliament. And until now they have not allowed it. It's quite surprising, because you have investigations showing it would be a very good idea, a very good business case even from a socioeconomic point of view to have stricter low emission zones and congestion charge. But the politicians do not think about socioeconomics. They think about getting reelected, and that's everything that matter. So they are afraid of doing something that might scare away some of their voters. But in the Copenhagen municipality if they had the possibility they would introduce congestion charge and strict low emission zones immediately. But they just can't do it because a decision needs a law change and that can only be**

made by the National Parliament. It needs to be in place before they can do it, and that's the only reason why we don't have it.

N Okay. And that same thing goes for the low emission zones, you said?

K Yes. It's same. In Danish law it is specified exactly which requirements can be in low emission zones. And for the moment these specifications [were] introduced in 2006 in the law, and they haven't been changed since. And they only allow the municipality to put Euro requirements for trucks and buses, so heavy-duty vehicles that are more than 13 years old. And there's none left of those, so we have a low emission zone but without any kind of effect.

N Right, right. It needs to be updated.

K Yes. And until now, national politicians from different wings have not been able to do so.

N Right, right. So when you were making some of your estimations the air pollution data you were using was from the H.C. Andersens Boulevard monitoring system, I assume.

K Yes.

N We've had some struggles finding any data in Christianshavn. Do you know if there's any sort of traffic data or air pollution data that would help us?

K There's definitely traffic data, I think. I don't know, but I think there must be traffic data because you have bicycle lanes on the sides, and usually when you have a street having that, then you have traffic counting. Because to have the bicycle lanes you need to document that the bicycle and the car traffic have specific shares. So there must be car count[s] from it. You should be able to find it. It's called Traffic Counting, but of course in Danish. I can try to Google a little and see if I can find something, but it must be there for Prinsessegade. I'm pretty sure it is somewhere. So you know the number of cars, I think the key challenge is I don't know if you know the distribution of the cars, but I think these countings have the heavy-duty vehicles and cars separated. But I'll try to find out.

N Okay, yes! That would be a big help. So one of the challenges we're having is trying to somehow quantify how we think our different solutions will make an impact. So we wanted to see how you had made that estimation, which was based on some assumptions. But I can tell you a little about our solutions

K Yeah.

N I'm not sure if you're aware of this, but there was a bus gate on Prinsessegade that was up for quite some time. It only allowed public buses and residents through. So apparently just recently part of the road was reopened last year, and the area has already seen some increase in traffic. So one of our solutions is investigating why it was reopened and trying to potentially close it again to have only public transport vehicles be able to utilize the road to reduce through traffic.

K That sounds reasonable. I remember I had a friend living out there, so usually I went by bicycle.

N Yeah. So that was one of the solutions. I guess it was potentially removed because of political reasons but it seems kind of unclear.

K Yeah. You should be in Denmark because we're a very small country. A very small group can have a very high influence, especially when we talk municipalities. So my guess is that they build lots of new apartments out there and there were some people angry because they couldn't use the route with their cars, and then they did some lobby work, and then they had it reopened. I guess that's what happened; I don't know.

N Right, right, we've heard a lot of potential things like that, but nobody seems to know for sure.

K No. But we can ask because usually the people working in the administration in Copenhagen, they are quite honest about this sort of thing. Of course they will not say it was because of lobby work. They will say it was because of a political wish. And then, of course it's possible to go into the abstracts or summaries from the political meetings when the decision was [made], and see what is the background. And they will probably say that they had a letter from, I don't know, signed by 200 people living in this area that want to have it reopened. It is quite [unintelligible], things like that, but that could potentially be [why]. But you're right; if you close the street, then you will have less traffic passing through the street, and then you'll have less air pollution. It's quite simple. There's no magic in that.

N Yeah, exactly! [Laughs] And similarly to that, we were looking at just trying to convert the road to a bike or pedestrian [or bus] road, but it is a bit of a challenge because [other than] Prinsessegade, there really isn't another route that goes from southern to northern [Amager].

K For me as a person, it sounds like a great idea because we always use our bikes here. But in Denmark buses are seen as—they're subsidized by the municipalities, so you cannot have a commercial company run the buses because even the most busy buses, they're in minus [profits]. So in Denmark I think buses are seen as a kind of "social help" for old people who cannot use bicycles, or for people who have problems and are unable to bike. So it's mainly seen as some kind of social help because in reality it's very good socioeconomics to skip the buses, because then you have much more people using bicycles and the exercise they get will make them much healthier. And that will have a very positive influence on society and reduce the healthcare costs quite a bit. So it's actually quite positive to get rid of the buses because many of them, the people taking the buses, will subsidize or will change to a bicycle. And then society won't need to subsidize the buses. But there you have the challenge because they're subsidized by the municipalities, it's the regions in Denmark where municipalities, regions and the government [all have a stake in removing buses]. And the regions, they will gain from it because they will have low health costs. And the municipalities could gain from it because they don't need to subsidize the buses, but they will have all the complaints from the older generation that are unable to bicycle. They are very, very strong; we have an organization for old people that has more than 1 million members in Denmark. And since all of them can vote, it's probably 25% of the votes, so it's very strong. So the politicians think about that, this organization will go out publicly and speak against them and probably try to execute old petitions speaking for it. But, on the other hand, we have some projects with electrical bicycles.

N Oh, yeah.

K The share of electrical bicycles is increasing fast in Denmark. We get more and more different types of electrical bicycles, and they seem to get old people to use bicycles. So there's a potential there that might be better for even the old people and better for cyclists. But I would agree. I guess you could just take the bus gate where cars cannot pass, [and just] introduce that again and then you'd have the reduction, which could have been far worse, to measure the air pollution. [Measure it] before they reopen the street and then after, and then compare the air pollution. That could have been quite funny or interesting.

N Yeah, that would have been interesting.

K But that's a little late now, of course.

N Of course. Yeah, unfortunately we don't have too much time here. So another thing we wanted to look into is trying to incentivize public and alternative transport. So, kind of like what you were

saying, try to promote people using the bicycles, and basically anything that would get a number of passenger cars off the road.

K That's difficult, but it's very important because the car ownership in Copenhagen and in Denmark is increasing, fast. Some years ago we had about 10,000 sold private vehicles every month. Now it's about 17,000. So we've had just from a few years an increase of 70%. Of course the financial crisis reduced it a little bit, but really there's a huge share of Danes buying cars. So the key is to turn this around, because if people have a car then they use the car. Even though they say it will only be in the weekends when they go to their summerhouse, it never ends like that. All investigations show that if people have a car, no matter if they just bought it to use in the weekends, they start to end up using it every day. So incentivizing is a good idea, but then you need to make it more expensive to have a car, or more difficult to park a car, that's another possibility. That's what the municipality could do, decrease the number of spaces for parking or [close parking lots].

N Yeah. One of the ways we were looking at this approach was trying to potentially partner the public transportation companies or even bike shops with each other and with other local companies to potentially have some sort of collaboration in order for people to get discounts on using these types of transportation. I'm not sure if that's anything that's been considered or done before.

K I don't think that we've tried to "pool" them or "combine" them. There have been moves to combine trains and bicycles, but there are always new ways to do things. There's a Danish company called GoMore, where if you have a car, then to have carpooling, you can announce that you go from Point A to Point B, when you do it and when you go back, and then people can by the Internet go in and go with you, and then you decide what they pay depending on how far they travel with you. Stuff like that is quite reasonable; it just doesn't quite work. I mean, carpooling would be excellent because in Copenhagen there's completely traffic jams, and in rush hours there's about 1.1 persons average per car. So if you had just 2 persons per car, you would almost have no traffic jam. So the potential there is huge! There's 5 seats in each car, but only 1.1 of them is used. But it just doesn't seem to work in reality. I don't think why, but it just doesn't.

N Yeah. Right, sometimes it's just hard to change people's behavior.

K Yeah, but I think a congestion charge would change that. At least when you saw how people will deal with congestion charge: you'll have people using bicycles, of course you'll have people still going by car, you'll have using public transport, and then with carpooling and car sharing, you would [see it] increase quite a bit. So it is possible; the potential is there. It's just, to make it more expensive or more difficult to have a private car, and more expensive through the congestion charge or settle it by road pricing. And then for the more difficult [people], I think the only thing you can do is to reduce the space there for parking in Copenhagen. The challenge is just that many of these private companies own the parking basements. So it's not like *public* spaces, at least not most of it. It's private companies that open parking basements and earn good money on it.

N Right. Is there anything you think that could be done, say, to make public transportation options either cheaper or more appealing, rather than making private cars more expensive?

K I think we should take care about making it cheaper because what we have seen in Copenhagen, for example, is if you make public transport cheaper, you will have bicyclists starting to use public transport. And that's the last thing we want, because then they get less exercise and become a higher cost burden to society. So I think [out of] the only things you can do, of course you can improve

regularity, meaning the buses drive on time, every time. That would definitely help, the same with trains. But the prices, I don't think you should change that because there's just a risk that the bicyclists will start using the public transport. But in the regularity, that's the most important when you ask people, especially people having a car. They are willing to maybe leave their car if they know the train is running on time. But in reality it's maybe running on time, more than 95% of the time. The problem is still the last 5% of the time where people get too late to a meeting or too late at work or too late at home to pick up the children, and it's this 5% of the time they remember, and that causes the challenges. So even though our train companies can say, "We're running on time more than 95% of the time," that's just not enough; it needs to be 99.99%. And I don't know if that's possible.

N [laughs] Rights.

K I mean, I hate myself. Usually I always use my bicycle, but sometimes I take the train. And I'm shocked that sometimes they just cancel a train to Jutland, and then you need to wait 40 minutes for the next train. And I have a meeting and everything; how can they do that? How can that even be legal? I'm really shocked because I have a meeting and appointment; they can't just cancel a train, but [apparently] they can without any compensation. I think that's the really shocking thing, and that's why many car owners don't want to use public transport, because they can count on the car. It's working 99.99% of the time, or at least 99.9%. The last few 0.01% is, of course, if they found out there's damage and it needs to be repaired. But 99.9% of the time it's working, and if the public transport wants to compete, it needs to be working 99.9% of the time as well. And no excuses, and no strikes, and no "all that crap." It just needs to be working. So I think that would help, but not lower prices because that would just have bicyclists going public transport.

N Okay. Well, I know you said you had only about a half hour, so I don't want to keep you.

K But you know, if you take this bus [gate], where only busses can pass, that's again making it more difficult to be a private car owner. And that in itself will make people and maybe use the bicycle instead. So, as I said, there's two ways: either you make it more costly to have a car, or you make it more difficult to have a car. And that's the way to force people to rethink their transport, and then of course you could try to give them a "carrot" as well. [As in], we increase the regularity of public transport; I'm just not sure it's possible. To ?overhaul? the system, I think it would be extremely expensive to do it that way, but of course you can combine the two things and say, "Okay! We use the harder arguments like higher prices and difficulties in having a car on one side, and then at the same time, we legalize this by giving them a carrot and saying we invest more in public transport and better bicycle conditions." So you probably need both to legalize: you go hard on the cars, and then you need a carrot as well. I think you need to do that. At least, that's a way. And then, of course, you can do all sorts of motivations for electrical cars. That would help, but it would take a very long time.

N Yeah, absolutely.

K Keep on [unintelligible], and then let's see if it's needed, and if can find the time, we might have a coffee after Easter.

N Thank you so much! Your insight has been very helpful.

K But just one last question.

N Sure!

K Now, you look upon air pollution, but [have] you only look[ed] up air pollution for traffic or air pollution in general?

N Well, we started out looking broadly at just air pollution in general, but talking with our sponsoring organization Miljøpunkt, we kind of narrowed down the car traffic being a problem in the area.

K It might be, I'm actually not quite sure. I'm not convinced, because you have Christiania, and they don't have district heating. So they're burning wood, and it causes huge air pollution with particulate matter. So it's probably wise to limit your project to cars, and of course continue with that, but maybe you should mention in the Perspectives that it would be wise to look upon other pollution sources. The huge residential burning in Christiania causes enormous pollution; you know that if you go there for a walk in the winter. And that should maybe be included if you make another analysis.

N That's very interesting. We did know a little about the wood burning stoves but we did not know that it was mostly coming from Christiania.

K But it's a big issue in all of Copenhagen. I just mentioned for the record that they made a detailed investigation of the number of stoves in Copenhagen, and there's only 16 to 17 thousand stoves, so that's very little. They only cover fewer than 5% of the energy in Copenhagen. But in one winter season they emit as much particulate matter as all traffic emits in one year. So you could forbid just 16 to 17 thousand stoves only contributing to fewer than 5% of the energy, and then you could reduce the same particle emission as by banning all cars. It's quite an interesting calculation, but of course you have to do something about both car traffic, but I think the other way is when Christiania is just next to [Prinsessegade] with the huge wood burning, it could be an important issue if you want to improve air quality in the area. But you could mention it in the Perspectives, that it should be taken into account as well.

N Yes, absolutely. Thank you for mentioning that.

K You're welcome. But keep on working with it, and then see if we can meet for coffee after Easter.

N Great! If we have any follow-up questions, we'll be sure to let you know. Thank you so much!

K And [I might not] reply to the email, I get way too many emails and I work very much abroad. So if you don't get a reply, send a message to this number. The day after I'll send you a call, and it would be great to reply. If you just do that, that would be excellent.

Poul Cohrt (PC) Interview

March 24, 2017 – 12.00

Attendees: Emily Matsco (EM), Ian Vossoughi (IV), Emilee Gancarz (EG), Nicole Luiz (NL), Yao Long (YL)

Research Questions:

1. What do the locals think is the biggest problem regarding the traffic on Prinsessegade?
2. Have the previously attempted congestion mitigation strategies (bus gate) reduced Prinsessegade's daily traffic congestion?
3. What is the community willing to do to solve this problem/ what would the community be in support of?

PC Yeah, hello?

EM Hi, is this Poul?

PC Yes it is.

EM Hi, my name is Emily, and I'm one of the students working with Marianne at Miljøpunkt

PC Oh yes yes, quite!

EM Hi! I'm here with the rest of my team so there are 5 of us here

PC Beg your pardon?

EM There are five of us here. So we're all working with Marianne—
[moved phone to get a better connection]

EM So do you mind if we record this call for our paper and other references?

PC Okay! You conduct it by telephone, right? No trouble, no trouble.

EM Okay great, thank you! So to start, what is your role exactly within the local committee?

PC I'm the chairman of the local committee.

EM Okay, great! And how exactly does the local committee engage with the local community, or the public in the area? Do you do a lot of events with them and things like that?

PC Well you can compare it to London, UK, [where] you have boroughs.

EM Okay.

PC And each borough has its own committee.

EM Oh, right.

PC And it's comparable to that, with only one exception: that we are not allowed to accept taxes.

EM Okay. And then, our project is about the traffic congestion on Prinsessegade. So have you experienced this congestion on Prinsessegade and what times do you think it's the worst?

PC Well, of course it's worst about rush hours. That'll be about 8-9 in the morning, about 4-5 in the afternoon.

EM Okay, great. And has the local committee come up with any ideas or thoughts on ways to improve this traffic congestion?

PC We certainly have indeed, and we are about to make a new plan for the traffic of Christianshavn. But we have many so far.

EM Okay! So, our main solutions that we've researched and thought about is taxing cars and road tolls, but we spoke with Erling and he told us that was not possible because of more political reasons. But one of the main things we're trying to think about is public transportation for the general public; do you have any thoughts on that? Or an increased frequency of bus line and public transportation in that area?

PC As far as I can see, of course public transportation could be vastly improved. For the more improved public transportation, the less entitled people [feel the] need to use their cars.

EM Mm hm.

PC Actually, cars cost money, and a lot of money. And they're damn impractical in town.

EM Okay.

PC You can't really park them anywhere, you get into all kinds of congestion. But as long as public transport isn't ample, [unintelligible], cars must be an alternative for people who have to go to their jobs somewhere else.

EM Right. And that development on Christianshavn with all the apartments being built; do you think that will contribute a lot to increased traffic congestion?

PC Well, there's a tendency for new apartments being built to be fairly luxurious, and therefore expensive apartments. And the wealthy people have a tendency to prefer cars. So there might be a

connection there. Then we might have a lot of people who move out here, they do so because they like the atmosphere in this part of town. Therefore they might not be just so entitled to have cars. In many families, they even want to have two cars. And as you know, as our street was constructed in 1600-1700, it's not built for that sort of traffic. And you can't do anything about the streets without taking away the houses, which is a very expensive and very impractical thing to do.

EM Yep. And the other thing that we were considering was the road closing, and possibly creating a pedestrian or bike road out of Prinsessegade. We researched it and found that it was closed for a few years, and then recently reopened. Do you have any information on that situation?

PC Well, we've had no closed roads. Just for a very short period, connected to the festival or something like that. We've been able to close the road for a day or two, which actually matters quite a lot and ensure that people could find other ways. So we had a very positive experience and got to talk about the quality of the area in those days.

EM But there was a bus gate in Prinsessegade a couple of years ago, where only buses and residents could use that road.

PC Oh yeah, that's been taken out of operation.

EM Okay. Do you know why?

PC Oh, well... The true story, I think, was that in the very late night, when they were negotiating at the town hall to make up a deal, somebody came up with the idea that "you give me that, I'll give you that."

EM Okay, yeah, that's what we've been hearing.

PC At that time, it was late in the night. They saw that our new exercise center, the Fitness World we call it, was lying on the other side of that bridge. So they thought by that they might help the traffic going to that. But actually at that time at night they didn't realize that it was lying on the other side of the bridge, so it had no effect. You know, political problems in the late night. And you can't get politicians to admit they made a mistake.

EM Right. And when you close the road a day at a time completely, do you think that the traffic ended up other places? Did other places get congested, or did it just figure itself out?

PC Well, I think one thing that some of the traffic went other ways to get through, but some prefer to take public transportation, yeah, because it's more practical. And a very few got very frazzled that they couldn't drive through the street.

EM That is good to know. And when the bus gate closed, were the local residents of Christianshavn upset by that?

PC Pardon?

EM When the bus gate closed and the road reopened to everybody, were the residents of Prinsessegade and Christianshavn upset about that?

PC Yes, of course, and they still are.

EM Okay, that's good to know.

PC The idea was that to please these politicians, they would take the bus gate out of operation for a year, and then measure the intensity of the traffic and publish their findings. This, however, has not happened yet, and now it was a year and a half ago.

EM Oh, wow. And so, in doing our research and everything, we would, at the end of our project, like to host an open forum for residents of Christianshavn.

PC Host an open what?

EM Forum. Like a group interview.

PC Okay, yes.

EM For residents of Christianshavn, and we're looking into different locations to host that, and Marianne mentioned you guys might have a local committee office that we could potentially use. Is that an option for possibly late April?

PC Well, there are rooms that we could go. It depends on how many you expect to come.

EM Yeah, we would like to limit it to 30?

PC Well it could be done. You know, we have a community house in Christianshavn which offers rooms for events and occasions.

EM Okay, great.

PC You need to book the room, and they are booked pretty well in advance. So you should be pretty quick to book it if you like.

EM Yeah, definitely. And do you guys have a local newspaper or website that we would be able to advertise this event on?

PC We have a local newspaper, but it comes once a month. And it actually has its deadline today.

EM Okay. So maybe not then. [laughs]

PC No pressure, pressure!

EM And is there anybody else you think we should talk to about this, or any other thoughts you have on this problem that we would be interested in?

PC I know that in the greater community, the council of Copenhagen. We have an alderman who's responsible for this and who has made a plan for renovation of our main street.

EM Okay.

PC He's called Morten Kabell. You could contact him and ask him about the main street, called Torvegade, and the renovation.

EM All right, great! Thank you. And, anything else? [looks to others, who shake their heads 'no'] All right, I think that's all of our questions answered. Thank you so much for talking to us.

PC Okay, you're quite welcome! Hope you can use it for something.

EM Yes, definitely. Thank you so much.

PC Okay. Goodbye and have a good day!

EM Yeah, have a great day.

PC Thank you.

Appendix B: Open Forum Notes

April 19, 2017 – 16.30-17.30

Open Forum

Attendees: Emily Matsco (EM), Ian Vossoughi (IV), Emilee Gancarz (EG), Nicole Luiz (NL), Yao Long (YL)

Research Question:

What does the Christianshavn community think of our proposed solutions?

Legend:

Road Closure

Stricter Policy

Alternate Transport

Community Outreach

- Is it feasible to close the road?
 - Politics don't want that, they do not like the idea of the bus gate
 - It restricts access
 - They would have to build a bridge
 - The detour (road in Amager) vs. going on Prinsessegade
- The speed limit on Prinsessegade was recently lowered to 30 km/h, but it won't help pollution since it'll just make the cars even more backed up.
- Queuing is a big issue on the narrow street. The route around (the Amager road) is much more open. No high buildings, lots of trees
- Does it pollute more to go along the detour?
- Reintroduce the bus gate, but possibly move it towards Torvegade, before the canal
 - The development is going to bring in a lot of new people, big problem.
- Three options – walk, bike, or ferry. We want to focus on green mobility. It might be fun to write down the time it takes to drive on Prinsessegade and find a parking spot, then send that to politicians.
- No parking in the area, smaller vehicles
- Before Prinsessegade was constructed:
 - Barriers to prevent travel
 - Police don't want barriers, it's inconvenient to get to Christiania
 - It's not safe, but it makes people drive slower
- Many commuters come from outside Christianshavn. Think of round route buses to mobilize them. It would connect other locations to Christianshavn. Flexible options are key with commuters.
- "Car roadblock poles" (pillars) were suggested for Prinsessegade back when it was being planned and they asked us for input. They slow down speeds and worked very well in Paris.
- Prinsessegade's Christiania is the issue. Plenty of accidents from cyclists. They fought the police on the issue tooth and nail, but to no avail.

- Trees would absorb some pollution, but they're hard to fit on the street.
- Some oaks can grow tall and not wide at all. The roots grow straight down and don't spread out too wide. We used them in the harbor.
- Could probably use grates over the roots on street-level, like in New York.
- Education:
 - Not optimistic
 - Danes are less inclined to be considerate
 - Getting more dangerous (riding on sidewalks, etc)
 - Cars might actually be more considerate
 - If the will is there to educate/make awareness it would work
 - Kids are being educated, but not adults
 - Educating the public depends on getting scientific facts about the matter out to the public. For example, using TV propaganda specials or PSAs.
- The conversation has always been making Prinsessegade more safe
 - Schools, roads, but pollution isn't a prevalent topic itself
 - There needs to be a larger focus (don't focus on just schools and roads, expand to include air pollution-if you solve air pollution, you'll likely be solving some of the other problems too)
- Might not be able to impose more car restrictions in the near future (because of the development)
 - Think about what restrictions to focus on
- Observations:
 - Lots of trucks on Prinsessegade
 - Buses and trucks are the worst emitters
 - Impose environmental zones, regulate trucks, should be Euro 6 or above
 - The company City Logistik has electric trucks to distribute food
 - There isn't much room for the trucks on Prinsessegade, so get them out
 - Truck companies didn't want to talk to us
 - Take local transport
 - Zone could be Sankt Annæ to the canal, that's all we need for the zone
 - Need to prevent buses from idling, or go electric
 - Buses, heavy transport vehicles are the biggest producers of UFPs. A lot of them are owned by the same company. Could we keep them out with an environmental zone? The street should now be Euro 6/VI only. Or, no driving during the school rush hours if your car is not electric.
- This would provide more safety to tourists and the associated traffic. Could we ask Tour Buses to become electrical? They could also pass through bus gates.
- There's an iPhone add-on to measure pollution. High school kids [have or could] measure them for projects and/or internships.
- If normal traffic pollution measures are compared to those that experimentally isolate certain vehicular variables (maybe by using Car Free Sundays and the like), we can determine which types of vehicles are the most critical to causing air pollution.

- Whenever we talk about closing Prinsessegade, there's always pushback from representatives of neighboring streets that would be alternate routes. They don't want the extra traffic any more than Prinsessegade does. There's no place to really funnel it out right now.
- There has been similar successes in past efforts. Like the 5A bus: its pollution levels were measured and the bus line was branded "The most polluting bus in all of Europe," so the government had no choice but to make the necessary changes to clean it up. Likewise, the 37, 8A, and 9A have adopted changes to become cleaner routes. It worked by showing the government our good story of UFPs and their destruction of good health. Miljøpunkt did it all.
- Measurements and testing factors to see the effects
- It's possible that companies will absorb the cost and won't change traffic
- That's why we should get local businesses to only allow electric trucks to deliver goods. In Norway, they have areas where it's free to park only electrical vehicles. Also, road closings teach people where the alternate routes are and how to use them.
- It takes time to change behavior
- Norway provides free to park electric cars, making it easy to make the right choice
- There's some push and pull between Prinsessegade and the detours
- What does it take to implement an environmental zone?
- Make sure it's Euro 6 standards. Euro 4 is not good enough.
- There were recently tests conducted in Fredricksberg and Copenhagen, of converting parking spaces to "shared" car/bike spots. Bonuses are given to car owners who let people use their cars.
 - Requires some education about it too
- Awareness is good if you have a good story
- Impose Euro stickers on Danish cars
- In Copehagen and Frederiksburg, remove parking lots to increase activities
- If you get rid of your car, there will be a bonus
- Shared car program
- There have been "cellar mechanics" below Nørreport Station who will repair bikes that people leave while they ride the S-Train. That's a good incentive and public transit incorporation.
- There are many possibilities that bikes provide. In Sweden, there's a program where you can rent a bike for half a year in college, and get it repaired [for free]. There weren't any problems with illegally-parked bikes, either, since the mentally-handicapped are assigned to make new parking spots. It's a good community outreach program that gave them jobs to do.

Appendix C: Traffic Sources of Air Pollution

Estimated sources contributing to the average concentration of particles and nitrogen dioxide on H.C. Andersen' Boulevard in Copenhagen (Press-Kristensen, 2016)

	PM10 (ug/m3)	PM 2.5 (ug/m3)	UFP (#/cm3)	N02 (ug/m3)

Passenger Cars	Exhaust	1	0.7	3650	14.5
	Non-exhaust	7	1.5	0	0
Taxis	Exhaust	0	0	0	2.3
	Non-exhaust	0.9	0.2	0	0
Vans	Exhaust	0.8	0.6	3250	6.5
	Non-exhaust	1.6	0.3	0	0
Trucks	Exhaust	0.3	0.2	950	10
	Non-exhaust	1.5	0.3	0	0
Buses	Exhaust	0.2	0.1	650	5
	Non-exhaust	0.8	0.1	0	0