



Zero Emission Public Transport

General presentation – data from 2022, 2023
Jon Stenslet, manager Vehicles and depots - Ruter As

Ruter#

This presentation:

- Aims to convey conceptual information/overview
- Some information may be inaccurate or not be very latest status
 - For latest public info, please refer to:
 - <https://ruter.no/en/about-ruter/reports-projects-plans/>
 - Annual report: <https://aarsrapport2022.ruter.no/>
 - Tender sites: <https://ruter.no/kollektivanbud/moter/>
 - <https://ruter.no/kollektivanbud/arkiv/>

Latest news..

- <https://www.electrive.com/2023/04/17/oslo-unibuss-commissions-183-electric-buses/>
- <https://bus-news.com/norway-man-to-supply-76-electric-lions-city-e-buses-to-oslo/>
- <https://www.sustainable-bus.com/news/nobina-ebusco-oslo-2023/>
- Video in article, Reuters:
 - <https://www.reuters.com/world/europe/e-bus-deal-puts-oslo-track-zero-emissions-public-transport-goal-2022-10-14/>

Ruter - PTA in Oslo + part of Viken county



Oslo + Viken

- Population 1,3 mill
- 2 counties
- 22 + 1 municipalities
- 100 km north to south

Ruter is a publicly owned non-profit company:
Political owners Oslo 60% and Akershus county 40%.

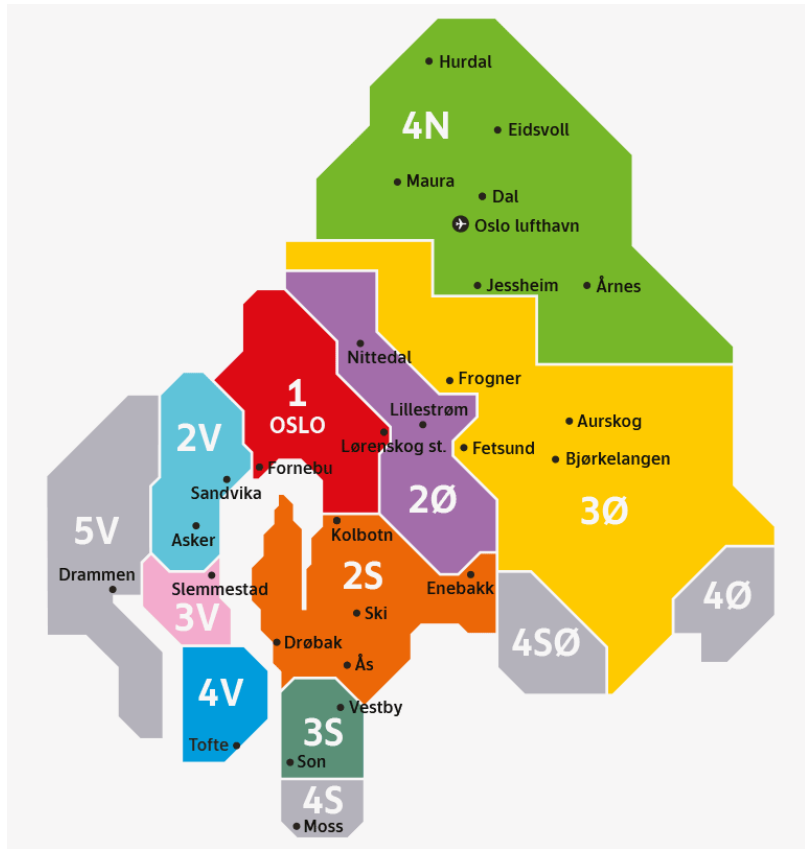
Ruters region represents 50% of public transport travels in Norway

Ruter#

Main specs – Ruter As

- Oslo + Akershus part of Viken county
- Approx # vehicles in tendered services:
 - 1400 buses (<50% city buses)
 - 600 minibuses and other vehicles
- 398 million travels per year (pr 2019)
 - incl bus, train, metro, tram, ferries
- 2023: approx 95% of pre-pandemic travel numbers are back

Customers buy only one ticket
to ride on all transport modes



Ruter#

Our strategy for a sustainable freedom of movement



Deliver sustainable freedom of movement in our region through ownership of the preferred customer interface

Offer attractive services to our customers:
Wider transport options—greater individualisation

Build on our current position, services and infrastructure

Data-powered service development

Leverage market dynamics through smart partnerships



Ruter#

Organization of public transport according to the Ruter model

(numbers pre covid-19 pandemic)



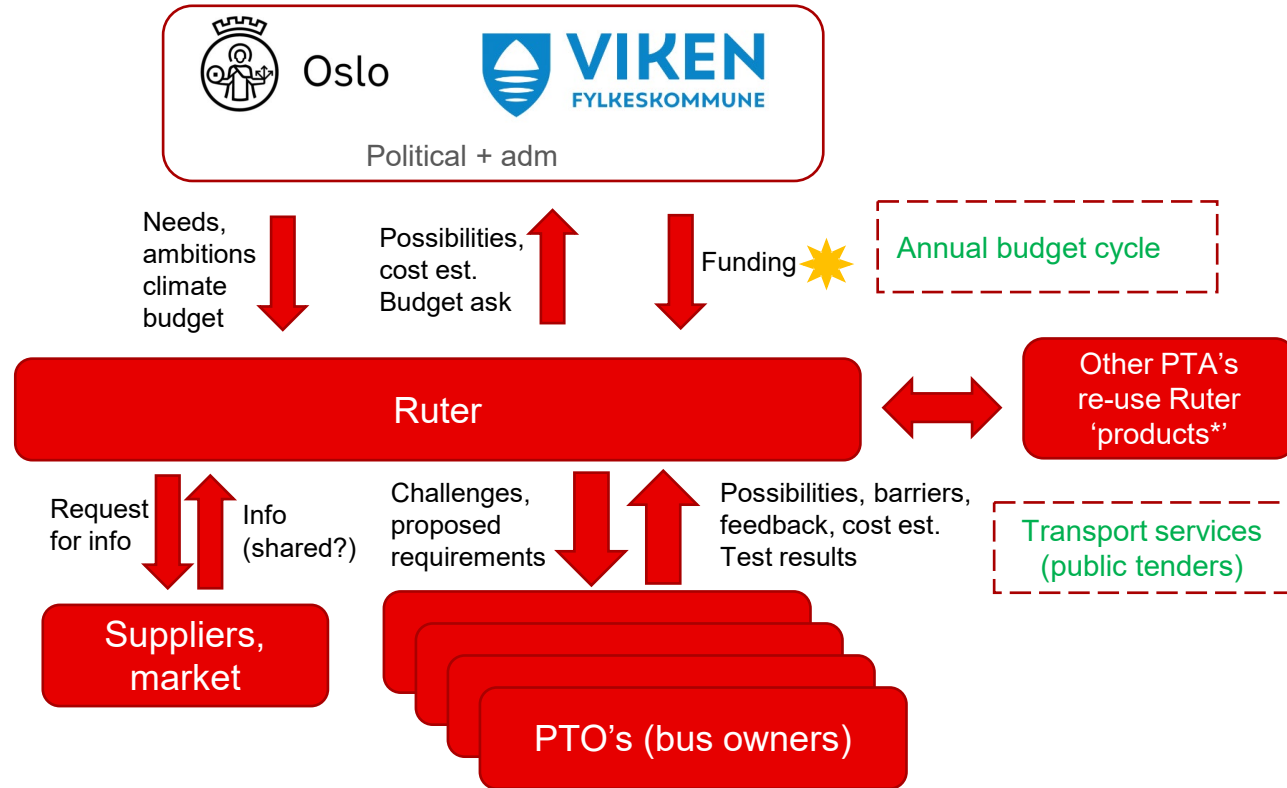
BANE NOR



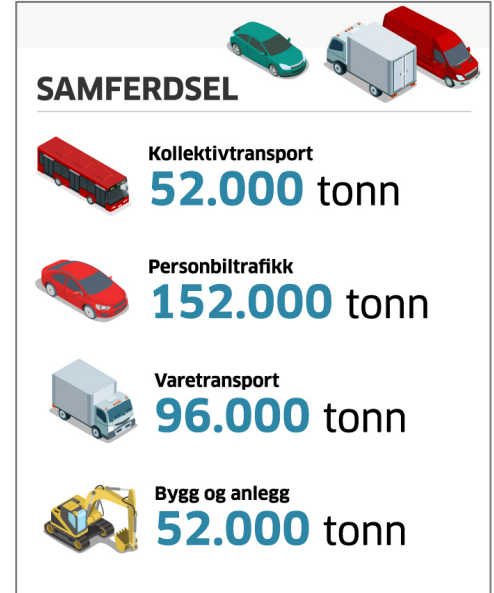
Oslo kommune
Bymiljøetaten

Ruter#

Governance and funding



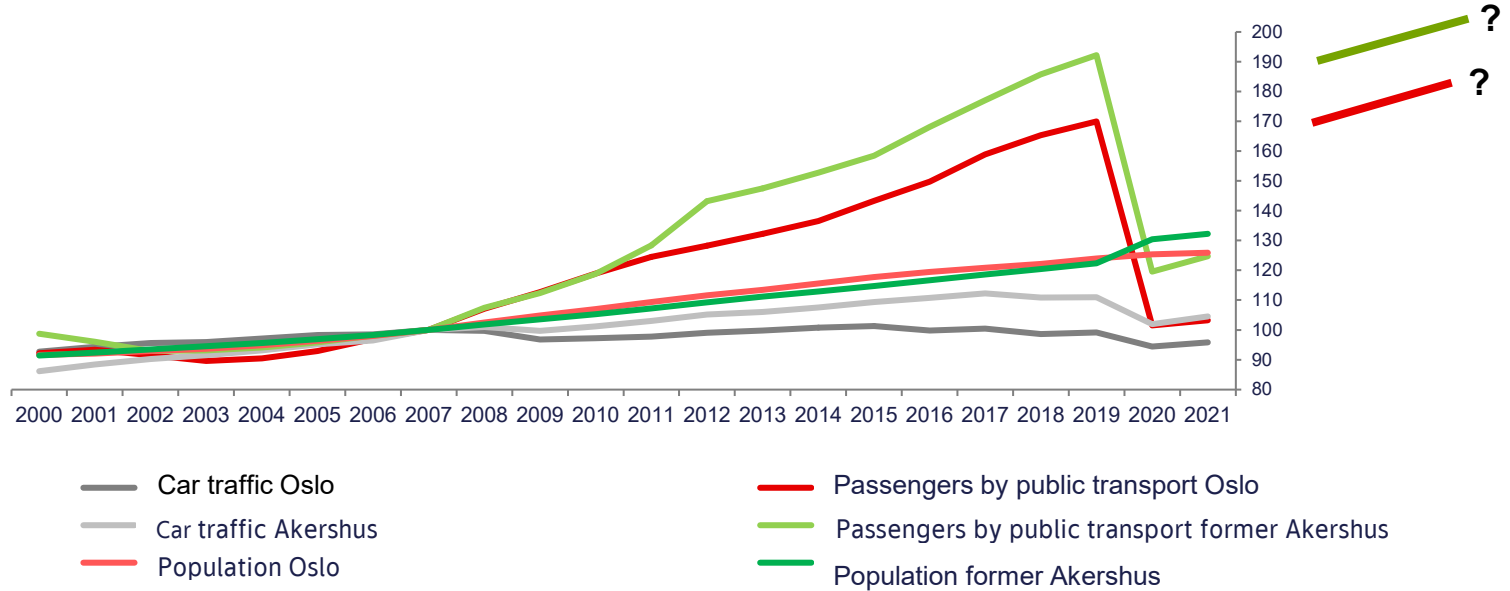
2017 budget Oslo:
planned emission cuts



*) Ruter 'products': tender documents/process, some IT-systems, ticketing setups, learnings

Ruter#

15 years of growth in public transport..



Transport is the biggest source of CO2 emissions in Norway

- High % of electricity is from hydropower
- 61 % of Norway's CO2 emissions stem from transportation, 4% are produced by public transport
- **The city of Oslo** aims to reduce greenhouse gas emissions by 95% within 2030
- **Akershus/Viken County Municipality** aims to reduce greenhouse gas emissions by 55% within 2030, and 85-90% by 2050





What we think the future will look like

- What can be electric will be electrified.
- All future contracts require zero-emission operation
- We have to widen our perspectives and consider emission-free solutions in the entire value chain. Maybe even have to change it.
- Data, IoT, and autonomous vehicles will shape entirely new transport habits.
- The solutions will be shared and resource-effective, yet will be perceived as individual and personalized.

Ruter#

Battery electric buses in service for Ruter

2022: 265 e-buses in Oslo and Viken

2023: Passing total 500 e-buses (contracted)

2025: Expected total 700-900 e-buses

2028: All 1400+ buses* battery electric
- or biogas or hydrogen

- Latest contracts/tenders awarded:
 - Oslo Inner-city, 183 e-buses, starting April 2023
 - Oslo East, 2x76 e-buses, starting December 2023
- Upcoming:
 - Follo contract, starting 2025
 - Romerike and Asker/Bærum expected start 2027-28

*) There may be exceptions where it is not possible or practical to use zero emission vehicles. Examples: Weight restricted roads, bridges, passenger capacity vs battery size / range needed,



Ruter's model and new technology



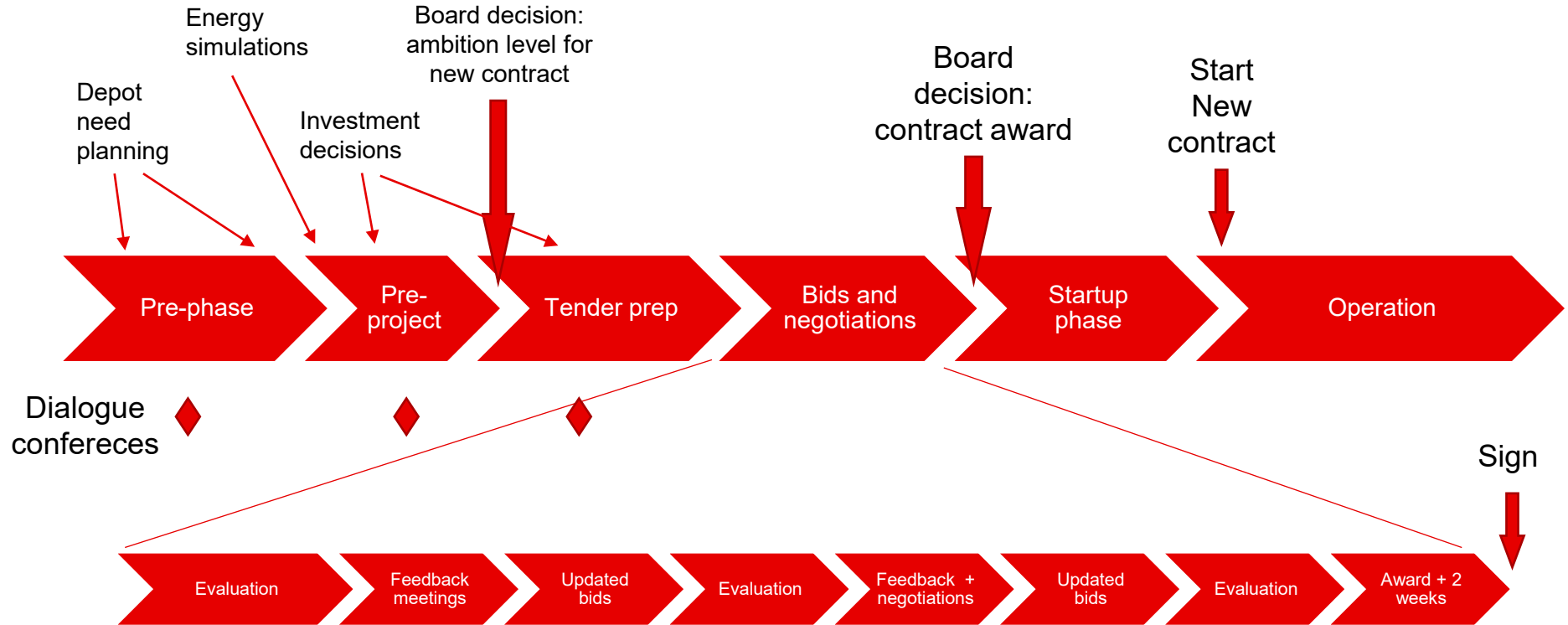
The model

- Ruter buys bus and boat services in tenders
- Technology neutral, but prepare for expected solutions
- Ruter determines functional requirements
 - New requirements: RFI process and dialogue conferences, ahead of tendering process
 - 'zero emission' = requirement or evaluation criteria
 - Plug type if e-buses: CCS2 or pantograph up, 4 pin
 - Ferries: no specific requirement
- Operators choose buses/vessels and charging / fuel type
- Ruter prepares bus depots, grid connection (11kV) and building permits for charging stations

Benefits to Ruter from applying this model

- Make use of latest market innovations
 - no lock-in on old style tech
- PTO responsible for both buses and chg infra

Procurement process and preparations (simplified)

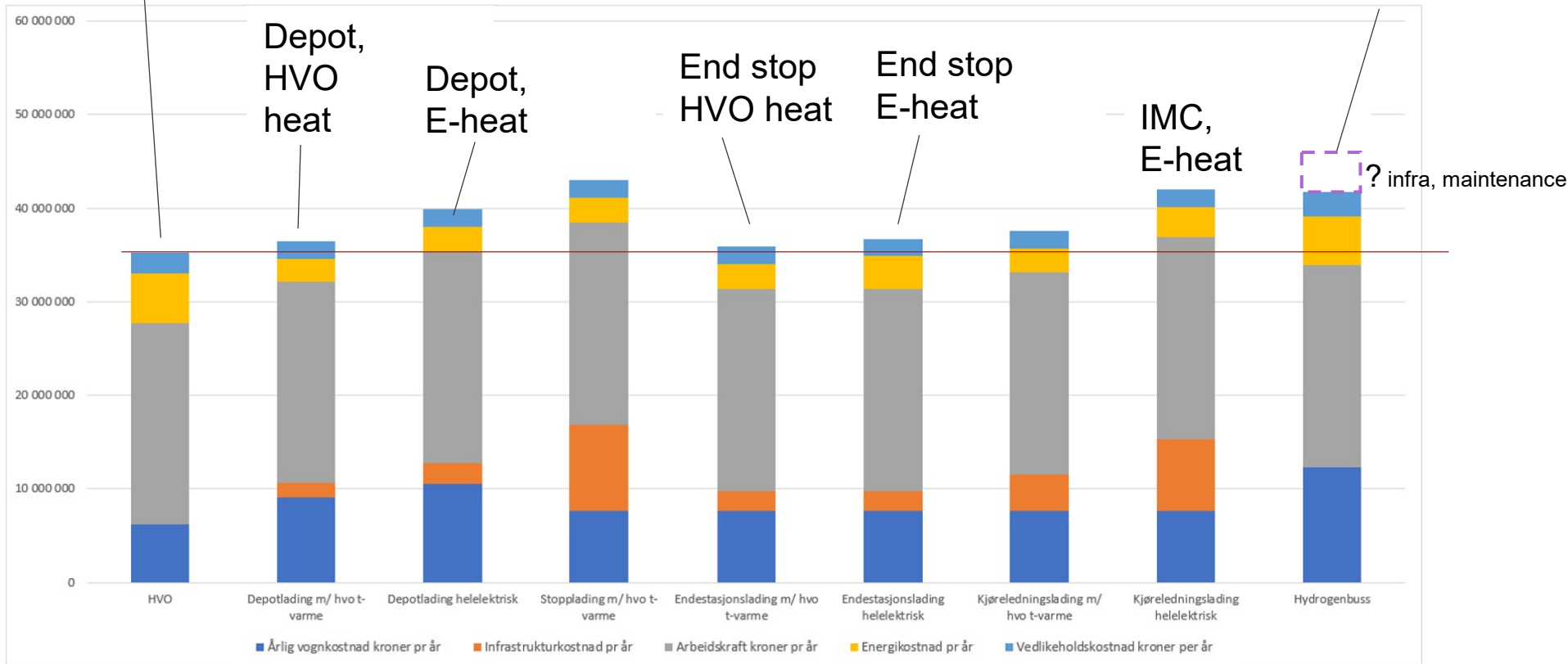


Reference:
HVO buses

Line 54 – energy / TCO simulation

Charging concepts

*Hydrogen
scenario:
(5 EUR/kg)*

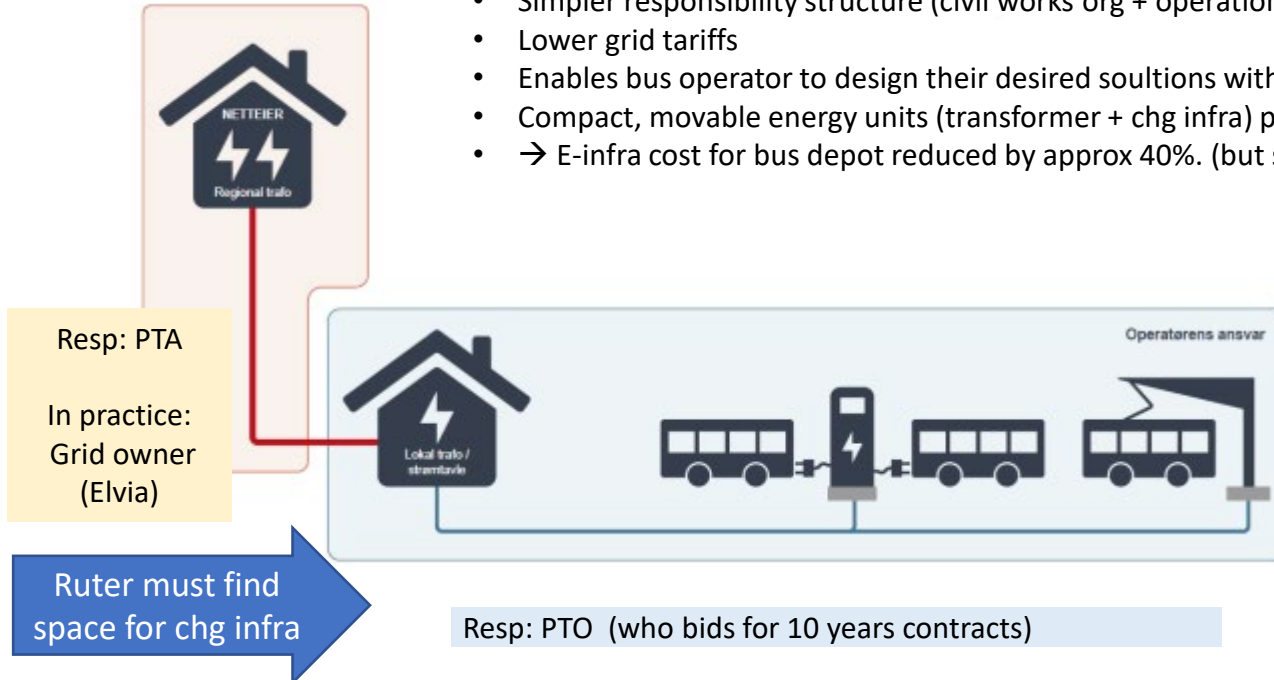


!! Numbers are different for each bus line.

Ruter#

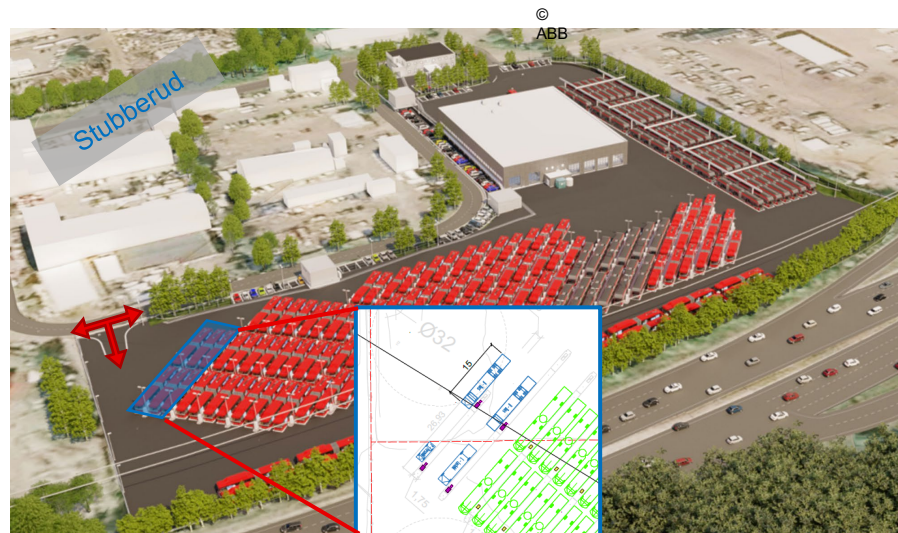
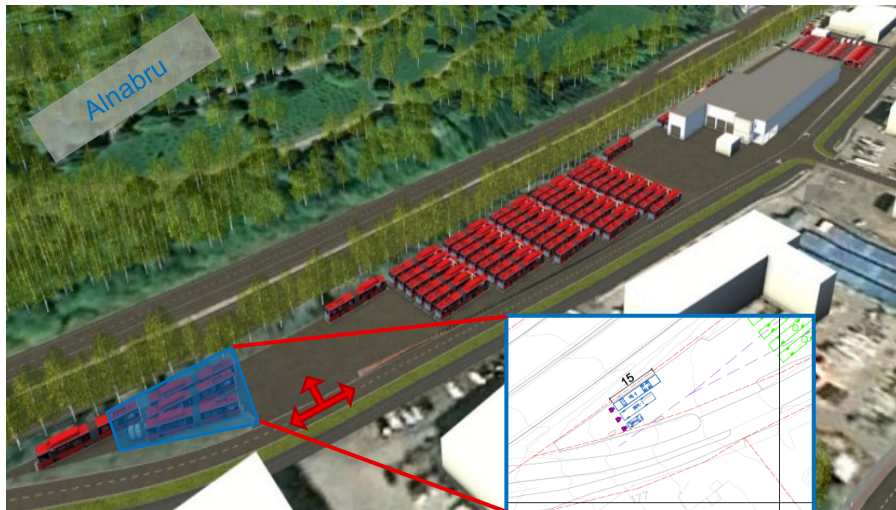
Change in preferred business model from tender in 2022:

- PTO also responsible for substation at depot
- PTO is high voltage customer (11 kV). Ruter has prepared depot and HV concession.
- This enables more flexibility to choose optimal solutions (less cost, less heat loss, etc)
 - Less connection points
 - Simpler responsibility structure (civil works org + operational org)
 - Lower grid tariffs
 - Enables bus operator to design their desired solutions without pre-defined low voltage interface
 - Compact, movable energy units (transformer + chg infra) possible
 - → E-infra cost for bus depot reduced by approx 40%. (but some more operational competence required)



EaaS – Unibuss in Inner City – start April 2023

- Open to everyone, around the clock.
 - 3 pcs. 175 kW EaaS at Alnabru
 - 4 pcs. 175 kW EaaS at Stubberud
- All chargers are connected in pairs to be able to deliver up to 350 kW via one liquid-cooled cable, and thus well prepared for future vehicles



End of key topics for buses

Ruter#

Ruter#

Electric Boats



Realization of zero 2028 – waterborne transport

Nesodd ferries 2019/2020

- Three ferries – one operator
- Norway's largest car-free passenger connection
- Covers 70% of Ruter's boat passengers
- Ferries converted from LNG to battery electric operation

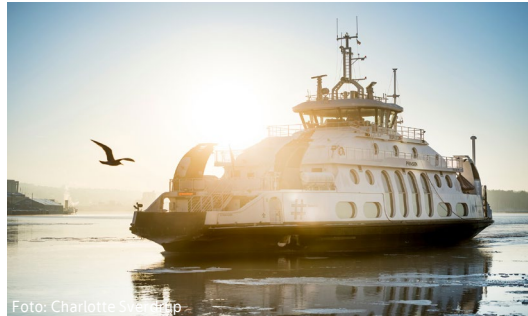


Foto: Charlotte Sævi

Island boats 2021

- Contract entered into January 2020
- Five all-electric modern boats with high quality
- Capacity increases by over 40%
- Increased offer by 15%
- Good environmental solutions (reuse and recycling)



Foto: Gisle Haakonsen

High speed ferries 2024

- Ferries are to be converted to battery electric in 2024
- Charging: exchanging battery packs by using on-shore crane to switch battery pack on boat in 3 minutes.
- 2x battery packs on deck
- Slow charge batteries on-shore



Technology development in the procurement process (island ferries)

- Five identical boats from Boreal
- Compared to the current offer, the new deal includes
 - 35% increase in capacity
 - 10% increase in service
 - Costs reduces by 1 MNOK
- High quality boats and charging infrastructure
- Universally designed
- Possibility of autonomous boats in the future



Solutions built in Oslo region
– early stages, pilot testing

Early test: 300 kW charging at end stop, pole-mounted pantograph



Ruter#

Early test: 400 kW charging at end stop, bus-mounted pantograph



Ruter#

Main choice so far: Fast charging at depot (300kW)



Also 50kW charging
by pantograph



Ruter#

Trend: 150 kW plug-in charging at depot



Ruter#

Trends in Ruter area – Oslo and Viken

- City buses: cheapest TCO is battery electric fleet
- Electric heating (pre-heat at depot + use heat pumps on route)
- Challenging temperature requirements
 - Still working on defining acceptable temperature limits for customers
 - Preparing for real time monitoring of cabin temperature
- Fast charging → Depot charging
- High voltage grid connection on depot (same as Tesla supercharging stations)
 - PTO resp for substation 11kV → 400-1000V
 - This enables better possibility for optimized solutions
- EaaS – Energy as a service: More companies able to offer mixed users
- Regional buses: longer routes, may allow biogas for non-city buses (tbd in 2022)

Development of battery-electric bus fleet

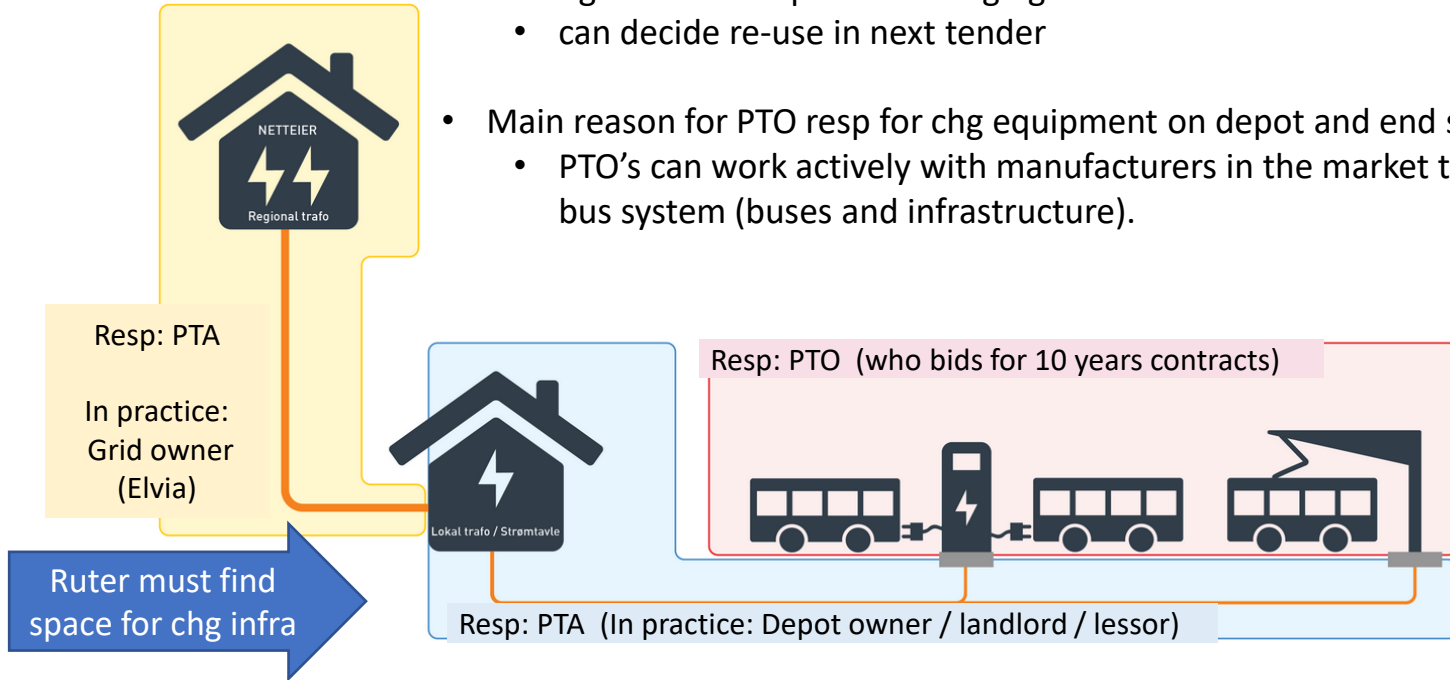
Project/ Tender	Qty	Mfg	Bus type	Charging concept	Charging power (kW)	Battery capacity (kWh)	Battery type	Panto type
Test 2017	2	Solaris	Solo	Pantograph	300	75	LTO	Up
Test 2017	2	Solaris	Solo	Pantograph	400	125	LTO	Down
Test 2017	2	BYD	Articulated	Plugin	80	307	LFP	-
Oslo 2019	30	VDL	Articulated	Pantograph	300	170	LTO	Up
Oslo 2019	10	VDL	Solo	Pantograph	300	127	LTO	Down
Oslo 2019	20	BYD	Articulated	Pantograph	300	348	LFP	Up
Oslo 2019	4	Solaris	Solo	Pantograph	400	146	LTO	Up
Oslo 2019	6	Mercedes	Solo	Pantograph	250	243	NMC	Up

Development of battery-electric bus fleet

Project/ Tender	Qty	Mfg	Bus type	Charging concept	Charging power (kW)	Battery capacity (kWh)	Battery type	Panto type
Romerike 2019	17	Volvo	Solo w/ seatbelts	Plugin	150	200	LFP	-
Romerike 2019	22	BYD	Articulated w/ seatbelts	Pantograph	300	348	NMC	Up
Vest 2020	18	BYD	Solo LE Cat II	Plugin	50	382	LFP	Up
Vest 2020	23	BYD	Solo Cat II w/ seatbelts	Plugin Pantograph	50 300	348	LFP	Up
Oslo South	83	VDL	Articulated w/ seatbelts	Plugin Pantograph	300	420	LFP	Up
Oslo South	19	VDL	Solo w/ seatbelts	Plugin Pantograph	300	348	LFP	Up
Oslo South	7	BYD	Solo LE Cat II	Plugin Pantograph	400	350	LFP	?
Oslo indre by	183	Solaris	Articulated	Plugin	150	528	NMC	-

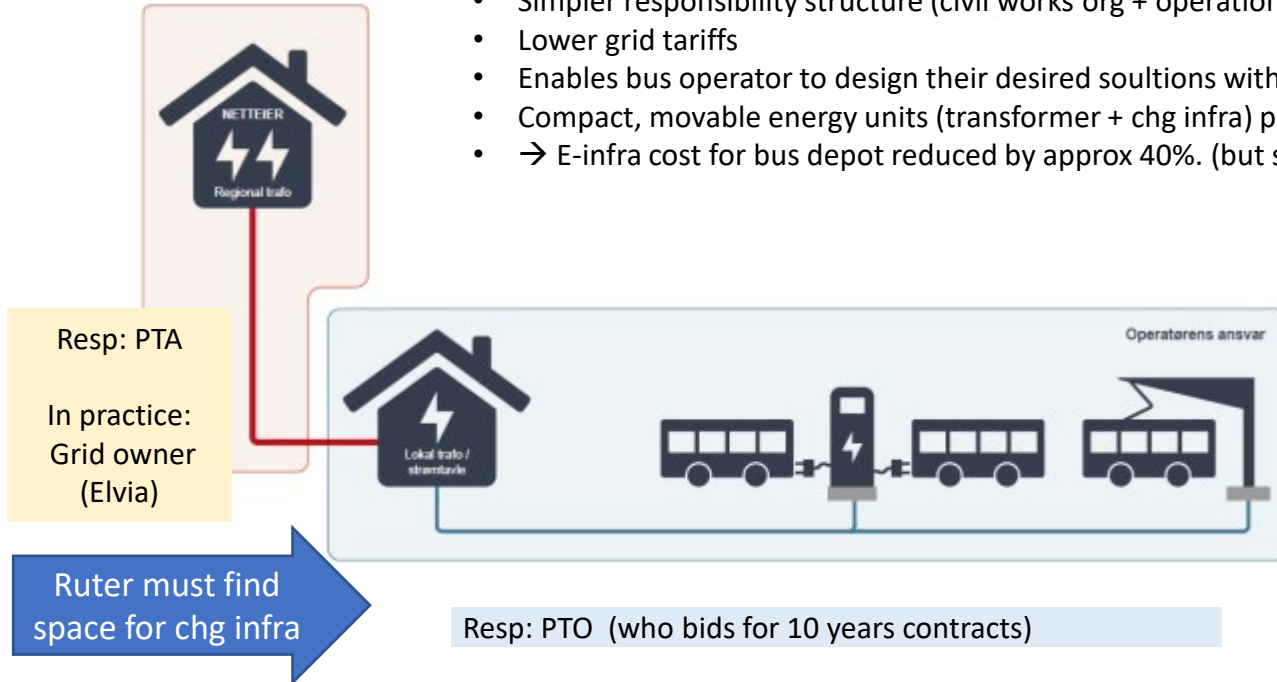
'Short' description of Ruter's chosen business model for charging infrastructure (until 2021)

- Ruter is PTA, renting depot from depot owner. PTO rents depot from Ruter during contract.
- Secondary voltage (power supply for chargers) is 400V
- PTO is low voltage customer
- Ruter gets ownership of the charging infrastructure at end of contract
 - can decide re-use in next tender
- Main reason for PTO resp for chg equipment on depot and end stations:
 - PTO's can work actively with manufacturers in the market to offer the most optimal e-bus system (buses and infrastructure).



Change in preferred business model from tender in 2022:

- PTO also responsible for substation at depot
- PTO is high voltage customer (11 kV). Ruter has prepared depot and HV concession.
- This enables more flexibility to choose optimal solutions (less cost, less heat loss, etc)
 - Less connection points
 - Simpler responsibility structure (civil works org + operational org)
 - Lower grid tariffs
 - Enables bus operator to design their desired solutions without pre-defined low voltage interface
 - Compact, movable energy units (transformer + chg infra) possible
 - → E-infra cost for bus depot reduced by approx 40%. (but some more operational competence required)



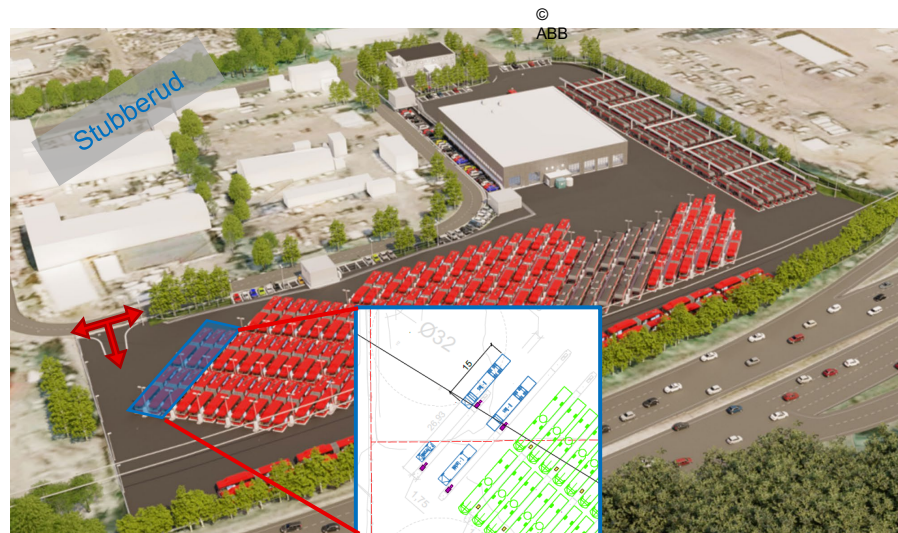
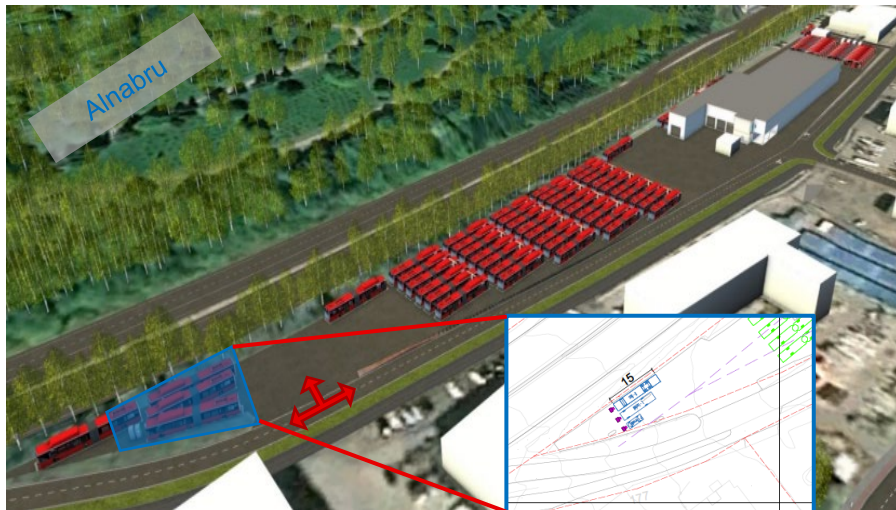
Energy as a Service

- Energy as a Service means that a third party (or Ruter or PTO) can take responsibility for supplying energy to the bus / battery.
- This can also develop the service to supply energy to other markets; Truck, van, car, etc.
- This can have consequences for sustainability, financing and business development.
- Opportunity for sharing: Higher utilization of space and electric infrastructure



EaaS – Unibuss in Inner City – start April 2023

- Open to everyone, around the clock.
 - 3 pcs. 175 kW EaaS at Alnabru
 - 4 pcs. 175 kW EaaS at Stubberud
- All chargers are connected in pairs to be able to deliver up to 350 kW via one liquid-cooled cable, and thus well prepared for future vehicles

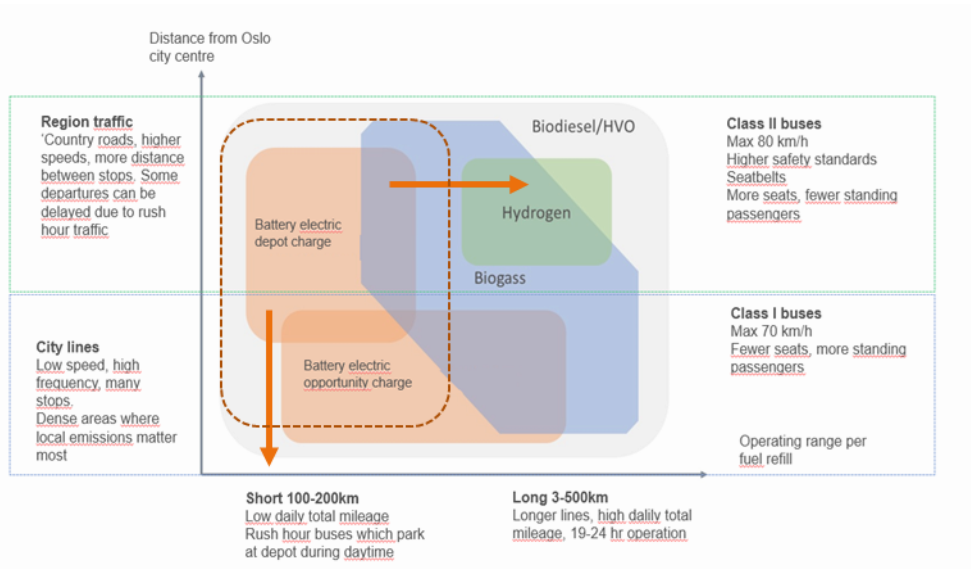


Extra info: zero emission boats

11/2/2023

Ruter#

Zero-emission innovations are rapidly changing our initial assumptions



Initial assumptions from 2016 are already outdated

- Range has improved
- More diversification – zero-emission buses for regional lines are now available
- More overnight charging at depot - less dependency on opportunity charging
- Improved batteries, reduced costs
- → Ruter leaving it to the public transport operators to compete on offering the most cost-effective and innovative system solutions

Energy as a Service

- Energy as a Service means that a third party may provide energy for vehicles/batteries.
- This can also develop the service to supply energy to other markets; Truck, van, car, etc. Cooperation with other companies in need of charging infrastructure may enhance and speed up the green shift.
- This can have consequences for
 - Sustainability
 - Financing and business development
 - Shared use of public space and land area



Substation Rådhusbrygge 4

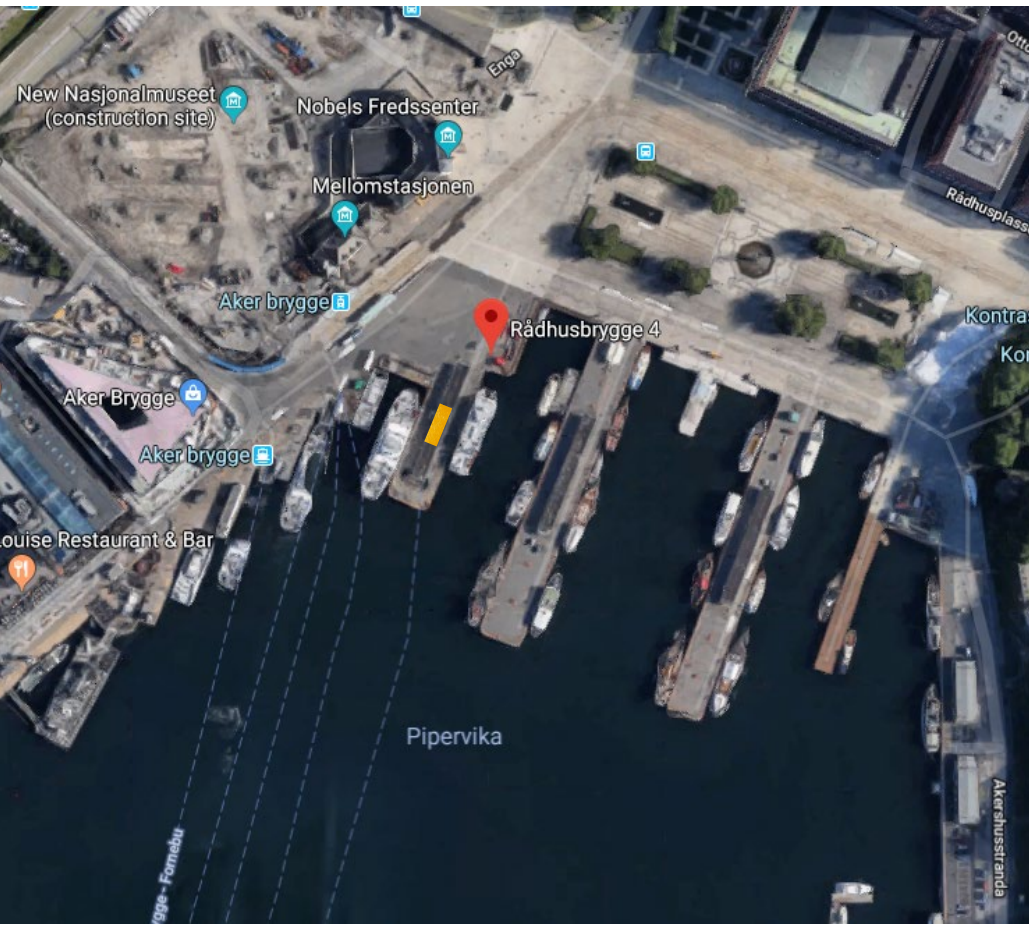
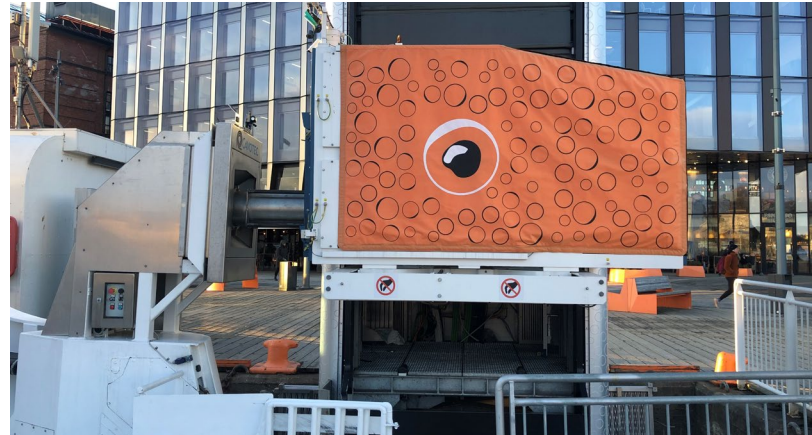


Photo: Oslo Port Authority

Ruter#

Charging Oslo-Nesodden



Ruter#

Charging Island boats



Ruter#

Technical data batteries boats

	Operator	Qty	Charging concept	Charging power	Battery capacity	Battery type
Commute: Oslo - Nesodden	Norled	3	Plugin tower	3200 kW	2018 kWh	NMC
Recreation: Islands boats	Boreal	5	Pantograph	1300 kW	1082 kWh (may expand to 1582 kWh)	Corvus Orca Energy