Kristianstad University
SE-291 88 Kristianstad
+46 44 250 30 00
www.hkr.se

Independent project (degree project), 15 credits, for the degree of Bachelor of Environmental Science with Specialization in Strategic Environmental Work.
Spring Semester 2021
Faculty of Natural Science

# Climate Neutral Roadmap in Fossil Free Competitiveness for Paroc, Sweden

What Paroc can do to meet up with the roadmap from Fossil Free Sweden.

**Felix Mörck**

Kristianstad University
SE-291 88 Kristianstad
+46 44 250 30 00
www.hkr.se

Självständigt arbete (examensarbete), 15 hp, för Kandidatexamen i miljövetenskap med inriktning mot strategiskt miljöarbete.
Vårterminen 2021
Fakulteten för Naturvetenskap

# Klimatneutral Färdplan i Fossilfri Konkurrenskraft för Paroc, Sverige

## Vad Paroc kan göra för att möta upp färdplanen från Fossilfritt Sverige.

**Felix Mörck**

## Author

Felix Mörck


## Title

Climate Neutral Roadmap in Fossil Free Competitiveness for Paroc, Sweden. What Paroc can do to meet up with the Roadmap from Fossil Free Sweden.


## Supervisor

Beatrice Hallén, Sr Sustainablity Leader Insulation Business Europe, Owens Corning.

Jörgen Svensson, EHS Manager, Paroc, Sweden.

Stefan Trobro, Senior Lecturer in Water and Environmental Technology, Kristianstad University.

## Examiner

Lennart Mårtensson, Professor in Environmental Technology, Kristianstad University.



## Abstract

Today's society is standing in front of a revolution where fossil energy should be replaced with renewable energy. Governmental agencies and policy makers have formed goals and regulations to become greener, and the organisation Fossil Free Sweden has published roadmaps for fossil free competitiveness. Therefore, this report has connected Paroc's operations with a roadmap for fossil free competitiveness to form a strategic environmental plan. Early, it was recognized that the field was big and a limitation to $CO_2$-emissions during production were established. The facts were gathered mostly throughout literature studies, scientific publications/articles, and personal communication with personnel at Paroc/Owens Corning. The results gave a description over fossil free competitiveness for the construction sector, previous, and current sustainability efforts at Paroc. After that, the report lifted suggestions of modifications to the

mainstream process. Focus laid on the reduction of coke, propane, and dolomite. Later, the report discussed a possible strategy to become fossil free by 2045. It found out that there are many approaches to become climate neutral. Moreover, a need for practical testing of the solutions in the mainstream processes, and that emissions can be calculated in an absolute of relative way.

**Keywords**

Climate neutral, Fossil free, Mineral wool, Competitiveness, Intercommunion, Plasma burner, Oxy fuel, Hydrogen gas.

# Preface

I want to thank The University of Kristianstad for three interesting and exciting years as a student in environmental science. Especially Stefan Trobro, Peter Åberg and Lennart Mårtensson for their commitment during the program. During my time at the university, a new perspective has opened, and it will be following me for the rest of my life. In the future, the education will help me to be a small part in the transition to a sustainable society.

Also, I want to thank Beatrice Hallén, Veronica Sjödin, Jörgen Svensson and Jan Bengtsson at Paroc for the opportunity to work with them. Their advice during my internship and bachelor's thesis have been critical to the results of my reports. You gave me many sleepless nights, but it was totally worth it!

I wish you an interesting reading!

Felix Mörck

# Contents

# 1. Introduction

One of the greatest challenges of the future for our generation is to combat climate change, and it is not a single player game because the whole world needs to cooperate to become climate neutral (net value of zero anthropogenic $CO_2$). In 2008, the world used 492 exajoules of primary energy and 12.9% was from renewable resources. It means that 87,1% was coming from non-renewable resources (for instance coal, oil, and natural gas). These sources are contributing to the climate change through global warming because of a heat absorption from the anthropogenic $CO_2$ (sources from underground which is not included in the natural circles) (Edenhofer et al., 2012).

The number of challenges related to reduce the 87.1% to 0% are many, but we are seeing a trend where the renewable resources (for instance, solar, wind, hydro energy, and biofuels) are replacing non-renewable ones (for instance, petroleum, natural gas, and coal) at a faster rate for every year (Edenhofer et al., 2012).

Sweden is one of the countries that wants to be the first climate neutral country and a role model for other countries in their transition to renewable energy. Therefore, the organization Fossil Free Sweden has been arranged on an initiative from the government. They have published roadmaps for fossil free competitiveness (competitive market without fossil fuels) for different branches, where industries and organizations are working towards a reduction of fossil fuels. Also, goals have been established for the different sectors to become climate neutral and big stakeholders have signed the roadmap. Moreover, they are presenting a current situation and future challenges together with suggestions for practical implementations (Fossil Free Sweden, 2018).

One of the sectors is the construction sector and it stands for more than 20% of Sweden's total emissions of $CO_2$. Paroc (mineral wool producer) is a company withing the business and big Swedish purchasers of insulation (Skanska, NCC) have signed the roadmap and want to follow it for a climate neutral construction sector in 2045 (Fossil Free Sweden, 2018).

## 1.1 Background

Owens Corning (owner of Paroc) is a multinational business focusing on producing roofs, fiberglass, and insulation. Every year, they are releasing a public sustainability report (work for a positive development of economy, society, and environment) over their operations to show sustainable goals, planned improvements, and what they have done to create a better world (Owens Corning, 2021).

Owens Corning is presenting facts about environmental materiality for their different regions in the world. Energy efficiency (more products out of less energy), renewable energy and combating climate change are important for the company globally, but in Europe, combating climate change is higher than for any other region (Owens Corning, 2021). To add, Sweden wants to be a role model for the European Union, and the world, in combating climate change (Fossil Free Sweden, 2018).

It means that Paroc's plants in Sweden are living in a time where change is occurring and will accelerate in the next coming years. According to Owens Corning (2021) and Jörgen Svensson[1], Paroc has done a lot to reduce their waste to landfill and will continue to reduce it to generate a circular economy for Paroc. However, Paroc has seen a development in Owens Corning's sustainability reports, where combating climate change has become more important for every year.[2] Therefore, Paroc wants to come closer to climate neutrality to meet up with a futural market, where low carbon dioxide emission will be a key factor for the sales (Fossil Free Swede, 2018).

Appropriate for the moment is that Fossil Free Sweden's (2018) roadmap is made for companies who want to take part in the fossil free competitiveness. For Paroc, it means that their environmental work can be related to the roadmap to show customers, suppliers, and authorities what they are doing for fossil free competitiveness.

[1] Svensson Jörgen. EHS-manager Paroc, Hässleholm. Microsoft Teams meeting 03/15–2021

[2] Hallén Beatrice. Sr Sustianability Leader Insultion Businiess, Europe. Microsoft Teams meeting 04/12–2021

## 1.2 Summary of Fossil Free Sweden's Roadmap

This section will (in brief) describe the related suggestions to Paroc's operations. It is divided into a summary and exhortation, vision about becoming climate neutral, readjustment for the construction sector, current situation, opportunities/challenges, concurrence, and a suggestion of a journey for companies within the field (Fossil Free Sweden, 2018).

### 1.2.1 Exhortation

Of the people involved at Fossil Free Sweden's (2018) events, 91% confirmed that the climate issue will have a great impact or be crucial for the construction sector within the coming 5 years. Therefore, the following goals have been established for the sector:

Table 1: The presented goals from Fossil Free Sweden (2018).

| **Year** | **Goal** |
|---|---|
| 2045 | The net value of carbon dioxide emissions will be 0 |
| 2040 | 75% of the greenhouse gas emissions will be reduced (in comparison with the levels of 2015) |
| 2030 | 50% of the greenhouse gas emissions will be reduced (in comparison with the levels of 2015) |
| 2025 | The emissions of greenhouse gas will show a distinct decreasing trend. |
| 2020-2022 | Companies within the construction sector should have mapped their emissions and established own climate goals. |

Moreover, they divided their exhortations into key factors and different target groups. They are listed below in bullets:

**Key factors:**

- United action, leadership, and knowledge.
- Long-term perspective.
- Linear to circular processes.
- Efficient usage of biobased raw materials.
- The public procurement should be the engine for a transition.

**Parliament and Government:**

- Laws which are set up from a long-term perspective and creates a competitiveness.
- Create prerequisites for a transformation within the base-industry for the construction sector.
- Create an action plan for the needed transition.
- LCA (Life Cycle Analysis) for buildings and climate declarations for construction products.
- Change the rules for classification of waste for an increase in reusage.
- Work for lower capital investment to stimulate investments with low climate affection.
- Introduce incitements for an energy efficiency which is defendable from an LCA-perspective.
- Create an open database with climate-data for the construction sector.
- Give a suitable actor the mission to make the climate affection visible throughout the entire value chain.
- Give a suitable actor the mission to create criteria for a climate neutral procurement.

**All actors:**

- Set up and implement climate goals.
- Increase the competence within the construction sector to show the opportunities for a decrease in greenhouse gas emissions.
- Use procurement and strategies to increase the cooperation between actors of the value chain.
- Leave information about climate affection, even though it is not a requirement from the customer.
- Create sustainability reports.
- Digitalize the entire plan and construction process.

**Customers:**

- Be aware of the climate affection early in project stages within the plan and construction processes.
- Prioritize innovative solutions.
- Follow up climate requirements critically.
- Require reusage of products and materials.
- Implement pre-qualification requirements.

**Consultants and architects:**

- Suggest solutions with low climate affection, efficiency, flexibility, and removability.
- Create prerequisites for climate neutral solutions.

**Entrepreneurs:**

- Create scalable production methods with reusage, closed material circulation, and climate neutrality.
- Create climate and competence requirements for suppliers and be critical in their scrutiny.

(Fossil Free Sweden, 2018)

### 1.2.2 Vision for climate neutrality in 2045

In 2045, climate neutrality should be valued high by the market, and it should be an advantage to think in a long-term perspective. Climate neutral products are a matter of course and some are working under negative greenhouse gas emission because they are producing more renewable energy than they are using. This is possible due to a shift in technology. Moreover, we are not throwing anything away and waste is not existing due to that action. Buildings are constructed in an efficient way and laws are supporting and driving the development forward in a cooperative world (Fossil Free Sweden, 2018).

In 2030, our lifestyle has clearly changed and the work with climate neutrality have begun to give results. The circular economy is implemented within different fields and we have begun to see the first climate neutral products. Furthermore, procurement requirements have been developed and it frames sustainable innovations together with cooperation. Finally, LCA from design to usage has been developed, and laws are keeping up with related requirements for climate neutrality (Fossil Free Sweden, 2018).

Too add, Fossil Free Sweden (2018) is mentioning that the whole value chain of the construction sector should be involved in the work. However, they also want to count in international emissions to reduce the risks of productions moving abroad. In simpler terms, they mean that the construction sector should look at their products from a perspective of consumption (Fossil Free Sweden 2018).

A realistic picture of 2045 can be flexibility, self-determination, and security. A company is unattached to a geographical position and is working a lot over the internet but has offices where they can group together for specific meetings. Furthermore, the construction sector has swapped to become a branch of restauration (Fossil Free Sweden, 2018).

### 1.2.3 The transition of the construction sector

Today, the construction sector is in a situation where it will not hold together if it continues without any transformation. At the same time, the population is growing, and the world economy is expected to triple. Therefore, a transition is highly needed and in

2015, The Paris Agreement gave the sustainability work a boost (Fossil Free Sweden, 2018).

Sweden wants to be a role model and that requires a power of action and a strategy. The construction sector in Sweden has a revenue of 1100 billion SEK/year and 550 000 workers. With such numbers, no actor can drive the work for climate neutrality alone and a cooperation within the value chain is needed (Fossil Free Sweden, 2018).

### 1.2.4 Description of current situation and trends

The society has paid more attention to the construction sector recently due to its $CO_2$ emissions. In 2014, it was 15 million tons $CO_2$ equivalents (22 million with heating included) and half of it was from importation. Moreover, it is discussed that the best chance to improve the reduction of $CO_2$ is in a project start phase because few parameters are locked (Fossil Free Sweden, 2018).

The fabrication of building materials has the biggest impact with 80% of the emissions and the sector can expect a possible investment of 25-75% more (steel, concrete, cement) than today. However, the final product will be 0.5% more expensive than today (Fossil Free Swede, 2018).

Some improvements have already been done. For instance, the electricity in Sweden is close to climate neutrality and the total usage of electricity is calculated to be lower in 2035 than today. Energy efficient buildings are a key factor to succeed with this calculation. (Fossil Free Sweden, 2018).

At the same time, we are living in the fourth industrial revolution, where digitalization and automatization is doing a transition to our tradition market. For the sustainability, it gives advantages for both economy and environment because we do not have to travel as much. Moreover, it is possible to analyze data quicker and release standards with databases. Also, CCS (carbon capture storage) is a developed technique where some actors are working under negative emissions (Fossil Free Sweden, 2018).

At the market, certifications are important to the marketing and environmentally friendly obligations are increasing in popularity for investors. To keep this work in a

positive direction, it is essential that the construction sector continuous its improvements. Therefore, the ethics of a company is becoming more important and valuation-controlled companies will drive the development forward (Fossil Free Swede, 2018).

### 1.2.5 Opportunities and challenges

Sustainability is becoming more central for the construction sector, especially for the younger generation. Still, there are some issues to deal with. For instance, there is a conflict between authorities and the market about the division of labor. The companies want the authorities to become clearer in their willing, but authorities want the market to solve the problems themselves (Fossil Free Sweden, 2018).

Therefore, it is encouraging to have a common target image. It is said that a reduction of greenhouse gases with 50% is possible with existing technology, and a clear business connection with goals of low emissions will give us the right incitements. A suggested solution is to let business models evaluate emissions. Today's models are not doing that, and it can result in market failures for environmentally friendly goods and services (Fossil Free Sweden 2018).

Another described solution is better standards, and it needs to support the environmental goals of our future. Moreover, that related laws within the field are keeping up with the vision. For instance, the waste legalization needs to be changed to make it possible for the market to recirculate waste at local plants (Fossil Free Sweden, 2018).

To bring the opportunities to life and face the challenges, there is a need for leadership and increased competence within the field. Brave leaders must enter the market and show that Sweden is a role model. Then, it is required that reports represent longer timeframes and not only a quarter of a year (Fossil Free Swede, 2018).

### 1.2.6 Competitiveness

The future brings the market into a world where sustainably work is crucial for a company's survival and efforts are making a positive impact on the revenue. Long-term investments will pay off better than short-term ones for both companies and society. Therefore, all actors need to set up requirements for customers and suppliers. It can be a threat for small companies, but it is also important to mention that environmentally friendly solutions are giving opportunities for small companies too (Fossil Free Sweden, 2018).

However, some companies are still only looking at the price. Therefore, it is also important to follow up the requirements. Otherwise, we will not receive any climate benefits. Moreover, without any evaluations, it is possible that manufacturing is being moved to other countries, where the requirements are not as environmentally friendly as Sweden's (Fossil Free Swede, 2018).

## 1.3 Purpose and problem statements

The purpose of this report is to connect Paroc's environmental work with the roadmap from Fossil Free Sweden (2018). Moreover, to try to implement Paroc's mainstream process with the goals and ambitions the roadmap have for a fossil free competitiveness in 2045. Therefore, the following problem statements have been formed:

- What environmental activities have Paroc already done, which meet up with the values of Fossil Free Sweden's roadmap?
- What environmental activities are Paroc working with today, which meet up with Fossil Free Sweden's roadmap.
- What environmental activities are suitable for Paroc to meet up with futural goals and ambitions of the roadmap, and how does it contribute to society as a whole?

With the problem statements answered, the report will define a potential strategic environmental plan for Paroc. It will include activities to meet up with the roadmap's goals and ambitions for a fossil free competitiveness in 2045.

## 1.4 Limitations

The study will only focus on Paroc inSweden and their sustainability work (only environmental) to meet up with the roadmap from Fossil Free Sweden (2018). Also, it will specifically focus on the direct $CO_2$ emissions and options of how it can be possible to become climate neutral, because of the increased attention within that field (Owens Corning, 2021), rather than circular economy and waste reduction. However, waste, and circular economy can still be mentioned in the report if it is related to the carbon dioxide emissions. According to Persson et al. (2019), it is likely to occur because of positive synergy-effects generated with environmental improvements. Furthermore, Fossil Free Sweden has made roadmaps for more sectors than the construction sector (Fossil Free Sweden, 2021), but the report will not put any attention to these reports.

# 2. Materials and Methods

The study was theoretical, and no practical test were used as a method. Therefore, the materials were scientific websites, reports, articles, literature, and qualitative interviews. Moreover, personnel at Paroc were a highly important source of information when Paroc's activities were related to the roadmap. Their knowledge was important to use in the research of possible techniques and to find relevant sections in the roadmap from Fossil Free Sweden (2018). Most of this information was gathered from a plant in Hässleholm. To add, the roadmap from Fossil Free Sweden states both goals and needed work to succeed with a transition to fossil free competitiveness.

Furthermore, the result was established by continuous discussions with personnel at Paroc to find out more about their specific situation. After the discussions, research about useful methods in the process could be limited (chapter 3.4.1-3.4.6). That made it easier to do research and Google Scholar was an effective tool to gather information from scientific publications. After that, a strategic roadmap for Paroc to become fossil free was formed by connecting useful technologies with matching calculations of $CO_2$ reduction to meet up with the roadmap from Fossil Free Sweden (2018). The roadmap for Paroc was based on the goals from Fossil Free Sweden and connected with relevant activities for Paroc to work with during different time periods.

The method was not quantitative because the purpose was to create a roadmap for Paroc as a specific organization. Therefore, the roadmap has a qualitative perspective. The reason to this is because it will give Paroc a higher value when the report is being presented for stakeholders. However, other plants within Owens Corning, or within the field, are welcome to use this report for their purposes because several of the solutions can be adapted at more plants with related activities.

For both Paroc and the report, it is important to have a high scientific value. It was generated by evaluating the sources of the report. The environmental field is under an ongoing development, and the rate is fast. Research are continuously being updated and sometimes, contradictory theories are presented. This can lead to uncertainties within

the reliability of the sources. Moreover, there can be “fake news” published to mislead readers for politic or economic reasons. Therefore, it is important to take a critical standpoint when writing a report (Persson et al., 2019).

Persson et al. (2019) are presenting questions to ask when evaluating resources. These questions will be used as a checklist for the sources of the report to increase the scientific value:

- Who is the author of the work?
- Who is the publisher of the work?
- What is the purpose of the content?
- Who the author has as the target group?
- Is the information up to date?
- How trustful is the content?

(Persson et al., 2019)

Finally, it is essential to present the sources in a structural and organized way. Therefore, the Harvard referencing system was used in the report. The University of Borås (2020) has a guide for the Harvard system and it was used. Also, tables and figures were presented according to the Harvard referencing system with headings over the tables and headings under the figures.

# 3. Results

## 3.1 Owens Corning's sustainability report

Owens Corning has plants in 33 countries and around 19 000 employees all over the world. Paroc is a part of the multinational business and their sustainability work. Therefore, relevant information about Owens Corning's sustainability report will be presented in this section.

The concern is continuously working for better energy efficiency and identification of areas for improvement. A goal is to use 100% renewable electricity by 2030. In 2018 (base year), the amount was 48% and in 2020 it was 51%. Moreover, they have an energy reduction goal of 20% until 2030 and a reduction of 11% has been accomplished to 2020 (base year 2018) (Owens Corning, 2021).

To improve the renewable energy platform, long-term power purchase agreements are an important factor for the concern. Also, initiatives with solar-, wind- and hydroelectric projects have been accomplished. Moreover, they participated in 31 energy recovering projects, which saved 43 135 MWh. To add, the energy efficiency showed an improvement in energy efficiency with 728 616 MWh (10 279 010 MWh in 2019 and 9 550 394 in 2020) (Owens Corning, 2021).

In terms of climate change, they have a goal of 50% reduction of greenhouse gases by 2030 for scoup 1 (direct emission from own manufacturing) and scoup 2 (indirect emission from own manufacturing). In 2020, 14% had been reduced compared to the base year (2018). Also, they are working towards the 1.5-degree goal from the Intergovernmental Panel in Climate Change (IPCC) (Owens Corning, 2021).

To keep up the sustainability work, the concern has formed a strategic approach towards climate change, and some of the strategies are presented below:

- From a short-term perspective: Collaborate with scoup 3 emissions (indirect emissions from the supply chain).
- Find new renewable energy sources and sign long-term agreements.
- Continue with the research and development work to find new innovative solutions.
- Have knowledge sharing between the different plants of the concern.
- Understand the cost for emissions better and quantify the emissions.
- Create partnerships to address climate change.
- Make sure that their activities are meeting up with climate change policy from authorities.
- Participate in non-government organizations to drive the work with energy efficiency forward.
- Encompass all scoup emissions related to the concern. The work is ongoing and since 2010, 35% of scoup 1 and 2 emissions have been reduced.

(Owens Corning, 2021)

## 3.2 Previous sustainability work at Paroc

For the last 10-15 year, Paroc has continuously worked with improvements within the process (LEAN) and reduced the amount of coke (pyrolyzed fossil coal) in their cupola ovens (melting ovens). Also, they have worked with recirculation of waste to minimize the use of virgin materials.[3] Moreover, in Hässleholm, the efficiency has improved with 32% (energy used/ton insulation produced) between 2013-2018, and the plant is only using green electricity since 2019.[4]

[3] Hallén Beatrice. Sr Sustianability Leader Insultion Businiess, Europe. Microsoft Teams meeting 04/12–2021

[4] Svensson Jörgen. EHS-manager Paroc, Hässleholm. Microsoft Teams meeting 04/15–2021

Recently, oil has been replaced by propane for better efficiency and lower carbon dioxide emissions. A new product (Paroc NATURA Lana) has been released and it reaches climate neutrality throughout low $CO_2$ technology and carbon offsetting as the more environmentally friendly option for customers.[5] Also, Paroc is declaring their products according to the EPD (Environmental Product Declaration) and their thermal insulation (from the plants in Hässleholm and Hällekis together with the Finnish plant in Parainen) emits 1.28 kg $CO_2$-eqv/$m^2$ ($CO_2$ equivalents/$m^2$) for a standard building insulation product (Paroc EXTRA) (Hauan, 2020).

## 3.3 Current Sustainability work at Paroc

Paroc is aware of the roadmap from Fossil Free Sweden (2018). Therefore, they are constantly trying to improve the mainstream process. For instance, they have increased their interest in bio-based fuels at the plants in Sweden[6], and a new production line with an electric oven is under investigation. If finalizing according to ongoing preparations on environmental permitting, Paroc's site in Hällekis increases its maximum capacity from 100 metric tons to 140 metric tons annually. As low-carbon melting technology is in the scope, the $CO_2$ emissions would (if the project is realized) drop substantially, and less virgin materials would as well be used, supporting a transition towards the circular economy (Paroc, 2021a).

Still, the majority of Paroc's plants is using cupola ovens where coke, dolomite, and gas (natural gas or propane) are essential for the production line to operate properly. Coke is the main source of direct $CO_2$ emissions, but the gas and dolomite are contributing too. (Paroc, 2016).

[5] Hallén Beatrice. Sr Sustianability Leader Insultion Businiess, Europe. Microsoft Teams meeting 04/12–2021

[6] Svensson Jörgen. EHS-manager Paroc, Hässleholm. Microsoft Teams meeting 03/15–2021

Table 2: Amount of raw material at the plant in Hässleholm which generated $CO_2$ emissions, and the level of production in 2015 (Paroc, 2016).

| **Material** | **Unit** |
|---|---|
| Coke | 5861 metric tons |
| Propane | 30.4 metric tons |
| Dolomite | 7690 metric tons |
| Fuel-oil 1 | 1174 $m^3$ |
| $CO_2$ emission | 23 877 metric tons |
| Total production of insulation | 30 215 metric tons |
| $CO_2$/metric ton insulation | 0.79 metric tons |

In table 2, fuel oil is represented, but removed from the process between 2015-2019. Therefore, statistics from 2019 is presented below:

Table 3: Amount of raw material at the plant in Hässleholm which generated $CO_2$ emissions, and the level of production in 2019 (Paroc, 2020).

| **Material** | **Unit** |
|---|---|
| Coke | 7138 metric tons |
| Propane | 1965 metric tons |
| Dolomite | 8649 metric tons |
| $CO_2$ emission | 30 292 metric tons |
| Total production of insulation | 40 954 metric tons |
| $CO_2$/metric ton insulation | 0.74 metric tons |

According to Fossil Free Sweden (2018), the base year of the roadmap is 2015. Therefore, the emissions from 2015 are central for the report. A chart with the distribution of $CO_2$ emissions in Hässleholm[7] are presented below (Paroc, 2020):

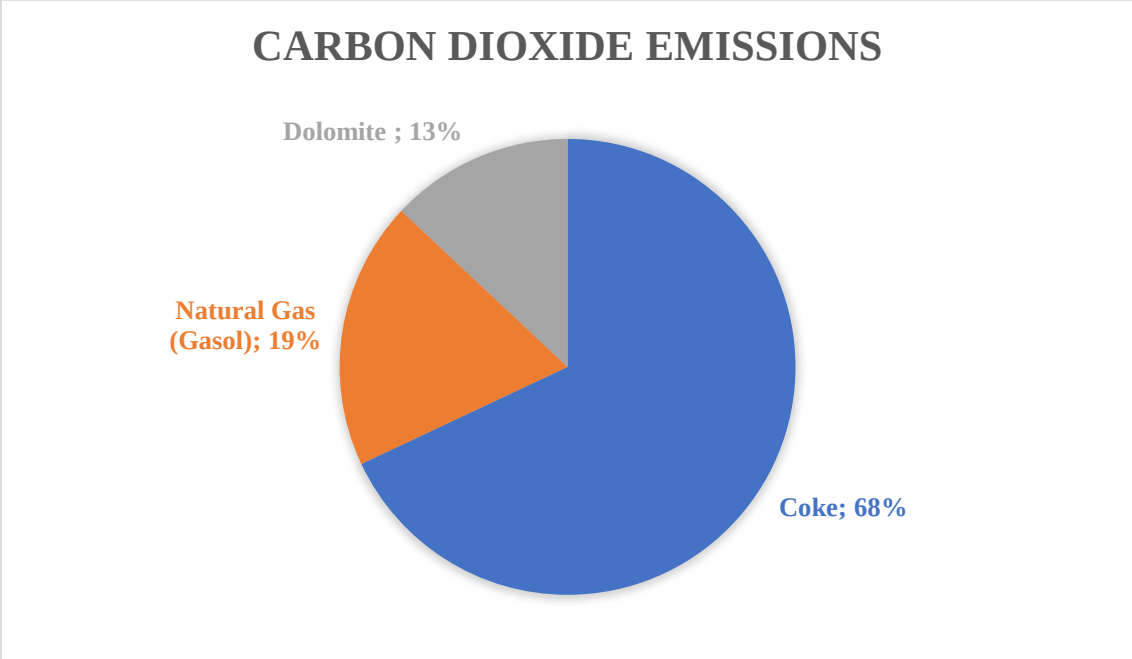


Figure 1: Sources of $CO_2$ emissions for the plant in Hässleholm 2019 (Paroc, 2020). Illustration: Felix Mörck.

Furthermore, Söderberg[8] mentions different approaches for how the emissions should be compared with the base year. Here, it is important to know that this comparison is only important for the goals of 2030 due to that the emissions should be 0 by 2045. In brief, according to Söderberg[8], there are two ways to think about the halving of emissions by 2030:

[7] Svensson Jörgen. EHS-manager Paroc, Hässleholm. Microsoft Teams meeting 04/15–2021

[8] Peter G Söderberg. Author Fossil Free Sweden. Email-conversation. 04/18–2021.

1. In absolute numbers, which means that the total emissions of 2015 should be halved by 2030 and no exceptions are taken to an increased rate of production.
2. In relative numbers, which means that the emissions of a produced unit should be halved by 2030.

Söderberg[8] also mentions that absolute numbers are the used approach for Fossil Free's (2018) roadmaps. However, they are still aware of that some companies must expand for the society to succeed with the transition from fossil based to fossil free (for instance, wind turbine manufacturers).

## 3.4 Futural sustainability work at Paroc

Paroc will continue to work for better efficiency, non-fossil materials, and reuse of materials for a circular economy. However, they are aware of upcoming goals of the future, electric ovens, and climate neutral insulation (NATURA Lana). Moreover, the change from oil to propane, as well as exchange to renewable electricity, have been essential for their reduction of greenhouse gases.[9]

Now, they are also looking for methods to replace the dolomite with a better, sustainable option. Moreover, to replace the fossil-based gas with gas from renewable sources and find ways to reduce the amount of coke in the existing cupola ovens.[10] The electric ovens have been a solution to reduce the amount of coke due to the fuel-change. Paroc is expecting about 20% better efficiency and 80% direct $CO_2$-reduction from the melting process with electric ovens, if 100% renewable energy is used (Paroc, 2021b).

Still, there can be other possible methods to use for the reduction of coke in Paroc's cupola ovens. Therefore, an inventory of possible modifications to the cupola ovens is presented below:

[9] Hallén Beatrice. Sr Sustianability Leader Insultion Businiess, Europe. Microsoft Teams meeting 04/12–2021

[10] Svensson Jörgen. EHS-manager Paroc, Hässleholm. Microsoft Teams meeting 04/15–2021

### 3.4.1 Oxy fuel combustion process

Oxy fuel can reduce the needed amount fuel in an oven due the use of pure oxygen instead of air. Then, the fuel burns more efficient. It leads to an increased flame temperature and a higher concentration of $CO_2$ for the flue gases (containing mostly carbon and steam) ((Markewitz et al., 2012), (Mathieu, 2010)). In normal cases, a flue gas contains around 12-15% $CO_2$, but it is possible to reach concentrations of around 89% with oxy fuel. Therefore, it is easier to separate the $CO_2$ from the flue gases with a carbon capture storage technology (CCS) and transport it to a place where it can be stored into the ground (Markewitz et al., 2012).

However, it is important to keep in mind that nitrogen compounds ($NO_x$) in the flue gases can increase during the combustion processes with oxy fuel due to the oxygen-rich environment in the oven. However, it can also decrease due to the reduction of nitrogen when pure oxygen is used instead of air. Still, there are losses in efficiency because of the production of pure oxygen (7% points) and the separation unit for $CO_2$ (8-10% points) at a pilot power plant (Markewitz et al., 2012).

### 3.4.2 Plasma Burner

A plasma burner operates with electric current and blown air to form a flame with high energy intensity and temperature. Therefore, it decreases the time for a melting to occur (Volokitin et al., 2014). According to Askarova et al. (2007), the plasma burner can decrease the consumption of coal/coke in a boiler and increase its efficiency. Tests have been made on coal combustion boilers and the authors mention that savings of 20 000 metric tons of fuel-oil have been accomplished.

Moreover, low temperature plasma was tested for the construction sector after the financial crises in 2008 to improve the efficiency for the sector. Tests were made on mineral fiber where the raw material was silicate based. The tests resulted in a positive effect on the fiber strength and thermal resistance (Shekhovtsov et al., 2021).

Furthermore, there have been an experimental project on ash in Kazakhstan to form mineral fiber with a low temperature plasma at 3000-5000 ℃. The plasma increased the rate of melting and speeded up the generation of mineral fiber from the melt. Still, the quality of the fiber met up with the technical specifications for mineral wool (Volokitin et al., 2014).

### 3.4.3 Hydrogen gas

Recently, a new project has been developed by LKAB, SSAB and Vattenfall to produce fossil free steel. The idea is to use hydrogen gas as the fuel to create a direct reduction of the iron in the ore (Jernkontoret, 2020). Research has been done on the temperature profile of hematite pellets with temperatures up to 900 ℃ to crack the pellet (Brännberg Fogelström, 2020).

It is an endothermic reaction where the temperature difference between the surface and the center of the pellet has been important to create the cracks. Moreover, the experiment proven that a higher temperature gave a bigger difference between the surface and the center of the pellet. Therefore, higher temperatures created bigger cracks in the pellet (Brännberg Fogelström, 2020).

In simpler terms, hydrogen is possible to use as a direct fuel in an oven, but it can also be used to produce electricity as fuel. It is done by a fuel cell where hydrogen gas and oxygen react with an efficiency of 70% (up to 90% if the generated heat is recovered). Later, the generated electricity can be used in various electrical equipment (Chalmers, 2009).

Finally, hydrogen gas is undergoing a development in a fast rate. Von Dalwigk et al. (2021) describes hydrogen gas as an important fuel to replace fossil fuel and the Swedish society is investing to create a market where the gas is used for heavy industries and transportation. Still, it is essential to keep in mind that hydrogen gas from fossil-based electricity is worse for the environment than fossil fuels itself, due to energy losses during the conversions (Tester et al., 2012). Today, challenges are within production and storage, but also to produce enough of green electricity to support the production of green hydrogen gas (von Dalwigk et al., 2021).

### 3.4.4 Flow-heaters and air heating cassettes

To create a melt for mineral wool, the temperature needs to be around 1600-1700 ℃ (Volokitin et al., 2014). Coke is a fuel to heat up the cupola ovens, and natural gas can be used to preheat air. However, it is possible to replace some of the natural gas and coke with energy from electrical heaters. Kanthal (2021a), is marketing a heating cassette for furnaces to maintain a temperature and the product can heat up air to 800 ℃. Moreover, they have a flow-heater with a maximum temperature of 1100 ℃ and an efficiency of 95% (Kanthal, 2021b).

Another manufacturer of flow-heaters is Elmess (2021). Their product can heat up air to 1200 ℃ under no pressure and 900 ℃ as a pressure device. Also, it is mentioned that the flow-heater can be used for the industry to heat up gases (Elmess, 2021).

### 3.4.5 Swishing from natural gas to biogas

A change of fuel from natural gas to biogas has been made within the glass industry in Germany by Fiehl et al. (2017). In the study, a pipeline was installed between a glass factory and a biogas plant. The fuel-change was concluded to have no negative effects on the operation. Instead, it was not seen as economically viable, even though the ecological benefits were seen as a major advantage. However, the authors also mentioned that biogas can be more lucrative in the future. Also, the biogas was not available enough to support the production rate at the glass factory. Therefore, a recommendation was to combine natural gas with biogas in the pipeline (Fiehl et al. 2017).

### 3.4.6 Replace dolomite with slag

The dolomite stood for 13% of the direct carbon dioxide emission at Paroc in 2019 (Paroc, 2020). Also, it is a virgin material in the process, according to Jörgen Svensson.[11] However, there is a possibility for replacement due to the produced slag (by-product called "Petrit E") by a steel manufacturer in Höganäs. Today, it is used for mineral wool production (Haase, 2017).

Moreover, dolomite is a mixture of calcium, magnesium, and carbonate ($CaMg(CO_3)_2$). It does not have any components of silicon because it is classified as an anhydrous carbonate mineral (Warren, 2000). In comparison with dolomite, Höganäs (2019) has another product called "Petrit T." It has a high concentration of belite ($C_2S$ or $Ca_2SiO_4$), and agricultural enterprises are using the product for replacement of lime ($CaCO_3$), as a soil-improving additive (Al-Jabban et al., 2019).

## 3.5 Intercommunion

Paroc is working for a sustainable development with both authorities, customers, and suppliers. To find raw material close to the factories is important for Paroc to reduce emissions and contribute to a sustainable intercommunion. For instance, the plant in Hässleholm buys diabase from a local company and slag from the steel manufacturer in Höganäs.[11]

Also, since January, they are working with waste handlers in a project called "REWOOL." The plant is taking back insulation leftovers from customer installations and feeds it back into the mainstream process. The result is saved resources, less waste to landfill and a decrease in $CO_2$ emissions (Paroc, 2021c).

[11] Svensson Jörgen. EHS-manager Paroc, Hässleholm. Microsoft Teams meeting 04/15–2021

### 3.5.1 Certifications

- ISO-14001: A certification for environmental management systems (Karlsson, 2021)
- BES 6001: A certification for environmentally responsible purchases (Baker, 2020).
- EPD: Environmental product declaration, third-party verified documentation to transparently communicate the life cycle impact from products. The GWP (Global Warming Potential) indicator focuses on greenhouse gases and the emissions from raw material extraction to the end of the products life are counted (Hauan, 2020).

### 3.5.2 Assessment systems

- Building product declaration: An assessment for a product's environmental affection during its lifecycle.
- Building product assessment: An assessment where some of Paroc's products have been assessed in and published in a database.
- BASTA: A register of chemicals where Paroc can publish products. They must meet up with the critics from the BASTA organization (builds on the REACH-regulation) (Paroc, 2021d).
- Sunda Hus: Assessment where the purpose is to see how good a product is from an environmental and health perspective (Paroc, 2021d)
- The Nordic Swan: Guarantees that environmental critics are met. Today, there are no critic for insulation in a big perspective, but it is possible to receive a Nordic Swan for a building with insulation from Paroc (Paroc, 2021d).
- Green Building Council: Certifications of environmentally friendly buildings with an international approach. It gives actors a possibility to compare experiences and learn from each other (Paroc, 2021e).

## 3.6 Futural modifications to the plants

The plants with coke-driven cupola ovens need to be prepared for major modifications in the future to meet up with the roadmap from Fossil Free Sweden (2018). Today, improvements have been done to optimize the process. Therefore, the relative emissions have declined. This work will continue, and this report recommends that major and minor modifications are needed to decrease the $CO_2$ emissions. Different options are presented below:

### 3.6.1 Modification or replacement of existing cupola ovens

The installation of an electric oven in Hällekis is under investigation (Paroc, 2021a). That kind of installation is to be considered as a major modification because it would require a new production line. Moreover, Paroc is already having electrical ovens abroad.[12] In fact, Paroc was the one to invent the electrical melting technology and the first installation is still running in Pargas, Finland[13]. Therefore, it is proven that an electric oven is possible for mineral wool production. However, there are other sustainable methods to install too, and they will not require as drastic changes as an electric oven will do.

It would be interesting to look for modifications which would make it possible to run the coke-driven cupola ovens on different fuels. In the sections 3.4.1-3.4.3, three methods are represented as a technique to generate heat in more environmentally friendly way.

For instance, it might be possible to covert the cupola oven to an oxy fuel version where the high concentration of $CO_2$ can be captured and stored underground (Markewitz et al., 2012). That would result in an eco-friendlier plant. Moreover, the plasma burner is an experimentally proven option for the process to generate heat ((Shekhovtsov et al., 2021), (Volokitin et al., 2014)). If it is installed, an amount of coke can be replaced, and it is possible to use climate compensating methods if some coke is needed in the process.

[12] Svensson Jörgen. EHS-manager Paroc, Hässleholm. Microsoft Teams meeting 04/15–2021

[13] Hallén Beatrice. Sr Sustianability Leader Insultion Businiess, Europe. Microsoft Teams meeting 05/10–2021

Finally, the future might have a lot to give to Paroc. The HYBRIT project is in its start-phase, and it would be interesting to see if it is possible to melt rocks with hydrogen gas. Currently, Brännberg Fogelström (2020) has proven that it is possible to create cracks in hematite pellets at 900 ℃. Therefore, it would be interested to see what will happen to the raw material in Paroc's process if it is heated to 1600-1700 ℃.

If none of the three methods above is lucrative enough, the electrical oven is a proven option. However, carefulness should be taken to the method due to the required amount of electricity. For an electric oven to be environmentally friendly, it needs to operate on renewable (green) electricity. Otherwise, it would be less efficient due to the energy losses during an energy conversion (Tester et al., 2012).

In Sweden, a transition to renewable energy is ongoing (Fossil Free Sweden, 2018), but the amount needs to increase to support the replacement of fossil fuels in the country. Paroc is not the only company with dependence of fossil fuel, and it can lead to an increased demand for renewable electricity during the transition. At the same time, Sweden wants to replace the nuclear power and has already closed reactors, which has led to an affection on the total energy production (Lindholm, 2021). For instance, the oil power plant in Karlshamn began to operate in 2020 due to a lack of electricity, and the closing of nuclear reactors is described as one reason to the start-up (Björkman, 2020).

### 3.6.2 Electrical heating

It is important to know that 2045 is more than 20 years from today, and that climate neutrality is seen from a long-term perspective. Therefore, 2030 is the first step in Paroc's journey, and it is possible to see in Owens Corning's (2021) report, where the year 2030 is used as the goal.

For the coke-driven cupola ovens, it is possible to do minor adjustments by 2030, and later focus on major replacements/modifications to the ovens. With electrical heating cassettes and flow heaters ((Kantahl 2021a), (Kanthal, 2021b), (Elmess, 2021)), it is possible to heat up the process between 800-1100 ℃.

For Paroc, it means that the electric heaters can support the ovens with air up to 1100 ℃. After that, the coke heats up the raw material to the needed 1600-1700 ℃. Then, a part of the coke can be reduced due to the electric heaters. If that electricity is renewable, it will result in a decrease of $CO_2$ emissions from the plants.

### 3.6.3 Replace fossil-based gas with gas from renewable sources

Another minor modification to the process would be to replace the existing fossil-based gas with gas from renewable sources, like biogas. In closely related industries (glass industry), biogas showed no difference in product quality when the natural gas was replaced (Fiehl et al. 2017). Therefore, it would be highly recommended to try the biogas because it would be able to reduce the 19% (figure 1) of the natural gas emissions.

Also, it is interesting to use biogas as the fuel for other purposes. For instance, a suggestion is to investigate how biogas will work as oxy fuel in the cupola ovens. If possible, the technique described by Markewitz et al. (2012) can be used as a bio-CCS (bio-carbon capture storage) to generate negative emissions (Johannesson, 2020). For the plants, that would make it possible to still use some coke in the process by 2045 because some parts of the plants will work under negative emissions. Furthermore, Fossil Free (2018) mentioned that CCS technologies can be used in the future, and this is an example of how Paroc can use it.

### 3.6.4 Replace dolomite with Petrit T

A replacement of dolomite with a greener option would decrease the carbon dioxide emissions with 13% (figure 1). Petrit T has been able to replace lime as a soil improver, and the chemical compounds of lime and dolomite are similar (except from the magnesium) (Warren, 2000). However, the belite in Petrit T is not having any carbonate which can emit carbon dioxide. Still, the belite can replace lime as a soil improver and therefore, it would be interesting to see if Petrit T can be used in Paroc's process too. If possible, Paroc will be one step closer to the goals from Fossil Free Sweden (2018).

## 3.7 Calculated reduction of carbon dioxide at Paroc, Hässleholm

To meet up with the goals from Fossil Free (2018), the direct absolute emissions of $CO_2$ from Paroc, Hässleholm would need to be at the level of 11 938.5 metric tons by 2030. Moreover, the emissions of $CO_2$ were 30 292 metric tons in 2019 (table 2):

11 938.5/30 292=0.394 → 39.4%

The emissions need to be 39.4% of the levels from 2019, and some of the suggestions above (or other) need to be implemented at the plant. In figure 1, the different sources of $CO_2$ are distributed as:

- 68% coke (20623 metric tons)
- 19% propane (5890 metric tons)
- 13% dolomite (3779 metric tons)

32% of the emissions can be reduced by replacing propane with biogas and replacing the dolomite with a different compound (for instance Petrit T):

30 292-5890-3779=20 623 metric tons of $CO_2$, if the propane and dolomite are replaced. 20 623 is the amount of coke and this consumption needs to be reduced:

20 623-11 938.5=8684.5 metric tons of $CO_2$ from the coke need to be reduced to meet up with the goals of 2030. That is:

8684.5/20 623=0.421 →42% of the amount currently used at the plant in Hässleholm.

Too add, all the 11 938.5 metric tons needs to be reduced by 2045.

## 3.8 Strategic roadmap for Paroc to become fossil free

A plan is needed to become climate neutral. It involves actions from all actors at the market to succeed (Fossil Free Sweden, 2018), and Paroc is one of the actors of the early stage as a manufacturer of building materials. The roadmap to become fossil free will focus on the stage of production, and no other stages (for instance transportation).

Table 4: The reports suggestion of a roadmap for Paroc to become fossil free.

| **Action** | **Year** |
|---|---|
| Emissions are tracked and Paroc has set up goals according to the roadmap from Fossil Free Sweden (2018). | 2021-2022 |
| Propane has been replaced by biogas. | 2022-2025 |
| The dolomite has been replaced with a slag, which is not emitting $CO_2$ at the same levels (for instance Petrit T). | 2022-2025 |
| New laws, which encourage Paroc's sustainability efforts, have been established.<br><br>Environmental standards have begun to form and become central for the sector. | 2025-2030 |
| 42% of the coke (2019) have been replaced with biogas or electricity as fuel. Options can be plasma burners, oxy fuel, or electrical heaters. | 2025-2030 |
| The plants have reduced their emissions with 50% (base year 2015). Now, they begin to look for the best possible option to become climate neutral by 2045.<br><br>The market has responded to a transition. EPD's, standards, databases, and procurement requirements are functioning well for Paroc's products.<br><br>Laws are supporting Paroc's transition to become climate neutral. | 2030-2032 |
| The efficiency of the new technology has been improved over time and they have a solution for how they should become climate neutral.<br><br>Options can be to improve the efficiency even more for the oxyfuel, plasma burners or electrical heaters and use CCS to become climate neutral.<br><br>Moreover, hydrogen gas or electric ovens can be used to replace the existing cupola ovens. | 2032-2045 |
| Paroc has, with or without CCS, become climate neutral. | 2045 |

Note that the goal of 75% of reduction by 2040 is not mentioned. That is due to a recommendation from this report, where a two-stage rocket is recommended. First, Paroc is doing minor modifications at the plants to reduce the emissions by 50%. Later, major modifications are done to become climate neutral. Hopefully, it is possible to become climate neutral before 2045 with the technology mentioned in this report. If Paroc succeeds to become climate neutral by 2045, they would be a role model in Sweden and other sectors as a manufacturer of insulation. Later, it can inspire other companies to do the same, which can accelerate Fossil Free Sweden's (2018) goals about climate neutrality and fossil free competitiveness.

### 3.8.1 The reports recommended technique for Paroc to become climate neutral

Based on the results, the report recommends Paroc to replace fossil-based gas with gas from renewable resources and dolomite with a slag. Moreover, to use either renewable gas or electricity to preheat the cupola ovens. Later, the cupola ovens should be rebuilt to support oxy fuel because that technique is not as major as an electric oven, but still possible to meet the goals from Fossil Free Sweden (2018). Also, it does not burden the electricity grid as much as a technique with electric ovens.

# 4. Discussion

## 4.1 Sources of error

The calculations have been based on statistics from Paroc and their environmental reports to the County Administrative Board. The measurement methods are not mentioned, and there can be uncertainties in measurement. However, these are seen as negligible in the report because authority reports are seen as a reliable source (Persson et al., 2019).

It is also important to mention the fast changes within the industry sector. The report has tried to find as fresh sources as possible, but techniques can change fast over a year. Some of the techniques in the results have existed for a long period of time, but never been used to produce insulation on a large scale. Therefore, there are uncertainties if the techniques will work, and the reader should see the techniques as suggestions for further research and implementation.

Also, there are several organizations working for climate neutrality, and they might have other suggestions for how a transition should work. However, it is tough to meet up with several organization’s suggestions. Therefore, the report has pointed its focus on Fossil Free Sweden (2018) to deliver quality instead of quantity. Therefore, there might be missing aspects in this report, which other authorities and organizations are seeing as highly important.

## 4.2 Absolute and relative emission

The base year is central in the comparison between emissions from different years. 2015 is the base year for this report (Fossil Free Sweden, 2018). Therefore, it is essential to compare the emissions from 2015 with Paroc's latest report from 2019 (Paroc, 2020).

According to Söderberg[14], the absolute direct emissions would have been 23 877 metric tons of $CO_2$ (table 2) in 2015 and 30 292 metric tons (table 3) in 2019. Moreover, the relative direct emissions would have been 0.79 metric tons of $CO_2$ (table 2) in 2015 and 0.74 metric tons in 2019 (table 3).

It means that the absolute emissions have increased between 2015 and 2019. However, when comparing table 2 and 3, the production has increased too, and improvements on the plant have led to an increased consumption of propane.[15] Still, other improvements have been done to the plant. It has led to a decrease in relative emissions with 50 kg $CO_2$/ton insulation produced.

The goal of 2030 is a reduction with 50% compared to the base year (table 1), and neither the absolute nor relative comparisons (table 2) are meeting up with that goal today. In fact, the relative emissions need to be 0.395 metric tons $CO_2$/ton insulation produced and the absolute would need to be 11 938 metric tons of $CO_2$.

It leaves a question of what kind of measurement Paroc should use for their emissions. According to Söderberg[12], the absolute is the preferred one in the report from Fossil Free Sweden (2018). However, he also mentioned that some branches need expansion to support the transition from fossil fuels to climate neutral alternatives. Furthermore, research has been done by a third-party organization and reported by EURIMA (European Mineral wool Association). They concluded a ratio of 1/200 for mineral

[14] Peter G Söderberg. Author Fossil Free Sweden. Email-conversation. 04/18–2021

[15] Svensson Jörgen. EHS-manager Paroc, Hässleholm. Microsoft Teams meeting 04/15–2021

wool. It means that the emissions of 1 metric ton $CO_2$ at the fabrication stage of mineral wool saves 200 metric tons during its lifetime in a building (Paroc, 2021f).

This ratio can argue for an essential need of mineral wool to succeed with the transition from fossil fuels to climate neutrality. However, this report will focus on absolute emissions, and not relative. It is tougher, but we also need to keep in mind that the emissions need to be zero by 2045. In that case, it does not matter if the calculation is based on absolute or relative emissions because it needs to be zero, either way.

## 4.3 The demand of electricity in the future

Fossil Free Sweden (2018) and (Edenhofer et al. 2012) mentions that electricity is needed to succeed with a transition to renewable energy. With a demand of 87.1% fossil fuel in 2012, it is a big challenge, even though Fossil Free Sweden (2018) writes about a decreased demand of electricity in the future because of better energy efficiency.

In the future, we can see a trend in more solar, wind and hydro energy, but it is important to mention the rate of development. If heavy industries (like Paroc) are doing a fast transition, the electric infrastructure might not keep up with the rate and it is possible that oil power plants are needed to support the demand of electricity (Björkman, 2020). At the same time, nuclear power is shutting down in Sweden (Lindholm, 2021) and that is decreasing the supply of electricity in the future.

In brief, the Swedish society is increasing the supply of renewable electricity and decreasing the fossil-based electricity. Then, if companies want to electrify their fossil-based processes, the demand increases, but will we be able to generate electricity at the same rate as our sectors are switching to renewable electricity?

This is an uncertainty for the future, and a reason to why this report is recommending oxy fuel for Paroc’s cupola ovens. It will target other fuels and techniques and does not burden the future demand of electricity. Moreover, decreases the chance for a startup of oil power plants.

## 4.4 Paroc's possible contribution to the society as a whole

By following the roadmap, Paroc will participate in the transition to climate neutrality. Moreover, if Paroc becomes climate neutral before 2045, it is possible to become a role model and leader of the transition within the construction sector. A reduction of more than 30 000 metric tons of $CO_2$ is not done over a day and requires a long-term perspective.

Role models, valuation-controlled companies and brave leaders are mentioned as essential factors for the construction sector to success with the transition (Fossil Free Sweden, 2018), and Paroc's roadmap will make it possible to meet up with these essential factors. Also, by continuing the work with certifications, standards, and intercommunions, Paroc will participate in the development of a valuation of $CO_2$. That can be positive for the procurements (Fossil Free Sweden 2018).

Furthermore, Paroc has an opportunity to be a role model for other countries too. This is possible due to their owner, Owens Corning. Their report (Owens Corning, 2021) shows progress in environmental work and is based on the whole concern. However, the EU has tougher restrictions and Sweden wants to be the role model in EU (Fossil Free Sweden 2018). It means that environmental regulation will be a tough challenge for Swedish companies, but not a subject to be worried about.

Instead, Paroc can be a role model for sustainable development within Owens Corning. Then, production lines of glass fiber, glass wool and roofs can use necessary parts of the work Paroc has done. It leads to an internal intercommunion and can generate sustainable efforts all over the world.

In total, by following the roadmap of this report, Paroc will be a part of the fossil free competitiveness Fossil Free Sweden (2018) mentions as needed for a circular and well-functioning market. Paroc's transition will put pressure on other companies to become climate neutral and other companies will do the same to Paroc and Owens Corning.

An interesting example is the investigation of the electrical oven in Hällekis and the plans communicated regarding building of an electrical oven in Eskilstuna by the

concurrent, Rockwool (2021). It shows a fossil free competitiveness, where the two companies are building plants driven on renewable electricity. To Fossil Free Sweden (2018), this is essential actions for a fossil free future.

Therefore, with electrical ovens in the middle of Sweden, transportation can be an important factor for Paroc in the future. Shorter transports will result in less $CO_2$. Then, by making the modifications to the plant in Hässleholm, Paroc will be able to produce and deliver mineral wool with short distances over the dense areas of Sweden and abroad (Denmark). That will put more pressure on actors and be another step for the fossil free competitiveness.

# 5. Conclusion

Paroc and Owens Corning have set up goals and made practical improvements in their processes for the environment. Still, there are challenges ahead for Paroc's plants with cupola ovens. The electric ovens are a proven option. Right now, one is under investigation in Hällekis. However, there are other options too. With a market where the demand of electricity is increasing, other climate neutral options can be strategic to use in the future.

For instance, oxy fuel, plasma burners, electrical heaters and hydrogen gas might be possible to use as modifications to the cupola ovens. Moreover, they can be either minor (to meet up with the 2030 goals) or major (to meet up with the 2045 goals). Also, it is possible to replace the fossil-based gas with renewable gas and maybe it is possible to replace the dolomite with slag (for instance Petrit T would be interesting to try).

The purpose and problem statement of the report were met, and a strategic plan could be formed. It is challenging because the report based its calculations on the absolute emissions, and that makes the goals of 2030 tougher to meet. However, due to the need of insulation for a climate neutral transition, Paroc's products can be one of the accepted to an increased consumption of $CO_2$. It would make relative emissions more defensible for Paroc.

Furthermore, according to the absolute emissions, a replacement of dolomite and propane would require a decrease of 42% coke (2019 compared to 2015). Therefore, it is important to follow up the methods in this report and search for ways to install one (or more) of them into the mainstream process. Still, there can be other methods too, which is why the report will recommend being open minded for innovative solutions.

Finally, the report found out that Paroc had several certifications and intercommunions, which is very important for the transition to a climate neutral society. Therefore, Paroc and Owens Corning need to continue this work because it will help to improve standardizations, certifications, procurements, and laws of the Swedish society.

More research about the suggested methods is needed, and the biggest challenge will be to adapt the modifications in this report. If they are used and function well in the process, Paroc can look for future where they are in the front of the fossil free competitiveness.

# 6. References


Al-Jabban, W., Laue, J., Knutsson, S. & Al-Ansari, Nadhir. (2019). *A comparative evaluation of cement and by-product Petrit T in soil stabilization.* MDPI: Basel. https://www.diva-portal.org/smash/get/diva2:1374489/FULLTEXT01.pdf [04-22-2021]

Askarova, A. S., Karpenko, E. I., Lavrishcheva, Y. I., Messerle, V. E. & Ustimenko, A. B. (2007). *Plasma-Supported Coal Combustion in Boiler Furnace.* Research Gate: Berlin. https://www.researchgate.net/publication/3168239_Plasma-Supported_Coal_Combustion_in_Boiler_Furnace [04-19-2021]

Baker, B. (2020). *Certificate of approval*. Bre: Watford. https://www.paroc.se/hjalpmedel/miljodokumentation [04-21-2021]

Björkman, F. (2020). *Lönsamt för kraftjätten att elda olja I Sverige igen*. https://www.di.se/nyheter/lonsamt-for-kraftjatten-att-elda-olja-i-sverige-igen/ [04-22-2021]

Brännberg Fogelström, J. (2020). *Experimental study of the temperature profile in an iron pellet during reduction using hydrogen gas.* KTH: Royal Institute of Technology: Stockholm. http://kth.diva-portal.org/smash/get/diva2:1389477/FULLTEXT02.pdf [04-22-2021]

Chalmers. (2009). *Vad är en bränslecell?* https://web.archive.org/web/20090530141708/http://fy.chalmers.se/~f1xjk/FysikaliskaPrinciper/Projekt/Projekt30/vadar.html [04-22-2021]

Edenhofer, O., Pichs-Madrunga, R., Sokona, Y., Seyboth, K., Matschoss, P., Kadner, S., Zwickel, T., Eickemeier, P., Hansen, G., Schlömer, S. & Stechow, C. (2012). *Renewable energy sources and climate change mitigation. Summary for policymakers and technical summary.* IPCC: Geneva. https://www.ipcc.ch/report/renewable-energy-sources-and-climate-change-mitigation/ [04-12-2021]

Elmess (2021). *Electrical flow heaters.* *https://www.elmess.de/en/products/flow-heaters.html* [04-19-2021]

Fiehl, M., Leicher, J., Giese, A., Görner, K., Fleischmann, B. & Spielmann, S. (2017). *Biogas as a co-firing fuel in thermal processing industries: implementation in a glass melting furnace.* Elsevier: Amsterdam. https://www.sciencedirect.com/science/article/pii/S1876610217327911 [04-19-2021]

Fossil Free Sweden. (2018). *Färdplan för fossilfri konkurrenskraft: Bygg- och anläggningssektorn.* Fossil Free Sweden: Stockholm. https://fossilfrittsverige.se/en/roadmap/the-construction-and-civil-engineering-sector/ [04-12-2021]

Fossil Free Sweden. (2021). *Roadmaps for fossil free competitiveness.* https://fossilfrittsverige.se/en/roadmaps/ [04-12-2021]

Haase. (2017). *Från rest till bäst.* *https://www.hoganas.com/sv/insikt/nyheter/2017/fran-rest-till-bast/* [04-20-2021]

Hauan, H. (2020). *Environmental product declaration.* The Norwegian EPD Foundation: Oslo. https://www.epd-norge.no/isolasjon/paroc-stone-wool-thermal-insulation-extra-article2805-321.html [04-21-2021]

Höganäs (2019). *Sustainability report 2020*. Höganäs: Höganäs. https://www.hoganas.com/globalassets/download-media/corporate/sustainability/sustainability-report-2020.pdf [04-20-2021]

Jernkontoret. (2020). *HYBRIT-fossilfri stålproduktion.* https://www.jernkontoret.se/sv/vision-2050/koldioxidfri-stalproduktion/ [04-22-2021]

Johannesson, A. (2020). *Negativa utsläpp möjliga redan 2025.* https://www.energiforetagen.se/pressrum/nyheter/2020/juni/negativa-utslapp-mojliga-redan-2025/ [04-23-2021]

Kanthal. (2021a). *Air heating cassettes.* https://www.kanthal.com/en/products/air-heaters/air-heating-cassettes/#tab-information [04-19-2021]

Kanthal (2021b). *Flow Heaters.* https://www.kanthal.com/en/products/air-heaters/flow-heaters/ [04-19-2021]

Karlsson, P. (2021). *Certifikat ISO 14001.* Research institutes of Sweden: Borås. https://www.paroc.se/hjalpmedel/miljodokumentation [04-21-2021]

Lindholm, K. (2021). *Elproduktion.* *https://www.energiforetagen.se/energifakta/elsystemet/produktion/* [04-22-2021]

Markewitz, M., Kuckshinrichs, W., Leitner, W., Linssen, J., Zapp, P., Bongartz, R., Schreiber, A. & Müller, T.E. (2012). *Worldwide innovations in the development of carbon capturing technologies and the utilization of* $CO_2$. Royal Society of Chemistry: London. https://juser.fz-juelich.de/record/22655/files/FZJ-22655.pdf

Mathieu, P. (2010). *9 – Oxyfuel combustion systems and technology for carbon dioxide ($CO_2$) capture in power plants.* Elsevier: Amsterdam. https://www.sciencedirect.com/science/article/pii/B9781845695330500096 [06-08-2021]

Owens Corning. (2021). *2020 Owens Corning Sustainability Report.* Owens Corning: Toledo. https://www.owenscorning.com/en-us/corporate/sustainability/docs/2021/2020-Owens-Corning-Sustainability-Report.pdf [04-19-2021]

Paroc. (2016). *Textdel-2015 års miljörapport Paroc Hässleholm.* Paroc: Hässleholm. http://extra.lansstyrelsen.se/smp/Sv/Pages/default.aspx [04-12-2021]

Paroc. (2020). *Textdel-2019 års miljörapport Paroc Hässleholm.* Paroc: Hässleholm. http://extra.lansstyrelsen.se/smp/Sv/Pages/default.aspx [04-12-2021]

Paroc. (2021a). *Paroc bjuder in till samråd för ny produktionslinje I Hällekis.* https://www.paroc.se/koncept/paroc-ansoker-om-samrad [04-15-2021]

Paroc. (2021b). *Miljömässiga fördelar med elektrisk smältning.* https://www.paroc.se/hallbarhet/pionjar-i-elektrisk-smaltning [04-16-2021]

Paroc. (2021c). *Rewool-Återvinning för alla. https://www.paroc.se/hjalpmedel/paroc-rewool* [04-21-2021]

Paroc. (2021d). *Bedömingsystem för produkter. https://www.paroc.se/hjalpmedel/miljodokumentation/miljobedomning-av-produkter* [04/21-2021]

Paroc. (2021e). *Bedömningssystem för byggnader*. *https://www.paroc.se/hjalpmedel/miljodokumentation/miljobedomning-av-byggnader* [04-21-2021]

Paroc. (2021f). *Bakom siffrorna: Hur hållbar är stenull?* https://www.paroc.se/hallbarhet/bakom-siffrorna-hallbar-stenull [04-22-2021]

Persson, C., Andersson H., Dahlqvist, C., Nihlgård, B. & Bramryd, T. (2019). Människa och miljö med praktisk vägledning för projekt. *Studentlitteratur: Lund.* ss. 62.

Rockwool. (2021). *Rockwool I Eskilstuna*. https://www.rockwool.se/om-oss/rockwool-i-eskilstuna/ [04-27-2021]

Shekhovtsov, V. V., Volokiton, O. G., Skripnikova, N. K, Volokitin, G. G. & Semenovkhy, M. A. (2021). *Thermal Plasma in Construction Industry.* IOP Publishing: Bristol. https://iopscience.iop.org/article/10.1088/1755-1315/688/1/012010/meta [04-19-2021]

Tester, W. J., Drake, M. E., Driscoll, M. J., Golay, M. W. & Peters, W. A. (2012). Sustainable Energy. *MIT Press: Cambridge.* ss. 1-100.

University of Borås. (2020). *Guide till Harvard systemet.* University of Borås: Borås. https://www.hb.se/globalassets/global/hb---externt/biblioteket/akademiskt-sprak/harvardguiden_version9_7.pdf [06-08-2021]

Volokitin, O. G., Volokitin, G. G. & Skripnikova, N. K. (2014). *Mineral fibre production based on ash from The Republic of Kazakhstan using Low-temperature plasma.* Springer: New York. https://link-springer-com.ezproxy.hkr.se/content/pdf/10.1007/s10717-014-9577-2.pdf [04-19-2021]

Von Dalwigk, I., Söderbom J. & Ghaem, S. (2021). *Vätgas för flexibelt och robust energisystem.* Energimyndigheten: Eskilstuna. http://www.energimyndigheten.se/globalassets/energieffektivisering_/program-och-uppdrag/sektorsstrategier/vatgas-for-flexibelt-och-robust-energisystem.pdf [06-08-2021]

Warren, J. (2000). *Dolomite: Occurrence, evolution, and economically important associations.* Elsevier: Amsterdam. http://saltworkconsultants.com/downloads/Dolomite_Warren_2000.pdf [04-18-2021]