AIM
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INTEGRATED
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SYSTEM

Corporate value chain analysis Alfen Transformer stations

CO_2 Performance Ladder and GHG Protocol

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ALFEN
POWER TO ADAPT

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Revision	**Section**	**Change**
2	Whole document	Update data and recalculation for 2019, addition option C., translation.
1.4		Added relevant $C0_2$-emission categories, Revised re-use part.
1.3		Added Ms-cables and Ls-cables
1.2		Implemented changes as discussed with BB 7-9
1.1		Initial release

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1 Introduction

Since 2016, Alfen N.V. (further Alfen) is certified according to level 4 of the CO_2 performance ladder. This means that Alfen has insight into its own CO_2-emissions. Twice a year the Scope 1 and 2 emissions are investigated and reported.
As part of the CO_2 performance, the value chain analysis of the transformer stations, published in the year 2015, has to be updated.

1.1 Scope

This report provides the Scope 3 Green House Gas (GHG) inventory of Alfen transformer stations produced and installed at Alliander project locations and shows the corporate value chain and indirect emissions produced during the product's life cycle.
Indirect emissions are emissions that result from Alfen's activities, but that occur at sources owned or controlled by another company [202].

Accessible stations are not included in this update, due to the previously calculated small contribution to CO_2-emissions in relation to the efforts required for data collection. Also special products are not included, due to the different configuration and the limited number thereof.

The following components are involved in the calculation of the CO_2-emissions:

- Housing
- Medium voltage switch(es)
- Low voltage installation
- Transformer
- Medium voltage cables
- Low voltage cables

No data is available on the lamp set and the shields in the transformer stations, so these have been disregarded.

1.2 Purpose of document

The purpose of this document is to understand the value chain emissions of transformers and also the impact of refurbishment. The aim is to identify the opportunities for reducing the carbon footprint and to set reduction targets.

Information on the most significant emissions will help in communication the potential risks of the emissions to Alfen's stakeholders and engage them with actions planned to reduce the associated risks.

1.3 Structure of the report

Chapter 4 describes the value chain of transformer stations and provides insight into qualitative information. Chapter 5 focuses on each category of the value chain and gives a short overview of the carbon dioxide emissions. Chapter 0 gives a comparison between a new and refurbished station based on an example. In Chapter 7 opportunities for improvement are summarized. Chapter 8 sets an objective and action plan for further development. And, finally Chapter 10 presents the results of the calculations and other sources in the annexes.

1.4 Calculation methods

Alliander is a framework for the assessment of the most significant emissions in Alfen's corporate value chain. Data from 2019 has been used.
Information on the quality of the data and used databases is included in Chapter 9.

1.5 Reporting Principles

Corporate value chain report is based on the requirements of CO_2 Performance Ladder and GHG The Corporate Value Chain (Scope 3) Accounting and Reporting Standard. The following reporting principles are applied in this report:

- Relevance
- Completeness
- Transparency
- Consistency
- Accuracy

2 Abbreviations & Definitions

2.1 Abbreviations

Abbreviation	Description
AIM	Alfen Integrated Management system
CO2	Carbon dioxide

Table 1 - Abbreviations

2.2 Definitions

Definition	Description
CO2 chain analysis	

Table 2 - Definitions

3 References

3.1 AIM Documents

Ref.	Document Title	AIM Document Number	Extern Document Number
[101]	Materiality analysis	AIM-QHSE-GEN-1.00-01-MA-01	

Table 3 – AIM Documents

3.2 External Documents

Ref.	Document Title	Alfen Document Number	Extern Document Number
[201]	https://www.liander.nl/over-liander/werkgebied		Liander website
[202]	GHG Protocol		2011
[203]	GHG Protocol - Corporate Value Chain (Scope 3) Accounting and Reporting Standard		2011

Table 4 – External Documents

4 Value chain end-of-life-processing transformers

Alfen develops, designs and produces transformer stations for various markets. In this chain analysis, the transformer stations as supplied to the network company Alliander are discussed in more detail.

Figure 1 - Process transformers shows the value chain of transformer stations. In this figure Alfen and project location are added to visualize the different locations. The assembly stage is indicated by a dotted line, as this is a Scope 1/2 process. The other processes are Scope 3. To keep a good overview, the different transport phases are simplified by a blue line.

In the case of Alliander there are three possible variants for the end-of-life processing of sold products:

A) Alliander decides on the waste processing of the transformer stations without the intervention of Alfen. This is most common. Here a transformer station has a lifespan of 50 years.
B) Alliander sends the transformer stations back to Alfen after the end of their life. At Alfen the products are refurbished. Refurbished stations can be reused by Alliander or used by other customers. The refurbishment reduces waste, because the following parts are reused: housing, transformers and medium voltage switches. The service life in the case of conversions is 70 years instead of the standard 50 years. After this period, waste must still be processed.
C) After the end of their life transformer stations are refurbished at the project location. This option reduces as much waste as in option B, but reduces CO_2-emissions in transport.

Figure 1 shows that the steps in option A, B and C are almost identical. The (marked) differences are: the lifespan, for the second assembly extra materials and semi-finished products are purchased and transported and extra waste is created and transported. With option C there is no transport back to Alfen.
The question that is attempted to answer in the following chapters is: What is the difference in CO_2-emissions between options A, B and C?

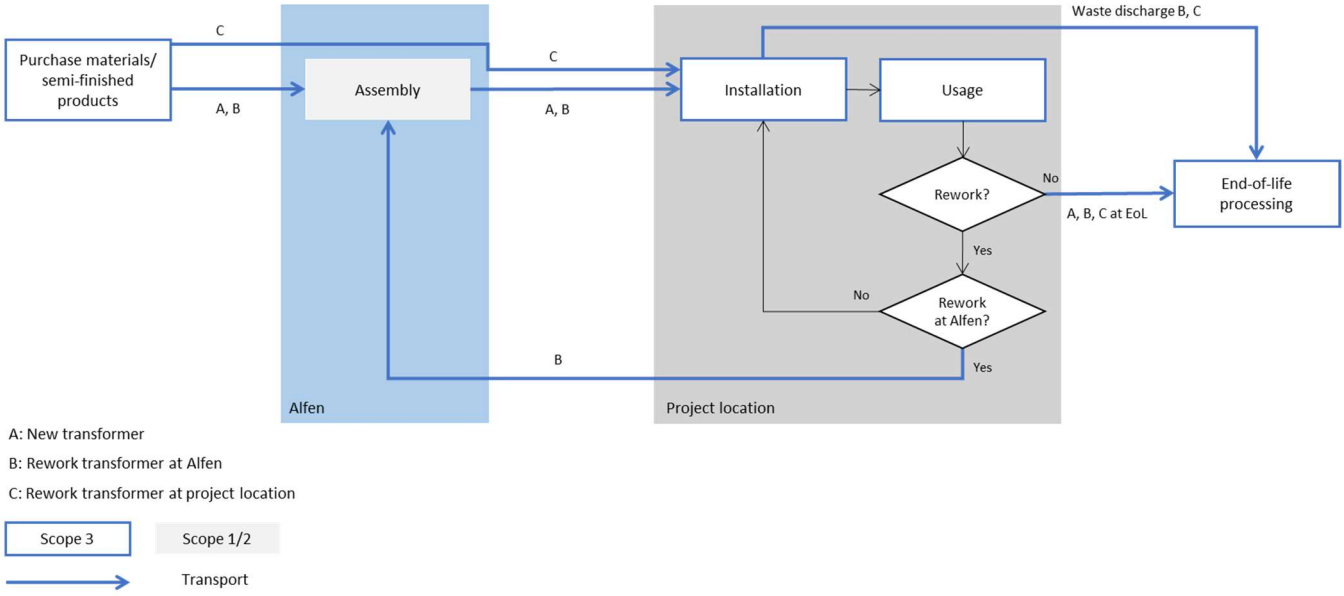

Figure 1 - Process transformers

4.1 Chain partners end-of-life processing

In the value chain the following partners can be distinguished:

- Customers
- Waste processors
- Suppliers of materials and transport

Information on chain partners is included in Annex A.

5 Relevant Scope 3 CO_2-emissions Alfen

With reference to the report "Materialiteitsanalyse CO_2 Prestatieladder" [101] the following Scope 3 CO_2-emission sources are relevant in the value chain for the transformer stations to Alliander:

- Purchased materials and semi-finished products;
- Transport and distribution (upstream and downstream);
- Use of sold products;
- End-of-life processing of sold products.

In 2019, an amount of 801 compact stations were produced and installed for Alliander. The amount of refurbished stations is not registered and therefore not known.
In this Chapter the emissions of the relevant Scope 3 categories will be calculated for the regular process, option A in chapter 4.

5.1 Purchased materials and semi-finished products

Part of the Scope 3 inventory is an analysis of the purchased materials and semi-finished products necessary for the production of transformer stations. The measurement is based on the CO_2-emission factors of the main components in the product, like steel, copper and concrete (see Chapter 9). Table 5 provides a list of the main components and the related CO_2-emissions.

Product	Emission (tonnes CO_2e)
Housing stations	1,409
Medium voltage switches	238
Low voltage distributor	156
Transformers	2,152
Low voltage cables	42
Medium voltage cables	145
	4,142

Table 5 - Emissions produced and installed products

The total CO_2-emissions in this category are 4,142 tonnes of CO_2. And 83 tonnes per lifeyear.

SF_6 gas
SF_6 gas is used in some transformers. This gas is currently not used in Alliander products and therefore does not contribute to CO_2-emissions. Since this gas contributes to the greenhouse effect, it should be avoided in the future to avoid increasing emissions.

About 86% of this emissions is caused by the transformers and the housing of the stations. Figure 2 shows the ratio of the emissions. Detailed information is provided in Annex B.

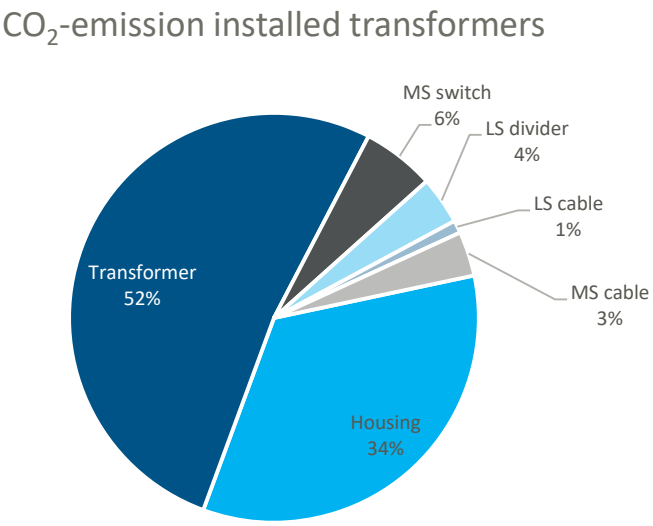

Figure 2 -CO_2-emission installed transformers

5.2 Transport and distribution

In the regular process, transport takes place three times in the chain:
1) upstream transport when supplying (raw) materials;
2) downstream transport when delivering to the customer; and
3) transport to the waste processor after the end of its life.

Alfen works with about 300 suppliers. Annex A, Table 12, provides an overview of the top twenty suppliers with the highest turnover.

In order to measure the impact of upstream and downstream transportation, the whole list of suppliers is analyzed. As it wasn't possible to identify the exact logistics of the product's components and the amount of transports with regard to Alliander, the average CO_2-emission per transformer station produced in 2019 is calculated. A starting point for the measurement was the quantity and traffic of transportation consisting of two parameters: amount in tonnes and distance in kilometers. Assumption is that every delivery contains one tonnes of cargo transported by a gasoline truck using the shortest route from supplier's main office in the Netherlands to Hefbrugweg 28 in Almere.
The total weight of 801 transformers is 3,511 tonnes. This weight is based on the weights of the end products.
The emission factor of 0.259 or 0.432 kg CO_2 per tonne-kilometer has always been assumed.

Supply raw materials
De average distance to the top 20 suppliers is 380 km.
Total CO_2-emissions are 345 tonnes.

Delivery to customer
Based on a worst-case scenario, the average distance from Alfen to the working area of Alliander is 113,3 km. Transporting the products over this distance causes an emission of 161 tonnes of CO_2.

Transport to waste processor
The transformer stations are disposed as waste after the end of their life. The distance from Alliander to the waste processor is unknown. A distance of 150 kilometers has been assumed for this. This transport emits 136 tonnes of CO_2.

Type transport	Weight (tonnes)	Emission factor	Distance (km)	CO_2-emission (tonnes CO_2)
Delivery materials	3,520	0,297	380	345
Delivery to customer location	3,520	0,297 or 0,481	113	161
Transport to waste processor	3,520	0,297	150	136
				643

Table 6 - CO_2-emissions transportation

Total emissions in this category are 643 tonnes of CO_2, corresponding with 13 tonnes per year of life.

5.3 Use of sold products

During its lifetime a transformer has energy losses. In the case of the grid companies, and therefore Alliander, the transformer station is subject to 60% load. The losses are calculated on this basis.
The losses differ per transformer. The higher the power of the transformer, the higher the losses. Table 7 gives an overview of the transformer types used for Alliander.

Alliander's energy network is not 100 % fossil fuel energy free. In worst case scenario infrastructure at all Alliander locations is powered by non-renewable energy, so for the calculation the emission factor "gray electricity" is used.

Transformer type	Amount	PV STAT (kW)	kWh/ day/ station	Loss / year/ station (kWh)	Total loss during lifetime (tonnes CO2)
250-630	449	1.95	46.74	17,082	248,542
630-1250	29	4.38	105.15	38,369	36,119
1000-2500	23	7.62	182.93	66,751	49,832
					334,493

Table 7 - Emissions use of sold products

This amounts to a CO_2-emission of 334,493 tonnes of CO_2 or 6,690 tonnes of CO_2 per year during a 50 year lifetime.

5.4 End of life processing

After expected lifetime of 50 years, transformers enter the phase of the end of their life. This means that the product can to be treated as a waste.
To calculated CO_2-emission form waste processing emission factors for standard waste processing from Defra are used. This means a part is recycled and a part is disposed. This is an changes compared to previous version when it was assumed that all waste was dumped.

Table 8 gives the CO_2-emissions from the end-of-life processing of transformer stations produced for Alliander in the year 2019.

Product	Emission (tonnes CO_2e)
Housing stations	3,8
Medium voltage switches	1,0
Low voltage distributor	1,2
Transformers	17,4
Low voltage cables	0,3
Medium voltage cables	1,2
	24,9

Table 8 - Emissions end-of-life processing produced and installed products

The end-of-life processing ensures a CO_2-emission of 25 tonnes of CO_2, corresponding with 0.5 tonnes CO_2 per lifeyear.

5.5 CO_2-emission value chain

The relevant categories in the value chain contribute to CO_2-emissions with 339,302 tonnes of CO_2.
The use of sold products contributes the highest values.

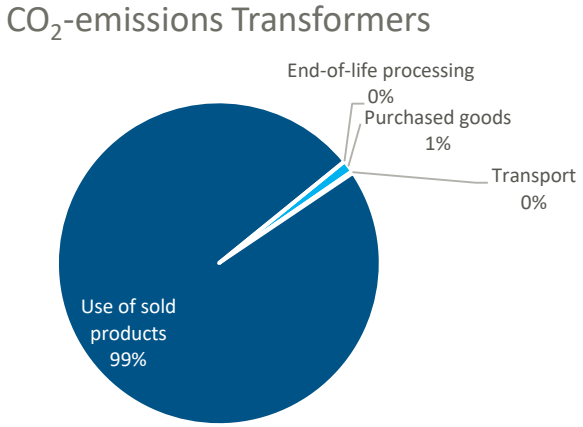

Figure 3 - CO_2-emission transformer stations

6 Comparison new & refurbished station

There are two options for refurbishment, at Alfen (B) or at project location in the field (C). In this Chapter the difference between option A, B and C, displayed in Figure 1 - Process transformers in Chapter 4, is calculated.

- Option A is to produce a transformer substation and process it as waste after 50 years.
- Option B is the refurbishment of a station at Alfen location, where some parts are reused. The product has a lifecycle of 70 years.
- Option B is the refurbishment of a station at project location, where the same parts are reused, and the product also haves lifecycle of 70 years.

In 2019, in total approximately 120 transformer stations were converted, of which approximately 30 in the field. The amount for Alliander and the amount per type is unknown. Therefore the calculation is performed for transformer station type 10A. The reason is that this type is the most produced for Alliander (396 transformer stations).

Refurbishing products only provides theoretical savings, since the product will be completely processed as waste at the end-of-life stage. This determines the emissions for the purchase of new materials and the end-of-life and for transport weights.

6.1 Purchased goods and services

In this category option B and C run the same cycle as option A, but twice. But in the second part, less parts are purchased , because housing, transformer and medium voltage switches are reused. As a result, option B has higher emissions. However, this is divided by a longer lifespan.
Assumption is the housing is reused in 100% of the cases and the medium voltage switch, the transformers and the medium voltage cables in 50% of the cases.

6.2 Transport

In this category the difference between option A and C and option B in the extra transport to Alfen for refurbishment and (back to) project location. Furthermore, there is an extra waste stream to the waste processor for the replaced parts.

6.3 Use of sold products

In this category there is no difference between option A, B and C in usage per life year. It is possible that transformers consume more electricity with a longer life. However, no information is available on this.

6.4 End-of-life processing of sold products

Option B and C include additional end-of-life processing for the replaced parts.

6.5 Results

Based on calculations with current data and assumptions, the result is that CO_2-emissions in case of refurbishment are comparable to the CO_2-emissions for new installations. This is due to the great influence of the usage phase and the availability of data on refurbishment.

According to current calculation the difference is only 5 grams of CO_2 for refurbishing at Alfen and 11 grams for refurbishing at location. The temporary results are added in Annex D.

7 Opportunities for Improvement

The medium voltage switch and transformers at Alliander are part of contracts between suppliers of Alfen and Alliander. This means that for possible improvement measures, cooperation is necessary to achieve an optimal result.

1. Increase refurbishment of products
As described in Chapter 0, the refurbishment of transformer stations can lead to a reduction in CO_2-emissions, but the available data is not sufficient to perform a proper calculation.
The advice is to set up a good registration of reused or replaced materials per refurbished station.

2. Avoid using SF_6 gas
This gas is currently not used in Alliander's products, so this will not yield any CO_2 savings. However, this gas contributes to the greenhouse effect and will therefore to be avoided in the future to ensure that emissions do not increase.

3. Decrease energy losses
The use of the products causes high CO_2-emissions. The electrical losses of the transformers are a dominant factor.
Energy losses have the greatest impact on the carbon footprint, but can be least affected.
A reduction possibility for electrical losses and therefore CO_2-emissions, is thickening copper and/or aluminum in the transformers. This change also has disadvantages for Alfen due to increasing material costs and waste processing. Research into the optimal configuration (cost and energy loss) is advised.

4. Improve data quality
Secondary sources were often used in the assessment. Data quality can be improved by requesting (field) data from chain partners.
Also improvement of registration contributes to better data quality, such as registration of material data and refurbishments (see also point 1) per product type.

8 Objectives and action plan

This chapter describes the objectives for this chain analysis together with an implementation plan to achieve the objective.

A contract was signed at the end of 2019 with Alliander for the refurbishment of transformer stations. Details of which stations is still under discussion at the time of writing this report. Objective for the next three years is to use the data on refurbishments to update this chain analysis.
A second objective is to investigate options for reducing energy losses.

A number of actions will be taken to achieve these objectives.

Action	Realisation
Monitor refurbishment of products (materials and types)	31-12-2020
Avoid using SF6 gas	31-12-2020
Investigate possibilities to reduce energy losses	31-12-2020
Improve data quality	31-12-2020
Update value chain analysis	31-12-2020

Table 9 - Action plan

9 Data quality

Various data sources have been used to quantify the CO_2-emissions. Both information from chain partners and own measurements (primary data), as well as own estimates and general data (secondary data), have been used.

Source of the emission factors are: the published factors of www.CO2-emissiefactor.nl. Any other sources of emission factors used are listed in Table 10. Table 10 also mentions the quality of the source.

Data	Source	Quality
Specifications medium voltage (Xiria)	Information ABB/ Eaton	primary
Specifications medium voltage (Magnefix)	Estimation	secondary
Specifications low voltage installation	Estimation/ measurement	secondary/primary
Specifications concrete	Information Voorbij	primary
Specifications transformers	Estimations/ information CG	secondary/primary
Emission factors	Emission factors Defra V1.2, Circular Ecology ICE database V3.0 and V2.0	secondary
Emission factors epoxy, iron and copper	Joulz ketenanalyse 2011 (Joulz, 2011)	secondary
Specifications cables	ERP-systeem/ technical specialist Alfen	secondary
Recycling percentage	Estimation	secondary
Life cycle	Estimation	Secondary
Oil	(Energiedragerslijst, 2013)	Secondary

Table 10 - Quality data used

10 Annexes

Number	Title
Annex A	Information on chain partners
Annex B	Calculations
Annex C	Transport
Annex D	Comparison option A, B and C for type 10A

Table 11 – Overview of annexes

The annexes are only available to chain partners and can be requested via the e-mail address qhse@alfen.com.