

Cruising to Greener Ports

INVESTIGATING COPENHAGEN'S CANAL TOUR BOATS



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Sponsored by Marianne Spang Bech

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**CRUISING TO GREENER PORTS: INVESTIGATING
COPENHAGEN'S CANAL TOUR BOATS**

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submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the degree of
Bachelor of Science**

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This report represents work of one or more WPI undergraduate students submitted to the faculty as evidence of a degree requirement. WPI routinely publishes these reports on its web site without editorial or peer review.

Abstract

We partnered with Miljøpunkt Indre By & Christianshavn on a project to advance the movement to phase out diesel fuel in Copenhagen's canal tour boats. Current regulations allow diesel boats to operate until 2037, contradicting city-wide progress toward carbon neutrality goals. Our communications with local residents, canal tour companies, relevant committees, and political leaders, revealed complex political dynamics hindering change. We proposed recommendations for the government, tour boat companies, and Miljøpunkt Indre By & Christianshavn that could catalyze meaningful action.



Executive Summary

Copenhagen, Denmark, is renowned as one of the greenest cities in Europe, ambitiously setting a goal to achieve carbon neutrality by 2035. Regulations have been implemented across the municipality to mitigate emissions from businesses, car traffic, and public transportation. A 2019 agreement allows the unregulated operation of diesel-fueled tour boats in the canals of Copenhagen until July of 2037.

Miljøpunkt Indre By & Christianshavn has been pushing Copenhagen to phase out diesel canal tour boats. To advance the movement to phase out diesel fuel in Copenhagen's canal tour boats, we identified three objectives:

- (1) Investigate local perceptions surrounding the operation of diesel canal tour boats.
- (2) Understand the barriers and incentives influencing the timeline of emission mitigation.
- (3) Develop a collaborative process to build a constituency and catalyze action.

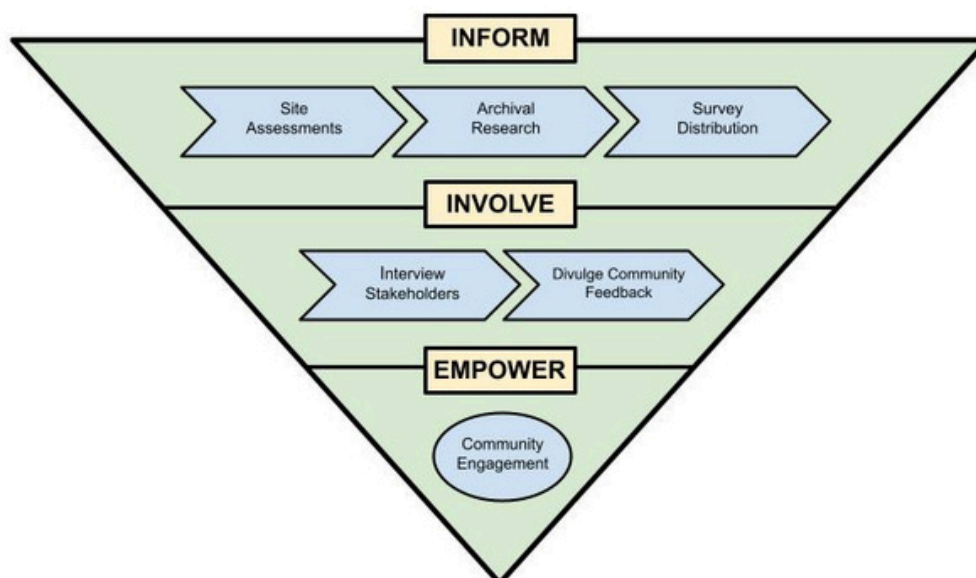
Pollution Concerns

Nettobådene and Strømmma are the two leading canal boat tour companies in Copenhagen. Both operate

fleets of long, narrow canal boats that host tours departing from Nyhavn or Gammel Strand. The combustion engines used in these boats release compounds that are associated with airway inflammation, oxidative stress, exacerbated asthma symptoms, and increased incidence of cardiovascular disease. Additionally, PM₁₀, NO₂, and CO are associated with stress, reduced quality of life, depressiveness, and suicidal ideation (Shin et al., 2018). Emissions from canal boats are not just physical; combustion engines are noisy. Noise pollution can cause annoyance, chronic stress, and sleeping problems in humans (Slabbekoorn, 2019). These negative impacts on human health highlight the grave costs of such emissions. The residents of Copenhagen have already expressed concerns about the noise from both the engines and the loudspeakers that are used to narrate the canal tours.

Our Approach

We developed a set of data collection strategies to meet each objective, summarized here:



Flow chart depicting the methodology used to achieve our goal.

Executive Summary

Observations and Data

Our air quality data confirmed that harmful levels of pollutants are being released from the canal boat engines. The air quality sensors registered the maximum reading of 500,000 ultrafine particles per cubic centimeter (PT/CC) five separate times on the Nettobådene boat tour. At one point, while under one of the bridges, the maximum reading was held for 40 seconds. The noise meter captured a peak reading of 108.8 dB as the engine revved. During the tour the boat's engine was disruptive, interfering with our ability to hear the guide.



Our team taking measurements aboard a Nettobådene canal tour (Photo credit: Rachel Foye, March 22, 2024)

Why The Delay?

We found that the topic of green conversion of diesel boats was polarizing, revealing that political agendas and economic incentives are at the root of the problem. Frustrated residents expressed that they simply do not understand how such a major oversight could have occurred, allowing the canal tour boats to operate unregulated until 2037. Our interviewees conveyed their urgent desire for change. We also observed that the residents were aware that other

European cities, such as Amsterdam, have successfully converted their canal tour boat fleets to electric power. Participants conveyed a strong sense of disappointment that Copenhagen has not followed suit. Interviews with a Strømme representative indicated that conversions could be completed by 2034 if they began now. However, a stalemate in the negotiations between Strømme, Copenhagen municipality, and By & Havn has put green conversion on the back burner. There is little economic incentive to convert right now.

Recommendations

Our recommendations are designed to increase community awareness of air and noise pollution across the canal district. We believe that an informed community is an empowered community, leading to greater accountability within government organizations and the private sector.

For the Municipality & Parliament

Create and Enforce Zero-Emission Zones:

We recommend that the Top Mayor, Minister of Environment, and By & Havn work together to implement a zero-emission zone that includes the regions of Nyhavn, Christianshavn, and Indre By.

Implement a Transparent and Rolling Contract Process:

We recommend instating a rolling contract with terms renegotiated periodically (every year, for example), as opposed to the current long-term fixed contracts.

Executive Summary

Reduce Idling Times for Watercraft:

The canal tour boats spend significant time idling, wasting fuel and polluting the air. We suggest that the municipality expand the idling ruling to explicitly include motor watercraft.

Establish a New Air Quality Monitoring Station:

For years, the canal tour boats have polluted the city, especially Nyhavn, without accountability. We propose that the municipality install a new monitoring station in Nyhavn so that locals and visitors are informed and engaged.

For Canal Tour Boat Companies

Prioritize Measures to Reduce Air Pollution:

Install lithium-iron-phosphate batteries, battery monitoring software technology, and a charging station at the shipyard, allowing for overnight charging.

Prioritize Measures to Reduce Noise Pollution:

Maintain the personal appeal of tours by broadcasting to personal headsets instead of loudspeakers.

For Miljøpunkt Indre By & Christianshavn

Catalyze Change Through Creative Means:

Our team sees an opportunity for art and media as a platform for an awareness campaign. Placing the work in high-traffic areas attracts the attention of community members and stakeholders, inspiring conversations and action.

Final Thoughts

During our time in Denmark, we gained valuable insight from residents about the nexus between business and politics. The parties responsible for the decision-making process comprise a complex web of interconnected agendas. Our eyes have been opened to how crucial productive communication between stakeholders is to green conversion. Through our community engagement, we discovered that negligence has delayed green conversion, stagnating progress toward climate goals. We used this knowledge to generate recommendations to reduce the negative community impact caused by diesel tour boats and push for more public participation in permit decisions. We hope that our efforts to build a constituency and catalyze action for concrete change can resonate with our final message: **change lies in the hands of all community members.**

Acknowledgements

We would like to thank all of our colleagues and partners who made this project a success:

We greatly appreciate the guidance and support of Professor Robert Hersh and Professor Ingrid Shockey of Worcester Polytechnic Institute. Their advice and criticism were essential to our success.

We are incredibly grateful for the dedication of our sponsor, Marianne Spang Bech of Miljøpunkt Indre By & Christianshavn. Her passion, knowledge, and heart empowered us and made us feel welcome. We deeply appreciate Tanya Ærtebjerg for her care, advice, and friendship.

We would like to thank interview participants and survey respondents for sharing their experiences and trusting us with their stories.

We value the support from the various communities we encountered through our project, especially the Lokaludvalgs of Christianshavn and Indre By who welcomed us to their meetings and conferences.



(Photo credit: Rachel Foye)

Authorship



(Photo credit: Ian Poulsen)

Our team has fulfilled the requirements of this report by working on nearly all aspects as a group. Instead of breaking up the writing into primary writer, primary editor, etc. we took it on as a team. We broke up each section of the report evenly to produce a rough draft and then edited it together to ensure there was a coherent and uniform voice present throughout the report. We embarked on site assessments, canal tours, and conducted interviews together. Our collaboration was present throughout each stage of the report's development.

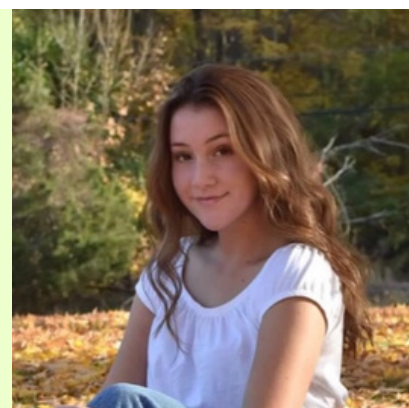
This work is original to the project authors and study participants and was not generated or assisted using ChatGPT or AI tools.

Meet The Authors



Hello! My name is Emma Carroll, and I am studying Mechanical Engineering. I live in Rochester, Massachusetts. As a music lover, if you don't find me hugging a tree, then I am probably on a swing listening to my many playlists. This project not only taught me valuable lessons in teamwork, but also presented the humbling experiences of learning from Copenhagen's passionate community. Living in Copenhagen will always hold a special place in my heart.

Hej! My name is Molly Cronin. I am a Mechanical Engineering student from Cumberland, Rhode Island. I love the beach, thrifting, and spending time with friends. Through this experience I have learned so much about the canal districts of Copenhagen, Denmark while surrounded by individuals passionate about sustainability and the state of the environment.



Hi! My name is Rachel Foye and I am a Data Science student from Rochester, Massachusetts. In my free time, I enjoy yoga, art, hiking, and spending time by the water. I'm immensely grateful for the opportunities I have had while studying in Copenhagen, which have deepened my passion for sustainability and taught me how to harness voices to empower meaningful change.

Hej! My name is Ian Poulsen. I am a Computer Science student from Rochester, New York. I enjoy making art, listening to music, and hanging out with my cats. Working on this project has given me passion, hope, and a deep sense of connection to the wonderful people of Copenhagen who have welcomed us with open arms.



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Introduction

Copenhagen, Denmark, is renowned as one of the greenest cities in Europe, ambitiously setting a goal to achieve carbon neutrality by 2035. Regulations have been implemented across the municipality to mitigate emissions from businesses, car traffic, and public transportation. However, a 2019 agreement allows the unregulated operation of diesel-fueled tour boats in the canals of Copenhagen until July of 2037.

Miljøpunkt Indre By & Christianshavn, a non-profit organization, has been pushing Copenhagen to achieve sustainability goals since its founding in 2008. Miljøpunkt dedicates its efforts to enhancing biodiversity, reducing noise, and protecting the climate with the ultimate goal of transforming Copenhagen into a fully green city. Miljøpunkt sees inconsistencies between the 2037 agreement for diesel tour boats and the city-wide goal of being carbon neutral by 2035. If the agreement remains in effect, emissions from diesel-fueled canal boats will continue to pollute the surrounding neighborhoods, contributing to detrimental health and environmental

impacts, and posing a greater challenge for the city to offset its carbon emissions by the current deadline.

The goal of this project was to advance the movement to phase out diesel in Indre By & Christianshavn's canal tour boats. To meet this goal, we identified three objectives:

1

Investigate local perceptions surrounding the operation of diesel canal tour boats.

2

Understand the barriers and incentives influencing the timeline of emission mitigation.

3

Develop a collaborative process to build a constituency and catalyze action.

Meeting these objectives supported Miljøpunkt's mission to accelerate the timeline for phasing out diesel-powered canal tour boats, empowering residents to take action.



Figure 1: Copenhagen canal tour boat departing Nyhavn (Photo credit: Rachel Foye, March 12, 2024)

Background

Locating Copenhagen's Canal Cruise Industry

1.5 million tourists sail through Copenhagen's canals annually on commercial boat tours, which provide entertainment and education for guests of all ages (Tourism Group International, 2022). The tours focus on the central historical port regions of Christianshavn, Nyhavn, and Indre By, and include opportunities to see iconic Danish architectural landmarks and cultural attractions (see Figure 2).

The two leading canal boat tour companies in Copenhagen are Nettobådene and Strømma. Both operate fleets of long, narrow canal boats that host tours departing from Nyhavn or Gammel Strand, narrated in English and Danish. Strømma is more

direct in branding itself as a sustainable business. According to the website, the company claims it is working "to reduce [its] climate emissions by replacing fossil fuels with renewable fuels" (Sightseeing by Boat Copenhagen, Denmark | Stromma. Com, n.d.). However, as of April 2024, only two of Copenhagen's 27 canal boats operate on electric power – both owned by Strømma (Tourism Group International, 2022). Established before Strømma, Nettobådene is their main competitor. However, they have significantly fewer boats in their fleet. Nettobådene does not advertise sustainability efforts on their website or during their tours.



Figure 2: Indre By outlined in green, Christianshavn in red, and the port of Nyhavn in yellow (Google Maps, 2024).

As Copenhagen adopts sustainable practices, the tourism industry as a whole is a critical sector with room for improvement. With the city's interest in preserving the balance of built and natural environments, "to pursue sustainability is to create and maintain the conditions under which humans and nature can exist in productive harmony to support present and future generations" (US EPA, 2014). These practices come to fruition through both individual efforts and complex community cooperative initiatives. Businesses in Copenhagen, such as Strömma and Nettobådene, can be leaders in prioritizing sustainable practices. As an increasingly green city, efforts from businesses to join in on the green revolution may be economically advantageous. Strömma and Nettobådene could reap benefits from greener fuel conversion if they embrace the movement and appeal to certain environmentally conscious consumers.



Figure 3: Strömma's main dock in Nyhavn (Photo credit: Rachel Foye, March 12, 2024)

Denmark's Green Revolution: Leading the Charge in Sustainable Living

Denmark is making meaningful progress toward establishing an efficient energy system and creating cleaner spaces for its residents (Sustainability and the Danes, n.d.). The country is ahead of many other nations in transitioning towards a zero-carbon lifestyle and Copenhagen, in particular, has been a global leader in environmental initiatives. In 2017, Copenhagen crafted an action plan that aligned with the United Nations Sustainable Development Goals (SDGs) to ensure accountability for advancing its social, environmental, and economic objectives in the city. This plan aims to elevate the quality of life across the city, integrating seamlessly with new and existing environmental initiatives. Copenhagen city officials view the SDGs as a framework to bolster their commitment to providing universal access to clean energy, constructing resilient infrastructure, and fostering the development of resilient communities (KBH 2025 Climate Plan | Sustainable Urban Development, n.d.). Operating under the SDG umbrella, the city has made progress toward these long-term goals. Several environmental achievements have been accomplished throughout the city, but most notably, Copenhagen achieved a remarkable 72.6% reduction in CO₂ emissions in 2021 compared

to the Climate Plan's base year of 2005 (KBH 2025 Climate Plan | Sustainable Urban Development, n.d.). Furthermore, the city witnessed a milestone in 2022, with wind and solar energy contributing to 59.3% of all Danish electricity consumption (Sustainability in Copenhagen, n.d.).

The city has implemented environmental requirements for taxis, established hundreds of kilometers of bike paths, and promoted electric vehicles to consumers through an energy labeling campaign (A Greener Transport System in Denmark, n.d.). Furthermore, the rail systems undergo continual expansions and renovations to enhance their appeal as a reliable transportation option (A Greener Transport System in Denmark, n.d.). Similarly, a system of electric harbor ferries operates seamlessly in Copenhagen's waters without emitting harmful pollutants (see Figure 4).

Emphasizing a commitment to clean air, the city has established environmental zones on land, regulating the vehicles permitted to operate in specific areas and effectively minimizing particle emissions in densely populated areas (A Greener Transport System in Denmark, n.d.).



Figure 4: One of Copenhagen's fully electric municipal harbor buses (Photo credit: Rachel Foye, March 15, 2024)

Partners In Community Planning and Decision-Making

Copenhagen's success in sustainability initiatives lies mainly in the hands of its politicians, who hold the power to change the law. These politicians work closely with the twelve local committees representing the districts of Copenhagen, providing a link between citizens and lawmakers (Forslag Til Kommuneplanstrategi 2023, n.d.). The Indre By Lokaludvalg (Inner City Local Committee) and Christianshavn Lokaludvalg (Christianshavn Local Committee) are the two committees responsible for promoting the interests of Copenhagen's port-side communities. By & Havn, the owner of the 2037 permit, is another critical partner in change. Owned by the Copenhagen Municipality and the Danish government, the public company is involved in urban development throughout the city and manages the Port of Copenhagen. Therefore, their role is critical in creating agreements for land and water use. Cooperation with local organizations and committees, political figures, and By & Havn are instrumental in enforcing policy changes in the canal tour industry.

The Christianshavn local committee has ambitions to be CO₂-neutral by 2030. As laid out in the published 2023-2026 Christianshavn District Plans, the group aims to foster sustainability by renovating homes in Christiania, repurposing buildings, developing more green living spaces, and encouraging the rewilding of Refshale Island (Forslag Til Kommuneplanstrategi 2023, n.d.). Christianshavn will also enforce licensing regulations for boats and regulate public music use (Forslag Til Kommuneplanstrategi 2023, n.d.).

Christianshavn's local committee is fighting for reduced emissions firsthand by pushing for the replacement of diesel and petrol-powered boats with electric boats. According to Copenhagen Municipality's "Clean Air for Copenhagen" plan, the goal for 2025 was to enforce "stricter requirements for clean air zones without prior legislative changes"

across all aspects of city life. This plan includes the introduction of "marine environmental zones to encourage smaller businesses in the inner harbor to be based on new fuels such as electricity, hydrogen, or gas" (Københavns Kommunes hjemmeside, n.d.). Similar to other European cities, the Copenhagen Municipality has plans to implement tax exemptions for boat companies utilizing electric power. However, they have yet to do so. Copenhagen can strengthen its reputation as a green capital by developing green ports. The conversion process would also allow boat companies to brand themselves as environmentally conscious, appealing to the values of certain consumers.

The use of fossil fuels in Copenhagen's private and commercial boats is slowly being phased out through initiatives similar to Christianshavn's. However, the municipality does not have the authority to introduce new regulations or modify the 2037 permit, so it might be necessary to prove that the current operations of diesel boats violate existing air quality standards if the municipality is to intervene. Accountability and rapport between Copenhagen's residents, policymakers, and private sector is critical to its success in achieving its climate goals.



Why the Focus on Diesel? Breaking Down Impacts

The combustion engines used in canal tour boats release compounds that harm humans and ecosystems. These emissions vary considerably depending on the type of fuel used, but the most common fuel for these boats is marine gas oil (diesel). Marine diesel combustion engines release significant levels of gas particles, including carbon dioxide (CO₂), carbon monoxide (CO), sulfur dioxide (SO₂), ammonia (NH₃), methane (CH₄), and nitrogen oxides (NO_x) (Ramsay et al., 2023). They also emit particulate matter, including elemental carbon, black carbon, and other organic matter (Di Natale & Carotenuto, 2015). Scrubbing technology exists to reduce airborne emissions, particularly of heavy metals and sulfur. However, engines with scrubbers still release significant amounts of harmful compounds into the surrounding waters, contributing to acidification and eutrophication (Johannes et al., 2020). While they are effective at reducing some aspects of emissions, scrubbers are an insufficient solution for the scope of this problem.

It is well known that diesel engine emissions have a wide range of impacts on humans. Particulate matter less than 2.5µm in diameter (PM_{2.5}), ozone (O₃), and nitrogen dioxide (NO₂) are associated with airway inflammation and hyper-responsiveness, as well as oxidative stress (Guarnieri & Balmes, 2014). NO_x, PM_{2.5}, and PM₁₀ are associated with exacerbated asthma symptoms and may even cause incident asthma. Sulfur dioxide causes bronchoconstriction, especially in asthmatics (Guarnieri & Balmes, 2014), and CH₄ emissions are associated with increased incidence of cardiovascular disease (Mendoza-Cano et al., 2023). The literature also suggests relationships between these emissions and mental health outcomes. Long-term exposure to PM_{2.5} and PM₁₀ is strongly associated with risk of depression, and short-term exposure to PM₁₀ is associated with an increased risk of suicide (Braithwaite et al., 2019). Additionally,

PM₁₀, NO₂, and CO are associated with stress, reduced quality of life, depressiveness, and suicidal ideation (Shin et al., 2018). These negative impacts on human health highlight the grave costs of such emissions and the urgency of addressing them.

Europeans are becoming increasingly concerned about the effect of air pollution on their health and the environment. A 2022 Eurobarometer survey collected the responses of 26,509 individuals from various social and demographic groups on behalf of the European Commission and revealed a strong desire to strengthen international air quality regulations (Zero Pollution, n.d.). Approximately 88% of respondents believe that occurrences of respiratory diseases and asthma are serious issues that are more frequent due to air pollution (Zero Pollution, n.d.).

Emissions from canal boats are not just physical; combustion engines are noisy. Loud sounds in close range can physically damage tissue and permanently or temporarily impair hearing in many animals (Slabbekoorn, 2019). Lesser levels of noise can impair some animals' ability to communicate with members of their species, as well as induce stress and deter them from living near sources of anthropogenic sound. In humans, noise pollution can cause annoyance, chronic stress, and sleeping problems (Slabbekoorn, 2019). Residents of Copenhagen have already expressed complaints at the noise from canal tour boats, both from the engines and the loudspeakers that are used to narrate the tour. Tourism Group International suggested that the switch to electric motors and the use of headphones would significantly reduce air and noise pollution and improve the experience for passengers (2022).



Learning From Transitions to Electric-Powered Boats

Several European cities, known for their canal tour boat tourist attractions, have already successfully transitioned to fully electric fleets, including the city of Amsterdam. Recognizing the harm directly related to these boats' substantial carbon emissions, the Amsterdam municipality implemented regulations mandating the switch from diesel to electric power by 2025 (Sterling, 2020). Boat companies in Amsterdam had to convert to electric boats to abide by the law. According to a BBC article, if Rederij Kooij, the owner of one of the city's largest fleet of canal tour boats, refused to convert to electric, he would not “get a permit to operate, so our boats will be just scrap metal” (*How Amsterdam's Canal Boats Are Going Electric - at a Cost*, 2018). While this transition created logistical and economic challenges for boat companies, Kooij handled the inconvenience proactively. Opting for a gradual approach, he decided that while the boats were brought into the shop for routine maintenance, the mechanics would replace the diesel engines with battery-operated ones. This phased strategy resulted in the complete conversion of the entire fleet within a year (Sterling, 2020). Kooij highlighted the cost-effectiveness of this method, stating that the alternative option of building a new electric canal boat would cost around one million euros, but converting the boats during routine maintenance added only about 50,000 euros to the repair bill, making this approach far more financially viable (Sterling, 2020). According to the Paris Process on Mobility and Climate, a group supporting sustainable transportation initiatives, the boat companies should recoup their costs in about 12 years (*How Amsterdam's Canal Boats Are Going Electric - at a Cost*, 2018). The electric boats can also be fully charged within 10 hours and run on a full battery charge for about two days. On top of this, these lithium-iron-phosphate batteries charge faster and hold the charge longer than traditional lithium-ion batteries, proving to be a more environmentally friendly alternative (*How Amsterdam's Canal Boats Are Going Electric - at a Cost*,

2018). When it comes to charging batteries, Amsterdam faced the challenge of where to place charging stations and the frequency of their installments. They were able to limit the need for many charging stations by installing monitoring software on boats to alert the boat skipper if they are driving too fast, which can drain batteries faster (*How Amsterdam's Canal Boats Are Going Electric - at a Cost*, 2018). Therefore, constant monitoring alerts boat headquarters and skippers of the status and safety of onboard equipment, allowing the prevention of system failure. This example of the transition from diesel to electric-powered boats in Amsterdam highlights many barriers Copenhagen might encounter if a similar initiative was implemented.

Despite its initial challenges, the phased conversion strategy can be a cost-effective and environmentally conscious approach. According to Strømme Denmark CEO, Mads Vestergaard Olesen, having customers pay a higher price for electric boat tours will not offset the costs of converting his fleet to be fully electric. The economic incentive appears insufficient to push Strømme to convert more of their boats within the 2037 timeline. Without the competition of another equally impactful canal tour company leading the charge to green conversion on Copenhagen's waters, Strømme may have little incentive to make the necessary changes to offset its emissions. The use of green conversion refers to the process of converting current combustion engine boats to electric power. How this conversion takes form varies depending on the source of electric power (solar panels, hydrofoil, charging stations, etc.). Green conversion is an investment, however, as Copenhagen continues to prioritize sustainability, the municipality expects the long-term benefits of electric power to justify the investment in the canal boats.

Summary of Key Points

There are clear conflicts between canal cruise tourism upgrades and Copenhagen's commitment to sustainability. Combustion engines in canal boats are a challenge to Copenhagen's environmental and public health efforts, hindering the progress toward carbon neutrality. Other countries with similar environmental priorities have had success in phasing out combustion engines in the tour boat industry, and it is apparent that there is a valuable opportunity to engage in productive conversations, empower constituents, and catalyze action.



Approach

Our project aimed to advance the movement to phase out diesel in Indre By & Christianshavn canal tour boats through three objectives:

- (1) Investigate local perceptions surrounding the operation of diesel canal tour boats.
- (2) Understand the barriers and incentives influencing the timeline of emission mitigation.
- (3) Develop a collaborative process to build a constituency and catalyze action.

Our overarching approach was to inform, involve, and empower.



Figure 5: Our team distributing survey flyers around Christianshavn (Photo credit: Emma Carroll, March 18, 2024)

To meet our first objective, we conducted a site assessment at the ports in Christianshavn, Nyhavn, and Indre By to document the operation of the canal tour boats. We explored the ports, noting the number of canal boats in the water and the space they occupied. We also embarked on several tour boat rides, collecting air quality and noise pollution



Figure 6: Map of boat tour departing from Nyhavn (Google Maps, 2024)

measurements throughout the route. The circle markers in Figure 3 indicate the locations along the route where we collected data. We designed a survey for residents in the port districts to identify subjects well-connected to the canals and willing to share their opinions. This survey was distributed mainly through the flyer we designed, which can be found in Appendix A. We used snowball and purposeful sampling to target a range of perspectives that encouraged in-depth responses. To offset language barriers, we used translation software and enlisted the help of our colleagues to ensure accurate communication. Our survey, interview questions, and consent form can be found in Appendices B-D.

To achieve our second objective, we completed archival research focused on the laws and policies that enable the operation of unregulated diesel-fueled canal boats. We supported this research with content analysis of media reports and previous action campaigns. Interviews with the CEO of Strømme Denmark and a By & Havn representative were critical to gain an understanding of the barriers and incentives to green conversion.

Our final objective was conducted in collaboration with Miljøpunkt Indre By & Christianshavn, the Indre By Lokaludvalg, and the Christianshavns Lokaludvalg. We attended committee meetings and events sponsored by these three organizations to discuss the desires and experiences of locals. Input from participants in the political arena also contributed to a set of informed pathways forward. The data was compiled for a final presentation to

the Lokaludvalgs which captured the essence of our research and sparked important conversations.



Figure 7: Citizen's meeting panel discussion (Photo credit: Rachel Foye, April 10, 2024)

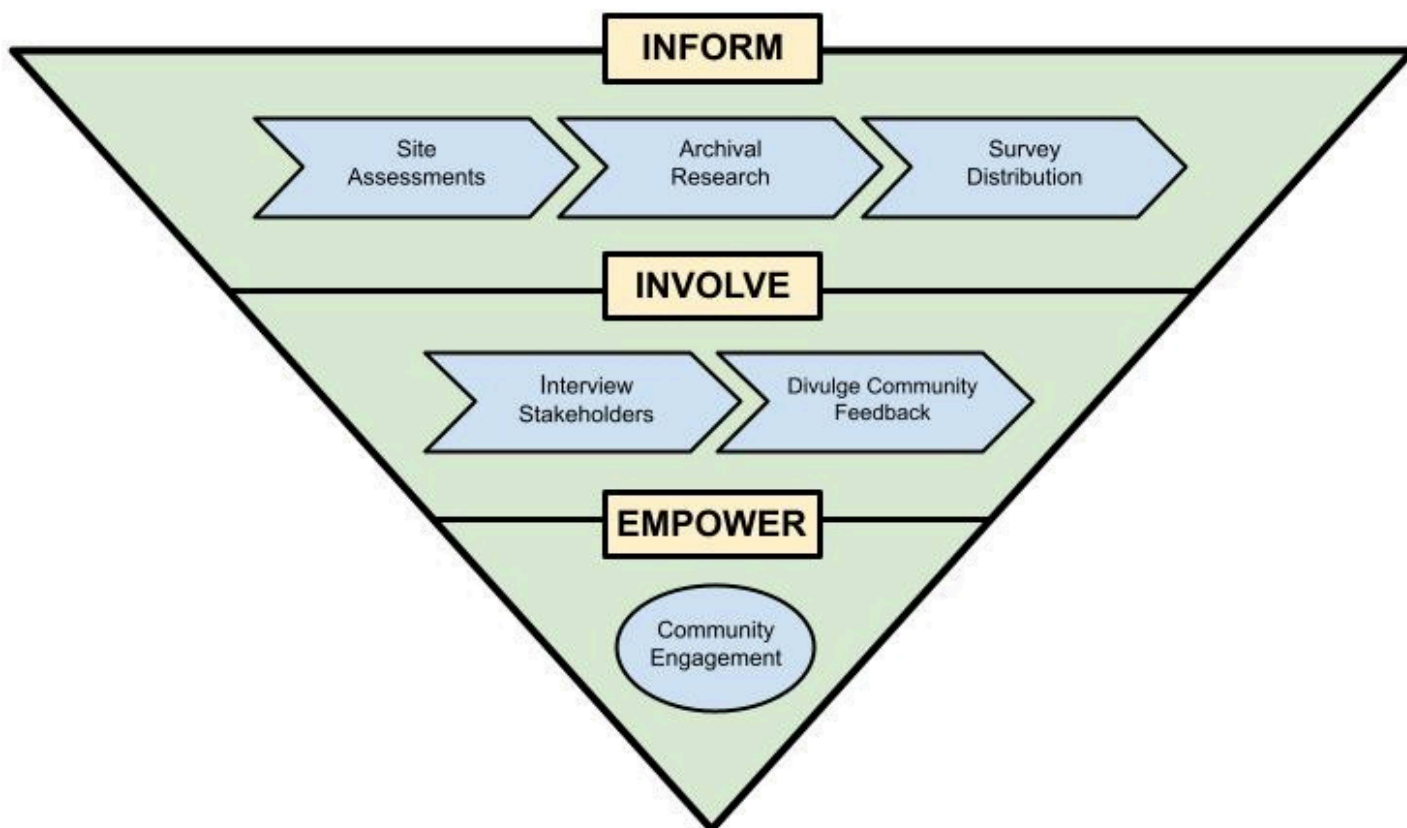


Figure 8: Flow chart depicting the methodology used to achieve our goal.

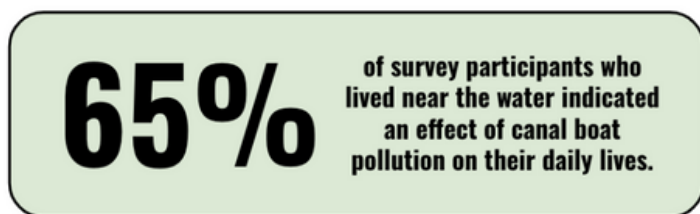
Results

Through our data collection, we found that the topic of green conversion of diesel boats was polarizing, revealing that political agendas and economic incentives are at the root of the problem. Here we present our findings by objective, beginning with investigating local perceptions surrounding the operation of diesel canal tour boats. We then examine the barriers and incentives of the green conversion process brought to light by community members and our interview with Strømme Denmark CEO, Mads Vestergaard Olesen. Finally, we elaborate on how our efforts led us to help build a constituency and to catalyze action.



Objective 1: Gauging Local Perceptions

To meet our first objective, we collected data through participant observation, surveys, and interviews. We began with a survey linked through a QR code on a flyer distributed to the members of the Indre By and Christianshavn local committees (see Appendix A). We also posted flyers around the neighborhoods of Christianshavn and Christiania. We received 80 responses, of which 60 indicated that they live near the harbor or one of the canals in Copenhagen. When asked about the disruptions related to air and noise pollution:



In addition, **96.2%** of survey respondents indicated that they did not believe that the operation of the current canal boats aligns with Copenhagen's sustainability goals. **96.3%** of respondents indicated that they would vote in favor of converting the current canal boats to electric power.

Our in-depth interviews with residents illuminated feelings of shock, confusion, and concern about the

current operation of diesel-powered tour boats within the canals of Copenhagen. It is important to be aware that survey participants who wished to be interviewed may be more motivated than others in the community to make their opinions about diesel pollution heard. Therefore, the survey results are more likely to reveal strong feelings in favor of regulating diesel fuel use in canal tour boats.

Frustration and exasperation were common tones across the interviews and written responses received through email. Participants expressed varying perspectives, many revealing the same underlying theme: negligence has allowed canal tour boats to operate unregulated until 2037. There were common patterns among interview responses. One was the knowledge of Amsterdam's success in converting to electric boats. Participants conveyed a strong sense of disappointment that Copenhagen has not made this issue as high of a priority, especially given that other cities have shown the process to be feasible. Another pattern among interviewees was the expressed need for pressure to be applied to politicians to make electric conversion a more pressing issue. Interviewees shared ideas as to why they believe there is a lack of regulation. Their opinions shed light

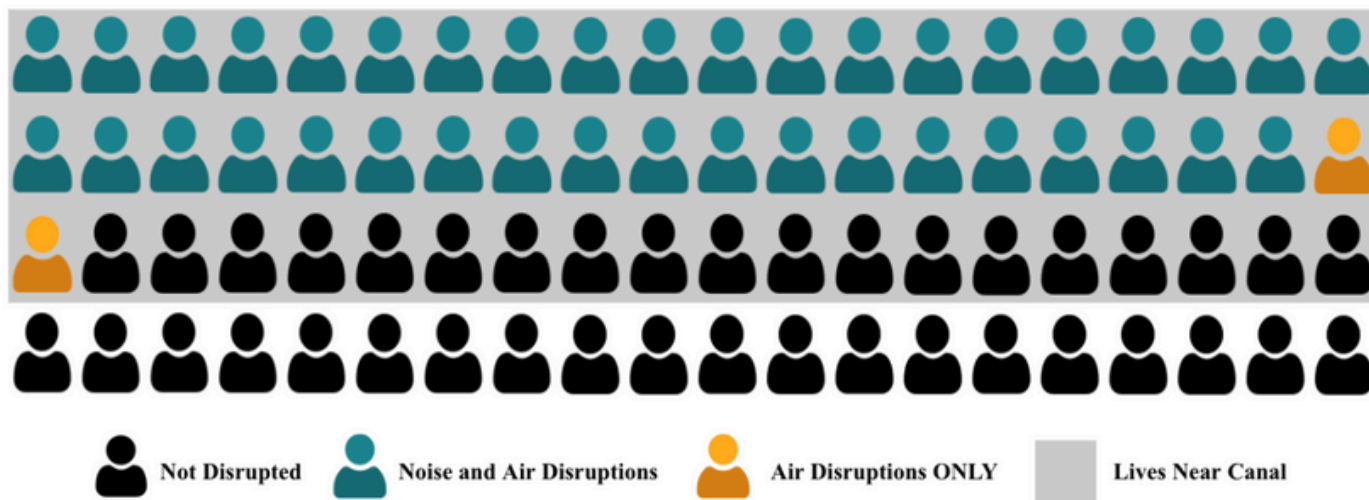


Figure 9: Participant survey responses highlighting 65% (39 out of 60) disruptions from noise and air pollution from canal tours.

on the tension between local well-being and tourism, as well as the drive to preserve historical maritime activities. Concerned about the local environment and the health of their neighbors, our interviewees conveyed their urgent desire for change. While expressing her frustration with the municipality and canal tour companies, Marianne Olsen, a member of the Christianshavn local committee, was at a loss for words as to why the 2037 agreement was passed. As a longtime resident of Copenhagen, she explained how, several years ago, she was forced to sell her cars in order to abide by local emission regulations, exclaiming, “We can't go with our car, but they can drive in the channels until 2037? I do not understand” (Marianne Olsen, March 21, 2024).

Michael Thorup, a member of Indre By local committee also expressed disbelief that Copenhagen, a city so dedicated to sustainable practices and emission reduction, has yet to regulate the operation of diesel canal tour boats. During our online interview, Thorup lifted his laptop to his canal-side window in his home to allow us to see the tour boats passing by. He informed us that with his window open, he could hear the acceleration of the motor and narration of the guide over the speakers, disrupting the peaceful atmosphere of his home (Michael Thorup, March 22, 2024).

He also noted that certain areas on the tour route are “quiet zones.” In these zones, guides cannot use the microphone. Residents in Christianshavn and

“It is really a disgrace for a ‘green city’ like Copenhagen”

Lotte Juul, Resident of Copenhagen Canal District

“Canal tour boats often intimidate and bully all other users of the water in the form of tailgating and horn honking. They do not own the water and need to respect other users like the rest of us.”

Public comment on the By & Havn website

Christiania filed complaints with the municipality about the noise. Strömme claims that after a polite conversation with these residents, the canal tour companies agreed to respect the quiet zones. However community members reveal another side of the story: after angry complaints and a push by wealthy locals to enforce a quiet zone, canal tour companies were forced to comply to maintain their reputation. The implementation of quiet zones indicates that people can convince corporations to change outside the boundaries of the legal system, yet Thorup believes this was largely feasible because of the residents' wealth and power. With ample time, energy, and influence, these residents created social pressure and brought about change. Despite the silence of the guides in these zones, the roar of the diesel engines remains.

Location/Comments	Average Noise (db)	Peak Noise (db)
While idling in Nyhavn	68.8	99.8
Started moving, guide speaking	71.9	108.8
Sped up, in harbor	77.8	103.8
Under bridge, engine revved	75.3	106.4
Under bridge, no revving	75.6	99.0
Quiet zone	71.2	-
In harbor	80.1	106.6
"Thread the needle" bridge	73.4	-

Table 1: Noise measurements taken on a Nettobådene boat tour.

While on the Nettobådene tour, we collected noise data with a Brüel & Kjær Sound Level Meter (Model 2250 Light). The device was calibrated on January 1st, 2024 (see Appendix F). The noise meter captured a peak reading of 108.8 dB as the engine revved and the boat began moving. The engine was very disruptive, interfering with our ability to hear the guide. One group of passengers told us that they were unable to hear the guide for the majority of the tour.

The World Health Organization does not provide any guidelines for noise from marine traffic, which falls into the category of "neighborhood noise." There is little scientific research on exposure and health impacts of this kind of noise. However, they acknowledge that "as the sources may be located in close proximity to where people live, they can cause considerable concern even at low levels" (World Health Organization, 2019). The Environmental Noise Guidelines for the European Region strongly recommends reducing noise levels from road traffic to below 53 decibels Lden (expresses noise levels over a day, with penalties on evening and night emissions) (World Health Organization, 2019).

Our experiences on an electric canal tour boat were completely different. This tour was quiet and we were not exposed to diesel fumes, resulting in a much more enjoyable experience.

The air and noise pollution from diesel canal tour boats is problematic for the passengers and the people who reside and work along the canals. The fumes are highly concentrated in the narrow canals and under the low bridges farther from the open harbors. These emissions will likely expose people in Christianshavn, Indre By, and Nyhavn to unhealthy levels of pollutants such as NOx, CO, and ultrafine particles. The boats also expose residents to disruptive and irritating levels of noise.



Figure 12: Photo featuring air quality sensor (blue device and noise level meter (black device) (Photo credit: Molly Cronin, March 22, 2024).

Objective 2: Identifying Existing Barriers and Incentives

Our findings from Objective 2 provided insight into the factors influencing the timeline of emission mitigation. We interviewed the CEO of Strömma Denmark to discuss his point of view. We also contacted Nettobådene for a similar interview, which the company declined. Strömma CEO, Mads Vestergaard Olesen, explained that Strömma Denmark is ready to convert its fleet. He described the plan by referencing a timeline and graph of required investments and payoffs. Olesen claims the submitted plan to convert their fleet of canal tour boats could be completed by 2034 if they began conversion now. However, he emphasized that the depreciation profile on investments will not pay off until after the permit to sail in Copenhagen expires. The depreciation profile takes into account the decrease in value of Strömma's assets over time allowing for a reduction in taxes owed. As we understand it, the reduction in taxes balances the cost of conversion to electric. Olesen believes that there needs to be a considerable extension of their investments to counteract the conversion, exclaiming "it's not enough just to write them off in three years [if we have] no guarantee for being able to operate our business after" (Mads Vestergaard Olesen, April 2, 2024). The stalemate in the negotiations between Strömma, the Copenhagen municipality, and By & Havn has allowed Strömma to put green conversion on the back burner.

Olesen stated, "we need a push of a button to change something." Yet, he said it is "lousy" to require conversion now when the provisions of the permit had

no prior contingencies. Strömma feels attacked as a "tourist business" (Mads Vestergaard Olesen, April 2, 2024). By comparison to unregulated cruise ships or the many city buses, Olesen argued that Strömma's pollution seems minimal and that Strömma's contribution to poor air quality in the city is of a lesser degree.

From what we have learned, businesses are not equal in their needs or impact, but this does not mean responsibility can be simply passed off or dismissed.

"We are in a situation where everybody knows about it, but nothing is done."

Michael Thorup, Indre By Lokaludvalg Member

According to Olesen, Strömma understands its responsibility to Copenhagen and wants to convert its fleet of canal tour boats to electric. In Amsterdam, Vattenfall partnered with Strömma to electrify their boats by "supplying fossil-free electricity to the Strömma project" (Vattenfall, n.d.). The installation of charging stations for easy access during boat operations is a challenging project. However, Amsterdam made the investment and worked with contractors to install boat charging stations on land and floating stations on water (Sterling, 2020). The city initiative to ban petrol and diesel boats by 2025 started the push for rapid conversion efforts (The Islander, 2019). Copenhagen could have similar success in shortening the timeline of phasing out diesel boats in canals and harbors if they were to pass stringent legislation to ban them.

"People always overestimate what they can do in one year, but they underestimate what they can do in 10-20 years"

Kees Koolen, founder of Super B battery supplier

Olesen was quick to acknowledge that without legislative repercussions, there is little economic incentive to convert to electric boats right now. Therefore, Olesen insisted we must continue to ask “why” to get to the bottom of the change many Copenhagen residents wish to see happen and address “how” the change can come to fruition.

The potential barriers and incentives involved in regulating the operation of canal tour boats were also illuminated during our interviews with residents. Passionate about the well-being of his community, Michael Thorup expressed his desire for immediate change; however, he candidly admitted that this issue is currently facing a democratic problem (Michael Thorup, March 22, 2024). In his eyes, everyone in the city knows that the tour boats must be converted to electric power to meet long-term environmental goals and standards. Thorup shared that when the Christainshavn quiet zone was implemented, the community and municipality pushed for the change, working successfully with the tour boat companies to shift their practices to uphold the community's needs. Thorup believes that with the same motivation and drive from all parties involved, change could be enacted once more (Michael Thorup, March 22, 2024).

“But do we really have time to wait?”

Michael Thorup, Indre By Lokaludvalg Member

We conducted an interview with a By & Havn representative who wished to remain anonymous. According to the interview, the representative does not have access to the agreement or Strömme's proposal for green conversion because their work revolves solely around the legalities of permitting. They also stated that the company stands as a landlord of the water and can not act as a private company. Therefore, without proper legislation regarding the environment, By & Havn currently

does not have the grounds to make demands of canal tour boats to convert to electric. Standard Danish contract law indicates that a tour boat company would need to violate the conditions of the permit or agreement for it to be voided. For example, if the company has outstanding dues or operates over the speed limit too often, jeopardizing the safety of passengers or other boaters, then By & Havn has the authority to void the contract. Our discussions during this interview also revealed that the municipality and Parliament consult By & Havn during the process of proposing plans or passing laws that affect land and water use. Input from By & Havn is vital to ensuring green conversion in the future, but as was made very clear, By & Havn cannot prioritize anything unless legislation is in place.

“The DEPA only administrates current legislature and cannot therefore comment on the lack of rules regarding use of diesel fuel in canal tour boats. We have no comment on why boats are not regulated in a similar manner to land environmental zones”

Lasse Kondrup, Technician from the Ministry of the Environment

While seeking more information about why the regulations differ between land and water, we attempted to communicate with policymakers. In an email exchange with Lasse Kondrup, a technician from the Ministry of the Environment, he stated that he could not “comment on the lack of rules regarding use of diesel fuel” (Personal communication, April 16, 2024). We were also directed to Emma Knudsen, a representative from the Information Centre for The Danish EPA who told us, “your question is of political matter, and it is a political decision whether boats are regulated, and if there should be environmental zones on land but not on water. Therefore, we cannot supply an answer to your question” (Personal communication, April 15, 2024). We reached out to the Minister of Environment for comment, from whom we have not received a response. A lack of communication and transparency from these policymakers is evident.

Objective 3: Build a Constituency and Catalyze Action

Through our data collection efforts, we encountered a community that is very passionate about our project. The local committees remained engaged in our research and supported our findings. We conducted interviews, participated in committee meetings, and volunteered at events that allowed us to gather data and make connections.

We first designed a survey to gauge the effect of the canal tour boats on the community. Analyzing the survey data revealed that the impact on the daily lives of Copenageners is enough to warrant action. The survey was a gateway to interviews with community members. The interviews gave us valuable insight as community members provided varying outlooks on why the regulations for businesses operating diesel fuel boats have been delayed. The interviews reveal patterns of similar community concerns, calls to action, and guidance for future progress. We have also submitted progress updates to the Miljøpunkt newsletter and had numerous email exchanges with people of high authority, such as the Minister of

Environment, the Top Mayor, and a By & Havn representative.

At the April 10 Christianshavn and Indre By Citizens Meeting, the attendees, panelists, and politicians were very engaged in the discussion of the canal tour boats. The discussion revealed major frustrations from citizens in the audience and strong support for our project. We prompted a new level of community engagement with our presentation, which was written about in an article the following day by Kristine Ammitzbøll-Bille, a candidate for Copenhagen City Council. She directly called out Strømme, saying “either Strømme must do something themselves (the best), or By & Havn must renegotiate (the next best)” (Ammitzbøll-Bille, 2024). In response, Strømme quickly released a statement clarifying their desire to convert their fleet to electric, explaining that they have been in contact with By & Havn to find a solution (Olesen, 2024). Collecting community feedback, stories, and data amplified our desire to cultivate a continuous conversation and maintain project momentum.



Figure 13: Our sponsor, Marianne Spang-Bech, presenting our findings at a citizens' meeting (Photo credit: Rachel Foye, April 12, 2024).

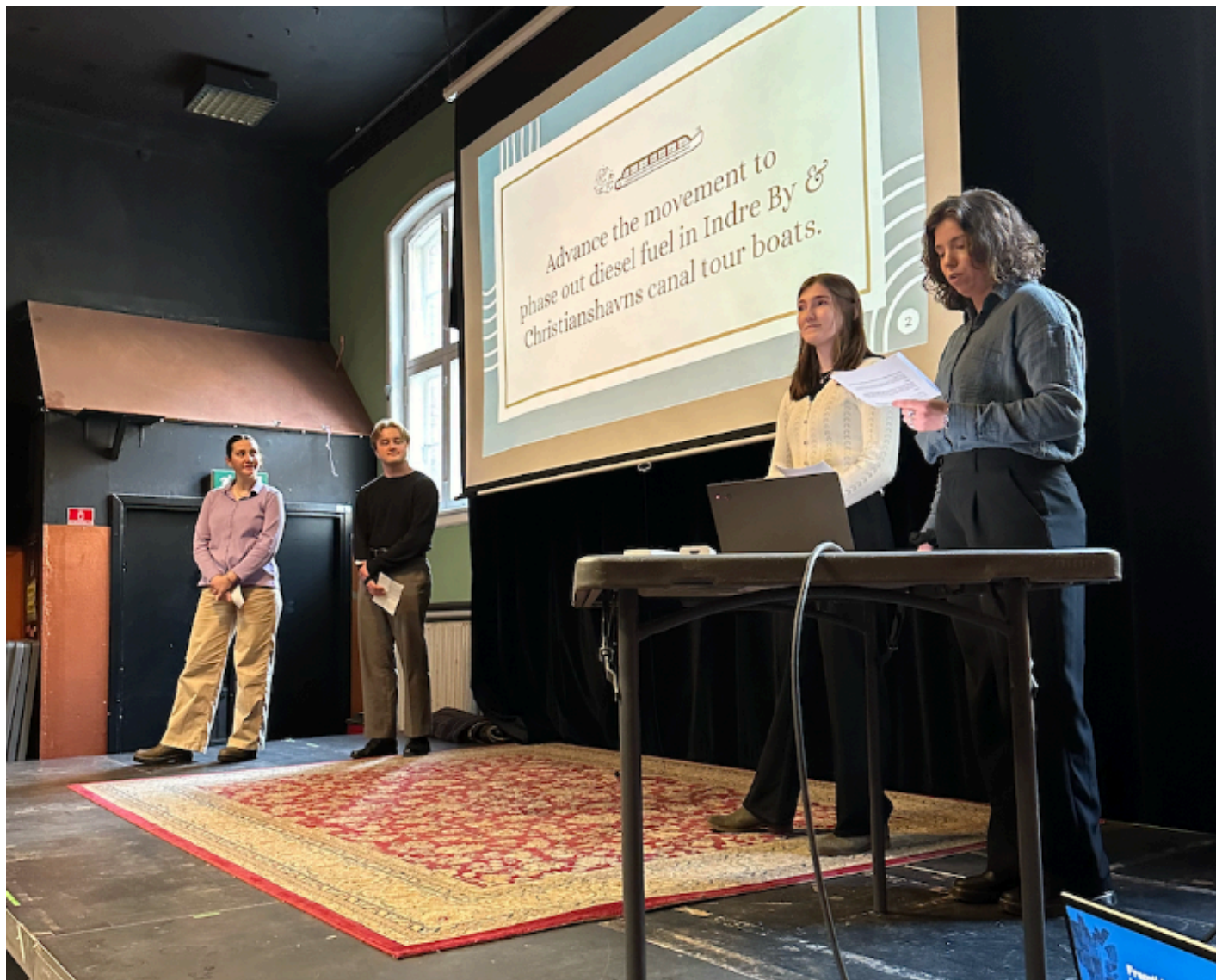


Figure 14: Our team presenting our findings at the joint meeting of the Indre By and Christianshavns Lokaludvalgs. (Photo credit: Marianne Spang-Bech, April 24, 2024).

On Wednesday, April 24 our team met with the Lokaludvalgs of Christianshavn and Indre By in Beboerhuset to present our project findings and recommendations. Our presentation was met with gratitude and pride from the community. One attendee highlighted the importance of our findings, and suggested that our results should be taken to higher government officials. Another member recommended that we contact the media to spread our message. A man on the local committee said that our outside perspective provided an important point of view. Our presentation led him to question why the boats have not been converted already.

A representative from Strømme was also present at the meeting. He thanked us for our presentation and offered his input on our project, stating that Strømme boats do not use diesel and are instead powered by another type of fossil fuel. He also informed us that the price to convert a canal boat to electric was a major obstacle, a shared sentiment by all Strømme representatives we have interacted with. Disapproving community members offered respectful rebuttals to his statements. The dialogue amongst community members of differing points of view cultivated the conversations we hoped our work would inspire.

Discussion

Our sponsor, the Strømme CEO, and community members have all reiterated throughout our investigative process the need to ask why. This project revealed a process full of conflicting agendas and arguments. The involvement of various interested parties in the permitting process allows space for multiple agendas to influence the timeline of the future. As a business, Strømme desires financial security. If they are to invest in electric boats, they need reassurance that they can continue to operate them in Copenhagen's canals. This could take the form of an agreed-upon timeline that accounts for the needs of all parties. The municipality needs to promote the interests of Copenhagen's residents and protect the local environment by regulating how businesses can operate. By & Havn, which permits Strømme and Nettobådene to sail, must be strategic when awarding permits in order to maintain the interests of stakeholders.

The role of politics between businesses, landowners, and municipalities dramatically influenced the outcome of the 2037 agreement. As the climate crisis grows in intensity, the shift in the mindset of policymakers will result in a push for more sustainable business practices. Strømme is now facing the challenge of keeping up with the expectations of residents and politicians. Regardless of who is to blame for delaying the green conversion of the canal tour boats, it is evident from our interview with Mads Vestergaard Olesen, communications with politicians, and discussions with local community members that something is amiss. Lapses in communication between critical stakeholders have significantly hindered actual progress toward green conversion.

Throughout our data collection process, the community's passion for the environment and phasing out of diesel boats was evident.

Copenhagen's longstanding history of environmental advocacy and support from the community enabled our project to expand its audience. While politicians have the power to legislate change, the people have the power to demand it. The legal pathway to impose regulations is complex, but with enough pressure, these companies may be compelled to change. The future of the canal tour industry ultimately lies in the hands of the community members such as the passionate residents who volunteered to be interviewed, local committee members, and our colleagues at Miljøpunkt who wish to see the plans for change become reality.



(Photo credit: Ian Poulsen)

Strömma Stronghold

Strömma's closest canal tour competitor is Nettobådene, but there is not much competition. The two companies do not negotiate due to their complicated origins. It is essential to highlight the dynamic between the two companies. From our observations and site assessments of Nyhavn and Christianshavn, we have seen far more Strömma tours, indicating its popularity and dominance in Copenhagen's canals. Nettobådene runs a few boats every day at scattered times. This disparity in the canal boat tour market share does not incentivize Strömma to convert to electric. Strömma's business model and sustainability report clearly emphasize its efforts to counteract food waste, protect endangered wildlife, conduct canal clean-ups, and install sea bins while managing to avoid confronting the more significant problems at hand: diesel pollution and combustion engine noise.

However, Strömma is making significant headway at its other locations across the globe. In Norway, Strömma boats have been approved to run on hydrotreated vegetable oil (HVO 100) in 2024 due to municipalities passing zero-emission zones. In the Netherlands, since 2023, all 15 of Strömma's open canal tour boats have been powered by electricity thanks to the stricter government policies and the municipality's 2025 goal of zero emissions. These examples show that Strömma has been able to convert its fleet to electric or HVO when regulatory standards require it.

According to Chapter 1, Section 3 of the Danish Environmental Protection Act published by the Ministry of the Environment, "emphasis must be placed on what can be achieved by using the best available technology, including less polluting raw materials, processes and facilities and the best possible anti-pollution measures. In this assessment, special emphasis must be placed on preventive efforts through the use of cleaner technology"

(Miljøministeriet, 2001). This is the law, and it must be upheld. We believe that even with the permit conditions in Copenhagen, it is Strömma's responsibility to hold itself accountable for meeting the community's needs. However, the willingness to do what is right for the Copenhagen community is not enough to motivate a business decision. It appears that what is needed is a ban on sailing diesel boats in Copenhagen's canals, in the form of zero-emission zones. This is what Amsterdam did, leaving green conversion as the only path forward.

In the meantime, Strömma Denmark has presented "a plan for a 100 percent conversion of the fleet that can be done without cost to parties other than Strömma" (Mads Vestergaard Olesen, April 2, 2024). They "are just waiting for the response, hopefully in the form of a framework that correlates to the large investment" (Mads Vestergaard Olesen, April 2, 2024). This raises the question: why has this plan not been accepted? During an email correspondence with Olesen following our interview, he insisted that the green conversion proposal and permit to sail were confidential. Therefore, we were not granted access to review these documents, leaving us with unanswered questions about the feasibility of their proposed plan and the stipulations addressed in the permit about green conversion.

Multiple companies have attempted to capitalize on Strömma and Nettobådene's shortcomings. Hey Captain applied to establish operations out of Nyhavn in November 2022, boasting smaller electric-powered boats (7.7 x 2.5m). Their boats hold twelve passengers and claim to provide a more authentic experience featuring "hidden gems," not just the typical tourist attractions. Tourism Group International (TGI) also applied to operate in Nyhavn in July 2023, with smaller electric boats (10 x 3.15m and 12.5 x 3.75m). Elbådfart similarly applied in August 2023 with their electric

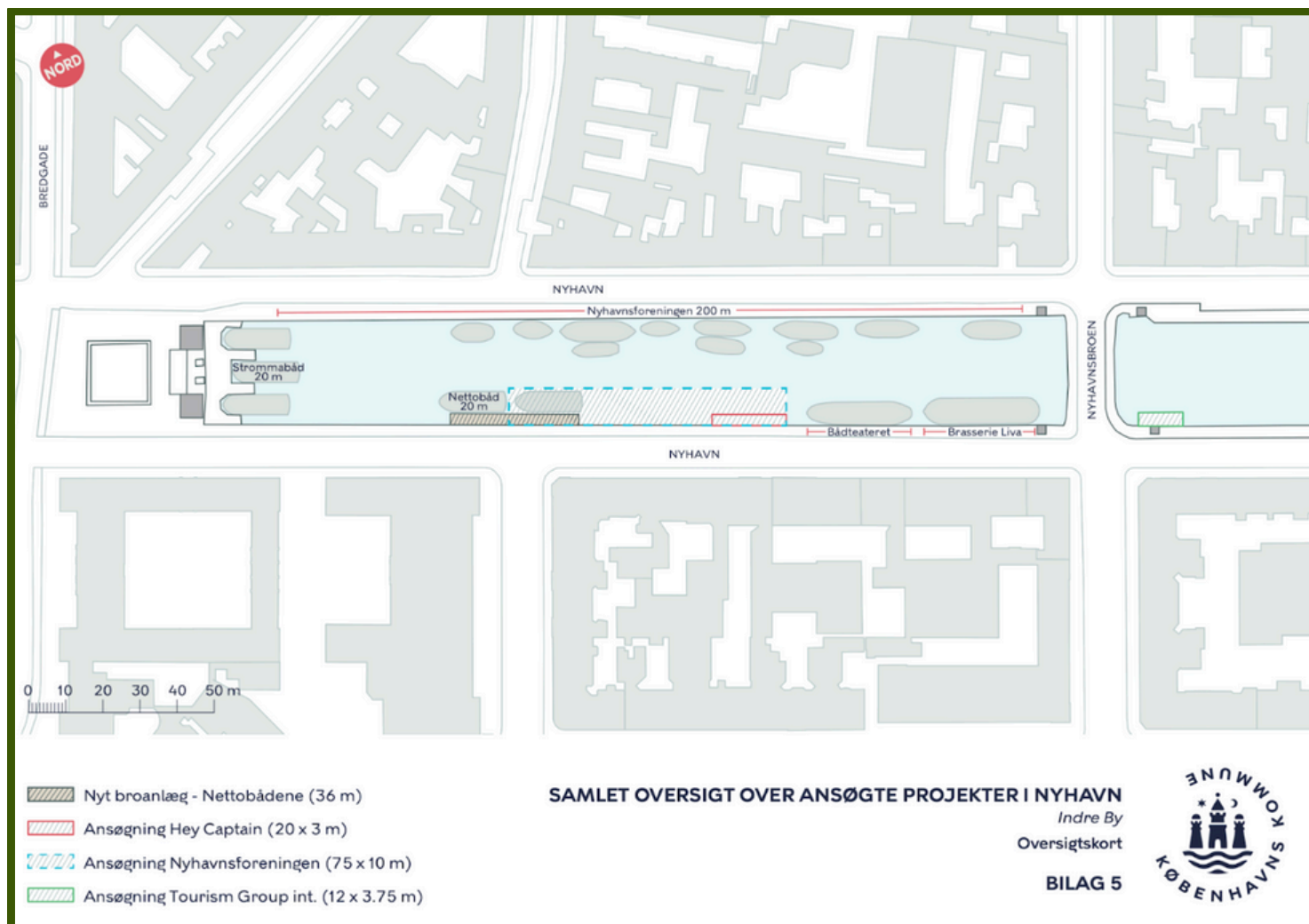


Figure 15: Map outlining the applications by Hey Captain, TGI, and Nyhavnsforeningen to occupy and/or build docks, as well as the existing space occupied by Strømme and Nettobådene. El-bådfart also applied to build a 10-meter dock on the shady side of the canal, but did not specify exactly where (Københavns Kommune, 2023).

boats (8.5 x 2.3-2.5m). The final group fighting for a spot is Nyhavnsforeningen, an association that seeks to preserve and strengthen the cultural heritage of Nyhavn. They wish to use the remaining space in Nyhavn to display antique and historical boats.

The Technical and Environmental Committee denied all applications for canal tour boats to use the vacant bulwark in Nyhavn. They recommend the space be used by Nyhavnsforeningen to display veteran ships (Fremtidig anvendelse af bolværk i Nyhavn, Indre By | Københavns Kommunes hjemmeside, n.d.). They believe that any new tour boats in Nyhavn would increase traffic and pose safety concerns, yet fail to

address the safety concerns due to the existing larger canal tour boats of Strømme and Nettobådene. The failure of these three companies to establish their businesses in Nyhavn represents an increasingly visible problem in Copenhagen's canal tour industry: there is no competition against Strømme. A By & Havn representative confirmed that when it comes to permit applications for sailing, there is no priority given, it is simply a case of who got there first. (Personal communication, April 22) Whether intentional or not, Strømme's presence and dominance drives other tour boat companies out of the tourism industry, further stalling green conversion.

Stalling - But at What Cost?

Strømme Denmark can postpone the conversion to electric until the government enforces environmental law. There is currently little financial incentive for companies like Strømme and Nettobådene to convert their fleets, and the municipality has yet to provide one. Interviewees expressed feelings of helplessness as Strømme's operations are prioritized over their well-being. Marianne Olesen concluded, "It's a really good deal for [Strømme] but a bad deal for everyone living here" (Personal communication, March 21, 2024). Environmental standards set by the municipality in 2018 acknowledge Copenhagen's responsibility to develop as a sustainable global city. Despite the extensive written plan that clearly outlines mitigation strategies to combat pollution, the permit was still passed in 2019, allowing the tour companies to continue operating unregulated. This leaves minimal defense for Strømme's claim that the current push for green conversion in Copenhagen was sprung upon them. However, the complex

dynamic between the municipality and By & Havn has made it challenging to regulate the operations of Strømme and Nettobådene. Therefore, the two companies can stall their conversion to electric, leaving the residents of Copenhagen to absorb the health and environmental externalities.

The interviews we conducted, boat tours we embarked on, and our participation in local committee meetings has evolved our understanding of the complex dynamic between community members of varying social and political standings. We have seen both sides – the drive for change and the pushback. We met with many who are passionate for green conversion and many who feel that this change is a daunting feat. We anticipate that our research has shed more light onto the factors that have delayed green conversion. Hopefully, our work has provided insight into feasible solutions and advanced the movement to phase out diesel in Copenhagen's canal tour boats.

Recommendations

Our recommendations are designed to increase community awareness of air and noise pollution across the canal districts. **We believe that an informed community is an empowered community**, leading to greater accountability within government organizations and the private sector. We hope that these recommendations can be implemented as soon as possible.



Recommendations for the Municipal Government of Copenhagen

Create and Enforce Zero-Emission Zones

In a personal communication, Top Mayor Sophie Hæstorp Andersen confirmed that “the municipality currently has no authority to impose requirements on the boats sailing in the harbor” (April 12, 2024). By & Havn has asserted that they do not have the ability to modify the sailing permit or agreement to add environmental stipulations without consent from the canal tour companies. However, the Top Mayor told us that she is in contact with the Minister of Environment, working towards the possibility of “designat[ing] Copenhagen Harbor as a maritime environmental zone where it is not legal to sail with the most polluting boats” (Personal communication, April 12, 2024). This strategy is very similar to Amsterdam’s, which effectively banned the use of diesel fuel in these zones. We strongly recommend that Copenhagen pursue this avenue to phase out diesel and other fossil fuels in its waters.

In 2023, By & Havn held workshops to include residents in the dialogue surrounding a zone plan for the port of Copenhagen. By & Havn intends to create a plan that will reflect the interests of those who utilize the port. Our communication with the representative from By & Havn confirmed that the zoneplan is not currently intended to include any environmental zones, except for the already protected conservation areas. However, in the legislation of zero-emission zones, collaboration with By & Havn will be necessary. We hope that the Top Mayor, Minister of Environment, and By & Havn can work together to implement a zero-emission zone that includes the regions of Nyhavn, Christianshavn, and Indre By.

Implement a Transparent and Rolling Contract Process

There is a clear lack of communication and accountability between the municipality, By & Havn, and the tour companies operating on the canals. Specifically, Strömme claims that there is no mention of emission mitigation in the original permit, and they are now frustrated that there are growing pressures to renegotiate. The original permit, allegedly having no mention of sustainability requirements for the canal tour boats, has enabled the boat companies to blame the municipality and continue to operate using diesel fuel. The municipality recognizes the need for green conversion in canal tour boats as “[they agree] that it is important to phase out diesel-powered boats in the harbor. That said, the municipality currently has no authority to impose requirements on the boats sailing in the harbor” (Personal communication, April 12, 2024).

Efforts of direct collaboration between the Top Mayor and the Minister of the Environment could be key to developing legislative reform and is essential to resolving this issue. Developing a symbiotic relationship is necessary to cultivate agreements for change to occur.

We recommend instating a rolling contract with terms renegotiated periodically (every year, for example), as opposed to the current long-term fixed contracts. Shorter rolling contracts would increase adaptability and dissipate conflicts surrounding the terms, encouraging fluidity in negotiations.

Reduce Idling Times for Watercraft

In 1990, the Copenhagen Municipality adopted a law prohibiting motor vehicles from idling for more than one minute (Københavns Kommune, 2021). There are exceptions, such as being stuck in traffic or to keep hazard lights on. This ruling applies to cars, taxis, trucks, and motorcycles. When idling, engines are less efficient, so more pollutants are released through the exhaust (Københavns Kommune, 2021). If not abided by a 1,000 DKK fine is issued.

The canal tour boats spend significant time idling as passengers board. This wastes fuel and pollutes the air. Before leaving the dock in Nyhavn for the Nettobådene canal tour, the boat idled for approximately 15 minutes as passengers found their seats. While on the Strömma tour, we idled for approximately 7 minutes when stopped in Gammel Strand, and the build-up of fumes in the canal was apparent from the strong smell.

We suggest that the municipality expand the idling rule to explicitly include motor watercraft.



Figure 16: Cover of a brochure for the idling law (Københavns Kommune, 2021).

Establish a New Air Quality Monitoring Station in Nyhavn

Copenhagen has three official air quality monitoring stations, yet none of them are near Indre By or Christianshavn where pollution from marine traffic is highly concentrated (see Figure). These stations provide data on levels of PM_{2.5}, PM₁₀, ultrafine particles, NO₂, and black carbon, which can be monitored online.

Residents deserve to know about air quality conditions where they live. For years, the canal tour

boats have polluted the city, especially Nyhavn, without accountability. We propose that the municipality install a new monitoring station in Nyhavn to ensure locals and visitors know what they are breathing in. The data could be made available through the existing online platform to ensure that it is easily accessible and can be compared to the other monitored locations. The data could also be visualized on a display screen in a high-traffic part of Nyhavn, so residents and visitors can be informed of the current air quality measurements without the need to navigate the online platform.

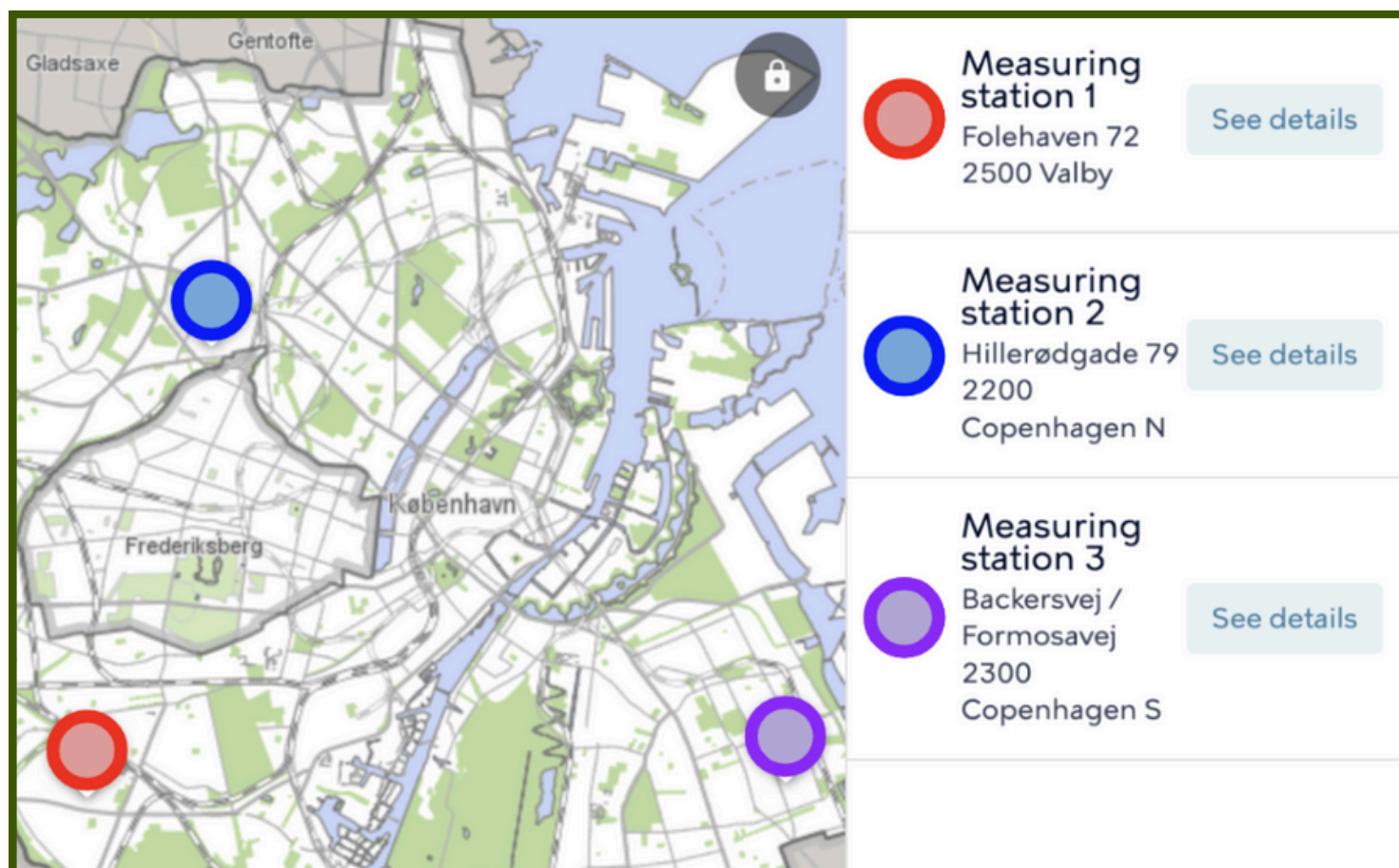


Figure 17: Map of air quality monitoring stations in Copenhagen as of 2024 (Københavns Kommune, n.d.).

Recommendations for Canal Tour Boat Companies

Prioritize Measures to Reduce Air Pollution

Amsterdam's process is a relevant example of how the conversion of Copenhagen's canal tour boats can be financially feasible. According to Strömma's CEO, Mads Vestergaard Olesen, he expects the next diesel boat conversion to cost approximately €600,000 (personal communication, April 10, 2024). He emphasized that it is tricky to estimate cost because every boat conversion is different due to factors like the current engine model, boat size, and asset worth. However, the cost and feasibility of implementing electric boats can be optimized by following the example set by Rederij Kooij's company. Kooij's strategy of phased conversion during annual maintenance would allow for a gradual implementation of electric boats into the current operations of Strömma and Nettobådene. Olesen recognizes the need for a powerful charging station at their current boatyard to ensure the company wouldn't need permission to install charging stations at their current docks in Nyhavn or Christianshavn.

As previously stated, newer lithium-iron-phosphate batteries charge faster and hold their charge better than traditional batteries, allowing for an overnight charge and ease of sailing during the day without the need to stop and recharge (Sterling, 2018). The addition of battery monitoring software during conversion can ensure the safety of electric boat operations by tracking the boat's status, providing peace of mind for boat operators concerned with safety (Sterling, 2018). Overnight charging, monitoring software, and a one-time installment charging station at the current shipyard could be part of a feasible plan for green conversion.

Prioritize Measures to Reduce Noise Pollution

Technical solutions to counteract the noise pollution of Copenhagen's diesel canal tours exist, but feasibility and cost limit the options. It is important to note that a large contributor to the noise pollution in the canals and harbors is the engines powering the boats. The louder the engine, the higher the volume of the speaker system must be so that passengers can hear the guides over the roar of the engine. Therefore, if Strömma or Nettobådene partnered with a company like Silent Events, who provide technology to enhance user experience through personalized audio, they could collaborate to provide optimal customer comfort and quality sound for an improved listening experience on their canal tour boats. Using radio transmitters, headsets, and a microphone, tour companies could maintain the personal appeal of their tours without loudspeakers. Passengers could hear the tour guides without disruption to the community beyond the boat. Simon Frederiksen, who works on the Management, PR, and Concept Development teams for Silent Events, estimated that the total cost of obtaining this technology for a single canal tour boat that fits 150 passengers would be just under 68,000 Danish kroner (personal communication, April 15, 2024). Canal tour guides would still be able to conduct live tours and maintain the individuality and humor they bring to the experience. Another option is to pre-record the canal tour script and broadcast this to the passengers' headsets on board the boat. This option could allow passengers to customize their listening experience by choosing their preferred language. If this option were implemented, tour guides would not be needed on the boats, providing a possible incentive for tour boat companies to invest in altering the current speaker system.

Recommendations for Miljøpunkt Indre By & Christianshavn

Catalyze Change Through Creative Means

As the movement to phase out the use of diesel fuel in canal tour boats continues to build momentum, it is essential to continue to engage and empower the residents of Christianshavn and Indre By who are affected. Throughout our interactions with key stakeholders, we have learned that voices can be an incredibly powerful tool in driving change.

Facilitating conversations to bolster voices that may otherwise go unheard is critical in building a strong community of active participants.

Creative works can be a powerful means of spreading awareness and engaging individuals in a movement.

In an article published by the National Endowment for the Arts, artist Marisa Morán Jahn was asked to help spread the word about the passing of the Domestic Worker Bill of Rights in New York.

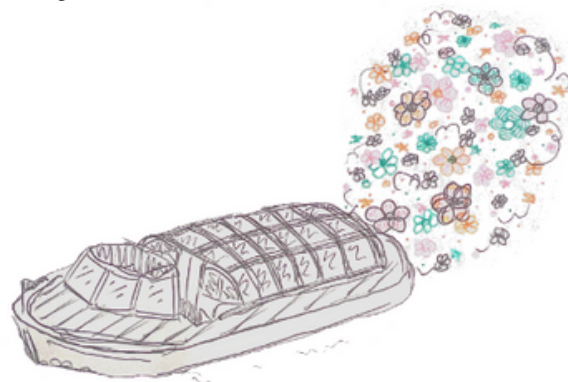
Challenged to empower workers to view themselves as a community with the power to make a change, Jahn developed several platforms including a mobile app, radio show, and poster-sized artwork, which successfully amplified the workers' voices. As a result of her efforts, Jahn concluded that “the arts are particularly useful for building a movement, building a sense of cohesiveness, and empowering a group of people” (Empowering Through Art, n.d.). Similarly, our team sees a key opportunity for carefully constructed artistic developments or engagement strategies to be integrated throughout the movement for canal tour boat conversion.

Paintings, collages, vision boards, posters, and murals are powerful tools that could be used creatively to depict the urgency of phasing out the operation of diesel canal tour boats. The strategic use of color, quotations, and images could be used to the advantage of the movement, providing viewers with

the opportunity to react and speak out. Some artistic elements could include depictions of environmental pollutants, the health of community members, water quality, and noise levels.

Deliberate and strategic placement of these art installments is essential to consider. Placing the work in high-traffic areas along the canals of Indre By and Christianshavn will attract the attention of community members, hopefully inspiring conversations that may not have occurred otherwise. Compelling art activism could also be displayed at the Christianshavn and Indre By local committee meetings, brought to the attention of By & Havn, and shared with the municipality. Art can remind those in power of the pressing need to implement emission regulations for vessels operating throughout the canals.

The media could also be utilized as a means to reach a broad audience. Discussing the movement on public radio or television could prompt critical conversations and spread awareness of the movement. Lars Trier Mogensen, the moderator for the citizens' meeting we attended, hosts a radio show called P1. This could be a possible means for spreading awareness of our project and the ongoing green conversion movement. As a moderator, Mogensen encouraged panelists to share their stances and aimed to get to the crux of the issues by asking critical questions. People like Mogensen are a valuable addition to the constituency pushing for the success of green conversion.



Artistic depiction of a canal tour boat (Ian Poulsen).

Final Considerations and Limitations

Evolving discussions with our sponsor, Marianne Spang-Bech, has led us to consider future iterations to this project. Numerous proposals and strategies have been developed by the municipality, including the 2018 municipality planning strategy and the 2019 municipal plan for land use. These plans offer a great foundation for change, but the actual laying of bricks has been limited. How can these plans become a reality?

Since undertaking this project, we have completed archival research and enlisted the help of our sponsor to track down the 2037 permit, but have yet to see it. As addressed earlier in this report, we have been denied access to Strömme's conversion proposal to By & Havn. Thanks to Spang-Bech, we officially applied for legal access to the permit. According to Spang-Bech, receiving access to such a document usually is given within two business days. We have yet to receive the permit. It is critical to analyze both the permit and Strömme's proposal to By & Havn to better develop the political and legal contexts of this project. After an interview with a By & Havn representative, we learned that the process of handling permits and contracts is separate.

The board of directors handles commercial contractual agreements such as the 2037 agreement whereas lawyers handle the permits. It is important to note that according to contract law, the contracts and permits are legally binding, which is why until 2037, no changes can be made to the agreed-upon permit and agreement stipulations awarded to canal tour companies.

We now understand that an emphasis on the health of canal tour boat operators would provide an excellent platform for Miljøpunkt to push this project forward. These operators are more frequently exposed to the pollution from these boats and therefore are critical stakeholders that require further investigation. Finally, a rumor circulating the community emerged through interviews and meetings. The rumor claims that Strömme's diesel canal tour boats from Amsterdam were moved to Denmark after Amsterdam banned diesel and petrol-powered boats. Mads Vestergaard Olesen claims that all of Strömme Denmark's boats were built and sold in Denmark. We can neither confirm nor deny this rumor based on the information acquired through our research process. Further investigation into this rumor would provide an important addition to the scope of this project.

Conclusion

Our project was framed around the initial research question: Why are diesel canal tour boats unregulated until 2037? During our time in Denmark, we have gained valuable insight from residents about the nexus between business and politics. The parties responsible for the decision-making process comprise a complex web of interconnected agendas. Our analysis required the valuable input of all critical stakeholders impacted by the diesel canal tour boats. We are deeply grateful for the candid participation of local committees, politicians, canal tour businesses, and community members. Our eyes have been opened to the importance of productive communication between stakeholders. We discovered that stalemates in dialogue can lead to negligence and delays, which in turn limit progress toward climate goals. We hope our efforts to build a constituency and catalyze action for concrete change can resonate with our final message: **change lies in the hands of all community members.**



Sculpture on display in Christiania (Photo credit: Ian Poulsen, March 18, 2024).

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Appendix A: Flyer – Grønne Havne

Grønne havne

MILJØPUNKT
INDRE BY & CHRISTIANSHAVN
AGENDA 21 FOR ET BÆREDYGTIGT KBH



Vidste du, at flertallet af kanalrundfartsbådene, som sejler i Københavns Havn og kanaler, sejler på diesel og forurener? Det vil vi gerne lave om på og vi vil gerne have dig med.



Scan med kamera for at deltage
i vores undersøgelse

English Translation: Green harbor – Did you know that the majority of canal tour boats that sail in Copenhagen's port and canals run on diesel and pollute? We want to change that and we want you to join us. Scan with camera to participate in our survey.

Appendix B: Survey – Hvorfor diesel?

Vi bruger dine svar og data til et bæredygtighedsprojekt i Miljøpunkt Indre By & Christianshavn. Det er vores håb, at vi med jeres svar om, hvordan kanalturbådene påvirker dig, kan fremme den grønne omstilling af kanalturbådene i Københavns Havn. Tusind tak for dit input!

Bor du tæt på havnen eller en af kanalerne?

Ja Nej

Forstyrrer luftforurening fra kanalturbådene aspekter af dit daglige liv?

Ja Nej

Forstyrrer støjforurening fra kanalturbådene aspekter af dit daglige liv?

Ja Nej

Tror du, at kanalturbådsindustrien er på linje med Københavns bæredygtighedsmål?

Ja Nej

Ville du stemme for at konvertere nuværende kanalbåde til elektriske både?

Ja Nej

Vil du være villig til at mødes med os for at diskutere yderligere? I så fald bedes du angive dine kontaktoplysninger, helst e-mail:

We will use your answers and data for a sustainability project in Miljøpunkt Indre By & Christianshavn. It is our hope that with your answers about how the canal boats affect you, we can promote the green conversion of the canal boats in the Port of Copenhagen. Thank you for your input!

Do you live close to the harbor or one of the canals?

Yes No

Does air pollution from the canal tour boats disrupt aspects of your daily life?

Yes No

Does noise pollution from canal tour boats interfere with aspects of your daily life?

Yes No

Do you think the canal tour industry is aligned with Copenhagen's sustainability goals?

Yes No

Would you vote to convert current canal boats to electric boats?

Yes No

Would you be willing to meet with us to discuss further? If so, please provide your contact details, preferably email:

Appendix C: Interview Guides

We are a group of students from Worcester Polytechnic Institute (WPI) in the United States. We are conducting interviews to learn more about the perceptions of the operation of diesel-fueled canal tour boats in the ports of Copenhagen. The final results will be made public, and you may remain anonymous upon request.

Questions for local residents:

1. Why did you want to do this interview? What drew you to our project?
2. We want to hear your thoughts, opinions, experiences, and stories about canal cruise boats operating on diesel fuel.
3. Given that the city of Copenhagen is aiming to achieve carbon neutrality by 2035, what is your opinion on the current agreement allowing canal cruise boats to operate using diesel fuel until 2037?
4. Do you have any ideas as to why the 2037 agreement was passed?
5. Would you favor regulation to phase out combustion engines in harbor/canal cruise boats?
6. What would it take to phase out combustion engines in cruise boats within Copenhagen's harbor and canal districts?
7. Do you have any outreach strategies or recommendations for our team as we continue our research?

Questions for Strömme CEO:

1. What will it take to phase out combustion engines in tour boats within Copenhagen's harbor and canal districts by 2035?
2. Can we have a copy of Strömme's proposed plan to convert the Danish fleet?
3. How does Strömme's environmental goals compare to those of Nettobådene?
4. How did Strömme handle the quiet zone implementation in Christianshavn?
5. Do you think using solar powered vessels is feasible?

Appendix C: Interview Guides (cont.)

Questions for By & Havn representative:

1. Can you provide us with a brief overview of the permit to sail? What is the process of giving the permits for sailing?
2. Why are the sailing permits not modifiable? In what cases could the permit be modified or voided?
3. Why are there no stipulations in the permit for environmental goals? Why was this permit allowed to pass given Copenhagen's clear green agenda (outlined in Danish Environmental Protection Act, 2018 municipality planning strategy, and the 2019 municipal plan for land use)?
4. What is the current status of the zone plan for Copenhagen's waters? Will this include emission-free zones?
5. What power, if any, does By & Havn have to enforce businesses to convert to electric?
6. Why were Tourism Group International, Hey Captain, and El-Bådfart (other tourism groups) rejected from their application to operate in Nyhavn?
7. Do any companies get priority in sailing permits in Copenhagen's canals?

Questions for Silent Events representative:

1. How do you think Silent Events technology could change the canal tour experience, for both customers and those who live near the canals?
2. How feasible is it to implement this technology on an existing canal boat?
3. Have you thought about partnering with a canal tour boat company to utilize your technology?
4. What is the expected cost to purchase Silent Events technology for a canal tour boat that seats 150 passengers?

Appendix D: Interview Consent Form

Without recording, we will ask if we have permission to record. If the participant answers “yes”, then tell the participant the following with the camera/recorder rolling:


“This project involves recording interviews as part of an educational project. By appearing on camera/audio, you are consenting to the use of your image/voice for the purpose of our project, which will be published on the WPI website.”

“Please tell us your name and title (if applicable).”

“We are here on (date of interview) to talk about...” continue with interview questions.

At the end of the interview, we will offer to send the interviewee a recording of the interview if they want it. The interviewee can withdraw their consent for us to use the video recording at any time during the interview process.

Appendix E: P-Trak Ultrafine Particle Counter Calibration Certificate

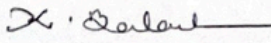
		<h2>Calibration Certificate</h2>									
		<p>TSI Instruments Ltd, Stirling Road, Cressex Business Park, High Wycombe, HP12 3ST, UK TEL: +44-(0)1494 459200 FAX: +44-(0)1494 459700 www.tsi.com</p>									
<table border="1"> <tr> <td style="text-align: center;">CALIBRATION STANDARDS USED</td> <td style="text-align: center;">MODEL</td> <td colspan="2" style="text-align: center;">P-TRAK® Ultrafine Particle Counter 8525</td> </tr> <tr> <td style="text-align: center;">PortaCount Bench UK1</td> <td style="text-align: center;">SERIAL NO.</td> <td colspan="2" style="text-align: center;">8525-11100001</td> </tr> </table>		CALIBRATION STANDARDS USED	MODEL	P-TRAK® Ultrafine Particle Counter 8525		PortaCount Bench UK1	SERIAL NO.	8525-11100001			
CALIBRATION STANDARDS USED	MODEL	P-TRAK® Ultrafine Particle Counter 8525									
PortaCount Bench UK1	SERIAL NO.	8525-11100001									
VERIFICATION DATA (PARTICLE CONCENTRATION)											
TESTING NUMBER	MEASURED CONCENTRATION IN <i>Particles/cm³</i> Tolerance: 95% to 105% of standard										
	TESTING STANDARD	INSTRUMENT OUTPUT	PERCENT OF STANDARD								
1	100.5	100.0	99.41								
2	314.9	314.5	99.87								
3	731.8	726.0	99.20								
4	2120.2	2098.6	98.99								
5	5872.6	5856.7	99.73								

* Indicates out of tolerance condition

TSI Instruments Ltd does hereby certify that the above described instrument conforms to the original manufacturer's specifications (not applicable to As Found data) and has been tested using some (but not all) standards whose accuracies are traceable to National Standards or have been derived from accepted values of natural physical constants or have been derived by the ratio type of self calibration techniques. This report may not be reproduced, except in full, unless permission for the publication of an approved abstract is obtained in writing from the calibration organisation issuing this report.

Measurement Variable	System ID Number	Date Last Calibrated	Calibration Due Date
DC Voltage	E006226	09-06-23	09-06-24
DC Voltage	E006225	09-06-23	09-06-24
Particle Concentration	UK3772171302	09-02-23	09-02-24
Particle Concentration	UK3772171304	09-02-23	09-02-24
Particle Concentration	E006278	15-12-23	15-12-24

Calibration procedure used: 10000005005 Overall Rating: PASS







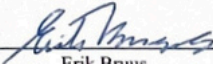
 Calibrated By

Dec. 20, 2023

 Calibration Date

TSI P/N 2300157

Appendix F: Brüel & Kjær Sound Level Meter Calibration Certificate

 HOTTINGER BRÜEL & KJÆR The Calibration Laboratory Teknikerbyen 28, DK-2830 Virum, Denmark				 DANAK CAL. Reg. No. 307 Member of EA MLA	
CERTIFICATE OF CALIBRATION			No: CDK2400151		Page 1 of 11
CALIBRATION OF					
Sound Level Meter:	Brüel & Kjær Type 2250 Light	No: 3002828	Id: -		
Microphone:	Brüel & Kjær Type 4950	No: 2827103			
PreAmplifier:	Brüel & Kjær Type ZC-0032	No: 18725			
Calibrator:	None				
Software version:	BZ7130 Version 4.7.6	Pattern Approval: -			
Instruction manual:	BE1853-11				
CUSTOMER					
Fonden Miljøpunkt Indre By & Christianshavn Brolæggerstræde 14A, stuen 1211 København K Denmark					
CALIBRATION CONDITIONS					
Preconditioning:	4 hours at 23°C ± 3°C				
Environment conditions:	See actual values in <i>Environmental conditions</i> sections.				
SPECIFICATIONS					
The Sound Level Meter Brüel & Kjær Type 2250 Light has been calibrated in accordance with the requirements as specified in IEC 61672-1:2013 class 1. Procedures from IEC 61672-3:2013 were used to perform the periodic tests. The accreditation assures the traceability to the international units system SI.					
PROCEDURE					
The measurements have been performed with the assistance of Brüel & Kjær Sound Level Meter Calibration System 3630 with application software type 7763 (version 9.0 - DB: 9.00) by using procedure B&K proc 2250-L, 4950 (IEC 61672:2013).					
RESULTS					
Calibration Mode: Calibration as received.					
The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor $k = 2$ providing a level of confidence of approximately 95 %. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the device(s) under calibration. The results are only applicable for the specific device(s) listed above.					
Date of calibration: 2024-01-09			Date of issue: 2024-01-09		
 Lene Petersen Calibration Technician			 Erik Bruus Approved Signatory		
Reproduction of the complete certificate is allowed. Parts of the certificate may only be reproduced after written permission.					