Open University Cyprus

Faculty of pure and applied sciences

Sustainable Energy Systems

Master Thesis

Reducing the ecological and the energy footprint in a company through redesigning the energy resource (renewable energy sources), eco-design (green buildings for energy saving) and improvement of production/commercial processes to reduce energy consumption and waste

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Supervisor

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fulfilment of the requirements for the postgraduate degree
In Sustainable Energy Systems
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ABSTRACT

Over the last decades, in both global and pan-European levels, there has been an unprecedented increase in the interest regarding the unwanted greenhouse gas emissions due to their harmful nature. Energy has always been an indispensable commodity for humanity, but the face of the energy field is changing drastically through the decades. The modern lifestyle leads to increased energy consumption, which is tending growing up year after year. This has been translated into innovative changes in the field of energy demand management, building eco-design, renewable energy sources best integration and improvement of production/commercial processes with ulterior motive a better environmental and energy footprint. The following Master Thesis was conducted with the purpose to investigate the ecological and the energy profile as a natural follow-up of a company operating in North Germany. For a better and in-depth research process, the qualitative approach has been selected, and related data were collected from this type of company. More specifically, this research was based on policies, practices and common accepted strategies to ensure the enhancement of business profile. The survey findings revealed that the initial expectations of discovering energy leakages and improvement opportunities in the company were true and as a result, have sparked off new ideas and possible actions. For that reason, three distinct scenarios were analysed, each offering at a different level an upgrade of environmental (less CO2 pollution), financial (corporate income increase) and energy (lower electrical and thermal needs) profile of the enterprise. The value of this study lies in the fact that our research results contribute to the knowledge of the people associated with energy consumption management and, in addition, is optative to be useful either to small or large scale users or other researchers.

Keywords: Carbon dioxide, Sustainable Consumption & Production, Greenhouse Gas, Renewable Energy Sources, Energy Management System, Cost Benefits Analysis, United Nations Framework Convention on Climate Change, Energy Performance, Eco-design, Carbon footprint, Energy consumption, Energy Policies, Waste treatment, Raw material.

ΠΕΡΙΛΗΨΗ

Τις τελευταίες δεκαετίες, τόσο σε παγκόσμιο όσο και σε πανευρωπαϊκό επίπεδο, υπήρξε μια άνευ προηγουμένου αύξηση του ενδιαφέροντος για τις εκπομπές αερίων του θερμοκηπίου λόγω της βλαβερής τους φύσης. Η ενέργεια ήταν ανέκαθεν απαραίτητο αγαθό για την ανθρωπότητα, αλλά το πρόσωπο του ενεργειακού πεδίου αλλάζει δραστικά από τη μία δεκαετία στην άλλη. Ο σύγχρονος τρόπος ζωής οδηγεί σε αυξημένη κατανάλωση ενέργειας, η οποία τείνει να μεγαλώνει χρόνο με το χρόνο. Αυτό έχει μεταφραστεί σε καινοτόμες αλλαγές στον τομέα της διαχείρισης ενέργειας, του οικολογικού σχεδιασμού κτιρίων, την ενσωμάτωση των ανανεώσιμων πηγών ενέργειας και της βελτίωσης των παραγωγικών/εμπορικών διαδικασιών με πρωταρχικό κίνητρο ένα καλύτερο περιβαλλοντικό και ενεργειακό αποτύπωμα. Η ακόλουθη μεταπτυχιακή εργασία πραγματοποιήθηκε με σκοπό τη διερεύνηση του οικολογικού προφίλ και ως φυσικό επακόλουθω την παρακολούθηση τών ενεργειακών χαρακτηριστικών μιας εταιρείας που δραστηριοποιείται στη Βόρεια Γερμανία. Για μια καλύτερη και σε βάθος ερευνητική διαδικασία, επιλέχθηκε η ποιοτική προσέγγιση και συλλέχθηκαν σχετικά δεδομένα από την παραπάνω εταιρεία. Πιο συγκεκριμένα, αυτή η έρευνα βασίστηκε σε πολιτικές, πρακτικές και κοινές αποδεκτές στρατηγικές για τη διασφάλιση της βελτίωσης του εταιρικού προφίλ. Τα ευρήματα της έρευνας αποκάλυψαν ότι οι αρχικές προσδοκίες για εύρεση διαρροών ενέργειας και ευκαιριών βελτίωσης στην εταιρεία ήταν αληθινές και είχαν ώς αποτελέσμα την προκλήση νέων ιδεών και πιθανών δράσεων. Για το λόγο αυτό, τρία διαφορετικά σενάρια αναλύθηκαν με το καθένα να προσφέρει σε διαφορετικό επίπεδο αναβάθμιση τών περιβαλλοντικών (λιγότερη ρύπανση CO2), οικονομικών (αύξηση εταιρικού εισοδήματος) και ενεργειακών (χαμηλότερες ηλεκτρικές και θερμικές ανάγκες) χαρακτηριστικών της επιχείρησης. Η όποια αξία αυτής της μελέτης έγκειται στο γεγονός ότι τα ερευνητικά μας αποτελέσματα συμβάλλουν στη γνώση των ατόμων που σχετίζονται με τη διαχείριση και κατανάλωση ενέργειας και, επιπλέον, ευελπιστούμε να είναι ωφέλιμη είτε σε χρήστες μικρής ή μεγάλης κλίμακας είτε σε άλλους ερευνητές.

Λέξεις-κλειδιά: Διοξείδιο του άνθρακα, βιώσιμη κατανάλωση και παραγωγή, αέριο θερμοκηπίου, ανανεώσιμες πηγές ενέργειας, σύστημα διαχείρισης ενέργειας, ανάλυση οφέλους κόστους, σύμβαση πλαίσιο των Ηνωμένων Εθνών για την αλλαγή του κλίματος, ενεργειακή απόδοση, οικολογικός σχεδιασμός, αποτύπωμα άνθρακα, κατανάλωση ενέργειας, ενεργειακές πολιτικές, απόβλητα επεξεργασία, πρώτη ύλη.

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Targatzakis Spyridon

May, 2020

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ACRONYMS AND ABBREVIATIONS

BAT: Best Available Technology

CBA: Cost Benefits Analysis

CO_2: Carbon dioxide

COP: Conferences of the Parties

EEG: Erneurbaren Energie Gesetz (Renewable Energy Law)

EnMS: Energy Management System

EnPIs: Energy Performance Indicators

EPC: Energy Performance Certificate

ETS: Emission Trading System

EU: European Union

GDP: Gross Domestic Product

GHG: Greenhouse Gas

Gt: Gigatonnes

IPCC: Intergovernmental Panel on Climate Change

IRR: Internal Rate of Return

ISO: International Organization for Standardization

kg: Kilogram

kWh: Kilowatt-hour

LCOE: Levelized Cost of Electricity

LED: Light Emitting Diode

mcf: Mega Cubic Feet

mmBtu: Million British Thermal Units

Mtoe: Millions of Tonnes of Oil Equivalent

NDCs: National Determined Contributions

NECPs: National Climate and Energy Plans

NPV: Net Present Value

OECD: Organisation for Economic Cooperation and Development

O&M: Operation and Maintenance Cost

PDCA: Plan-Do-Check-Act

PV: Photovoltaic

RES: Renewable Energy Sources

SCP: Sustainable Consumption & Production

SDGS: Sustainable Development goals

SDS: Sustainable Development Scenario

UNFCCC: United Nations Framework Convention on Climate Change

UPS: Uninterruptible one Power Supply

USD: United States Dollar

VAT: Value Added Tax

INTRODUCTION

The contemporary energy and carbon footprint topic is nowadays taking on an international dimension through awareness of the global warming as a commonly accepted issue. As stated by an adequate number of institutions and ordinary peoples, solutions and new ways of dealing are needed on a global level, which, will not be based on temporary and emergency measures. Every one of us individually, but also as a whole pitch in but in a negative way to raise the amount of unwanted gases causing a chain reaction that after a point, would not be controllable anymore. This way, speaking about terms like the carbon footprint is anticipated an alleviation of bad human habits in favour of the environment and a long term environmental stability. Many countries around the world are pursuing energy independence through the usage of renewable energy or by improving the energy consumption methods to save money and achieve energy autonomy. In this way, focusing the worldwide concerns with respect to these and different issues on the financial, innovative, institutional and ecological circles has provoked a rapid spread ranging from technologies and methods till public promotion about the environmental impact and the overall energy mix with and without energy efficiency, all over the world. Continuously pollution, the rapid climate change and the energy supplies still poses enormous challenges among the nations, requiring major changes in the energy behaviour and of course politics globally.

The idea, which will try to build on below is a part of a general system working hard to detect sources of energy leakage in any possible form (electricity, thermal, motion etc.) in order to optimize or harness them differently. In simple words, the energy production companies worldwide are ready to shuffle off the traditional energy sources and production methods, starting a new era that links the energy demand with trustworthy high energy efficiency procedures, products and in a broader sense human behaviour. Therefore, the main target that draws our attention is basically the operational qualification of the industrial sector, which happens to feature a plethora of opportunities, if a company or an industrial plant examined in depth. For that cause, various laws and regulations have promoted by governments to ensure the stimulation and commercialization of renewable energy sources, energy efficiency and a

number of techniques in order to deal with problems such as the climate change, the unwanted CO_2 emissions and the depleted fossil fuels. Speaking about primary objectives, through the project will be touched the ecological and energy footprint in a specific type of company (manufacturing and service business) and amend positively the energy and environmental flaws, that almost every corporation cannot easily track down and as a natural consequence have not been yet upgraded. This way, hoping to designate appoint all the possible energy leakage and as a next step, some commonly accepted practices appertain to the redesign of the energy resource use, the eco-design and renewable energy sources sector will be proposed to achieve a more environmentally friendly company profile.
All this can be realized by carefully analyze the following basic research questions that serve our primary cause and namely are:

- How do the energy use and carbon footprint affect public opinion and what will be their impact on the competitive world in the near future?
- How much is the energy and carbon leakage of specific potential and scale business?
- Where and in which way this kind of negative leakage can be spotted?
- How the under investigation company should manage the findings in order to become more sustainable? What actions can improve the production/commercial processes to achieve the goal of reduced energy consumptions and waste?
- How should the available techniques and innovative ideas in the field of renewable energy sources and green buildings design be combined so that a better result can be achieved?
- What would be the economic, technical and ecological impact of the best case scenario, where all the proposed solutions are implemented?

Consequently the study consists of three essential parts. The first one describes the theoretical framework and is divided into three sub-chapters. More specifically, the first chapter deals with the global review of the increased energy consumption and the international market trend to disengage from old environmental unfriendly habits and trace a new energy plan toward sustainability. Then the definition of the term "*ecological and energy footprint*" will conceptually clarified and a further association with methods to cope with this problem (in case of negative footprint) is going to be tried. Chapter two presents the policies and practices for the modernization and decarbonization of the industrial sector, with particular regard to the EU countries, and the role of the authorities and the company itself to achieve the desired goals. In addition, an allusion to methods target to abolish these energy intensive practices will concern us too. The third chapter discusses the importance of better energy efficiency from the economical and from the social/environmental point of view. Indicate the difficulties might be faced because of the employees, the business unwillingness or even the climatic conditions that sometimes hold back these processes and similar nature topics.

In the second part, the theoretical part goes behind the curtain and a practical example goes in front and highlights the importance -necessity of my research. An empirical study requires several data to be collected and rightly presented. This data will lead to a part of tables and diagrams and a cost-benefits analysis to certify the financial viability of this kind of plan-investment.

The final or third section, followed by the presentation of the results, summarizes all the findings together with the associated theory and the central idea willing to give prominence to. Finally, some suggestions for further research are meant to be presented.

Undoubtedly, the theoretical analysis of the topic will point out its importance. Still, in order delving deeper into the under examination issue, all the research questions would be touched one by one. After putting into effect, a relevant case study in a real life example, the significance of this study could be easier proved and directly contributed, even in the smallest degree, to a specific part of the scientific or corporate world and indirectly to the society and the environment.

The rhetorical question "*Why should we even bother?*" answer is that redesigning the energy resource use, eco-design and improvement of production/commercial processes to reduce energy consumption and waste, rewarding all possible aspects of sustainable development that targeting sustainability without depletion of valuable natural resources and strengthen sustainable competitiveness with stress on the next presented: • Economic growth • Social cohesion • Employment • Competitive power in international competition • Using resources in an efficient and sustainable way • Minimizing negative environmental impacts (Vanags & Butane, 2013).

PART A: THEORETICAL BACKGROUND – LITERATURE REVIEW

1. CHAPTER: INTRODUCTION TO THE SUBJECT OF ENERGY EFFICIENT USE IN RELATION TO THE CARBON FOOTPRINT

1.1. DEFINITION OF CARBON FOOTPRINT

An appropriate definition of carbon footprint is that the total amount of greenhouse gases produced to directly and indirectly, support human activities usually expressed in equivalent tons of carbon dioxide (CO_2). The carbon footprint of a single person is the sum of all emissions of CO_2 (carbon dioxide), which was induced by his/her activities in a given time frame. Typically, a carbon footprint is calculated for the period of a calendar year (Time for Change, n.d.).

The distinguishing of domestic carbon footprint is more clear in the next figure (Figure 01), where a usual breakdown of domestic footprint by origin is given. When it comes to domestic carbon footprint and as indicated by the figure above (Figure 01), it is synthesized by the consumption, including clothing, footwear, and household and personal goods, all of which accounts for a significant amount of an individual carbon footprint because these thinks have associated emissions from gathering materials, production, and transport. Besides that, is important to be familiar with the carbon footprint that transportation activities like simply driving polluting cars could contribute negative too. Conscious (consumers, citizens) for this type of activities could wisely choose group transportation alternatives such as trains or buses. They definitely pollute with less CO_2 per person, but still, have emissions that are associated with them.

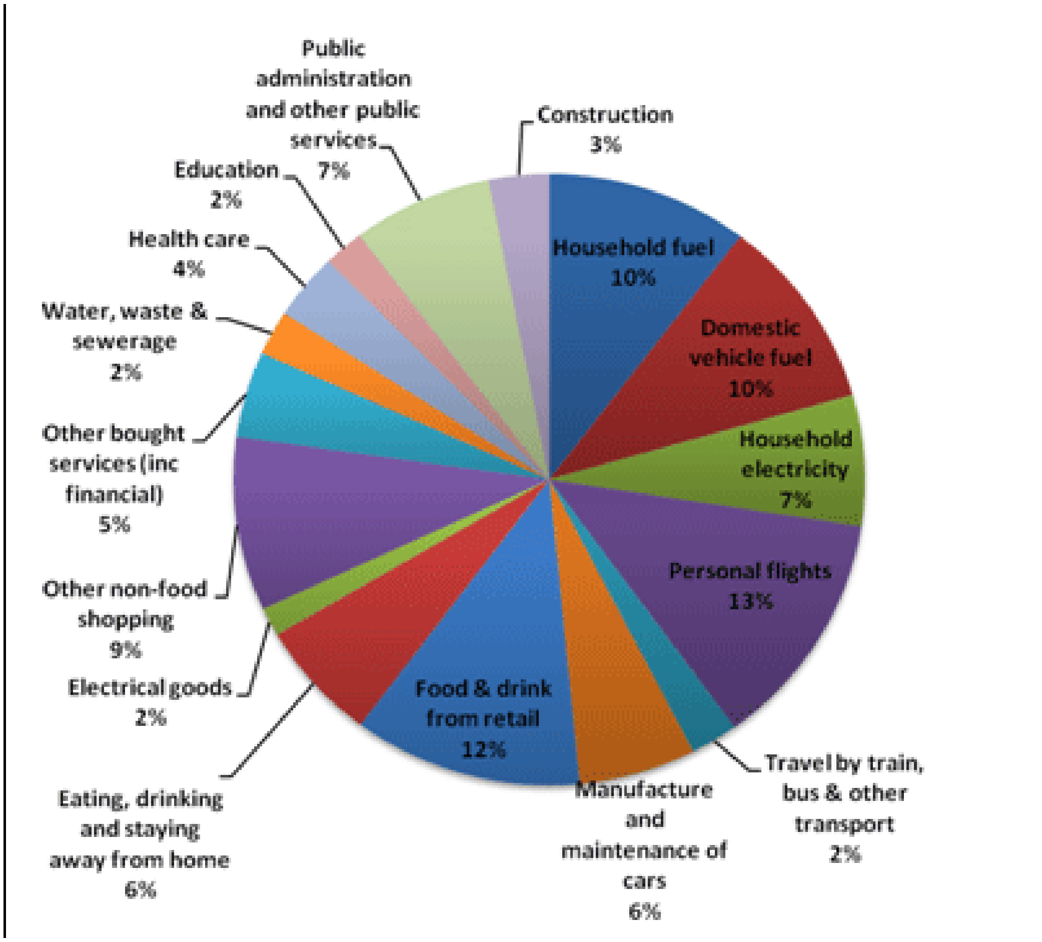

Figure 01: Breakdown of a typical domestic carbon footprint by origin (Parliament, 2011)

Likewise, industrial or public sector exhibits the exact same pollutant factors because they are a partially human-centered design. In the same time are responsible for other polluting actions calling for improvements and are going to be investigated below as the study unfolds. Identically, the ecological footprint is a method calculating the impact of a person or community or a corporation on the environment, expressed as the amount of land required to sustain their use of natural resources (Lim, 2018).

The ecological footprint is one way of measuring sustainability, which refers to the ability of a population to support itself in the present without compromising that ability for the future and like the carbon footprint is a way of asses the environmental impact. Noticeably, the carbon footprint is currently the most rapidly growing component blamed for over 60% of humanity's overall Ecological Footprint and for this reason, many research or ground-breaking technical ideas consider as a comparable unit of measurement the CO2 emissions (Lim, 2018).

This negative correlation between the required energy use and land is well displayed in the figure 02. The figure 02 prove the steady increase of land required (measured in Number of Earth or very often in global hectares per person), which at the end of the 60s was more than one planet and at the end of 2016 was calculated little more than 1.7 planets. Unquestionably, the carbon and all related actions are responsible for the biggest share approaching alone one planet land need (Global Footprint Network, 2020).

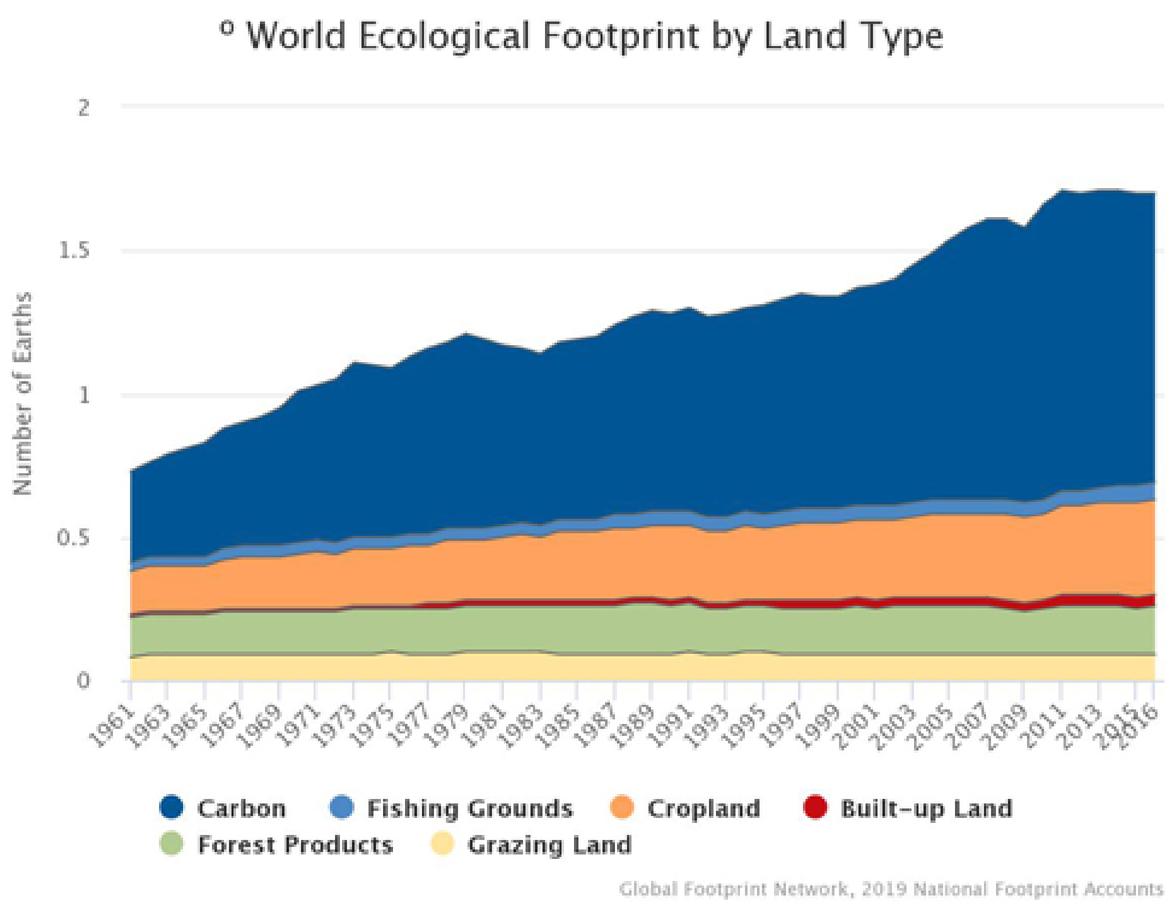

Figure 02: World ecological footprint by land type (Global Footprint Network, 2019)

1.2. WHY THE CALCULATION OF CARBON FOOTPRINT DEEMED TO BE IMPORTANT

The answer to this question is self-answered if light is going to be shed on the term "*Climate Change*". The issue Climate Change, also known as Global Warming, is the name given to long term changes to temperature in and around the earth's surface, which causes long term shifts to weather patterns. In line with the experts opinion, impacts the whole earth and is not limited to only one or two areas. This phenomenon has led to the melting of polar ice sheets and glaciers resulting to a rise in sea levels. Furthermore, extreme weather events like typhoons and hurricanes are becoming more common in some zones of the world, while other areas suffer more punishing droughts and heat waves (Carbon Footprint, n.d.).

Coupled with the climate change the carbon footprint is considered to be a very powerful tool to comprehend the impact of personal behaviour on global warming. The majority of people see the amount of CO_2 produced by their activities and they personally are willing tom make steps against global warming and sensitize the other lack of awareness. This is why the calculation and constant monitoring of personal or bigger scale carbon footprint at any event essential (Afework, Hanania, Stenhouse & Donev, 2018).

Estimation of the carbon footprint in land area does not infer that carbon sequestration is the sole answer to the carbon dilemma. It just indicates how much required biocapacity dealing with untreated carbon waste and preventing a systematic carbon build-up in the atmosphere. Mostly, this approach mobilizes people to handle the climate change challenge in a holistic way. The burden remains unshifted to one natural system (directly confronted), never affecting the other. Actually, the atmospheric pollution problem emerges because the planet does not have enough biocapacity to withstand and to neutralize all the carbon dioxide (Global Footprint Network, 2019).

1.3. GLOBAL REVIEW OF ENERGY CONSUMPTION AND INTERNATIONAL MARKET TRENDS

As the climate crisis escalates more and more human getting worried about it and trying to cut down as far as possible, their ecological footprint going after different bad habits according to their lifestyle. For instance, some proposals of a famous daily newspaper like "*The Guardian*" include:

- Less air travels for frequent flyers (aviation sector is a large carbon footprint emitter)
- Less beef and lamb meat consuming
- Space heating due to bad insulation
- Replace of old gas and oil boilers and similar infrastructures
- Reduce car mileage per year and use an electric vehicle
- Replace lighting bulbs and upgrade the lighting system
- High efficiency electrical appliances
- Invest in renewable energy
- Buy gas and electricity from retailers who sell renewable power
- Pick over companies supporting low carbon future

(Goodall, 2017)

Behind the words of an international leverage newspaper can someone glean that the community and consumer sentiment slowly change and in a few years the green profile of an enterprise will not be anymore an optional but to the contrary will be a prerequisite.

An "archenemy" of the environment is the anthropogenic CO2 emissions result from burning fossil fuels because of energy production and fuel consumption. Most widespread in areas like the below given:

- Electricity production
- Industrial sector

- Transportation
- Agricultural sector
- In the residential sector

(Ntanos, et al., 2015)

A frequent method of CO_2 emission from the fuel consumption prediction is the creation of three different scenarios (Figure 03). The majority of the outlooks even if the scenario is plausible, rational or normative project grow of the emissions due to fuel consumption (exclude Shell sky) showing that it might be too late to reach the goal of 1.5 °C or later in the future the net zero emissions, if the combined effort does not start first think tomorrow.

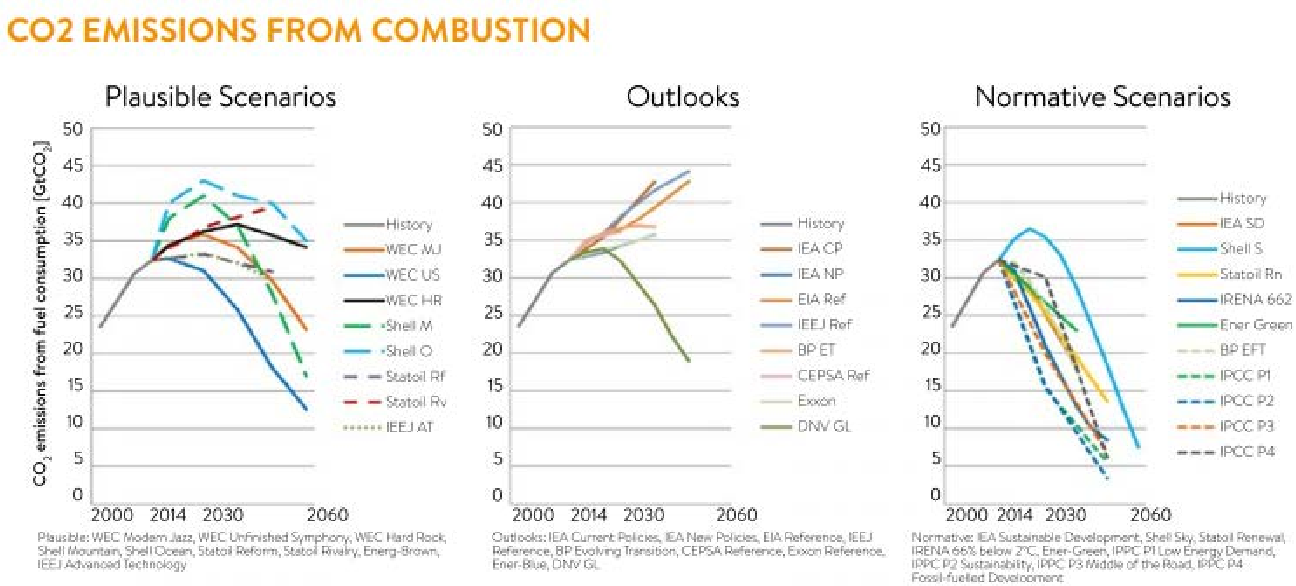

Figure 03: CO2 emission build-up through the years (World Energy Council, 2019)

The Sustainable Development Scenario maps out an approach to meet completely the sustainability goals, requiring fast and broad changes across all parts of the energy system. The breadth of global consumer demands means that there are no uncomplicated or individual solutions. The acute emissions cuts are performed across the board by dint of multiple fuels and technologies, offer efficient and cost-effective energy services for everybody. In fact, the trend in reduction of CO_2 emissions predicts a kick-off in 2020 anticipates by 2050 the Gt of CO_2 to be cut off by half and this may bring us a step closer to the limit the global temperature to 1.5 °C (IEA, 2019). This is better visualized in the following figure 04

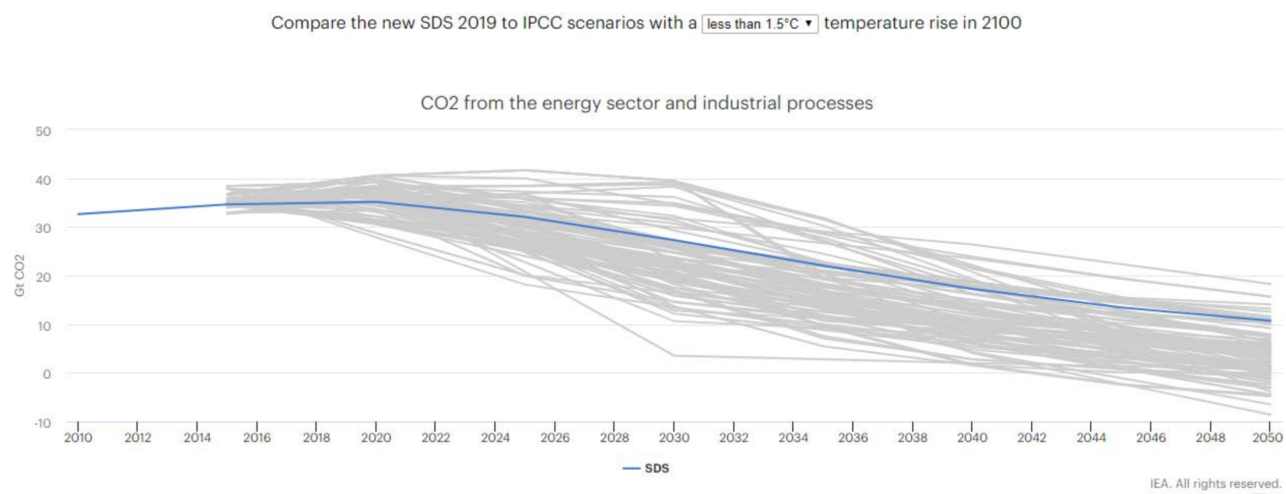

Figure 04: CO2 in the energy sector, starting from 2010 until 2050 and linked to the 1.5°C scenario (IEA, 2019)

The ultimate target is unquestionably the environmental protection through energy conservation, reduce pollution and slow down of the global warming phenomenon.

In terms of emissions and based on the below figure (Figure 05), the industrial sector comes in the second emitting place of energy-related CO2. Unfortunately, the industry would still emit 5.1 Gt of CO2 in 2050. As per the REmap Case, the industry will become the largest source of emissions with the predicted share rising from 29% to 46% of annual emissions by 2050 (between the largest emitters are the chemical, petrochemical and steel because being energy intensive and high temperature processes very difficult to completely decarbonise but the share of the other types of companies is noteworthy). The renewable energy sources together with other actions is expected to increase their share in energy use almost to 63% and drop-off in the CO2 emissions close to 5.1 Gt CO2/year thanks to the drastic measures. The anticipate total investments required until 2050 estimate to be on a global scale more or less 5 trillion USD (IRENA, 2018).

The speedup in energy consumption during 2018 (+2.3%) was driven by high growth in electricity and also gas demand. Internationally, a significantly grew in energy consumption encouraged by the sustained economic growth and rising demand in many countries. Chinas growth rate in energy use was 3.7%, first energy consumer since 2009 because of the strong industrial demand and fuel consumption followed by the United States that reached a record high of 2.3 Gtoe in 2018, up to 3.5% as a result of adverse weather conditions (hot summer, cold winter). Another way around, the European Union has succeeded, a good reduction of -1%, where Germany had -3.5%, partly thanks to decreasing consumption in the power sector and energy efficiency improvements. Looking the numbers by region, in the first place in 2018 was Asia with 5,859 Millions of tonnes of oil equivalent (Mtoe), second was North America with 2,558 Mtoe and after was coming to Europe with 1,847 Mtoe in a year. Then came CIS with 1,081 Mtoe and Africa with 850 Mtoe. Second to last was Middle-East with 803 Mtoe and final position belonged to the pacific region with 158 Mtoe (Enerdata, 2019).

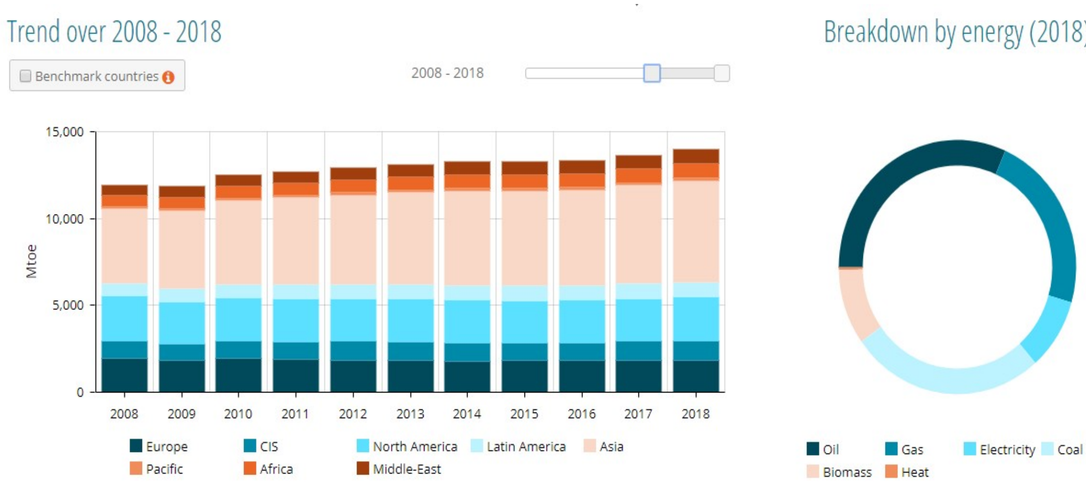

Figure 05: Energy consumption 2008-2018 by region (Enerdata, 2019)

Looking at a future not so far away, for 2030, the target is already set much higher aiming at 40% GHG emission reduction. The industries have a crucial role to play and the persistence of applying carbon reduction methods in the industrial processes in dependence on the rest of the energy sectors bringing us one step closer to a gateway to a green planet.

Pursuing a minimum of 1.5°C global temperature reduction by limiting the CO2 and other harmful emissions is a tricky business. For that cause no one should sit out of this moral purpose and first of all the industries, which have tremendous environmental impacts and well-hidden opportunities (IPCC, 2014· UNEP, 2018).

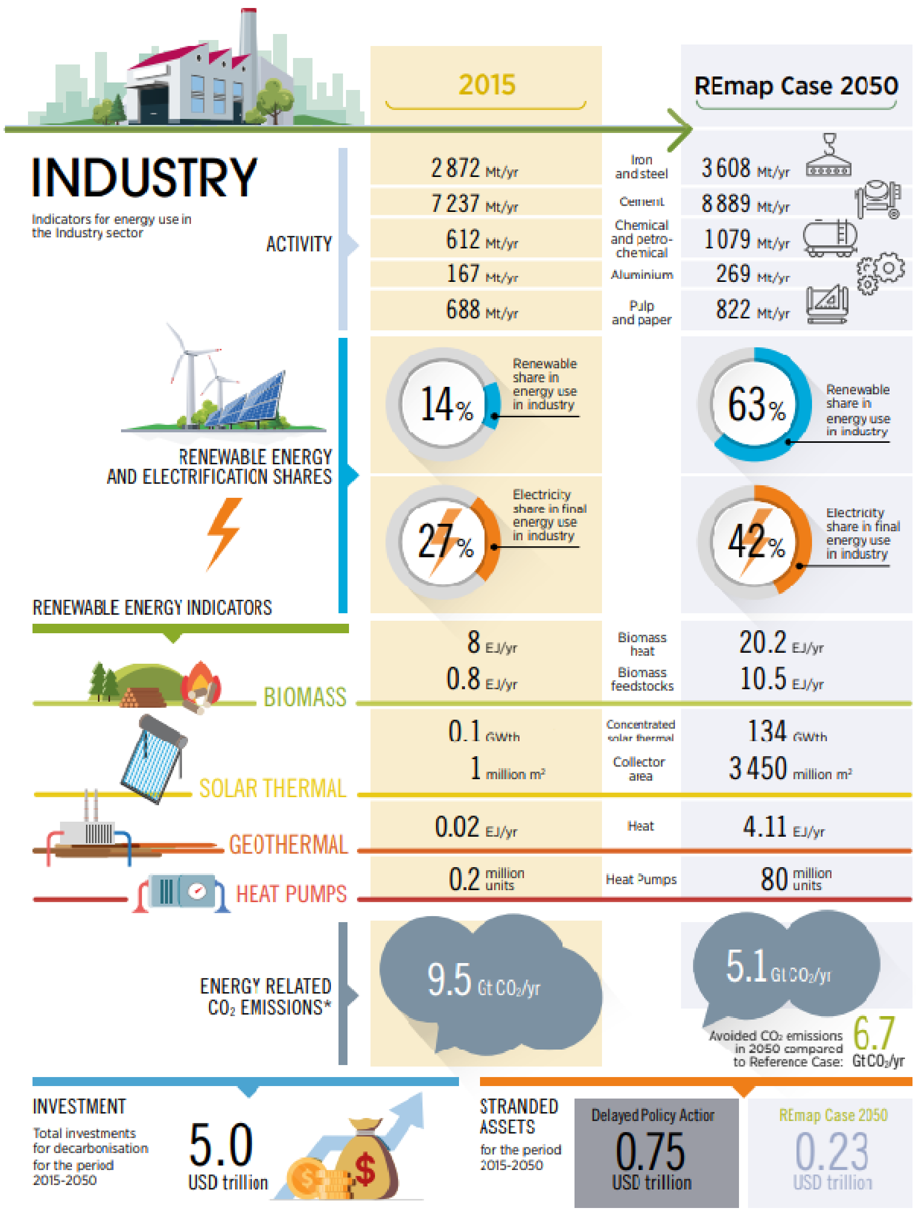

Figure 06: Infographic industry sector (IRENA, 2018)

1.4. ENERGY EFFICIENCY FROM THE SOCIOECONOMICAL POINT OF VIEW

Usually, referring to the topic of carbon footprint enhancement gives the wrong impression that only the environment can take advantage of this process, but this is far from being true. In a great degree, the socio-economic aspect earns benefits from the exploitation of the energy conservation methods, making the process very attractive for potential investors. Among the many benefits that stimulate people to make further upgrades and live a more mindful lifestyle could be the next presented:

Social:

- Improved living and working standards
- Higher profit margins are redistributed regularly as increased wages
- Positive health impact
- Lower unemployment rates
- Natural resources preservation
- Increased safety

Economical:

- Positive impact on Gross Domestic Product (GDP)
- Job creation
- Industry stand a greater change for long-term competitiveness
- Better quality of goods and improved services
- Increased budget for further investment
- Reduce or avoid pollution taxes and levies

(European Commission, 2017)

2. CHAPTER: POLICIES AND PRACTICES

2.1. INTERNATIONAL ENERGY POLICIES AND PRACTICES

Back in 2015, a historic year in which 196 parties met under the Paris Agreement to transform their developmental paths to guide the world into a path towards sustainable development aimed at curbing the increase in temperature to 1.5 to 2 degrees Celsius over pre-industrial levels. Through the Paris Agreement, was consorted by the parties, a long-term adjustment target, to the target of increase their ability to adapt to the unfriendly impacts of climate change and to advance climate rebound and low greenhouse gas emissions in a way that also, does not menace production of essential foods. In addition, they agreed to labour on the compatibility of economic runs with a path concerning low greenhouse gas emissions and climate-friendly growth.

Nationally-defined Contributions (NDCs) are at the centre of the Paris Agreement and the deed of these long-term purposes. The NDCs embodies each country's strain for abatement a reduction in national emissions and the adjustment of the conflicts of climate change. The Paris Agreement calls for each Party's:

I. preparation,
II. communication,
III. and maintenance.

(United Nations Climate Change, 2020)

In consecutive National Determined Contributions (NDCs) that it aims to manage those points. The Contracting Parties shall follow national mitigation measures to achieve the objectives of these interplays. Together, these climate actions help determine if the world brings the long-term goals of the Paris Agreement and the purpose of achieving the targets as soon as possible into global maximum greenhouse gas emissions. At the same time, according to the best available sciences, there are efforts to achieve a balance between anthropogenic emissions from pollutant sources in the second half of this century. The increase in emissions of these gases will require more time from developing country Parties to rationalize their use and reduce them and that emissions reductions will be made on the basis of sustainable development and poverty eradication efforts, which are critical development priorities for many developing countries. Each climate change design mirrors the country's ambitions to reduce issuance, taking into account households conditions and potential (UNFCCC, 2020a).

Markedly, a few words about the most important agreement will showcase the value and the high priority of the issue of climate change. Further down are presenting some pivotal moments of the carbon emission policies and regarding decisions.

i. **The United Nations Framework Convention on Climate Change:**

Referring to the United Nations Framework Convention on Climate Change (UNFCCC), they allude to an international pad of the environment, adopted on 9 May 1992, which was signed at the Rio de Janeiro Earth Summit held from 3 to 14 June 1992. It entered into force on 21 March 1994, following confirmation by an adequate number of countries. The objective of the UNFCCC is "*to consolidate and control greenhouse gas centralization in the earth's atmosphere at levels that will forestall dangerous anthropogenic interference with the climate system*" free greenhouse gas emission limits are mirrored in this framework for Member States without mechanisms to enforce it according to law. Negotiation, according to the description of the framework becomes international treaties (so-named protocols or agreements) to define further admeasures to achieve the global goal of the UNFCCC. The UNFCCC has set as its first task the signing of ethnic greenhouse gas stocktaking for greenhouse gas emissions and redeployment that were used as a reference for the creation of the 1990 benchmark levels, all for the accession of the Annex I countries (industrialized countries members of OECD) to the Kyoto Protocol and the commitment countries to reduce greenhouse gas emissions. The above countries have to abide their inventories annually to the UNFCCC databases. The UNFCCC entered into force on 21 March 1994, as mentioned before, and has almost universal membership. One hundred ninety-seven countries have ratified the Convention and are called Contracting Parties. The UNFCCC named as a "Rio Convention", is one of the three affiliated at the Summit of Rio in 1992. "*Family*" of Rio Conventions, is the United Nations Convention on Biological Diversity and the Convention to Combat Desertification. The above three actions are inseparably corporate. Based on the above fuselage, the Joint Liaison Group was also set up to amplify collaboration amid the above pacts. All of them are connected with the ultimate goal of developing synergies and groups in their activities and on issues of mutual interest. The Ramsar Convention on Wetlands is also incorporated into the above. As mentioned above, it is clear that the final goal of the UNFCCC is to impede hazardous interference in our climate system. Initially, the Intergovernmental Negotiating Committee (INC) presented the text of the Framework Convention at the New York Summit from 30 April to 9 May 1992. The Convention enjoys broad legitimacy, mostly due to its almost universal membership (United Nations, 1992).

ii. **Conferences of the Parties (COP):**

The Parties to the Convention meet annually since 1995 at the Conferences of the Parties (COP). These conferences include an assessment of each country's progress in addressing climate change both locally and wider. In 1997, the Kyoto Protocol, established legal indebtedness and obligations for developed countries, and it was introduced to reduce greenhouse gas emissions during the period 2008 - 2012. In line with the Cancun Agreements in 2010, it is entirely distinct that the overall overheating of the planet should be reduced to 2°C than the pre-industrial levels. The protocol has been amended to include the 2013-2020 period in the Doha Amendment. Lastly, in 2015, the Paris Agreement, which is subject to emission reductions from 2020, to the commitments of the countries to favoured national and non-fixed levies, was approved. The Paris Agreement entered into force on 4 November 2016 (UNFCCC, 2020b).

iii. **Kyoto Protocol:**

The UNFCCC contracting parties, following the signing of the UNFCCC, met at conferences on consultation and how to achieve the Treaty's objectives. At the 1st Conference of the Parties (COP-1) meeting, the Parties decided that the objectives of the Contracting Parties to stabilizing emission levels at 1990 levels up to 2000 were "*inadequate*". Further, discussions at subsequent conferences led to the Kyoto Protocol. The Kyoto Protocol sets targets for greenhouse gas emissions for developed countries which are binding in international law. The Kyoto Protocol was adopted in Kyoto, Japan on 11 December 1997 and entered into force on 16 February 2005. There are 192 signatory parties to the protocol after Canada's withdrawal in December 2012.

The Kyoto Protocol is an international treaty that extends the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The Framework Convention in substance commits the contracting States to reduce their greenhouse gas emissions and scientific consensus on global warming. The Kyoto Protocol had two commitment periods, the first of which lasted from 2008 to 2012. The second round of commitments is for the period 2013 to 2020 and is based on the Doha amendment to the protocol as mentioned above, which has not entered into force.

- The US has not ratified the Kyoto Protocol while Canada was withdrawn in 2012. The Kyoto Protocol has been ratified by all other Annex I Parties.
- All Annex I parties (excluding the US) participated in the first Kyoto commitment period.
- 37 Annex I countries and the EU have agreed on the Kyoto secondary targets. These countries are the European Union, Ukraine, Croatia, Belarus, Iceland, Norway, Switzerland, Kazakhstan and Australia.
- Belarus, Kazakhstan and Ukraine have stated that they can withdraw from the protocol or not put the amendment in line with the objectives of the second round directly.

- Japan, New Zealand and Russia actively participated in the first round of the Kyoto Protocol but did not take on new targets during the second commitment period.
- Other developed countries with no secondary targets are Canada (which left the Kyoto Protocol in 2012) and the United States.
- Negotiations took place in the context of the UNFCCC annual climate change conferences on the measures to be made after the end of the second commitment period in 2020. This led to the adoption of the Paris Agreement in 2015, of the UNFCCC as a separate agreement and not part of the Kyoto Protocol amendment.

(United Nations Sustainable Development, 1992)

iv. **Bali Action Plan:**

Under the Bali Action Plan, adopted in 2007, all parties in the developed countries agreed on "*quantified emission reduction and reduction targets, while ensuring comparability of efforts between them, taking into account differences in their national situation*". The developing country Parties have fallen in with the "*NAMAs (nationally appropriate mitigation actions) in the context of sustainable growth backed up and enabled by technology, funding and capacity building, in an immeasurable, communicable and corroborated way*". Between them, 42 developed, 57 developing and the African Group countries have given their agreement to mitigation targets to UNFCCC Secretariat (group of countries within the UN) (UNFCCC,2020d).

v. **Copenhagen Accord and Cancun Agreements:**

In the context of the Copenhagen negotiations in 2009, some countries produced the Copenhagen Accord. The agreement states that global warming should be kept below 2.0 °C. The Agreement-Accord does not determine what the baseline is for these temperature targets (e.g. concerning pre-industrial, or 1990 temperatures). The UNFCCC mentions that these targets are always related to pre-industrial temperatures. One hundred fourteen countries granted their accordance to the Accord. The UNFCCC Secretariat marked that "*stated parties [...] have stated in their transmittance to the Secretariat, especial views on the assumptions of the Agreement and affiliated matters under which the Agreement was agreed*". The Agreement has not been authoritatively endorsed by the Conference of the Parties. Instead, COP "*took note of the Copenhagen Accord*".

Under the agreement (Accord), 17 developed country Parties and the EU-27 gave their submission on mitigation targets. Also 45 developing country parties submitted, too. Some developing country Parties also reported the need for international support in their plans. Under the Cancun Agreements, developed and developing countries have submitted climate change and mitigation plans to the UNFCCC (Werksman, 2009).

vi. **Paris Agreement:**

As part of the "*Durban Platform for Enhanced Action*", the parties' agreement was reached in "*creating a protocol, a new legal instrument, or an agreed outcome with legal force (in other words) under the Convention applies to all Parties*". In Durban and Doha, the parties - with great concern-stressed that current efforts to maintain and stabilize global warming below 2 or 1.5 °C appear to be inadequate targets in relation to the pre-industrial level.

The Paris Climate Agreement or the Paris Climate Agreement (French: Accord de Paris) is about an agreement under the United Nations Framework Convention on Climate Change (UNFCCC) on mitigation, adaptation and financing (for the reduction of greenhouse gas emissions) from 2020 and on. The agreement aims to the response to the global threat of climate change, aiming the stabilization for the global warming in this century, well below 2 degrees Celsius (above pre-industrial levels) and seeking to continue efforts to curb climate change temperature increase even further at 1.5 degrees Celsius.

According to the Paris Agreement, each country is able to determine plans and reports about its contribution, in order to mitigate global warming. There are no law mechanisms forcing a country to set a specific target with a particular end-date, but each target should go beyond and further than previously set objectives. In 2015, all 196 parties in the Convention attended the UN Climate Change Conference in Paris, 30 November - 12

December, and gave their approval, with a consensus, in the Paris Agreement, with the ultimate goal of limiting the global warming to less than two degrees Celsius (even attempts to limit growth to 1.5 degrees Celsius). The Paris Agreement entered into force on 4 November 2016 (UNFCCC, 2020c).

Mostly, over the last two decades, as a result of intensive efforts in the international climate policy (milestoned by the international climate summits on the United Nations Framework Convention on Climate Change UNFCCC notably the Kyoto Protocol in 1997 and the Paris Agreement in 2015) and emerging consumer awareness there is a developing interest in the quantification of businesses carbon footprints. Following this, there have been various activities, guidelines, rules and calculation methods developed not long ago to be able to quantify the level of greenhouse gas emissions. A well known and widely applied accounting tool is the one called Greenhouse Gas (GHG) Protocol, serving as a standard for measuring and reporting organizational level direct and indirect greenhouse gas emissions, with a vast number of organizations using it back in 2007 (World Resources Institute, 2004).

This kind of protocol forms the basis of the ISO 14064 standard (first time published in 2006 and is since then nonstop revised) on organizational level greenhouse gas quantification and reporting (ISO, 2017).

Dreaming of the Paris Agreement goal of limiting warming to 1.5 or even 2 degrees Celsius in a best case scenario, rapid reduction of CO_2 emissions are desired (or stressing that deep cuts in other than CO_2 crucial emissions climate forcers is absolutely essential, but only this action will not be sufficient (IASS, n.d.).

The ambitious 2°C Scenario would require a peerless ramp up of all low-carbon technologies internationally. A challenging set of policy measures, counting in the rapid phase out of fossil fuel subsidies, CO_2 prices rising to unparallel levels, extensive energy market reforms, and stringent low-carbon and energy efficiency mandates would be required for this transition. Those policies planned to be presented quickly and comprehensively across all nations in order to accomplish the 2°C Scenario, with CO_2 prices reaching up to (USD) 190$ for each tonne of CO_2 emitted. The situation likewise requires more extensive and more profound worldwide endeavour’s on technology innovation cooperation to encourage low-carbon innovations advancement and deployment. All improvements to energy and material effectiveness and higher deployment of sustainable power source are necessary parts of any international low-carbon change. Additionally, in 2°C Scenario, aggressive efficiency measures would be expected to bring down the energy intensity of the global economy by 2.5% annually in time between 2014 and 2050, where wind and solar combined would become hopefully the largest source of electricity until 2030. Electricity markets redesign will bring major changes thanks to the large shares of renewable integrated, alongside with new strict rules and proper technologies to ensure flexibility. By 2050, the intention is that nearly 95% of electricity would be low-carbon, 70% of new vehicles would be electric, the entire existing building stock would have been retrofitted, and the CO2 emissions coming from the industrial sector would be 80% lower always compared to the most recent calculations. Indeed, a fundamental reorientation of the investments and a fast acceleration of demand-side investments deemed to be inevitable. For that cause, are needed around USD 3.5 trillion in energy sector investments on average each year between 2020 and 2050. The additional net total investment, relative to the patterns that arise out of the current climate pledges, would be equivalent to 0.3% of global gross domestic product (GDP) in the year 2050 (OECD/IEA & IRENA, 2017).

At present, many notable reports and climate actions are setting an alter and more restrained target of tackling the global warming to 1.5°C in comparison to the pre industrial levels. As set out by the 2030 agenda for sustainable development and more specific the 13th goal of sustainable development (SDGS) "*Take urgent action to combat climate change and its impacts*" speaking about the pressure put on the environment and the necessity of planning ahead toward reaching that target (United Nations, 2015).

Same motive is followed also by the 6th IPCC assessment Report, which is an intergovernmental panel on climate change, assessing in regular basis the scientific information are useful to develop climate polices or actions. One of the many reports clearly distinguish the impact on the planet of 1.5°C and 2°C temperatures above the pre-industrial conditions showing that an additional 0.5°C of warming will cause acute environmental problems and presumably in some cases/regions major disasters (IPCC, 2018a · IPCC, 2018b).

Scientists around the world are aware that applications of the carbon footprint concept in practice can be tricky and are many different frameworks providing a methodology for quantifying organizational carbon emissions. For addressing the corporate level footprint, the widely used Greenhouse Gas (GHG) Protocol (WRI and WBCSD, 2004) ranks emissions into three main scopes:

- 1st Scope: Direct emissions from sources possessed or operated by the company or public organization (for instance own trucks, gas heating systems and so on).
- 2nd Scope: Electricity indirect GHG emissions depends on the generation of power somewhere else utilized by the company/organization (the GHG protocol addresses only electricity, however, steam or heat could be ditto covered within this scope).
- 3rd Scope: Rest of indirect GHG emissions as a voluntary group of the protocol, third Scope that considers treating of any further emissions, like the upstream and downstream phases of product life cycles (a good example are raw material extraction or usage of products).

(Ranganathan & Bhatia, 2004)

Stein and Khare (2009) assert that generally indirect (third Scope) emissions account for the largest share of corporate carbon footprints (Stein & Khare, 2009). The following figure 07 summarize the main scopes of the GHG Protocol, where is evident the distinction between the direct and the indirect emissions.

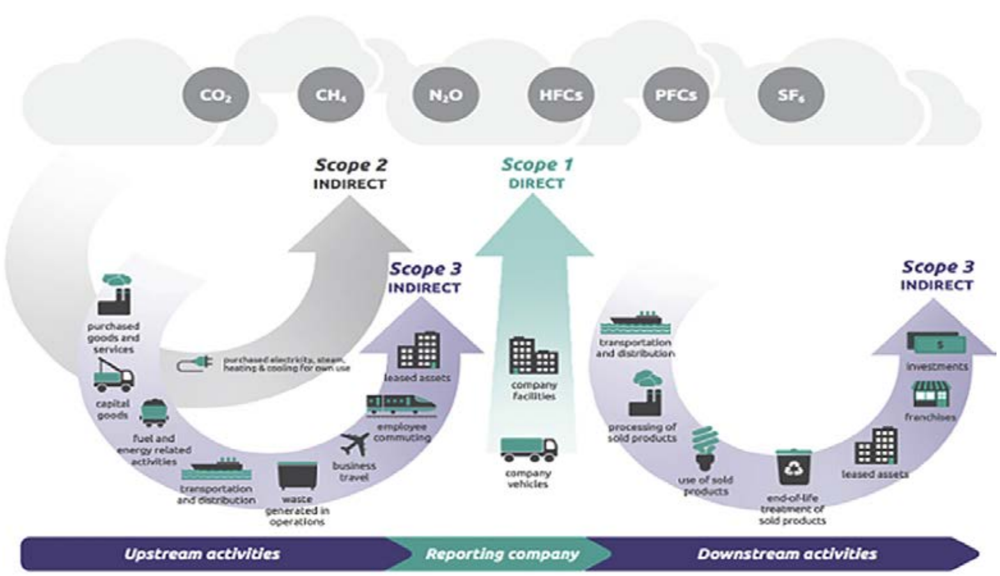

Figure 07: Harmful emissions main scopes and their grading in direct and indirect (Harangozo & Szigeti, 2017)

2.2. ENERGY POLICIES AND PRACTICES IN EU

An EU framework proposes new targets and measures to make the state member's economies and their energy system more competitive, secure, and sustainable. The continued commitment and concern of the European Commission of this transition process intended to launch discussions on how to give these policies continuity to the end of the current 2020 framework and how the next steps should be done. Major targets such as reduction of greenhouse gas emissions and increasing the use of RES, a new governance system and performance indicators are on the daily agenda. More specific, it proposes improved energy efficiency via possible amendments to the energy efficiency directive, European guidelines and energy efficiency investment objectives, which are founded on the experts work hoping for a low carbon economy (Medina, Camara & Monrobel, 2016).

Various laws and regulations have promoted by governments to ensure the stimulation and commercialization of renewable energy sources in order to deal with problems such as climate change, the unwanted CO_2 emissions and the depleted fossil fuels. The European Union Members have agreed to achieve the following goals by 2020:

i. 20% reduction in greenhouse gas emissions

ii. Increase the rate of penetration of renewable energy sources to 20% of final consumption

iii. Improvement of energy efficiency by 20%

(European Commission, 2019a)

In the eyes of the European Commission and the people in charge, fair enough, the carbon footprint reduction can be realized with the proper combination of all the aforementioned targets indicated. By giving emphasize only on one goal, the likelihood of a zero or near to zero carbon footprint either talking about a domestic user or a more substantial consumer (industry, public organization) would be much lower.

In the same direction, the new 2030 revised climate and energy framework, including the EU-wide targets and policy objectives for the period from 2021 to 2030 are the below:

- At least 40% cuts in **greenhouse gas emissions** (from 1990 levels)
- At least 32% share of **renewable energy**
- At least 32.5% improvement in **energy efficiency.**

(European Commission, n.d.a)

These changes to the original plan were adopted by the European Council some years ago, in October 2014 and the targets for renewable energy and energy efficiency were revised upwards in 2018. All Member States are obligated to conform to integrate National Climate and Energy Plans (NECPs) and also had to submit their draft plans by the end of the year 2018 (final plans due date was the end of 2019). As key factors of that energy plan, cradling the minimum of the sectors usually call for improvements. Namely, the following topics are energy strategy, energy efficiency, renewable energy, markets and consumers, energy security, technology and innovations, infrastructure, international cooperation, oil, gas, coal and last but not least the nuclear energy (European Commission, n.d.a).

Additionally, a premature target has been adopted to "open the road " for more intensive actions to lead the way to climate neutrality. Through investing in realistic solutions, empowering the EU citizens and aligning key areas like finance and industrial policies, on 28 November 2018, the Commission presented its long-term strategic vision for a prosperous, modern, competitive and climate-neutral economy by 2050 (European Commission, n.d.b).

The 2050 EU horizon prepares itself for a climate neutral economy by 2050. For instance, a strategy should outline a vision of the deep socio-economic transformations needed, engaging all involved sectors for a climate-neutral economy. It seeks to ensure that this transition is socially fair, enhancing the competitiveness of the EU economy and industry on global markets, securing high quality jobs and sustainable growth in Europe. Hence, the road to climate neutral economy encapsulates some strategic priorities and points. The figure 08 displays them briefly and among others, can also seen the industrial modernization that will bother us later and the maximize energy efficiency benefits (European Commission, 2018).

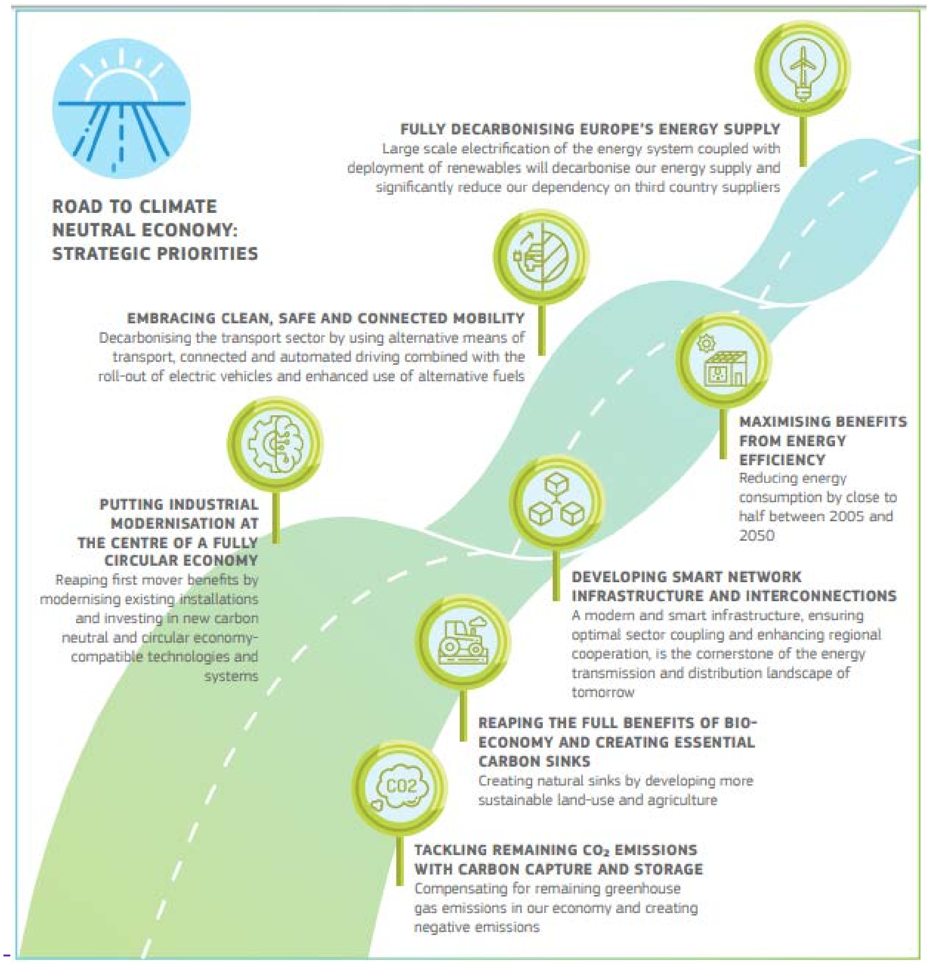

Figure 08: Strategic priorities toward a neutral economy (European Commission, 2018)

The European Union (EU) has subscribed this reduction of energy in comparison with a specific baseline projection. This goal is otherwise called the 20% energy consumption reduction target. At the end of the day, the 20% goal is attainable, but at the same time, not that easy going as presented in the next figure. During 2017 the primary energy consumption was still above the desired target, close to 1,550 Mtoe or 5.3% above the given aim. In 2020 must be more than 1,483 Mtoe (1,086 Mtoe final energy). The long term target in 2030 is a 22.6% decrease compared to 2017 measurement or otherwise translated 1,273 Mtoe of primary energy consumption (956 Mtoe final).

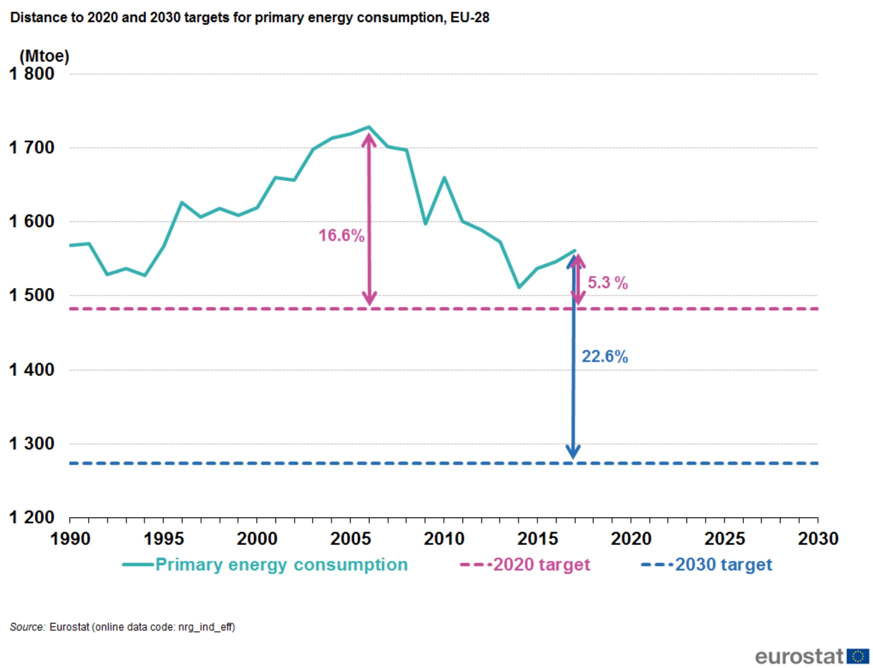

Figure 09: Distance to 2020 and 2030 targets for primary energy consumption, EU-28 (Eurostat, 2019)

Indeed, using resources more efficiently saves costs, and reduces environmental damage. This statement is not only limited to CO2 greenhouse gas emissions but influences several aspects of nature. Worldwide, many countries and big scale consumers seek ways to reduce consumption, to treat and re-use water, and to find possible ways to take advantage of the raw materials and waste. After a closer look at the policies adopted on resource efficiency internationally, it can be said that every decision or regulation has a considerable weight. The local authorities, reasonable enough, year after year puts extra pressure on companies to conform with these legislations and in parallel for that reason support infrastructure companies in improving their performance or the procurement function to easier survive in volatile markets. A continuous improvement approach keeps the energy and money savings in the long run (Energy Efficiency Trends and Policies In Industry, 2015) (European Commission, 2018).

Another vital info shows the criticality of the issue is that all EU-countries, as parties to the UNFCCC and its Kyoto Protocol, are required to report to the UN:

- Annually on their greenhouse gas emissions ('greenhouse gas inventories');
- Regularly on their climate change policies & measures and progress towards the targets ('biennial reports' and 'national communications')(European Commission, n.d.c).

Annual reporting: screening their emissions under the EU's Climate Monitoring Mechanism, this sets the EU's own internal reporting rules based on globally concurred commitments and covers points like:

- ✓ emissions of 7 greenhouse gases
- ✓ projections & policies to cut greenhouse gas emissions
- ✓ national measures to adapt to climate change
- ✓ low-carbon strategies
- ✓ financial and technical support to developing countries (Copenhagen Accord and 2010 Cancún Agreements)
- ✓ national governments' use of revenues from the auctioning of allowances in the EU emissions trading system

Regular reporting to the UNFCCC: developed countries are required to make "national interchange communications" to the United Nations at least one time in 4 years, with data on:

- ✓ emissions and removals
- ✓ policies and measures to reduce emissions
- ✓ provision of financial, technological and capacity building support
- ✓ other activities undertaken to implement the Convention

(European Commission, n.d.c)

3. CHAPTER: CORPORATE WORLD AND ROOM FOR IMPROVEMENT

The rapid development in technology the last few decades broaches the matter of energy efficiency as a primary topic in many intercourses over the years. An excessive and unbridled requirement for every kind of energy and especially electricity without second thoughts has been at the top priority of the industrial customers, but this correctly changed since the environmental impact proved to be tremendous. This philosophy targets every aspect of the economy, focusing not only on the domestic building consumers and the public sector but on the big players as well.

3.1. ENERGY INTENSIVE INDUSTRIAL PRIVATE OPERATORS

An uncontrollable demand for products has grown a lot, along with energy consumption and $CO2$ emissions. As countermeasures, modest improvements have been made in industrial productivity, in renewable heat uptake, together with favourable policy and innovation steps. Nonetheless, progress is far too slow and rapid efforts on all fronts will be required to get the industry on track with the Sustainable Development Scenario (SDS). Several techniques are used to satisfy the energy consumption needs and there are strongly affected by the geographic area and its latitude. The latitude every region, the climatic conditions and the adaptability tag not only the industry, but also the government, offers different opportunities for saving measures and at the same time plays a crucial role in how energy intensive an enterprise can be. As a general rule, some heavy industries consuming and therefore emitting the most significant amount of unwanted gases. More specifically, in 2017, iron & steel (2 Gt), cement (2.2 Gt), chemical & petrochemical (1.2 Gt), Aluminum (0.3 Gt), pulp and paper (0.2 Gt) and the rest of the industries (with 2.5 Gt). From 2030 onward, the total amount of 8.5 Gt (24% of global emissions) is expected to start dropping despite the expected industrial production growth (and population growth) in order to harmonize with the SDS. The next figure (Figure 10)proves the previous point, that $CO2$ GHG production was steadily increased the last years because of the massive demand for electricity and other forms of energy and in parallel the uncareless use of them.

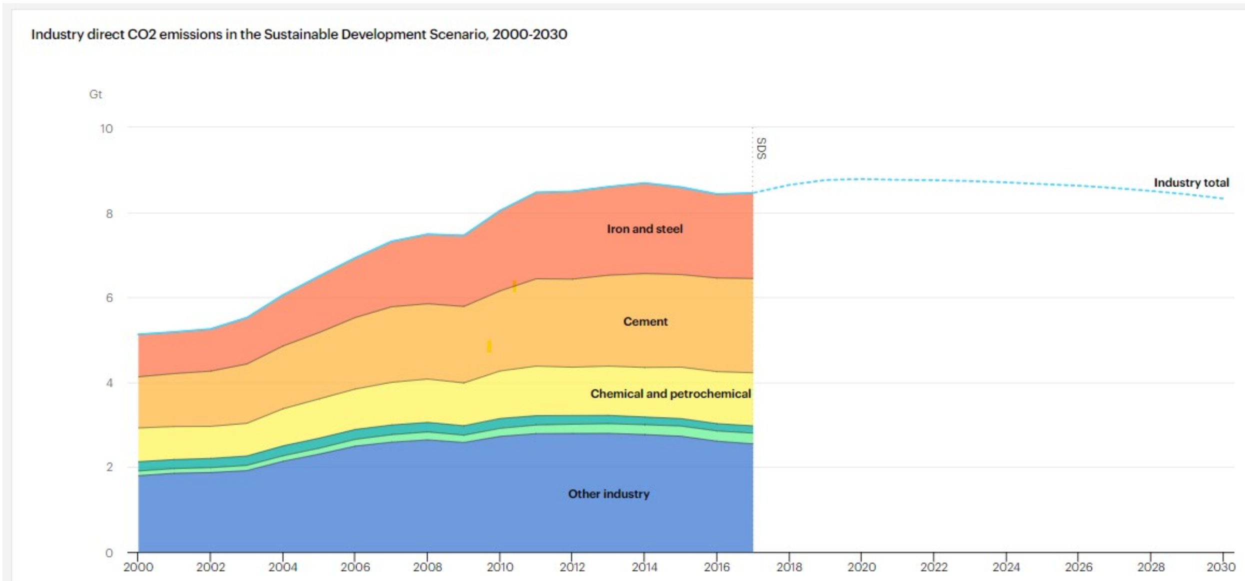

Figure 10: Industry direct CO2 emissions in the sustainable development scenario 2000-2030 (Pales, Levi & Vass, 2019)

Worth mentioning is also the gradual change occurring in the Industrial energy productivity (industrial value added per unit of energy used) that has risen in most regions since 2000 and is absolutely connected with the energy efficiency. Traditionally, the best enhancements in energy efficiency have been succeeded in developed nations, which will in general spotlight on higher-value industrial items, while nations in which industrialization progress came later have shown comparatively little progress.

Not long ago, in Middle East, the industrial productivity has declined as a result of strong development in energy-intensive fabricating subsectors somewhere in the range of 2004 and 2010 (particularly in the cement subsector) and in 2017 presents a value of 269 USD/GJ. Same path has followed china with little changes in industrial productivity or even fell during the 2000s. Nowadays, industrial energy efficiency financial investment was more or less USD 40 billion, whereas China represented 37% of the total in 2018 (88 USD/GJ) and North America's share dropped from 17% in 2015 to below one tenth in 2018 (256 USD/GJ). Between other regions stands out Europe with remarkable constant advance year after year, keeping the upper hand in the energy efficiency sector (269 USD/GJ). This reflects, how the energy intensive facilities are phasing out and the new constructed absorbing a sufficient part of the similar nature investment (Pales, Levi & Vass, 2019) (figure 11).

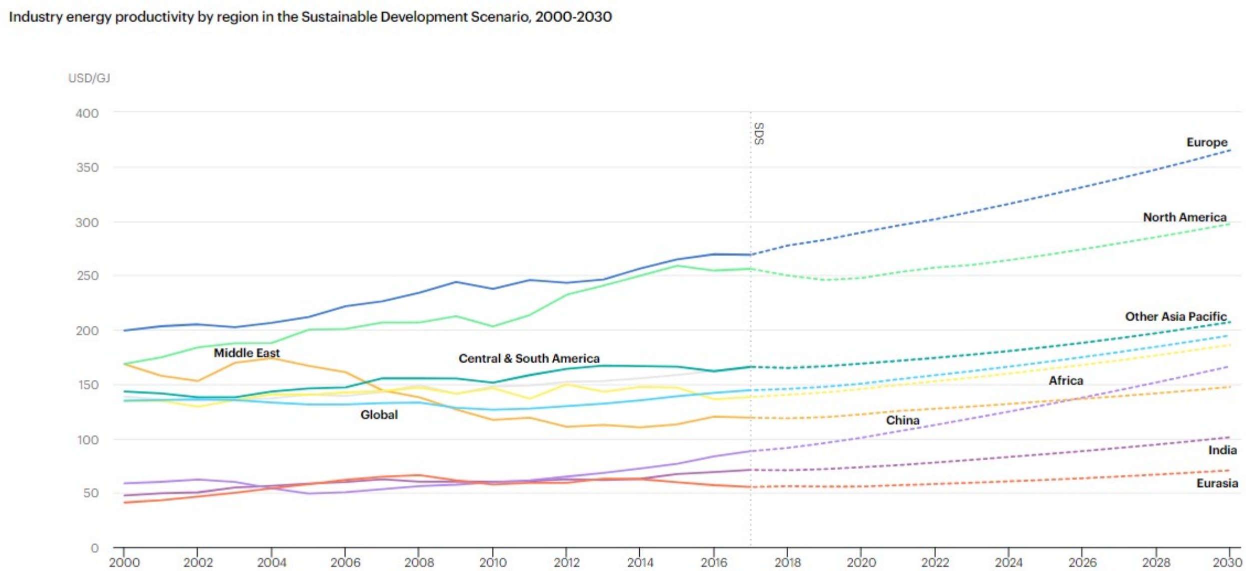

Figure 11: Industry energy productivity by region in the sustainable development scenario, 2000-2030 (Pales, Levi & Vass, 2019)

Pursue an industry with zero carbon dioxide is a great challenge because there are several obstacles blocking the way. On one hand the sector is very heterogeneous with a wide range of processes and products, meaning the number of crosscutting solutions is limited and on the other hand, except fossil fuel combustion emissions, some processes produce CO2 as a by-product of the chemical reaction (best example is cement manufacturing). These so-called 'process emissions' cannot be addressed with energy efficiency measures or by switching fuels. Lastly, unlike the electricity sector, products have to be always competitive in worldwide markets, decreasing the degree for organizations to assimilate or pass any extra expenses to consumers - making low carbon technologies uneconomical. Hopefully, by 2050 most of the industries will already be working this very moment with the Best Available Technology (BAT), limiting the ability for further improvements (OECD, 2018 · The Climate Group, 2016).

3.2. ENERGY MANAGEMENT AND RELATED METHODS

For this purpose, every once in a while, the human interest in the energy sector field shifts from one innovation to the another, in favour of more energy save sustainable solutions linked to the targets mentions before. Many worldwide accepted tools for addressing climate change impacts by amending possible mistakes and update energy usage fail to drive future growth. When referring to energy intensive consumers like public corporations or private companies, there is a great probability of finding out high or low importance hidden failures. The interactions between the two sectors are strong and the good practices are from both sides desirable. Focusing more in corporate world business development and the effort to minimize the environmental impact occur from this side, a stricter legal framework was established based on the trading system such as the European Union Emissions Trading System (EU ETS) or the ISO 50001 implementation. On the one hand EU ETS is one of the most important tools for cutting the greenhouse gas emissions from all wide ranging facilities either in private or in the public sector (also at a later point has covered the aviation sector). EU ETS was adopted back in 2003 by the EU directive. It entered for the first time into force on 16 February 2005 by the European Union parliament, following confirmation by an adequate number of countries inside or outside the European Union. It is regarded as a cornerstone in the battle against climate change and is still the most significant carbon market internationally (European Commission, 2013). On the other hand the ISO 50001: 2011 has three main benefits of money saving, resource conservation and tackle of climate change (direct or indirect mitigate climate change impact) playing already a vital role and being developed by several companies (Enerit, 2016). A more recent concept called Zero Emission Buildings adopted as a vision and a target by industrial sectors with similar targets (also in the domestic building sector). The zero or near zero emission building concept brings in more transparent view the idea of producing at least the same amount of energy consumed during a year of use (for electricity, heating, cooling or other fuel). It is finding more application in the housing sector, but slowly steps into bigger scale projects. Optimal thermal performance, daylight and solar shading systems, development of windows and glazing systems and many other passive ideas solutions as of interaction between user needs, building services and better integration of renewable technologies included in a broader list of actions for energy building independence (U.S. Department of Energy, 2015).

All this and many other tools and mechanism in the final analysis, reducing in a high degree the energy needs of the big players and aiming a cleaner, sustainable future.

Linked with the aforementioned information, the environmental management field welcomes now and then broadly synonymous concepts that target this drive towards sustainability. A recently joined concept or industrial strategy named cleaner production is favoured by case advantage of the tools, methods, technologies and many other factors imposing actions and reducing energy consumption and raw materials. This concept prevents the extra waste generation and finally could boost the financial profits and the productivity of the company. As the most considerable advantage of cleaner production strategy can be identified that it does not deny by any means the company growth. It is just insinuated that growth should be achieved by ecologically approved methods (Nilsson, Lars Rydén, Darozhka & Zaliauskiene, 2007).

Earlier a more general approach has been demonstrated, but the topic holds our interest is by far the idea of turning to an ecological solution in the private sector. Many thematic fields planned to be included in the study comprise the renewable energy sector, energy efficiency, cleaner production strategies, energy and environmental policies, a company's ecological and energy footprint and finally the smart and efficient buildings or in more widely context also in cities (or otherwise said the surrounding environment).

A looking-forward idea like the concept of Sustainable Consumption & Production (SCP) has evolved, in a repeating cycle process with principal steps of sustainable development minimizing the negative environmental impacts of consumption and production systems while promoting quality of life (see also figure below). Frequently used definition of SCP is: "*the use of services and related products which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emission of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of future generations*" (ISSD 1994).

Moreover, the International Institute for Sustainable Development list the underlying key principles:

1. Improving the quality of life without increasing environmental degradation and without compromising the resource needs of future generations.
2. Decoupling economic growth from environmental degradation by:
• Reducing material/energy intensity of current economic activities and reducing emissions and waste from extraction, production, consumption and disposal.
• Promoting a shift of consumption patterns towards groups of goods and services with lower energy and material intensity without compromising the quality of life.
3. Applying life-cycle thinking which considers the impacts from all life-cycle stages of the production and consumption process.
4. Guarding against the rebound effect, where efficiency gains are cancelled out by resulting increases in consumption.

(UNEP, 2011)

UNEP describes this Green Economy as “one whose growth in income and employment is driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services” (UNEP, 2011). Overall, the concepts of the Green Economy and Green Growth should not be seen as alternative definitions of sustainable development, but as specific pathways that can assist countries in achieving sustainable development. Further resources effectiveness can be accomplished by expanding resource productivity (value-added / resource use) or reducing resource intensity (resource use / value-added). It is associated with strategies like dematerialisation, such as fuel-efficient cars or zero energy buildings and many other creative plans. All of them call for preserving resources so that future generations would never face deprivation of them. Preferably, no manufacturer or service provider should avoid excess use of raw materials if the same good or process could be made with fewer raw materials or any other form of energy needed and thus at a lower cost (UNEP, 2015).

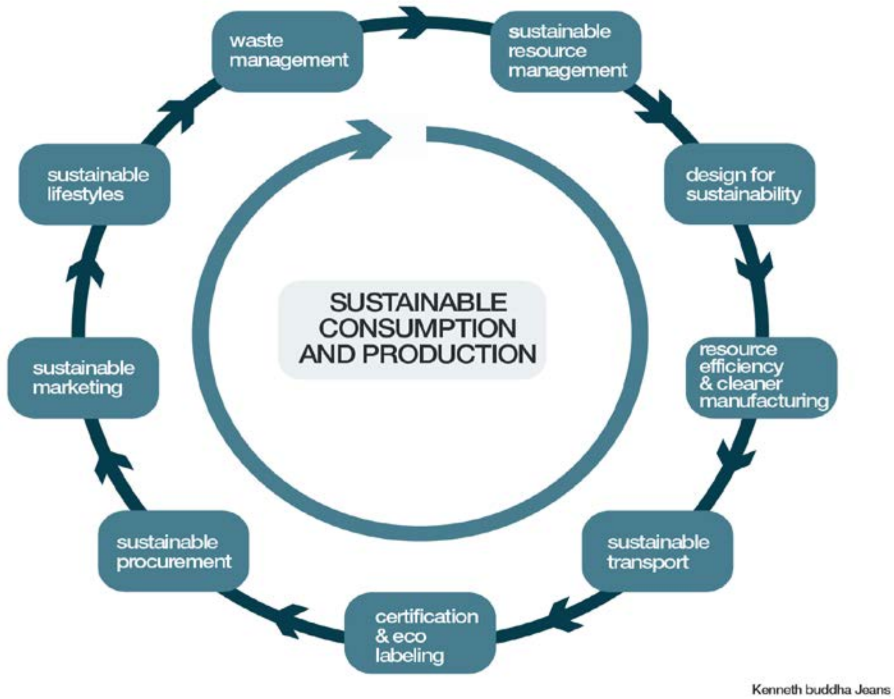

Figure 12: Sustainable consumption and production holistic diagram (Lyngaas, 2016)

Emphasizing mostly on the resource efficiency, cleaner manufacturing and the waste management and thus the energy demand as a subpart of this general goal of environmental protection, the companies should follow exact energy policies set, carry out and maintained by the responsible management. The development of a business energy policy in respect of the company targets and ambition is a tricky and time-intensive procedure, since it has to re-evaluate often depending on the circumstances. The energy policy must definitely state the commitment to achieve energy efficiency improvement, and well-written statement of the company's energy policy could enable the energy manager to act autonomously accomplishing its goals. Simultaneously, it must be documented, understandable and received by all the affected subjects (staff, suppliers, customers). Conjointly, a circular economy is a hot topic in today's scientific, industrialists and various decision-makers circles and straggling for a smooth transition because it will not happen by itself. Plenty of companies have begun a circular production design such as Timberland (turn tires to shoes), Johnson controls (recycles batteries), Aquazone (turning wastewater into fertilizer) or Vigga (with a shared wardrobe for children) (Benzaken, 2018).

As per the European Parliament, the benefits of the switch to a circular economy will be tremendous for the EU companies, save 600€ billion and a total greenhouse gas emission by 2-4% (and as "side effect" more than 580,000 new jobs in EU only) (European Parliament, 2015).

The so called industrial ecology aspires to do the production and an enterprise in whole to follow the path of sustainable development. The concept of an industrial system in which there is no sign of energy leakage or resource waste, have created a network and activities fit into a larger industrial system. For instance, one company could use a waste of other companies as inputs, and in general they could make an effort to a dynamic collaboration with the intention of each one of them to save as many resources as possible (Nilsson, Lars Rydén, Darozhka & Zaliauskiene, 2007).

Similarly, the enhancement life of the society can potentially upgrade by the correct waste management. These kinds of strategies are taking official form by the legal authorities and after harmonization of the national laws began to pervade the local society. In the case of waste proper management could not be different. The last few decades, several steps toward this direction have been done not only in European level but also in international, increasing the interest drastically from simple people till cooperative companies (European Commission, 2019b). The main goal of the waste management is first of all the public conform to the important recycling and reusing practices and secondly the large industries or the substantial public services to follow or upgrade their specific techniques concerning this major issue. A straightforward hierarchy should be applied and follows out repeatedly the steps illustrated in the next figure (Figure 13):

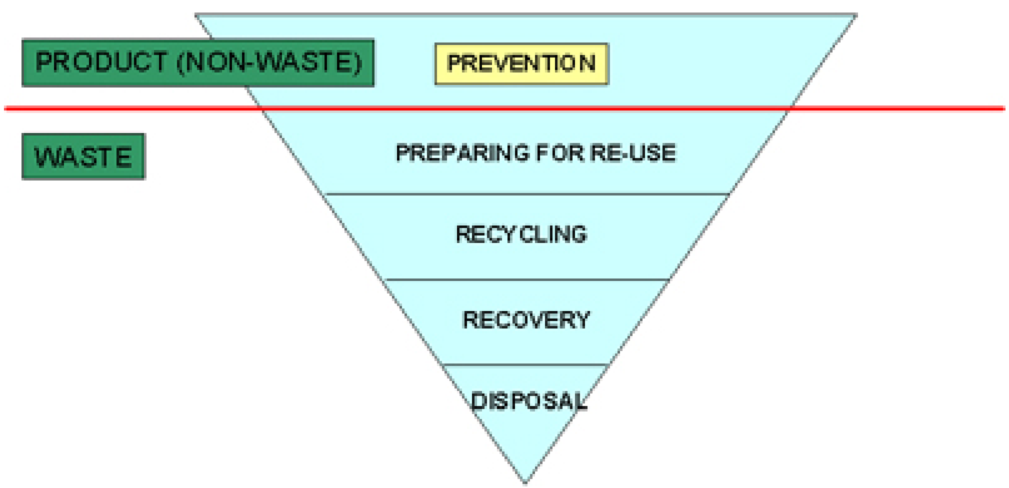

Figure 13: Waste management hierarchy (European Commission, 2019b)

3.3. ENERGY EFFICIENCY BARRIERS TO INDUSTRIAL ENVIRONMENT

Unfortunately, the massive potential of energy efficiency and their benefits are not matched with an appropriate level of company adoption. This “energy gaps” are seen in all economies and the essential job of strategic policies should be to maximize the take-up on economic opportunities given to reduce these gaps. This sub-chapter examines this kind of obstructions both at the government level and within the stakeholder enterprises (Apeaning, 2012).

The Harvard Business Review (Harvard Business Review, 2011), has surveyed large enterprises across the globe and discovered from these sources that are not commonly reported in the energy management and energy efficiency sectors, but only to business and management affiliates. Looking at figure 14 shows the top ten barriers that the Harvard Business Review saw as impending. Seven out of ten were internal issues within the influence of top management and controllable by the association itself, when the other three were more external to the organization.

Internal reasons:

- Failure to assess the side effects and/or consequence of doing nothing
- Uncertainty over the viability of proposed energy savings projects
- Leadership attitudes towards avoiding new costs
- Insufficient collaboration among stakeholders in the company
- Corporate culture resistant to new ideas for improvement
- Financial constraints such as a high return on the investment required
- Poor innovation by existing suppliers and business partners (shorter barrier with 4%).

External reasons:

- Energy suppliers wanting to maintain the status quo
- The number and complexity of regulations
- Lack of government funding.

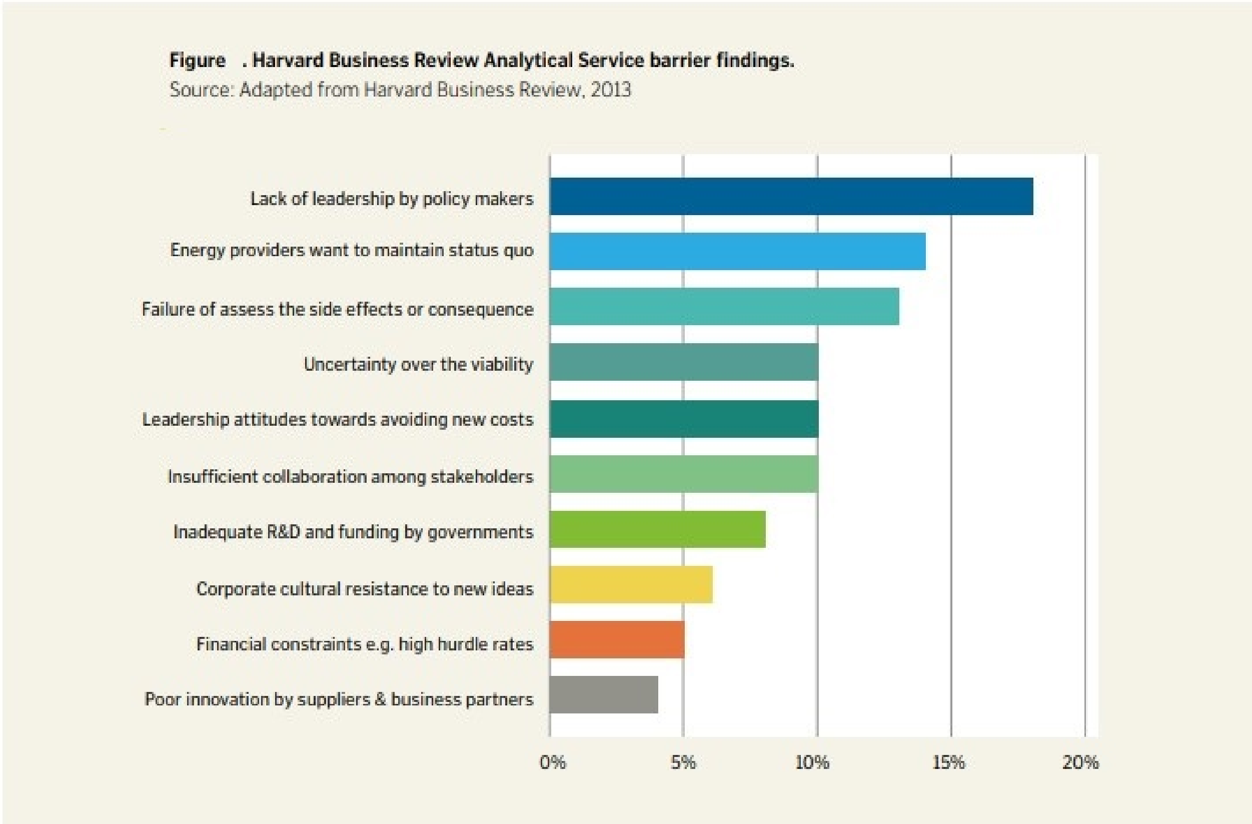

Figure 14: Harvard Business Review Analytical Service barrier findings (Apeaning, 2012)

3.4. PROCEDURES FOR CORRECTIVE AND PREVENTIVE ACTIONS

As explained before, an energy management system (EnMS) following some specific standards is one of the best solutions to confront energy efficiency and similar type challenges. The basic underlying of an energy management standard is to guide for the modernization of industrial facilities and better integration of energy efficiency into their management practices, comprising aligning production processes and upgrade the energy efficiency of industrial systems (Ginley & Cahen, 2008).

In particular, an energy management standard offers to specialists best practices framework for organizations to develop all that think viewed as imperative for the improvement of energy performance (energy efficiency goals, plan interventions, prioritize measures needed and investments, screening and record results and guarantee continuity typifies some of them) (UNIDO, 2009). Typical management standards (including energy management systems) are designed based on Plan-Do-Check-Act (PDCA) four stage model, which cultivate an organizational culture of better energy efficiency in every department by setting realistic goals in a gradual and continuous manner (Figure 15) (UNIDO, 2009).

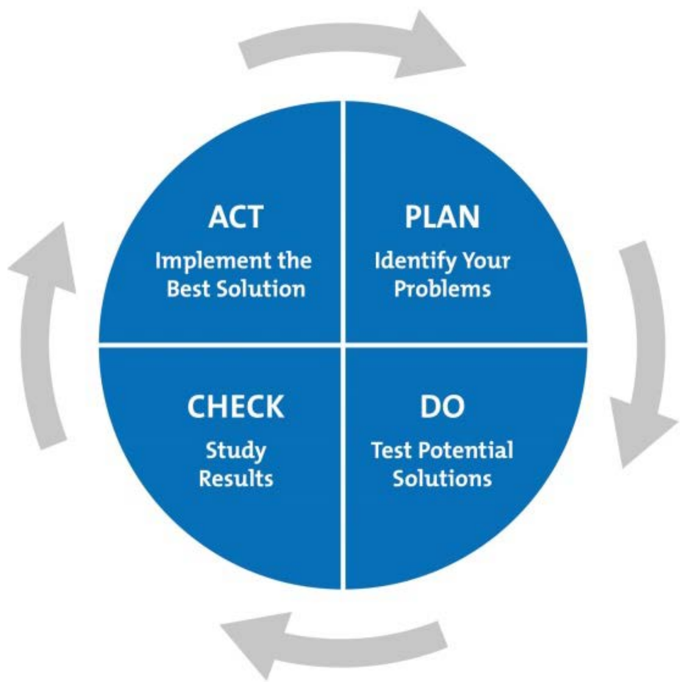

Figure 15: The Plan-Do-Check-Act energy management cycle (MindTools, n.d.)

In brief the four phases:

I. Plan phase:

A core requirement of an energy management standard is the set-up of an energy policy, which entails the continual improvement in energy performance, in achieving objectives and targets, support the purchase of energy efficient products and services and must be communicated if updated to all employees. The European standard approved by CEN in 2011 states that in firms without a plan in place, chances for improvement may be already discovered but may not be promoted or fulfil because of organizational barriers. During that phase, an energy review is conducted in order to set up an energy baseline to compare old and new energy performance, energy performance indicators (EnPIs), objectives, targets and action plans to deliver the improved energy performance outcomes. Therefore, an energy audit is conducted at the beginning to predict both the present and past energy consumption of the facility and in a later stage to examine the progress level of the ongoing scheme (BSI Standards Publication, 2012).

II. Do phase:

The next stage includes the implementation of the energy program by aligning activities of the company with the equipment systems and processes to reduce energy usage. A prosperous energy management program starts with a solid commitment to continuous improvement (Worrell, Bernstein, Roy, Price & Harnisch, 2008).

Hence, it is involving the assigning of management duties and the creation of a cross-functional energy committee in the Plan Phase. The initial step in an energy management program involves the training of the organization workers and the supervisors at a large level. This step serves the goal of building the needed energy management competence and informs all the affected subjects. A proper move will be the creation of an energy manual or other form of a sharing document. The process should be established allowing the employees to suggest improvements to the EnMS and also defining roles, responsibilities and authorities (BSI Standards Publication, 2012).

III. Check phase:

This phase gives the opportunity through monitoring and measuring the performance (by conducting energy audits) to compare the objectives and the targets in terms of energy saving. It is necessary to identify and analyse any budget shortfalls or implementation errors making the needed corrections to realize the primary goals. For that cause the goals should be quantifiable to facilitate the evaluation of improvements.

In later stages of the ISO application after exhaustively control or after internal/external audits, the energy manager could be confronted with some energy goals failures due to non-conformities. This aberration from the future expected targets could be flattened out if some corrective or preventive actions will be taken (BSI Standards Publication, 2012).

IV. Act phase:

The last step before this circle process ends up to the first stage and is called Act Phase and involves management reviews of planned internal and external reports pertaining to the performance of the energy management program. It is important for an enterprise to identify the missed hotspots and to act upon them to become energy efficient (BSI Standards Publication, 2012).

In a general context, the result of internal or external audits, monitoring and other checking process almost always reveal that energy is poorly managed in the industrial area. An energy efficiency gap could happen because of the low implementation energy efficiency measures. Simultaneously disclose that the important barriers impeding the implementation of cost effective energy efficiency technologies or measures in the surveyed firms principally stems from rational behavior economic barriers, which are deeply connected with the lack of government frameworks or enterprises have the tendency to sweep the problems under the carpet.

3.5. TECHNOLOGIES APPLIED FOR ENERGY EFFICIENCY AND CARBON FOOTPRINT REDUCTION

In large industries, energy efficiency can be improved by three different approaches as the next below:

a) Energy savings by management
b) Energy saving by policies/regulations
c) Energy saving by technologies

(Abdelaziz, Saidur & Mekhilef, 2010)

Although the first two have been analyzed sufficiently, on the last one, some additional information is considered vital. Thinking of the increase digitalization of the industrial sector, new requirement and approaches toward industrial building construction or renovation have become an obligation. Especially in the EU industrial market, which shows off a good ecological footprint, is unacceptable to hold out on these changes. In energy efficiency direction, three cores upgrade targets of the building envelope, technical building equipment and sustainable building systems are the most common. In a few words:

I. Firstly, a modern envelope with the latest architectural solutions for insulation, sealing windows and facades or,
II. Secondly, lighting, heating, hot water, ventilation and building automation system are essential to go ahead or,
III. Lastly, as energy efficiency is an element of sustainability, the building construction and operation works under a "Cradle to Cradle" design principle including a renewable energy integration, optimized water management, daylighting, air quality, enhancement of stakeholder's well-being etc.

(Federal Ministry for Economic Affairs and Energy, 2015 · Federal Ministry for Economic Affairs and Energy, 2019 ·EE-Highrise, n.d.)

Nonetheless, there is no dilemma with which one should someone deal the most, the more, the better. Currently, a plethora of available techniques divided into low, moderate or major cost can be proposed and applied in any kind of industrial plant to attain the desired targets. The proposed solutions are foremost accompanied by introducing intelligent systems and secondarily by a gradual changing of staff bad habits. One of them or more together are commonly applied by industrial companies producing significant amounts of products for the mass market or locally, for the purpose of keeping competitiveness in high levels by radically minimizing the cost production. Broadly speaking, all the methods as mentioned earlier are proper to count on them in the primary stage and also good enough for the later stage (action stage).

Notably, the large and medium-sized companies' use a number of technologies which suit them very well and have good economic and technical prospects. If they are not applied in the first place, they could be used as a second line of defence against non-conformities and might help to overcome possible deviations.

Namely, some of these methods are:

i. Keeping low the evaporation rates
ii. Recovering energy from any possible source (i.e. Vapor)
iii. Energy storage systems
iv. Mechanical filters
v. Automation systems
vi. Using variable speed drives
vii. Power generation from renewable energy sources
viii. Power factor correction
ix. Reducing start up time for boilers, conveyors etc.
x. Energy efficient equipment and appliances
xi. Often perform maintenance of electromechanical equipment
xii. Environmental friendly raw material
xiii. Waste material treatment
xiv. Training staff (seminar)
xv. Collaboration between companies to exchange ideas and knowledge
xvi. Take advantage of the surrounding environment (passive building design)

(Sturma, et al., 2013)

The proposed solutions fall into several cost categories, but as a general rule, the low-cost solutions are better to be implemented first before moving on the expensive alternatives.

PART B: METHODOLOGY – DATA COLLECTION

4. CHAPTER: RESEARCH METHODOLOGY

4.1. DESCRIPTION OF THE PROBLEM

To restate our research problem, it will provide us with useful information about the unsolved question of high emission of unwanted greenhouse gases due to the undesirable energy leakage occurring in any phase of the production procedure. This will bring out some concerns and explain the rationale behind this study case. The increase of the production and the financial benefits ensue from the energy efficiency upgrade is where this study emphasized the most. To back up this assertion, based on internal performance tracking data, on average, a decent amount of energy misses out every year is presumed to be found.

A pivotal point in the choice of subject was firstly the researcher's personal interest in this type of environmental and company upgrade. Another reason for the topic selection was the personal involvement in this specific medium size enterprise as an employee, where energy intensive tasks taking place, structural and production gaps are offered for improvements and the necessity of a multidimensional probe of the economic, technical and ecological aspects to be fulfiled.

4.2. RESEARCH OBJECTIVES AND RESEARCH QUESTIONS

This thesis aims to:

- Identify in which way does the energy use and the carbon footprint affect public opinion today and try to indicate the future impact.
- Specify or indicate the level of energy and carbon leakage of specific potential and scale business.
- Highlight the energy leakage and point out where and in which way can be spotted.
- Indicate how the under investigation company should manage the findings in order to become more sustainable and mention actions can improve the production/commercial processes to achieve the goal of reduced energy consumptions and waste.
- It will give prominence to the available techniques and innovative ideas in the field of renewable energy sources and green buildings design be combined so that a better result can be achieved.
- Finally, will emphasize on the economic, technical and ecological impact of the best case scenario, where all the proposed solutions are implemented.

4.3. METHODOLOGICAL APPROACH TOOLS

The qualitative case study methodology, chosen as the research method, provides the tools to study complex phenomena within their contexts. When the research approach is applied accurately, it becomes a valuable method to develop thorough a theory or evaluate a program, and then to develop well-pointed interventions (Baxter & Jack, 2010).

The information acquired using qualitative data collection methods can be utilized to discover new ideas, opportunities, and issues, test their worth and accuracy, formulate forecasts, explore deeper a particular field more, and explain the numbers gathered up using quantitative data collection techniques. This information is not estimated using hard numbers so charts and graphs can be created, but they do not close the door on them, something that serves our cause. They pose and at the same time answer the question "*why*" and are open-ended until further research one day will be conducted. In general, the qualitative research data is suitable for theorizations and hypothesis development for the company energy profile gaps and concurrent afford an initial understanding of corporation energy efficiency concepts.

Ultimately, qualitative data are meant to generate through the following methods:

- Texts and documents
- Images and symbols
- Observations and notes

(Pickel, 2019)

The methodological approach tools for carrying out the study grouped as follow:

1) Read background material
2) Observation and unobtrusive data collection, similar to a preliminary industrial energy audit, to record all the potentially important information:
   All the factors determine the manufacturing process from the hot water needed to the paper recycling will be taken into account.
3) Exploitation of business-ready material (publicly available or not).

In brief, the main milestone phases of our research will include: estimation of the background energy footprint and carbon footprint in a selected company / commercial building / industrial building, analyze the re-design plan, its characteristics, suggested improvements, expected results, then follow a Cost-Benefit analysis of suggested options, estimation of carbon footprint reduction from suggested options, estimate the new energy & carbon footprint combined from all sources and improvements and an estimation of energy and money savings.

4.4. COST BENEFIT MODEL AND FRAMEWORK

A key objective of this study is to compare the costs and benefits of a future intervention to lead some positive changes, but this must be by any mean financially viable.

The cost-benefits analysis (CBA) aims at identifying and valuing the impacts of a project in terms of their effects on social well-being, comparing the positive effects (benefits) with the negative effects (costs).

The essential theoretical foundations of CBA are:

- Costs and benefits (money spent versus energy saved) are declared in monetary terms to make comparisons.
- The present value of benefits must exceed the present value of costs.
- The gradual methodology is adopted (comparing the scenario with the implemented changes with a counter factual baseline scenario without the implemented changes).

As long as there is no “standard” format for performing a CBA, some core elements are often presented across almost every analysis. By using the most well fitted structure of our situation or sometimes by using commercial tools a right end result for safe decision can be produced. Targeting a broad view of costs and benefits the below points illustrate the general steps characterize the process:

1. Set up a framework to summarize the parameters of the analysis: An accurate analysis requires first the establishment of a framework based on the under examination company. In the present case the main goal and objective trying to address with our enhancement proposals, in order to be successful has to cover two basic needs. In the first place should be financially viable for the enterprise and at the same time should lead to a noteworthy energy use reduction that lead inevitably to an environmental friendlier image of the company. A common tactic is to establish a “common currency” to compare more accurately those two. For instance, € spent/CO2 avoided.
2. Detect all costs and benefits so they can be arranged by type, and intent: This step it is essential to go beyond the obvious. Except of the direct costs, other cost categories you must account for, if arise from the propose changes, can be: indirect costs, intangible costs that are difficult to quantify like reduced customer satisfaction or improved employee morale. Lastly, some opportunities cost happens due to the new strategies.
3. Assume lifetime of the project/initiative and then calculate total costs and benefits: Depending on the circumstances and the kind of system or strategy willing to apply the lifetime should be accordingly predetermined.
4. Make a comparison of cost and benefits by utilizing the aggregate information: After that, tally the entire value of benefits and costs. A simple assessment of cost-benefit and project

decision without running back to the framework step does not deem as correct. If the goals marked are successful, then it is ok to proceed further, if falling short, then alternatives have to seriously be considered. As an example same amount of capital investment could bring better environmental results, when plowed into a different technology.

5. Analyze the outcome and make some final recommendations: As a last step, a short comment about the results and recommendations to improve them is always welcomed.

(smartsheet, 2020 · European Commission, 2014.a · Harvard Business School Online, 2019)

Our focus will be on the financial analysis, including the investment cost after the proposed measures, the operation and maintenance cost (O&M) and the revenues from the energy-efficient consumption. In addition, the economic analysis comprising the produced social benefit analysis, which are mainly linked here to the CO2 emissions in tonnes of carbon dioxide equivalent (tCO2e).

Also for a better performance of a CBA, some preliminary methodology choices were made:

i. The reference period considered in this analysis is adapted by case to the minimum of the years anticipated the system to last, so as to evaluate the environmental and economic effects during the system implementation as well as its good expected outcomes after the implementation.
ii. The residual value is set at zero since it is assumed that at the end of the reference period the new installations and machines will have given almost all their potential, thus the market worth will be insignificant.
iii. A correct social discount rate the investment is crucial and Lurse estimated a social discount rate for Germany banks finding that a 2.33% p.a. in 10 year average rate would be appropriate. Although, better regulation guidelines state "*the recommended [real] social discount rate is 4%*".

(European Commission, 2014.a & European Commission, n.d.)

5. CHAPTER: DATA COLLECTION

5.1. DATA COLLECTION CHRONICLE

Data were collected during the spring semester of the 2019/2020 academic year. One of the very first steps was the preparation of a checklist with all the materials considered valuable for our study. With this in hand, i got in touch with the head of the department, who is responsible for managing topic related to the building operational qualification. After giving us the necessary permission and after agreeing wth all the terms and procedures to be followed, he gave us access and let us keep a record of the useful information in order to evaluate better the operational conditions of the company.

Beside with data for the period of our interest before and during the audit, other energy historical and production data have been collected before the beginning of the walk through audit process.

More specific,

I. Energy bills and invoices for the last 2 to 3 years,
II. Monthly production data for the last 2 to 3 years,
III. Architectural and engineering plans of the plant and its equipment,
IV. General information about the plant (year of construction, ownership status, renovations, types of products, operation schedule, operating hours, etc.)
V. Status of energy management and any energy-saving measures implemented

After a preparatory review of the data gathered, one test audit was conducted. Identify the parts of the enterprise should be examined and have a general picture of the plants energy use, operation and energy losses. After giving a final form and refreshing the key points, the main audit was ready to go underway. At the suggestion of the head of the department, the preliminary audit took place one day, where the company was in full operation. The production process and energy consumption were subtly documented.

5.2. DATA COLLECTION, OTHER PROCEDURES AND GOALS

First, as earlier explained, the direct observation is one of the most passive qualitative data collection methods, whereby the data collector can take a more participatory stance, watching and meanwhile taking down notes, photos, and so on. Always hoping for the best possible and unbiased record keeping, without affecting the naturalness of the actions being observed. Secondly, the content analysis embodies data that are already available and supports the primary hypothesis. Various documents from different sources, to be more reliable, are meant to be used in this case, such as expert research articles, approved government reports, and online data sources. All this information will be cross checked with the data acquired from the company under investigation and will complete the puzzle of carbon footprint and energy efficiency correlation.

A brief chronicle of how do the data have been gathered will be provided in the next chapter.

Our intention is to include in the data underneath:

I. All energy sources used by the company and their billing data over a set period.
II. Electricity loads for the inner workings like goods manufacturing, cooling loads, hot water needs and gas for heating.
III. Information relating to hot water systems and space heating and cooling.
IV. Lighting appliances used within the property (interior and exterior). Space occupancy raises the energy required.
V. Electrical appliances used in both kitchens.
VI. Number of people and their working hour. Energy demands in proportion to their office duties and their daily routine at work.
VII. Company optional amenities and their loads (here dressing-room).

VIII. Departments of the company and energy requirements originate from their tasks (PCs, air-compressors, lacquering of printed circuit boards or test equipment, indoor air system, data server, etc.).

IX. Physical characteristics of the building, type, size, material, roof type and shape, windows and indoor climate.

X. Surrounding environment description (vegetation, other buildings).

XI. The materials go for recycling or discarded (paper, shipping box, broken electrical goods of the -company, garbage's, montage metallic pieces, spare cables, plastic and glass parts).

XII. Old Energy performance certificate or EPC (if existing)

(Ambrose & James, 2017)

After that point, the main idea of an energy audit will be followed, but with a different way of execution in harmony with our case study (Hasanbeigi & Price, 2010 · CIPEC, n.d.). An overview of the adapted to my needs industrial type audit, planned to be held includes the following steps and their substeps presented in figure 16 below:

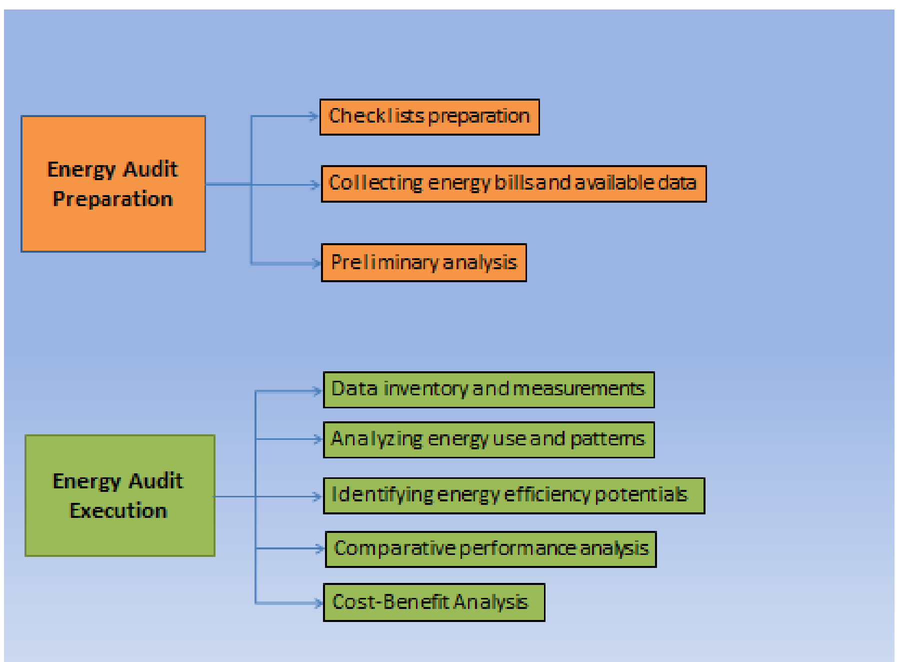

Figure 16: Overview of industrial type energy audit planned to be conducted

All previously presented, comprise the steps of a shorter and partially completed audit, because my energy audit part, will end up at an earlier point or better articulate it will skip some steps. For the purpose of making our points more obvious, the steps given above are concisely laid out in the next table 01:

	Checklist preparation	Collecting energy bills and available data	Preliminary analysis	Data inventory and measurements	Analyzing energy use and patterns	Identifying energy efficiency potentials	Comparative performance analysis	Cost-Benefit Analysis
Description	Preparation of an audit checklist helps us to conduct a systematic and consistent audit include steps to be taken for the energy audit.	Historical data collected at the beginning of the process	It helps to better understand the plant by providing a general picture of the plant energy use, operation, and energy losses.	Is one of the main activities of energy auditing. Without adequate and accurate data, an energy audit cannot be successfully accomplished.	The load requirements of all the electricity-using equipment in a plant, it can be useful for determining the characteristics of the power requirements and for understanding the power supply economics.	There are various energy systems that can be found in almost all industrial plants such as motor systems, steam systems, compressed-air systems, pumps, and fan systems. These are so-called "cross-cutting" technologies.	Past performance vs Best Practices: qualitative comparing against certain, established practices or groups of technologies considered to be the best in the industry.	For further information, refer to sub-chapter 4.4.
Data required	Data and information needed, required measurements, basic equipment to be assessed, list of sections should be included.	Energy bills and invoices, monthly production data, architectural and engineering plans of the plant and its equipment, status of already existing energy-saving measures and general information about the plant.	This effort provides enough information to undertake any necessary changes in the audit plan.	Some data are readily available and can be collected from different divisions of the plant being audited. Some other data can be collected through measurement and recording.	Load/Demand profile Electricity loads can change over time based on changes in end-user demand.	Cross-cutting technologies that can be further analyzed if applicable or not.	Past performance vs Best Practice tables	For further information, refer to sub-chapter 4.4.

Table 01: Preparation for the energy audit and energy audit execution steps

PART C: CASE STUDY IMPLEMENTATION - ANALYSIS - RESULTS

6. CHAPTER: CASE STUDY IMPLEMENTATION

6.1. COMPANY PROFILE AND BACKGROUND

The research sample will be an international company comprised of over 150 employees located in North Germany and its professional portfolio includes, but is not limited to aircraft cabin electronics, comprehensive electrical engineering services, electronic design, and certification services. Beside the manufacturing products, services and other challenges handling in the aviation sector is also developing products enduring success in the maritime sector. The headquarter is in the technology park directly adjacent to the Bremen Airport, where the majority of the production process occurs. The twin buildings sheltering the company, and the energy consumptioned will be under examination. The prevailing climatic condition is moderately continental characterized by cold winters, with average daily temperatures around 0 °C (32 °F) or slightly above, and warm summers, with maximum temperatures around 22/24 °C. Bremen is slightly milder, but it is also rainy and windy because of the influence of the North Sea (maritime climate) (Climatestotravel, n.d.).

The twin buildings consisting of two floors and are split into different departments. The first floor shelters mainly offices for the engineering, sale, administration and some other departures too. One main kitchen, one ancillary and six restrooms. In addition, the ground floor shelters

primarily the manufacturing department, depot, the management and development departments, some auxiliary rooms (for servers, heating system, and ventilation system), four restrooms and two dressing rooms.
In the near term, the European Union countries will keep up to lead as providers of electrical and electronic goods. Between 2000-2008, a steady increase has been observed and struggling to remain competitive in the long run, but with the strong competitiveness coming from the Far East like China and Japan or South Korea is expecting a further loss of market ground. On the electrical good sector, the impact on the environment tend to be smaller and energy efficiency is much less of concern, hence the statistical probability of ferret out tremendous energy leakage is also minimal, nonetheless still important (European Commission, 2014).

6.2. DATA EXPOSITION

After the company profile description, the next step will present some basic information and other official documents provided by the company over the current condition of the company looking back at the past. Almost, over a year ago, to have a retrospect of the energy needs of the company and down the road to correlate all the data exposed here with the refine scenario and put the business plan for the sake of the environment together.

To get started with the data exposition, the planting plan illustrates the grounds of the enterprise and its surrounding environment (Appendix A.1.). The plan demonstrates that the company already cared about the nearby vegetation and beside the necessary parking spots has planted different types of tree species, something that is always a plus for the company`s eco profile.

Also, right below, a site plan of the buildings (Lageplan), a report of the building operation (Anlage Betriebsbeschreibung) and an urban planning have been provided (Städtebauliche Kennwerte) (Appendix A.2.). The useful information that can be tracked down is the operating time (Betriebszeit) between 07:30 and 18:30 daily, except weekends. In addition, the operational activity (Tätigkeit), which is design and development and manufacture of aeronautical systems. The type and quantity of substances used in the company (Art und Menge der beim Betrieb verwendeten Stoffe) are circuit boards, cable and housing made of metal. The operational waste (Betriebliche Abfallstoffe), which are purely solid and presenting a short description of workrooms and social rooms as well (Arbeitsräume and Sozialräume). Finally, the urban planning provides information like the gross floor area (Bruttogeschossfläche) of the ground floor (Erdgeschoss) and upper floor (Obergeschoss), which for both are 2,544.76 m² (1,272.38 m² each). The total gross room volume for the whole building is 10,051.80 m³ and a breakdown of the area per working room (Flächennachweis) and also two more ground plan drawings of the first (A.3) and ground floor are given (A.4).

Moving on, the electricity consumption and cost as statistically gathered by the company for the last 5 years (Appendix B.1). This short analysis, displays the electric energy needs of the company and the capital spent to cover that fundamental need. The consumption and the price as well go up and down, but at the end of every year the final consumption turns out to be at the same level. For example, in 2018 the energy consumption was measured at 261,340 kWh and cost 43,912€ or in 2019 was measured at 263,404 kWh and cost 50,516€. Beside, an information feature of exceptional interest, is the electricity load profile measured every 15 minutes in a typical working day (B.2) showing that energy is also absorbed outside of the working hours due to background processing, stops rarely running (company server, pcs, fire and security systems etc.). In the end, it is presented the consumption of natural gas and the occurred cost during a one year period from 04/2018 until 04/2019 and measured at 121,138 kWh purchased for 5,558.31€ (B.3).

Moreover, it has been provided a layout diagram of the light fixture and a photo of the fluorescent lamps that will concern us later (Appendix C.1). The right choice of windows and insulation material type and of course form, offers good thermal insulation and constrains the heat exchange between the inside and the outside environment. Therefore, the U-value (defines the heat loss of the buildings, which should be as close as possible to zero) is illustrated for the external walls and windows (C.2). Right below, an annual energy demand evaluation report (C.3) and the overall energy needs per month (C.4) have also been provided, indicating the good thermal factor of the company.

Other information or supplementary notes worth mentioning are the below listed:

- The hot water needs are covered by small electric water heaters under the kitchen or bathroom sinks (Appendix C.5). Hence, no extra data could be collected.
- The recycling segregation process followed by the company is to divide the paper, plastic, glass and rest garbage's in different bins. Additionaly, existing two bins only for photocopies and other documents. Lastly, the manufacturing department doing electronic scrap recycling and small diameter cable recycling. As a rule the faulty materials are given back to the suppliers.
- Unlikely, data like monthly or annual quantity of goods manufacturing has not been given by the company. The same holds for any information related to capital gains, even though the sale of the products or other engineering services offered by the company. Thereby, the link of energy saving measures to the product or gross profit to develop metrics is not feasible (e.g. kWh/sold products, GJ/annual gross profit, etc.).
- The cooling load is a part of the electricity load profile (Air-Condition) and no extra load profile is available.
- The kitchen appliances (fridges, microwaves, dish machines and the electric ovens) are all up to date and of high energy class.
- No extreme heat or other energy leakages during the manufacturing process could be identifed. Processes like burn-in (electrical stress test of products), lacquering of printed circuit boards, the high voltage test or even the simple function tests absorb a descent amount of electricity, but there is no big room for improvement there because they are all of them already automatize.
- No energy performance certificate was available.

7. CHAPTER: ANALYSIS AND RESULTS

A benchmarking involving the energy efficiency of a company is intended to assess the energy performance relative to its own past performance or even against competitive companies. Yet another target has been the assessment of the energy performance improvement after putting into action the improvement measures. This section of the study brings into a clear view of the facility-level that allows managers to prioritize poor performance practices and make them consider their option for more attractive enterprise transformations. This benchmarking is available in several ways and the methods would be applied on the basis of company realm or scale and may be:

- Internal or Past performance: Make a comparison of current versus historical performance.
- Industry average: Make a comparison using an established performance metric, like the average performance of a peer group.
- External or Best in class: Make a comparison using not the average, but against the best in the industry market.
- Qualitative or Best Practices: Make a qualitative comparison against certain, established practices or groups of technologies deemed to be the best in the industry.

(Hasanbeigi & Price, 2010 · US EPA, 2010)

In order to stand behind the idea aspire to prove, the most fitting benchmark will be the best practice method/qualitative method to have a yardstick of energy performance in this specific type of company, which constitutes the backbone of the study and simultaneously achieving a very good connection between literature review and case analysis.

7.1. BASELINE SCENARIO OF CURRENT SITUATION

Building up an energy use and energy intensity baseline pattern is a significant method, to begin with the management of the corporate energy. This enables us to create a baseline for making a year after year efficiency investment return. Hence, all the information collected will come now in handy and the minimum energy performance of the last 12 months will give us the starting point for setting energy improvement objectives just as a comparison point for assessing any future endeavour that upgrades the overall energy consumption performance.

As a rule, a key point of a baseline diagram can be the calculation of the total reductions in energy consumption, including kilowatt hours per year and cubic feet of natural gas per year, which in this case is the best applicable too.

Important Notes:

1. The average electricity industrial tariff in Germany was almost 16 ct/€ per kWh (see also figure 17).
2. One cubic feet of gas is equal to 0.29 kWh (1 m^3=35.3147 ft^3).
3. Natural gas price for business purposes in Bremen and customers with an annual consumption up to 150,000 kWh is net 0.0513 €/kWh and the gross price is 0.061 €/kWh (SWB Erdgas plus).
4. The average emission factor of CO_2 in Germany is 0.560kg CO_2 per kWh.
5. Average natural gas CO_2 is 53.06 kg per mmBtu or 53.06kg per 1mcf (1,000 cubic feet) and by burning natural gas is 0.185 kg/ kWh.
6. Each tree is assumed to absorb 23kg of CO_2 throughout its life.
7. Metric units of CO_2 in Kg/kWh saved to identify the environmental profits.

(Nelson, 2017 · Amelang, 2019 · US EPA, 2014 · SWB, 2019. · CarbonIndependent.org, 2019 · Norsk olje&gass, n.d.)

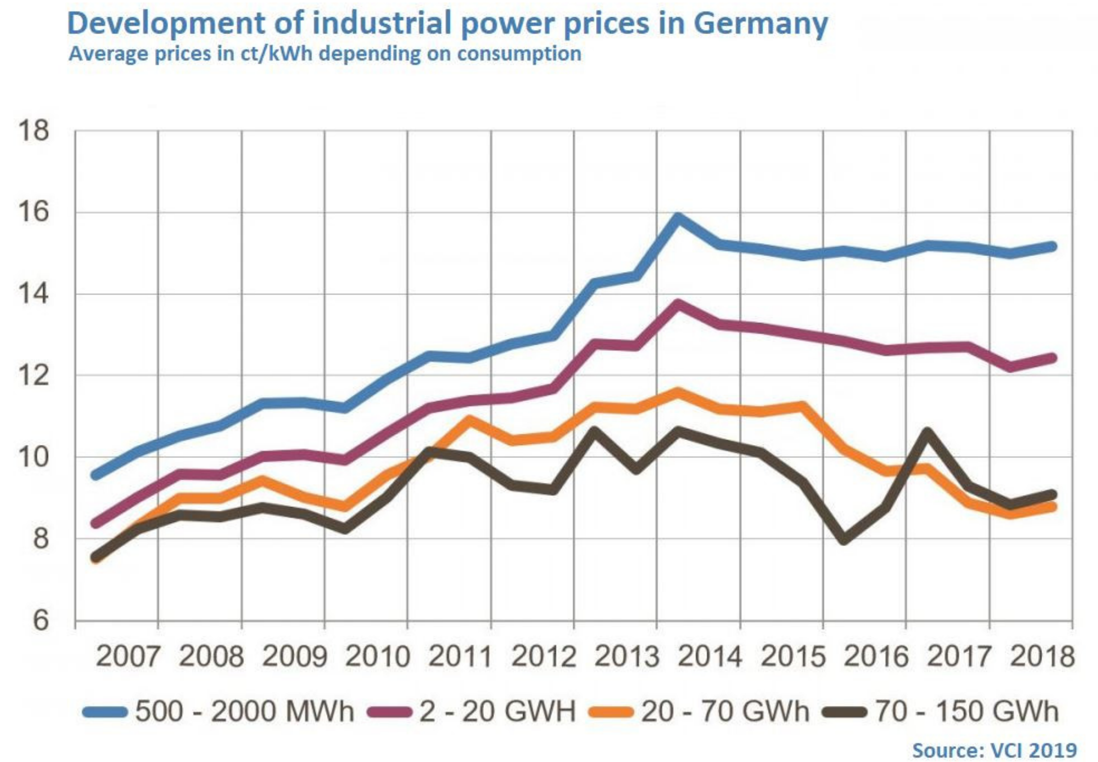

Figure 17: Industrial power price in ct/kWh in Germany 2018 (Amelang, 2019)

Having a deep understanding of the current condition encountered in this business, leads us to deal with the high amounts of energy utilized for heating in the form of natural gas or the large amount of conventional electricity used for diverse in-company activities and more pointedly the lighting system and a partial electricity self-sufficiency.

7.2. ALTERNATIVE SCENARIOS PROVIDE BETTER ENERGY EFFCIENCY

As stated in chapter 6.2., the production processes following the company does not hide out any extreme energy loss and for that reason, the attention will be focused on green energy production solutions (weak scenario 2 and strong scenario) and secondary on an energy building saving measure (weak scenario 1).
The case study is split into two parts, the technical part with appropriate energy performance indicators and the economic part consisted of a financial profit analysis, which is obviously coupled with the technical part. This way, is much easier to put in order the calculation needed

so that the project objectives can be carried out. By adjusting the baseline scenario and proposing two alternative scenarios, one weak constraint and a second stronger constraint, will give a more realistic-look of the connection between energy, cost and as a natural consequence the proportional reduction of CO_2.

The weak scenario, pursue the economic development of the company, but achieving in meanwhile the energy saving and emission reduction plan formulated by us below but with a more moderate implemented solutions. The target is, through some low cost ideas to reduce energy consumption by 1% every year for the next 10 to 20 years. Under the strong scenario, the changes should not be financially unattractive, and some more "aggressive" methods will be practiced aiming a total reduction of 2% every year in the long run, again in 10-20 years. The reference time point, which all the progress is measured is the baseline year and the financial investigation will be based on the German tariff rates as the subject of examination is located and do foremost business with other German firms (Li & Dai, 2019).

7.2.1. Technical analysis

Weak Scenario:

All the changes proposed further down on one side will bring a slight improvement in the overall energy requirements of the company and on the other side are financially affordable. The three upgrades were thinking to use, are given below:

1) ***Replacement of all fluorescent bulbs to high efficient led lamps*** **(conventional electricity reduction)**

To start, the choice of LED lamps for office use instead of the older technology of fluorescent hanging on the ceiling tile has plenty of advantages. First of all the efficiency of the LED lamp ranges from 37 to 120 Lumens/watt or even more as the technology is continuously developed, when the Fluorescent has 50 to 100 Lumens/watt. Secondly, they characterized by great lifespan range from 25,000h to some cases 50,000h before the lamp replacement (payback investor over time), when the typical fluorescent have an average lifespan of 7,000h to 15,000h. Another pro of the LED is the ability to turn on/off without flicker and instantaneously respond. The only category of LED lighting is not taking the lead is the buying cost. A fluorescent depending on the technology costs 2€ to 30€ for 100w, when the LED lights require for the same rating 10€ to 20€ (StouchLighting, n.d.).

The company has the commonly used 4-ft-long tubular lamps of 8/8-in diameter (T8 type), which could be replaced by the T8 linear LED lighting system. Comparing to the fluorescent and according to several studies, a 40% energy save can be achieved having numerous positive side effects like better visibility, mood effect, color appearance and of course work performance (factors that are not here easy expressible in numbers). Last but not least, factoring in the potential of fluorescent lamps to emit toxic gases when discarded, the frequency of replacement and the much lower efficiency, tend to emit up to 60% more CO_2 emissions in comparison to the LED solution (Goonasekara & Kjaerboe, 2012).

Unfortunately, the exact energy absorbed by the fluorescent lamps cannot be monitored because we have at our disposal only the overall electricity consumption in a year. In order to back up our assertion, the space analysis of both buildings will be used to hazard a guess of the lamp units require replacement and then to estimate the energy saved and at a later point to conduct the financial and cost benefit analysis. Hence, (Table 02):

LIGHTING	
Total area of both buildings	2 x 2,544.76m²=**5,089.52m²**
Area might use fluorescent units	**4,000m²**
Average Lumen required per m² (office)	**500 Lumens**
Total Lumens	**2,000,000 Lumens**
Maximum hours of lighting needed in a year	4h x 240days=**960h**
Typical T8 Fluorescent Unit Consumption	3x32w=**96w** (3x2,500lumens=7,500)
Fluorescent Units of 96w required	**266 units**

Fluorescent expected annual consumption	**24,515kWh**
Fluorescent Lighting Cost	0.21€/kWh x 24,515=**5,148€**
Typical T8 LED equivalent lamp	3x17w=**51w** (3x2200lumens=6,600)
LED Units of 51w required	**303 units**
LED expected consumption in a year	**14,835kWh**
LED Lighting Cost	0.21€/kWh x 14,835kWh=**3,115€**
Energy Saved	**9,680kWh**
Proportional Energy Saved	**39.5%**
Money Saved annually	**2,033€**
Proportional Money Saved	**39.5%**
CO2 Avoided Annually	9,680 kWh x 0.56kgCO2/kWh**=** **5,421kgCO2 or 5.421 ton**

Table 02: Lichting analysis (Jappah, 2018 • Bristol Sparky, 2020 • Stravoravdis, 2013 • StouchLighting, n.d. • ShineRetrofits, 2017 • Jayaweera, 2014)

2) Solar thermal system for space heating (conventional gas reduction)

Especially in winter the demand for space heating is essential to achieve the best possible thermal conditions for the employers, and as the summer is coming closer, this need is slowly declining. The rooftop has enough space to ‘‘host’’ the solar thermal collectors to back up the existing gas system during the cold winter months (see also strong scenario relevant analysis). Usually, a typical close loop installation for a solar thermal project in a house or a small scale company includes the following basic components:

1. **The solar thermal collectors**. Divided into three subcategories the flat-plate collectors, the vacuum flat plate collectors and last but most expensive version, the vacuum pipe collectors. Undoubtedly, it is one of the most important parts of the system and should carefully be chosen according to the expected results.

2. **The storage tank**. The second component beside the solar collector is considered very important, since solar energy is a time-dependent energy solution. The energy needs cannot easily synchronized because the most demanding periods are during the nights. As a rule, the absence of sun automatically creates the need for energy storage until the energy needs meet the substantial share. For the majority of solar thermal systems, the sensible heat of stored water is preferred.
3. The next and vital component is the **heat exchanger**. This mechanical device is useful for thermal energy transfer and commonly used at different temperatures between a solid surface and a kind of fluid or solid particulates. However it is used mostly, as a heat transferring method between fluids without any other interaction like external heat. In addition, the performance should be as high as possible, with very low pressure and in case of storage tanks frequently is used as an internal component (spiral form).

(One Community, n.d.)

Some small components will also be used, like hot water mixing valves, safety valves and air eliminators to avoid the negative effect on the mass flow of the system. Additionally, some pumps, safety valves and a central electronic controller (AEE INTEC, 2009). The previously described components are represented in the next schematic diagram (Figure 18). Of course, there are always some smaller components, but there are not playing a crucial role in the system being relatively cheap (for example mounting material like screws, metallic bases etc.). Regularly, a commercial system nowadays offers daily during the winter, water with temperature about 50°C, which is enough space heating, with a maximum of 55°C are required for a radiator thermal system at design weather conditions (Radson, 2012).

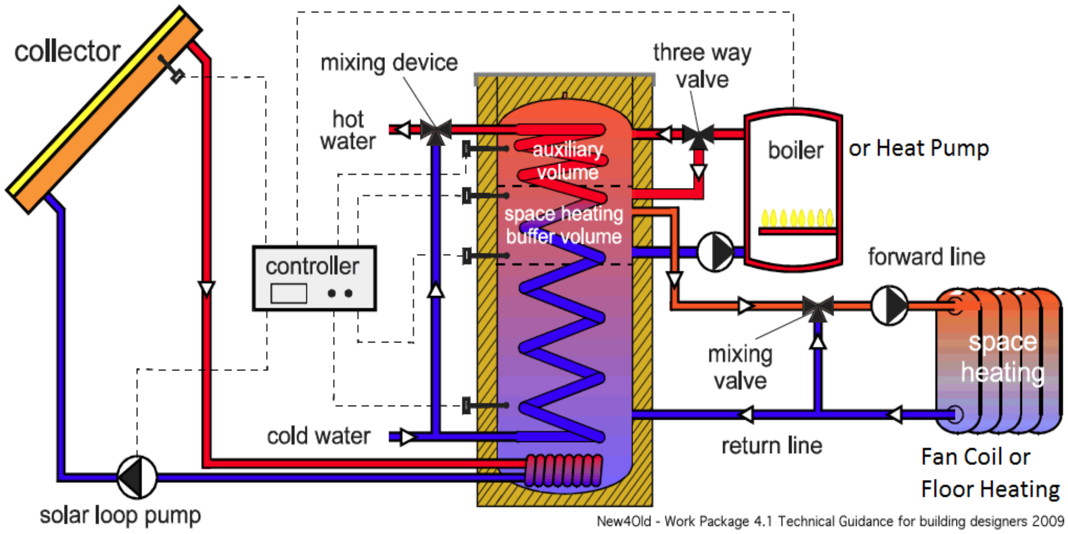

Figure 18: Schematic diagram of the basic components of solar thermal system (Net Green Solar, n.d.)

After the first step, the analysis regarding the heat loads of the company dependent on time will make obvious, how big are the demanded loads and which time of the year what percentage will contribute the solar system to the total calorie consumption needed. A basic thing to know before any further analysis is the analogy between the electric KW to thermal Kcal/h:

kW= 0.001163 x Kcal and Kcal= 859.84 x kW

The buildings thermal insulate is at normal level because of the construction, which is build up some years ago. Important also for the calculation is considered the perimeter around the building, which is free of obstacles like walls and other buildings meaning bigger indoor thermal factor. Finally, the height from the floor to the ceiling in the ground floor is 3.1m and in the first floor is 3.3m. Presuming that not the entire place requires heat, after obtain the space sizes given by the company, the area requires daily heating:

Ground floor both buildings: 730m^2 x 3.3m x 2 buildings=>4,818m^3

First floor both buildings: 580m^2 x 3.1m x 2 buildings=>3,596m^3

Thus, 8,414m^3 of total 20,103.6m^3 (10,051.80m^3 total area of each building).

In order to calculate the final calorie consumption per hour we could use the following equation:

V x K x C = Kcal/h

V= size in m³

K=Thermal insulates factor (2.5 for normal insulate, 2 for very good and 1.5 for excellent insulate)

C=target temperature in comparison with the external ambient temperature (worst case scenario)

And as an example: 8,414m³ x 2 x (21°C - (-3)°C)= 302,904 Kcal/h

To make this more accurate, based on the average temperatures in the city according to google weather, the following table (table 03) was created:

	TEMPERATURE MIN (°C)	TEMPERATURE MAX (°C)	WORKING HOURS PER DAY (HEATING)	WORKING HOURS PER DAY TOTAL (h)	V (heating spaces size) 8414m³	K (Thermal factor)	C (Temperature Diference) Target Temperature-Mean average Temperature	Demands during working hours (Kcal) V x K x C = Kcal / h	Kcal per month needed (Kcal/h*hours*work days)
MONTH							*i.e. 21°C - (Max temp+Min temp/2)*		
JAN	-1.0	4	07:00-16:00	7.5	8,414.00	2	19.5	328,146.00	49,221,900.00
FEB	-1.0	5	07:00-16:00	7	8,414.00	2	19	319,732.00	44,762,480.00
MAR	1.0	9	07:00-14:00	6	8,414.00	2	16	269,248.00	32,309,760.00
APR	3.0	13	07:00-12:00	4	8,414.00	2	13	218,764.00	17,501,120.00
MAY	7.0	18	00:00:00	0	8,414.00	2	n.a.	n.a.	n.a.
JUN	10.0	21	00:00:00	0	8,414.00	2	n.a.	n.a.	n.a.
JUL	13.0	23	00:00:00	0	8,414.00	2	n.a.	n.a.	n.a.
AUG	12.0	23	00:00:00	0	8,414.00	2	n.a.	n.a.	n.a.
SEP	9.0	19	00:00:00	0	8,414.00	2	n.a.	n.a.	n.a.
OCT	6.0	14	07:00-12:00	4	8,414.00	2	11	185,108.00	14,808,640.00
NOV	3.0	8	07:00-14:00	6	8,414.00	2	15.5	260,834.00	31,300,080.00
DEC	0.0	5	07:00-16:00	7.5	8,414.00	2	18.5	311,318.00	46,697,700.00
								Annually energy for heating (Kcal)	**236,601,680.00**
								Annually energy for heating (Kw)	**275,167.75**

Table 03: Annual energy demands in Kcal and in kW

We shall not forget that the consumer needs are different from one person to the other and there are many of factors we that should take into consideration to approach the internal thermal comfort in working places. As a consequence, to regard those numbers approximate and as much as possible close to reality.

The next part of the project regarding the size of the install system and the energy yield that can offer proportionately with the working time of the installation seasonal and per day of work is going to be introduced. According to the consumer needs, during a cold winter day the energy demands on average get close to 492 kW so that the system can warm up adequate the water and meet the owner's expectations. Important notice, that for every kW given by the system we gain around 860 Kcal/h. That practically means, if we would like to achieve a minimum target of 50% solar thermal energy production by the collectors, the solar collectors must be the vacuum pipe collector type and the size of installed collectors should be coming up to 51m² (Northern Lights, 2017).

The climate in North Germany and the annual average irradiation having an optimal angle is about 1050 KWh/m² (Figure 19). The collectors planned to be used, on the one hand, are more expensive, but on the other hand, as the temperature differential between the ambient temperature outside and the operating temperature inside tending to be bigger this type of solar collectors become the obvious choice and offers an efficient up to 70% for water temperature at 50°C (Ahmad Al-Nimt et al., 2017) (Figure 20). Additionally, due to their cylindrical design they operate better with less reflection, especially in locations where the sun not only during the day, but also during the year has considerably angle changes (Figure 21). To continue the study, if a 102m² collectors will be installed on the building's rooftop with the optimal winter performance, then the system will contribute during cold winter months (December until February) an average about 1.44 KWh/m² and in the table above is visible, how much is the average contribute per month (Table 04):

	Average irradiance (KWh/m²)	System performance 70% for 50°C hot water (KWh/m²)	System contribute Kwh*51m² (KWh/m²)	Daylength and productive hours (h)	System contribute per day of use (KWh)	System contribute per month of use (KWh)	System contribute for heating (kcal)
MONTH							
JAN	1.23	0.861	43.911	7	307.38	9,528.69	8,193,146.23
FEB	2.1	1.47	74.97	8.5	637.25	17,842.86	15,342,004.74
MAR	2.81	1.967	100.317	10.5	1,053.33	32,653.18	28,076,513.30
APR	3.59	2.513	128.163	12	1,537.96	46,138.68	39,671,882.61
MAY	4	2.8	142.8	13	1,856.40	57,548.40	n.a.
JUN	3.67	2.569	131.019	13.5	1,768.76	53,062.70	n.a.
JUL	3.76	2.632	134.232	12.5	1,677.90	52,014.90	n.a.
AUG	3.72	2.604	132.804	11	1,460.84	45,286.16	n.a.
SEP	2.98	2.086	106.386	9.5	1,010.67	30,320.01	n.a.
OCT	2.1	1.47	74.97	8	599.76	18,592.56	15,986,626.79
NOV	1.33	0.931	47.481	7.5	356.11	10,683.23	9,185,864.18
DEC	1	0.7	35.7	7	249.90	7,746.90	6,661,094.50
					Total energy producted (kWh)	**381,418.26**	
					Total energy used exclusively for heating (kWh)	**143,186.10**	
					Total energy used for heating (Kcal)		**123,117,132.35**

Table 04: The system contributes during a year

For the creation of the previous calculation of the monthly effectiveness of the collectors a solar irradiance calculator has been used (Solar Electricity Handbook, 2017).

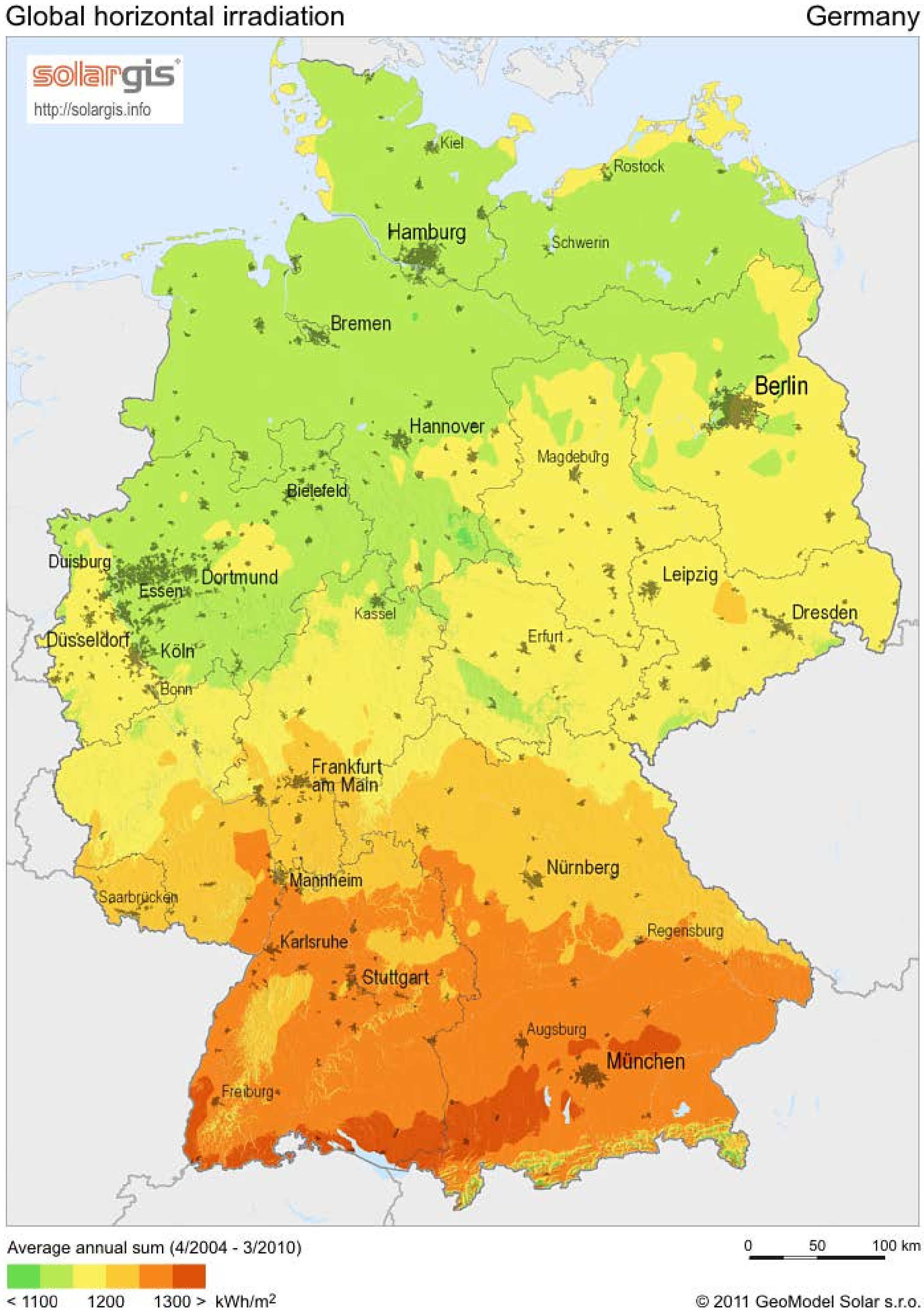

Figure 19: Annual irradiation Germany (Solargis, 2011)

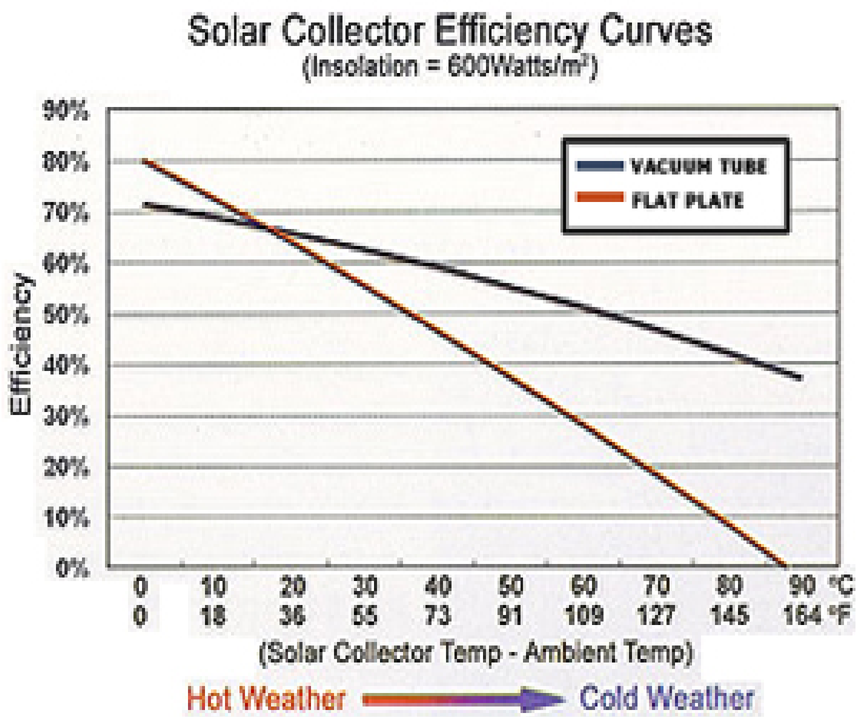

Figure 20: Solar collectors efficiency curve (Solar solutions, n.d.)

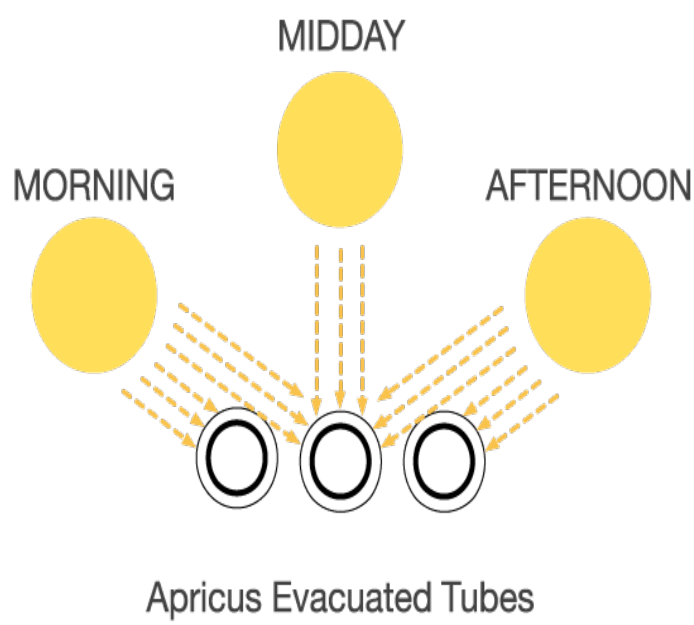

Figure 21: Evacuated tubes working principal (Apricus Solar Hot Water Systems, n.d.)

Matching of demands versus energy production and auxiliary system contribution:

Obviously, extra energy support from another source, other than the solar system, is required to satisfy the energy needs, especially in winter when solar energy is not stable. This source, for instance, is the already existing natural gas heater and this can be seen in the schematic diagram given above (Figure 18), where the gas boiler contributes to the system to achieve easier and at relevant times the right water temperature. In the following table is described the percentage of the power coming from the system and what part is coming from the auxiliary source in comparison to the demanded thermal energy (Table 05):

	Monthly needs for heating (Kcal)	Monthly contribute of solar system (Kcal)	Monthly contribute of auxilary system (Kcal)	Monthly needs for heating satisfied by solar system (%)	Monthly needs for heating satisfied by auxilary system (%)	Percentage of the solar system contribute, available for other hot water needs	Extra cost for natural gas in € kWh x price per kWh (€)	Total cost for natural gas without solar system. [Total needed Kcal ÷ (859.84 kcal x 0,0610€ per kWh)]
JAN	49,221,900.00	8,193,146.23	41,028,753.77	16.65%	83.35%	0.00%	2,910.72 €	3,491.97 €
FEB	44,762,480.00	15,342,004.74	29,420,475.26	34.27%	65.73%	0.00%	2,087.19 €	3,175.60 €
MAR	32,309,760.00	28,076,513.30	4,233,246.70	86.90%	13.10%	0.00%	300.32 €	2,292.17 €
APR	17,501,120.00	39,671,882.61	0.00	226.68%	0.00%	100.00%	0.00 €	1,241.59 €
MAY	n.a.	n.a.	n.a.	n.a.	n.a.	100.00%	0.00 €	0.00 €
JUN	n.a.	n.a.	n.a.	n.a.	n.a.	100.00%	0.00 €	0.00 €
JUL	n.a.	n.a.	n.a.	n.a.	n.a.	100.00%	0.00 €	0.00 €
AUG	n.a.	n.a.	n.a.	n.a.	n.a.	100.00%	0.00 €	0.00 €
SEP	n.a.	n.a.	n.a.	n.a.	n.a.	100.00%	0.00 €	0.00 €
OCT	14,808,640.00	15,986,626.79	0.00	107.95%	0.00%	7.95%	0.00 €	1,050.58 €
NOV	31,300,080.00	9,185,864.18	22,114,215.82	29.35%	70.65%	0.00%	1,568.86 €	2,220.54 €
DEC	46,697,700.00	6,661,094.50	40,036,605.50	14.26%	85.74%	0.00%	2,840.33 €	3,312.90 €
						Total cost with solar system	**9,707.42 €**	
						Total cost without solar system		**16,785.34 €**
						Heating Annual Profit	**7,077.91 €**	

Table 05: Solar system and auxiliary system contribute

The first thing should be marked in Table 05 is the drastic reduction in the gas consumption, something that has a corresponding amount of profit of **7,077.91€** per year, if we consider that the price of gas will stay fixed (a readjustment is more than possible at least one time per year).

The rest of the hot water does not use for heating could supply other hot water needs such as hand wash, for the dishwashers or direct dish washing in the kitchen and more rarely taking a bath. Especially during the summer months the hot water requirements will cover entirely by the solar collectors since the heating system does not absorb any energy. Another parameter worth mentioning is that during the weekend staying closed and the hot water according to hot water tank manufacture will lose around 1-2 kWh of heat per day. The larger the water storage tank, the higher will be the heat loss, something that requires good insulation to avoid reheating and perhaps will lead to cost rise (Viessmann, n.d.).

Last but not least, the avoided CO_2 emission annually would be around 26.49 tonCO_2 (see table 06 underneath).

Solar kWh for Heating	**143,186.10 kWh**
CO2 Avoided Annually	0.185 kgCO2/ kWh x 143,186.10 kWh **=26.490 kgCO2 or 26.49 tonCO2**

Table 06: CO2 emission annually

Strong Scenario:

This scenario has more extensive capital requirements and some radical changes, but aim at much greater conventional electricity disengagement. More specifically, the only betterment solution has been thought is a ***PV system on the tilting roof for electricity generation***. This combines two out of the many methods mentioned in sub-chapter 3.5. Below are presented some basic calculations.

Location: The office buildings were examined and the information from the Bremen Solar Cadastre was also used for the report. The Solarkataster Bremen is a solar roof website showing online, whether the roof area is suitable for photovoltaic use or not (Solarkataster, 2019).

The statics or the age of the roof area is not taken into account. However, there is information about the height of buildings, slope of roofs and the shadow cast by the surroundings, e.g. through trees or buildings in the neighborhood. All of this is relevant to the potential of a roof to convert solar radiation into electricity.

<u>Size, orientation and shading of the PV system:</u> The office wings are covered with calcite sheets and incline approximately 10 degrees. They were built in 2005 and 2013, respectively. The inner central area is covered with glass elements. The buildings are approx. 64m long and the part that can be covered with PV modules is 6m wide on each side. There are almost no components that protrude above the metal sheets and therefore cast shadows. The roof areas face to the southwest and northeast. All roofs were only viewed from the ground (Figure 22 and Figure 23).

Figure 22: View of an office building from the front

Figure 23: View of an office building from the side

According to our own calculations, an output of approx. 100 kWp can be installed on each office wing. It was assumed that the modules would be fixed up right and not across the roof covering.

If the modules are installed in landscape format, plus the small roof area connecting the two buildings, then the total output could be approx. 125.5 kWp per office wing. Apart from the connecting central wing and the adjoining narrow middle roof areas (width approx. 3.7m), both the entire southwestern and northeastern roof halves were used. Only the variant with the southeast orientation, in which the modules are installed parallel to the narrow roof side, was examined in more detail. A PV system with a total output of approx. 251 kWp could thus be implemented on both buildings together (calculations are not based on shading) (Figure 24 and Figure 25).

Figure 24: Office buildings with the central glass domes

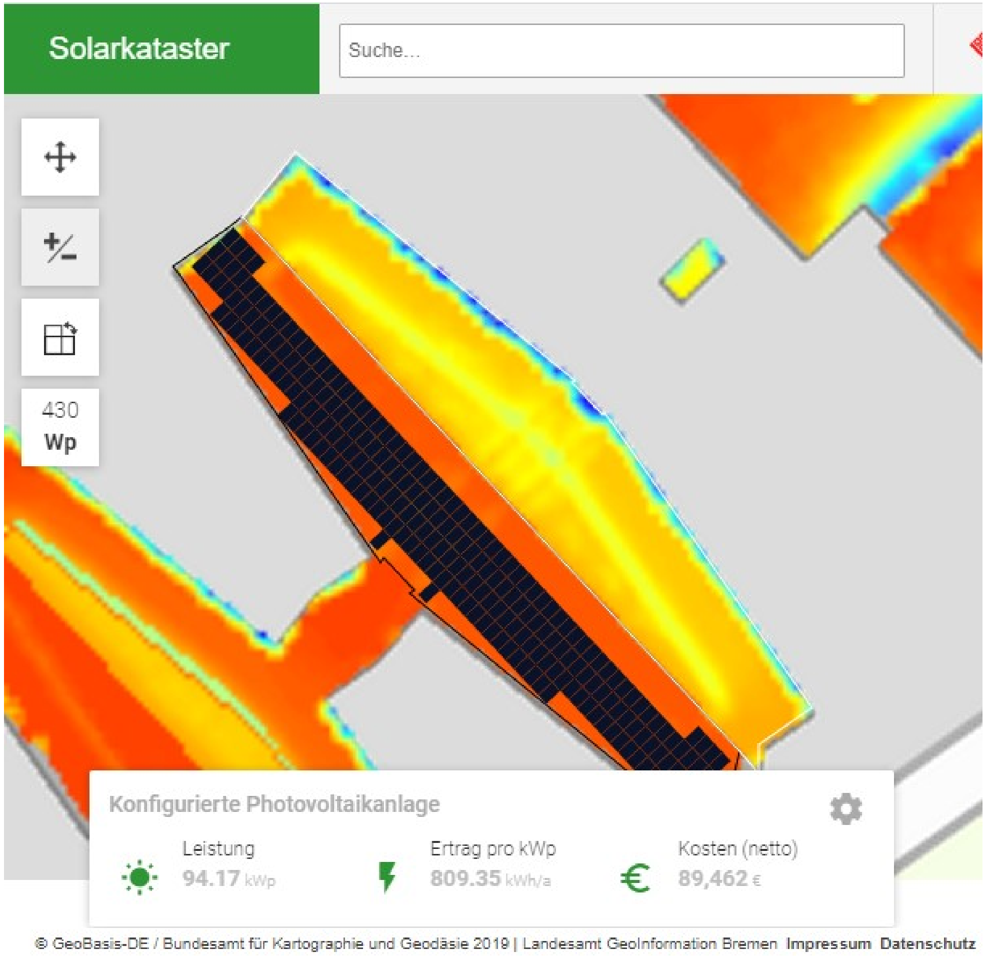

Figure 25: Possible allocation plan of PV modules on building A based on the Solarkataster program (Solarkataster, 2019)

<u>Own consumption:</u> The economic viability of the PV system is primarily based on self-consumption. Feeding the solar electricity into the public grid should be due to the unattractive remuneration, kept as low as possible. The Erneurbaren Energie Gesetz (EEG) or in English renewable energy law, remuneration for this electricity still provides an important contribution to the profitability of the PV system. When considering profitability, two factors are crucial. Firstly, the amount of self-consumption and secondly, the electricity purchase price. The net electricity price of 17.643 Ct/kWh or 21 Ct/kWh gross price valid in 2020 was used. The company's annual electricity requirement is approximately 261,400 kWh annually (2018 stats). Only if the system operator and the pantograph are identical, it is self-consumption in the legal sense, i.e. under this condition, an EEG surcharge reduced from 100% to 40% of the electricity

used for this size of system. If this is not the case, then 100% of the EEG surcharge must be paid. The company's load profile from 2018 was used as the basis for the simulation and with a system size of 251 kWp, approx. 48% of solar power could be used directly on-site. The solar coverage would be 39%, i.e. the company has to buy a correspondingly smaller amount of electricity from the energy supplier. From a system size of 100 kWp, the electricity must be marketed directly. From this limit, the requirements for protection and telecontrol technology increase significantly entailing considerable costs.

Electricity storage system: The share of self-consumption can be further increased by integrating a storage system. The integration of a lithium-ion storage was also calculated in the following simulation. If a storage facility with a capacity of 50 kW and a usable battery capacity of 69 kWh were connected, an additional 19,134 kWh* of solar energy could be consumed on-site and the contribution would increase from 48% to 57%. If the usable battery capacity were doubled from 69 kWh to 138 kWh with the same nominal output, the own contribution would increase to 64% and also about 34,239 kWh* of the solar power would be consumed on-site.
* This is the net battery energy to cover consumption, i.e. Losses in the battery itself, as well as through charging and discharging processes are not included. In total, with a battery capacity of 69 kWh, 19,134 kWh of solar power is used to charge the battery. With a capacity of 138 kWh, it would be 33,867 kWh.

Main Connection: Wesernetz will be the network operator, which should plan a power transformer of 250kVA for the company. In addition, the provisions regarding the network connection itself, the necessary measures and costs with regard to protection and telecontrol technology, feed-in management (including remote control) and the measurement concept are also relevant. For example, for a maximum active power of a generation plant of 135 kW, a simplified plant certificate B is required, which is associated with considerable costs. There are also annual measuring point operating costs and costs vary depending on the connection. With a low-voltage connection with registering performance measurement, Wesernetz in Bremen charges, for example, approx. 300 euros net per year. These costs were taken into account in the profitability calculation. It must be ensured that an offer for a PV system contains all the necessary costs.

Fire protection and lighting protection: The fire protection regulations must be observed for module assignment and cable routing. There is no external lightning protection system. In general, a PV system on the roof does not increase the risk of lightning strikes because the height of the building is not or only marginally changed by the PV system. This applies to saddle as well as flat roofs.

Basic of plant design: Roofs with southwest to southeast orientation and a roof pitch are well suited between 25° and 50°, but in these latitudes 36° is ideal. The system is used for flat roofs elevated. In the case of grid-connected systems, the normal electricity network serves as storage: the electricity is supplied via Inverters converted into grid-compliant alternating current and if possible consumed on site. It can be at least temporarily stored in a separate solar battery, and the surpluses are fed into the network.

Solar modules and yield: Modern commercial crystalline solar modules can absorb up to 22% of the solar radiation convert it to electricity. The manufacturers give guarantee periods between 15 and 25 years for the solar modules as a sign of the high quality standard and the high life expectancy of the products. Now, a PV system with a nominal output of 1 kWp requires a pitched roof area of approx. 7m² (PV system raised to 10° and facing south.) or approx. 12m² flat roof area with elevated systems. The average yield of a PV system in Bremen is between approx. 825 kWh/kWp and 875 kWh/kWp.

Yield forecast with PV-Sol: A yield forecast was carried out using the PV-Sol simulation program. The long-term climate data set from Bremen was used as the basis for the yield forecast. Based on the system utilization rate, the performance ratio and the specific annual yield, the expected yield and the quality of the system can be estimated. The performance ratio often also called quality factor (Q) describes the ratio between the realized yield and the theoretically possible yield that the solar modules could produce at a constant temperature of 25 °C in an ideal, loss-free system. Powerful PV systems achieve a performance ratio of well over 80%. The specific annual yield describes the average expected annual yield in kWh per kWp.

The forecast shown in the Table 07 at the next page determined a specific annual yield of 847 kWh/kWp for a PV system with 251 kWp on the two buildings. The southeast and south-west oriented modules have a significantly higher specific annual yield than the northeast facing modules on the two roof halves of the office wing (see Table 07). The absolute annual yield is on average around 212,300 kWh. Direct self-consumption is estimated at 48%, i.e. approximately 102,800 kWh of solar power can be used immediately in the company be consumed. This means that of the original 261,400 kWh, only about 158,600 kWh would have to be obtained from the energy supplier. This significantly reduces the electricity bill. If an additional battery storage system with a nominal output of 50 kWh and a usable capacity of almost 70 kWh is installed, the self-consumption increases to 57%.

PV power	**251 kWp**
PV Surface Area	**1,374 m²**
Power Requirements per year	**261,400 kWh**
PV generator energy (AC grid)	**212,334 kWh**
Grid feed	**90,602 kWh**
Direct consumption	**102,792 kWh**
Own consumption via battery	**18,940 kWh**
Internal consumption share	**57%**
Total annual yield	**847 kWh/kWp**
Avoided CO2 emissions annually	**118.91 tons**

Table 07: Yield forecast for a PV system with 251 kWp and 69 kWh battery

*The results were determined using a mathematical model calculation. The actual annual yields of the photovoltaic system can vary due to fluctuations in the weather, the efficiency of modules and inverters and other factors (Wirth, 2020).

The next figure 26 shows that in a PV system with 251 kWp in winter almost all of the electricity generated is immediately used by the company. From March to September, however, a substantial part is fed into the public grid. On average, as already mentioned, 48% is used immediately in the company and a further 9% after temporary storage in the battery. If the battery capacity is doubled, the cached share increases from 9% to just fewer than 16%.

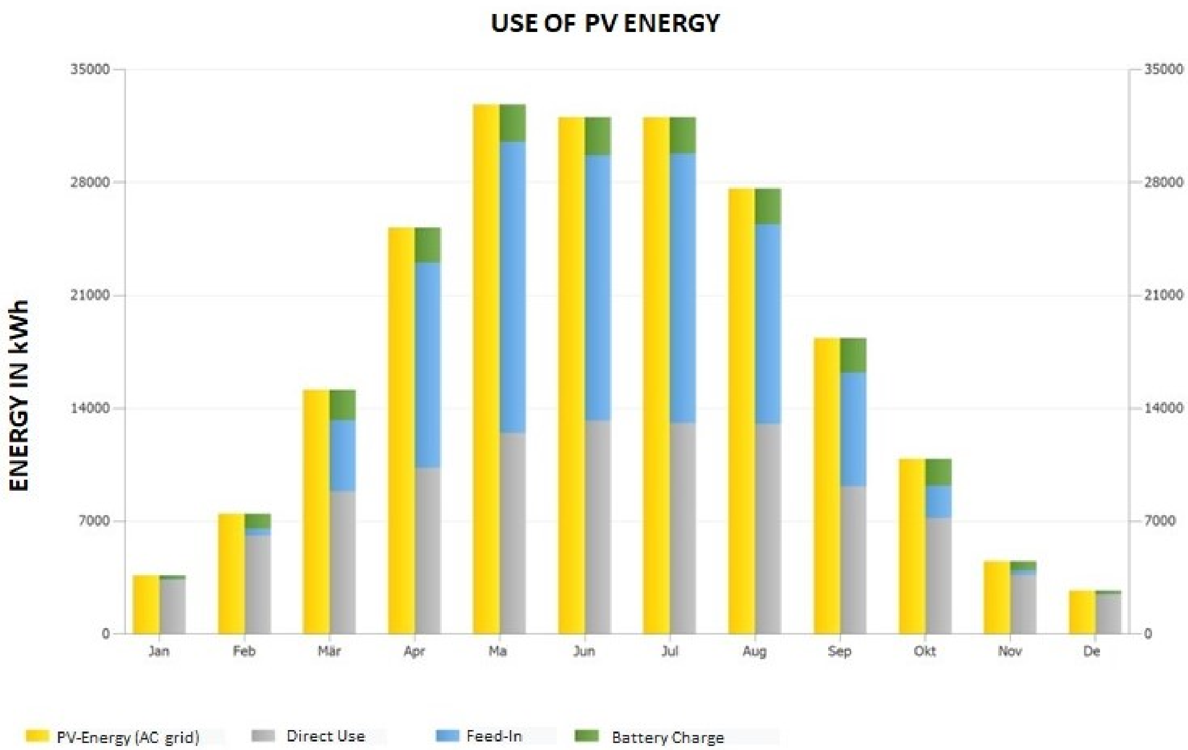

Figure 26: Use of PV electricity (251 kWp PV and 69 kWh battery)

Looking at Figure 27, the degree of self-sufficiency, i.e. the solar coverage share, it can be seen that in summer the PV system partially covers up to two thirds of the demand, but in winter only a fraction of the energy comes from the solar system. The annual solar share is 45%. With double battery capacity, the degree of self-sufficiency is 50%.

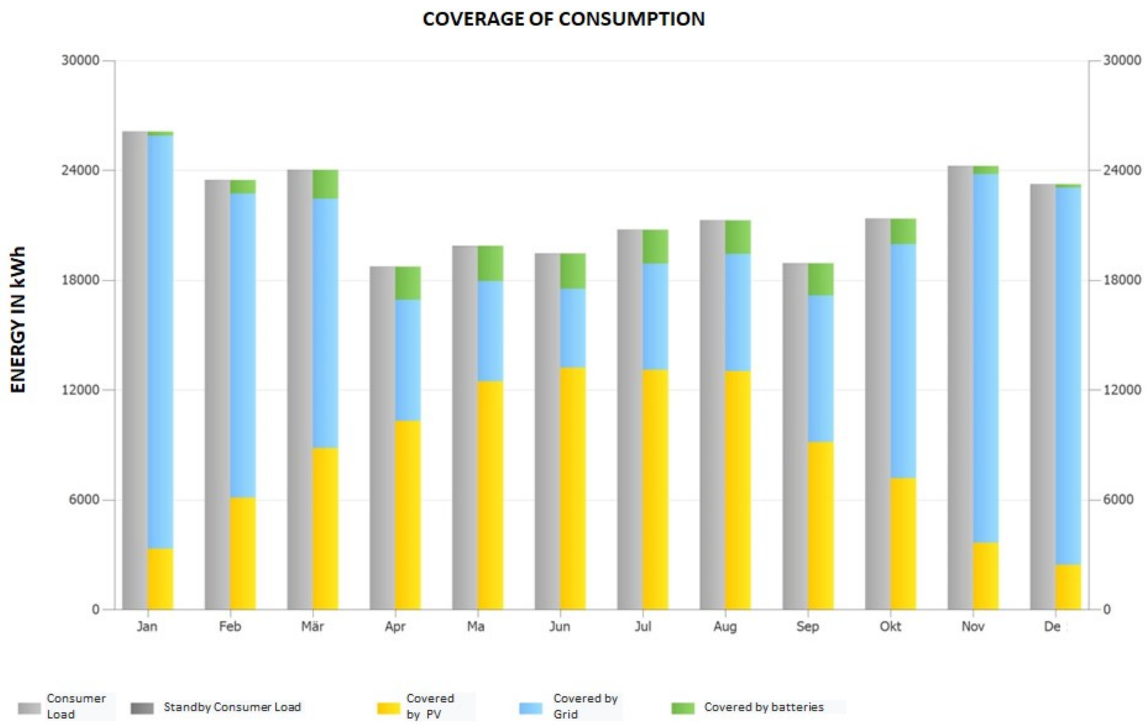

Figure 27: Coverage of electricity requirements (251 kWp PV and 69 kWh battery)

7.2.2. Financial analysis

A financial analysis evaluates the net-benefits of a project investment in reliance on the difference between the old project conditions without any change and the future vision with the changes already implemented. Also the financial analysis of the project compares benefits and costs to the company by using local market prices to verify the balance of investment and their sustainability (CFI, 2015).

<u>**Weak scenario:**</u>

1) ***Replacement of all fluorescent bulbs to high efficient led lamps*** (conventional electricity reduction).

No further examination requisite for the financial analysis. The table 02 above proofs already a cost reduction of 39.5%. Only information deemed to be important for the cost-benefit analysis is the LED ceiling lights purchase and installation cost will be 16€ per LED tube or per LED unit 3x16€=48€. Thus, 303 units x 48€= 14,544€.

2) ***Solar thermal system for space heating*** (conventional gas reduction).

Nowadays an important role investing in a technological application is the total cost of the installation, which can vary in size, quality of the collectors and type of technique. A normal installation includes all the already mentioned parts like the hot water tank, pipes, control panel, the most expensive part of the solar panels. A medium scale system will be priced at approximately 57,200€ (Lutz, 2008). This cost is calculated as follows:

i. Vacuum solar panels: $51m^2 \approx 51$ Solar panels $1m^2$ ($1.16m^2$ gross area) each. Hence, 51 panels x 720€=36,720€ (VolksSolaranlage, 2014). Plus 19% VAT, then 43,700€.
ii. The cost of a 1,000ltr hot water tank is around 1,500€.
iii. A control unit is estimated at 1000€.
iv. Other materials like pipelines, mixing valves and pumps will cost around 3,000€.
v. Montage, special permission license and installation cost depend on the building and the local market prices is estimated to be around 8,000€.
vi. Operation and Maintenance cost per year of use will be 2% of the installation cost and hence, equal to 1000€.

(Tjengdrawira, Richter & Theologitis, 2016 · Solaranlagen, 2020 · Barta, n.d. · Vailant Deutschland GmbH & Co. KG, n.d.)

Strong Scenario:

The PV system on the tilting roof for electricity generation comprises the following basic points:

Cost:

The net cost of a large rooftop system is around 900 euros per kWp. Due to the high technical requirements and the associated considerable additional costs for a PV system of this size were expected to cost a total of € 1,000/kWp. The costs of storage systems vary extremely depending on the provider and the range of functions. According to the database of the *PV magazine*, the price per kWh is more usable storage capacity for the Commercial 50 series of the German company *Fenecon* at 500€ to 550€ (the price per kWh of usable storage capacity is up to 100 kWh 550€ and up to 500 kWh 500€ but provider name the lowest price level). A big advantage is that the system can be expanded at any time. Peak shaving and quick charging of electric vehicles are feasible, but neither the emergency power supply nor an uninterruptible one Power supply (UPS) are possible options. Furthermore, for the storage system considered here nominal output of 50 kW and usable battery capacity of 69 kWh, assumes a cost of 38,500€. If the battery capacity is doubled to 138 kWh, 70,000€ are used as the investment sum (pv magazine, 2019).

Financial Remuneration:

For a system >100 kWp, the so-called market premium model is mandatory, i.e. the electricity must be marketed directly. For this purpose, a mixed value based on the different remuneration classes* is created. The values to be applied for the kilowatt hour fed into the public grid are currently only available until January 2020**. For a solar system with 251 kWp, which will be put into operation in 2020, 7.95 Ct/kWh*** is expected to be invested. If a lower average monthly income is achieved on the stock exchange, the market premium compensates for this up to the amount to be invested. The system operator, therefore, receives a mix of exchange proceeds and market premium (minus the commission) from his service provider, who is the direct marketer. Since the average monthly exchange electricity price is used to calculate the market premium, more or less money can be made depending on sales skills and solar power production. If there is self-consumption, the EEG contribution obligation for self-consumed electricity is reduced from 100% to 40%. In 2020 this will be 2.7 Ct/kWh.

* The remuneration classes are up to 10 kWp, up to 40 kWp and up to 750 kWp. Up to 10 kWp, the value to be applied in 2020 for the market premium model is expected to be 9.86 Ct/kWh, up to 40 kWp 9.59 Ct/kWh and up to 750 kWp 7.63 Ct/kWh. The values are based on the assumption of a degression of 1.4% in this period.

** The degression is recalculated every three months based on the previous addition.

*** A management premium of 0.4 Ct/kWh is not included here.

7.3. COST BENEFITS ANALYSIS OF ALTERNATIVES AND RESULTS

Weak Scenario:

1) ***Replacement of all fluorescent bulbs to high efficient led lamps*** (conventional electricity reduction).

Profitability calculation: With all this in mind, the next step will be the cost-benefit evaluation. For this reason should prepare, in order to anticipate the economic performance of the system, a cost analysis based on Internal rate of returns (IRR) and Net present value (NPV) terms. Thinking about the expense of intensity utilization during a 10 year time span, because LED lights are very durable and their replacement will definitely be postponed for quite some time. In this manner the entire cost expected to be low in the case of LED lights. The simple cost-benefits analysis in the way described further on verifying their profitability (Goonasekara & Kjaerboe, 2012)(Table 08):

Year	Cash Inflow and Cash Outflow (€)	Total Cash Outflow (€)	Total Cash Inflow (€)	Internal Rate of Return after 10 years
1	2,033.00 €	-16,186.46 €	22,260.78 €	**38%**
	-14,694.00 €			
2	2,073.66 €			
	-153.00 €			**Discount Rate**
3	2,115.13 €			4%
	-156.06 €			
4	2,157.44 €			
	-159.18 €			**Net Present Value**
5	2,200.58 €			**5,017.44 €**
	-162.36 €			
6	2,244.60 €			
	-165.61 €			
7	2,289.49 €			**Inflation**
	-168.92 €			2%/year
8	2,335.28 €			
	-172.30 €			
9	2,381.98 €			
	-175.75 €			
10	2,429.62 €			
	-179.26 €			

Table 08: IRR-NPV analysis of LED lamps

Where,

Cash Outflow:

- 14,694€ for LED lamp replacement cost.
- 150€ lamps for maintenance and replacement of defects lamps per year for 10 years (assumed to be 1% of the total investment cost).
- With a reasonable discount rate at 4% (the interest rate that could have been earned, if the money had been put in the best alternative investment). The discount rate is also not adjusted for inflation (flat rate).
- Plus a small but inevitable core inflation happens every year in the height of 2% (price and services increase at the economy over a time period).

Cash Inflow:

- 2,033.00€ income with LED lamps.
- Plus 2% extra indirect income every year due to the anticipated electricity price increase.

Thus, the IRR was estimated to be **38%** and the NPV close to **5,017€**.

2) ***Solar thermal system for space heating (conventional gas reduction).***

<u>Profitability calculation:</u>

The basic benefits originate from the gas reduction (30.2% annually), that practically means 6,960.34€. However, this price will change year after year due to the unpredictable nature of the weather or natural gas prices (environmental and national economies factors uncertainties). Furthermore, some extra reduction of electrical power for the daily warm water will be observed, when the warm water is not supplied to the heating system (5 months/annually), and this will reflect in the electric bill. For 15years minimum lifetime of vacuum collectors the table below represents the foresees profit (Bhatia, 2014)(Table 09):

Year	Cash Inflow and Cash Outflow (€)	Total Cash Outflow (€)	Total Cash Inflow (€)	Internal Rate of Return after 15 years
1	7,578.00 €	-69,291.28 €	121,982.27 €	**76%**
	-58,344.00 €			
2	7,653.78 €			
	-1,136.28 €			**Discount Rate**
3	7,730.32 €			4%
	-1,159.01 €			
4	7,807.62 €			
	-1,182.19 €			**Net Present Value**
5	7,885.70 €			**46,153.24 €**
	-1,194.01 €			
6	7,964.55 €			
	-1,205.95 €			
7	8,044.20 €			**Inflation**
	-1,230.07 €			2%/year
8	8,124.64 €			
	-1,254.67 €			
9	8,205.89 €			
	-1,279.76 €			
10	8,287.95 €			
	-1,305.36 €			
11	8,370.83 €			
	-1,331.46 €			
12	8,454.53 €			
	-1,358.09 €			
13	8,539.08 €			
	-1,385.25 €			
14	8,624.47 €			
	-1,412.96 €			
15	8,710.72 €			
	-1,441.22 €			

Table 09: IRR-NPV analysis of Solar thermal collector system

Where,

Cash Outflow:

- 57,200€ for the solar system installation cost
- 1144€ for maintenance and operation cost per year for 15 years (assumed to be 2% of the total investment cost, this include a proper check of the pump, controllers and sensors as of the periodical cleaning of the collectors from the dust. This way, the smooth functioning of the system can be kept).
- Like before, with a reasonable discount rate at 4%
- Plus the inflation happens every year in the height of 2%

Cash Inflow:

- 7,078€ income with the solar system under function
- Plus 1% extra indirect income every year due to the anticipated natural gas price increase.
- Plus a hypothetical 500€ per year for hot water heating during the summer months and provided by the system.

After 15 years continued use (lifetime) and the IRR level is estimated at **76%** and the NPV at around **46,153€**. That leads us to the conclusion, that after 7-8 years it will overcome the initial invest cost of approximately 57,200€ and year by year the system will bring only profits at the enterprise budget.

Strong Scenario:

Profitability calculation:

The profitability of a photovoltaic system depends on the costs of the system and the specific electricity yield per year. For the profitability calculation, an investment calculation was carried out again using the internal rate of return method but deployed slightly differently. The average return (internal rate of return) is given as a measure of profitability (the internal rate of return method makes it possible to calculate a theoretical average annual return for an investment or an investment with irregular and fluctuating income).

Also, the capital value* is the sum of the discounted annual income. A positive capital value means profit and, a negative capital value means loss. When calculating the capital value, a constant income tax rate of 30% and a linear depreciation without special depreciation and without investment deduction were used. A 1% was chosen as the interest rate for determining the capital value. The amount of the capital value provides an indication of how much more profit is being made compared to an investment that pays 1% interest (based on a term of 20 years plus the investment year).

Initial equity also includes the value added tax (VAT) and upfront costs, e.g. burdens necessary for planning and interim financing of the added value costs. It should be noted that every solar power generation is a commercial activity and when electricity sold is taxable as income for the enterprise. It is possible to claim that the sales tax and the operator can offset the input tax against the sales tax received by the tax office.

The investment can be here 100% self-financed. The table 10 further down shows the specifications and the results of the calculations. It is assumed that it is self-consumption, i.e. system operator and pantograph are identical and therefore only a reduced EEG surcharge has to be paid.

Since the solar power must be marketed directly, it depends on several circumstances, whether the system operator achieves a profit in the amount of the value to be invested or falls below or exceeds it. In the following it is assumed that the value to be applied minus 0.4 Ct/kWh (share that the legislator provides for as a so-called management bonus) is always achieved. Under these conditions and with the stated information, the following result is obtained (Table 10 and Table 11):

First Year	
Plant system performance	251 kWp
Electricity production	212,597 kWh
Costs of the system (without VAT)	251,000 €
Initial equity (including VAT and start-up costs)	298,690.00 €
Plant running costs	€ 5,973
Specific electricity yield	847 kWh/kWp
Yield reduction per year	0.40%
Direct use in% of solar yield	48%
Value to be applied (according to market premium model)	0.0795 € /kWh
Inflation rate p.a.	2%
Interest rate for cash value determination (discount rate) p.a.	1%
Interest rate on reinvestment p.a.	2%
Annual total electricity consumption	261,400 kWh
Electricity price in the first year (net)	0.17643 €/kWh (gross 0.21€/kWh)
Gross electricity price increase p.a.	2%
General Renewable electricity surcharge	0.06756 €/kWh
Reduced renewable electricity surcharge	0.02752 €/kWh
Individual tax rate	30%

Table 10: Efficiency of a 251 kWp system without storage

Year	Cash Inflow and Cash Outflow (€)	Total Cash Outflow (€)	Total Cash Inflow (€)	Internal Rate of Return after twenty years
1	63,591.39 €	-1,130,468.93 €	1,282,579.74 €	**13%**
	-336,341.41 €			
2	63,921.47 €			**Discount Rate**
	-38,499.16 €			1%
3	64,075.86 €			
	-38,845.35 €			
4	64,072.17 €			
	-39,194.88 €			**Net Present Value**
5	64,071.13 €			**138,031.68 €**
	-39,547.79 €			
6	64,072.77 €			**Interest Rate on Reinvestment p.a.**
	-39,904.14 €			2%
7	64,077.13 €			**Inflation**
	-40,263.98 €			2%/year
8	64,084.25 €			
	-40,627.37 €			
9	64,094.14 €			
	-40,994.37 €			
10	64,106.85 €			
	-41,365.03 €			
11	64,122.41 €			
	-41,739.41 €			
12	64,140.86 €			
	-42,117.57 €			
13	64,162.23 €			
	-42,499.57 €			
14	64,186.56 €			
	-42,885.47 €			
15	64,213.88 €			
	-43,275.34 €			
16	64,244.23 €			
	-43,669.24 €			
17	64,277.65 €			
	-44,067.23 €			
18	64,314.18 €			
	-44,469.39 €			
19	64,353.86 €			
	-44,875.78 €			
20	64,396.72 €			
	-45,286.47 €			

Table 11: IRR and NPV of a 251 kWp system without storage

With an output of 251 kWp and a price of EUR 1,000/kWp (all costs are included here, conservative estimation), the system generates a surplus of EUR **138,031** over the entire 20-year period without a storage system and this positive capital value indicates a clear profit. On the one hand, these surpluses are taxable and, on the other hand, future surpluses have a lower value than today**. The decisive factor for economic consideration is the capital value. The electricity generation costs are 9.9 Ct/kWh and, plus the reduced EEG surcharge of 2.7 Ct/kWh, are much cheaper than the net electricity price of 17.643 Ct/kWh (0.21 Ct/kWh gross). Self-consumption is approximately 48% of the solar power produced because as it is easily understood the company can not be open 24/7. The renewable electricity surcharge in Germany for self-producers will have a reduce price of 0.02752 €/kWh (0.06756 €/kWh) ***. Taking into account running costs, 2% inflation and a 1% discount rate, as well as a 2% increase in electricity prices, the PV system has a return of **13%**.

*The capital value of an investment is the sum of the present values of all payments (deposits and withdrawals) caused by this investment. The present value is the value that future payments have in the present. It is determined by discounting future payments. This makes payments that occur at any point in time comparable. Due to the existence of interest, the same amount of money has a higher value the sooner can be got. This relationship is represented by computing operations of discounting and compounding.

**To determine the current value of future payments, future payments must be discounted. The result after tax and the interest rate for determining the present value are relevant for such discounting.

***Follow links (Thalman & Wehrmann, 2020) and (Bundesnetzagentur, 2020)

Plant system performance	251 kWp
Costs of the system (without VAT)	251,000 €
Investment costs for Battery storage (69 kWh)	*38,500 €*
Initial equity (including VAT and start-up costs)	*344,505 €*
Plant running costs	€ 5,323
Specific electricity yield	847 kWh/kWp
Yield reduction per year	0.40%
Direct use in% of solar yield	48%
Additional direct use via battery storage	*9%*
Total use of solar yield	*57%*

Table 12: Economy of a 251 kWp system with 69 kWh battery

If the same PV system were equipped with a storage with a usable capacity of 69 kWh for a very reasonable price of 550 €/kWh, the self-consumption would increase from 48% to 57%, i.e. more solar power could be used on site. The other conditions are as set out in Table 12 and the cost benefits result are the following (Table 13):

Year	Cash Inflow and Cash Outflow (€)	Total Cash Outflow (€)	Total Cash Inflow (€)	Internal Rate of Return after twenty years
1	59,299.65 €	-1,130,969.55 €	1,200,784.23 €	**6%**
	-379,924.14 €			
2	59,699.67 €			**Discount Rate**
	-36,231.35 €			1%
3	59,831.25 €			
	-36,577.58 €			
4	59,832.09 €			
	-36,927.14 €			**Net Present Value**
5	59,835.10 €			**57,352.20 €**
	-37,280.09 €			
6	59,840.32 €			**Interest Rate on Reinvestment p.a.**
	-37,636.48 €			2%
7	59,847.78 €			**Inflation**
	-37,996.36 €			2%/year
8	59,857.49 €			
	-38,359.79 €			
9	59,869.48 €			
	-38,726.82 €			
10	59,883.79 €			
	-39,097.51 €			
11	59,900.44 €			
	-39,471.93 €			
12	59,919.46 €			
	-39,850.12 €			
13	59,940.88 €			
	-40,232.16 €			
14	59,964.73 €			
	-40,618.10 €			
15	59,991.04 €			
	-41,008.00 €			
16	60,019.85 €			
	-41,401.94 €			
17	60,051.17 €			
	-41,799.97 €			
18	62,917.91 €			
	-42,202.17 €			
19	60,121.52 €			
	-42,608.59 €			
20	60,160.60 €			
	-43,019.32 €			

Table 13: IRR and NPV of a 251 kWp system with storage

The IRR would decrease significantly from 13% to **6%** and the same applies to capital value, which would decrease from EUR 138,031 to EUR **57,352** because of the higher initial cost. The existence of a battery even though it increases the sentiment of energy independence turns out to be financially a more risky choice since the owner has to wait almost till the end of the system to acquire money back from the investment. Also, if the annual peak load minimized accordingly, the additional costs could be at least partially offset by the storage. However, it should be noted that this can only be achieved during summer by storing electricity in the battery from the energy supplier at times of low workload.

Another good metric to prove one's system profitability is the so-called levelized cost of electricity (LCOE). LCOE is a holistic way to determine the cost of 1 kWh by taking all the expenditures during the lifetime of a project and the total energy produced (CFI, n.d.).
For both cases it will be a good metric of system efficiency, if compared with the keep rising gross price of 0.21 €/kWh given by the supplier and more detailed in table 14 can be seen that the electricity generation costs would be exactly 1 ct per kWh more expensive, but still much cheaper than the 0.21 €/kWh. In return, of course, the degree of self-sufficiency increases.

LCOE	**Cost Factors**	**Cost/Energy**	**LCOE Without EEG Surcharge**	**Final LCOE**
LCOE without storage	(Initial cost+O&M+Discount rate+System lifetime) ÷ Sum of generated energy	(298,690€+145,128€+1%) ÷ 4,094,179 kWh	0.108 €/kWh + 0.02752 €/kWh	0.136 €/kWh
LCOE with storage	(Initial cost+O&M+Discount rate+System lifetime) ÷ Sum of generated energy	(344,505€+145,128€+1%) ÷ 4,094,179 kWh	0.119 €/kWh + 0.02752€/kWh	0.147 €/kWh

Table 14: Levelized cost of electricity

To summarize in short, all the findings of both scenarios according to the results of the Cost-Benefits analysis could be said that no matter which solution will promote, all of them at the end will positively contribute financial and ecological. The common currency mentioned in subchapter 4.4 will be as follows (see next table 15) and whichever scenario would promote the capitals might be spent to prevent one tonne of harmful emissions are relatively close to each other with a slight lead to *Weak Scenario 2* utilize solar thermal methods for space heating.

	SCENARIO		
	Weak Scenario 1	Weak Scenario 2	Strong Scenario
"COMMON CURRENCY"	14,694€ / 5.421tonCO_2 =2,710.57 €/tonCO_2	57,200€/26.49tonCO_2 =2,159.30 €/tonCO_2	344,505€ / 118.91tonCO_2 =2,897.19 €/tonCO_2

Table 15: "Common currency" comparison

As a final financial evaluation, the next supporting table (Table 16) accumulates the three recommended scenarios and focus on the annual profit as well as the time in years required for the capital recuperation and some others financial information. Although the environmental protection is a noble purpose, in no event a company would consider it is a money investment if there is not a guaranteed payback.

	SCENARIO			
SECTOR	Weak Scenario 1	Weak Scenario 2	Strong Scenario	**LEAD SCENARIO**
Initial Capital Payback (yr)	*7*	*7.5*	*6.5*	*Strong*
Total Money Profit at the end of the project (€)	*5,017*	*46,153*	*57,352*	*Strong*
Average Annual Clear Profit (€)	*502*	*3,076*	*2,867*	*Weak Scenario 2*
Payback in comparison	*34.2*	*79.1*	*15.1*	*Weak Scenario 2*

to the initial capital (%)				
CO_2 Avoided (ton)	*5.421*	*26.49*	*118.91*	*Strong*
Money spent to CO_2 avoided (€/tonCO_2)	*2,710*	*2,159*	*2,897*	*Weak Scenario 2*

Table 16: Evaluation of each scenario

As a rule, to become aware of project ability to implemented free of risk, without entering blindly and if in the last analysis worth undertaking, a feasibility study would prove the level of success (Kenton, 2019).

RECOMMENDATIONS AND DISCUSSION

The results of this analysis bring into question the cost-effectiveness of energy management tactics that inevitably takes an international dimension, without being confined to the "narrow" borders of one sector but being expanded in different forms to all the areas of human activity.

According to the conclusions of the present study after observing the tables, figures and any other provided information, it can be safely stated that energy efficiency improvements are not by any means a "*leap of faith*" for the company. On the contrary, if the details of a business venture are well examined, it is a secure investment with a positive contribution to the already impaired environment. Therefore, a modern tactic direct people to use simulation as a strategy to explore whether the real system is too expensive, elaborate, risky or not. As a result, is to put theories into the test phase helping the optimization or in time project cancelation (Hesselbach et al., 2011).

It is always important to go beyond the obvious and the existence of specialized staff and infrastructures points in this direction. Under the conditions described, any scenario or business venture applied, would offer a positive final result and only if unexpected or difficult to predict conditions an opposite result might occur. Most assuredly, several energy alternatives can be promoted over the scenario expound on this study. A throwback to the theory part and a more in depth analysis of the company, will make available more environmental friendly improvements. The researcher's point of view at least hopes to give the a “qualitative” difference and wants to cover, as far as possible, an existing deficit concerning studies, both in Germany and elsewhere in the EU, regarding the effectiveness of the practices applied to find energy plan faults and confront them. Finally, is expected this work to be a springboard for further research in different countries and companies in the future.

Moreover, over the years, the emission trading system (ETS) was developed on the basis of cap and trade system and has undergone big changes during the years. Aiming the industrial competitiveness, the European council and parliament attended to ensure a sufficient reduction in the CO_2 and the other emissions. Then came up the idea of a progressive innovation fund with approximate size of not less than 450 million allowances (one ton of emissions per allowance), which represents a market valuated at 3 billion € in 2017 and some million allowances (close to 50 million) are in stock up to be available, but first in the second half of the period 2021-2030 (European Commission, 2017a). The cap according this system reward the companies with allowances, which can be freely traded (sell to or buy from one company to the other) as needed (Muûls et al, 2016). Thinking of the continuous price adjustment with a clear tendency to move up and the gamut of companies included in this emission system, even more companies should take care of their emissions and start thinking more sustainable to avoid penalties or overpaying allowances due to their beyond the limits harmful gas emission. Germany has a strong presence in every sector of the ETS, encourage companies to invest and could lead the fight against the greenhouse effect (Verschuuren and Fleurke, 2014).

The last point worth discussing, is the research delimitations that blocked to a certain degree this study and also how it will be possible for researcher to overcome future barriers.

Research Delimitation:

The study investigation gathered data and recorded the conditions operating the company in the study area that in some cases do not reflecting the situation in the company for an extended period of time. These conditions are subject to variation due to yearly weather conditions or working stress to meet deadlines. For example, the data finally collected may reflect only an unusual winter season with temperatures way above the typical average in North Germany (heating data) or an extraordinarily amount of orders rearranging the typical processes followed by the company. In addition, some data may not be possible to be collected due to company unwillingness to provide them or even because nobody was willing to spent the time or had the intention of tracking them down (i.e. quantity or kind of waste material). Another, limitation factor might be the limited knowledge of the respondent to give feedback regarding the energy related topics. Also, the lack of adequate time is a limiting factor because in general, an energy audit or energy management procedure is a time-consuming “battle”, lasting minimum a year or more to meet the expected standards. Unluckily, taking as a fact the time-limit and lack of adequate equipment, the kind of audit which will be carried out is proportionally equal to a walk through audit or other framed preliminary audit, where the level of detail is kept lower and the analysis tends to be simpler (Baechler, Stecker & Shafer, 2011).

Although, the cost-benefit analysis makes a decision simpler, relying entirely on it will be a mistake because of disadvantages such as the difficulty to predict all variables, better suited to short length projects since the targeting eroding as the project goes further out (Harvard Business School online, 2019). In addition, the analysis focused to the direct visible energy savings because quantitative are easier measurable, when the indirect energy profits are requiring data of the payback energy, something that involves many companies (i.e. recycling) and gear the interest toward a wider range of researches. Unfortunately, the track performance over time after following the first or the second scenario to determine if energy performance being improved or worsening over time and the actions should be taken cannot implemented in this case study.

Finally, it must be said that because of the quantitative small sample size limited to one organization, the research findings cannot be completely generalized for the whole spectrum of the electric and electronic goods. Nevertheless, the results of the essay will offer a broader perspective. The case study has definitely merits over simple qualitative or quantitative methods, having only a weakness for achieving scientific generalizations, despite the fact that is designed to do so (Hammersley, Foster & Gomm, 2000). An assessment for some parts of the research required quantification and these assessment was subjective and depends on the researcher bias. Though, the result of the evaluation gives a good basis for inferring the kind of energy efficiency implementation changes and the driving forces for energy efficiency enhancement (Pickel, 2019).

However, these limitations do not defeat the purpose of this case study, but may leave aside some energy hotspots, that will left intentionally blank and create a subtle difference to the final results.

Overcome of barriers:

To begin with, it was found that the implementation or even a combination of good energy practices could lead to an improvement of enterprise production processes, finances and their environmental adaptability. Some very common barriers like:

- lack of awareness,
- lack of confidence
- and lack of funds.

These three can be overcomed by advising energy saving expertise to identify the opportunities and propose a solid evidence-based business case. This case will be followed by thoroughly conducted analysis and condition evaluation. In addition, an accredited supplier scheme taking advantage of energy efficiency finance given occasionally will bring the desirable results. The complexity of some environmental and legal prerequisites and financial conditions, chokes the growth of energy efficiency upgrades. Anyhow, the enterprise should pursue intensely to stay competitive, profitable mitigating the risks in order to drive the energy save changes down to the last detail.

Solutions at every price, as an alternative to energy intensive methods can always be adopted. Making the employees feel more environmental responsible till being a first-mover within an industry or by increasing the revenue from a new product thanks to spare money from the energy saving measures could be enough to convince all the stakeholders make a move.

CONCLUSION

To sum up, all the things touch on briefly, struck a chord with common interest. Decarbonization of the industrial sector requires well plant steps, awareness and patience from everybody. Not everything about the current practices is considered flawless, but by and large, the system and the general philosophy of slowly getting away from bad practices and adopting ginger habits working in favour of the environmental protection. It is definitely worthy to deploy high standards energy management solutions, guided by the specific ISO and rules developed the recent years, for any project scale with a maximum level of personal or collective interest needs and a total control over the available budget, promising a better future, wherein the experts with its vital role cogitate only the common good. In pursuit of establishing a global carbon market, EU possesses the appropriate experience for actively support and could help to reach that goal. For countries like Germany, huge potential in each sector has been observed and for that reason it is always has a crucial role to play. Future technology development, anticipated to come soon, would be helpful to exceed the desired targets. Already numerous steps have already been set off toward this direction, especially for countries with a leading role in the area of energy performance. Any legislation must be implemented in the best possible way and if the consumers fail to comply, set of supplementary measures should be taken. Many technological developments have greatly increased the portion of energy saved, but at the same time owing first to the overwhelming cost these methods are left behind in the eyes of the potential investors. Out of any discussion, averting a climate change disaster goes together with all the sector mentioned earlier. Further use of alternative technologies characterized equally by high effectiveness and much better environmental rate such as the wind or solar energy, could slowly substitute the conventional energy wrongly overused the last decades magnifying the problem. From relatively simple technologies till small operational transformation inside organization, well known processes with robust characteristics and great efficient nowadays many actions-ideas waiting to gain ground. In this perspective, more researches should be done for understanding in detail the business requirements and finally have a beneficial effect on tomorrows expected energy and environmental predicament.

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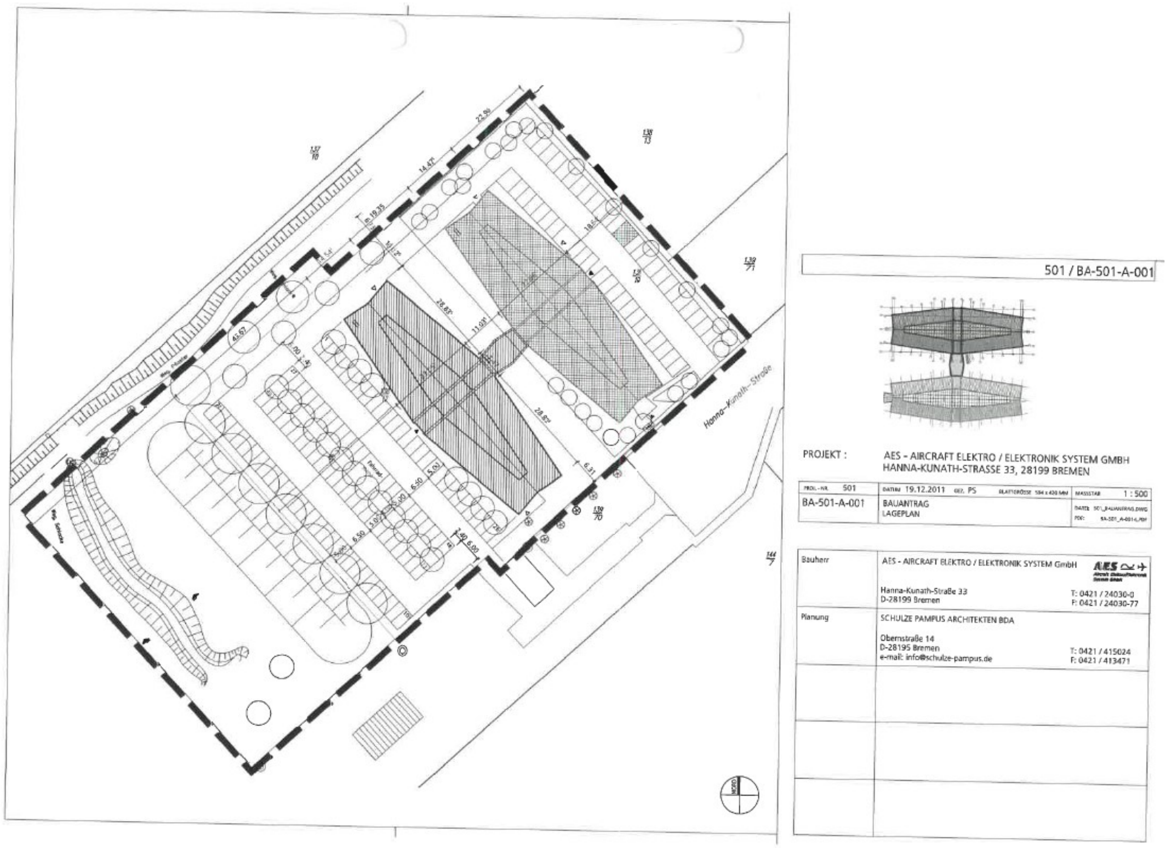
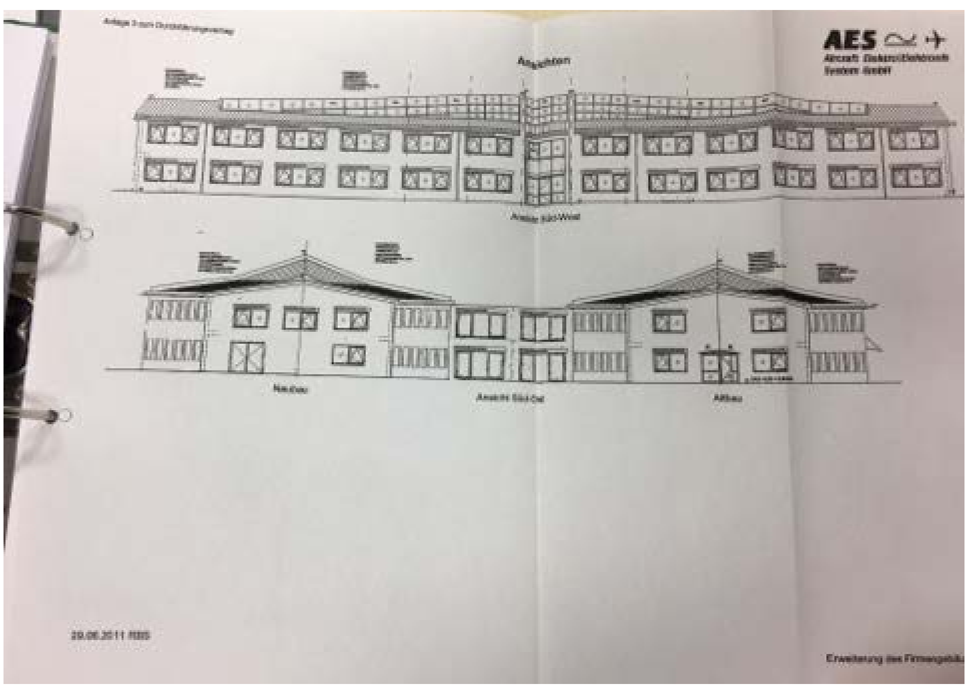
APPENDIX A

A.1: Planting plan





Side and front view of the buildings

Anlage BETRIEBSBESCHREIBUNG **nach § 9 Abs. 4 BremBauVorlV für Arbeitsstätten, insbesondere gewerbliche Anlagen**	zum Bauantrag vom: Aktenzeichen (falls vorhanden):
Kurzbezeichnung des Vorhabens: Neubau eines Büro- und Produktionsgebäudes	Betreiber (falls bekannt): AES GmbH

nichtzutreffendes bitte streichen oder mit - entfällt - kennzeichnen, im Bedarfsfall besonderes Blatt beifügen

1.	**Nutzung**					
1.1	Art der gewerblichen Anlage oder Tätigkeit	Konstruktion, Entwicklung und Fertigung von luftfahrttechnischen Systemen				
1.2	Betriebszeit	Wochentage		Uhrzeit (von – bis)		Zahl der Schichten
		Montag - Freitag		07:30 - 18:30 Uhr		1
1.3	Art und Menge der beim Betrieb verwendeten Stoffe	Elektrische Halbzeugnisse (Platinen), Kabel und Gehäuse aus Metall				
1.4	Betriebsbedingte Einrichtungen, ortsfeste Maschinen oder technische Arbeitsmittel und Anlagen	entfällt				
1.5	Art , Menge und Ort der gelagerten gefährlichen Stoffe	entfällt				
1.6	Einrichtungen für ordnungsgemäße Instandhaltungsarbeiten am Gebäude	entfällt				
2.	**Zahl der Beschäftigten**					
		männlich		weiblich		
		über 18 J.	unter 18 J.	über 18 J.	unter 18 J.	insgesamt
	nach Durchführung des Bauvorhabens	89	1	30	1	121
	davon in der stärksten Schicht	89	1	30	1	121
3.	**Arbeitsräume**					
	Besondere Arbeitsschutzmaßnahmen	Raum	Art / Ursache		Maßnahme	
	z.B. in Bezug auf: Lüftung, Einwirkungen durch Gefahrstoffe oder Lärm am Arbeitsplatz, Rutschhemmung, o.a. unzuträgliche Einwirkungen	Burn in	Wärmeentwicklung		Einbau Lüftungsanlage	
4.	**Sozialräume**					
	Angaben über vorgesehene und vorhandene Sozialräume: z.B. Pausen-, Umkleide-, Wasch- und Toilettenräume	Pausenraum, Toiletten				
5.	**Anlagen, für die ein besonderes Genehmigungsverfahren erforderlich ist.**	entfällt				
6.	**Umweltschutz**					
6.10	Luftverunreinigung durch	☐ Rauch ☐ Aerosole	☐ Ruß ☐ Dämpfe	☐ Staub ☐ Gerüche	☐ Gas ☐ Sonstige	
	Bezeichnung der Stoffe:	entfällt				
6.11	Lage der Emissionsöffnungen (Grundriss und Höhenangaben)	entfällt				

6.12	Maßnahmen zur Verminderung der Emission	entfällt		
6.2	Geräusche (wenn möglich, Werte angeben in dB (A))	Ursache, Dauer und Häufigkeit		
		Tageszeit (06:00 – 22:00 Uhr)		Nachtzeit (22:00 – 06:00 Uhr)
	Einzelgeräusche	entfällt		
	Allgemeines Betriebsgeräusch	entfällt		
	Verkehrslärm auf dem Grundstück	entfällt		
6.21	Lage der Geräuschquellen / Austrittsöffnungen, ggf. Größen- und Richtungsangaben	entfällt		
6.22	Maßnahmen zur Verminderung der Geräusche	entfällt		
6.3	Erschütterungen, mech. Schwingungen, Ursache und Häufigkeit	☐ kurzzeitig	☐ in Intervallen	☐ dauernd
		entfällt		
6.31	Lage der Erschütterungs- oder Schwingungsquellen	entfällt		
6.32	Maßnahmen zur Verminderung von Erschütterungs- oder Schwingungsübertragungen	entfällt		
6.4	Betriebliche Abfallstoffe	☒ fest	☐ flüssig	☐ sonstige
	genaue Bezeichnung	Elektroschrott		
6.41	Durchschnittliche Menge pro Zeiteinheit	50 kg im Quartal		
6.42	Zwischenlagerung und Verbleib	im eigenem Haus, ordnungsgemäße Entsorgung		
6.5	Besondere betriebliche Abwässer, deren Art und Behandlung sowie Verbleib der Rückstände	entfällt		
7.	**Sonstige Angaben und Hinweise**	Der Flur im Obergeschoss des Neubaus wird als Pausen- und Kommunikationsfläche genutzt		

Ort, Datum Bremen, 19.12.2011	**Unterschrift Bauherr/in**

Ort, Datum Bremen, 19.12.2011	**Unterschrift Entwurfsverfasser/in**

AES Aircraft Elektro / Elektronik System Gmbh
Hanna-Kunath-Straße 33

STAND 19.12.2011
28199 BREMEN
SCHULZE PAMPUS ARCHITEKTEN BDA

Städtebauliche Kennwerte

Nachweis der Grundflächenzahl (GRZ) 0,6

Grundstücksfläche	9267,62 m²
zulässige GRZ	0,6
Bruttogrundfläche	1272,38 m²

GRZ $\frac{1272{,}38\ m^2}{9267{,}62\ m^2}$ **0,14 GRZ** < **0,6 GRZ**

Nachweis der maximalen Höhe baulicher Anlagen

zulässige maximale Höhe baulicher Anlagen OK 12 bzw. OK 16

maximale Höhe der baulichen Anlage = **10,10 m OK** < **12 + 16 OK**

Berechnung der Gesamt-Bruttogeschossfläche BGF

Erdgeschoss	1272,38 m²
Obergeschoss	1272,38 m²
GESAMT	**2544,76 m²**

Berechnung Bruttorauminhalt BRI

Erdgeschoss	1272,38 m²	x	3,30 m	4198,85 m³
Obergeschoss	1272,38 m²	x	3,10 m	3944,38 m³
Dach	1272,38 m²	x	1,50 m	1908,57 m³
GESAMT				10051,80 m³

AES Aircraft Elektro / Elektronik System GmbH
Hanna-Kunath-Straße 33

STAND 19.12.2011
28199 BREMEN
SCHULZE PAMPUS ARCHITEKTEN BDA

Flächennachweis EG (Bestand)

Windfang	4,90 m²
Empfang	68,67 m²
Vorraum H-WC-01	4,13 m²
H-WC-01	6,02 m²
D-Umkleide	25,59 m²
H-Umkleide	30,54 m²

Gesamtfläche EG (Bestand) 139,85 m²

Flächennachweis EG (Neubau)

Vorraum D-WC-01	5,23 m²
D-WC-01	5,35 m²
Beh.-WC	8,71 m²
D-WC-02	5,35 m²
Vorraum D-WC-02	5,23 m²
Vorraum H-WC-02	4,13 m²
H-WC-02	6,02 m²
Flur-01	79,93 m²
Werkstatt	32,95 m²
LP	29,36 m²
Produktion	316,07 m²
Büro-Prüfer	29,36 m²
Kleinteilelager	28,80 m²
Burn In	27,23 m²
Server	13,78 m²
Teeküche	9,12 m²
Stopp	9,57 m²
Flur-02	22,93 m²
Treppenhaus	23,11 m²
Abstellraum	1,89 m²
Haustechnik	9,03 m²
Klima	15,66 m²
Büro + Inst.	37,06 m²
EMV	36,06 m²
Verpackung	22,24 m²
Fertigteillager	62,71 m²
Versand	16,99 m²
WE /WA	40,53 m²
Lager	282,87 m²

Gesamtfläche EG (Neubau) 1187,27 m²

Flächennachweis OG (Bestand)

Vorraum H-WC-01	4,13 m²
H-WC-01	6,02 m²

Gesamtfläche OG (Bestand) 10,15 m²

AES Aircraft Elektro / Elektronik System GmbH
Hanna-Kunath-Straße 33

STAND 19.12.2011
28199 BREMEN
SCHULZE PAMPUS ARCHITEKTEN BDA

Flächennachweis OG (Neubau)

Vorraum D-WC-01	5,23 m²
D-WC-01	5,35 m²
Gäste-WC-01	4,16 m²
Gäste-WC-02	4,16 m²
D-WC-02	5,35 m²
Vorraum D-WC-02	5,23 m²
Vorraum H-WC-02	4,13 m²
H-WC-02	6,02 m²
Flur-01	59,88 m²
Büro-01	27,29 m²
Besprechung	28,80 m²
Büro-02	28,80 m²
Büro-03	28,80 m²
Büro-04	28,80 m²
Büro-05	22,69 m²
Büro-06	19,14 m²
Büro-07	22,69 m²
Büro-08	28,80 m²
Büro-09	28,80 m²
Büro-10	28,80 m²
Büro-11	28,80 m²
Büro-12	27,29 m²
Treppenhaus	6,22 m²
Technik	7,88 m²
Flur-02	336,87 m²
Pool-Büro-01	27,29 m²
Pool-Büro-02	28,80 m²
Pool-Büro-03	28,80 m²
Pool-Büro-04	28,80 m²
Pool-Büro-05	28,80 m²
Pool-Büro-06	34,01 m²
Pool-Büro-07	34,01 m²
Pool-Büro-08	28,80 m²
Pool-Büro-09	28,80 m²
Pool-Büro-10	28,80 m²
Küche	56,88 m²

Gesamtfläche OG (Neubau) **1153,77 m²**

Flächennachweis Gesamt (Bestand + Neubau)

Gesamtfläche EG (Bestand)	139,85 m²
Gesamtfläche EG (Neubau)	1187,27 m²
Gesamtfläche OG (Bestand)	10,15 m²
Gesamtfläche OG (Neubau)	1153,77 m²

Gesamtfläche (Bestand + Neubau) **2491,04 m²**

AES Aircraft Elektro / Elektronik System Gmbh **STAND 19.12.2011**
Hanna-Kunath-Straße 33 **28199 BREMEN**
SCHULZE PAMPUS ARCHITEKTEN BDA

Stellplatznachweis

Nachweis der notwendigen Stellplätze

Notwendige Stellplätze für Bürogebäude geplante Nutzfläche	1 Stellplatz je 40 m² Nutzfläche 1.940 m²
ergibt 49 erforderliche Stellplätze	
Anzahl der vorgesehenen Stellplätze	102

Nachweis der notwendigen Fahrradstellplätze

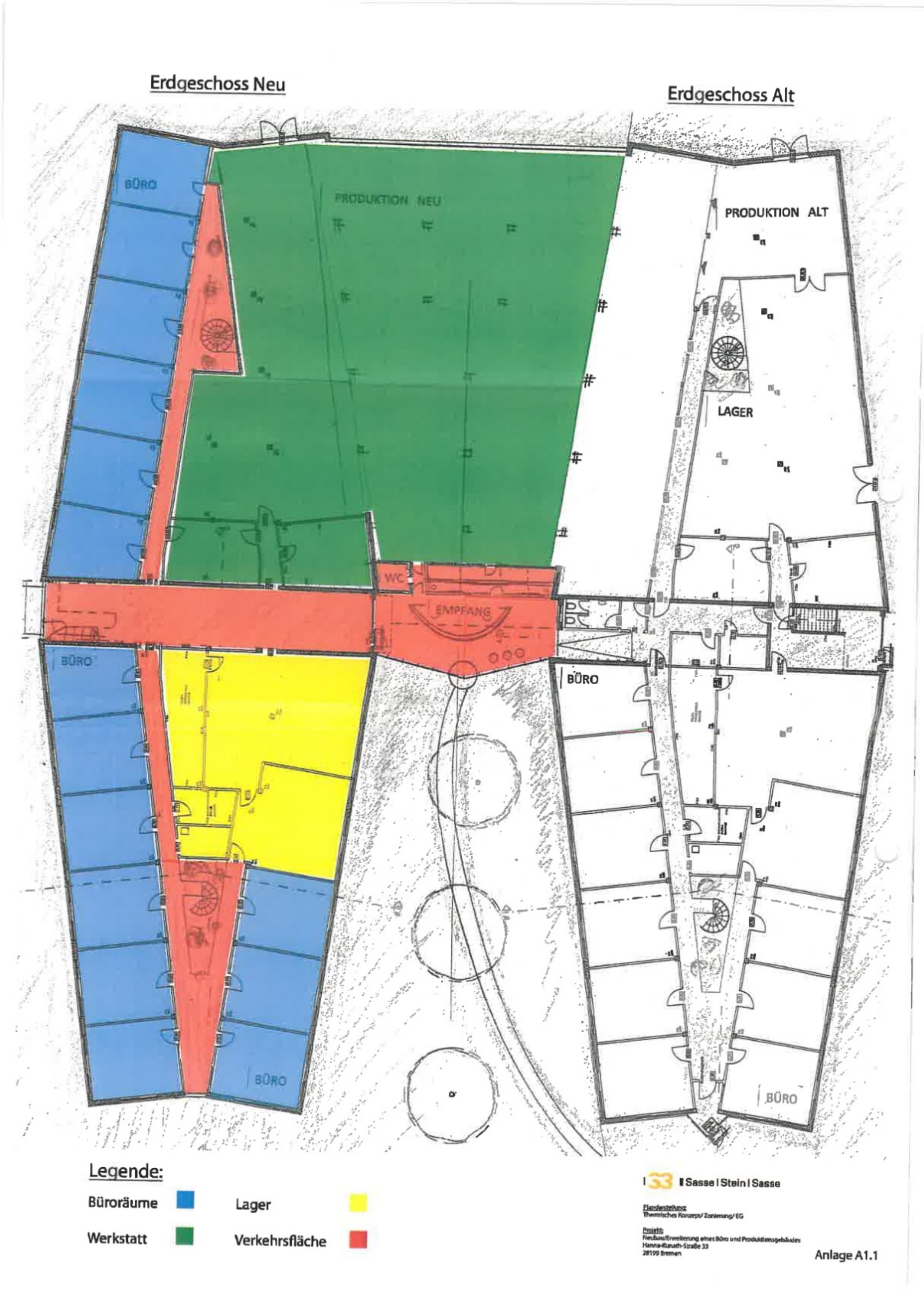
Notwendige Stellplätze für Bürogebäude geplante Nutzfläche	1 Stellplatz je 60 m² Nutzfläche 1.940 m²
ergibt 32 erforderliche Stellplätze x 1,5 m²	**48 m²**
Fläche der vorgesehenen Stellplätze	57,60 m²

Schulze Pampus Architekten BDA **Telefon: 0421/41 50 24 Telefax: 0421/41 34 71**
Obernstraße 14 28195 Bremen **eMail: info@schulze-pampus.de**

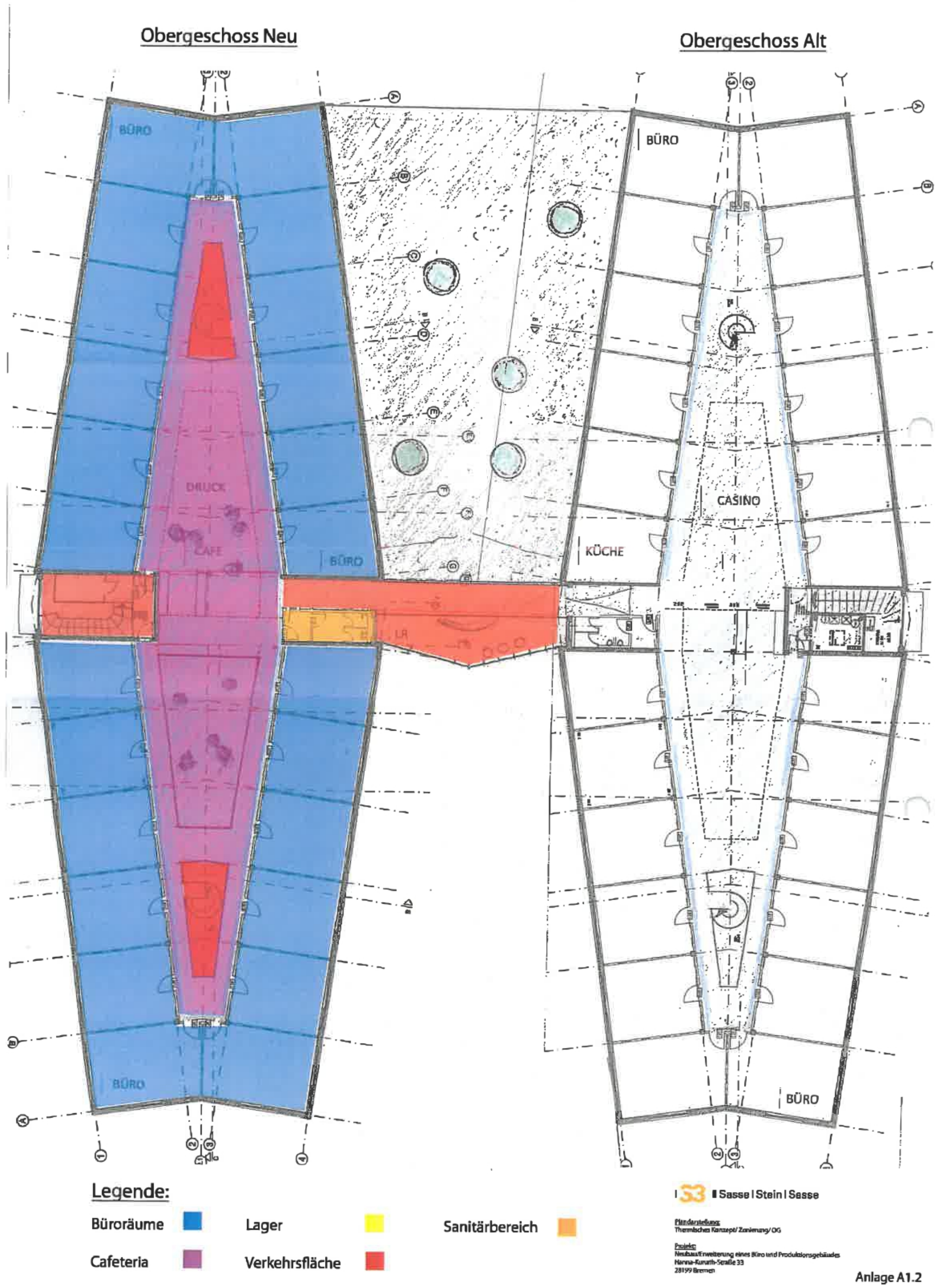
Projekt: **501**	AES Aircraft Elektro / Elektronik System GmbH Hanna-Kunath-Straße 33	Seite:	1
Bauherr:	AES Aircraft Elektro / Elektronik System GmbH Hanna-Kunath-Straße 33 28199 Bremen	Datum:	19.12.2011

Nr.	Bauteil	Material / Sonstiges	Brandschutz
1	Bürotrennwände	Gipskarton	
2	Flurtrennwände	Kalksandstein	mind. F 30
3	Bürotüren		
4	Treppenhauswände	Stahlbeton	F 90
5	Treppenhaustüren	Glastüranlage	RS-Tür
6	Geschossdecken	Stahlbeton	F 90
7	Dachkonstruktion	Holzbauweise mit Metalleindeckung	
8	Außenwandverkleidung	Kalksandstein / Wärmedämmverbundsystem	A
9	Dämmstoffe Außenwand	Schwer entflammbar	B2

A.2: Site plan of the buildings, report of the building operation and urban planning



A.3: Ground plan of the ground floor



A.4: Ground plan of the first floor

APPENDIX B

SWB Strom
Vertragskonto: A-96531539
Telefonnummer: 0421 988-68144

	Jan 14	Feb 14	Mrz 14	Apr 14	Mai 14	Jun 14	Jul 14	Aug 14	Sep 14	Okt 14	Nov 14	Dez 14	
Verbrauch kWh	25.494	23.596	22.497	17.518	17.551	18.582	24.456	20.254	20.773	21.058	22.796	23.867	281.882
Netto €	5.732,28 €	4.848,87 €	4.599,07 €	3.647,03 €	3.564,50 €	3.848,09 €	4.909,25 €	4.175,25 €	4.262,09 €	4.327,18 €	4.644,38 €	4.861,75 €	53.579,52 €

	Jan 15	Feb 15	Mrz 15	Apr 15	Mai 15	Jun 15	Jul 15	Aug 15	Sep 15	Okt 15	Nov 15	Dez 15	
Verbrauch kWh	26.455	24.054	25.073	15.778	17.578	18.554	19.381	17.207	18.388	21.049	22.630	22.252	269.397
Netto €	6.201,39 €	4.727,11 €	4.583,40 €	3.786,73 €	3.579,20 €	3.745,79 €	3.908,76 €	3.511,46 €	4.420,96 €	4.213,54 €	4.490,61 €	4.435,80 €	50.602,86 €

	Jan 16	Feb 16	Mrz 16	Apr 16	Mai 16	Jun 16	Jul 16	Aug 16	Sep 16	Okt 16	Nov 16	Dez 16	
Verbrauch kWh	25.865	24.054	23.070	20.700	18.781	20.789	19.400	20.733	20.422	20.407	23.181	22.638	280.023
Netto €	4.611,95 €	4.285,82 €	4.124,07 €	3.817,12 €	3.326,63 €	3.627,96 €	3.424,31 €	3.634,22 €	3.573,34 €	3.582,87 €	4.007,78 €	3.934,20 €	45.750,47 €

	Jan 17	Feb 17	Mrz 17	Apr 17	Mai 17	Jun 17	Power Manager Jul 17	Power Manager Aug 17	Power Manager Sep 17	Power Manager Okt 17	Nov 17	Dez 17	
Verbrauch kWh	25.261	21.965	21.934	19.030	19.650	20.663	20.966	20.538	20.309	22.062	26.509	25.863	285.100
Netto €	4.391,72 €	3.820,77 €	3.860,50 €	3.456,10 €	3.606,23 €	3.692,42 €	3.746,80 €	3.723,16 €	3.687,23 €	4.153,51 €	4.850,09 €	4.959,28 €	47.919,90 €
							322,49 €	68,98 €	93,89 €	570,64 €	842,31 €	1.025,06 €	2.943,38 €

	Jan 18	Feb 18	Mrz 18	Apr 18	Mai 18	Jun 18	Jul 18	Aug 18	Sep 18	Okt 18	Nov 18	Dez 18	
Verbrauch kWh	26.112	23.482	23.584	18.747	19.862	19.454	20.734	21.259	18.924	21.373	24.226	23.223	281.340
Netto €	4.225,36 €	3.886,29 €	3.997,74 €	3.181,67 €	3.361,86 €	3.290,52 €	3.497,42 €	3.578,25 €	3.208,92 €	3.684,34 €	4.031,92 €	3.887,68 €	43.911,66 €

	Jan 19	Feb 19	Mrz 19	Apr 19	Mai 19	Jun 19	Jul 19	Aug 19	Sep 19	Okt 19	Nov 19	Dez 19	
Verbrauch kWh	27.781	23.910	24.089	20.305	21.832	20.773							138.690
Netto €	5.225,82 €	4.515,66 €	4.587,42 €	3.919,56 €	4.182,61 €	4.000,46 €							26.411,52 €

2015	Weniger kWh	-12.485	2.976,66 €
2016	Plus kWh	10.626 -	4.852,39 €
2017	Plus kWh	5.077	2.169,43 €
2018	Weniger kWh	-3.760 -	4.008,24 €
2019			

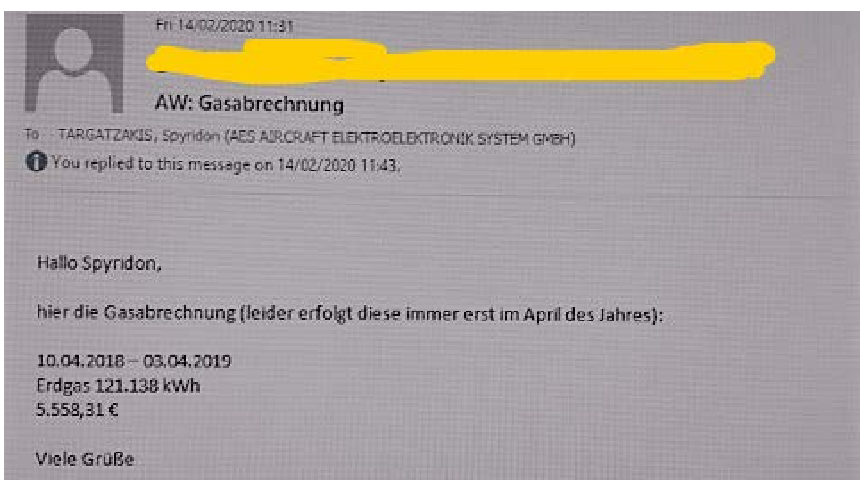
B.1: Electricity consumption and cost 2015-2019

SWB	**Strom**														
Vertragskonto: A-96531539															
Telefonnummer: 0421 988-68144															
	Jan-14	**Feb-14**	**Mar-14**	**Apr-14**	**May-14**	**Jun-14**	**Jul-14**	**Aug-14**	**Sep-14**	**Oct-14**	**Nov-14**	**Dec-14**			
Verbrauch kWh	28,494	23,996	22,497	17,518	17,551	18,582	24,456	20,254	20,773	21,058	22,796	23,887	**261,862**		
														2015	
Netto €	5,732.28 €	4,848.67 €	4,599.07 €	3,647.03 €	3,664.50 €	3,848.09 €	4,969.25 €	4,175.25 €	4,262.09 €	4,327.18 €	4,644.36 €	4,861.75 €	**53,579.52 €**		
														Weniger kWh	
														-12,465	**2,976.66 €**
	Jan-15	**Feb-15**	**Mar-15**	**Apr-15**	**May-15**	**Jun-15**	**Jul-15**	**Aug-15**	**Sep-15**	**Oct-15**	**Nov-15**	**Dec-15**			
Verbrauch kWh	26,455	24,054	23,073	18,778	17,578	18,554	19,381	17,207	18,386	21,049	22,630	22,252	**249,397**		
Netto €	5,201.39 €	4,727.11 €	4,583.40 €	3,786.73 €	3,579.29 €	3,745.79 €	3,908.76 €	3,511.48 €	4,420.96 €	4,213.54 €	4,490.61 €	4,433.80 €	**50,602.86 €**	**2016**	
														Plus kWh	
														10,626	**- 4,852.39 €**
	Jan-16	**Feb-16**	**Mar-16**	**Apr-16**	**May-16**	**Jun-16**	**Jul-16**	**Aug-16**	**Sep-16**	**Oct-16**	**Nov-16**	**Dec-16**			
Verbrauch kWh	25,868	24,054	23,070	20,700	18,781	20,769	19,400	20,733	20,422	20,407	23,181	22,638	**260,023**		
Netto €	4,611.95 €	4,285.82 €	4,124.07 €	3,617.12 €	3,326.83 €	3,627.96 €	3,424.31 €	3,634.22 €	3,573.34 €	3,582.87 €	4,007.78 €	3,934.20 €	**45,750.47 €**		
														2017	
														Plus kWh	
							Pow er Manage	Pow er Manager	Pow er Manager	Pow er Manager				**5,077**	**2,169.43 €**
	Jan-17	**Feb-17**	**Mar-17**	**Apr-17**	**May-17**	**Jun-17**	**Jul-17**	**Aug-17**	**Sep-17**	**Oct-17**	**Nov-17**	**Dec-17**			
Verbrauch kWh	25,261	21,965	21,934	19,030	19,650	20,663	20,986	20,838	20,309	22,062	26,539	25,863	**265,100**		
Netto €	4,391.72 €	3,820.77 €	3,860.59 €	3,458.10 €	3,606.23 €	3,682.42 €	3,746.80 €	3,723.18 €	3,667.23 €	4,153.51 €	4,850.09 €	4,959.26 €	**47,919.90 €**		
ca. Preis kWh/€	0.17 €	0.17 €	0.18 €	0.18 €	0.18 €	0.18 €	0.18 €	0.18 €	0.18 €	0.19 €	0.18 €	0.19 €			
							322.49 €	88.96 €	93.89 €	570.64 €	842.31 €	1,025.06 €	**2,943.35 €**		
	Jan-18	**Feb-18**	**Mar-18**	**Apr-18**	**May-18**	**Jun-18**	**Jul-18**	**Aug-18**	**Sep-18**	**Oct-18**	**Nov-18**	**Dec-18**		2018	
														Weniger kWh	
Verbrauch kWh	26,112	23,452	23,984	18,747	19,852	19,454	20,734	21,259	18,924	21,373	24,226	23,223	**261,340**	**-3,760**	**- 4,008.24 €**
Netto €	4,325.36 €	3,886.29 €	3,997.74 €	3,181.67 €	3,361.65 €	3,290.52 €	3,497.42 €	3,578.25 €	3,208.92 €	3,664.34 €	4,031.92 €	3,887.58 €	**43,911.66 €**		
ca. Preis kWh/€	0.17 €	0.17 €	0.17 €	0.17 €	0.17 €	0.17 €	0.17 €	0.17 €	0.17 €	0.17 €	0.17 €	0.17 €			
	Jan-19	**Feb-19**	**Mar-19**	**Apr-19**	**May-19**	**Jun-19**	**Jul-19**	**Aug-19**	**Sep-19**	**Oct-19**	**Nov-19**	**Dec-19**		2019	
Verbrauch kWh	27,781	23,910	24,089	20,305	21,632	20,773	20,568	20,473	17,688	19,939	23,545	22,701	**263,404**	Plus kWh	
														2,064	6,604.77 €
Netto €	5,225.82 €	4,515.66 €	4,587.42 €	3,919.55 €	4,162.61 €	4,000.46 €	3,978.62 €	3,962.19 €	3,467.04 €	3,869.87 €	4,479.77 €	4,347.42 €	**50,516.43 €**		
ca. Preis kWh/€	0.19 €	0.19 €	0.19 €	0.19 €	0.19 €	0.19 €	0.19 €	0.19 €	0.20 €	0.19 €	0.19 €	0.19 €			

B.1: Electricity consumption and cost 2015-2019

10/01/2018 00:00	6.85	10/01/2018 06:00	6.95	10/01/2018 12:00	14.6	10/01/2018 18:00	12.05
10/01/2018 00:15	6.825	10/01/2018 06:15	9.025	10/01/2018 12:15	14.425	10/01/2018 18:15	11.65
10/01/2018 00:30	7.2	10/01/2018 06:30	9.35	10/01/2018 12:30	14.075	10/01/2018 18:30	9.6
10/01/2018 00:45	7.375	10/01/2018 06:45	10.425	10/01/2018 12:45	13.65	10/01/2018 18:45	7.65
10/01/2018 01:00	6.825	10/01/2018 07:00	10.775	10/01/2018 13:00	13.875	10/01/2018 19:00	6.475
10/01/2018 01:15	6.9	10/01/2018 07:15	11.8	10/01/2018 13:15	13.425	10/01/2018 19:15	5.575
10/01/2018 01:30	6.875	10/01/2018 07:30	12.675	10/01/2018 13:30	13.5	10/01/2018 19:30	6.1
10/01/2018 01:45	6.875	10/01/2018 07:45	12.475	10/01/2018 13:45	14.1	10/01/2018 19:45	5.35
10/01/2018 02:00	6.875	10/01/2018 08:00	12.85	10/01/2018 14:00	13.85	10/01/2018 20:00	5.9
10/01/2018 02:15	5.5	10/01/2018 08:15	12.975	10/01/2018 14:15	13.7	10/01/2018 20:15	5.225
10/01/2018 02:30	5.7	10/01/2018 08:30	13.25	10/01/2018 14:30	13.125	10/01/2018 20:30	6.175
10/01/2018 02:45	5.7	10/01/2018 08:45	15.15	10/01/2018 14:45	13.05	10/01/2018 20:45	5.325
10/01/2018 03:00	5.55	10/01/2018 09:00	16.55	10/01/2018 15:00	14.05	10/01/2018 21:00	5.975
10/01/2018 03:15	5.475	10/01/2018 09:15	16.575	10/01/2018 15:15	14.4	10/01/2018 21:15	5.225
10/01/2018 03:30	5.625	10/01/2018 09:30	16.475	10/01/2018 15:30	13.525	10/01/2018 21:30	5.95
10/01/2018 03:45	5.475	10/01/2018 09:45	17.125	10/01/2018 15:45	13.275	10/01/2018 21:45	7.15
10/01/2018 04:00	5.65	10/01/2018 10:00	15.9	10/01/2018 16:00	13.175	10/01/2018 22:00	6.95
10/01/2018 04:15	6.35	10/01/2018 10:15	15.75	10/01/2018 16:15	12.725	10/01/2018 22:15	6.9
10/01/2018 04:30	6.875	10/01/2018 10:30	15.275	10/01/2018 16:30	12.625	10/01/2018 22:30	6.925
10/01/2018 04:45	6.825	10/01/2018 10:45	15.3	10/01/2018 16:45	12.975	10/01/2018 22:45	6.925
10/01/2018 05:00	6.75	10/01/2018 11:00	15.7	10/01/2018 17:00	12.85	10/01/2018 23:00	6.925
10/01/2018 05:15	6.825	10/01/2018 11:15	14.525	10/01/2018 17:15	11.9	10/01/2018 23:15	6.95
10/01/2018 05:30	6.8	10/01/2018 11:30	14.35	10/01/2018 17:30	12.65	10/01/2018 23:30	6.925
10/01/2018 05:45	6.825	10/01/2018 11:45	14.325	10/01/2018 17:45	11.475	10/01/2018 23:45	6.975

B.2: Electricity Load profile every 15 minutes in a typical working day


Fri 14/02/2020 11:31

AW: Gasabrechnung

To TARGATZAKIS, Spyridon (AES AIRCRAFT ELEKTROELEKTRONIK SYSTEM GMBH)

You replied to this message on 14/02/2020 11:43.

Hallo Spyridon,

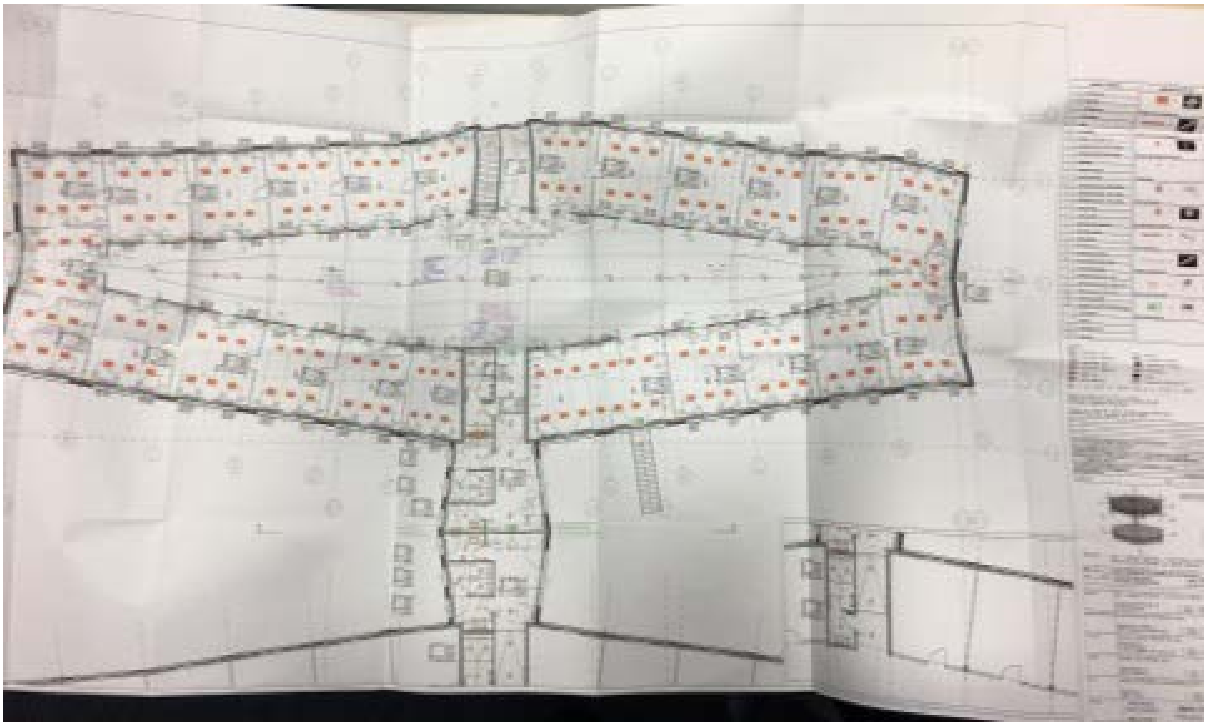
hier die Gasabrechnung (leider erfolgt diese immer erst im April des Jahres):

10.04.2018 – 03.04.2019
Erdgas 121.138 kWh
5.558,31 €

Viele Grüße

B.3: Gas consumption and cost 04/2018-04/2019

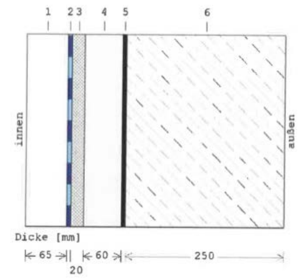
APPENDIX C



C.1 :Light fixture diagram

C.1: Fluorescent lamp

BPL-StB250-WD60-TSD20-ZE65



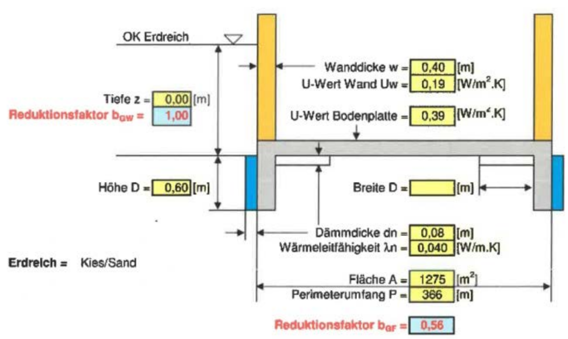
Verwendet für:
Bodenplatte (U=0,393 W/m²K)

Schicht	Material	Dicke [mm]	? [W/mK]	μ_{min}/μ_{max}	s_d-Wert [m]	Anteil [%]
1	DIN V 4108 1.4.1 Zement-Estrich	65	1,400	**15** / 35	0,975	100,0
2	Dampfsperre PE-Folie sd=50m	0,5	0,500	**100000** / 100000	50,000	100,0
3	DIN 4108 EPS Trittschalldämmplatte 040 DES	20	0,040	**20** / 50	0,400	100,0
4	DIN V 4108 5.2 Expandierter Polystyrolschaum GW 0,0338 Kategorie II	60	0,035	**20** / 100	1,200	100,0
5	DIN EN ISO 10456 Bitumen Membran/Bahn	1,5	0,230	**50000** / 50000	75,000	100,0
6	DIN EN ISO 10456 Beton armiert (mit 1% Stahl) 2300	250	2,300	80 / **130**	32,500	100,0

Anmerkung:

U-Wert-Berechnung für den Bauteilaufbau ohne Berücksichtigung von Korrekturfaktoren.

U-Wert-Berechnung für erdberührte Bauteile nach DIN EN ISO 13370



Resultate Bodenplatte

Charakteristisches Bodenplattenmass	B' =	6,97	[m]
Wirksame Gesamtdicke der Bodenplatte	d_t =	5,49	[m]
Zusätzliche wirksame Dicke der Randdämmung	d' =	3,92	[m]
Wärmedurchlasskoeffizient Bodenplatte	U_f =	0,39	[W/m².K]
Korrekturwert bei Randdämmung	$\Delta\Psi$ =	-0,049	[W/m.K]
Wirksamer Wärmedurchlasskoeffizient ohne Randdämmung	**Uo =**	**0,23**	[W/m².K]
Wirksamer Wärmedurchlasskoeffizient mit Randdämmung	U_{bF} =	0,22	[W/m².K]
Reduktionsfaktor Bodenplatte	b_{GF} =	**0,56**	[-]

Anmerkung:

U-Wert-Berechnung für den Bauteilaufbau ohne Berücksichtigung mit Korrekturfaktoren.

Berechnung der Sonneneintragswerte nach DIN 4108-2 (07/2003)

Raum:	AES - Flurzone OG				
NRF:	336,78	m²	Höhe:		m
Orientierung:	NO,SW		Breite:		m
Lage:	OG		Tiefe:		m
Sonnenschutz:	**außenliegend, Fc <= 0.4 (Verschattungsgrad min. 60%)**				

Berechnung des Sonneneintragskennwertes

Fensterfront 1:				
Fensterfläche (Rohbaumaß)		$A_{W,1}$ =	175,22	m²
Gesamtenergiedurchlassgrad der Verglasung nach DIN EN 410		g_1 =	0,22	
Abminderungsfaktor für Sonnenschutzvorrichtung		$F_{C,1}$ =	0,40	
	$g_{total,1} = g_1 * F_{C,1}$	$g_{total,1}$ =	0,09	
Fensterfront 2:				
Fensterfläche (Rohbaumaß)		$A_{W,2}$ =	175,22	m²
Gesamtenergiedurchlassgrad der Verglasung nach DIN EN 410		$g_{,2}$ =	0,22	
Abminderungsfaktor für Sonnenschutzvorrichtung		$F_{C,2}$ =	0,40	
	$g_{total,2} = g_2 * F_{C,2}$	$g_{total,2}$ =	0,09	
Nettogrundfläche (lichte Maße)		A_G =	336,8	m²
Sonneneintragskennwert	$S = \Sigma_j (A_{W,j} * g_{total,j}) / A_G$	S =	0,092	

Ermittlung des maximal zulässigen Sonneneintragswertes

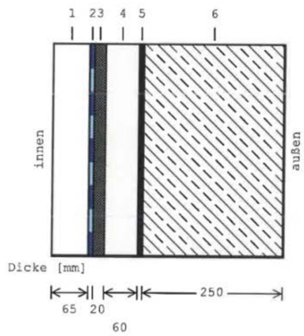
Gesamte Fensterfläche (Rohbaumaße)		$A_{W,gesamt}$ =	350,4	m²
Fensterfläche nach Norden, Nordosten oder Nordwesten		$A_{W,nord}$ =	87,5	m²
Außenwandfläche (Außenmaße; ohne Fenster)		A_{AW} =	0,0	m²
Dach- oder Deckenfläche (Außenmaße)		A_D =	375,4	m²
Gewichtete Außenflächen	$f_{gew} = (A_W + 0,3\ A_{AW} + 0,1\ A_D) / A_G$	f_{gew} =	1,15	
geneigte Fensterfläche	0° < Neigung < 60%	$A_{FE,Dach}$ =	350,44	m²
	$f_{nord} = A_{W,nord} / A_{W,gesamt}$	f_{nord} =	0,25	
Kennwert für Bauart		Bauart =	0,10	
Anteilige Sonneneintragskennwerte:				
Klimaregion		S_x =	0,03	
Bauart	S_x = Bauart * f_{gew}	S_x =	0,12	
Erhöhte Nachtlüftung		S_x =	0,02	
Sonnenschutzverglasung		S_x =	0,03	
Nordorientierung		S_x =	0,02	
Fensterneigung		S_x =	-0,12	
Zulässiger Höchstwert des Sonneneintragswertes	$S_{zul} = \Sigma S_x$	S_{zul} =	0,095	

Die Anforderungen zum sommerlichen Wärmeschutz werden eingehalten.

Bautechnik

Verwendete Konstruktionen

BPL-StB250-WD60-TSD20-ZE65

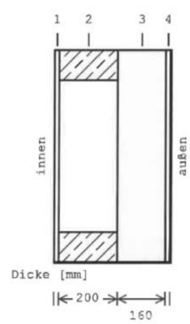


Verwendet für:
Bodenplatte (U=0,393 W/m²K)

Schicht	Material	Dicke [mm]	λ [W/mK]	μ_{min}/μ_{max}	s_d-Wert [m]	Anteil [%]
1	DIN V 4108 1.4.1 Zement-Estrich	65	1,400	**15** / 35	0,975	100,0
2	Dampfsperre PE-Folie sd=50m	0,5	0,500	**100000** / 100000	50,000	100,0
3	DIN 4108 EPS Trittschalldämmplatte 040 DES	20	0,040	**20** / 50	0,400	100,0
4	DIN V 4108 5.2 Expandierter Polystyrolschaum GW 0,0338 Kategorie II	60	0,035	**20** / 100	1,200	100,0
5	DIN EN ISO 10456 Bitumen Membran/Bahn	1,5	0,230	**50000** / 50000	75,000	100,0
6	DIN EN ISO 10456 Beton armiert (mit 1% Stahl) 2300	250	2,300	80 / **130**	32,500	100,0

Beschreibung:

AW-KS_200-WDVS_160_EPS



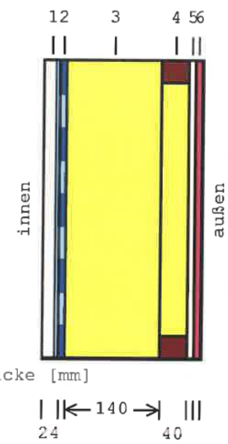
Verwendet für:
Außenwand NO (U=0,187 W/m²K)
Außenwand NW (U=0,187 W/m²K)
Außenwand SO (U=0,187 W/m²K)
Außenwand SW (U=0,187 W/m²K)

Schicht	Material	Dicke [mm]	λ [W/mK]	μ_{min}/μ_{max}	s_d-Wert [m]	Anteil [%]
1	DIN V 4108 1.1.1 Putzmörtel aus Kalk, Kalkzement und hydraulischem Kalk	15	1,000	**15** / 35	0,225	100,0
2	DIN V 4108 4.2 Mauerwerk aus Kalksandsteinen 1800	200	0,990	**15** / 25	3,000	71,4
	DIN EN ISO 10456 Beton armiert (mit 1% Stahl) 2300	200	2,300	**80** / 130	16,000	28,6
3	DIN V 4108 5.2 Expandierter Polystyrolschaum GW 0,0310 Kategorie II	160	0,032	**20** / 100	3,200	100,0
4	DIN V 4108 1.1.1 Putzmörtel aus Kalk, Kalkzement und hydraulischem Kalk	12	1,000	15 / **35**	0,420	100,0

Beschreibung:

KS-Thermohaut besteht aus einer tragenden KS-Mauerschale und einem beliebigen Wärmedämmverbundsystem (WDVS) nach allgemeiner bauaufsichtlicher Zulassung.

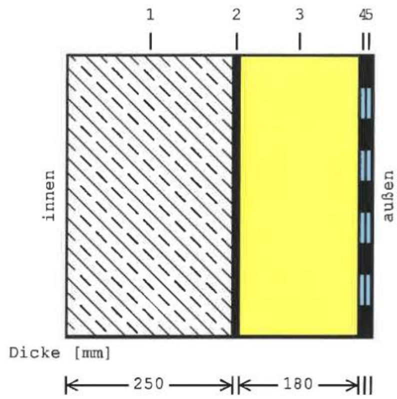
DA-HS24-ASD200_MW-SF



Verwendet für:
Dach NO (U=0,191 W/m²K)

Schicht	Material	Dicke [mm]	λ [W/mK]	μ_{min}/μ_{max}	s_d-Wert [m]	Anteil [%]
1	DIN EN ISO 10456 Konstruktionsholz 500	24	0,130	**20** / 50	0,480	100,0
2	Diffusionsdichte Schicht sd>1500m (z.B. Metallfolien oder Bitumenbahnen mit ALU-Einlage o.ä.)	1	0,170	**1500000** / 1500000	1500,000	100,0
3	DIN V 4108 5.1 Mineralwolle GW 0,0338 Kategorie II	140	0,035	**1** / 1	0,140	100,0
4	DIN V 4108 5.1 Mineralwolle GW 0,0338 Kategorie II	40	0,035	**1** / 1	0,040	85,0
	DIN EN ISO 10456 Holzwerkstoffe Spanplatte 900	40	0,180	**20** / 50	0,800	15,0
5	EN ISO 6946 Luftschicht 10mm (Wärmestrom aufwärts - schwach belüftet)	8	R=0,068 m²K/W	1 / 1	0,008	100,0
6	DIN EN ISO 10456 Metalle Stahl	0,8	50,000	999999 / **999999**	799,9992	100,0

DA-StB200-WD180/MW



Verwendet für:
Dach Verbinder (U=0,184 W/m²K)

Schicht	Material	Dicke [mm]	λ [W/mK]	μ_{min}/μ_{max}	s_d-Wert [m]	Anteil [%]
1	DIN EN ISO 10456 Beton armiert (mit 1% Stahl) 2300	250	2,300	**80** / 130	20,000	100,0
2	DIN EN ISO 10456 Bitumen Membran/Bahn	2,5	0,230	**50000** / 50000	125,000	100,0
3	DIN V 4108 5.1 Mineralwolle GW 0,0338 Kategorie II	180	0,035	**1** / 1	0,180	100,0
4	DIN V 4108 7.3.3 Glasvlies Bitumendachbahnen nach DIN 52143	2,5	0,170	**20000** / 60000	50,000	100,0
5	DIN V 4108 7.3.1 Bitumendachbahnen (DIN 52128)	2	0,170	10000 / **80000**	160,000	100,0

Beschreibung:

Blende auf Abstandshalter

Fenstertypen

FE-WSG-1.2_0.60

U-Wert [W/(m²K)]	1,21
g-Wert [-]	0,60
g-Korrektur [-]	0,90
Lichttransmissionsgrad τ_{D65} [-]	0,72
U-Verglasung [W/(m²K)]	1,00
Sonderverglasung	nein
Beschreibung	-

FE-WSG-1.4_0.42

U-Wert [W/(m²K)]	1,43
g-Wert [-]	0,42
g-Korrektur [-]	0,90
Lichttransmissionsgrad τ_{D65} [-]	0,70
U-Verglasung [W/(m²K)]	1,10
Sonderverglasung	nein
Beschreibung	-

C.2: Windows and walls U-Value

Gebäudeergebnisse

Jährlicher Nutzenergiebedarf	spezifisch [kWh/(m²a)]	absolut [kWh/a]
Heizung	78,53	185.194,77
Trinkwarmwasser	3,47	8.184,08
Beleuchtung	10,34	24.376,26
Belüftung	0,00	0,00
Kühlung	18,10	42.677,47
Gesamt	110,44	260.432,58

Jährlicher Endenergiebedarf (brennwertbezogen)	spezifisch [kWh/(m²a)]	absolut [kWh/a]
Heizung	30,74	72.480,13
Trinkwarmwasser	1,65	3.886,88
Beleuchtung	10,34	24.376,26
Belüftung	0,57	1.354,84
Kühlung	8,86	20.888,81
Gesamt	52,15	122.986,92

Endenergiebedarf nach Energieträgern (brennwertbezogen)	spezifisch [kWh/(m²a)]	absolut [kWh/a]
Strom-Mix	52,15	122.986,9
Gesamt	52,15	122.986,9

Jährlicher Primärenergiebedarf (heizwertbezogen)	spezifisch [kWh/(m²a)]	absolut [kWh/a]
Heizung	79,91	188.448,34
Trinkwarmwasser	4,29	10.105,89
Beleuchtung	26,88	63.378,28
Belüftung	1,49	3.522,59
Kühlung	23,03	54.310,90
Gesamt	135,60	319.765,97

EnEV-Werte	Ist-Wert	Soll-Wert	% vom Soll-Wert
spez. Transmissionswärmeverlust H'_T [W/(m²K)] (für KfW)	0,470	–	–
H'_T des Referenzgebäudes [W/(m²K)]		0,546	86,1 %
spez. Primärenergiebedarf [kWh/(m²a)]	135,60	164,06	82,7 %

Bautechnik

Bauteilliste

Bauteile

Bezeichnung	Fläche [m²]	Nettofläche [m²]	Aus-richtung	U-Wert [W/(m²K)]
Bodenplatte	1273,57	1273,57	horizontal	0,440
Außenwand NO	403,14	272,29	Nordost	0,190
Außenwand NW	187,59	149,06	Nordwest	0,190
Außenwand SO	187,59	137,35	Südost	0,190
Außenwand SW	404,00	260,16	Südwest	0,190
Dach NO	594,74	419,52	Nordost	0,190
Dach SW	603,73	428,51	Südwest	0,160
Dach Verbinder	110,49	110,49	horizontal	0,180

Fenster

Bezeichnung	Fläche [m²]	U-Wert [W/(m²K)]
Fenster 3.76x1.45	294,41	1,21
Fenster 2.51x1.45	21,84	1,21
Fenstertür 2.51x2.31	11,60	1,21
Fenster 1.30x1.45	22,62	1,21
Fenster 3.28x1.45	4,76	1,21
Fenstertür 3.28x2.51	8,23	1,21
Dachverglasung	350,44	1,43

C.3: Annual energy demands evaluation

Monatswerte

	Nutzenergiebedarf [kWh/a]	Endenergiebedarf [kWh/a]	Primärenergiebedarf [kWh/a]
Januar	43.579,89	19.861,21	51.639,14
Februar	34.008,42	15.550,54	40.431,40
März	27.592,31	12.499,62	32.499,01
April	13.043,21	6.684,85	17.380,60
Mai	10.033,41	5.547,41	14.423,25
Juni	11.094,80	5.702,56	14.826,65
Juli	14.363,56	6.663,18	17.324,27
August	11.627,32	5.807,32	15.099,03
September	8.715,46	5.102,47	13.266,42
Oktober	17.908,84	8.647,29	22.482,96
November	29.183,68	13.183,38	34.276,79
Dezember	39.281,67	17.737,11	46.116,48

C.4: Overall energy needs per month

C.5: Electric Water heaters used by the company