34th Annual INCOSE international symposium

hybrid event

Dublin, Ireland
July 2 - 6, 2024

Integrating IoT Technology with a Systems Engineering Approach to Improve the GHG Emission Accounting in the Waste Management Industry

IoT & emission analysis

My background

- Bachelor in Computer Engineering
- M.Sc. in Systems Engineering
- Three years of hands-on experience developing Industrial IoT applications
- Currently work as a Solution Architect for a midsized government owned Norwegian company

Case background

The Industry Partner

- Is a waste management company
- Is in a renewing process
- Wanted to automate emission reports, gain emission awareness and provide emissions data to customers

The Company

- Has a data management platform & specializes in retrieving data from industrial equipment
- Wanted to gain knowledge on how to automate emission reports

Research Questions

What are the primary sources of emissions data?

How can IoT technology retrieve accurate energy consumption?

What is the industry standard for emission accounting for waste management companies in Norway?

What measures can the industry partner take to automate the emission accounting process?

What measures can the industry partner take to decrease emissions?

Problem statement

« There is a lack of **knowledge** on **collecting** and **analyzing emission data**. This is partly due **to inadequate regulations** and **standards**, which in turn is a **complication** for **analysis** and **data collection**. »

Rationale

Paris Agreement

IoT

Emission Awareness

Literature Review Hightlights

Industry standard for material reuse is 0.9%

Norway must reduce its emissions by at least 55% by 2030

The UN has SDG's connected to sustainable waste management

- SDG 12, Responsible Consumption and Production
- SDG 13, Climate Action
- SDG 15, Life of Land

30% of all nature on land should be protected
30% of partly damaged nature should be restored by 2030

New and strengthened emission reporting rules were implemented in 2023

Semi-Structured Interview

What laws and regulations do you have to follow regarding your emission reporting?

How are you retrieving emission data today?

What difficulties are you having while trying to access accurate data?

Do you have any ideas on how to automate emission reporting?

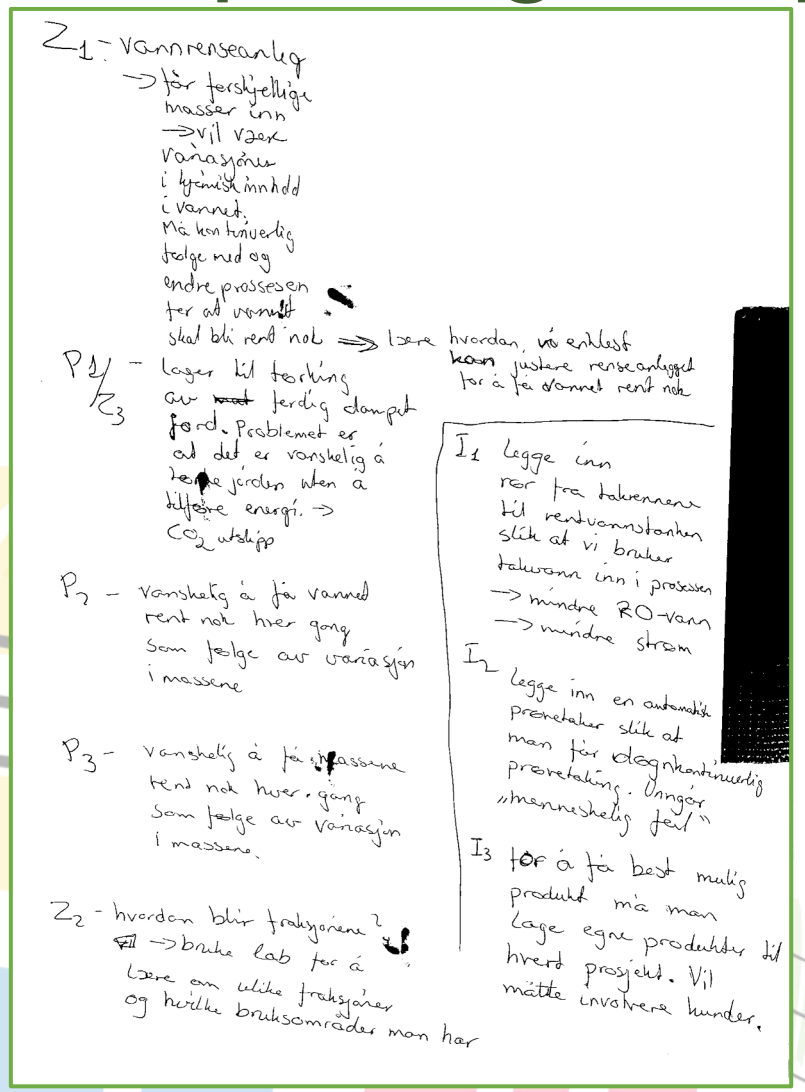
Do you focus on your emissions or your customers emissions?

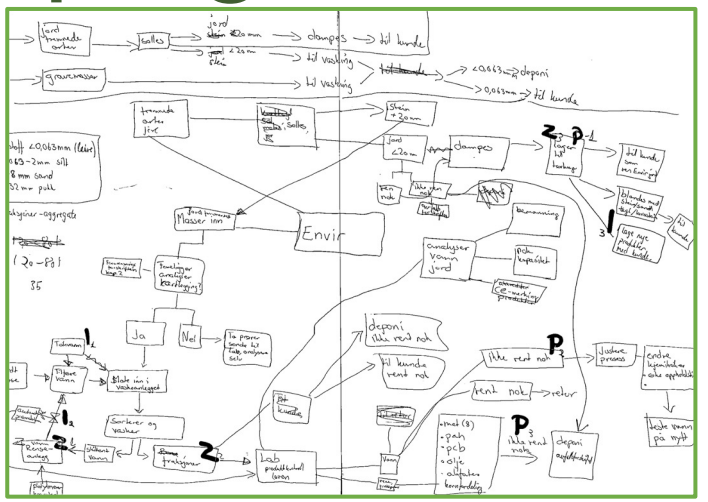
Site Visit

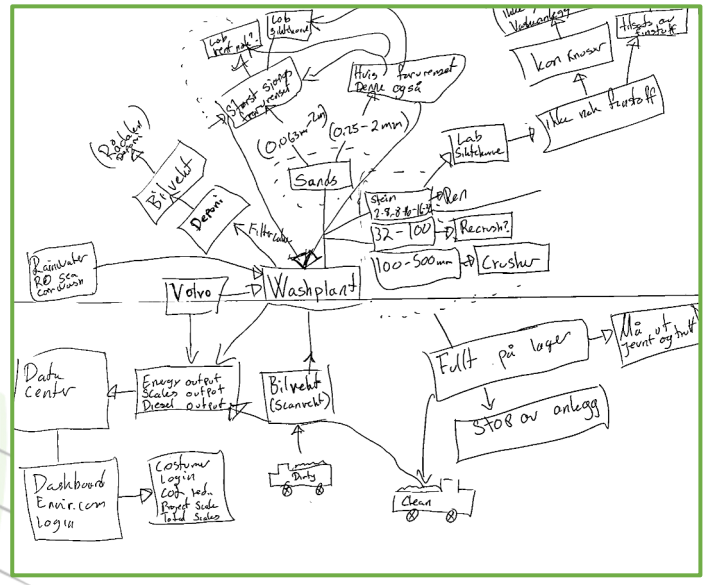
Got a feel of the operations

I certainly got another view than from my office!

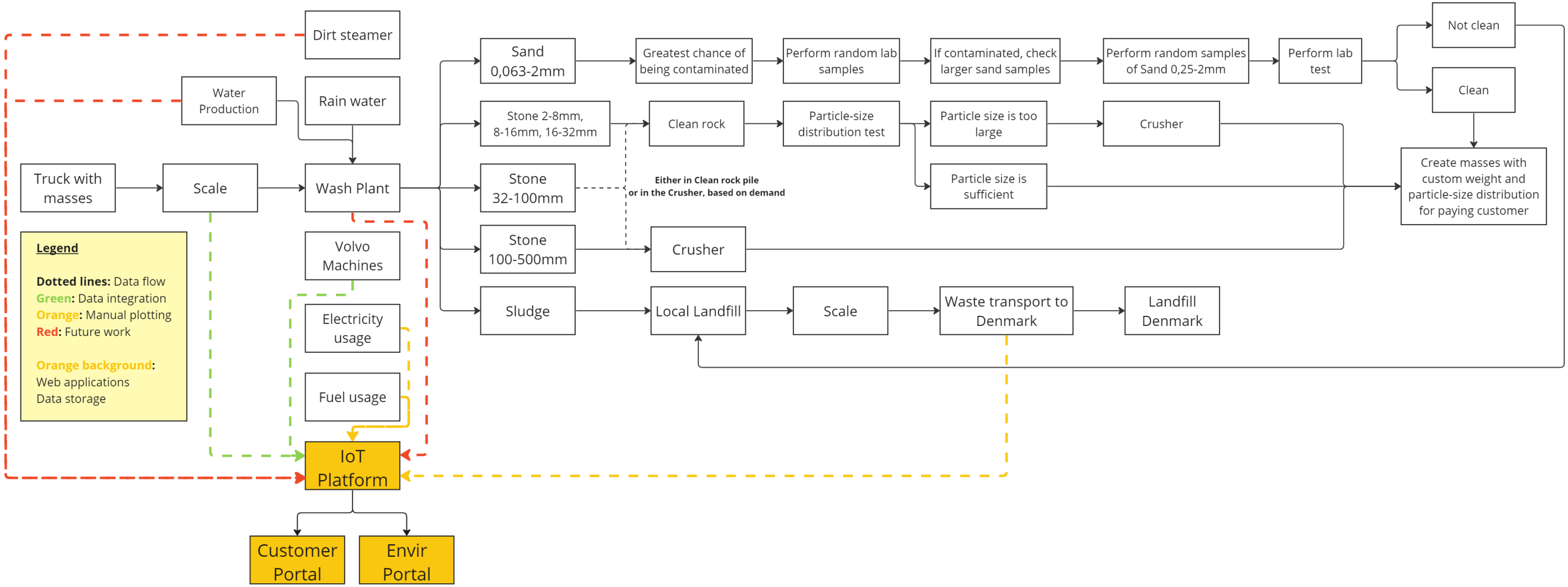
Workshop - Gigamapping



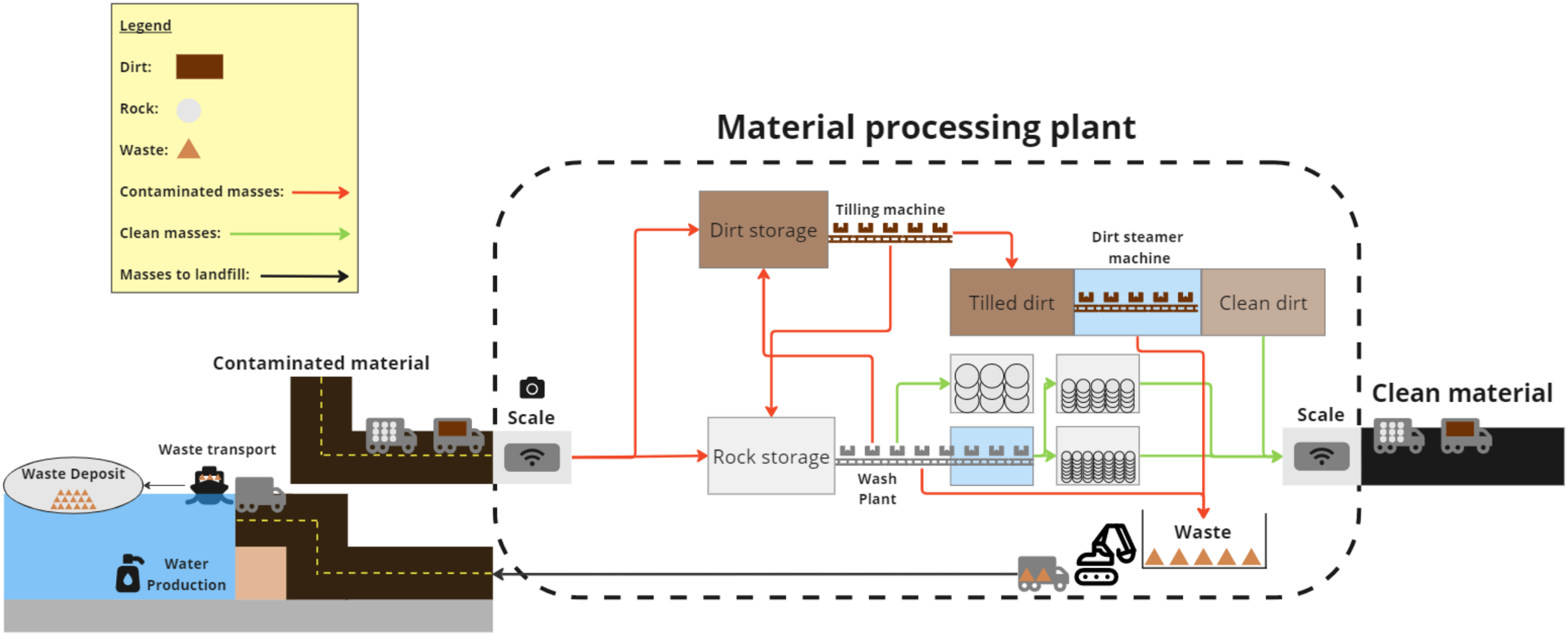




Workshop results -> Flowchart



Flowchart -> Concept of Operations



Emission Scope Definitions

Scope 1

(Direct emissions): Mainly fuel oil

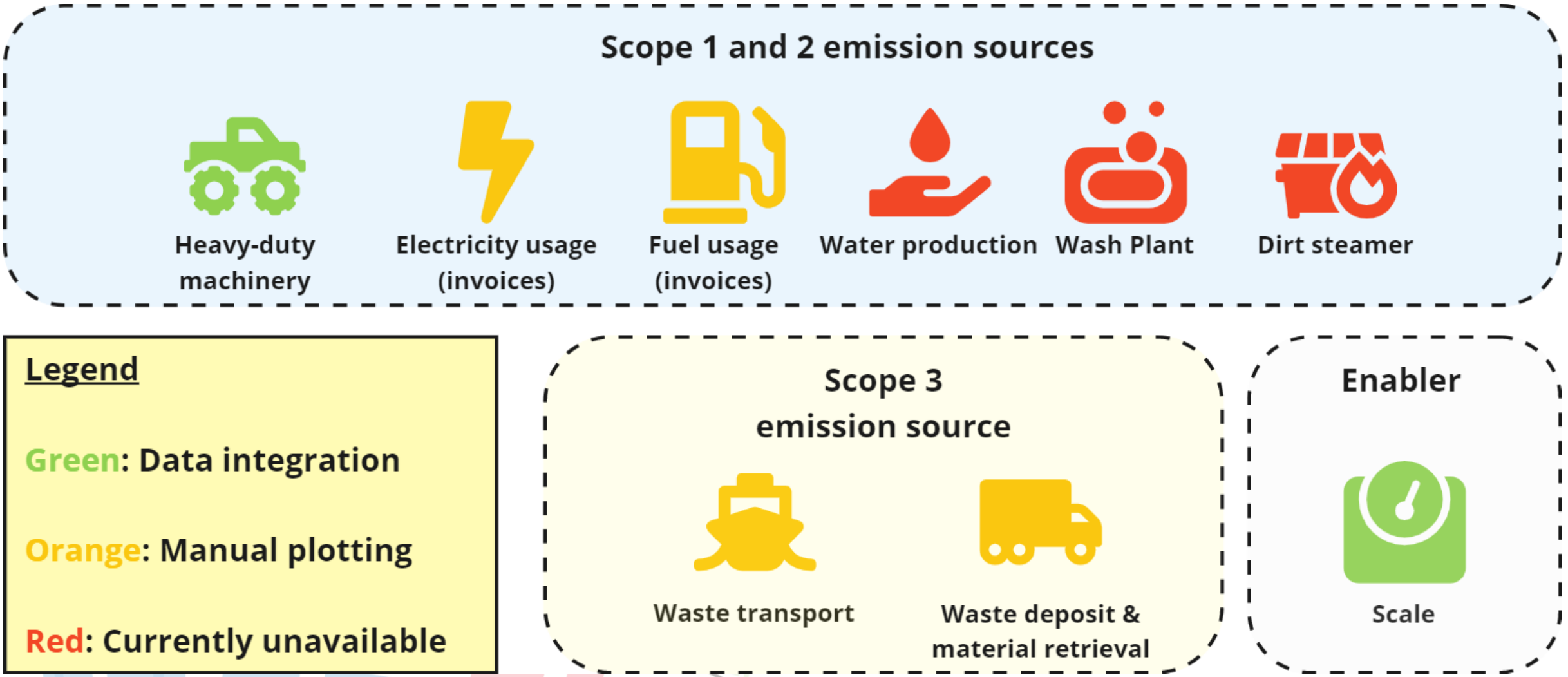
Scope 2

(Indirect emissions by owned equipment): Mainly electricity

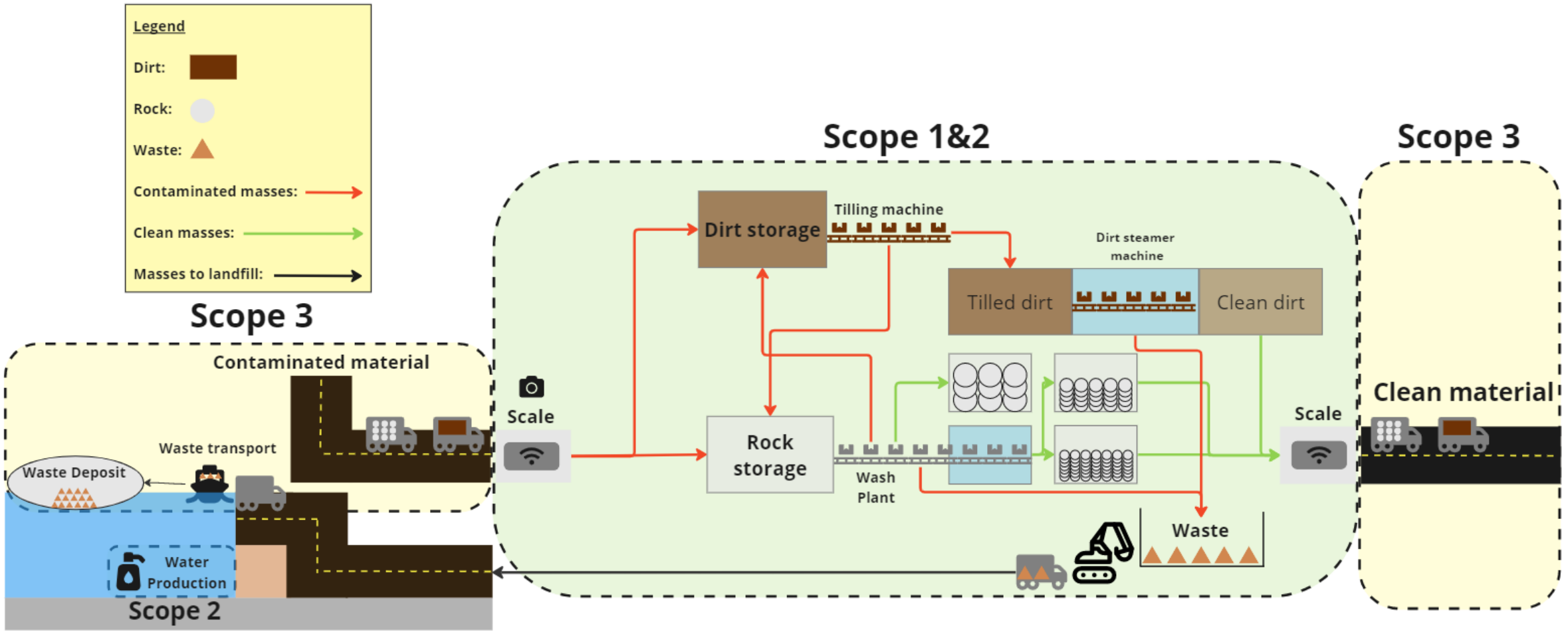
Scope 3

(Indirect emissions by not owned equipment): All types

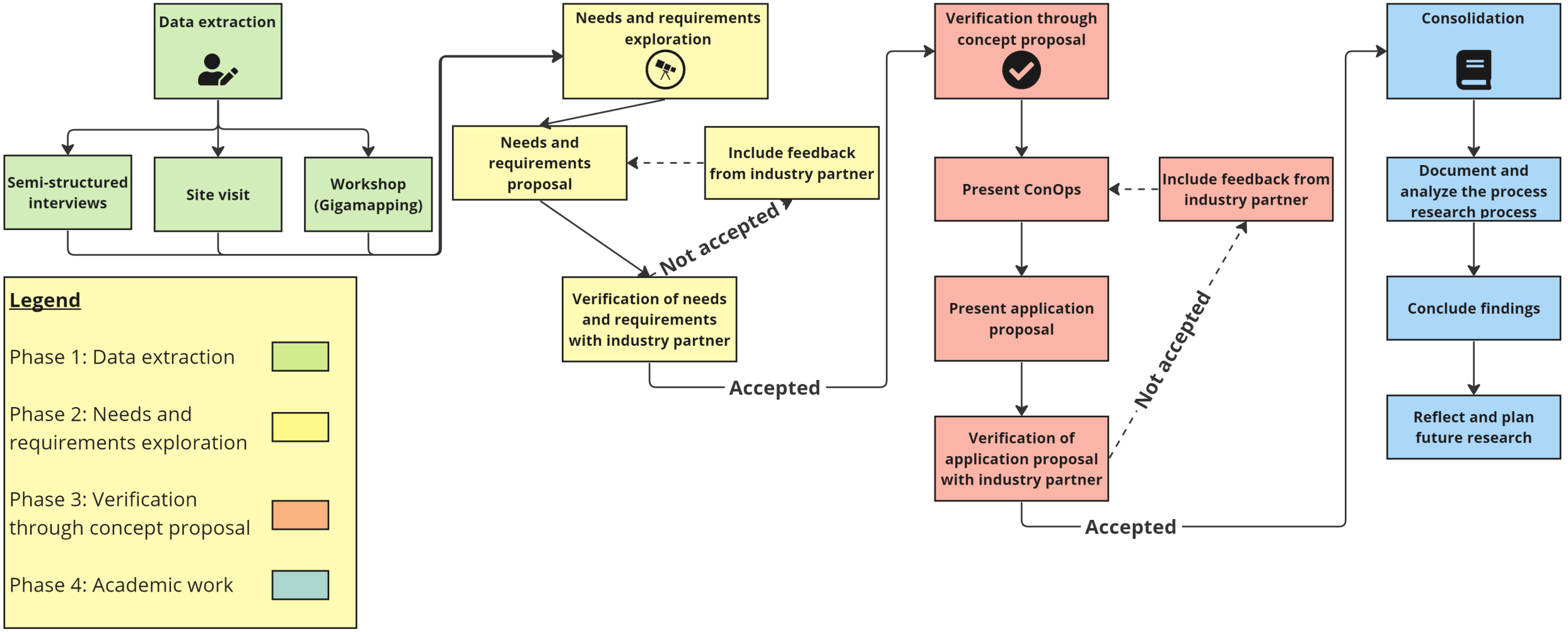
Identified Data Sources



Categorization of Emission Scopes



Research Methodology



Highlights for the Semi-Structured Interviews

Interviewees report on
Scope 1 & 2 emissions

The GHG Protocol was the most used
reporting framework

Motivation to report comes from owners,
customers, and regulators

CO2 accounting following formal accounting rules

Table 1: CO2 accounting industry partner February 2023

Scope	**Emission source**	**Emissions [kg CO2]**
Scope 1 (Direct emissions)	5 966L Biodiesel	14 974*[1]
Scope 2 (Indirect emissions)	23 897kWh electricity	263*[2]
Scope 3 (Indirect emissions)	N/A	-

*[1] *Biodiesel has an emission factor of 2,51kg CO2/liter* (Norwegian Environment Agency., 2021)

*[2] *Electricity has an emission factor of 0,011kg CO2/kWh (*Norwegian Water Resources and Energy Directorate et al., 2022*)*

Visualization of emissions

Concept proposal

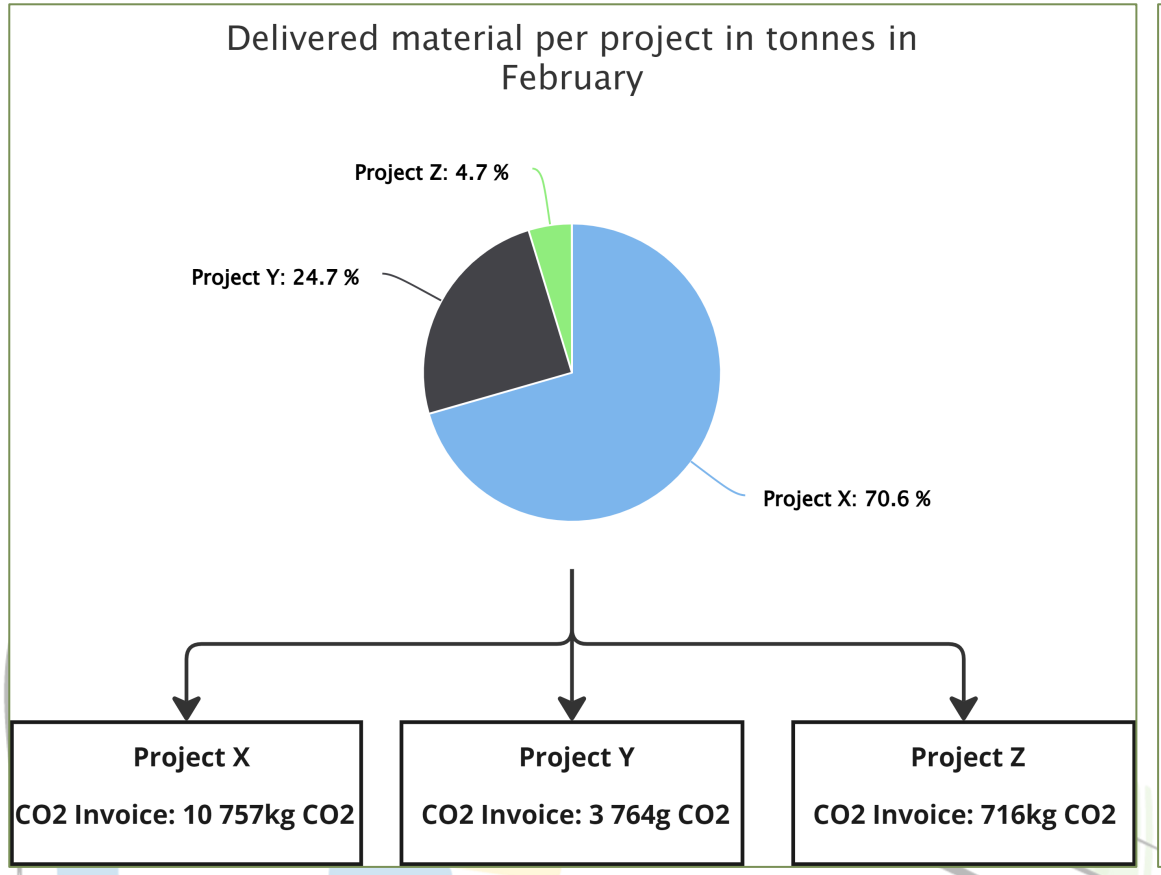


Table 2: Concept emission analysis with guesstimates on future energy usage

Scope	Emission source	Emissions [kg CO2]
Scope 1 (Direct emissions)	Excavator: 1 500L Biodiesel	4 000~
	Dump truck: 1 000L Biodiesel	2 500~
	Sum:	**6 500~**
Scope 2 (Indirect emissions)	Water production: 2 500kWh	25~
	Wash plant: 10 000kWh	100~
	Dirt steamer: 5 000kWh	50~
	Office and heating: 10 000kWh	100~
	Sum:	**275~**
Scope 3 (Indirect emissions)	Waste transport: 10 000L Biodiesel	25 000~
	Waste deposit & material retrieval: 5000L Biodiesel	12 500~
	Sum:	**37 500~**

Discussion

What are the primary sources of emissions data?

How can IoT technology retrieve accurate energy consumption?

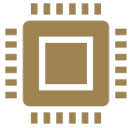
What is the industry standard for emission accounting for waste management companies in Norway?

What measures can the industry partner take to automate the emission accounting process?

What measures can the industry partner take to decrease emissions?

Limitations of the study

Small sample size



Focus on benefits

No filtering

Conclusion

Formal accounting rules fail to pinpoint exact measures

There is a lot of data available – the problem is making sense of it all

Contribution to knowledge and practice

Site visit -> Workshop -> ConOps -> Categorization of Emissions -> Concept

Emission reports can be automated

Future Work

- Investigate the adoption of IoT technology for emission accounting in other industries
- Research ways to automate the current manual task
- Examine long term effects of IoT-based solutions in reducing emissions
- Experiment with different workshop approaches

Thanks for listening

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Date 02.07.2024

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Mantena

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