Carbon Footprint Calculation and Proposing Green Growth Solutions Towards A Low Carbon Economy for Garment Technology Processes in Vietnam

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Abstract. Vietnam's textile and garment industry has been developing strongly and plays an increasingly important role in economic growth of the country since recent years. However, in Vietnam, there are currently no specific and officially published statistics on the carbon footprint in the garment industry. Meanwhile, Vietnam currently has strategies and policies for sustainable economic development based on the approach towards a low-carbon economy and green growth. Aiming at greenhouse reduction, a carbon footprint calculation method is presented. In carbon footprint calculations, allocation methodology is among the most significant. In this paper, based on characteristics of textile and apparel industry, process-level allocation methodology in textile and apparel industry was put forward with case study in 2020 for sewing processes for businesses of Vietnam National Textile and Garment Group (VINATEX). the amount of carbon that is emitted during the production process at the garment factory including 14 sewing lines at Phong Phu JSC and 3 sewing lines at Nha Be Garment Joint Stock Company. The results show that, on average, in 8 months of 2020, Phong Phu Garment Joint Stock Company discharged 334304.5548 Kg CO2e mean while Nha Be Garment Joint Stock Company emitted 118026,998 Kg CO2e.This case study had proposes options to reduce greenhouse gas (GHG) emissions, including: Designing appropriate factories, distributing and minimizing lighting equipment to minimize GHG emissions. Upgrading old production equipment with new, advanced and more energy-efficient ones is aimed at reducing emissions as well as improving product productivity.

1. INTRODUCTION

The textile & garment industry is one of the key industries in Vietnam, contributing great value to Vietnam's exports and GDP as well as solving employment [1]. Vietnam has known as the world's second largest exporter of ready-made garments (RMG), Fashion United, an international B2B fashion platform, quoted the World Trade Statistical Review 2021 released by World Trade Organization (WTO) [2]. The way to set a sustainable development pathway for fabric and garment production is to truly embrace principles and best practices on environmental protection, green production [3] and will be assist the transition of Vietnam's textile and apparel sector towards sustainable development and actively support the achievement of national development goals to get green growth model, as a means to achieve a low carbon economy and to enrich natural capital, will become the principal direction in sustainable economic development [4] of Viet Nam in the future.

To meet these challenges, Viet Nam needs to continue strengthening its institutional capacity, tackling economic reforms, massively adopting clean technologies and paying attention to the evolving people consumption patterns[5]. Far from decrying diversity, we should bear in mind that a diversity of standards and approaches is necessary given the many different purposes to which carbon foot-printing can be put e from product labelling to policy analysis and process design. The context of each carbon footprint calculation will have to influence the necessary and appropriate inclusions and choices. Finally, let us bear in mind that despite hundreds of years of global trade, and the increasing intensity of globalisation in the last century, there are still different shoe size scales in different countries. Therefore, it is to be expected that a diversity of carbon footprint standards will persist for years to come [7].

Vietnam needs to have research and publication on carbon footprint to move towards a sustainable development model, especially the garment industry in Vietnam, choosing a very important development model in which green growth is critical approach in line with global trends.

This research aim to calculate carbon footprint unit (CF) for the sewing technology process of some VINATEX companies, thereby comparing, giving out strengths and weaknesses in the production process. Based on the achieved results, concluded the advantages and disadvantages of each process and the ability to apply technology in Vietnam. Finally, giving recommendations and initially proposing solutions to reduce emissions to move towards a low-carbon economy and green growth under current Vietnam's conditions.

Objectives to be achieved of the study:

- Inventory of the amount of greenhouse gas emitted (kgCO2e) of the garment technology processes of the company under VINATEX.

- Comparing the shortcomings of each CF calculation process to draw experience to initially propose proposals to reduce CF emissions, thereby integrating green growth towards a low-carbon economy under Vietnam's conditions.

2. LITERATURE REVIEW

2.1 Carbon footprint inventory method

Regarding the current CF calculation, only GHG emissions are assessed at the product or plant, regional or national level, so it is not possible to infer the difference of technology across different processes. Therefore, the selection of an appropriate allocation method is a key issue that needs to be considered in the textile and garment industry, which has different levels of production technology.

Due to the specificity of the textiles and garment industry, it can be easily calculated when we divide the production into 3 sectors and each sectors has its own (CFU). Those 3 sectors are:

Sector 1 (S1) is the manufacturing process: in this process we will calculate the amount of GHGs emissions from production equipment (eg: sewing machines, cutting machines, bulldozers, ...)

Sector 2 (S2) is the auxiliary process of production: in this process we will calculate the amount of greenhouse gas emissions from equipment supporting the production process (eg: lamps, fans, exhaust fans, ...)

Sector 3 (S3) is the production operation process: in this process we will calculate the amount of greenhouse gas emissions from the equipment operating the production process in the office (eg computers, air conditioners, ...)

For the plants, monthly or annual data contained used energy and materials consumption data is easy to obtain. Accordingly, a solution combining the highly informative value of CF with a reasonable process-level allocation methodology is thought to be appropriate[6]. Data construction of CF shown as Fig.1.

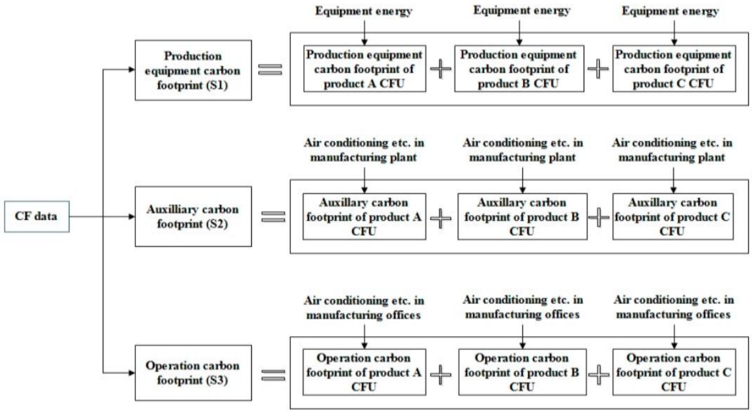

FIGURE 1. *CF construction data map* [6]

This method is calculated by sector (S1, S2, S3). During the production process, the equipment of each sector will consume a large amount of electricity, which means that a large amount of CF will be released into the environment, the equation is as below:

$$CF_{process}(x) = Q \times \frac{\sum_{i=1}^{n}(S_{pi}(x) \times T_{pi}(x) \times N_{pi}(x))}{\sum_{i=1}^{n}(S_{pi}(x) \times T_{pi}(x) \times N_{pi}(x)) + \sum_{j=1}^{m}\left(S_{aj}(x) \times T_{aj}(x) \times N_{aj}(x)\right) + \sum_{k=1}^{p}(S_{ok}(x) \times T_{ok}(x) \times N_{ok}(x))} \times C$$

$$CF_{auxiliary}(x) = Q \times \frac{\sum_{j=1}^{m}(S_{aj}(x) \times T_{aj}(x) \times N_{aj}(x))}{\sum_{i=1}^{n}(S_{pi}(x) \times T_{pi}(x) \times N_{pi}(x)) + \sum_{j=1}^{m}\left(S_{aj}(x) \times T_{aj}(x) \times N_{aj}(x)\right) + \sum_{k=1}^{p}(S_{ok}(x) \times T_{ok}(x) \times N_{ok}(x))} \times C$$

$$CF_{operation}(x) = Q \times \frac{\sum_{k=1}^{p}(S_{ok}(x) \times T_{ok}(x) \times N_{ok}(x))}{\sum_{i=1}^{n}(S_{pi}(x) \times T_{pi}(x) \times N_{pi}(x)) + \sum_{j=1}^{m}\left(S_{aj}(x) \times T_{aj}(x) \times N_{aj}(x)\right) + \sum_{k=1}^{p}(S_{ok}(x) \times T_{ok}(x) \times N_{ok}(x))} \times C$$

FIGURE 2. *The steps to divide the CF of individual product into three sections (S1, S2, and S3).*[6]

In that equation:

$\boldsymbol{CF_{process}}$(x) is the amount of GHGs of machinery and equipment discharged in the production process (kW.h)

$\boldsymbol{CF_{auxiliary}}$(x) is GHGs discharged by machinery and equipment in the auxiliary process (kW.h)

$\boldsymbol{CF_{operation}}$(x) is the GHGs of equipment and machinery that are discharged during the production operation (office's sector)

Q is the total power consumption of the plant

i is some particular production machine

n is the number of a particular production machine

j is any particular auxiliary machinery or equipment

m is the number of specific auxiliary machinery and equipment

k is machinery and equipment for specific production operations

p is the number of production machines and equipment for specific production operations

S_{pi} is the rated power of a certain production equipment

T_{pi} is the actual working hours per day of a cerain production equipment

N_{pi} is the number of a certain production equipment

S_{aj} is the rated power of a certain auxiliary equipment

T_{aj} is the actual working hours per day of a cerain auxiliary equipment

N_{aj} is the number of a certain auxiliary equipment

S_{ok} is the rated power of a certain operation equipment

T_{ok} is the actual working hours per day of a cerain operation equipment

N_{ok} is the number of a certain operation equipment

2.2 Areas of research

Using calculation methods to calculate CF of the high-class veston sewing process at Nha Be Garment Joint Stock Company and the process of sewing jeans and kaki at Phong Phu JSC. Compare each process from there to know the limitations and give recommendations.

In terms of space, the topic proposed CF inventory for the textile and garment industry in Vietnam specifically is VINATEX. The scope of data collection includes 2 garment enterprises under the Vietnam National Textile and Garment Group (VINATEX) including: Nha Be Garment JSC, Phong Phu JSC.

In terms of time, the topic analyzes and calculates CF technology and process in the two above enterprises in the period from the beginning of 2020 to the present, calculates and gives results from which to propose solutions for green growth towards a low carbon economy in the Vietnamese garment industry.

3. RESULTS AND DISCUSSION

3.1 Result of Carbon footprint inventory at Phong Phu JSC

The GHG emissions from the production of kaki and jean pants in Phong Phu JSC according to S1 are shown in Fig. 3.

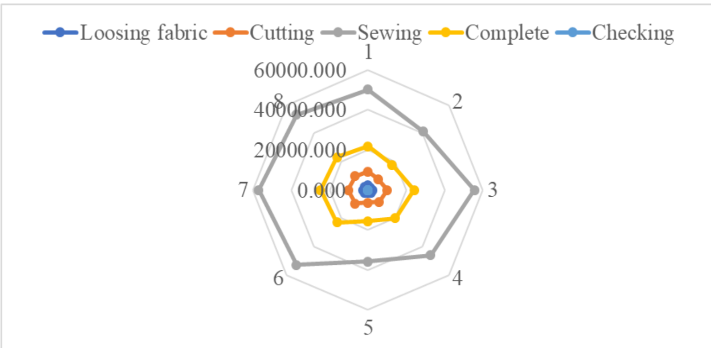

FIGURE 3. *GHG emissions over each month from S1 at Phong Phu JSC in 2020*

As Figure 3 shows that the GHG emissions from the loosing farbic process are the smallest with an average value over 8 months is 2095,807 $kgCO_2e$. The sewing process is the highest GHG emissions accounts for 49013,611 $kgCO_2e$ on average in 8 months. Since machinery and labor are concentrated mainly in sewing, the GHG emissions in this stage are very high, not to mention the use of high capacity irons leading to the highest GHG emissions in this stage.

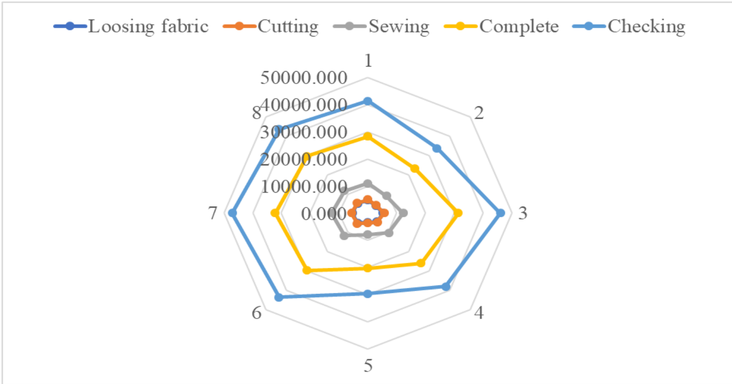

FIGURE 4. *GHG emissions over each month from S2 at Phong Phu JSC in 2020*

Compared to the production process, the production auxiliary process emits a lot of GHG compared to the production stage, for the sewing stage alone, S2 reaches an average of 10787,371 $kgCO_2e$, 1.5 times higher than the production stage. However, the checking stage reached the highest GHG emissions in the peak month reaching 47089,747 kgCO2e. Due to the large number of electric lamps used, the GHG emission in S2 is high.

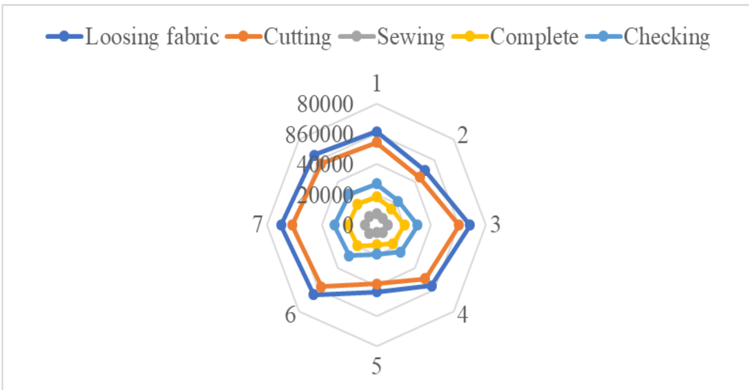

FIGURE 5. *GHG emissions over each month from S3 at Phong Phu JSC in 2020*

The highest value of the operating process is the loosing fabric process reaching a peak of 70039.25 kgCO2e. Because in the office block at this garment factory, many high-capacity devices such as computers, air conditioners, printers are installed. So the GHG emissions at this stage are the highest compared to the other 2 stages.

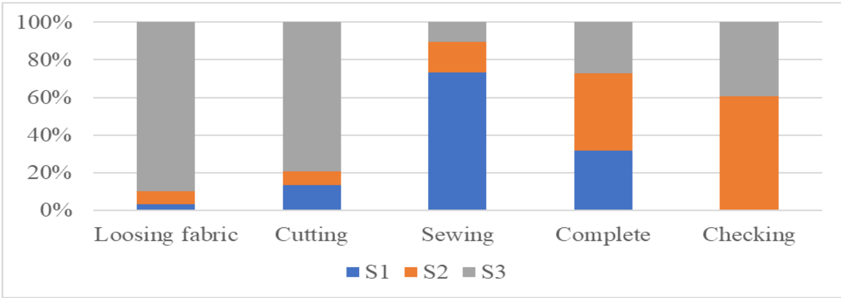

FIGURE 6. *The percentage of GHG emissions through each stage of Phong Phu JSC in 2020*

Each scale of S1, S2, S3 in each step shown as Fig. 6. In particular, we see that S3 accounts for the highest percentage of the total in the stages, in the checking stage, the GHG emissions due to S3 is the highest, followed by S2. Specifically, in the checking stage S2 accounts for more than 60% of the GHG released in this process.

3.2 Result of Carbon footprint inventory at Nha Be garment JSC

In the case at Nha Be Garment Joint Stock Company we see that the highest S1 is the veston sewing steps shown in Fig.7. Specifically, the average stage of sewing sleeves and collars in 8 months of GHG emission is up to 3235,984 $KgCO_2e$, peak months can reach 4569,899 $KgCO_2e$ (March).

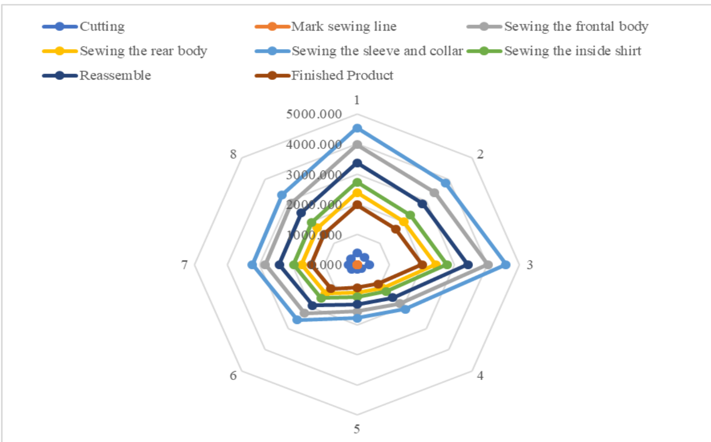

FIGURE 7. *GHG emissions over each month from S1 at Nha Be garment JSC in 2020*

In S2, reaching the highest amount of GHG emitted to the environment is the mark sewing line stage which averaged over 8 months at 11612.608 $KgCO_2e$ as shown in Fig.8. Next is the cutting to reach 11399.6 $KgCO_2e$. Due to the tight space of the veston sewing workshop and little direct light, the installation of many lamps, fans and exhaust fans for the whole workshop is very high in this stage.

In S3 the GHG amount of relatively homogeneous phases, there are only 2 high emission stages which are cutting and mark sewing line, respectively 3229,144 $KgCO_2e$, 3289,483 $KgCO_2e$. Because the operation room at Nha Be is small, it does not use many equipment with high energy capacity, so in general, at this stage, it does not emit as much GHG as in Phong Phu JSC.

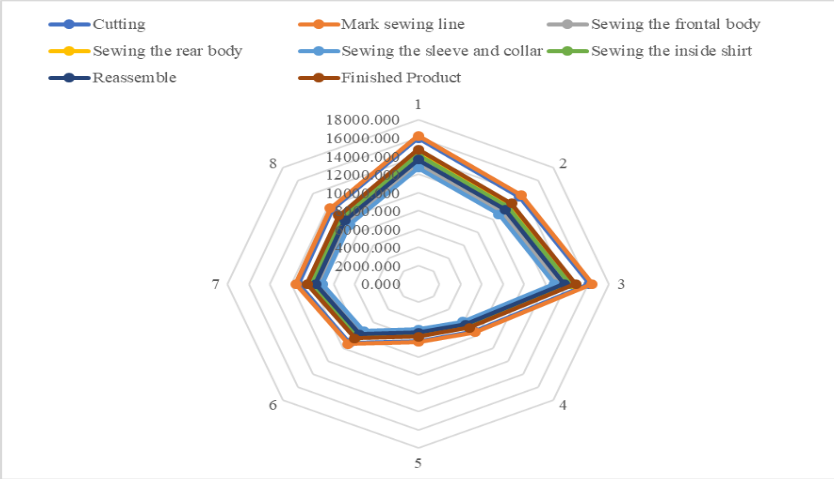

FIGURE 7. *GHG emissions over each month from S2 at Nha Be garment JSC in 2020*

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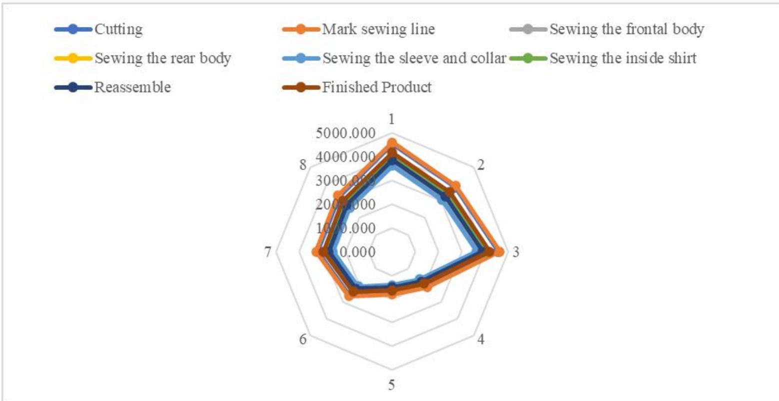

FIGURE 8. *GHG emissions over each month from S3 at Nha Be garment JSC in 2020*

As Fig. 8 shown that at Nha Be Garment JSC, the S2 of veston sewing accounts for the most, the highest in the finished product stage S2, up to more than 80% up to 80927,672 KgCO_2e, the average of 8 months. Because the space at the high-end veston garment factory has little natural light, production activities depend heavily on bulbs of up to 1100 bulbs that operate continuously for 10 hours / day. Hence the very high power consumption in S2 leads to the highest GHG emissions in S2.

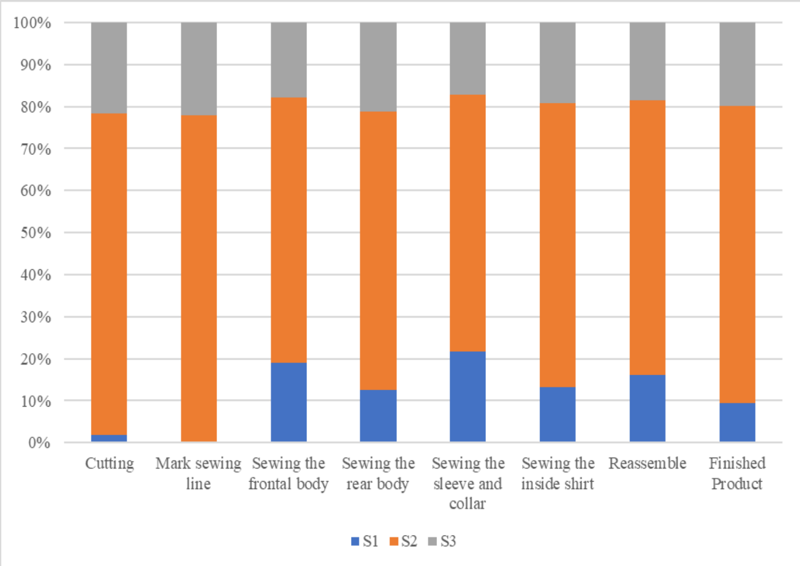

FIGURE 9. *The percentage of GHG emissions through each stage of Nha Be garment JSC in 2020*

3.3 Survey results

The cognitive survey on green growth and carbon inventory was conducted in 3 garment enterprises with officials and experts working in garment enterprises with 10 to 20 years of working experience including: Nha Be Garmen JSC, Phong Phu JSC, Viet Tien Garment JSC. Respondents for survey are the head of the department, the deputy head of the staff department and the specialists of the corporation or the main production workshops. There are 31 questionnaires doneand related documents.

The survey results on awareness, understanding as well as assessment of the importance of green growth and carbon footprint are shown in Fig. 10.

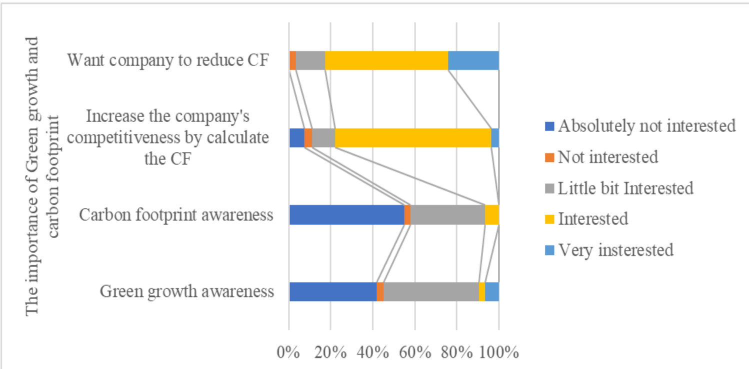

FIGURE 10. *The survey results on green growth and carbon footprint*

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When surveying, 48.38% think that in order to reduce carbon footprint, it is necessary to invest in finance, 74.19% think to reduce carbon footprints requires advanced applications. On the other hand, 51.61% said that it is necessary to improve staff qualifications in order to reduce carbon footprints and 41.9% think that focusing on production specialization will reduce the carbon footprint. However, 9.6% said there is no need to invest in anything to reduce the carbon footprint of their businesses. In general firms were also aware of the importance of the carbon footprint that could affect their businesses. Therefore, reducing carbon footprint is essential to be able to move towards a low carbon economy and towards green growth.

3.4 Initially assess carbon reduction opportunities for some production processes for the textile industry

when calculating for case study the carbon footprint at Phong Phu and Nha Be JSC, the author realizes many shortcomings in the sewing processes in these two companies. In Phong Phu, the garment factory is designed to be airy with lots of light, but unnecessarily overuse lights leads to wasteful energy consumption.

Cutting, ironing and sewing are described in several publications. For plants with low energy consumption of the actual technical processes, the supplementary processes such as ventilation, air conditioning and personnel facilities are usually the main contributors to the carbon footprint [7].

Similarly, in Nha Be, the arrangement of sewing lines is also not rational, leading to an inappropriate use of auxiliary production equipment. In addition, the machines at the two sewing factories are relatively advanced, but still some sewing lines use old models, which also contribute to the increase in GHG emissions in the sewing process.

The first step is to suggest opportunities to initially assess carbon reduction opportunities for Nha Be and Phong Phu JSC are as table 1 follows:

TABLE 1. *Proposing for the carbon emission reduction plan for sewing process*

Plan	Hypothesis	Benefits achieved
Rearrangement the sewing process stages so that it is reasonable.	By 2025, Phong Phu and Nha Be rearrange sewing processes in a specific and reasonable order, each stage is divided into a separate area not attached to many other stages.	Reduction of GHG emissions in S2, S3;
Upgrade machines in the production process, supporting production with new energy-saving models.	By 2025, Phong Phu and Nha Be renew 100% of equipment in their company.	Reducing GHG emissions in 3 processes: S1, S2, S3.
Research using environmentally friendly materials, easy to recycle and reuse.	By 2025, Phong Phu and Nha Be JSC use materials that can be easily recycled, reused and environmentally friendly.	Reducing GHG emissions, being able to reuse old and discarded products contribute to reducing solid waste discharged into the environment.

Enterprises should focus on GHG mitigation and solid waste reduction. Calculate the input materials, waste and associated costs at each stage of the production process. Enterprises need to fully comply with current environmental laws and understand the environmental requirements in the near future. Green production must be central to the management portfolio of the company. Pay real attention to employees and control the business development towards efficient green production. The goals can be to reduce production costs, reduce input costs, lower emissions and work safety.

Choosing the direction to reduce costs and meet environmental requirements. To cut costs and meet environmental requirements, businesses can choose from two directions. The non-tech direction needs to take precedence over because most involving operational improvements, controls, the idea of removing waste or changing materials are ideas that employees or staff members can suggest and execute. The main direction of technology is to improve or change technology, but this direction requires high costs and large changes in operations at the enterprise, so it is less priority and should only be considered.

3.5 Green growth solutions for the textile industry in Vietnam

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4. CONCLUSION

The case study has used the carbon footprint inventory method for sewing processes for businesses of VINATEX. From there, we can see the amount of carbon that is emitted during the production process at the garment factory including 14 sewing lines at Phong Phu JSC and 3 sewing lines at Nha Be Garment Joint Stock Company. The results show that, on average, in 8 months of 2020, Phong Phu Garment Joint Stock Company discharged 334304.5548 KgCO2e and Nha Be Garment Joint Stock Company emitted 118026,998 KgCO2e.

The allocation method used in this study has not been widely applied to calculate carbon footprint over the world , especially the textile industry, so the comparison of research results is also a limitation of this study. This is understandable because the textile industry is only developed in a few countries. However, the similarity in research approaches can be seen in the similarity of research results as the results of this case show that stage S2 is the most emitter in another study in China [6].] is similar when the CF of S2 (auxiliary CF) accounts for the highest proportion of the total CF. Reducing S2 emissions can be achieved by increasing unit productivity, energy-saving ancillary equipment and optimizing plant layout[6].

This research has proposed options to reduce GHG emissions, including: Designing appropriate factories, distributing and minimizing lighting equipment to minimize GHG emissions at S2. Upgrading old production equipment with new, advanced and more energy-efficient ones is aimed at reducing emissions as well as improving product productivity.

Based on case study, other garment enterprises can apply to calculate the carbon footprint for the company's process and identify appropriate GHG emission reduction solutions. Therefore, the topic has made scientific and practical contributions and contributed to supporting Vietnam to get the important database and achieve the goal of GHG mitigation in the garment and towrad a low carbon economy in the future

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