



Fossil-Free Port Project

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The Problem

- Tour boat and sea plane use of the canals and harbour causes air and noise pollution
- The municipality can not enforce electrification directly
- The proponents of making canals fossil free want a faster timeline



What is our project goal?

Our goal is to assist Miljøpunkt in hastening the electrification in the Port of Copenhagen before the current 2037 timeline by providing a thorough analysis of the obstacles and trade-offs of electrification.



Approach

Assess current problems associated with non-electric commercial vehicles



Explore the roadblocks towards conversion of electric boats

Determine tourist opinions to see if electrification leads to increased revenue

Current problems with non-electric commercial vehicles



Health Risks: Short-term for Adults

Within **1 day**:

- 2% increase in cardiovascular

Within **2 days**:

- 13% increase in COPD mortality
- 8% increase in asthma hospital admissions

Within **4-6 days**:

- 4% increase in respiratory hospital admissions

Health Risks: Short-term for Children

Within **3 days**:

- 4% increase in respiratory infection
- 4% increase in upper respiratory infection
- 6% increase in pneumonia

Effects strongest in children under 15 and boys

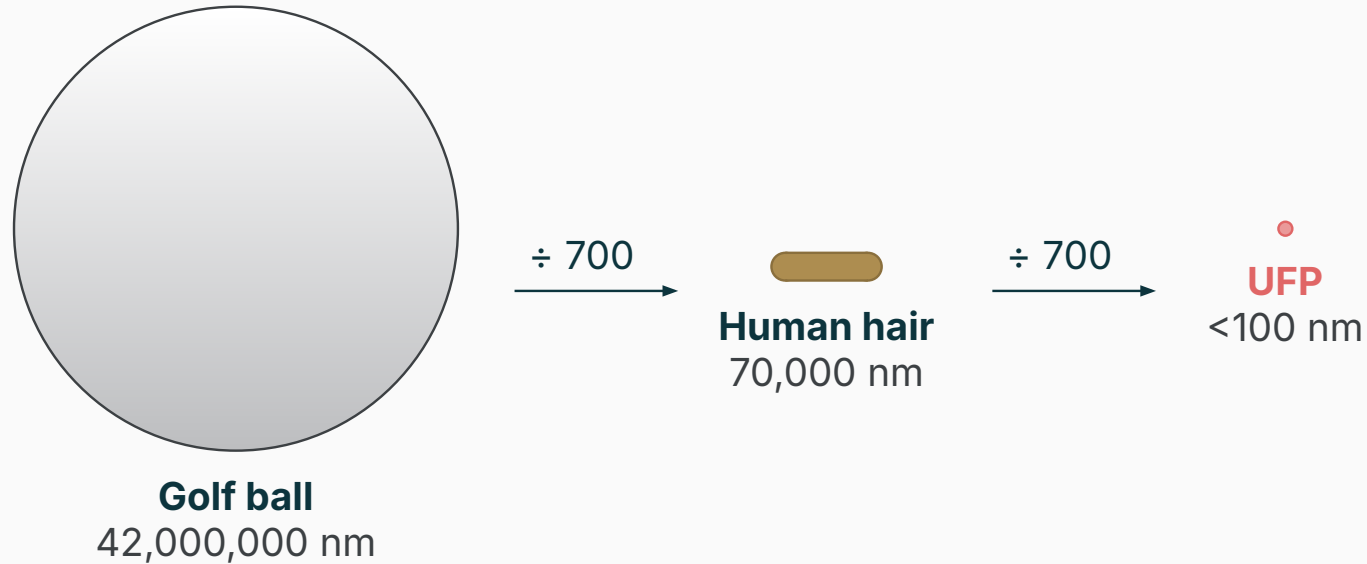
Health Risks: Long-term

Associations with:

- Cardiovascular disease
 - Diabetes
 - Stroke
 - Brain tumors
- Elevated C-reactive protein
(marker of systemic inflammation)

What is a UFP?

Definition: Particulates smaller than $0.1\mu\text{m}$



Each step is 700x smaller than the previous

Taking UFP Measurements of Canal Boats



How we measured

- P-Trak 8525 Ultrafine Particle Counter
- Wind Meter
- Notes on Variables

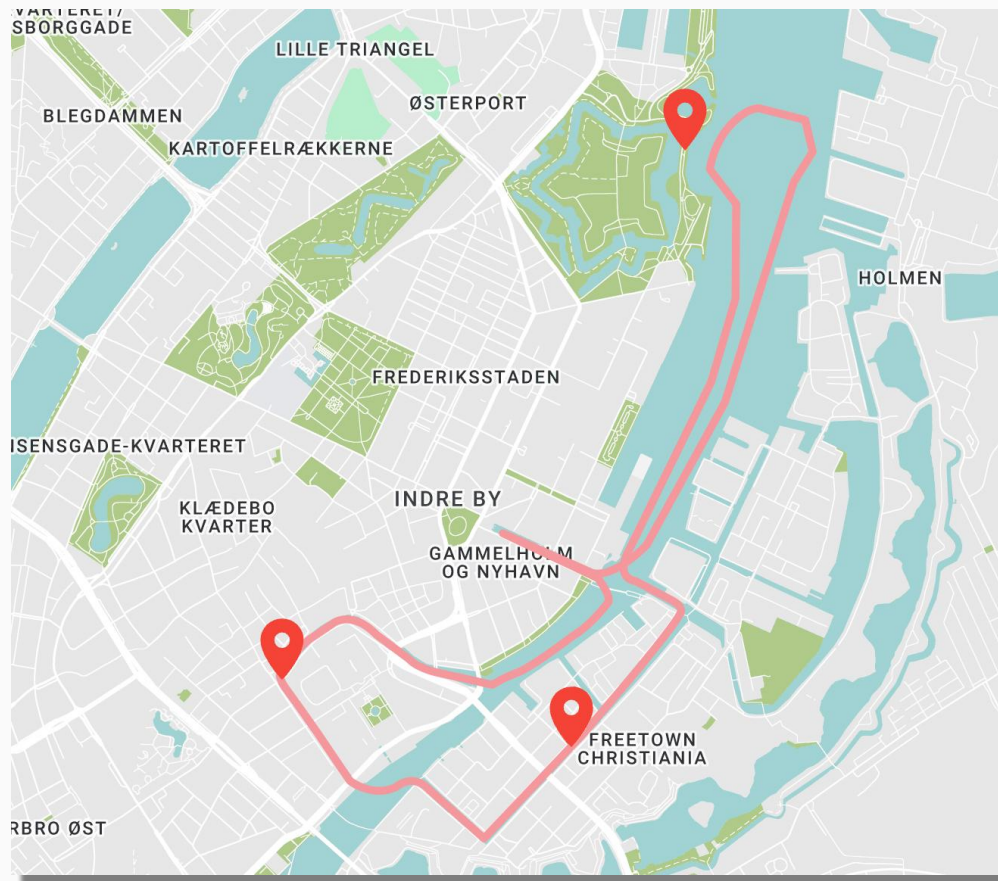
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Where we measured

Stormbroen

Snorrebroen

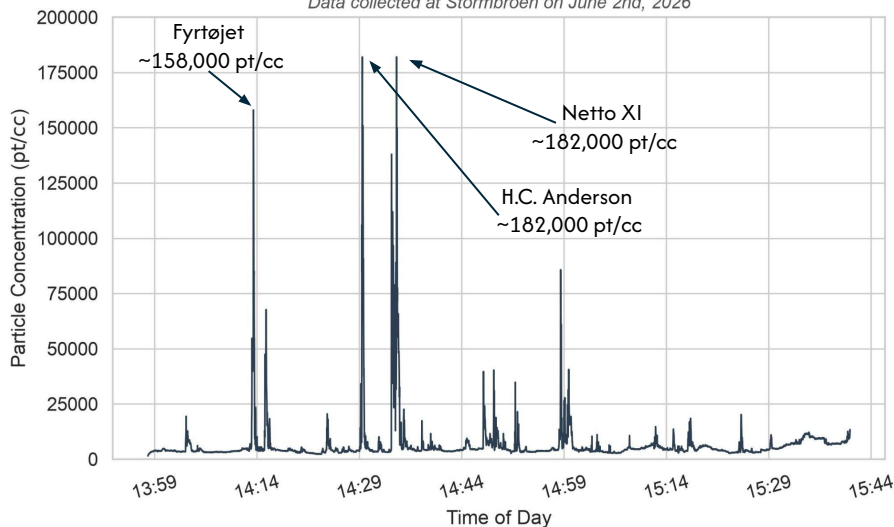
Langelinie Park



Our Measurement Findings: Both Bridges

Ultrafine Particle Measurements

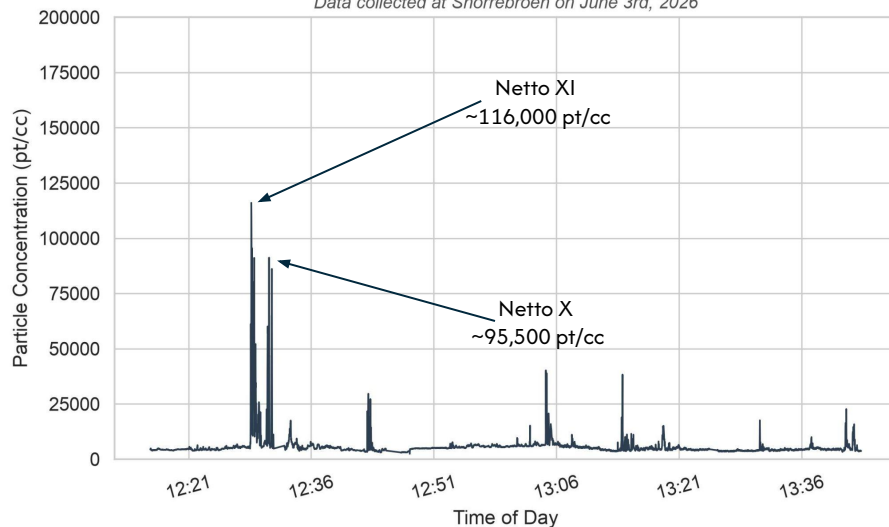
Data collected at Stormbroen on June 2nd, 2026



Wind range: 0 - 11.3 km/h

Ultrafine Particle Measurements

Data collected at Snorrebroen on June 3rd, 2026

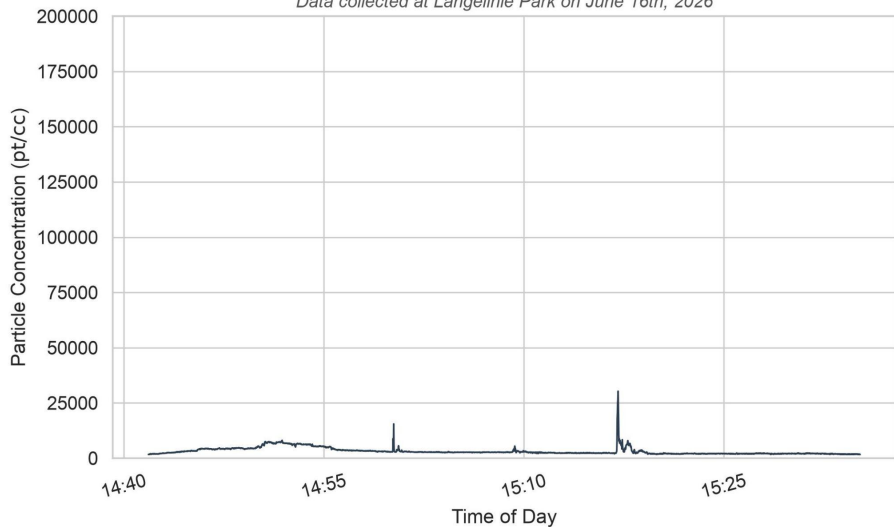


Wind range: 0 - 17.3 km/h

Our Measurement Findings: Langelinie Park

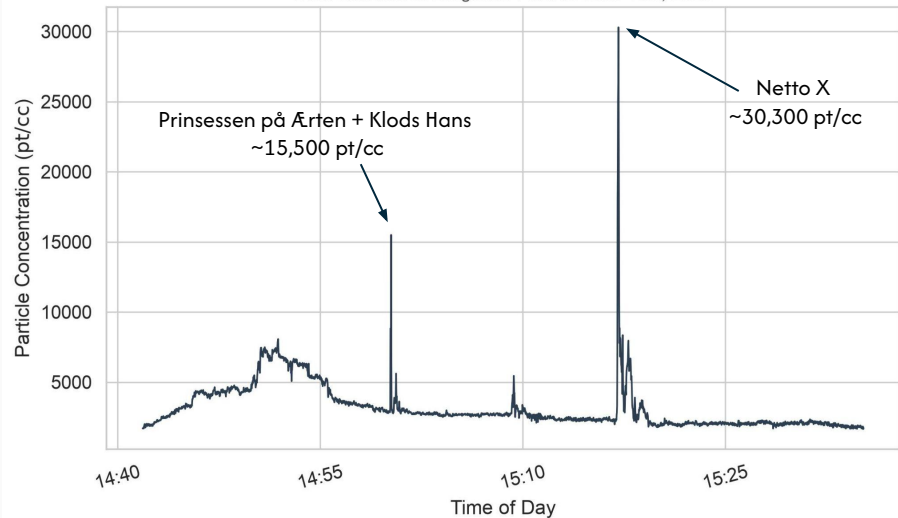
Ultrafine Particle Measurements

Data collected at Langelinie Park on June 16th, 2026



Ultrafine Particle Measurements

Data collected at Langelinie Park on June 16th, 2026



Wind range: 0 - 5 km/h

What this means

Canal boat emissions at Stormbroen exceed by **59 times** the UFP concentration already linked to a **13% increase** in COPD deaths and an **8% increase** in asthma hospitalizations in Copenhagen residents **within 48 hours of exposure**.

At Langelinie Park, concentrations still exceed by **10 times** the level linked to a **6% increase** in pneumonia hospitalizations in children **within three days**.

There is no safe exposure limit for UFPs. Unlike PM2.5 and NO2, **no WHO guideline exists**.

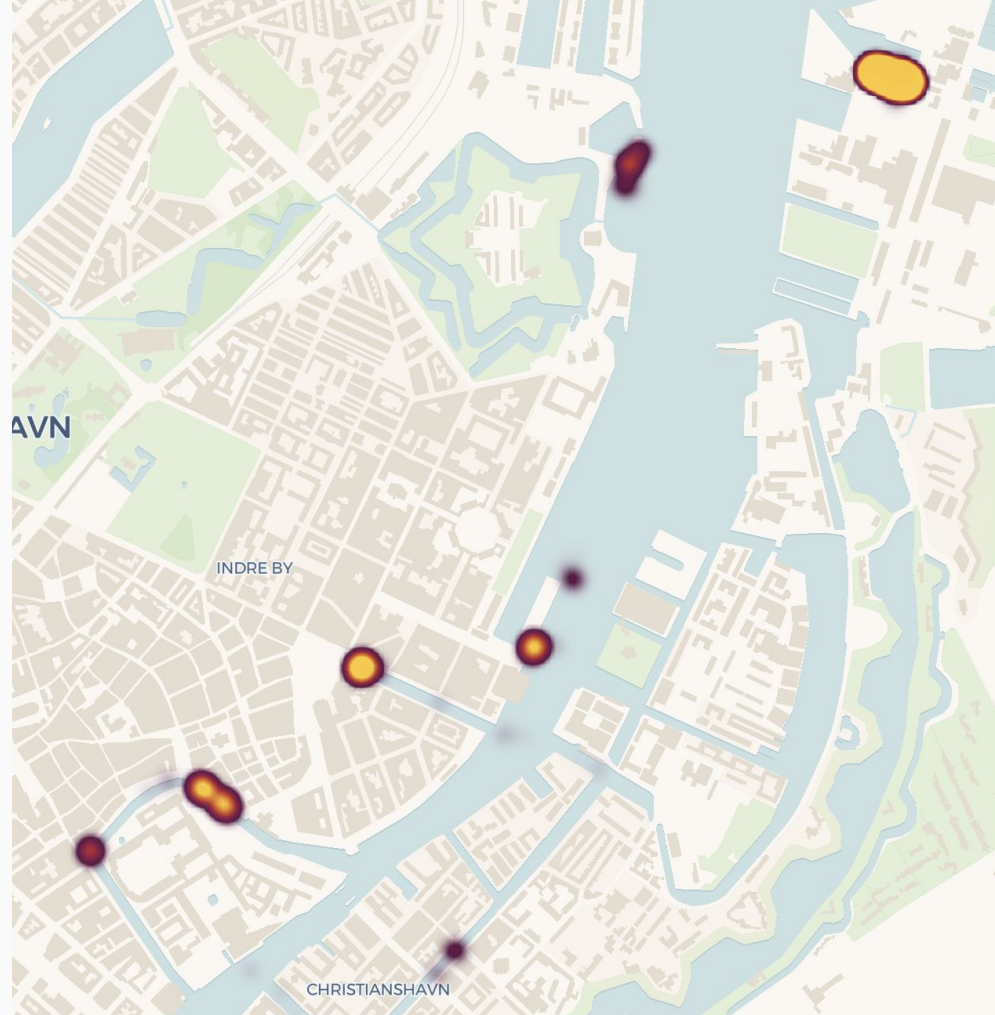
Seaplanes

- Our data collection was inconclusive
- UFP emissions have been recorded up to **80,000 pt/cc**
- Sound levels have been recorded **up to 90 dB**
- The previous IQP showed clear issues with the sea planes
- Currently operate in Langelinie Park
- Can pose significant health risk



Calculating CO₂ emissions

- Climate Change Implications
- Fuel Burned → CO₂ Emitted
- Stromma uses HVO



Calculated Power Needed to Move a Boat

Input Variable: Speed

Range: 0 kn to 14 kn



Resistance

$$R_f = \frac{1}{2} * \rho * WSA * 0.514V^2 * C_f$$

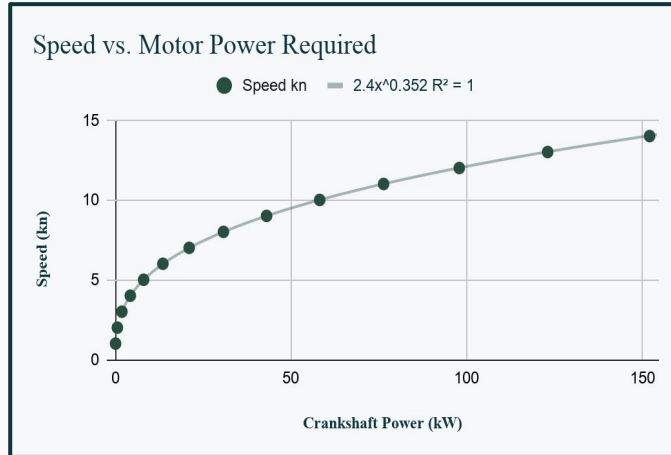
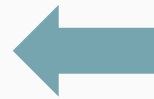
Resistance from water (N)



Power (thrust) Needed

$$P_e = R_f * 0.514V$$

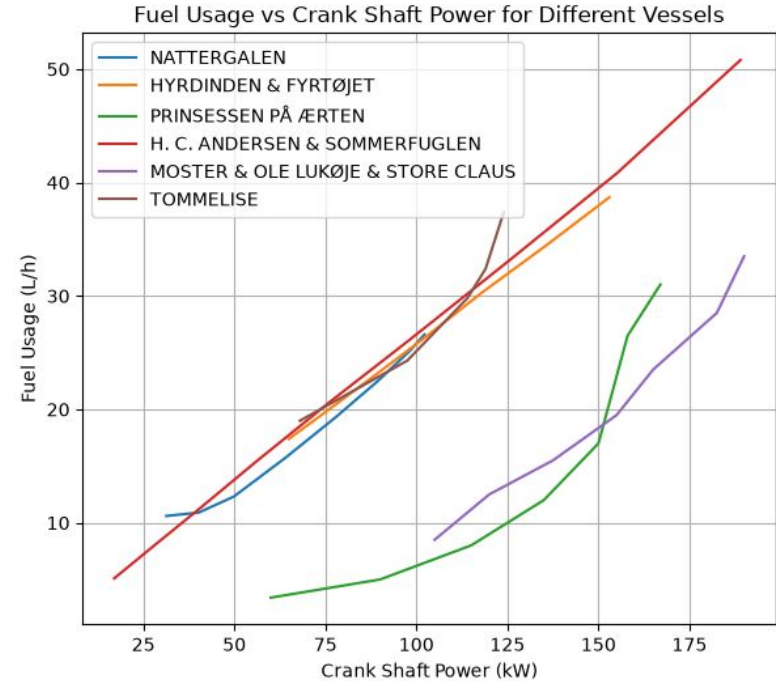
How much power (kW) is
needed to move a certain
speed



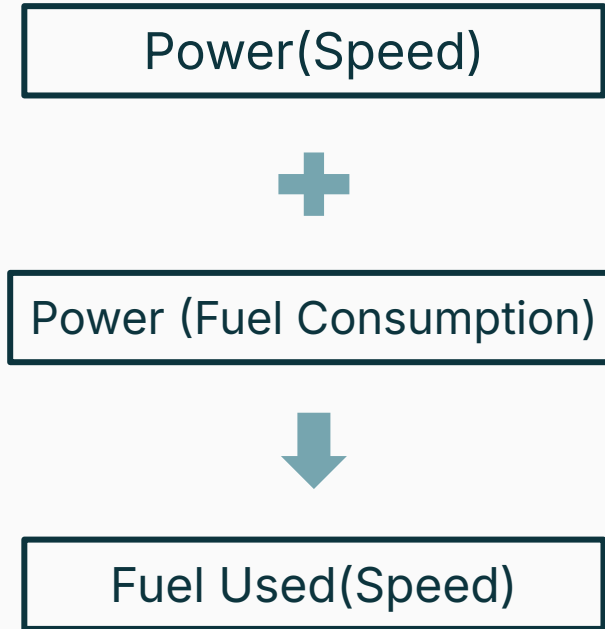
Power & Speed Relation

Calculating CO₂ Emissions

- Found in Danish Ship registry
 - Motor: make, year, and max effect
- How much does the motor need to work?



Calculating Fuel Consumption

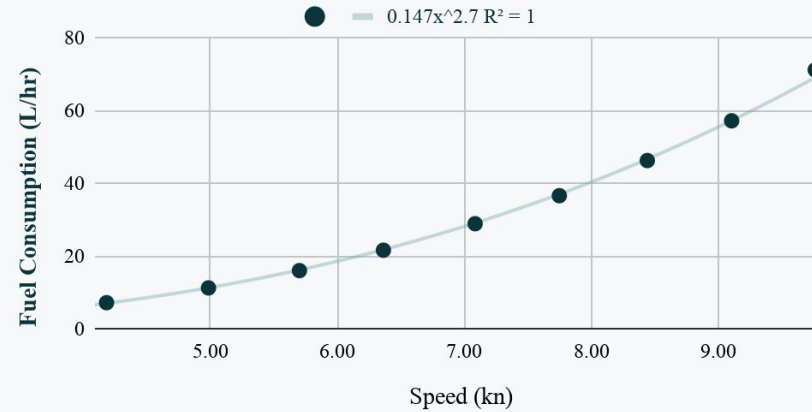


Ships: H. C. ANDERSEN & SOMMERFUGLEN			
Motor: Volvo Penta, TAMD 63 L-A			
Motor RPM	Thrust (kW)	Speed (kn)	Fuel Consumption (L/hr)
1000	4.845	4.18	7.14
1200	7.98	4.99	11.20
1400	11.685	5.70	15.96
1600	15.96	6.36	21.56
1800	21.66	7.09	28.84
2000	27.93	7.75	36.54
2200	35.625	8.44	46.20
2400	44.175	9.11	57.12
2600	53.865	9.76	71.12

Calculating Fuel Consumption

H. C. ANDERSEN & SOMMERFUGLEN Speed vs. Fuel Consumption

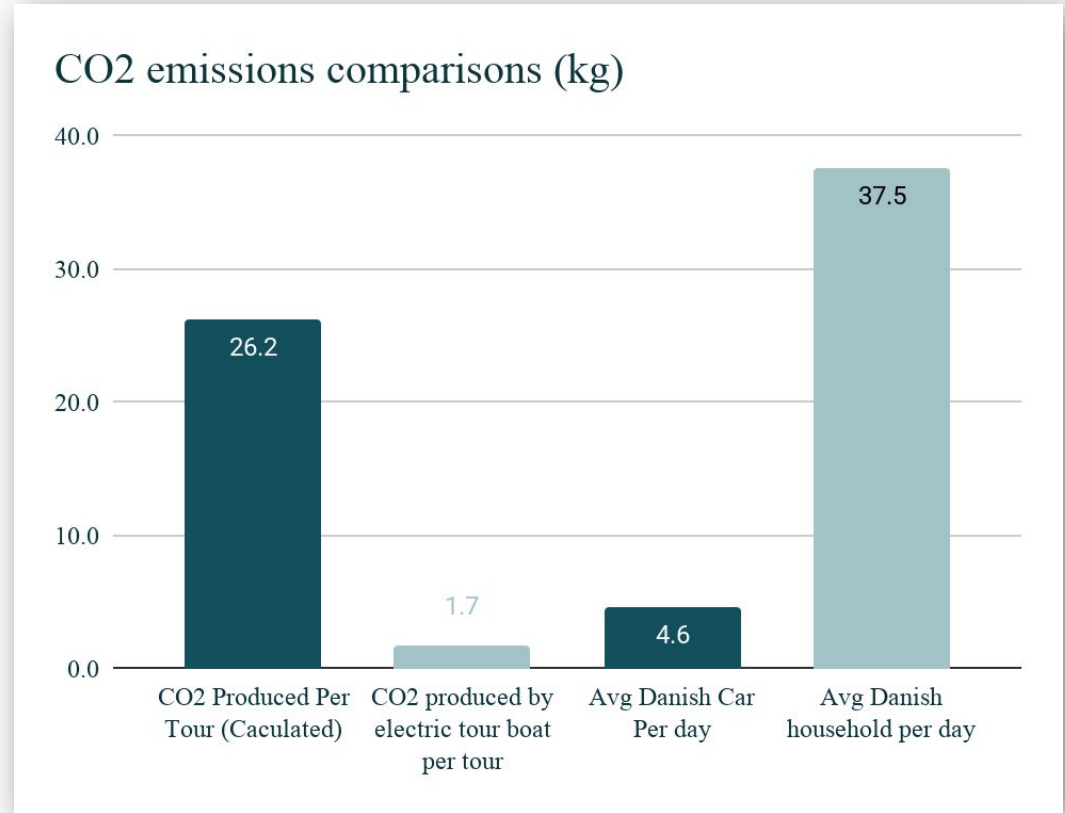
Motor: (Volvo Penta, TAMD 63 L-A)



- Avg Speed $\approx$ **5 kn** $\Rightarrow$ Fuel Consumption = **11.3 L/hr**
- Calculated Avg fuel consumption = **10.7L/hr**
- Stromma given value = **12L/hr**

Calculate the total CO₂ Emissions Per Tour

Each Tour Produced
Approximately **26.2kg**
CO₂/per tour

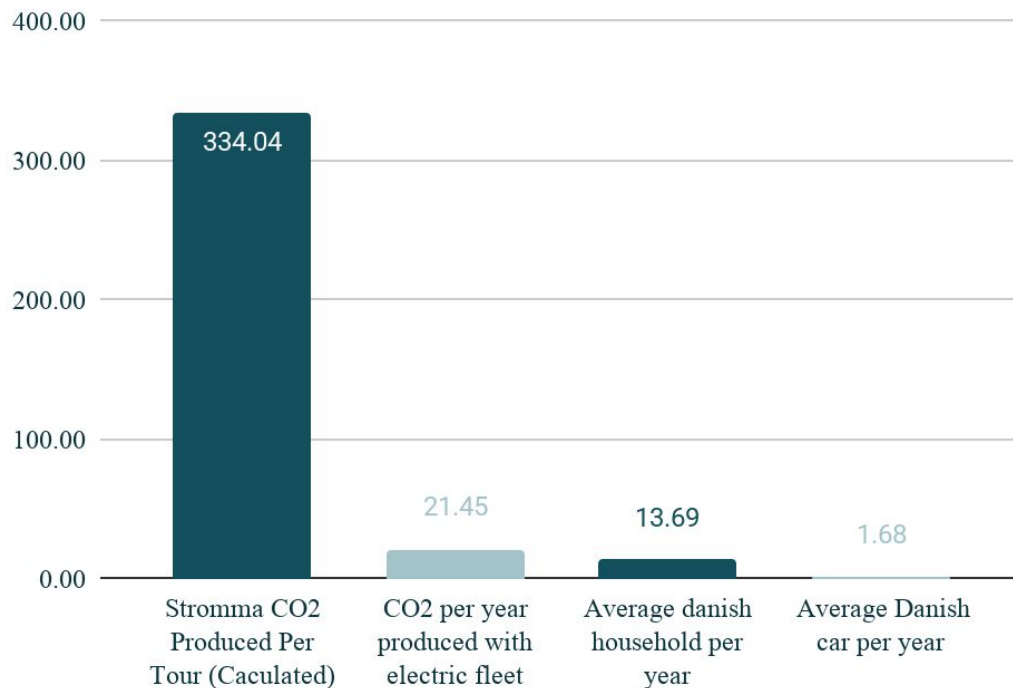


Calculate the total CO₂ Emissions Annually

With an estimated **12752**
tours in one year

≈ **210 cars**
≈ **28 homes**

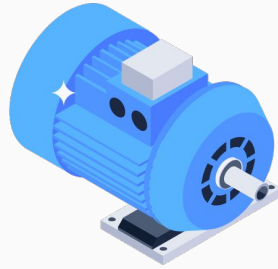
CO2 emissions comparisons annually (metric tons)



Find Cost and Infrastructure Required for Electrification



Electric Boats

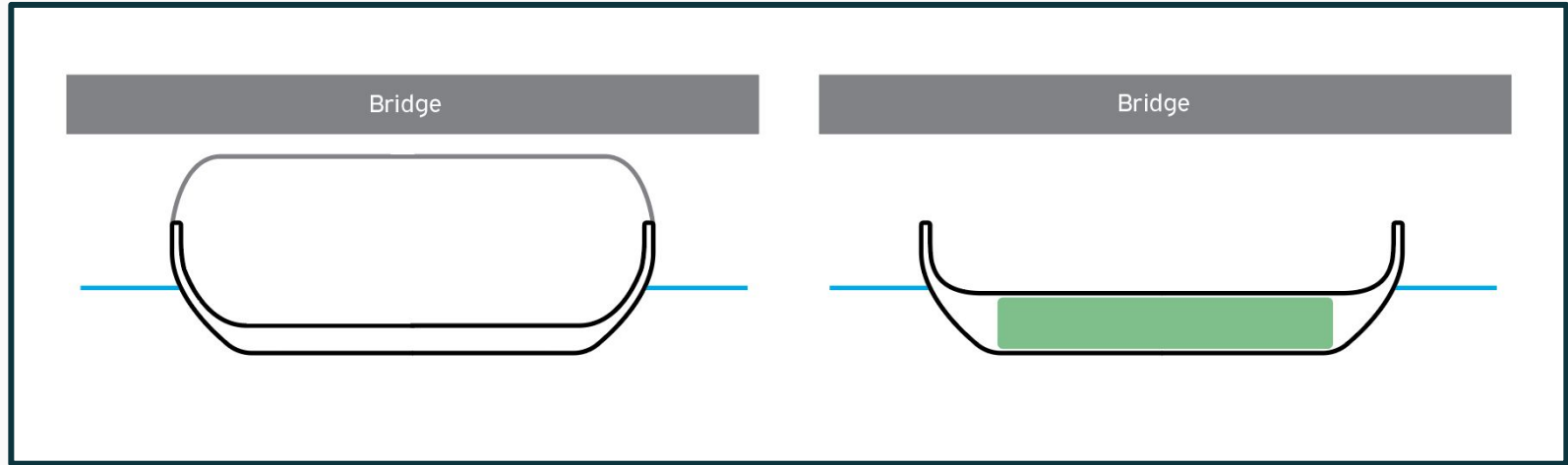


Electrification Technology

LiFePO_4 vs. Li-ion

- + Cheaper
- + Safer
- + More Cycles
- Lower Energy Density

The Bridge Clearance Issue



Power Grid Demand

Charging 10 Boats
Overnight

Worst Case

459.8 A

PER PHASE

Ideal Case

245.2 A

PER PHASE

Annual Cost Per Boat

1 diesel boat would use
8947 liters of HVO
annually.

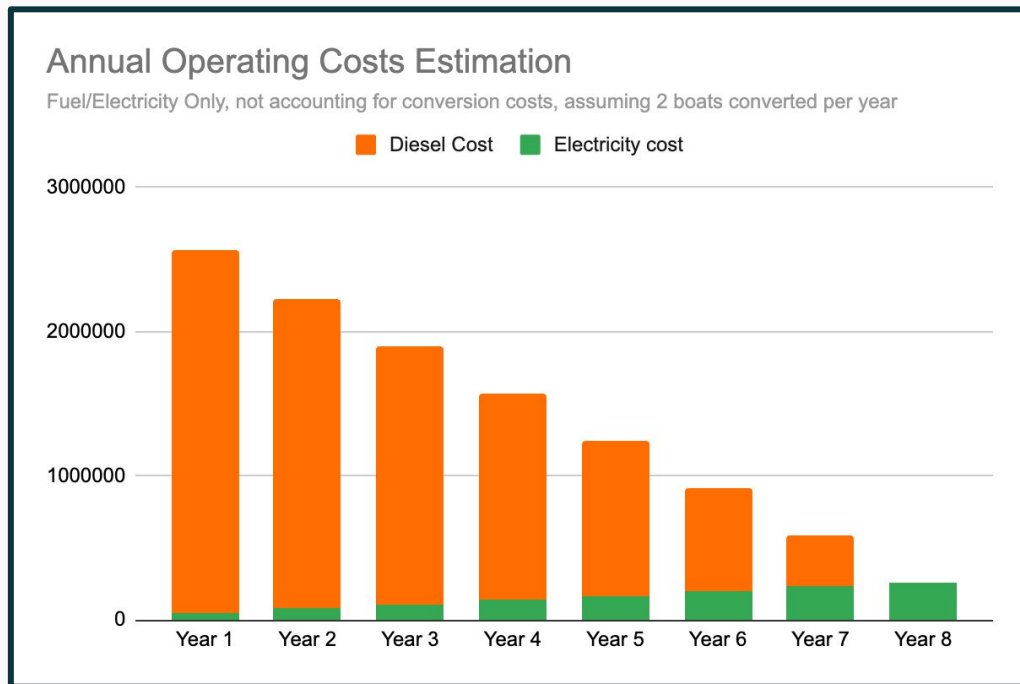
179,564.74 DKK

1 electric boat would use
15,463 kWh annually.

14,036.60 DKK

Economic Feasibility

Operating costs due to
fuel/electricity would
decrease by 89.7%

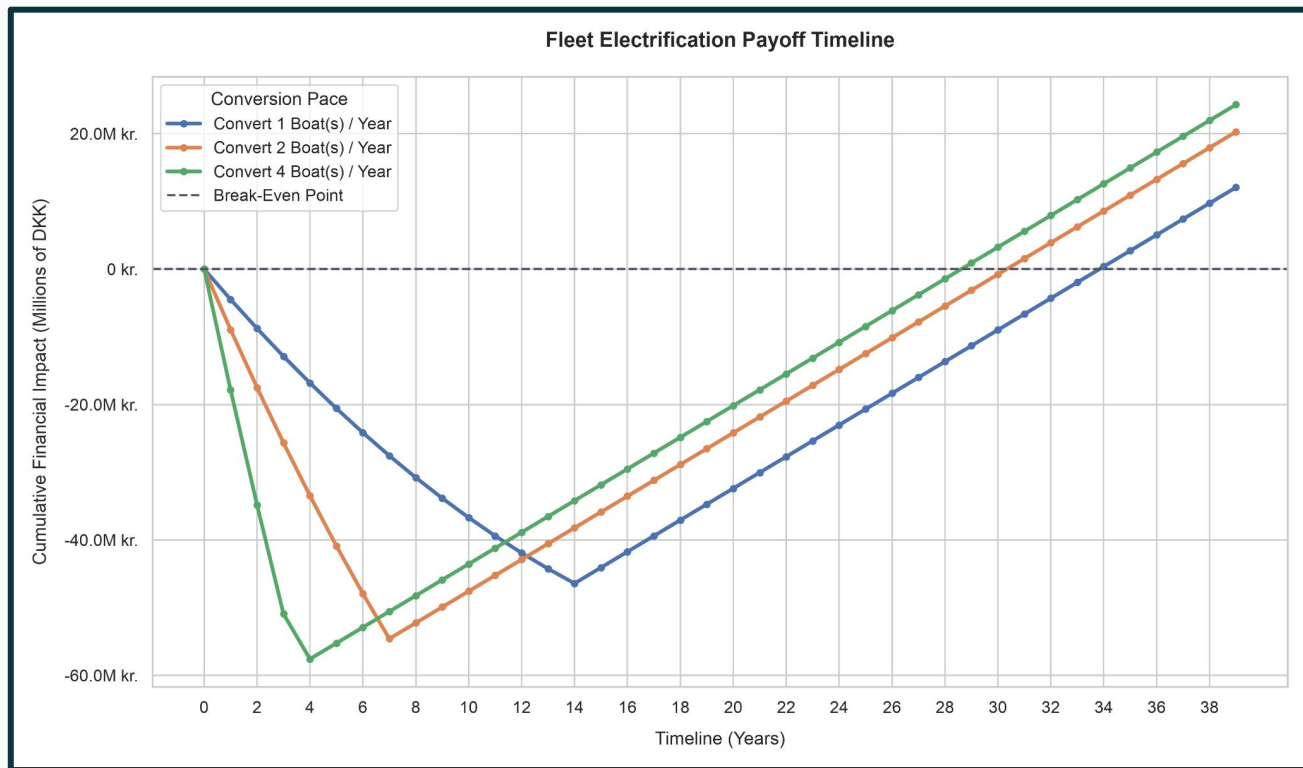


Conversion Rate

1 per year:
34 years

2 per year:
31 years

4 per year:
29 years



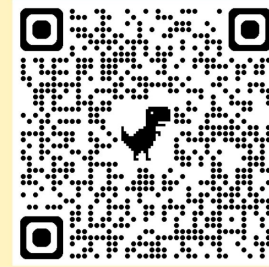
Conduct Surveys on Tourist Opinions



Offsetting Costs

- Are electric tour boats more popular for tourists?
- Would tourists pay more for a electric boat?

We are a group of students from the USA working with a local environmental group.



Please fill out this 5-question survey to help with our research on the electrification of tour boats in Copenhagen!



WPI

MILJØPUNKT
AGENDA 21 - FOR ET BÆREDYGTIGT KBH

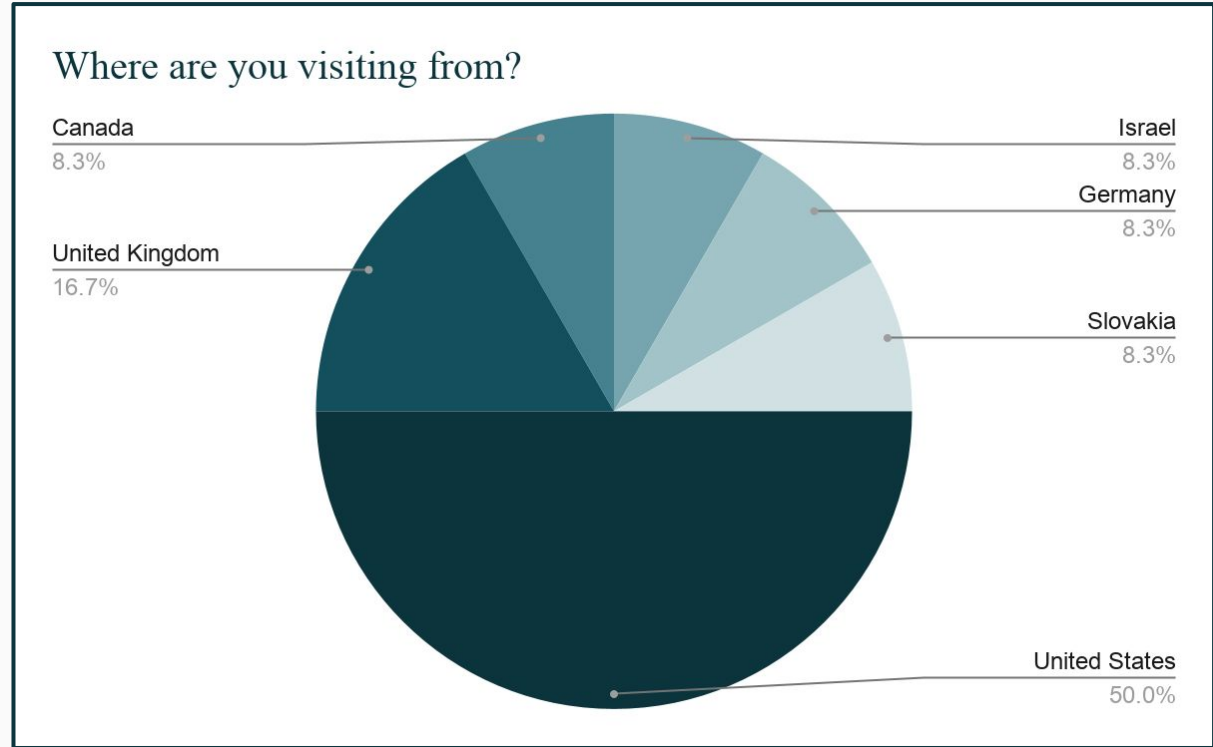


INDRE BY
CHRISTIANSHAVN

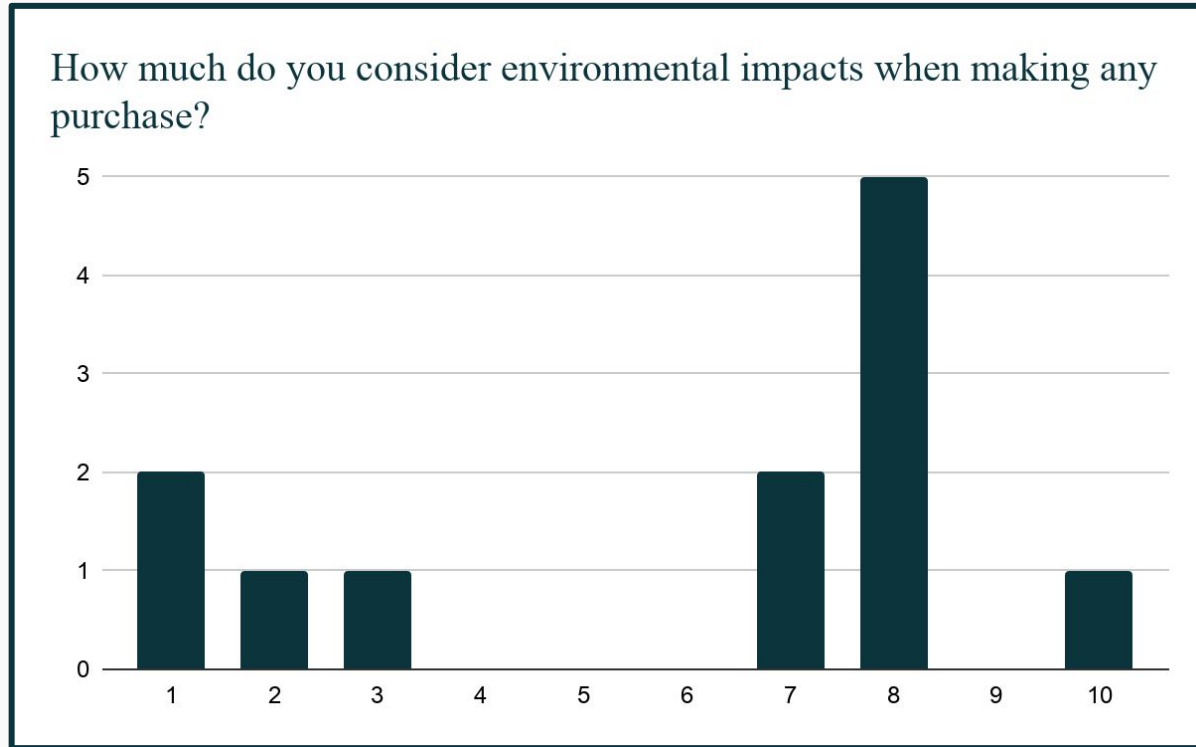
Details of the Survey

- Targeted tourists in Nyhavn and Christiansborg
- Targeted Tourist taking a Canal Tour
- 12 Respondents

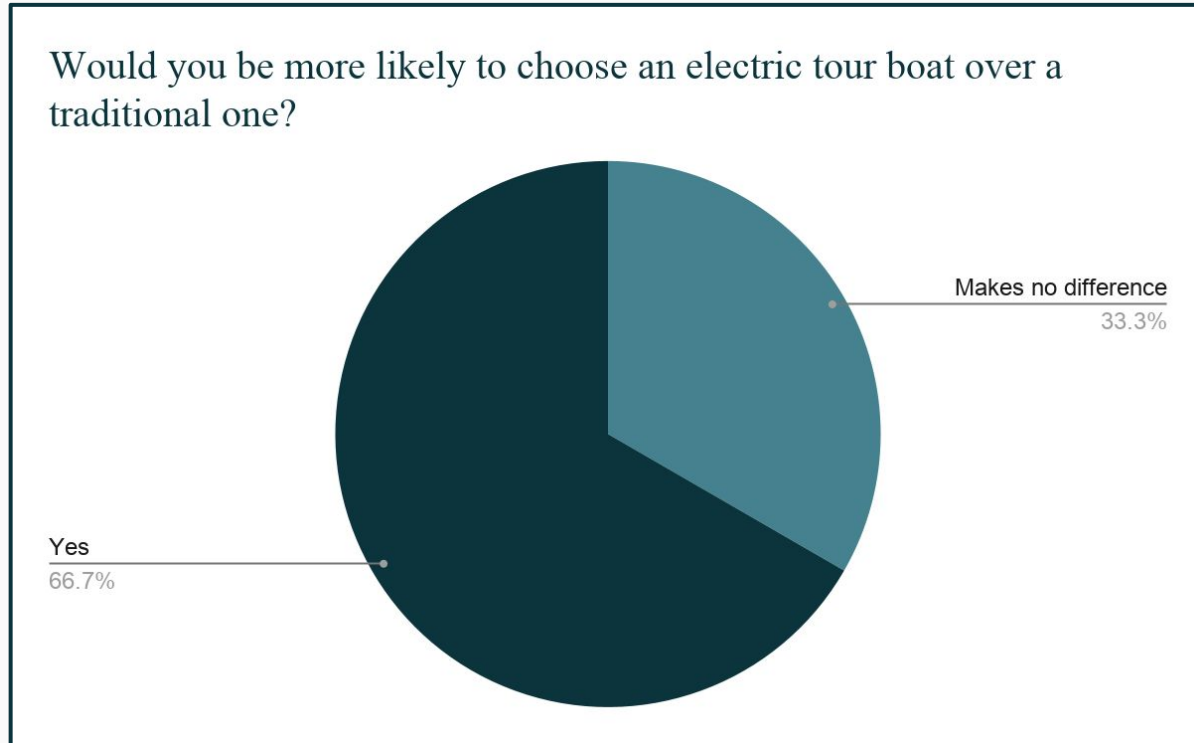
Nationalities



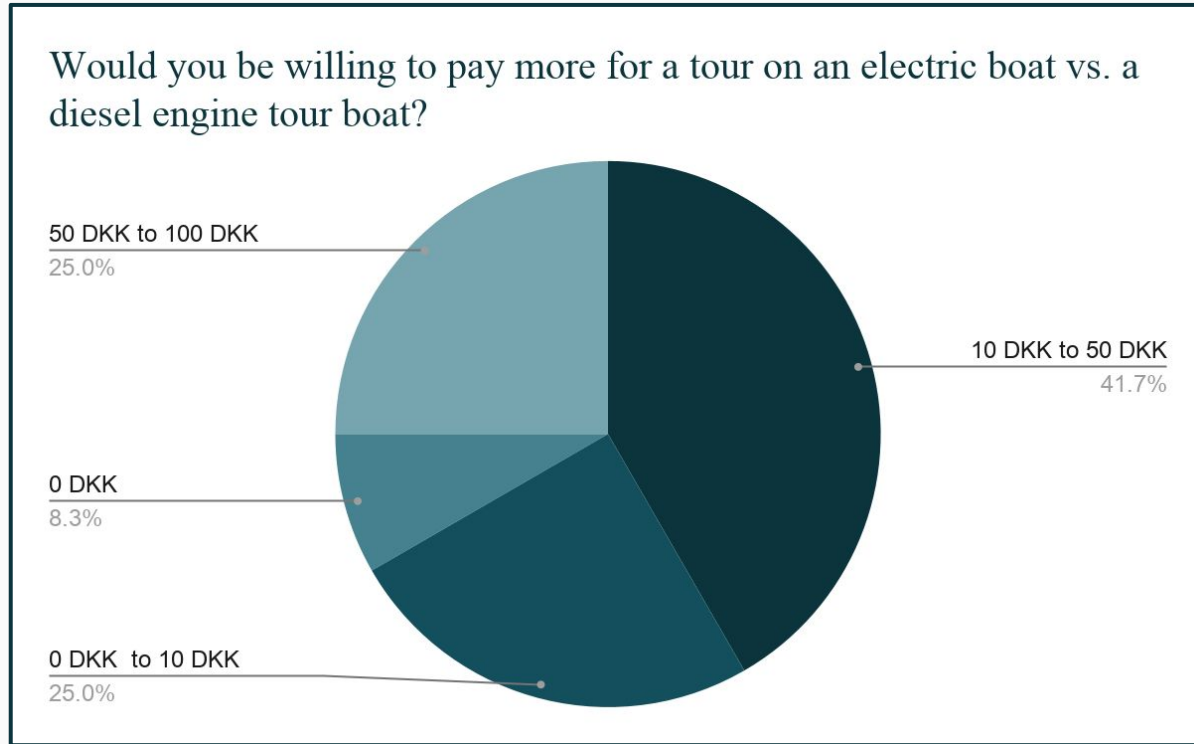
Respondents Showed Varying Interest towards Environmental Awareness



Respondents Showed More Interest in Electric Tour Boats



Respondents Showed Openness to Paying more for Electric Tours



What Can Be Done?

A Fossil Free Port Should Be a Major Focus

- Burning diesel has serious consequences on people's health
- Financially, electrification benefits all parties involved
- Electrification aligns with the goals of the municipality



What to Prioritize when Electrifying?

- Further investigate customer interest in electric tour boats
- Prioritize using the electric boats when possible
- Continue to push for electrification



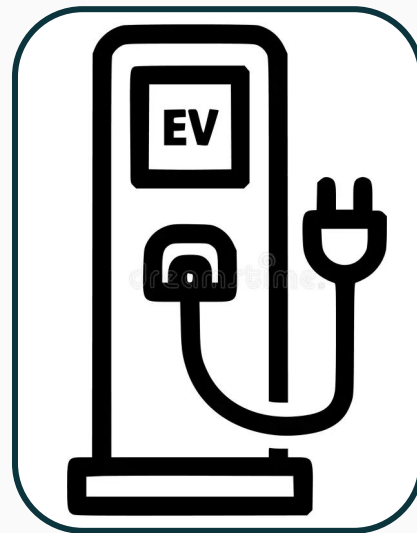
Extending Tour Boat Permits Based on Boats Converted

- Stromma wants a guarantee of canal sailing permission
- By & Havn have not offered any options
- With a guarantee, investments can begin



Find a Docking Location

- The current location is set to be developed
- A new docking location should be secured
- Municipality is interested in shared space
- Companies can invest in chargers
- All parties should work together to determine a long term location



Seaplane Dock Location

- Current location puts residents and tourists at risk
- Langelinie Park is not necessary for the sea planes to operate
- The municipality and By & Havn should act to find a new location



Any Questions?

