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CARBON FOOTPRINT CALCULATION FOR THE COMPANY

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The purpose of this thesis was to figure out the amount of the greenhouse gases the electrical and automation technology manufacturing company Satmatic Oy has produced in their operations during the year 2015. This research is part of Satmatic Oy's climate partnership actions and it was ordered by the project Satahima –Kohti hiilineutraalia Satakuntaa carried out by the Environmental Bureau of city of Pori.

The atmospheric burden of the well-mixed greenhouse gases has increased in accelerating speed during the last decades. Political decisions are important when fighting against the climate change but also corporations should take climate viewpoint into account in their business. Companies can participate the climate work by calculating their carbon footprint. This will help them to understand where the company's emissions are originating and recognize hidden costs or subjects for savings.

The carbon footprint for Satmatic Oy was calculated by following the instruction of Greenhouse Gas Protocol's Corporate Accounting and Reporting-standard. The research was done by collecting electricity consumption, heat consumption, waste management and business travelling data from Satmatic Oy and choosing suitable emission factors for all these actions. Then all this information was fed to carbon footprint calculation tool.

In 2015 Satmatic Oy produced about 180 500 kg of carbon dioxide equivalents. Most of the emissions were originated from the purchased electricity (85 600 kg of CO_2 equivalents). Business travelling and accommodation caused the second biggest amount of emissions (47 600 kg of CO_2 equivalents). In 2015 Satmatic Oy's carbon footprint is downsized by the use of their solar electricity plant and the effective recycling of the wastes. The further actions to diminish Satmatic Oy's annual carbon footprint could be the changing of the normal purchased electricity to renewable electricity and optimization of everyday energy use.

YRITYKSEN HIILIJALANJÄLJEN LASKEMINEN
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Tämän opinnäytetyön tavoitteena oli selvittää, kuinka paljon kasvihuonekaasuja muodostui sähkö- ja automaatiotekniikkaa valmistavan yrityksen Satmatic Oy:n vuoden 2015 toiminnoista. Tämä tutkimus on osa Satmatic Oy:n ilmastokumppanuus toimenpiteitä ja se tilattiin Porin kaupungin ympäristöviraston Satahima–Kohi hiilineutraalia Satakuntaa-projektin toimesta.

Ilmakehässä hyvin sekoittuneiden kasvihuonekaasujen määrä on kasvanut kiihtyvällä tahdilla viime vuosikymmenenninä. Ilmastonmuutoksen vastaisessa taistelussa poliittisilla päätöksillä on tärkeä rooli, mutta myös yritysten tulisi ottaa ilmastonäkökulma mukaan toimintoihinsa. Yritykset voivat osallistua ilmastotyöhön selvittämällä hiilijalanjälkensä. Tämä auttaa yrityksiä ymmärtämään, mistä yrityksen aiheuttamat päästöt muodostuvat ja tunnistamaan yrityksen toiminnan piilokuluja ja säästökohteita.

Satmatic Oy:n hiilijalanjälki laskettiin noudattamalla Greenhouse Gas Protocol-sivuston kehittämää yritysten hiilijalanjäljen laskentaan tarkoitettua standardia. Tämä tutkimus tehtiin keräämällä Satmatic Oy:ltä tietoa sähkö ja lämmön kulutuksesta, jätteiden käsittelystä ja liikematkustamisesta ja valitsemalla sopivat päästökertoimet näille toiminnoille. Seuraavaksi kaikki tämä tieto syötettiin hiilijalanjäljen laskentaan varten tehtyyn työkaluun.

Vuonna 2015 Satmatic Oy tuotti toiminnoillaan noin 180 500 kg hiilidioksidiekvivalenttia. Suurin osa näistä päästöistä muodostui ostetun sähkön (85 600 kg of CO_2 ekvivalenttia) kuluttamisesta. Liikematkustaminen, mukaan lukien majoittumisen, aiheutti toiseksi eniten päästöjä (47 600 kg of CO_2 ekvivalenttia). Vuonna 2015 Satmatic Oy:n oman aurinkosähkövoimalan käyttö ja jätteiden tehokas kierrätys vaikuttivat yrityksen hiilijalanjälkeen pienentävästi. Jatkossa Satmatic Oy voi edelleen pienentää hiilijalanjälkeään ostamalla tavallisen sähkön sijasta uusiutuvilla energiamuodoilla tuotettua sähköä ja optimoimalla energian käyttöään.

CONTENTS

1 INTRODUCTION

International Panel on Climate Change has published regularly comprehensive assessment reports reviewing the latest climate science. According to the latest, IPCC Fifth Assessment Report, atmospheric burden of the well-mixed greenhouse gases (GHGs) targeted by the Kyoto Protocol has increased from 2005 to 2011. The atmospheric abundance of carbon dioxide (CO_2) has increased 40% from 1750 to 2011. During the same time interval atmospheric nitrous oxide (N_2O) has increased by 20% and atmospheric methane (CH_4) by 150%. (IPCC 2013, 169) All these greenhouse gases have significant effects on the climate but CO_2 in the atmosphere has most influence on accelerating global warming. (Perlmutter & Rohstein 2010, 63)

Climate change policy is made in all arenas, from the international to the local level. The EU’s climate policy until 2020 will be framed according to the Kyoto Protocol to the United Nations Framework Convention on Climate Change and, within the EU, the climate and energy package. According to the targets of climate and energy package EU countries should produce 20% of their energy with renewable energy resources and improve their energy efficiency by 20% by 2020. In addition the EU's emissions reduction target is 20% compared to the 1990 levels by 2020, and 40% by 2030. (Website of Ministry of the Environment 2016)

Political decisions are important when fighting against the climate change but also corporations should take climate viewpoint into account in their business. The reasons for companies to invest on green business might be several: clients might be favouring ethically produced products, legislation might be requiring responsibility or the company management might want to act ethically. (Virtanen & Rohweder 2011, 296) The calculation of carbon footprint for company’s actions or for certain product is one way to participate to the climate work. By making carbon footprint calculation the companies can achieve transparency and get more valuable information about the environmental impact of their actions. Companies can also use carbon footprint calculation for analysing their productional details and to be able to recognize hidden costs or subjects for savings. (Antila 2010, 19)

2 BACKGROUND AND AIMS OF THE RESEARCH

2.1 Project: Satahima – Kohti hiilineutraalia Satakuntaa

Satahima –Kohti hiilineutraalia Satakuntaa is a project carried out by the Environmental Bureau of city of Pori and it last from 1.1.2015 to 31.12.2017. Satahima – Kohti hiilineutraalia Satakuntaa is the name of the project and means towards carbon neutral region of Satakunta. Satakunta is a province in southwest Finland.The project is funded by European Regional Development Fund (ERDF). In addition of city of Pori also the municipalities of Harjavalta, Huittinen, Kankaanpää, Ulvila, Säkylä, Rauma, Kokemäki, Köyliö, Nakkila, Pomarkku and the energy companies Pori Energia Oy, Rauman Energia Oy and Vatajakosken Sähkö Oy are involved. (Website of the Environmental Bureau of Pori 2015)

The aim of Satahima-project is to put targets of the climate- and energy strategy of Satakunta into action by municipalities, their citizens, and small and middle-sized enterprises together with energy companies and schools. The project will enhance the implementation of new technologies related energy efficiency and emission reduction. The project will also find and share information about the renewable energy forms and new business opportunities related to them. The Satahima-project cooperates with local operators, like universities, schools, companies and municipalities and develops already existing networks. The project enhances the research and development work related to carbon neutral and energy efficient solutions done by municipalities, energy companies and Satakunta University of Applied Sciences. The long-term aim of the project is to promote all the actions that take Satakunta closer to be carbon neutral. (Satahima-Kohti Hiilineutraalia Satakuntaa Participation Agreement 2015)

The actions of the Satahima-project are divided into three main topics: energy consulting, energy efficiency and climate partnership. The energy consulting is free service for local residents and for small and middle-size enterprises. The energy efficiency is about development and implementation of companies' voluntary energy efficiency contracts. (Website of the Environmental Bureau of Pori 2015)

The idea of climate partnership was developed in a climate project executed by the city of Pori. The project *Ilmastoasiat kunnassa – toimeenpanoa ja yhteistyötä* (in English: Climate issues in a municipality – enacting and co-operation) was organized together with municipalities of Nakkila and Ulvila in 2012-2014. In climate partnership companies and societies plan how they are going to cut down their greenhouse gas emissions and how they will achieve those emission targets. Climate goals and actions can be related for example to energy conservation, energy efficiency, waste management and logistics. (Website of the Environmental Bureau of Pori 2015)

Figure 1. Logo of climate partnership (Website of the Environmental Bureau of Pori 2015)

2.2 Presenting climate partnership company Satmatic Oy

Satmatic Oy is one of the leading manufacturers of electrical and automation technology in Finland. Satmatic Oy has two places of business: headquarters and factory are located in Ulvila (5000 m^2) and production office in Kerava (15000 m^2). The company employs 100 professionals in Ulvila and Kerava. Satmatic Oy is owned by a stock exchange company AS Harju Elekter. Satmatic Oy is offering custom-made service entities to its customers. These service entities can include contract based manufacturing, project delivery, planning- and installation services and maintenance work. In addition company manufactures a wide range of its own products like electric switchgears, automation centers, low voltage distribution transformers, solar electricity systems, charging units for electric cars and smart streetlight remote controlling systems. (Website of Satmatic Oy 2014)

According Satmatic Oy´s environmental policies all the produced waste is either possible recycled or disposed of by suitable techniques. Distribution of different kind of waste material is constantly followed up and corrective actions in waste management are implemented according to the results from follow-up. The environmental impacts of the company's actions are mostly shown as indirect impacts and production of recyclable waste that can be utilized in waste treatment plant. The most significant indirect impacts are for example emissions caused by transportation. Satmatic Oy is following up the changes that happen in its operational environment and is committed to take into notice the environmental aspect when improving its actions. Satmatic Oy is granted with environmental quality certificate ISO 14001:2004. (Website of Satmatic Oy 2014)

In 2015 Satmatic Oy made climate partnership contract and committed to take notice into climate matters and reduce its carbon dioxide emissions. These goals will be reached by improving the energy efficiency of the existing systems, increasing the awareness of the customers about benefits of solar energy systems and decentralized energy production, promoting the use of renewable energy forms and enabling the growth of electric traffic in Finland by developing and selling of charging units. (Website of the Environmental Bureau of Pori 2015)

2.3 Aims of the research

The aim of this research is to figure out the amount of the greenhouse gases Satmatic Oy has produced in their operations during the year 2015. The ordering of this research is part of Satmatic Oy's climate partnership actions and the purpose of this research is to help to understand where the company's emissions are originating. This carbon footprint report is done by collecting energy consumption, waste and transportation data from Satmatic Oy and feeding this information to an existing carbon footprint calculator. This research is expected to ease the making of company's future carbon footprint calculations and results of this research can be used as a base year when comparing calculation results of the coming years. In the end of the research there will also be some suggestion how company could reduce some of their emissions.

3 CARBON FOOTPRINT AS A GREENHOUSE GAS EMISSION INDICATOR

3.1 Greenhouse gas emissions

Greenhouse gases (GHG's) are those that absorb and emit infrared radiation in the wavelength range emitted by Earth. The United Nations Framework Convention on Climate Change (UNFCCC) wants to stabilize the greenhouse gas concentrations in the atmosphere to a level that wouldn't harm the climate system. The Kyoto Protocol requires its parties to bind to the targets that are based on six GHGs, including carbon-dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). (Rao & Riahi 2006, 178) In addition water vapor (H_2O) and ozone (O_3) are one of the most abundant greenhouse gases in the atmosphere but their effect to global warming is less concerned because human activities have only a small direct influence on the amount of atmospheric water vapor and ozone, on the other hand, is chemically reactive and relatively short-lived in the troposphere. (Perlmutter & Rohstein 2010, 58)

The atmospheric CO_2 originates from burning of fossil fuels in transportation, building heating and cooling. CO_2 is also released in deforestation and natural processes like decay of plant material. Methane originates to the atmosphere from human activities related to agriculture, natural gas distribution and landfills. Methane is also released from some natural processes. Nitrous oxide is also emitted by human activities such as the use of fertilizer and burning of fossil fuels. Natural processes in soils and the oceans also release N_2O. HFCs, PFCs and SF_6 concentrations have increased primarily due to human activities, like electronics and electricity industrial processes and in use as a refrigerant agent. (IPCC 2007, 135)

3.2 Global Warming Potential (GWP)

Different greenhouse gases can have different effects on the Earth's warming. These gases differ from each other by their ability to absorb energy and by how long they stay in atmosphere. The Global Warming Potential (GWP) has been developed to allow comparisons of the global warming impacts of different gases. GWP measures how much energy the emissions of one ton of gas will absorb over given time period compared to the emissions of one ton of carbon dioxide. The large GWP-value tells that the certain gas warms the Earth more than same amount of CO_2 over that time period. (Website of EPA 2016)

CO_2 has GWP of 1 because it is the gas being used as the reference. HFCs, PFCs and SF_6 are sometimes called high-GWP gases because they trap substantially more heat than CO_2. Fortunately concentrations of these compounds in the atmosphere are extremely low. GWP's can also be used to define the impact that greenhouse gases will have on global warming over different time horizons. These are usually 20 years, 100 years and 500 years. (Website of EPA 2016; Perlmutter & Rohstein 2010, 61) Atmospheric lifetimes and GWP's for the most significant greenhouse gases are presented in Table 1. Lifetimes and GWP's of PFC and HFC compounds vary slightly hence some compounds with average values were chosen to table 1 as examples.

Table 1. Lifetimes and GWP's of most significant greenhouse gases (IPCC 2007)

Greenhouse gas	**Atmospheric lifetime (yr)**	**GWP for given time horizon**		
		20 (yr)	**100 (yr)**	**500 (yr)**
carbon dioxide (CO_2)	50-200	1	1	1
methane (CH_4)	12	72	25	7,6
nitrous oxide (N_2O)	114	289	298	153
sulfur hexafluoride (SF_6)	3200	16300	22800	32600
perfluorocarbons (PFCs) *e.g. C_3F_8 (PFC-218)*	*2600*	*6310*	*8830*	*12500*
hydrofluorocarbons (HFCs) *e.g. CHF_2CF_3 (HFC-125)*	*29*	*6350*	*3500*	*1100*

3.3 Carbon footprint as a greenhouse gas emission indicator

When the effect of a certain action (like manufacturing a product) on climate change is wanted to be described, some common concepts like greenhouse gas emissions, climate effects and carbon footprint are used. These concepts usually mean more or less the same thing. The unit used in carbon footprint research is equivalent carbon dioxide (CO_2-eq). Amount of equivalent carbon dioxide for a certain action can be defined when summarizing together all the greenhouse gases caused by the action and then altering these emissions into equivalent carbon dioxide. Methane, nitrous oxide and halogen compound emissions can be altered to amounts of equivalent carbon dioxide by multiplying each emission with their GWP-value. The result will express relevance of that greenhouse gas for the climate change. (Nissinen & Seppälä 2008, 14)

Carbon footprint is considered to be an ambiguous term. There are several different standards and guidelines for calculating carbon footprint. Usually carbon footprint calculations are made for a certain product (Product Carbon Footprint, PCF) or for business activities (Corporate Carbon Footprint, CCF). Product Carbon Footprint determines all the greenhouse gases that are produced during the lifetime of the product, including greenhouse gases from raw-materials, manufacturing processes, transportation, usage and disposal. Corporate Carbon Footprint determines all the greenhouse gases that are produced in business activities during a certain time period (mostly one year). Usually greenhouse gas emissions from corporation’s electricity and heat consumption, business travelling, waste management and some of the sub contraction chains are included in the corporate carbon footprint calculations. (Kontiokorpi 2011, 34) This research is focusing on corporate carbon footprint and especially on Corporate Accounting and Reporting-standard which is presented in the next chapter.

4 CARBON FOOTPRINT CALCULATIONS FOR COMPANIES

4.1 Standards

The Greenhouse Gas Protocol (GHG Protocol) is the most widely used international accounting tool for government and business leaders to understand, quantify, and manage greenhouse gas emissions. The GHG Protocol supplies widely used greenhouse gas accounting standards, like Corporate Accounting and Reporting Standard (abbr. Corporate Standard) and Corporate Value Chain Standard. The Corporate Standard provides instruction on how a company should perform a GHG inventory. (Website of the Greenhouse Gas Protocol 2012)

4.2 Corporate Accounting and Reporting Standard

If a company is willing to carry out greenhouse gas inventory by following the Corporate Standard everything starts by setting **organizational boundaries** for the inventory. Companies differ from their actions and this is why carbon footprint calculation can be done by either using the equity share (greenhouse gas emission share is proportional to company's ownership percentage of the operation) or the control approaches (greenhouse gas emissions are calculated from all the operations the company or its subcontractor controls). (WRI & WBCSD 2004, 17)

The next step is to set the **operational boundaries** for the company's actions. This involves identifying emissions associated with its operations, categorizing them as direct and indirect emissions and choosing the scale of accounting and reporting for indirect emissions. In the Corporate Standard greenhouse gas emission sources are divided into three scopes. **Scope 1** contains direct greenhouse gas emissions that occur from sources that are owned or controlled by the company, for example, emissions from combustion in boilers, furnaces and vehicles or emissions from chemical production in process equipments. **Scope 2** contains indirect greenhouse gas emissions from the generation of purchased electricity consumed by the company. **Scope 3** includes company's all other indirect greenhouse emissions, like emissions from production of materials, usage of the product, outsourced services, leased vehicles, waste management and business travelling. Scope 3 is an optional reporting category in Corporate Standard and this means company can report any scope 3 emission it chooses. The reporting of greenhouse gas emissions coming under scope 3 has also its own standard, Corporate Value Chain Standard, which is presented in chapter 4.3. (WRI & WBCSD 2004, 25)

According to the Corporate Standard the carbon footprint calculation should take into account all of the six Kyoto Protocol gases (CO_2, N_2O, CH_4, HFC's, PFC's & SF_6). The emissions and their development in different scopes are presented in figure 2.

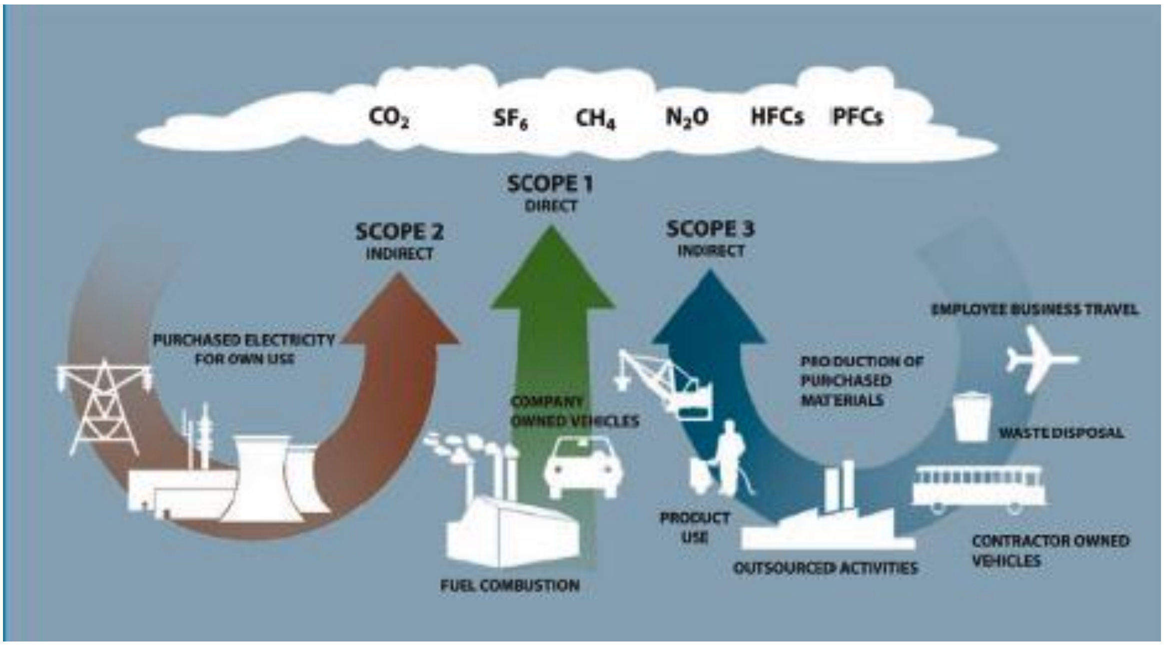

Figure 2. Different scopes and emissions according Corporate Accounting and Reporting standard. (WRI & WBCSD 2004, 26)

Once the inventory boundary has been established, companies generally calculate their carbon footprint using the following steps:

1. Identifying greenhouse gas emission sources.
2. Choosing the greenhouse gas emission calculation method
3. Collecting necessary data and choosing the emission factors
4. Feeding all the information to the proper calculation tool
5. Gathering the greenhouse gas emission data on corporate level (WRI & WBCSD 2004, 40.)

The carbon footprint report that has been made in a proper way should contain the description of the company, the boundaries used in the inventory, all the emissions that have been formed inside scopes (emission data separately for each scope), the year chosen as a base year, all the methods used for measurements or calculations and reasoning for outsourcing certain operations or emission sources. (WRI & WBCSD 2004, 63)

4.3 Corporate Value Chain Standard

When the quality of carbon footprint investigations developed, it was noticed that investigation involving greenhouse gas emissions only from scopes 1 and 2 were excluding some significant indirect emission sources. Corporate Value Chain Standard was developed for this shortcoming to provide guidance for companies to prepare and report a greenhouse gas emissions inventory that includes indirect emissions resulting from value chain activities (i.e. scope 3 emissions). (WRI & WBCSD 2011, 4)

Corporate Value Chain standard divides scope 3 emissions into upstream and downstream emissions (figure 3). Upstream emissions mean indirect greenhouse gas emissions related to purchased or acquired goods and services (capital goods, fuel and energy-related activities, upstream transportation, waste management, business travelling, employee commuting, upstream leased assets). Downstream emissions are indirect greenhouse gas emissions related to sold goods and services (downstream transportation, processing, usage and end-life treatment of sold products, downstream leased assets, franchises, investments). In the Corporate Value Chain standard it is presented in detail how all these company’s upstream and downstream emissions should be taken into consideration when making a carbon footprint investigation. (WRI & WBCSD 2011, 31)

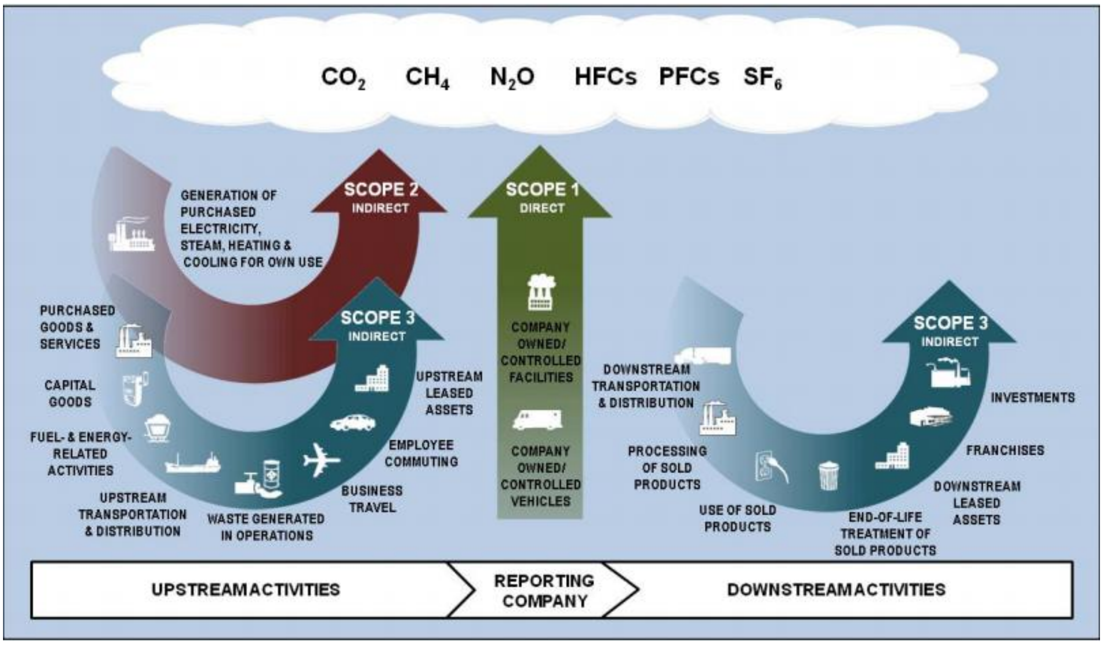

Figure 3. Different scopes and emissions from upstream and downstream activities according Corporate Value Chain standard. (WRI & WBCSD 2011, 31)

4.4 Carbon footprint calculation tool Y-HIILARI

When calculating the carbon footprint the most challenging part is to be able to gather representative and transparent data and to choose correct emission factors. There are several different kinds of carbon footprint calculation tools to help companies to make their own greenhouse gas inventories. (Kontiokorpi 2011, 58) Anniina Kontiokorpi developed one of these carbon footprint calculation tools in her Master's thesis. The name of the excel-based tool is Y-HIILARI and it imitates the emission inventory boundaries set by the Corporate Accounting and Reporting standard. (Website of Finnish Environment Institute 2013)

When using Y-HIILARI companies should have data on their heat and electricity consumption (how much heat/electricity is consumed in MWh/year and what kind of fuel is used to produce that energy), waste management (how many tons of waste is produced yearly and how many kilometers waste is transported), business travelling (how many kilometers company employees travel yearly by airplane/train/car etc.) and transportation (how many ton-kilometers company's products are transported yearly). All these data is fed into Y-HIILARI and tool calculates company's carbon footprint for that certain year. In the results Y-HIILARI presents emissions (in kg CO_2eq) from different sources separately and as a combined sum. (Webpage of Finnish Environment Institute 2013) The carbon footprint calculations of this research are partly done by using Y-HIILARI and partly by multiplying existing and edited emission data from company with suitable emission factors.

5 SATMATIC’S EMISSION SOURCES AND THEIR EMISSION FACTORS

5.1 Satmatic’s greenhouse gas emission sources and their scopes

From Satmatic’s business actions only the use of solar panels and air conditioning produces direct green house gas emissions. These direct emissions are considered to belong under the scope 1. Electricity and district heating Satmatic is using are purchased from the local energy company. Emissions from the electricity and district heating produced by the energy company and used by Satmatic are accounted as indirect greenhouse gas emissions and these emissions belong under scope 2. Scope 3 consists of greenhouse gas emissions from waste management and business travelling. Satmatic is also producing scope 3 emissions from transportation of their products but these emissions were leaved out of this calculation because transportation data was missing. These emissions are also indirect emissions. The scopes and emissions of Satmatic are presented in table 2.In the following chapters Satmatic’s emission sources are presented and the emission factor for each emission is estimated.

Table 2 Satmatic’s scopes and emission sources

Direct emissions	**Indirect emissions**	
SCOPE 1	**SCOPE 2**	**SCOPE 3**
-use of solar panels -use of air conditioning	-use of purchased electricity -use of purchased direct heating	-waste management -business travelling

5.2 Air conditioning

Hydrofluorocarbon emissions from the air conditioning sector originate from the leakages over the operational time of the equipment. These gases have 100-year global warming potentials, which are 140 to 11 700 times that of carbon dioxide, so their potential impact on climate change can be significant. Operation emissions for a given time period can be estimated by using the following information: AC equipment type in the facility, the number of AC equipments, original refrigerant charge in equipment (kg), the annual leakage from equipment of type (%) and the 100-year global warming potential of the refrigerant used in equipment. (WRI & WBCSD 2005) Satmatic is using air conditioning to cool down the factory hall and office building. Satmatic's air conditioning system is closed and regularly maintained system, so possible leakages are minor according Satmatic's personnel. According UNCPP (2000) the direct impact of refrigerant fluids on climate change is relatively small and this is why possible emissions caused by air conditioning are excluded from this investigation

5.3 Solar electricity

Photovoltaic modules enable the conversion of solar radiation to electricity by using solar cells. As the primary energy used is the solar radiation, this technology does not emit CO_2 to the atmosphere. When the life-cycle greenhouse gas emissions of use of photovoltaic cells is taken into consideration some emissions are formed. (Covenant of Mayors 2010, 19) In carbon footprint calculations only the emissions from operations are considered and in this case it means that producing solar electricity doesn't produce any greenhouse gas emissions.

On the roof of Satmatic's hall building there are 132 solar electricity panels. The solar system is grid-connected and its nominal power is 32,4 kW. In 2015 Satmatic's solar electricity system produced 22030 kWh. According GHG Protocol Guidance (WRI & WBCSD 2015, 35) emissions from electricity that comes from owned equipment and is consumed on-site can be considered as scope 1 emission. But in the case of grid-connected solar systems situation is usually such, that companies may consume some or all of the energy output from the PV panels, sell excess energy output back to the grid and purchase additional grid power to cover any remaining energy demand. In this kind of situation there should be measuring system so that the amount of on-site energy consumption from on-site system could be known. Satmatic didn't have this measuring system in use and so it was assumed that Satmatic is consuming all the energy that its solar electricity system is producing (nothing is sold back to the grid). This can be considered realistic assumption since the company is having several electricity consuming operations that need to be in operation at the same as PV panels are producing energy.

5.4 Heat consumption

The local distributor of district heating is energy company Pori Energia. In Pori Energia heat is produced in several heating plants and power plants (as combined heat and power). In Figure 4 the distribution of used fuels in heat production are presented. In Table 3 the emission factors for different fuels types are presented. Some of the fuels are considered to be carbon neutral biofuels (e.g. wood residuals) whose carbon dioxide emissions are not counted in the total emission amounts of greenhouse gases, nor are they taken into account in emissions trading but they should be still reported outside the scopes. This means that when calculating total emissions from biofuels only methane and nitrous oxide emissions are taken into account in calculations (Statistics Finland 2016). In addition of using different kind of fuels for producing the heat also waste heat from titanium oxide factory locating nearby power plants is utilized. For this waste heat emission factors were not available. Some of the heating plants also use electricity as the energy source and no emission factor for this electricity was determined since it is not considered a fuel. (Pori Energia 2016)

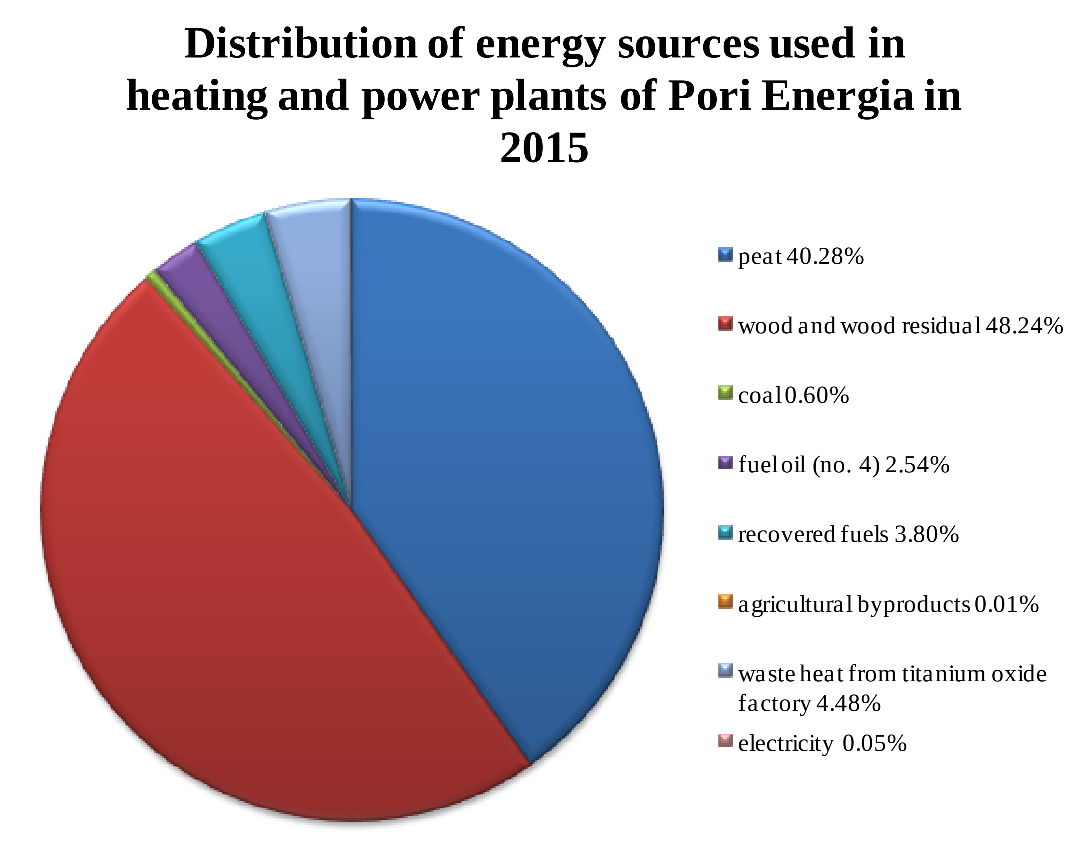

Figure 4. Distribution of energy sources (Pori Energia 2016).

Table 3. Emission factors of different energy sources used in heating plants and power plants of Pori Energia. **BIO**= considered as biofuel, n.a.= information not available. (The US Environmental Protection Agency 2014 & Statistics Finland. 2016)

Energy source	**CO_2-emissions (kg/MWh)**	**CH_4-emissions (kg/MWh)**	**N_2O-emissions (kg/MWh)**
peat	381.320	0.109	0.014
wood and wood residual **(BIO)**	319.812	0.025	0.012
coal	318.039	0.004	0.005
commercial heating oil	255.850	0.010	0.002
recovered fuels	114.480	0.109	0.014
agricultural byproducts **(BIO)**	402.902	0.109	0.014
waste heat from titanium oxide factory	n.a.	n.a.	n.a.
electricity	n.a.	n.a.	n.a.

5.5 Allocating greenhouse gas emissions from co-generation

In 2015 almost 96% of the district heating in Pori Energia was produced as co-generation. When heat and power are produced at the same plant the greenhouse gas emission from the plant should be allocated between these two energy forms. In benefit distribution -method emissions of co-generation of power and heat are allocated in relation to their alternative energy forms. Condensing power and heat only boilers are usually used as the alternative energy production methods. (Website of Motiva 2016) There are several calculation methods that enable to allocate emissions between the heat and power but in this research these calculations were not done since Pori Energia has already taken co-generation into account when estimating CO_2-emission factors for heat and electricity and announce that in 2015 CO_2-emission from heat production were 163 g CO_2 /kWh (Website of Pori Energia 2016).

5.6 Electricity consumption

Satmatic is purchasing also electricity from the energy company Pori Energia. In Pori Energia distribution of energy sources for electricity production in 2015 was following: fossil fuels and peat 33.5%, renewable fuels 30.7% and nuclear power 35.8%. About 44% of this electricity produced as co-generation. Pori Energia announce that in 2015 CO_2-emission from electricity production were 217.2 g CO_2 /kWh (Website of Pori Energia 2016) It is generally recommended that when calculating CO_2-emissions for purchased electricity both market-based and location-based emission factors are announced and compared (Website of Motiva 2016). Emission factors for electricity are presented in Table 4. Pori Energia does not announce methane or nitrous oxide emission factors and therefore location-based values were used for these emissions.

Table 4. Market-based and location-based emission factors for electricity production. (Website of Finland's Environmental Administration 2013; Website of Motiva 2016; Pori Energia 2016)

Emission factors for electricity	**CO_2-emissions (kg/MWh)**	**CH_4-emissions (kg/MWh)**	**N_2O-emissions (kg/MWh)**
Market-based (Pori Energia in 2015)	217.200	0.760	0.010
Location-based (average value in Finland in 2014)	209.000	0.760	0.010

5.7 Waste management

About 3 % of Finland's greenhouse gas emissions are caused by waste. This amount contains emissions from landfills, biodegradable waste composting and sewage sludge treatment. Additionally, transportation of waste and waste incineration generate also greenhouse gas emissions. (Dahlbo, Myllymaa, Manninen & Korhonen 2011, 2) Satmatic is producing mixed municipal solid waste, energy waste, wood waste, paper waste, hazardous waste and waste of electric and electronic equipments Most of the waste Satmatic is producing can be utilized by recovering materials and energy from the waste (for example through combined heat and power and ferrous metal recycling). Local waste management company distributed information about the amount of different waste components (in kg) produced by Satmatic and where these wastes were transported from Satmatic's headquarter in Ulvila. Distances (in km) between Satmatic's headquarter in Ulvila and the following waste treatment locations were estimated from the map.

Amount of greenhouse gas (CO_2-eq./ton of waste component) produced by the treatment of different waste components were taken from earlier research done in Helsinki metropolitan area by Finnish environment institute SYKE (Dahlbo, Myllymaa, Manninen & Korhonen 2011, Annex 1). These emission factors are presented in table 5.

Some companies may both generate waste that can be utilized as the energy source and consume energy that is generated by waste-to-energy processes. If a company purchases energy from the same facility that it sends its waste, it is probable that emissions from the incineration of the waste are double-counted (first in waste management, then in energy production). GHG Protocol recommends that in this kind of situations a company should only account for upstream emissions from purchased energy generated from waste in scope 2. (WR & WBCSD 2013a) Satmatic is purchasing district heating from the same company (Porin Energia) that it sends its waste. Porin Energia is producing energy by using recovered fuels and wood materials and because of this, the greenhouse gas emissions from incineration of energy and wood waste are not included to scope 3 (waste management) to avoid double counting of the emissions.

When calculating the emissions from waste transportation information from LIPASTO, a database for traffic exhaust emissions, by Technical Research Centre of Finland was used. It was assumed that waste components were transported by compression vehicle (volume 6 t) or by semitrailer (40 t). Wastes that were transported inside Satakunta area were transported by compression vehicle and wastes that were transported to further away were transported by semitrailer. Although the emissions from incineration of energy and wood waste are not taken into account when calculating total emissions from waste management, the transportation emissions of these waste fractions are still considered to the calculations.

5.7.1 Mixed municipal solid waste

Earlier mixed municipal solid waste was usually disposed off at landfill but in 2013 Finnish government set Decree on landfills (331/2013) that bans to landfill waste containing over 10% biodegradable materials. Mixed municipal solid waste was the second biggest waste component Satmatic was producing in 2015. Mixed municipal solid waste from Ulvila is transported to the incineration plant in Riihimäki.

5.7.2 Energy waste

Energy waste was the biggest waste component Satmatic was producing in 2015. Energy waste from Ulvila is transported to the power plant of Porin Energia located in Pori. The greenhouse gas emissions from incineration of energy waste are not included to carbon footprint calculations to avoid double counting of the emissions.

5.7.3 Wood waste

Wood waste was the fourth biggest waste component Satmatic was producing in 2015. Wood waste consists mostly of package materials. Wood waste from Ulvila is transported to the power plant of Porin Energia located in Pori. The greenhouse gas emissions from incineration of wood waste are not included to carbon footprint calculations to avoid double counting of the emissions.

5.7.4 Paper and carton waste

Paper and carton waste is the third biggest waste component Satmatic was producing in 2015. Local waste management company collects paper and carton waste to same bin and then transports this waste to Pori where there are facilities for separating these waste components from each other. Both paper and carton wastes are later on processed and recycled by paper mills. Satmatic is also producing paper documents that contain private information and they are treated so that information security is not threatened. This document waste is transported from Ulvila to Hämeenlinna where document waste is shredded and re-used.

5.7.5 Hazardous waste

Satmatic's activities don't exactly produce any hazardous waste apart from fluorescent tubes. These tubes are collected to the hazardous waste bin which is emptied by local waste management company. Usually hazardous waste is transported from Ulvila to Riihimäki where there are treatment facilities for hazardous waste. In 2015 hazardous waste bin was not emptied and therefore no greenhouse gas emission from treatment of hazardous waste was produced.

5.7.6 Waste of electric and electronic equipments (E-waste)

Satmatic is producing only small amount of e-waste annually and this e-waste consists mainly of old computers and monitors. Usually e-waste is transported from Ulvila to Pori where there is the first treatment point for e-waste waste. In 2015 e-waste bin was not emptied and therefore no greenhouse gas emission from treatment of e-waste was produced.

Table 5. Emission factors for different waste components. **ENERGY**=waste component is utilized for energy production in the same facility where the wastes are send. These values are reported here but not taken into consideration in calculations. (Dahlbo, Myllymaa, Manninen & Korhonen 2011, Annex 1)

waste component	**CO_2eq. kg/kg of treated waste**
mixed municipal solid waste	0.400
energy waste **(ENERGY)**	0.514
paper & carton waste *	0.550
document waste (paper) **	1.034
wood waste **(ENERGY)**	0.026
hazardous waste	1.395
e-waste	0.094

*amounts of paper and carton waste are not separated and therefore they are treated as one unit and average emission factor for paper and carton waste was calculated.

**document waste was treated as paper waste

5.8 Business travelling

Emissions from the transportation of employees for business-related activities in vehicles owned or operated by third parties are considered to scope 3 emissions. Also emissions from leased vehicles operated by the reporting company are scope 3 emissions. The emissions from business travel can be calculated by fuel-based, distance-based or spend-based method. If data on fuel use is unavailable, companies may use the distance-based method. The distance-based method involves multiplying activity data (for example vehicle-kilometres) by emission. Companies may also include emissions from business travellers staying in hotels for their calculations. (WRI & WBCSD 2013b)

Satmatic's engineers, technician and installers travel in Finland and to abroad for secondments. During 2015 there were flights between Helsinki and Poznan (Poland) and between Helsinki and Moscow (Russia). The secondments can last several months and that means several nights in the accommodations. Satmatic is not having any vehicles owned by the company but they are using leased vehicles for business travelling inside Finland.

To estimate emission factors from business travelling LIPASTO-database (by Technical Research Centre of Finland 2010) was used. The flights inside Finland were supposed to be done by propeller aircraft and flights to abroad by jet aircraft. The kilometres driven by passenger car or taxi were supposed to happen 65 % on the road and 35 % on the streets. Average emission factor (g CO_2-eq/person-km) between use of diesel and gasoline passenger car was calculated. Bus travelling was supposed to happen by city bus and train travelling by electric Intercity-train. Greenhouse gas emissions caused by staying overnight at hotel has been estimated in the research done by Seppälä et al. 2009 (Appendix 8). According Statistics Finland staying one night at the hotel in Finland cost 93,66 € in 2015. Website of Hotels.com made comparison between prices of the hotel night in Europe and stated that Finnish price for hotel night is at the average level in the Europe. Because of this it was decided that price of 94 €/one hotel night would be used in these calculations. Emission factors for business travelling are presented in table 6.

Table 6. Emission factors for travelling and accommodation (LIPASTO-database 2010; Seppälä et al. 2009)

Type of travelling	**CO_2 eq. (g/person-km)**
Flight in Finland, short distance*	190
Flight in Finland, long distance**	129
Flights to abroad, short distance*	271
Flights to abroad, long distance**	155
	CO_2 eq. (g/person-km)
Driving the passanger car***	104.5
Bus travelling	62
Train travelling	15
Taxi travelling***	104.5
Staying overnight at hotel	**CO_2eq. kg/€**
In Finland	0.5
In Europe	0.5

* less than 463 km
** more than 463 km
*** average emission factor between diesel and gasoline passenger car

6 RESULTS OF EMISSION CALCULATIONS

To be able to calculate Satmatic's annual greenhouse gas emissions an excel-based calculation tool was used. In this tool annual emission from different sources can be fed in to the tables and excel-tool calculates annual emissions. In this chapter the calculation methods and the results are presented. Calculation sheets and figures of the results are presented in Appendix 1.

6.1 Scope 1 emissions

Satmatic didn't have any scope 1 emissions in 2015. The emissions from air-conditioning were determined to be negligible because system is considered not to leak any HFC gases. Solar electricity system is not producing greenhouse gases during its operation.

6.2 Scope 2 emissions

The actions under scope 2 were the biggest emission source in Satmatic during 2015. Using of purchased heat and electricity produced about 130 500 kg CO_2 equivalents emissions which is about 70 % of the total emissions in 2015.

6.2.1 Heat consumption

When calculating the emissions from heat consumptions first the consumed heat energy for each fuel type was calculated. After that the amount of consumed heat (MWh) was multiplied with the emission factor of fuel type. To be able to calculate the amounts of carbon dioxide equivalent the Global Warming Potential for 100 years was used for methane (actual emissions x 25) and nitrous oxide (actual emissions x 298). In the case of biofuels (the wood and agricultural byproducts) the CO_2

emissions were not included to the scope 2 emissions but are reported separately. The results are presented in table 7.

Table 7. The results from emission calculations of the heat consumption. CO_2 emissions from biofuels (green text) are announced here but they are not included to the total emissions.

Heat consumption	**kg of GHG emissions**
CO_2 eq. emissions from heat consumption (excluding biofuels)	44 904.270
CO_2 emissions from heat consumption (only biofuels)	40 898.309
CH_4 and N_2O emissions from heat consumption (only biofuels)	4.712
Total emissions from heat consumption (excluding CO_2-emissions from biofuels)	**44 908.982**

6.2.2 Electricity consumption

When calculating the emissions from the electricity consumption the amount of consumed electricity (MWh) was multiplied with the emission factor. To be able to calculate the amounts of carbon dioxide equivalent the Global Warming Potential for 100 years was used for methane (actual emissions x 25) and nitrous oxide (actual emissions x 298). Market-based and location-based CO_2 eq. values were both calculated but only the market-based value was used in scope 2 calculations. The results are presented in table 8.

Table 8. The results from emission calculations of the electricity consumption.

Electricity consumption	**kg of GHG emissions**
Total emissions from market-based purchased electricity	**85 580.278**
Total emissions from location-based purchased electricity (reference value only)	82 646.261

6.3 Scope 3 emissions

The actions under scope 2 were the second biggest emission source in Satmatic during 2015. The waste management and business travelling produced about 50 000 kg CO_2 equivalents emissions which is about 30 % of the total emissions in 2015.

6.3.1 Waste management

When calculating the emissions from the waste management the amount of produced waste was multiplied with the emission factor of waste type. In the case of energy waste and wood waste, the emissions from the incineration of the waste fractions were leaved out of the total calculations to avoid double counting (emissions from waste incineration are already taken into account in scope 2 calculations: heat consumption).

In waste transportations calculations it was first investigated the amount of different waste fractions the garbage truck took at once. The amount of emptied waste fraction was multiplied with distance the garbage truck drove at once. This result tells ton-kilometers waste is travelling at once. After this ton-kilometers were multiplied with the emission factor of a certain vehicle type and then multiplied with the times the waste bins were emptied during the year. The final result tells the amount of emissions produced when transporting the wastes. The results of both calculations are presented in table 9.

Table 9. The results from emission calculations of waste management and transportation. The emissions from management of energy and wood waste are announced here (dark orange text) but they are not included into total emissions.

Waste component	**kg of GHG emissions from management**	**kg of GHG emissions from transportation**	
mixed municipal solid waste	1440	31.680	
energy waste **(ENERGY)**	2287.3	13.484	
paper & carton waste	1573	2.889	
document waste (paper)	260.568	2.107	
wood waste **(ENERGY)**	30.68	3.575	
hazardous waste	0.0	0.0	Sum of management and transportation
e-waste	0.0	0.0	
Sum	**3 273.568**	**53.734**	**3 327.302**

6.3.2 Business travelling

When calculating emissions from business travelling the travelled kilometers with different vehicle types are multiplied with the emission factors of the vehicle types (airplane, train, car etc.). When calculatingthe emissions from the accommodation the amount of spend hotel nights was multiplied with the average price of the hotel night and the with emission factor of the accommodation. The results are presented in table 10.

Table 10. The results from emission calculations of business travelling.

Travelling type	kg of GHG emissions
Flights to abroad, long distance	585.59
Driving the passanger car	18372.636
Staying overnight at hotel in Finland	19082.000
Staying overnight at hotel in Europe	8671.500
Sum	**46 711.726**

6.4 Total carbon footprint

In 2015 Satmatic produced about 180 500 kg of carbon dioxide equivalents. Most of the emissions were originated from the purchased electricity. In figure 5 amount of CO_2 equivalent emissions produced by different actions are presented.

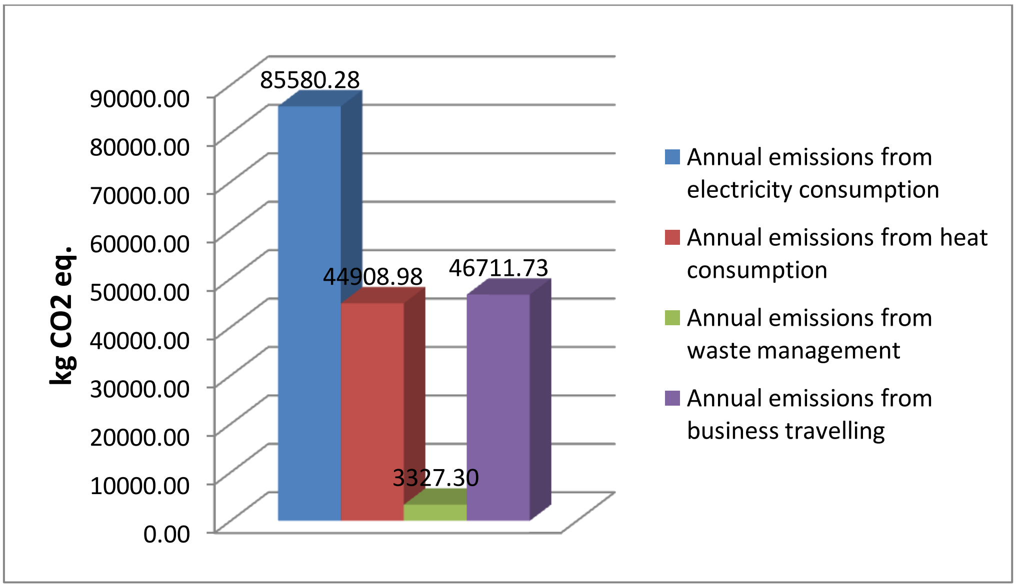

Figure 5. Amount of CO_2 equivalent emissions produced in Satmatic in 2015 by different actions.

7 CONCLUSIONS

7.1 Analyzing the results

Consuming the electricity causes most of the greenhouse gas emissions at Satmatic. In 2015 Satmatic used 357 807 kWh of purchased electricity and 22 030 kWh of solar electricity generated at Satmatic's own facility. The electricity purchased from the energy company Pori Energia is produced by using fossil fuels and peat (1/3), renewable fuels (1/3) and nuclear power (1/3) (Pori Energia 2016). Pori Energia is also selling electricity produced in wind power stations. If Satmatic would like to diminish the emissions from the electricity consumption it could change its electricity contract so that instead of purchasing "regular electricity" it could purchase wind or hydroelectricity.

The electricity produced by photovoltaic panels does not cause any greenhouse gas emissions but if Satmatic would not have these PV-panels, they would need to purchase this self-generated electricity from the local energy company. If this electricity generated in PV-panels in 2015 would have been purchased from Pori Energia it would have meant about 5 300 kg more CO_2 equivalent emissions.

Business travelling and accommodation caused the second biggest amount of emissions. It might be difficult for Satmatic to reduce the amount of business travelling because part of the work, like installation work, must be done on the spot and cannot be replaced with video meetings or with other ways that don't require travelling.

When calculating the emissions from heat consumption according the Corporate Standard CH_4 or N_2O emissions from biogenic energy sources use shall be reported in scope 2 but the amount of CO_2 produced from biofuel combustion shall be reported outside the scopes. The use of bioenergy is regarded to be carbon neutral action because CO_2 released to atmosphere in the burning of biogenic material is considered to bond back to the plants as a part of natural carbon cycle (Pingoud, Savolainen, Seppälä, Kanninen & Kilpeläinen 2013, 6). This calculation method affects clearly to the result of calculating the total emissions from heat consumption. If the CO_2-emissions from the biofuels would be included to calculations the amount of produced emissions would be almost doubled. A debate about carbon neutrality of biofuels is at the moment ongoing on European Union level because of the cultivation of energy plants requires more land which means that more land is cleared, thus releasing more carbon into the atmosphere (Website of European Parliament 2016). In Appendix 2 there is a figure that present how much burning of different fuel types produces emissions.

The waste management produced least greenhouse gas emissions from the sectors that were included to this calculation. The main reason for this is the Corporate Standard calculation method that advices to exclude the emissions from waste incineration from the total carbon footprint if the company is buying energy from the same facility it sends its wastes.

Some of the waste managing emissions could be avoided by recycling or recovering materials for energy production. When a material is recycled, it is used in place of virgin inputs in the manufacturing process, rather than being disposed. (Dahlbo, Myllymaa, Manninen & Korhonen 2011, Annex 1) According GHG protocol any claims of avoided emissions associated with recycling or recovering should not be included in the scope 3 inventory, but may instead be reported separately. Companies that report avoided emissions should also provide data proves that emissions were really avoided. (WR & WBCSD 2013a) In this report these negative avoided emissions were not reported because of missing recycling and recovering facts and figures.

7.2 Analyzing the methods

When a company is interested in to investigate the greenhouse gas emissions caused by their business actions they usually start by deciding when they will start collecting the emission data. Typically some certain year is chosen (as a baseline year) and it is decided what kind of information is collected and how data will be handled. (WRI & WBCSD 2004) In the case of Satmatic no upfront preparation was done because it was decided that carbon footprint investigation could be start immediately instead of waiting one year by collecting the data.

The most of the needed data was easily available because Satmatic has kept up bookkeeping about their annual energy consumption and waste production. Some of the emissions data needed to be asked from the companies Satmatic is buying services (like waste management services). Some data, like data from air-conditioning, was completely unavailable and the impact of these actions could be only estimated. Even thought the collecting of emission data throughout the year requires efforts and punctuality it is usually worth of it because this way it is easy to estimate the company's carbon footprint in the end of the year and missing data does not need to be looked for.

Finding the reliable emission factors is challenging. Usually source- or facility specific emission factors are preferred over the more generic or general emission factors (WRI & WBCSD 2011). But since all companies don't calculate and announce their greenhouse gas emissions and generic emission factors are needed to be used, it is crucial to be able to find that kind of emission factors that are calculated in the situations that resemble enough the real situations. For example some actions, like waste management, differ between countries and that is why it is important to prioritize emission factors calculated in homeland over foreign values.

When calculating the total greenhouse gas emissions for the certain company it is sometimes difficult to determine whether some action causes emissions for the reporting company or to someone else (like to customer). For example downstream transportation causes emissions for the reporting company only if the reporting company pays for transportation. Otherwise downstream transportation causes scope 1 and scope 2 emissions for transportation companies, distribution companies and retailers. (WRI & WBCSD 2011) Because of this the reporting company should be clearly aware of all the actions it is paying for.

7.3 Conclusions

When determining the carbon footprint for the certain company for the first time it is demanding and takes time. But after the calculation methods are decided and reliable emissions factors are found, the annual carbon footprint calculation gets easier in the following years. The first baseline study gives to company valuable information about the greatest emissions sources in their actions and helps to make plans for the possible emission reduction operations. In the following years the comparison of the calculation results tells whether these emission reduction operations have worked and what would be the next step in reducing of greenhouse gas emissions.

In Satmatic most of the emissions in 2015 are caused by electricity consumption. These emissions can be reduced by changing the normal electricity contract to contract in which most of the electricity is produced by renewable energy sources. Everyday use of electricity can be also examined and consider if there are some practices that waste electricity (like machines that are always on) and need optimization. Satmatic is already having a large solar electricity system that helps them to reduce greenhouse gas emissions every day and if the solar electricity system will grow even larger in forthcoming years it will increase the deal of emission-free electricity Satmatic is using.

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APPENDIX 1. EMISSION CALCULATIONS

In the following tables the calculations and results are presented to each emission source. The annual amount (in kg) of produced CO_2 equivalent is in bold with turquoise background in each table.

Table 1. CO_2 equivalent emissions produced from consumption of solar electricity.

Solar electricity			
SCOPE 1			
Consumed electricity (MWh/year)	**CO_2eq. (kg/MWh)** [3]	**Produced CO_2eq. (kg)**	
22.03	0	**0.000**	

Table 2. CO_2 equivalent emissions produced from consumption of heat.

HEAT CONSUMPTION				**GWP 100 years**							
SCOPE 2				**25**	**298**						
	Distribution of energy sources	**Consumed heat energy by energy source (MWh/year)**	**CO_2 (kg/MWh)**	**CH_4 (kg/MWh)**	**N_2O (kg/MWh)**	**CO_2eq. (kg/MWh)**	**Produced CO2 (kg)**	**Produced CH4 (kg)**	**Produced N_2O (kg)**	**Produced CO_2eq. (kg)**	
peat	40.28	106.728	381.320	0.109	0.014	388.315	40697.496	11.644	1.528	41444.054	
wood and wood residual **(BIO)**	48.24	127.833	319.812	0.025	0.012	324.084	40882.382	3.138	1.569	41428.411	
coal	0.60	1.581	318.039	0.004	0.005	319.759	502.870	0.006	0.009	505.588	
commercial heating oil	2.54	6.740	255.850	0.010	0.002	256.715	1724.344	0.069	0.014	1730.176	
recovered fuels	3.80	10.080	114.480	0.109	0.014	121.475	1153.943	1.100	0.144	1224.452	
agricultural byproducts **(BIO)**	0.01	0.040	402.902	0.109	0.014	409.897	15.926	0.004	0.001	16.203	
waste heat from titanium oxide factory	4.48	11.859	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
electricity	0.05	0.121	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
total	**100%**	**264.98**	**MWh**				44078.654	15.962	3.265	44904.270	a)
							40898.309	b)		41444.613	c)
										4.712	d)
										44908.982	**e)**

a) CO2 eq. emissions from heat consumption (excluding biofuels)

b) CO2 emissions from heat consumption (only biofuels)

c) CO2 eq. emissions from heat consumption (only biofuels)

d) CH4 and N2O emissions from heat consumption (only biofuels)

e) Total emissions from heat consumption (excluding CO2-emissions from biofuels)

Table 3. CO_2 equivalent emissions produced from consumption of electricity. Market-based is used in calculations. Location-based is for comparison.

Market-based		**GWP 100 years**						
purchased electricity SCOPE 2		**25**	**298**					
Consumed electricity (MWh/year)	**CO_2 (kg/MWh)**	**CH_4 (kg/MWh)**	**N_2O (kg/MWh)**	**CO_2ekv (kg/MWh)**	**Produced CO2 (kg)**	**Produced CH4 (kg)**	**Produced N_2O (kg)**	**Produced CO_2eq. (kg)**
357.807	217.2	0.76	0.01	239.18	**77715.680**	**271.933**	**3.578**	**85580.278**
Location-based		**GWP 100 years**						
purchased electricity SCOPE 2		**25**	**298**					
Consumed electricity (MWh/year)	**CO_2 (kg/MWh)**	**CH_4 (kg/MWh)**	**N_2O (kg/MWh)**	**CO_2ekv (kg/MWh)**	**Produced CO2 (kg)**	**Produced CH4 (kg)**	**Produced N_2O (kg)**	**Produced CO_2eq. (kg)**
357.807	209	0.76	0.01	230.98	**74781.663**	**271.933**	**3.578**	**82646.261**

Table 4. CO_2 equivalent emissions produced from waste management. The emissions from management of energy and wood waste are announced here (**dark orange text**) but they are not included into total emissions.

WASTE MANAGEMENT			
SCOPE 3			
waste component	**CO_2eq. (kg/kg of treated waste)**	**Amount of produced waste in kg**	**Produced CO_2eq. (kg)**
mixed municipal solid waste	0.400	3600	1440
energy waste **(ENERGY)**	0.514	4450	2287.3
paper & carton waste	0.550	2860	1573
document waste (paper)	1.034	252	260.568
wood waste **(ENERGY)**	0.026	1180	30.68
hazardous waste	1.395	0	0
e-waste	0.094	0	0
			3273.568

Table 5. CO_2 equivalent emissions produced from waste transportation.

WASTE TRANSPORTATION								
SCOPE 3								
waste component	**Amount of waste produced (tons) in year 2015**	**Times of waste bin emptyed in year**	**Amount of waste emptied at time (tons)**	**Distance waste is transported at time (km)**	**ton-km**	**Waste transportation vehicle**	**CO_2 eq. (kg/tkm)**	**Produced CO_2eq. (kg) in year**
mixed municipal solid waste	3.600	53	0.068	200	13.585	semitrailer	0.044	31.680
energy waste	4.450	53	0.084	30	2.519	compression vehicle	0.101	13.484
paper & carton waste	2.860	1	2.860	10	28.600	compression vehicle	0.101	2.889
document waste (paper)	0.252	1	0.252	190	47.880	semitrailer	0.044	2.107
wood waste	1.180	1	1.180	30	35.400	compression vehicle	0.101	3.575
hazardous waste	0	0	0.000	0	0.000	compression vehicle	0.101	0.000
e-waste	0	0	0.000	0	0.000	compression vehicle	0.101	0.000
								53.734

Table 6. Total CO_2 equivalent emissions produced from waste management and transportation.

Total CO_2 eq. emissions (kg) from waste management and tranportation
3327.302

Table 7. Total CO_2 equivalent emissions produced from business travelling and accommodations.

BUSINESS TRAVELLING				
SCOPE 3				
Type of travelling	**Flight kilometers**	**CO_2 eq. (g/hkm)**	**CO_2 eq. (g)**	**CO_2 eq. (kg)**
Flight in Finland, short distance*		190		
Flight in Finland, long distance**		129		
Flights to abroad, short distance*		271		
Flights to abroad, long distance**	3778	155	585590	585.590
				585.590
	Driven kilometers	**CO_2 eq. (g/hkm)**	**CO_2 eq. (g)**	**CO_2 eq. (kg)**
Driving the passanger car***	175814.7	104.5	18372636.15	18372.636
Bus travelling		62		
Train travelling		15		
Taxi travelling***		104.5		
				18372.636
Staying overnight at hotel	**Nights**	**€/night**	**CO_2 eq. kg/€**	**CO_2 eq. (kg)**
In Finland	406	94	0.5	19082.000
In Europe	184.5	94	0.5	8671.500
				27753.500
total				**46711.726**

* less than 463 km

** more than 463 km

*** average emission factor between diesel and gasoline passenger car

Table 8. Amounts of CO_2 equivalent emissions produced in Satmatic in 2015 by different actions.

Actions causing greenhouse gas emissions	**kg CO_2 eq.**		**distribution 100%**
Annual emissions from electricity consumption	85580.28	**kg CO_2 eq.**	47.405
Annual emissions from heat consumption	44908.98	**kg CO_2 eq.**	24.876
Annual emissions from waste management	3327.30	**kg CO_2 eq.**	1.843
Annual emissions from business travelling	46711.73	**kg CO_2 eq.**	25.875
Total carbon footprint in 2015	**180528.29**	**kg CO_2 eq.**	
	180.5	**tons CO_2 eq.**	

Figure 1.Distribution of greenhouse gas emissions in Satmatic in 2015 between different actions.

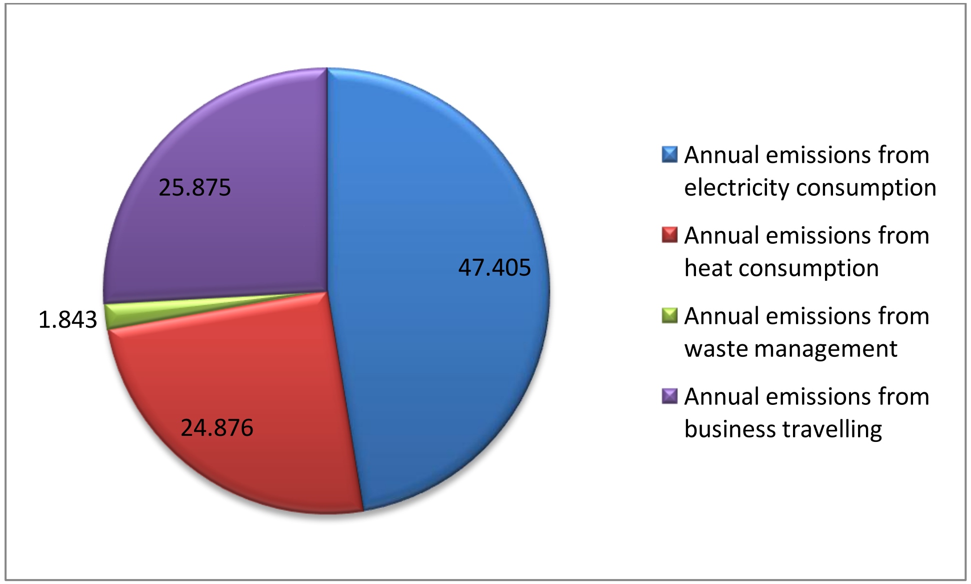

Table 9. Distribution of greenhouse gas emissions in Satmatic in 2015 between different scopes.

The distribution of greenhouse gas emission between different scopes			
scope	**content**	**kg CO_2 eq.**	**distribution 100%**
SCOPE 1	direct emissions from sources that are owned or controlled by the company	0.00	0.00
SCOPE 2	indirect emissions from the generation of purchased energy consumed by the company	130489.26	72.28
SCOPE 3	company's all other indirect greenhouse emissions	50039.03	27.72

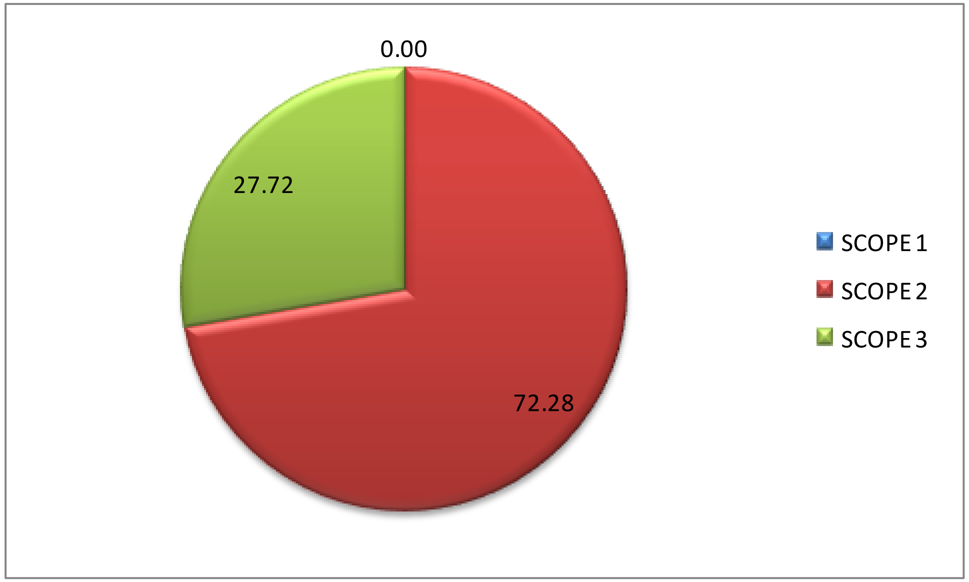

Figure 2. Distribution of greenhouse gas emissions in Satmatic in 2015 between different scopes.

APPENDIX 2. EMISSIONS FROM BURNING OF DIFFERENT FUEL TYPES

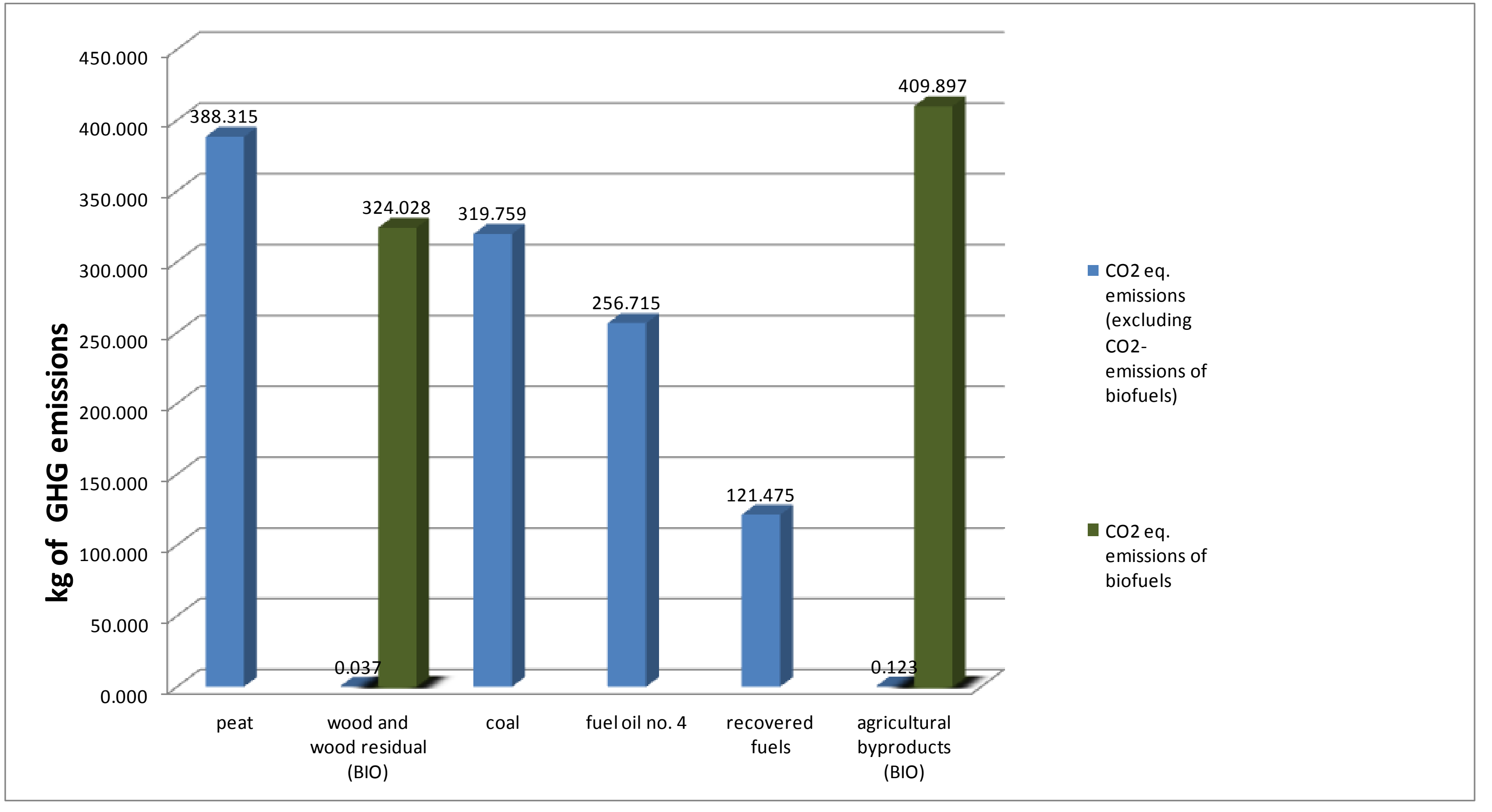

Figure 1. Emissions formed from burning of different fuel types (kg/MWh) used in heat production in Pori Energia. In the case of biofuels CO_2-emissions and other emissions (CH_4, N_2O) are presented in separate