Emission free construction sites

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From fossil free to emission free

2016
- ZEB Campus Evenstad
- Omsorgsbygg conference

2017
- RFFH innovative procurement guideline
- Fossil free requirements for public construction sites in Oslo

2018
- ZED project (one of the first large electric excavators)

2019
- Olav Vs street (one of the first emission free construction sites)

2020
- Standard climate and environment requirements in Oslo
- ConZerW
- NADA

2022
- Mapping
- Impact assessment
- Rogaland road map
- Storgata, Tromsø

2025

7 largest Norwegian cities goal of emission free public construction sites

2030

7 largest Norwegian cities goal of emission free construction sites

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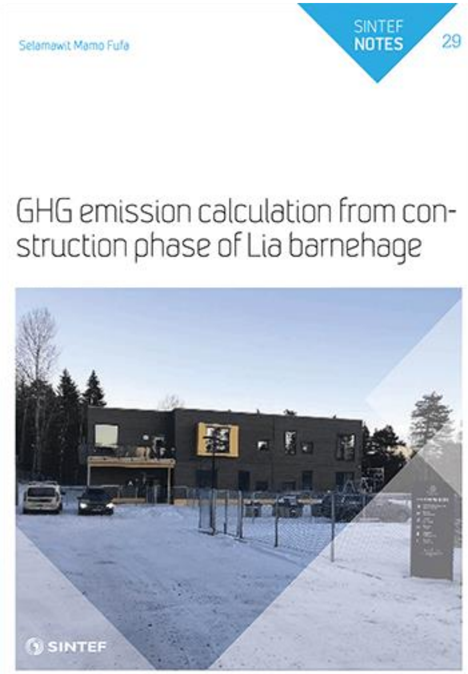
https://www.sintefbok.no/papers/index/36/sintef_fag



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Project goal

Develop future scenarios for the development of zero emission solutions for construction sites in 2025 and 2030 to identify how the City of Oslo can facilitate for desired development with effective instruments.

- Energy use and supply
- Cost assessment
- Market analysis
- Development scenarios

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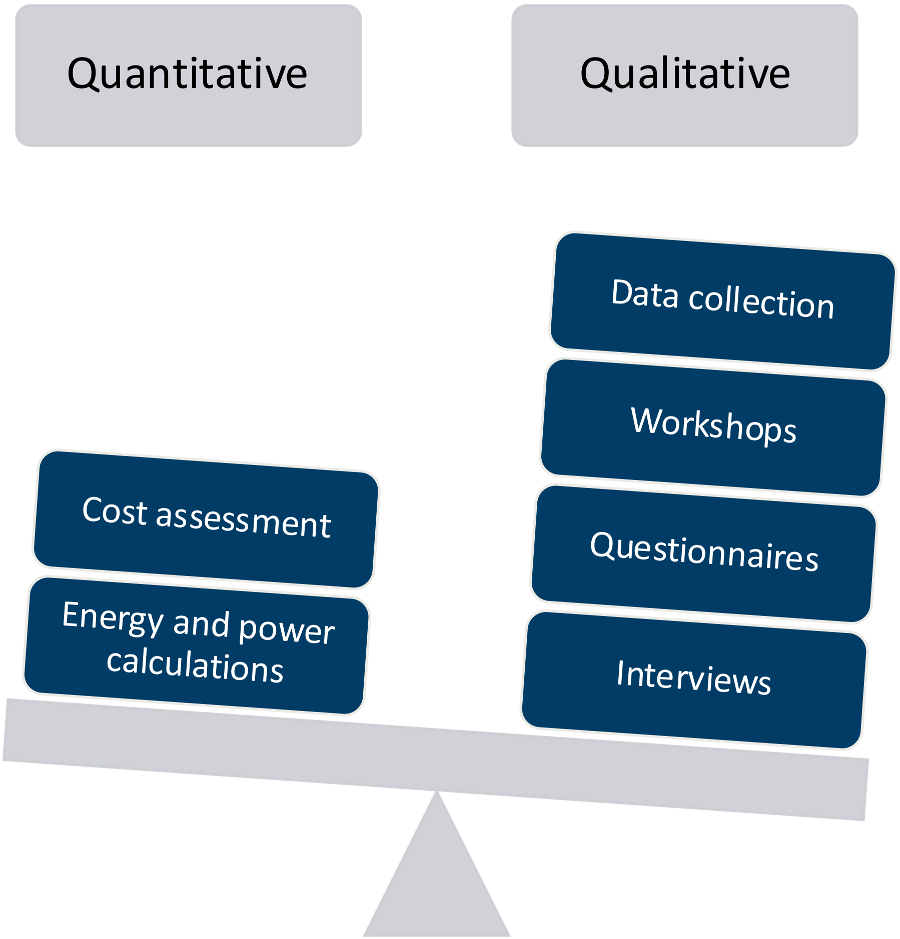
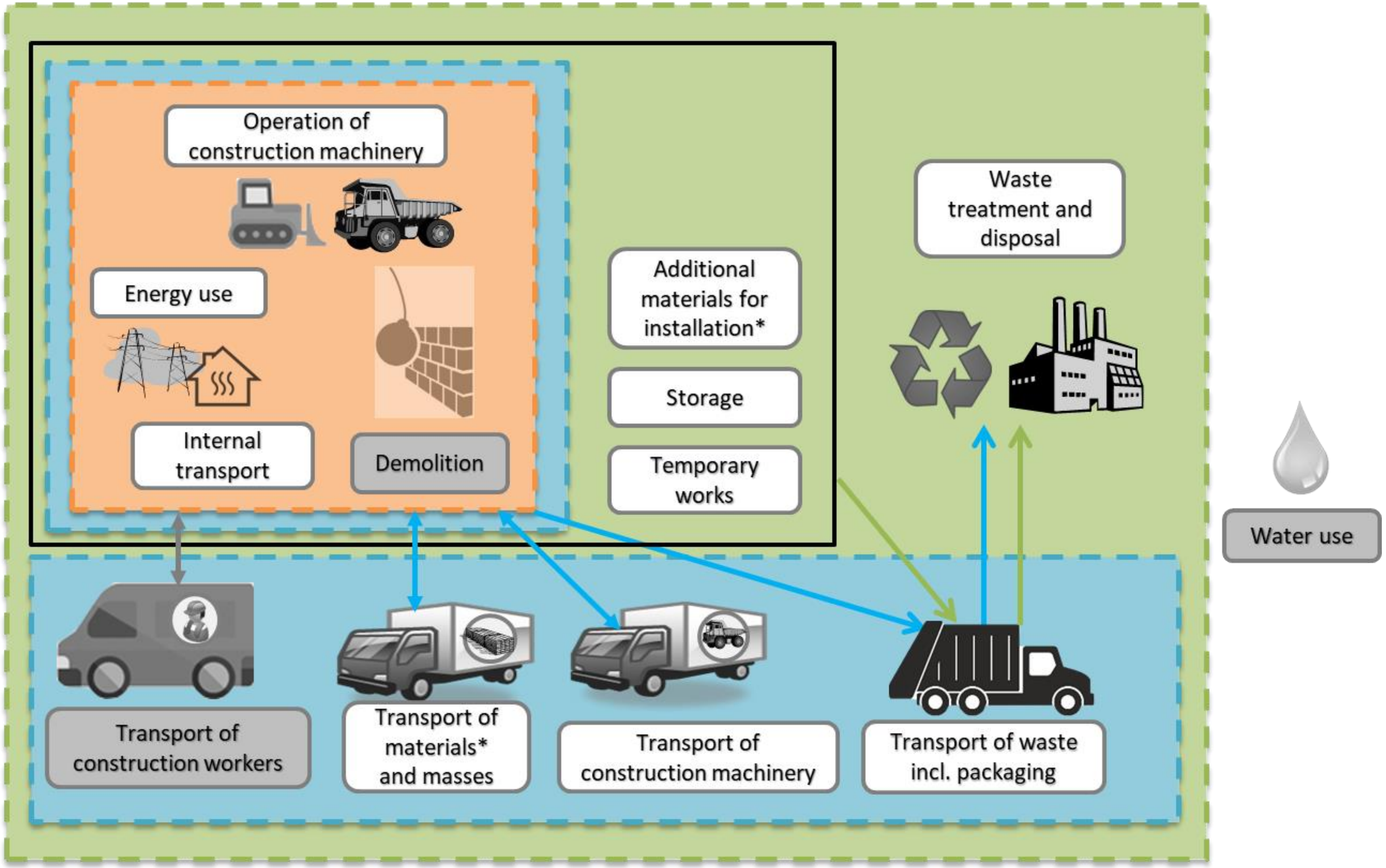
Method


Quantitative
Qualitative
Cost assessment
Energy and power calculations
Data collection
Workshops
Questionnaires
Interviews

System boundary



* Includes material losses

Energy modelling

- Data collection:
  - Key information about the project: start date, completion date, project type, size and schedule
  - Construction machinery: machine type, operation hours, technology, and details on transport to and from site.
  - Mass transport: vehicle type, amount of trips, technology and details on transport to and from site.
  - Goods transport: vehicle type, amount of goods, technology and details on transport to and from site.
  - Waste: waste reports, amount of waste per waste fraction, vehicle type, amount of trips and technology.
  - Construction workers: number on average per month, typical travel patterns for daily and weekly commuters and work hours.
  - Energy use for heating and drying.
  - Maximum power available on site.

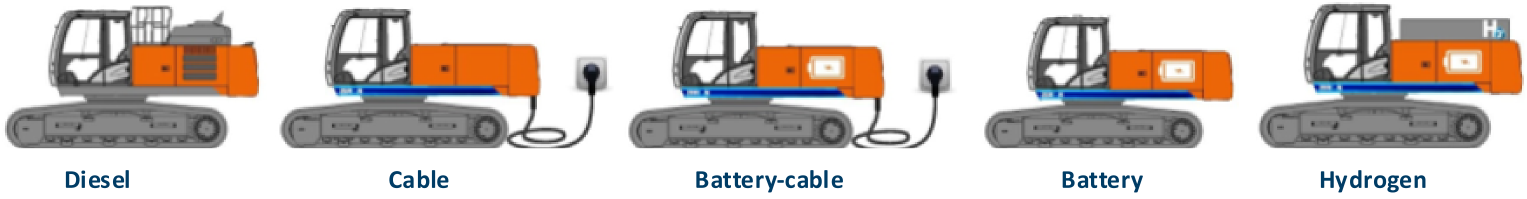
- Two modelled sites - 100% electric
  - Building site
  - Construction site

- Site activities:
  - Demolition
  - Groundworks
  - Superstructure
  - Façade
  - Internal works
  - External works
  - Transport
    - Person, mass, waste, goods, machine

Machine park

- Dumper trucks, excavators, wheel loaders, demolition machines, sorting machine, stampers, telescopic trucks, drying/heating systems, compressor, mobile cranes, tower cranes, vibration plates, drill rig, boom lifts, scissor lifts, woodchipper, rollers, battery packs, battery containers, PV microgrid, hydrogen fuel cells, lorries, vans, cars, concrete trucks and tractors.

List is not exhaustive



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Scenario analysis

Reference scenario

- Charging of external transport occurs on site
- Rapid charging and night charging on site
- Common lunch break for charging
- Charging of subcontractor's vans occurs on site

Average scenario

- Builds upon the reference scenario
- Includes some optimisation of the most energy demanding activities
- Construction machinery of different technologies (cable, battery, battery-cable)
- Staggered lunch breaks
- Some external transport is charged at transport depot and not on site

Optimised scenario

- Builds upon the average scenario
- The contractor has made a mass transport plan and energy plan
- Energy flexible solutions considered
  - District heating, hydrogen, battery containers etc. to relieve the grid
- All external transport is charged at transport depot and not on site

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Average energy demand

- Building site

	Reference			Average			Optimised		
Construction machinery	1st year	2nd year	TOTAL	1st year	2nd year	TOTAL	1st year	2nd year	TOTAL
– Demolition	60,667	0	60,667	60,667	0	60,667	60,667	0	60,667
– Groundworks	64,657	0	64,657	64,657	0	64,657	68,818	0	68,818
– Superstructure	96,952	0	96,952	96,952	0	96,952	96,952	0	96,952
– Façade	11,587	0	11,587	11,587	0	11,587	11,587	0	11,587
– Internal works	21,579	65,503	87,082	21,579	65,503	87,082	21,579	65,503	87,082
– External works	0	49,920	[illegible]	[illegible]	49,920	49,920	0	49,920	49,920
Construction worker transport	78,465	72,789	[illegible]	[illegible]	37,960	78,329	3,363	3,442	6,804
Mass transport	14,564	330	[illegible]	[illegible]	165	7,447	-	-	-
Waste transport	1,050	463	[illegible]	[illegible]	525	1,282	-	-	-
Goods transport	5,236	9,670	[illegible]	[illegible]	2,356	8,447	-	-	-
Construction site transport	897	318	1,215	608	449	1,057	-	-	-
TOTAL	333,906	188,212	522,118	295,810	153,383	449,193	262,965	118,865	381,830
Average annual energy consumption		261,059			224,596			190,915	

190 – 260 MWh

- Construction site

	Reference	Average	Optimised
Groundworks	140,439	140,439	144,699
Construction worker transport	35,618	19,311	2,470
Mass transport	86,430	36,383	-
Waste transport	223	111	-
Goods transport	449	225	-
Construction site transport	6,557	3,279	-
TOTAL	269,715	199,778	147,194

147 – 270 MWh

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Life cycle costs

- Costs
  - Investment/capital costs
  - Operational costs
    - Fuel and energy costs
    - Road tolls
    - Maintenance costs
    - Insurance costs
  - Residual value

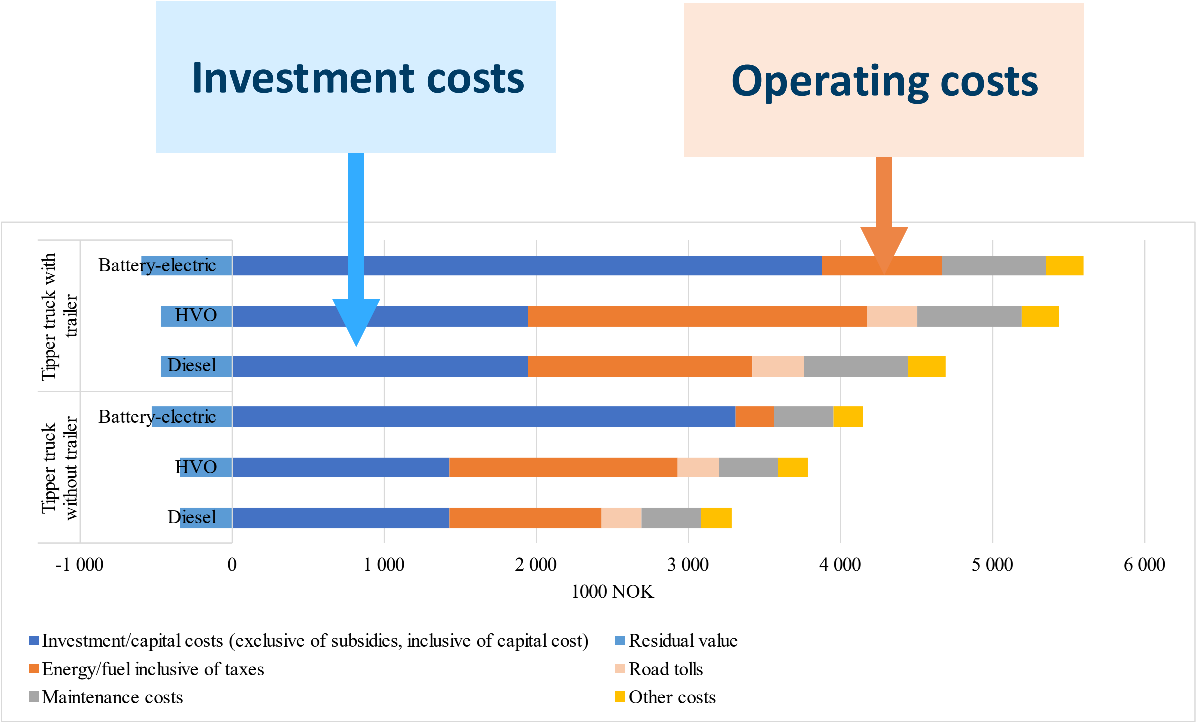
  - Small, medium and large excavator
  - Tipper truck with/without trailer

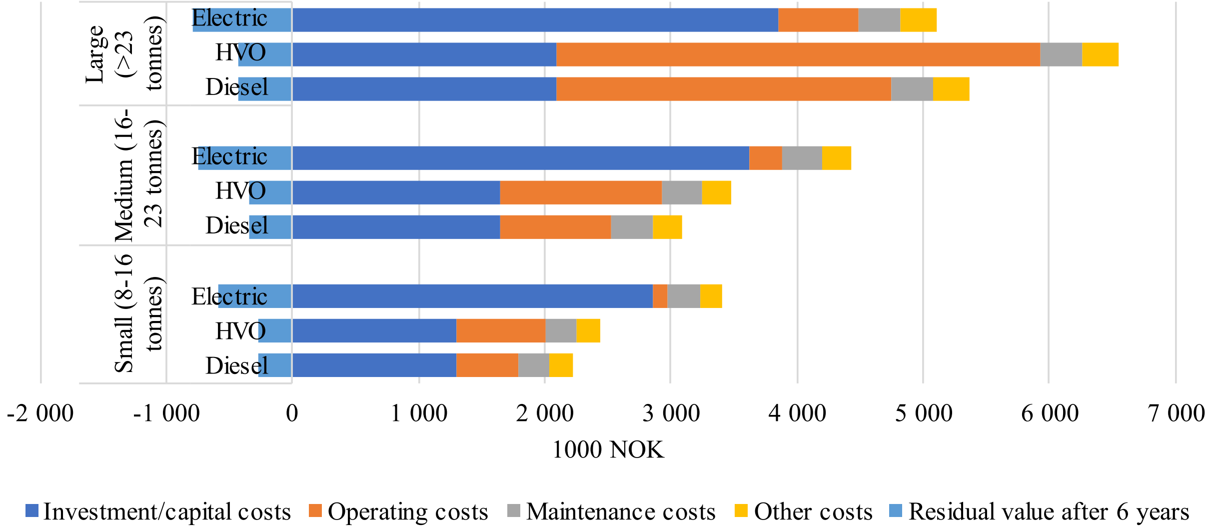
	2022	2025	2030
Diesel price in kr pr liter excl. tax	6,86	6,96	7,08
HVO price in kr pr liter excl. tax	12,24	12,96	13,75
Electricity price in kr pr kWh excl. tax	0,744	0,81	0,77
Rapid charging price in kr pr kWh excl. tax	3,2	3,48	3,31
Carbon tax in kr pr liter	2,05	3,28	5,32
Road tax in kr pr liter	3,52	2,91	1,88
Electricity fee in kr pr kWh	0,1541	0,1583	0,1541

Life cycle costs

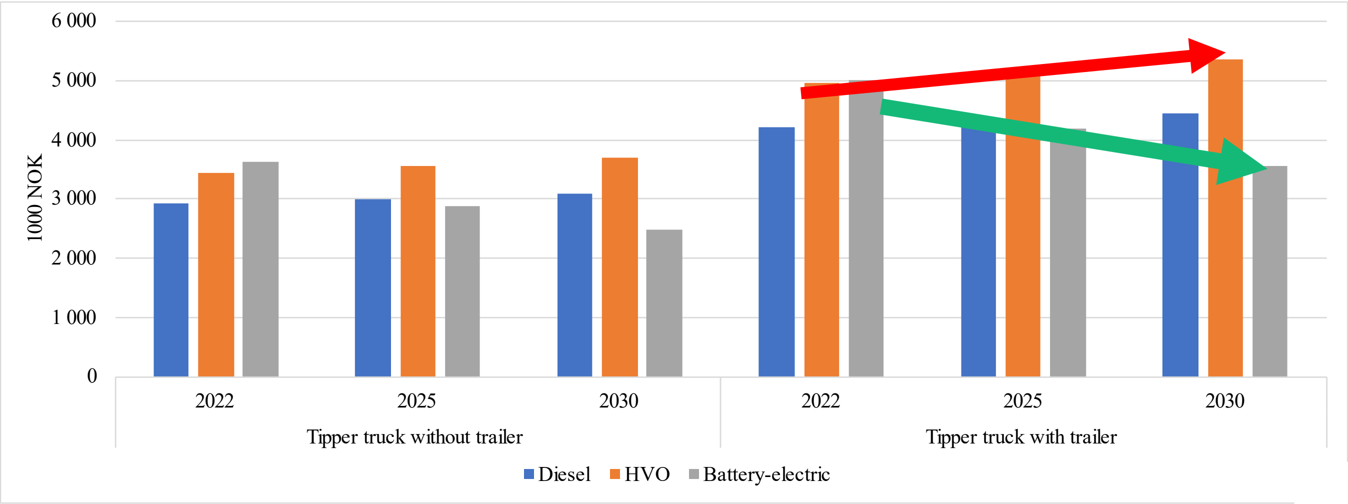
- Tipper truck with/without trailer
  - Lifetime 5 years
  - Annual travel distance
    - 40 000 km truck without trailer
    - 50 000 km truck with trailer
- Small, medium and large excavator
  - Lifetime 6 years
  - Annual operation: 1800 hours
  - Energy use per machine

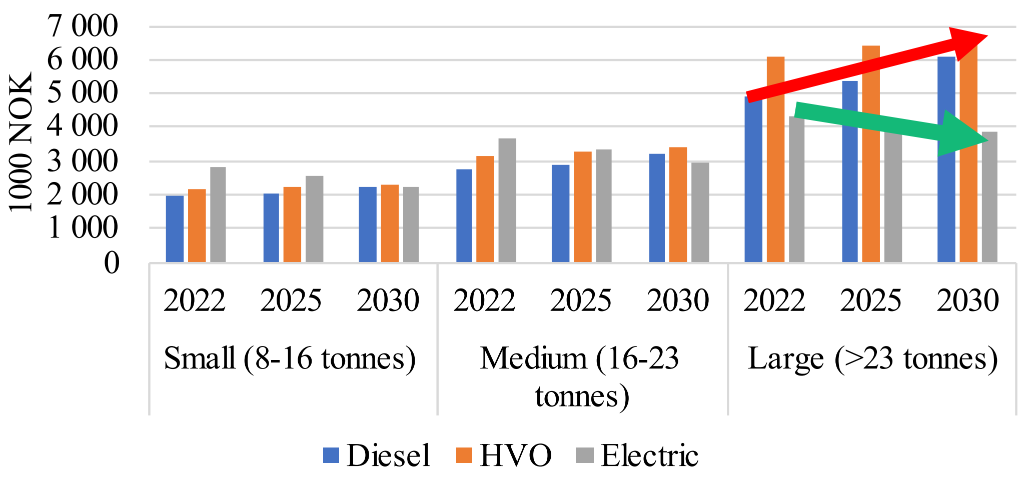
		Small	Medium	Large
Diesel	l/t	5.5	10	30
HVO	l/t	5.79	10.52	31.57
Electric	kWh/t	13	28	100





Development in life cycle costs





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Sensitivity analysis of energy prices

Pessimistic scenario

- High electricity prices
  - 3 times higher than reference
- Low CO_2-tax for diesel
  - 1.5 times lower than reference
- Lower HVO prices
  - Reduced by the same amount as the diesel costs

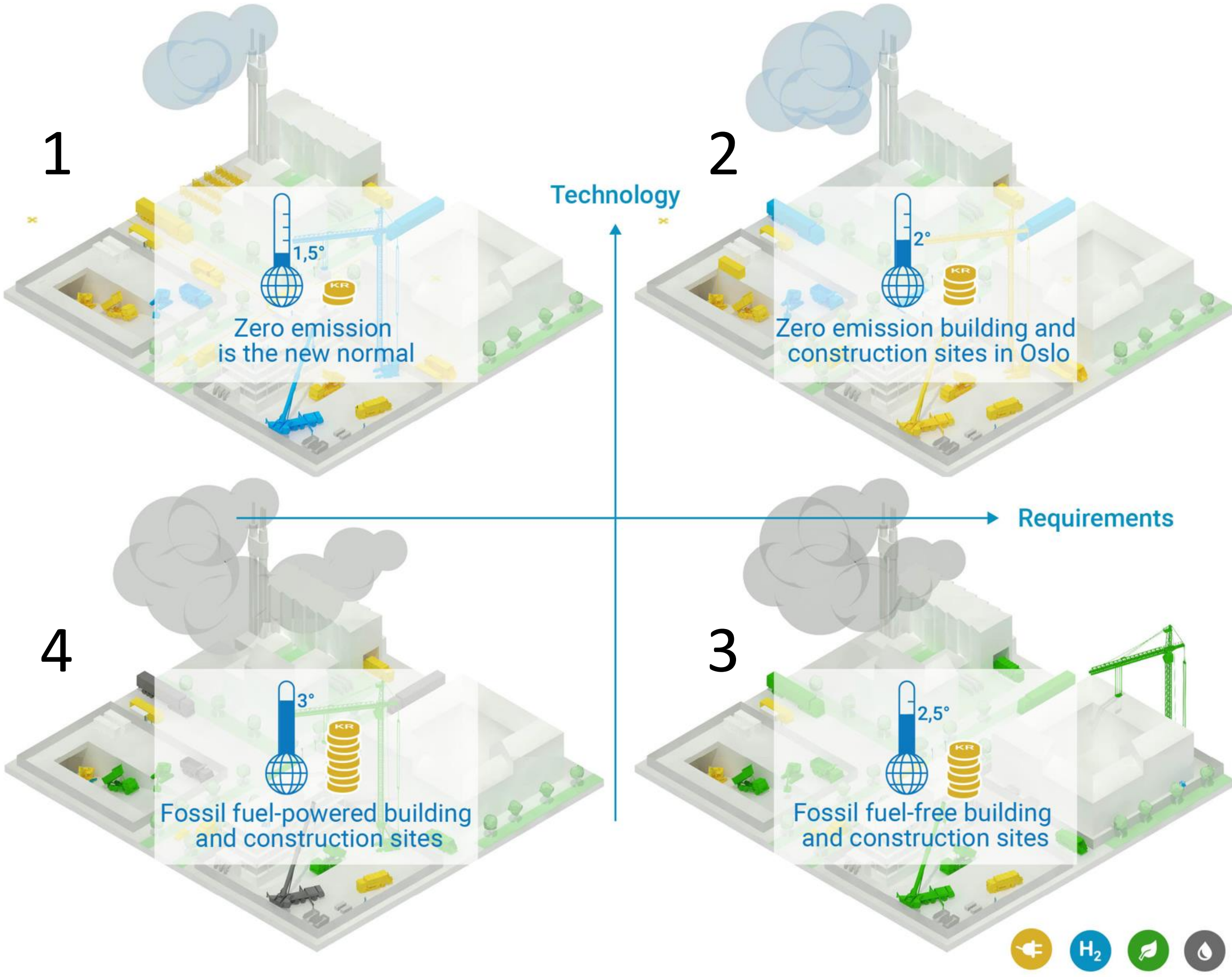
Optimistic scenario

- Low electricity prices
  - 75 % of reference
- High CO_2-tax for diesel
  - 1.5 times higher than reference
- Higher HVO prices
  - Increased by the same amount as the diesel costs

Additional costs

Additional cost in NOK per kWh		2022	2025	2030
Small excavator	Diesel to electric	[4.9] - [8.0]	[2.8] - [5.8]	[-1.0] - [2.6]
Small excavator	HVO to electric	[3.6] - [6.4]	[1.5] - [4.5]	[-1.9] - [1.9]
Medium excavator	Diesel to electric	[2.0] - [4.8]	[0.8] - [3.5]	[-1.8] - [1.5]
Medium excavator	HVO to electric	[0.9] - [3.5]	[-0.4] - [2.4]	[-2.5] - [0.9]
Large excavator	Diesel to electric	[-2.1] - [1.0]	[-2.5] - [0.4]	[-4.0] - [-0.4]
Large excavator	HVO to electric	[-3.4] - [-0.5]	[-3.9] - [-0.9]	[-4.9] - [-1.1]
Tipper truck	Diesel to electric	[1.94] - [4.19]	[-1.08] - [1.66]	[-3.08] - [0.15]
Tipper truck	HVO to electric	[1.20] - [3.67]	[-1.96] - [1.15]	[-4.15] - [-0.33]
Tipper truck with trailer	Diesel to electric	[1.44] - [3.02]	[-0.92] - [1.46]	[-3.00] - [0.06]
Tipper truck with trailer	HVO to electric	[0.7] - [2.51]	[-1.80] - [0.95]	[-4.07] - [-0.42]

Development Scenario Matrix



Conclusions

- There is a need to build charging infrastructure and facilitate access to the electricity grid
- There will be additional costs attached to electrification in coming years – also in a life cycle perspective
- Electrified building and construction sites can become competitive by 2030 given the conditions described in scenario 1
- We estimate that we are well on our way to scenario 1 or 2
- There is little to suggest that we will end up in scenario 4


Oslo
Power Up a
REneawable society

- NZC Power Up a REnewable society (PURE)
- 2024 – 2026
- € 600.000
- Oslo municipality, Bellona, Hafslund, SINTEF
  - WP1: Cross-sectoral collaboration for improved power and energy utilization
  - WP2: Guidelines for successful net-zero transition within heavy duty transport and the construction sectors
  - WP3: Scientific gains from Oslo's energy transition
  - WP4: Advancing zero emission construction and transport across the EU
  - WP5: Project coordination and communication

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Research questions

- What is the success rate of electrification in Oslo?
- What are the GHG emission savings and changes in power demands?
- How does seasonal variation affect energy and power demands?
- What are the changes in costs and savings from electrification?
- What are the key factors for success?
- How can zero emission construction machinery compete (and beat) conventional construction machinery?
- How can this knowledge be transferred to other cities and regions?

Teknologi for et
bedre samfunn