Sustainability-Driven Energy Management Systems for Multinational Organizations: A Case Study

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Abstract

A vital part of sustainable development and solving the sustainability challenge is to reduce the environmental and social impact of multinational organizations caused by their potentially unsustainable energy consumption.

The focus of this study is to create an energy management system for organizations to strategically transform their energy resources and energy consumption to reduce their socioecological impact. It is important to ask what are the critical elements that would hinder or allow for the shift to renewable energy and energy efficiency? It is also important to question how can those elements be integrated together to address the sustainability challenge with the energy consumption of multinational manufacturers?

A case study on an organization was done to identify some of the barriers and drivers, for them to implement sustainable energy management systems, and to modify the sustainable energy management system that proposes strategies around synergy between energy efficiency and renewable energy, to make it a decision-making tool focused on energy planning.

The construction of the tool, with the help of the case study organization and its decision makers, allowed the design of a more overarching tool that includes sustainability concepts and ensures the sustainability approach in its scheme and implementation.

Keywords

Sustainability, Management, Energy, Multinational, Transition, Incentives

Statement of Contribution

This thesis work has been the collaborative work of Anas Al-Daghestani, Mahinour AlKassem, and Qianxin Xu. From the moment we chose the project till the day of submission we have worked with passion and a relentless drive, for we are supporters of renewable energy.
To solve the problem at hand and answer the research questions effectively, the team has appointed different tasks for different team members. By mapping out the strengths and opportunities of improvement of each researcher, we have been able to work in synergy and harmony, and accomplish all that we have gone out to achieve.

The nature of our thesis; that required several methods to be carried out concurrently, and with the huge amount of the data collected, we were bound to have sleepless nights to carry out the analysis. Yet, with the efficiency in carrying out our tasks, and every individual's dedication to the project, the experience turned out to be gratifying. We have become the closest of friends and the synergy between us was impeccable.

The team has worked together on the development of the research questions and methods. All the methods were carried out in an agreement between the team members. The planning and outlining of the written report was done as a team to ensure that everyone is on the same page while the chapters are divided between the team members.

Anas contributed to the team by facilitating the meetings with the interviewees and ensuring the communications are on point. His valuable insight on several aspects of the thesis and providing a clear path for the team was important for the successful completion of the study. Anas's knowledge in IT communication technologies and in different platforms was vital for the smooth flow of the thesis. Anas worked mostly on the Results chapter.

Mahinour contributed to the overall goal by going through literature and databases none of us has been able to find. Her excellent research skills and amazing attitude towards the work and the team has made this thesis work even more fun for the team. The days that we have spent in her room writing down chapters and chapters of the thesis were priceless and will definitely be missed. And her knowledge in thermodynamics and other engineering concepts that she has brought to the team are invaluable. Mahinour mostly worked on the Discussion chapter of the report.

Qianxin contributed to the successful completion of this study by offering the team his great attention to details. His work in analyzing the data collected and in building complex formulas to create the most accurate results was vital to every aspect of the research. Qianxin's knowledge in Shanghai's regulatory frameworks and the environment has made him central to the case study's contribution to the thesis. His patience and his amazing attitude towards his friends made him even more valuable to the team. Qianxin mostly worked on the Introduction part of the report.

The work on this thesis has offered us valuable experiences in working with people of different backgrounds and in different disciplines. We have seen that our personalities have converged in the end and the synergy between us has become sturdy. This thesis has also has given us the opportunity to backcast from a future of clean energy and sustainable organizations.

Karlskrona, Sweden
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Anas Al-Daghestani Mahinour AlKassem Qianxin Xu

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We would also like to thank our secondary advisors Andre Benaim and Helena for their support and the valuable feedback they have given us to improve our thesis.

The support that we have received from the case study organization has been fundamental for our thesis. We would like to especially thank our contact person at the organization for his valuable input in our thesis and his prompt feedback and support for our team. We would also like to thank the global sustainability manager and the chief executive officer for giving us the privilege to work with their organization on this study and go beyond the theory and implement our ideas in real life situations. The idea of incorporating sustainability in their energy processes and operations stemmed from the ideology of their organization as a whole and the individuals within. Knowing that there are organizations out there with that passion for sustainability and the drive to improve their environmental and social impact inspired us to go further in our studies. So thank you for that.

We would also like to thank our program manager all the staff in the Strategic Sustainable Development department for their continuous support during this amazing journey. We also would like to extend our gratitude to Karl-Henrik Robert and Goran Broman for starting this amazing program and offering us this ecstatic experience. Their effort to develop this program is invaluable.

Finally, we would like to thank our fellow students in the MSLS program for their support to us during the process and their help in making this journey more fulfilling.

Executive Summary

Introduction

Since the beginning of the industrial revolution, society has grown in size and influence in the economic, social, and environmental levels compared to the biosphere within which we live. It has resulted in both positive and negative consequences. The industrial revolution participated in the wealth of society by increasing production size, improving the quality of life through transportation and building technologies, and life expectancy through advancements in medicine. On the other hand, the growth has had negative consequences such as poverty, inequality, and pollution because of unsustainable consumption and production patterns that rely on the burning of fossil fuels as the main source of energy. This has led to a systematic increase in CO2 levels in the atmosphere which also caused an increase in temperature levels on the planet and ultimately the appearance of the phenomenon known as the Global warming.

After the birth of the environmental movement in the 1960's, scientists and researchers have considered the negative consequences of the environmental impacts of the burning of fossil fuels and deforestation . This increase of awareness and consideration has helped scientists in developing more solutions that would assist in tackling the complex sustainability challenge.

Multinational organizations, which constitute a large part of society, nowadays are seeking to address the sustainability challenge by incorporate sustainability in their organizational structure and operations and implementing different strategies. One of the strategies is energy management, having a potential to solve the challenge by addressing the energy consumption and emission problems.

There are barriers and drivers that would hinder or help, respectively, medium-sized manufacturers from proficiently implementing energy management; such as the company's management structure, the and international and national regulations, financial and economic conditions of the organization, regional incentives, and geographical and climate conditions. These elements should be integrated together and considered when implementing an energy management system in a multinational organization.

Current existing energy management plans are discussing and providing solutions around reduction of energy consumption and improving energy performance in multinational businesses through proposing strategies and practices around energy efficiency. Yet they do not address the deployment of renewable energy together with energy efficiency in a synergetic manner to better achieve the required objectives of reducing their operational costs and environmental impact.
The Framework for Strategic Sustainable Development (FSSD) was developed to incorporate strategic sustainable development concepts based on a systems thinking approach where the problem is analyzed on five levels. It starts with understanding the bigger system where the problem is situated. Followed by identifying the principles for achieving success within the system, known as sustainability principles, based on scientific fundamental system conditions for sustainability.
The strategic level provides generic strategic guidelines of planning and acting towards success. This level is based on the backcasting concept. The actions level is where actions are proposed to help the system move to success and sustainability. Finally, the tools level, is where tools are used to assist the success of the system.

Since FSSD was also developed on a strategic planning model so it can be used multinational organizations to achieve a successful shift towards sustainability.
In our research, the FSSD approach is appropriate since the study requires systems thinking to simplify the complexity of energy systems, understand the interrelations between energy systems and the socioecological system, and finally reach the solution. The system in the study is energy consumption in multinational organizations, and its success is their shift to sustainable energy practices. To reach this success, guidelines, actions, and tools are needed to support the objective.

In this research paper, the focus is on one of the growing industries nowadays; the Coatings industry which is a part of several subsystems in relation to the global sustainability has a potential impact on sustainable development worldwide.

Although manufacturing processes in the coatings industry are not energy intensive, yet their operations patterns could be relatively energy consuming. Their dependence on national grids as their source of energy in the different countries could negatively affect the environment due to heavily relying on fossil fuels based energy sources. By implementing energy management systems to strategically switch to renewables together with adopting efficient strategies could reduce energy consumption and emissions in their different sectors, sites, and operational phases, they would be able to positively contribute to a more sustainable society. A case study was performed on one of the biggest competitors in the expanding coatings industry to emphasize the research and support fulfilling the aim of the research which is to explore the opportunities and develop a sustainability-driven energy management system for a multinational manufacturer addressing the critical elements that could help or hinder the implementation of such a system as well as considering the deployment of energy efficiency together with renewable energy in synergy.

The following research questions are answered in the search paper through the lens of various sustainability science methods, tools, and approaches.

1. What are the critical elements and key attributes of a sustainability-driven energy management strategy for a multinational, mid-size company?

2. How can these critical elements be integrated together to address the sustainability challenge within energy consumption for a multinational, mid-size company?

Methods

The research design chosen for this research is mixed method design that includes quantitative and qualitative research methods. This is done to consider time and resource limitations during the study. This design also helped in cover certain pitfalls that some methods had with strengths of others.

The methods section was divided into two phases. Phase I includes the methods to identify the critical elements that act as drivers and barriers to implementing energy management strategies, while Phase II includes methods to highlight the importance of using existing energy management systems to integrate the critical elements.

Methods to develop the energy management system include forming a *case study* with an organization with the intention to shift towards more sustainable resources, comprehensive data analysis of energy consumption, and energy management tools analysis through the lens of a sustainability development framework. Other methods were: holding interviews with key decision makers in the organization, site-specific questionnaires, and the implementation of a section of the tool on the case study organization.

Moreover, calculations and analysis were done on 21 documents that include energy intensity, energy consumption, site total production, energy costs, and cost-benefit analysis for four different sites in Chicago, Montbrison, Ras Al-Khaimah, and Shanghai. This assisted in strengthening the validity of the study and provided more insight on strategies associated with energy management of multinational organizations. All actions proposed for the case study sites were analyzed thoroughly to ensure that there are no future pitfalls. Predictive research was also used to identify energy objectives and highlight the path to achieving the results.

Results

The initial results from the literature review showed that there are some critical elements that organizations can utilize to strategically shift their energy consumption and production to become more sustainable. Yet, some organizations are not fully aware of the potential positive impact that those critical elements an offer. The identified critical elements from the content analysis in Phase I are:

1. Regulatory Frameworks
2. Economic and Financial Factors
3. Company's reputation
4. Incentives

From three different interviews with key informants in the case study organization, the team has new findings for the below critical elements:

1. Economic and Financial Factors
2. Company's Reputation
3. Incentives
4. Geographical Conditions

Then, in Phase II, the analysis of two different energy management systems ISO50001 and EN16001 identified some pitfalls and gaps that can be covered and addressed with the critical elements identified.

Potential tool users find the sustainability-driven energy management system appealing, but highlight the need for a more comprehensive cost-benefit analysis on any recommended action for top management and decision makers to make more strategic decisions. Decision makers also highlighted the need for a shorter return on investment with low initial cost on current plans to keep up with the currently low energy prices. This has highlighted the need for a new strategy to shift to renewable energy resources.

The results show that there are three different strategies that multinational organizations can implement to strategically shift their energy consumption and resources to become more sustainable. The strategies include renewable energy, energy efficiency, and synergy between renewable energy and energy efficiency.

It was also noticeable that synergy between renewable energy and energy efficiency is the most cost-effective strategy to implement for manufacturers due to its relatively immediate results, its low initial cost, and relatively short payback period.

Furthermore, calculations on energy intensity, energy consumption, and site production assisted the team in the analysis to identify potential areas of improvement and investment opportunities for the case study organization. Identifying the areas improvements helps in providing best practices for all kinds of manufacturers.

Discussion

The discussion phase focuses on assessing the ability of the team to answer the research questions from the results shown in the previous chapter. Thus, to answer the first research question, the barriers and motivators are:

1. Regulatory Frameworks
2. Economic and Financial Factors
3. Company's Reputation
4. Geographical and Climate Conditions

Then the critical elements are studied and discussed to in the context of different energy management strategies. Which helped in identifying systems that can be integrated with the critical elements. Thus, the second research question is answered: "by integrating the critical elements into existing energy management systems that include energy efficiency, renewable energy, and synergy between renewable energy and energy efficiency strategies.". This helped in the development of the sustainability-driven energy management system. This system includes an energy planning tool that was later implemented in the case study organization.

The tool covers the financial aspects of implementing the energy efficiency, renewable energy and the synergy between renewable energy and energy efficiency strategies by carrying out a cost-benefit analysis for each proposed action. This analysis includes variables such as costs variations, costs savings, initial costs, replacement and maintenance costs, cost reductions by incentives, and the compound effect of increasing energy prices. Consequently, the strategies proposed by the tool fit neatly into the business case for sustainability.

Conclusion

In conclusion, organizations must always identify their own critical elements that would hinder or motivate their sustainability-driven energy management systems. Keeping the critical elements in mind as the tool is implemented provides ease of access to renewable resources to organizations, hence, reducing the multinational manufacturers' environmental impact.

Renewable and energy efficiency are stepping stones of sustainable energy. The growth of the demand for energy must be within the sustainable range so that renewable energy can start taking over and ultimately eliminate the need for fossil fuel. So energy efficiency together with renewable energy must be used simultaneously in a sustainable energy future.

The recommendation put forward by the thesis is the need for further studies to evaluate the tool on an implementing organization to assess the impact that the system has on decision making at an organization level, and whether further amendments must be done on the tool to facilitate a more effective shift to renewable energy. The need for further studies is underpinned by the fact that the study was limited by time, resources, and the disregard of certain business aspects such as transportation, interaction with the suppliers and customers.

Abbreviations

ACM	The Association for Computing Machinery.
BAU	Business as Usual.
BP	British Petroleum
CAGR	Compound Growth Annual Rate
CSR	Corporate Social Responsibility
CTO	Chief Technology Officer
C2E2	Copenhagen Centre for Energy Efficiency
DoE	Department of Energy
EN-1600	European Standards
EnMS	Energy Management Systems
EnPI	Energy Performance Indicator
EE	Energy Efficiency
FEWA	The Federal Electricity and Water Authority
FSSD	Framework for Strategic Sustainable Development
GDP	Gross Domestic Product
GHG	Greenhouse Gas Emissions
HSE	Health, Safety, and Environment
HVAC	Heating, Ventilation and Air Conditioning
IEA	International Energy Agency
IEEE	The Institute of Electrical and Electronics Engineers
IEMA	The Institute of Environmental Management and Assessment
IRENA	International Renewable Energy Agency
ISO-50001	International Organization for Standardization
KPI	Key Performance Indicators
KWh	Kilowatt hour
LED	Light Emitting Diode
MEA	Middle East and Africa
PDCA	Plan-Do-Check-Act
PRC	People's Republic of China
PV	Photo Voltaic
RE	Renewable Energy
R&D	Research and Development
REC	Renewable Energy Certificate
SP	Sustainability Principles.
SSD	Strategic Sustainable Development
SEMS	Sustainability-Driven Energy Management System
SE4All	Sustainable Energy for All
UNGC	The United Nations Global Compact
USD	United States Dollar
5LF	The Five Level Framework

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1. Introduction

"We are the makers of our own state and individuals who realize the fact need not, ought not, to wait for collective action" --- Mahatma Gandhi (Gandhi 1959)

1.1. The Sustainability Challenge

"There is no 'Plan B' because we do not have a 'Planet B.' We have to work and galvanize our action," said Ban-Ki Moon, the Secretary-General of the United Nations, speaking to journalists after walking with 300,000 demonstrators in the People's Climate March in 2015 demanding measures to halt the advance of global climate change. Earth, our only habitable planet, includes two subsystems of primary concern; the biosphere and human society. Before the Industrial Revolution human society was relatively small compared to the biosphere in terms of resources needed to sustain life on Earth. Yet, since the beginning of the industrial revolution, society has grown in size and influence in the economic, social, and environmental levels. It has increased the wealth of society by increasing production size, improving the quality of life through transportation and building technologies, and life expectancy through advancements in medicine. On the other hand, the growth has negative consequences such as poverty and inequality because of unsustainable consumption and production patterns. Moreover, the growth in society has caused a systematic increase in CO2 levels in the atmosphere because of deforestation and the systematic increase in mining and drilling for fossil fuels, which caused the destruction of natural habitats. As well as burning of fossil fuels as the main source of energy to power the industrial revolution, which also caused an increase in temperature levels on the planet.

Before the birth of the environmental movement in the 1960's, little attention was paid to the negative consequences of the environmental impacts of the burning of fossil fuels and deforestation (Ward, Dubos, and others 1972). And after the decisions and the recommendations given in the United Nations Conference on the Human Environment, scientists and researchers around the world has started looking for the causes and answers for the current socioecological problems (Declaration 1972). Research has found that most of the unsustainability problems are caused by systematic unsustainable behavior by human society. This increase of awareness has helped scientists in developing more concepts that would assist in tackling the complex sustainability challenge (Robèrt 2009).

1.2. Sustainable Development

Sustainable development is a concept of development that was adopted to meet the needs of the present while preserving the ability of future generations to meet their needs (Brundtland et al. 1987). Around 43% of businesses of all different sizes, enterprise architecture, managements, and global footprints, continue to develop their efforts to incorporate sustainability into their goals, missions, or values (McKinsey&Company 2016). Doug Morrow vice president of research at Corporate Knights says: "Essentially, it is doing more with less, squeezing more output out of every capital input, including the financial, human, and natural capital." (Smith 2016). In brief, more sustainable companies are those performing the best in the economic, social, and environmental subsystems systems as compared to others in the industry. On the other hand, more than half of the businesses globally are not trying to incorporate sustainability in their business values due to several hurdles for sustainable development in businesses. One of the hurdles is the strongly held preconception that sustainability does not fit neatly into the business case since it does not show a clear financial benefit for organizations to implement sustainability. Also, lack of guidelines for engaging stakeholders efficiently and clear understanding of the sustainability challenge also impacts businesses' implementation of sustainability (Laughland and Bansal 2011).

1.3. Relevance of energy management for multinational manufacturers

To address the sustainability challenge, organizations nowadays are seeking to incorporate sustainability in their organizational structure and operations by implementing different strategies. One of the strategies is energy management, which became a topic of interest for organizations of all sizes and has been a subject of research by scientists and engineers for years (Aplak and Sogut 2013). Energy management is defined as the planning and operation of energy production and energy consumption. With suitable energy management in mid/large scale organizations, many costs and threats around the economic and socioecological impacts, related to its waste and contribution to climate change during the phases of manufacturing, can be eliminated, thus increasing profitability (Hatase and Managi 2015). On the other hand, energy prices are systematically increasing and environmental laws are becoming stricter; which has created an increasing demand for reducing energy consumption and similar costs in industrial organizations and to utilize other alternative energy resources (Schulze et al. 2016). Furthermore, current energy management plans are discussing and providing solutions around reduction of energy consumption in businesses and cities, yet they do not address transforming to renewable energy resources (Kantola and Saari 2013). Thus, integrating the SSD concepts, such as backcasting and systems thinking, into current energy management systems could help organizations in addressing the sustainability challenge more effectively. Moreover, improved energy performance of a company can have an impact on the company's image and offer benefits for an organization in the short and long terms (Introna et al. 2014). Also, there are barriers that would hinder medium-sized manufacturers from proficiently implementing energy management; such as the company's management structure, the number of employees, and international and national regulations (Epstein and Buhovac 2010).

1.4. Framework for Strategic Sustainable Development (FSSD)

Based on the concepts of SSD, the Framework for Strategic Sustainable Development (FSSD) was developed on a strategic planning model that can be used by SMEs and multinational organizations to achieve a successful shift towards sustainability (Robèrt et al. 1997; Robèrt 2000; Holmberg and Robèrt 2000). Many businesses and decision makers use the FSSD to integrate environmental and social considerations into strategic decisions and operations. Business leaders use the Framework to transform risks into opportunities for improvements by reducing operating costs, incorporate environmental and social concerns, make use of regional political conditions, and stay ahead of regulatory frameworks.

The FSSD methodology is based on a systems thinking approach where the problem or research is analyzed on five levels. It starts with understanding the bigger system where the problem or research question is situated. Then, the principles for achieving success within that system, known as sustainability principles, are identified based on scientific fundamental system conditions for sustainability. The sustainability principles state that:

In a sustainable society nature is not subject to systematically increasing…

1. …Concentrations of substances extracted from the Earth's crust.
2. …Concentrations of substances produced by society.
3. …Degradation by physical means. (Robèrt 2009)

In a socially sustainable society, people are not subject to structural obstacles to…

4 …Health
5. …Influence
6. …Competence
7. …Impartiality
8. …Meaning-making (Missimer 2015),

The third level, called strategic level, provides generic strategic guidelines of planning and acting towards success defined in the second level. This level is based on the backcasting concept from the SSD. Backcasting is a planning methodology that starts with defining a desirable future and then works backwards to identify actions and strategies to reach success (Robèrt 2009). The fourth level, called actions level, is where actions are proposed to help the system move to success and sustainability. The fifth and last level, called the tools level, is where tools such as energy management systems are used to support efforts to reach global sustainability. In this research paper, the FSSD approach is appropriate since the study requires a systems thinking to reach the final outcome. The system in the study is energy consumption in multinational organizations, and its success is to shift their energy practices to become more sustainable. To reach this success, guidelines, actions, and tools are needed to support the objective. Incorporating FSSD within energy management systems could help fill in the gaps and pitfall in existing systems as well as help shifting to a more sustainable future for energy.

1.5. Critical Elements as Barriers and Motivators

Multinational organizations that are situated in different regions with environmental protection policies and strategies can have positive contributions to the environment. The exposure of such organizations to different kinds of technology and resources in different regions can provide them with different options to choose different environmental protection technologies and energy resources (Svatikova et al. 2012). Furthermore, the exposure of multinational organizations to different ideologies and governmental policies around environmental protection can positively impact the organization's internal policies and future visions (Swamy 2014).

Hence, the first research question is *what are the critical elements and key attributes of a sustainability-driven energy management strategy for a multinational, mid-size company*?

1.5.1. The Regulatory Framework as a Driver

Practically, Popp (2002) found that environmental regulations in the US succeeded in restraining negative environmental impacts and ultimately prompt technological development. Similarly, the regulatory pressure was the second main driver of green technology in the paper and pulp industry in Spain (Rennings and Rammer 2009).

Looking into different patterns implemented in several countries, it was found that there are two quite different types of environmental innovators. Countries, like Belgium, Finland, Luxembourg, and Portugal, could be known as “proactive innovators” where companies mainly introduce environmental innovations as a result of current or expected market demand and because of voluntary agreements within sectors. Others, as the Czech Republic, Lithuania, Malta, Romania, and Slovakia, could be termed “defensive innovators” where companies mainly react to existing or expected regulations. The remaining countries (such as Sweden, Poland, France, Germany, Italy, Ireland, Latvia, the Netherlands, Hungary and, Estonia) have mixed profiles where no clear motivation for environmental innovation is dominant (Trucost 2016).

1.5.2. The business reputation as a Driver

Companies seek to enhance and protect their corporate image and reputation by showing respect for the environment and by taking actions towards this objective. Most accomplished Corporate Social Responsibility (CSR) practitioners of today, primarily began reporting their impacts due to negative publicity and brand image destruction generated by consumer campaigns and boycotts of their products in the 70s and 80s. They found that transparency of information is the only way to rebuild consumer trust. The rising relates to increased consumer pressure, awareness of environmental matters, and pressure on performance transparency and reporting requirements led to the increased importance of corporate image/reputation. Examples of this include initiatives such as the Global Reporting Initiative and Carbon Disclosure Project aiming to make visible companies impacts (Dangelico 2015).

As poor environmental performance could hurt a company’s reputation and value, companies aim to increase their reputation, competitiveness, and market position by reducing the cost of risks imposed by environmental, economic and social issues. For example, the April 2010 blowout at the Deepwater Horizon rig in the Gulf of Mexico. This accident killed 11 people and released a total of nearly five million barrels (780 000 m) of oil into the sea. The operator (BP) has set up a 20 billion USD fund to cover the costs including compensatory payments, cleanup costs, settlements and fines. Regardless of these huge costs, this accident affected unquantifiable effects to BP’s reputation still ongoing until now. Following the Deepwater Horizon disaster, BP witnessed its share price fall by 52% in 50 days due to the accident handling, and even now the share price has not recovered to pre- accident levels, a clear financial cost, yet unclear reputational cost (Zou et al. 2015).

1.5.3. Economic Uncertainty as a Barrier

The stability of the business environment is a key factor that determines the investment decisions that a multinational organization might undertake to tackle any environmental challenges they currently face (Svatikova et al. 2012). Taxes, interest rates, and exchange rates are considered the main indicators to measure the stability of the business and financial environment. An unstable business environment would be a one with unpredictability in taxes, interests, and exchange rates. This creates real problems for organizations attempting to implement a long-term business strategy that includes environmental protection policies and actions. This can cause inactivity around their investments, especially in sites and regions where financial and business environments stability are at their highest. The uncertainty of the type of technology to use to implement their sustainability-driven energy management strategies and the lack of appropriate knowledge and skills around how to operate those technologies and incorporate them into their business model negatively impact the organization's investment opportunities (Cavallo and Valenzuela 2007).

1.5.4. Financial Barriers

One of the key factors that act as a barrier for long-term investments to improve environmental protection is that the market is highly short-termed-oriented. Investors and other market participants are focused on the short-term plans such as increasing profitability and reducing costs at the expense of longer term plans such increasing energy efficiency and shifting to renewable energy resources (Kemp and Pontoglio 2011). Moreover, there are internal factors that negatively impact investment decisions such as the competition for capital within the company. This factor overwhelms multinational organizations' investments in environmental protection (Rademaekers, o.a. 2012).

1.5.5. Governmental Incentives

Incentives impact decisions a company makes regarding their environmental performance by changing the weight of the drivers and barriers discussed above. The main idea behind incentives is to empower the drivers and reduce the barriers, i.e. improve the potential for financial gains, or increase the power of company image and reputation, for example by improving access to information or creating 'smart' regulation or policy. Companies have increasingly been implementing measures and strategies to improve their environmental performance, including measuring their impacts and addressing them, reporting their emissions, ¨and implementing management systems. This highlights the fact that many companies accept the business case that proves that improving their environmental performance, and would bring them benefits such as cost savings, environmental risk reduction, staff engagement, reduced regulation, marketing opportunities etc. However, there is also an associated upfront cost, which prevents some companies from jumping on measuring and improving environmental performance and therefore might act as a barrier to companies (Davies and Mazurek 1996).

The Effectiveness of business incentives varies between the type and size of the business in different regions, sectors, and size of an organization. For instance, some administrative incentives work very well with SME's in a business oriented region, yet regulatory incentives would have minimum impact on them (Rademaekers, o.a. 2012).

1.6. The Importance of Energy Efficiency, Renewable Energy deployment, and the Synergies in Moving towards Sustainability

The necessity to make a change in the way energy is used and supplied throughout the world represents a challenge in moving towards sustainability. Currently, strategies for energy supply and use exist, yet none of them assist organizations in shifting to renewable energy and increase their energy efficiency in a synergetic manner to reduce costs and decrease their environmental impact. Energy, primarily from fossil fuels, underlies modern industrial development and standards of living. This energy use is creating both local environmental damage and contributing to changes in global climate. The challenge is to reduce energy use in industrialized countries while maintaining industrial and individual activities that are taken for granted. To meet legitimate demands for improved standards of living, new ways of energy generation must be found. New solutions must be set up to meet the needs for goods and services without burdens being placed, on the local economy, that prevent satisfaction of social needs such as education and health care. This also must be met without increasing existing environmental problems. However, it is not always easy to find solutions that are economical , environmentally, and socially sustainable (Ganda and Ngwakwe 2014). Also, the solution must be able to integrate all the elements that multinational manufacturers find critical to the implementation of sustainable energy management systems.

Therefore, the second research question is *how can these critical elements be integrated together to address the sustainability challenge within energy consumption for a multinational, mid-size company?*

Energy management system (EnMS) and Sustainable Energy Management System (SEMS) are the collection of procedures and practices to ensure the systematic tracking, analysis, and planning of energy use in industry. It is one of the effective approaches to improve energy efficiency in the industrial field because it helps companies with practices and procedures to continuously make improvements and capture new opportunities. Implementing EnMS and SEMS require the industrial manufacturers to develop, record and maintain the energy assessment. They need the organization to establish a regional and organizational energy baselines for the measurement of energy performance. Some energy management systems such as the standards published by the international organization for Standardization (ISO), are based on the Plan-Do-Check-Act approach to achieve continual improvement in energy performance. The first thing to do is the energy plan, determining the initial energy baseline and objectives as well as action plans. Then, implement the plans in "DO" phase, to achieve objectives for the improvement of energy performance. After the "DO" phase, actions are implemented if they are leading to the desired results, Afterward, the "Check" phase is where the results are compared to the objectives which are established previously. At last, in the "ACT" phase, the basis for further studies in order to improve the energy performance and EnMS constantly are established.

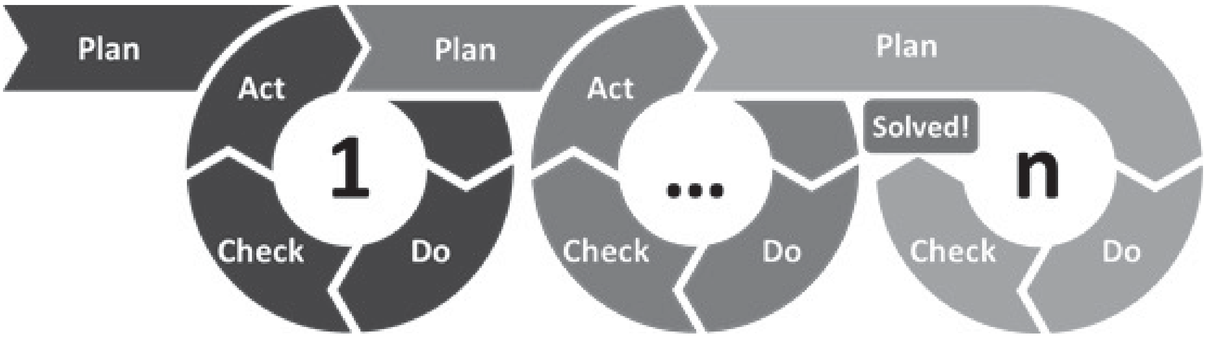

Figure 1.1 PDCA Flow

1.6.1. Energy Efficiency

Energy efficiency simply means using less energy to accomplish the same task. It refers to different policies, strategies, and technologies aiming at solving issues related to energy use to minimize greenhouse gasses emissions; which cause global warming, together with reducing financial costs. Because energy has been cheap and plentiful, use is often wasteful, creating both environmental damage and increased costs. Improving energy efficiency of the energy system needed results cost-effective energy savings and emissions reductions.

Governments and institutions are confronted with increased pressure to improve their energy consumption. If carbon substitution strategies are implemented, impacts on climate change will be minimized. Underlining the objective, states that energy associated carbon emission practices have the most influence on climate change. Thus, the improvement of energy efficiency should be the most prominent goal in energy frameworks and strategies J.F.B. Mitchell 2013).

There are several tools available for consumers and manufacturers to implement energy management systems. Some of those tools are the ISO50001 and EN 16001, that are also based on the PDCA management method, which is critical for actually realizing and sustaining the potential efficiency gains of new technologies or operational changes (Piñero 2009). Those tools primarily assist organizations in reducing energy use and reduce carbon emissions in a systematic way. (IETD 2016)

1.6.2. Renewable Energy

Renewable energy is derived from sources that are being replaced by nature, such as hydropower, the wind, solar, biomass or geothermal (Hiremath et al. 2009), and it plays an important role in meeting future energy needs and achieving sustainability. Although renewable energy is often perceived as a critical element in building a sustainable future for energy, the progress in its diffusion and deployment is slow. Rigorous applications of relevant theory and technologies are needed to accelerate the development and utilization of renewable energy, and to increase its contribution to the current energy supply mixes. The use of renewable energy (RE) offers a range of exceptional benefits, including decrease in external energy dependence; boost to local and regional component manufacturing industries; promotion of regional engineering and consultancy services specializing in the utilization of RE; increase in R&D, decrease in impact of electricity production and transformation; increase in level of services for the rural population; job creation, etc (Hepbasli 2008). Renewable energy sources are the fastest growing energy source in the world and various projections indicate that these resources will have a positive contribution in the future of tackling the sustainability challenge (Sieminski 2014). Currently, there is a tool that assists policy makers in lobbying for laws to help transform fossil fuel based energy generation to renewable energy generation. "SWITCH" is a tool created by professors and students at the University of Copenhagen in Denmark to assess economic and environmental implications of different energy scenarios. On the other hand, this tool is solely made for policy makers in a governmental context and it does not assess energy efficiency in relation to use or generation.

There are methods that multinational organizations and businesses can invest in renewable energy production. Seven of those methods are mentioned below

1- REC's or Renewable Energy Certificate, where companies would legally claim that they utilize renewable energy
2- Carbon offsets: organizations can invest in projects that reduce net carbon dioxide emissions.
3- Physical Purchase Agreements: An organization can purchase renewable energy from an offsite location to power their own facilities.
4- Virtual Purchase Agreements: Organizations can purchase renewable energy from a utility company yet get a different mix of energy to power their facilities. Yet, they can legally claim they utilize renewable energy.

5- Aggregated Purchase: To purchase and invest in renewable energy with a cluster of organizations that are physically close to their facilities.
6- On-Site Power: To purchase renewable energy technologies to generate energy on site.
7- Tax Incentives and Green Bonds and their equivalents: Organizations can invest in governmental or private projects that would implement infrastructure renewable energy technologies. (Laughland and Bansal 2011)

Examples of renewable energy usage are companies like SC Johnson, a global manufacturer of household cleaning supplies and other consumer chemicals, has been purchasing wind power from a dedicated nearby wind farm to help power its Bay City, Michigan, manufacturing facility, which produces Ziploc® Brand bags. The purchased wind power now supplies the facility with about 67% of its electricity and cuts 42,000 metric tons of GHG emissions annually. Trends nowadays show that organizations are communicating commitment to utilizing 100% renewable energy within a certain time frame (The White House 2015).

1.6.3. Synergies between Energy Efficiency and Renewable Energy

Energy efficiency and renewable energy are the two pillars of sustainable energy development. Both resources must be developed pointedly to stabilize and reduce carbon emissions. Energy efficiency can result in cost-effective energy savings and GHG emissions reductions. However, Energy efficiency pales in terms of its appeal against renewables. Renewable energy, on the other hand, often addresses challenges touching economics and short-term savings. A deliberate vision of a sustainable energy economy thus requires a considerable commitment to both efficiency and shift to renewable energy resources. Policies, programs, and tools for energy efficiency and renewable energy have been historically pursued separately. With the success of several clean energy industries, communities focusing on such technologies have been increasingly addressing different agendas creating some divergences in policy priorities, such as the Renewable Portfolio Standards and Production Tax Credits for renewables vs. Energy Efficiency Resource Standards, Public Benefits Funds, and appliance standards for efficiency. While each of these individual policies are worthwhile, synergies between efficiency and renewable energy could be realized if the different energy management systems combined their agendas more effectively in terms of intersystem communications to avoid overlapping, pitfalls, and increasing synchronization (Prinddle et al. 2013).

In 2012, the United Nations General Assembly declared 2014-2024 to be the Decade of Sustainable Energy for All (SE4All), underlining the importance of energy management to tackle the sustainability challenge and support sustainable development (Banerjee et al. 2013).

The evidence is emerging that combining energy efficiency with renewable energy deployment brings synergies that benefit both. In June 2014, REmap 2030 was launched, by the International Renewable Energy Agency (IRENA) of the Sustainable Energy for All (SE4All) with the aid of the Copenhagen Centre for Energy Efficiency (C2E2) for energy efficiency, which is a global, multi-stakeholder agenda proposing different energy management scenarios for implementing the initiative of the synergy between both energy efficiency and renewable energy deployment covering China, Denmark, France, Germany, India, Italy, UK, and US; which together cover half of the global energy use (Prinddle et al. 2013). An analysis of the tool shows that the combined potential of the technologies could reduce the total primary energy demand by up to 25% compared to business as usual in 2030. Through the deployment of renewable energy technologies alone or with only independent improvements of energy efficiency, a reduction of 5-10% in energy intensity by 2030 is estimated. On the other hand, the REmap tool, similar to the SWITCH tool, is designed to be implemented by policy makers in a governmental context rather than in an organization with limited resources (IRENA 2015).

1.7. Energy Management Systems Implementation

Energy Management Systems or EnMS rely heavily on the PDCA management standard to implement and operate the systems. To ensure the effective implementation of EnMS, requirements around the PDCA must be met. The ISO50001 energy management system requires the organization to follow specific steps, such as performing an energy review and baseline analysis, management review, documenting objectives and targets for energy consumption, communication, and monitoring. Nissan USA has implemented the ISO50001 and was able to save 1.2 million USD per year and 250 billion Btu. They have also invested 331,000 USD in carrying out the system. Nissan has prepared an energy team and ensured the management inclusion in the decision for the EnMS, which helped them achieve the energy reduction goals. An internal audit and management review were implemented reiteratively at all stages.

1.8. Case Study

Being a global midsize manufacturer, and the biggest competitor in the expanding coatings industry, our case study organization has a potential impact on sustainable development worldwide. Moreover, the organization is currently a responsible organization, in terms of environmental and social sustainability; while implementing the ISO50001 in two of their sites. This has helped them move forward in terms of reducing costs and improving their reputation, therefore, gaining a competitive edge in the coatings industry. The researchers and the case study organization have signed a confidentiality agreement, hence, the name of the organization and some specific data are not disclosed in the thesis.

1.8.1. Relevance of energy management for coatings industry

Coatings, or "preprinted metal coatings" is a process for coatings metal surfaces before fabrication to extend their lifetime. Coatings processes are considered relatively environmentally-friendly, since the materials used are bio-sourced, and waste generation is relatively low compared to other industries. Although the coatings manufacturing process is not energy intensive, yet the industry itself, being global, utilizes relatively high energy to run compared to other non-global industries.

The global coatings market has been segmented into several fields in different terms and from different perspectives. In terms of applications, the market is participating in the automotive, construction, appliances and other sectors including furniture, packaging, and HVAC. In terms of geography, the coatings market is segmented into Europe, North America, Latin America, Asia-Pacific, and the Middle East and Africa (MEA). The increasing demand for coatings from a number of end-use industries within developed regions like Europe and North America and the increase of urbanization in developing regions such as the Middle East and East Asia led to the flourishing of their markets and ultimately impacting the global market. Analysts forecast the global coatings market to grow at a CAGR of 6.51% over the period 2014-2019 (RESEARCHANDMARKETS 2016).

1.8.2. The Coatings Industry

A systematic increase in global population is expected to boost the construction, automotive, and appliances markets worldwide (Transparency Market Research 2016). Coatings industries are a part of several subsystems in relation to the global sustainability. The different ways that coatings industries interact with the subsystems would generate success for them in relation to sustainability. The biggest subsystem that coatings industries are a part of are the electronics, construction, and vehicle industries systems. The way that coatings industries provide products in the aforementioned systems is vital to their contribution towards a sustainable society. By providing sustainably-sourced products, taking into consideration environmental, social and ethical factors in the products' lifecycle, they can reduce the environmental impacts of the industry and positively contribute towards a sustainable planet (Leuenberger, Bartle, and Chen 2014). Another subsystem that they are situated in is the socioecological system; consisting of labor, consumers, suppliers, and nearby communities. By implementing sustainability-driven policies around these sectors, they will positively contribute to a more sustainable socioecological system (Mukherjee and Chakraborty 2013). One of the biggest systems that the coatings industries is dependent on is the energy sector. Although their manufacturing process is not energy intensive, their operations are running around the clock. Their reliance on national grids in the different countries could negatively affect the environment due to the heavy dependencies on fossil fuels based energy sources (Ediger et al. 2007). By implementing overarching energy management plans to strategically switch to renewables and reduce energy consumption in their different sectors, sites, and operational phases, they would be able to positively contribute to a more sustainable society (Baker and Solak 2014). Finally, the position of coatings industries in the global market has placed them in the trade regulations system. They have to follow many different local and international regulations in different countries such as REACH and UNGC, yet maintain their own core internal and external policies. Complying with environmental and social regulations and standards, would help them contribute to a more sustainable society and increase profitability (Jelinek and Bergey 2013). Therefore, as an industry, they are a key collaborator in terms of their influence and dependency on global sustainability.

1.9. Aim of Research and Research Questions

As mentioned previously in the introduction, the main focus of the thesis is to explore the opportunities and develop a sustainability-driven energy management system for a mid-size multinational manufacturer through the lens of various sustainability science methods, tools, and approaches.

1. What are the critical elements and key attributes of a sustainability-driven energy management strategy for a multinational, mid-size company?
2. How can these critical elements be integrated together to address the sustainability challenge within energy consumption for a multinational, mid-size company?

1.10. Scope and Delimitations

Our research aims to provide a sustainability driven energy management system for decision makers in multinational organizations to strategically shift their energy practices towards more sustainable practices. A case study was done on a mid-size, multinational coatings manufacturer to help identify critical elements to be integrated with existing energy management systems.

The research audience is multinational organizations that plan to incorporate more sustainable practices in their energy consuming processes and operations; and specifically decision makers and members of sustainability committees in those organizations. Multinational organizations implementing the sustainability-driven energy management system will reduce their negative impact on the environment due to fossil fuel based energy resources in different regions around the world. Thus, the sustainability-driven energy management system will contribute positively to global sustainability.

The research focuses on the environmental aspects (SP1 to SP3) of energy management systems and the strategies associated with them and it does not include the social sustainability principles SP4 to SP8.

The case study assisted in integrating critical elements that are missing in existing energy management systems by providing the team with inside information on a widely used energy management system. Also, by performing baseline analysis on their current energy practices, the team was able to identify opportunities and potentials to validate the strategies found in the research. Due to time limitations, the team was not able to implement any of the strategies beyond the baseline analysis. The research and analysis around the energy profile in 4.3 is useful for future development of the sustainability-driven energy management system to cover processes and operations in terms of energy of multinational organizations. In 4.3, the data received were not specific enough to have a complete baseline analysis and propose more specific actions for the case study sites to implement the SEMS. This was because of using questionnaires to have a picture of the operations and processes of the site. Physical site surveying would be a more effective way to have a baseline analysis and eventually propose more specific actions to the case study organization. As students living in Sweden; far from the chosen sites, there were not enough resources to support the such a method.

2. Research Design

In this section, the research design choice is explained and the methodologies adopted to answer the research questions are also portrayed.

Three considerations played into the decision to choose the research design; the research problem, the personal expertise of the researchers, and the time constraints. Based on those criteria, the mixed methods research was chosen as it is useful to capture the best of both quantitative and qualitative approaches in the form of collecting closed-ended and open-ended data in order to best understand the research problem of improving energy management systems to face the sustainability challenge. The team has also used a case study approach to an organization to fulfill two objectives; to collect data to assist in answering the research questions, and in validating our results and propositions.

In regards to the personal expertise of the researchers, the team has different backgrounds including technical/engineering backgrounds and non-technical backgrounds; which facilitated the structure of quantitative research and the flexibility of qualitative inquiry. The collective background of the research team in the area of strategic sustainable development assisted in diversifying the methods to answer the three research questions.

Mixed methods research is more of an approach than a methodology, which focuses on the research questions at hand. The research problem of forming a sustainability-driven energy management system requires an examination of real-life understanding of the different frameworks of decision making in multinational organizations from different perspectives. It also requires the application of quantitative research, such as energy data analysis, and qualitative data, such as interviews with decision makers for feedback and to re-iterate the process. The research problem also required data validation to strengthen the qualitative and quantitative data and generate possible solutions to the problem by using the case study approach.

Other benefits of the mixed methods for the team research approach was that it helped in closing gaps and addressed pitfalls that single method might have by using another method to complement it (Wilson and Creswell 1997). For example, the team has gathered quantitative data from questionnaires, such as energy consumption data, and qualitative data such as feedback from personnel. Finally, the team has acknowledged that the mixed method approach is time and resources compared to consuming rather than a single approach or design. Yet, the team has chosen this approach to ensure that the research questions are answered comprehensively.

2.1. Mixed Methods framework design

A research framework, as shown in figure 3-1, is chosen to provide guidance about all facts of the study, from assessing the general philosophical ideas behind the research questions to the detailed data collection and analysis which helps in establishing plans that are based on well-grounded ideas from the literature and well recognized by audiences.

The framework consists of three main elements; 1) knowledge claims, 2) strategies of inquiry which are the general procedures of the research, and 3) the methods, which are the detailed procedures for data collection (Wilson and Creswell 1997).

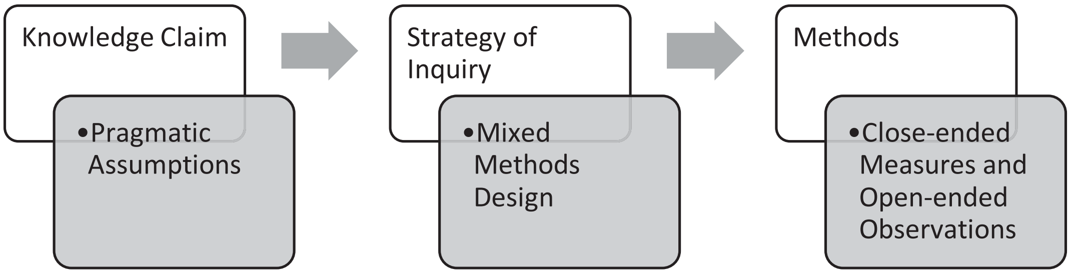

Figure 2.1: The research framework for mixed methods research design

2.1.1. Knowledge Claims

To build the research, the team started with certain assumptions about the research, including how the research was approached and the actions that will be taken to answer the research questions. In this research, knowledge claims were based on pragmatism; such as:

1. Consequences of actions
   Such as what will be the consequences of the actions that will cause the shifting to sustainable energy resources and energy efficiency.
2. Problem-centered
   Where the research has started to solve the problem of the difficulty to shift to renewable energy resources in global organizations.
3. Real- world practice-oriented
   Where there will be a set of recommended actions based on the sustainability-driven energy management system to analyze and validate the tool.

2.1.2. Strategies Associated with the Mixed Methods Approach

Recognizing that all methods have limitations and that some methods have biases inherited in them, the team has agreed to use two kinds of triangulations to seek convergence between qualitative and quantitative methods:

1. Data triangulation: a variety of data sources were acquired to ensure the validity and the objectivity of the actions taken based on the energy management strategy. The team has used a total of eight databases to acquire, compare, and then validate the data.
2. Methodological triangulation: Multiple methods were used concurrently to address and answer the research questions. Figure 2-2 illustrates the methodological triangulation that the team adopted in the study. The figure portrays the convergence of the concurrent methods used by the team to reach the final outcome. Quantitative and qualitative data were collected, then analyzed, and finally result were documented to reach the final outcome and validate the results. This framework was done cyclically.

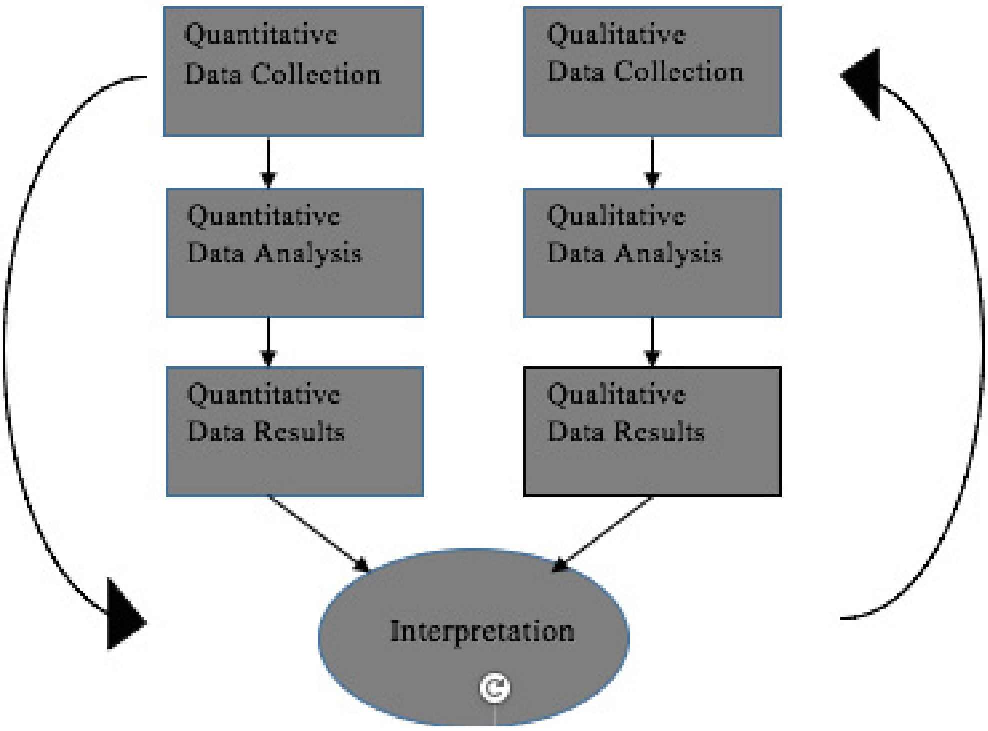

Figure 2.2 concurrent mixed methods design

2.1.3. Research Methods

Using different methods have led to the development of procedures for mixed methods strategies to address the research questions. The team used concurrent procedures by utilizing the methods in parallel as opposed to a sequential procedure to effectively answer the research questions.

To ensure proper data collection, a comprehensive analysis of the research problem and developing well-structured results, Concurrent procedures were chosen in which quantitative and qualitative data are converged. In this research design, both forms of data were collected at the same time during the study and then the information was integrated into the developed results. After collection of all the data, they were analyzed and data relevant to the research questions were documented and categorized to facilitate the formation of the profiles and the writing of the thesis.

There are methods based on SSD concepts used by the team to acquire data from the case study and from documents, and to find solutions. It was important to use SSD concepts such as backcasting to ensure the proper implementation of the REmap tool; since this tool requires backcasting from energy targets and ideal scenarios. Also, the team used the definition of sustainability based on FSSD sustainability principles. Moreover, FSSD analysis on tools is used to identify gaps and in energy management tools and attempt to fill the gaps with results found from the first research question around the critical elements.

The Case Study

The team contacted informants and decision makers in the case study organization who are located in Stockholm, Berlin, Goa, Montbrison, Chicago, Ras Al-Khaimah, and Shanghai. The sites were chosen ultimately by the Chief Technology Officer of the case study organization after agreement with the thesis team and the contact person in the organization. The choices were based on the diversity of the sites in terms of geographical locations, and energy intensity. Due to the physical distance between the team who was located in Karlskrona; Skype, Cisco WebEX were used to contact and interview the key informants. All the questions asked to the interviewees were open-ended questions. Questionnaires and emails with open-ended questions were also used to ensure the inclusion of all the sites and to gather all possible information in parallel due to time limitations of the site representatives and the thesis team. During the first interview with the two members of the global sustainability committee in the case study organization, the team was assigned to a contact person in the organization; who is an environmental scientist and a member of the global sustainability committee. Follow-up meetings were scheduled with the contact person and with an energy management team member in Montbrison, France.

The methods that the team has chosen to answer each specific research question are shown in the next pages. The methods are presented under each of the three research questions.

2.2. Phase I: Critical Elements

What are the critical elements and key attributes of a sustainability-driven energy management strategy for a global, mid-sized company?

To answer the first research question, **Document content analysis** was done to explore and summarize data around the drivers and barriers provided peer reviewed literature and reports from the case study organization. This was helpful in understanding the details of the barriers and drivers that hinders or helps multinational organizations from implementing the energy management system.

The analysis began with looking for organizations implementing energy management systems and organizations, Summon@BTH was the tool used to search within the databases that BTH is subscribed to. The databases used were:

1- Ebsco
2- ACM Digital Library
3- BTH bibilitekskatalog
4- British Library Public Catalog
5- IEEE

The keywords for the search included: “energy management”, “systems thinking”, “barriers”, “drivers”, “renewable energy systems”, “multinational organizations energy management”, “motivators”. This review resulted in articles and studies around regulatory frameworks, financial factors, and internal and external incentives. Also, in the case of not finding the required information from regional databases, the team started an email conversation with relevant informants to get the required information. For example, the databases in Ras Al-Khaimah do not provide information on the regulatory frameworks in the region, thus, the team contacted a representative of a utility company to get the information required.

After the literature review and identifying critical elements from different multinational organizations, **Key informant interviews** were set up with an environmental scientist, the global sustainability manager, and the chief technology officer of the case study organization who provided the team with individual perspectives and expertise in renewable energies, energy management and the needs of the case study organization. First, a Cisco WebEX interview with the CTO and the global sustainability manager was arranged to discuss the different barriers and drivers that would allow or hinder the organization from implementing renewable energy or energy efficiency systems. In this meeting, common barriers and drivers were discussed and the case study organization's priorities were identified.

The team went into more details by leading a **follow-up Skype interview** with the contact person in the case study organization. The questions were prepared in advance by the team members and sent to the contact person 24 hours before the Skype interview to prepare the interviewee for the detailed questions.

To support and validate the team's findings of the critical elements, a **Skype interview** was held with a member of the energy management team in the site of the case study organization in Montbrison, France. Questions were prepared before the interview to ensure that the team addresses all the critical elements from the literature review and previous interviews.

2.3. Phase II: Integration of the Critical Elements in Energy Management Systems

How can these critical elements be integrated together to address the sustainability challenge within the energy sector for a multinational, mid-size company?

To answer the second research question, **document content analysis** was performed to explore different energy management strategies, systems, and tools. The review began with looking for energy management systems in the industrial sector. The keywords used were "industrial energy management", "energy efficiency strategies", "renewable energy", "energy efficiency", and "multinational manufacturers". The search engine used were: "Ebsco", "Business Source Complete", "IEEE", and "British Library Public Catalog" through Summon@BTH. This review resulted in articles and studies around energy management for businesses but none about renewable energy adoption for organizations as parts of energy management. From this review, energy efficiency, renewable energy, and the synergy between energy efficiency and renewable energy were identified as strategies to assist organizations to transform their energy consumption. There are different tools that would assist in implementing the strategies, such as ISO50001 and EN16001. Both tools were analyzed separately from data collected from the literature and comparison was done between them to identify the better tool. The comparison was done on three levels; the baseline assessment level, the recommendation level, and the tool implementation level. Also, two other databases, IRENA, and IEA, were found during the review that proved to be helpful in the research process.

Comparison of different technologies in the key areas of improvement; lighting, heating/cooling, and machine drive. **Content analysis** was done on peer-reviewed articles and case studies to identify the key differences between technologies and highlight the best practices in the key areas of improvement. The keywords used for the review were "energy", "lighting", "efficient heating and cooling", "solar water heaters", "geothermal heat pumps", "PV cells", and "wind power". The databases used for the search were IRENA, IEA, ACM digital library, and arXiv. This method was used to better understand the synergy between renewable energy and energy efficiency management strategies.

Then, **questionnaire 1** was sent to the four chosen sites in Montbrison, Chicago, Ras Al-Khaima, Shanghai to enquire about their implementation of internal energy policies and/or governmental incentives and policies. All the sites replied to the questionnaires, and the team was able to identify how the sites integrate the critical elements in their strategies.

Thereafter**, Five Level Framework analysis and the FSSD analysis on tools** were used to assess ISO50001 energy management system which was already implemented in the infrastructure of several manufacturers around the world including the case study organization. This helped in better understanding the tool, assessing benefits, and identifying gaps in energy management plans. The understanding of the tool is based on the 5LF using the Systems level, Success level, Actions level, and Tools level for reference. The energy management system is assessed using the FSSD under the System, Success, Strategic, Actions categories to identify the pitfalls and gaps. At the systems level, the systems that the tool encompasses are identified to highlight the boundaries of the system and its relationship with the other subsystems. At the success level, the ideal scenario that the system should achieve is identified and the definition of success is highlighted. At the strategic level, the guidelines around energy efficiency and implementations are identified and assessed. At the actions level, actions that tool proposes to facilitate the implementation of the tool are identified and assessed. Finally, at the tools level, the strengths and gaps around the tool itself are identified.

Concurrently**, a skype interview with open ended-questions** with the HSE manager and the energy expert in the Montbrison, France site from the case study organization was held. This site is ISO50001 certified in 2015. This interview was important to understand the results achieved from implementing the ISO50001 EnMS. All the questions were prepared before the interview to address the identified gaps and strengths in the ISO50001 system.

2.4. Methods to Implement the SEMS

To cover the gaps of the energy management systems found using the methods in phase I and phase II, the team designed a new decision-making tool focused on energy planning. The tool includes critical elements that are not discussed in the EnMS. The design of the tool is grounded on energy policies and baseline analyses on the four chosen sites in Chicago, Ras Al-Khaimah, Montbrison, and Shanghai. Since the case study organization did not incorporate an energy policy in their sites, the team has **assumed an energy policy** and targets for each of the sites. The baseline analyses included:

- **Document content analysis to assess the regional conditions** in terms of renewable energy potentials, regulatory and incentives conditions, GDP, energy and electricity generation mix. The following is a list of the sites and the databases utilized to acquire the data:

  1- Chicago, Illinois

    - Renewable energy potential: IRENA, IEA, Rocky Mountain Institute.
    - Regulatory and Incentives conditions: IRENA, DsireUSA.
    - GDP: IEA
    - Energy and Electricity Generation Mix: IRENA, IEA, DoE

2- Montbrison, France

- Renewable energy potential: IRENA, IEA.
- Regulatory and Incentives conditions: IEA, IRENA
- GDP: IEA
- Energy and Electricity Generation Mix: IRENA, IEA.

3- Ras Al-Khaimah, UAE

- Renewable energy potential: IRENA.
- Regulatory and Incentives conditions: IRENA
- GDP: IEA
- Energy and Electricity Generation Mix: IRENA, IEA, FEWA

4- Shanghai, PRC

- Renewable energy potential: IRENA, IEA, National Statistic Bureau..
- Regulatory and Incentives conditions: IRENA
- GDP: IEA, National Statistic Bureau.
- Energy and Electricity Generation Mix: IRENA, IEA, National Energy Bureau.

Thereafter**, questionnaire two was sent** to collect site specifications for the baseline analysis, such as site surface area, production, energy consumption, technologies used, electricity sources and prices, energy utility bills, internal policies, site-specific targets/objectives. This information was gathered to identify areas of improvements on the site for the SEMS implementation. The areas of improvements are used as categories to implement the energy management strategies. Refer to Appendix B for the questionnaires.

After the collection of the production volume and total energy consumption, **energy intensities of each of the four sites were calculated**. This is done by dividing the energy consumption in KWh with the total production volume in tons. The unit of the energy intensity is KWh/ton. The calculations are shown in Appendix C.

To have a complete picture of the energy consumption and assess energy expenditure, differentiate the energy sources, and utility companies of the site, two calculation techniques were used to determine the organization's energy consumption.

1. Analysis of energy bills
2. Energy estimation

The results of the measurements were analyzed and documented in excel sheets.

Then the team adapted the **REmap 2030;** created by IRENA**,** into **REmap Tools for Businesses**. The original REmap 2030 tool is utilized to illustrate reference shift scenarios on a country level as mentioned in the introduction section 1.5.3. The team decided to utilize the tool on an organizational level due to its simplicity and its integration of several elements in its calculations. The REmap Tool for Businesses constitutes of three reference shift scenarios of energy efficiency, renewable energy, and synergy between energy efficiency and renewable energy were built with the reference year of 2015 and 2030 being the shift year. The scenarios show BAU predicted results and are compared them to shift scenarios after possible implementation of proposed actions. Actions were recommended under the three scenarios based on the comparison done on the different technologies mentioned above, the regional incentives, and the geographical and climate conditions. **Sustainability Principles Analysis,** introduced in 1.3 was done on each of the proposed actions in the three scenarios to ensure compliance with the sustainability principles. The analysis was done based on the team's understanding of the sustainability challenge and sustainability principles.

The impact in the 2030 shift year is translated to USD and calculated in excel by inputting the current data, initial costs, price increment rate with compound effect, efficiency, and energy prices. The excel sheet is included in Appendix C.

The Chicago site of the case study organization has already done a cost-benefit analysis on PV cells implementation on the site. Therefore, the calculations for the Chicago site reference-shift scenario were based on their own calculations. The team has added the BAU case to their calculations to highlight the long-term costs of not implementing the PV cells.

The following variables were included in the calculations for REmap Tool for Businesses; the energy efficiency scenario and the electric water heaters proposed action calculations:

1. Gas utility bills from the utility company to include costs and consumption
2. Cost of annual maintenance and complete replacement of the module after 15 years
3. Water heater efficiency
4. Initial cost of purchasing the new electric water heater
5. Compound effect over years in terms of gas prices increment of 5%
6. Governmental tax credit incentive off the initial cost of purchase and installation.

The following calculations were done for the REmap Tool for Businesses under the synergy between renewable energy and energy efficiency scenario; the action proposed for this scenario is the installation of geothermal heat pumps:

1. Gas utility bills from the utility company to include costs and consumption
2. Cost of annual maintenance of the module.
3. Heat pump efficiency
4. Initial cost of purchasing the new geothermal heat pump
5. Compound effect over years in terms of gas prices increment of 5%
6. Governmental tax credit incentive of 30% off the initial cost of purchase and installation.

Finally, the analyzed baseline data and energy review are communicated and illustrated in a form of a profile to be presented to top management. The profile begins with a cover page showing the system and site name. Then an indexed table of content is put together to facilitate the navigation between the different sections of the profile.

The profile was continuously improved with the help of the contact person of the case study organization to ensure that it can be read easily and any redundant information or data are excluded. There were **three feedback occasions** in total from the contact person to assist in this phase.

Concurrently, there were **eight skype interviews held** with a member of the sustainability committee in the case study organization to receive feedback on the energy profiles and continuously improve the design and data presentation throughout the study.

2.5. Validity

Due to the nature of the research and the amount of data collected by the team to perform the above methods, qualitative and quantitative methods were used. Quantitative research was used to gather information quickly and cover as many data points as possible; which was used to collect specific data from the four different case study sites. On the other hand, qualitative research was used to gain understanding of different energy generation and consumption strategies and how organizations can use them. In the research design, validity was implicitly and explicitly integrated to ensure the most appropriate results to be presented to the reader. Validity can be established by having (Thomas and Magilvy 2011):

1. Credibility: is the element that allows others to recognize the experiences in the study.
2. Reliability: the consistency of the measures used.
3. Transferability: is the ability to transfer findings or methods from group to another.
4. Dependability: which is reliability in quantitative terms; other researchers can follow the same terms.
5. Confirmability and objectivity: is established after establishing the above validations.

Credibility of information from the case study organization was established by holding interviews with three members of the sustainability committee and cross examining the transcripts to look for similarities between their views and ideas. In addition, there were eight interviews and meetings held with the contact person of the case study organization, using different interview techniques, and also using the words of the interviewee in the report to strengthen the credibility.

The reliability of the study was also established by achieving consistency and theory evidence after performing the calculations on the case study organization. Calculations were done on four different sites, while only one was presented due to time limitations. All calculations validate the theory evidence of cost savings and payback periods (Heale and Twycross 2015)

Furthermore, the transferability of the study was established by providing a solid description of the system to be studied. In this manner, the research methods and results can be transferred and applied on different groups of organizations with different variables.

Dependability of the study was also established by providing a structure and trail of decisions in the research that other researchers can follow. This was done by establishing the below:

1. The specific purpose of the study was explicitly mentioned,
2. the selection of the case study organization, the interviewees, and the case study sites were discussed.
3. Describing exactly how the data were collected
4. Discussing the interpretation of every finding and the answer to the two research questions.
5. And finally discussing the validation methods used in the research.

Confirmability and was finally established after maintaining a sense of awareness and openness to the study and unfolding results. The team mitigated the risks of being bias or subjectivity by opening discussions between the three researchers in the study. Each researcher presented different perspectives and point of views about the results and the researchers' assumptions were written down and identified. This was done by listing all the individual assumptions, and then turning all the assumptions into questions. Mapping the questions to expand the research approaches to identify more answers to the questions. Finally, the researchers would check if there are any further assumptions deduced from the previous assumptions. This allowed for the team to mitigate the bias by challenging their own assumptions, open up to more learning and to encourage the team to gather further evidence to validate the research. An example was when Anas Al-Daghestani had the pre assumption that only the REmap tool would help organizations in implementing actions based on cost benefit analysis. Yet, after discussing this assumption with the team it turned into the question, how can it help organizations in implementing actions? Then this assisted the team in finding more tools to help in using Remap and adapting it to develop the REmap Tool for Businesses.

Finally, in the implementation and development of the SEMS, the team was in regular contact with a member of the sustainability committee from the case study organization, who works directly with sustainability reports and external communication of CSR for the organization, to ensure the readability of the report to top management and decision makers. Four interviews in total were held for that purpose:

1. After every interview with the member of the energy committee, four changes were done on the profile based on feedback from the interviewee.
2. Results from Interview 1: Graphs showing wind speeds and light intensities were removed and changed with tabular wind speed and light intensity data to show renewable energy potential.
3. Results from Interview 3: Added temperature vs. energy use figure, interviewee said it was important to show correlation between the energy use and temperature to identify an area of improvement in certain seasons.
4. Results from Interview 4: Regional energy consumption was removed. Interviewee said it was redundant.

The AIC (Authentication-Integrity-Confidentiality) triad model is used to ensure data confidentiality, integrity, and availability. Due to confidential nature of the data collected from the case study organization, the team has safely secured the files in a standalone USB device with a two-factor authentication; biometrics (fingerprint), and password authentication (de Oliveira Albuquerque et al. 2014).

3. Results

The results section aims to support the process of answering the research questions after carrying out the methods in section 2.1.3. The results support the formation of the sustainability-driven system for energy management multinational organizations.

The results begin with identifying the critical elements from evidence in literature review and interviews. After the critical elements are identified, the results aim to integrate the critical elements together into existing energy management systems to tackle the energy consumption within the SSD concepts. Finally, the section will highlight the implementation of the tool to assist management in the case study organization to decide on strategies to implement on their sites.

3.1. Phase 1: The Critical Elements

In this the first phase, the team collected information and data from the methods used in phase I to identify the critical elements that would act as drivers or barriers for multinational organizations to implement energy management systems. From the **document content analysis,** the team found that the following are the key critical elements:

1. Regulatory Frameworks
2. Economic and Financial Factors
3. Company's reputation
4. Incentives

From three different interviews with key informants in the case study organization, the team has new findings for the below critical elements:

5. Economic and Financial Factors
6. Company's Reputation
7. Incentives
8. Geographical Conditions

3.1.1. Regulatory Frameworks

Document content analysis on data researched to understand the current situation of the four sites of the case study organization in terms of the regions' current regulatory frameworks. The team has found that the different regulatory frameworks in all the regions of the sites have different impacts on the operations and processes of the case study organization. For example China, 13th Five Year Plan for energy use and generation requires companies to reduce their GHG emissions by shifting to 15% renewable energy resources by 2020 (Feng, Ljungwall, and He 2015). Which means the site of the case study organization in Shanghai must work towards the reduction of their GHG emissions to meet the requirements. Another example is the Federal Appliance Standard in the United States; which requires commercial and industrial organizations to perform changes on cooling and heating devices to reduce their energy consumption (EIA 2016). Similarly, the site in Chicago must implement strategies reduce energy consumption by improving the performance of their heating and cooling systems. In France, the site in Montbrison has to abide by the Grenelle Law; which requires the case study organization’s site to increase their share of renewable energy by at least 23% before the year 2020 (MINISTÈRE DE L'ENVIRONNEMENT 2016).

Unlike the other sites and regions, the regulatory framework in Ras Al-Khaimah does not require the site in that region to implement any energy efficiency or renewable energy strategies. This information was collected from an email conversation due to the lack of databases as mentioned in the methods section.

Interview with a member of the sustainability committee of the case study organization shows that the site in Sweden has the highest effect on the internal policy of the organization to shift to renewables and adopt sustainability-driven strategies due to the governmental regulations in Sweden, and the positive impact on the organization’s ideology.

3.1.2. Economic, Financial Factors, and Incentives

Lack of resources is also a key issue for the organization in the case study. Highlighted in an interview with the global sustainability manager of the case study organization, where the interviewee said that mid-size organizations have economic burdens that would hinder them from applying new expensive technologies to support their energy consumption objectives. The interviewee also confirmed that the case study organization backed out of a project new LED lights fittings in Malaysia and Chicago due to the long term payback period and high initial cost.

Another interview with a member of the sustainability committee showed that it is vital to use governmental incentives to help them apply their sustainability policies and actions to increase their feasibility. It is also important for such an organization to develop their economic performance, improve their brand image, and ensure the harmony of their policies and actions with the overall goals of the company. Economic incentives such as tax credits and rebates are the best way to enhance the development of the company’s financial performance. The content analysis from databases in the four chosen sites of the case study organization shows that three of the four sites provide financial and administrative incentives for organizations that plan to their energy consumption. For example, the site in Chicago has the possibility to apply for the Business Energy Investment Tax Credit to receive a tax return of 30% on all of their renewable energy investment to reduce the return on investment period. Another example is the Notice of Promotion on PV Industry in Shanghai, where the site in Shanghai can apply for a price reduction and generate income from a feed-in tariff up to 1.5cents/KWh. In France, the site in Montbrison can apply for the ADEME to receive grants to perform site surveys and get income from feed-in tariffs. In contrast, the site in Ras Al-Khaimah has no possibility of applying for incentives due to the lack of incentives provided by the regional government. Refer to appendix A for a list of incentives.

Also, an interview with a member of the sustainability committee showed that the case study organization favor incentives that can reduce their administrative and regulatory burdens; ensuring that they can reduce reporting and inspections, means that they can redirect their focus on profitability and expansion.

3.1.3. Company's Reputation

An interview with the member of the sustainability committee of the case study organization confirms the need for multinational organizations to improve and sustain their reputation. The interviewee gave an example of opening a new site in Australia while already having a good reputation among the customers would be helpful in their marketing strategies. Furthermore, the interviewee highlighted that since the case study organization is not publicly funded and it's a family owned business, the reputation of the company comes second to financial growth.

3.1.4. Geographical and Climate Conditions

From the content analyses on documents from databases on the four different regions of the case study organization, the team has confirmed that countries around the equator have more potential for solar power generation than countries away from the equator and closer to the poles. Also, wind speed varies from one location to another. In general, regions close to the sea and ocean shores have higher wind speeds than other regions. The analyses also prove that for each region there are different energy capabilities and renewable energy potentials. For example, the site in Ras Al-Khaimah has a higher potential to implement energy generation from PV cells than the site in Shanghai. Since Ras Al-Khaimah has a potential of generating 2400 KWh/m^2 per year while in Shanghai, the potential is 1,600KWh/m^2; which is half the potential in Ras Al-Khaimah (IEA 2016). Refer to Appendix A for regional assessments data.

3.2. Phase II: Integration of Critical Elements Using EnMS

This section highlights the importance of energy management systems in the integration of the critical elements as a decision-making tool for organizations. First, the results of the content analysis around the energy management strategies; energy efficiency and the comparison between the ISO50001 and the EN16001, renewable energy, and synergies between renewable energy and energy efficiency are presented. Then key findings from the questionnaires sent to the four different sites of the case study organization are highlighted. The strengths and areas of improvements of the ISO50001 energy management system are underlined using the FSSD analysis on tools.

3.2.1. Energy Efficiency

Results from content analysis show that there are two main areas of improvement by energy efficiency:

1. Increasing technical efficiency by using energy efficient technologies.
2. Structural change in society to increase production and consumption of products with lower energy intensity.

Solar water thermal heater is an example of a renewable technology that offers efficiency for organizations that would implement it. This technology has an efficiency of 100% compared to its primary energy counterparts (IEA, 2014a). While an example of a structural change in the manufacturing sector is shifting from production of raw steel to recycled steel to reduce energy consumption and waste.

The team studied energy efficiency in different heating technologies and found that the electric water heaters provide up to 40% more energy efficiency and cost savings. This result was also used to propose energy efficiency actions in the implementation section 3.2.7.

The content analysis shows that there are two main tools used by multinational organizations to implement energy efficiency strategies; the ISO50001 and the EN16001. The team compared both tools by analyzing documents and case studies. As mentioned in phase II of the methods, the comparison is done on three levels; the baseline assessment level, recommendations level, and the implementation level. Both of the tools cover the same criteria to perform baseline assessment:

1. Energy consumption review.
2. Regulation compliance review
3. Internal Policies compliance
4. Production and intensity analysis.
5. Site specification analysis to identify possible actions.

In terms of the recommendations level, the ISO50001 offers internationally recognized best practices for energy efficiency. It also provides payback period information for each proposed action. In contrast, the EN16001 does not provide any recommendations or actions.

In regards to the implementation level, ISO50001 emphasizes on the role of top management by designating a person from the management for reviewing and implementing the EnMS, which is not emphasized by the EN16001. On the other hand, the tools have a similar implementation framework as shown below:

1. General requirements where organizations must define and document their scope.
2. Energy policy where the organization should form an energy policy and communicate it internally.
3. Energy planning where the organization reviews its energy consumptions and works towards an energy objective.
4. Training and competencies where the organization takes the responsibility to spread awareness on energy savings and train staff and management on energy efficiency,
5. Communication and documentation where the organization would communicate and document its policies, its results, and its energy performance.
6. Checking is where the organization would monitor and measure its results against the objectives and perform an internal and external audit on their current operations and processes.

3.2.2. Renewable Energy

Content analysis shows that there are different ways that organizations can invest in renewable energy and implement their technologies in their sites and facilities. The plans mentioned in the introduction, section 1.5.2, are highly dependent on the regional incentives to implement them in a more feasible way. In the study, the team has found that three out of four of the sites can make use of governmental incentives in the region to facilitate the implementation of renewable energy strategies. The site in Chicago of the case study organization can implement renewable energy strategies, such as PV cells installation, small wind turbines, and other renewable energy techniques. By applying for the Business Energy Investment Tax Credit provided by the United States Internal Revenue Service, the organization can save 30% of the initial cost of the projects. The team also found that the site in Montbrison, France, can apply at ADEME to receive a grant up to 40% of any renewable energy project cost. Refer to appendix A for the lists of incentives.

3.2.3. Synergies between renewable energies and energy efficiency

Results show that there are important overlaps between the two areas of renewable energy and energy efficiency. A number of technologies both offer savings in primary energy demand and also increase the share of renewable energy from 18% to 27% worldwide beyond a business-as-usual case where both energy efficiency improvements and renewables deployment follow the current policies. Examples of such technologies such as heating account for around 25% of global Total Final Energy Consumption. Air-to-air heat pumps are 200% more efficient than conventional boilers while geothermal heat pumps are 100% more efficient than air-to-air heat pumps. Thus, geothermal heat pumps that involve the synergy between renewable energy and energy efficiency is the most environmentally friendly option, in terms of carbon dioxide emissions, for an organization for space and water heating.

3.2.4. Results from Questionnaires

The results of the first questionnaire sent to the four sites of the case study organization show that three of the four sites have no energy management system in place, yet they have some actions in place that aim to improve energy consumption on the sites. In Shanghai, the site installed new outer air chillers as a cooling system that reduces energy consumption. In Chicago, the site has purchased and installed new boiler systems to increase space and water heating efficiency. In Ras Al-Khaimah, the site has installed a new grinding machine to improve the energy consumption of their operations. None of the sites mentioned integrate any external policies, internal policies, or incentives in their actions. Also, the sites do not make use of any of the regional renewable energy potentials based on their climate and geographical conditions.

On the other hand, the site in Montbrison, implement the ISO50001 energy management system and they are certified by a third party organization. Thus, this is the only site that implements an energy policy. Thereafter the team has arranged an interview with the HSE manager and the energy expert on site to further understand and study the result of the implementation of the ISO50001 tool.

3.2.5. Results from the Interview with the Site in Montbrison, France

From the interview, the team has found that the site has internal policies, and has had implemented actions in energy efficiency. The site has installed new L.E.D fittings in 15% of their lighting system on site. The site has achieved a total reduction of 3.5% in energy consumption on site from energy efficiency actions. The HSE manager emphasized on the role of top management in the implementation of the tool where it encouraged the commitment of all the employees in implementation the ISO50001 through communicating the energy policy of the site to all employees. The energy expert highlighted the importance of communicating the benefits of energy saving and efficiency for the organization and for the environment. The energy expert also discussed the difficulty of getting the audience to communicate the benefits internally because the site is old and it is difficult to change from their old ways and strategies to the new ones.

3.2.6. 5LF and FSSD Analysis on the ISO50001

Since the site in Montbrison, of the case study organization in France, implements the ISO50001. First a five level framework analysis to better understand the tool.

Table 3.1: 5LF assessment of the ISO50001

Level	ISO50001
System	ISO50001 is a certification tool that was developed based on elements from internationally known ISO management standards, ISO14001 environmental management system and ISO9001 quality management system. The tool is developed for combatting climate change, to sustain businesses, and improve corporate social responsibility on the energy level. This certification of this tool can only be done by a third party organization. The tool is used by local and international organizations of all sizes, that want to incorporate energy management strategies in their processes and operations. ISO50001 states assumptions that it provides business benefits such as "systematic reduction of energy consumption and carbon emissions for organizations implementing it" The tool is based on the PDCA framework for implementation
Success	The main purpose of the tool is to enable an organization to improve its energy performance in a systematic approach in terms of energy use, energy efficiency, and energy consumption. The tool defines successful implementation by top management support, sufficient resources allocation, and management commitment. The scope of the management tool is improving the performance of existing systems, purchasing of more efficient systems, and offering internationally recognized best practices.
Strategic	The tool assists in implementation of new energy-efficient technologies by providing guidance on how to benchmark, measure, and document energy use. Energy management team is to be formed and top management must be involved in the decision making.
Actions	The tool discusses actions based on the PDCA framework that the organization must undertake for the successful implementation of the tool. Actions such as energy policy documentation, training, internal and external communication, and energy review that includes internationally recognized best practices. The goals are stated with each phase and action. Those actions are aligned with the strategic and success level since they use the actions within the strategies to reach the success in terms of their energy performance.
Tools	There are several tools that the ISO50001 is based on. There is a measurement tool for energy review, monitoring and auditing tool for the checking phase, and other tools to improve management approaches.

After understanding the system using the 5LF assessment, FSSD analysis on tools was done on the energy management systems to identify the contributions and gaps on four levels of the FSSD; Systems level, Success level, Strategic level, and Actions level.

Table 3.2: FSSD analysis on the ISO50001 tool

Level	Contribution to the level	Gaps
System	The tool contributes to the energy management systems by providing guidelines and actions to strategically improve the implementing organizations' energy performance; thus, reducing their impact on society within the biosphere. The baseline assessment phase of the tool offers further information to understand the system from the energy perspective.	The tool only offers general assumptions that are not quantified. The tool describes its boundary around energy efficiency only. Which means there are no assessments of energy potentials in the region and how the implementing organization is situated in the region in terms of their energy mix, geographic and climate conditions, political conditions, and incentives.
Success	The tool elaborates on the system's definition of success by discussing combatting climate change through energy efficiency in organizations. If organizations utilize the tool and achieve the energy efficiency objectives, they can positively contribute to sustainability.	The tool's definition of success does not cover the full scope sustainability and only addresses the environmental sustainability principles mentioned in introduction 1.3. The tool does not discuss or address global sustainability in its long-term success definition.
Strategic	Guidelines to assist in implementing the tool as a framework, as mention in the 5LF strategic level. The tool utilizes backcasting approach by communicating energy objectives and providing guidelines to achieve the objectives strategically. The tool encourages participation of employees in implementing any of the strategies through internal and external communication. General actions provided by the tool are presented with energy savings benefits and payback period estimations it includes regulatory compliance in its strategies.	The tool does not assist sustainability practitioners in prioritizing actions since it does not offer a frame work for that. The tool does not help to achieve complete social sustainability. Actions that are provided by the tool or by the implementation of the tool are not assessed using the sustainability principles or the strategic guidelines for decision making, such as cost-benefit analyses, payback periods or flexibility within the actions for future improvements and developments.
Actions	As mentioned in the 5LF analysis table 5.1, the tool suggests actions that promotes the inclusion of top management in the decision making.	As mentioned in the 5LF analysis table 5.1, the ISO50001 provides internationally recognized best practices and actions that are generally contextualized they are not specific enough for multinational organizations different regions with different geopolitical conditions.

4. Discussions

The discussion phase focuses on assessing the ability of the team to answer the research questions from the results shown in the previous chapter. First, the critical elements are highlighted and their relationship to the first research question is explained, then the integration of the critical elements is clarified to answer the second research question. Then the implementation phase of the tool identified based on the first two research questions is elucidated.

4.1. Phase I: The Critical Elements

To answer the first research questions; some of the barriers and motivators are used as critical elements of the final sustainable energy management system to help organizations in their shift to more sustainable practices. The critical elements 4.1.1 to 4.1.4:

4.1.1. Regulatory Framework

Baseline analysis on each of the sites of the case study showed the difference in the levels of regulations and laws in each of the different regions. They also assist in competitiveness in the field if the regulations are met earlier or predicted before other competitors by identifying trends in region specific databases. Regulatory frameworks have influence on organizations to reduce their energy consumption and shift to renewable energy resources since there will be penalties for non-compliance. Hence, regulatory framework is considered to be one of the critical elements that drives organizations to implement SEMS.

4.1.2. Economic and Financial Factors

Keeping the economic conditions of a region and the site under consideration while using the SEMS is important. Since decision makers around that region tend to implement strategies that would increase profitability and decrease costs in the short term rather than invest in environment protection technologies and resource for the long term. Also, the budget of the site itself and the availability of resources in terms of time, workforce, and finances are important to keep in consideration. The structure and growth of the region that the site is situated in plays an important role in the implementation of energy efficiency technologies and strategies. Countries with stronger economies in terms of growth have a better probability to improve their energy efficiency businesses than countries with unstable or stalled economy.

It is important for an organization with limited resources to invest in the right direction; assessing this is based on analysis of the geographical and climate conditions that would allow for renewable technologies, regional incentives and regulatory frameworks that would support the investment plans, and by ensuring that the actions taken would meet the objectives without negatively affecting the organizations resources and socioecological conditions.

Furthermore, the research around the barriers and drivers excluded behavioral change in the consumer and decision makers' levels. Those elements are important to ensure businesses shift to sustainability-driven energy management strategies, yet due to the time and resource limitation of the thesis study, the team was not able to go deeper into those elements.

4.1.3. Company's Reputation

Multinational organizations tend to want to achieve a "greener" image by implementing plans that would decrease their carbon footprint and innovate ideas around environmental protection. Communicating their future plans and objectives around energy use can contribute positively to the company image and offers good "marketing" to their organization.

4.1.4. Geographical and Climate Conditions

Using IRENA and IEA as databases to assess site specific renewable energy generation potential was very helpful. Thus, geographical conditions are a vital critical element that needs to be considered when implementing an SEMS.

To increase profitability, organizations can implement different kinds of renewable energy resources, depending on the geographical location of the site, climate condition and availability of renewable sources. Some renewables need operating experience in regional climate conditions before performance can be optimized. It was especially useful for the team to work with a multinational organization as a case study having sites in different continents around the world. The team was exposed to diverse databases for data collection and communicated with different people with different cultures.

Moreover, the large share of energy consumption in industrial buildings is attributable to space heating and cooling varying with climate and geographical conditions. Comparing energy consumption of similar building construction and insulations in different location is usually an appropriate reference for users to improve energy efficiency. For instance, it would be optimal for the case study organization to use more natural light in the Southeast Asia like Malaysia while change the fluorescent bulb in Nordic sites for the winter nights.

Furthermore, there are several differences between countries in different regions in the context of the effectiveness of their incentives. For example, Nordic and Western European countries have the most mature markets in environmental performance, thus allowing for more effective and efficient energy management strategies. On the other hand, countries in the Middle East and Eastern Europe, only has the minimum or no regulations around environmental performance and reporting, thus hindering organizations' decision makers from implementing sustainability-driven energy management strategies. The variability of the policies and impacts of energy management strategies in different regions can hinder businesses' incentive to implement those plans due to complexity and the lack of a single strategy to cover their policies.

4.2. Phase II: Integration of Critical Elements Using EnMS

Since the thesis is about putting together a tool that allows mid-size multinational organizations to shift faster into more sustainable practices around their energy consumption and energy resources, several types of research and studies were reviewed by the team to identify differently, popular energy management systems or "EnMS" that mid-size organizations are using or have previously used. The tools and systems targeted by the team have to be utilized by organizations that are aware of the sustainability challenge and are laying the groundwork to reduce or eliminate their contribution to global warming and climate change, and the improvement of social sustainability of their employees and the societies and communities around them. Having these criteria is important to ensure that the scope of the research is focused on organizations that show understanding of the sustainability challenge, hence are not using the tool merely to save costs and increase revenue. As shown in the results section, the two main tools and energy management systems that are found by the team to cover the criteria mentioned are the ISO50001 and the EN-16001. Those two standards are similar to each other with only a few differences between the implementation and the inclusion of the staff and management members in the operation and checking phase. The framework and operation of the tools are highlighted in the results section of this chapter.

To make sure that the tool created by the team is appropriate, complies with full sustainability, and the that the tool is based on already established and case-study-verified EnMS's, the team has identified the gaps and pitfalls of the tools researched and have suggested the inclusion of several extra parts in the final SEMS or the sustainability-driven energy management system. For example, the EnMS do not include the baseline information about any regional incentives to apply any energy efficiency plans or renewable energy shifts. Administrative and financial incentives must be vital parts of any decision making a mid-size organization would do since it reduces any financial or human resources needed to implement any energy management strategy or action plan. Also, there are no suggestions or drivers in the framework of the tools to assist mid-size organizations in shifting to renewable energy resources or generating any off-grid clean energy. This section is one of the most important parts of the SEMS since it could reduce or even eliminate an organization's environmental footprint in all their processes and operations. Moreover, economic conditions of the sites are not mentioned in the EnMS; one of the key drivers and barriers for multinational mid-size organizations are the financial situations of each individual site. Since most multinational organizations allocate different budgets for different regions and different sites due to local economic conditions and labor regulations. Finally, the tools do not have any kind of analyses on their current situations or on any of the actions that they will implement to achieve their objectives to evaluate their compliance with the sustainability principles, explained in 1.3, or similar criteria to ensure that no unwanted results would occur that would affect the social or environmental aspects of the organization. This part is a vital part in the SEMS.

4.2.1. Energy Efficiency

From the results found in section 3.2.1, the team has found that energy efficiency strategies can provide the least possible energy costs saving actions. Organizations seeking energy objectives of higher standards cannot rely on energy efficiency plans alone. Other strategies must be implemented in synergy to achieve the required objectives effectively.

4.2.2. Renewable Energy

If renewable energy strategies are implemented effectively by utilizing different critical elements such as incentives and the different in regional renewable energy potentials, then the implementing organization can achieve better compliance with the sustainability principles. By shifting from fossil fuel based energy sources to renewable energy sources, the organization can reduce and even eliminate their carbon emissions and ultimately their contribution to the sustainability challenge. If achieved, organizations can improve their image in the market and increase their revenue. In regions where countries import their fossil fuel for energy generation, implementing renewable energy plans has the highest financial and environmental effect. This is because it eliminates the financial and environmental costs of transporting fossil fuels. It is also important to highlight that not all countries have fossil fuels as local resources, yet all countries have renewable energy potentials. This is underlined by the idea of the difference of the efficiency of converting the primary energy or raw energy into usable energy. In other words, synergy strategies such as solar water heaters provide 100% efficiency, unlike electric heaters that have thermal and electrical losses during transmission and conversion. This highlights the importance of implementing renewable energy strategies in organizations or energy management systems and tools.

Different technologies have different energy conversion rates and efficiencies. This can be highly dependent on the material used and the climate condition of the site.

4.2.3. Synergy between renewable energy and energy efficiency

Energy efficiency and renewable energy can complement each other in terms timing, economics, regional resources, and power generation performance. Energy efficiency offers savings with short and medium objectives, while limiting the long term objectives. Implementing renewable energy provides energy in the short term but offers opportunities that energy efficiency lacks over time. Moreover, energy efficiency can be achieved relatively cheaper than renewable energy because typically renewable energy generation is more expensive in terms of KWh than fossil fuel based power generation. On the other hand, combining the two methods potentially reduces energy systems costs. Implementing energy efficiency together with renewable energy can potentially provide regional economic benefits by increasing local investments and employment. Furthermore, implementing renewable energy together with energy efficiency strategies can improve overall power generation performance in different peak hours. By reducing demand during peak hours, the synergies strategy in an organization can reduce their environmental impact by not purchasing electricity when the costs are high and the emissions are peaking.

The results show that utilizing renewable energy and energy efficiency in synergy is the most cost effective and energy efficient method to reduce the environmental impact of their energy consumption. These technologies offer savings in primary energy demand and also increase the share of renewable energy; this increases both efficiencies of conversion and cost savings.

Based on the REmap tool; due to its success at a regional level, synergies can be incorporated into organizational tools, internal objectives and policies, and different EnMSs to accomplish the best results possible with the least amount of resources required.

To achieve this, a different tool must be designed to implement energy management plans that integrate strategic sustainable development and business growth on an organizational level.

So, an answer to the second research question, "*how can these critical elements be integrated together to address the sustainability challenge within energy consumption for a multinational, mid-size company?*", is to **use sustainability driven energy management systems that include energy efficiency, renewable energy, and synergy between renewable energy and energy efficiency strategies.**

4.3. SEMS Development and Implementation

In this section, the focus is on the development and the implementation of the sustainability-driven energy management system: SEMS. After the results from phase I and phase II, the critical elements are identified and the gaps in existing energy management tools are highlighted. This assisted the team in designing a tool that incorporates the missing critical elements in the energy management systems. The critical elements are:

1. Geographical and climate conditions
2. Incentives

This tool will be presented in a form of an energy profile to be used by top management as a decision-making tool focused on energy planning.

From content analysis and interviews with a site implementing the ISO50001 in Montbrison; the team found that there are three important key factors that top management in midsize multinational organizations should take into consideration as they go forward to implement the SEMS. The factors are; 1) providing general support to the system, 2) provide sufficient resources to apply the system and perhaps implement possible actions for synergies, 3) and being committed to the longer term implementation of the plan and for continuous improvement of the management systems. The tool design is divided into three sections, the energy policy, energy review, and the REmap tool.

4.3.1. Energy policy

Energy policy is a basis for implementing and improving an organization's energy performance. It also provides an outline for multinational organizations to set energy consumption targets and action plans to comply with the policy. Having an energy policy is similar to backcasting from success; where an organization would set the energy performance goal for themselves and backcast from that goal.

The policy would state compliance with local and regional regulations and continual improvements in energy performance. It would also show commitment to designing and purchasing of products and services that would contribute to a more efficient energy performance. The team believes that and organization forming an energy policy and incorporating it into their infrastructure increases their chances in improving their energy performance. Communicating the energy policy within the organization to all employees, especially when it is coming from the top management increases the likelihood of the commitment of the employees to the energy objective. This was confirmed by the interviewee, in section 3.2.5, with the energy expert in the site of the case study organization in Montbrison. The interviewee also highlighted the achievement of a better energy performance result than other sites of the case study organization after implementing the tool and communicating an energy policy.

To implement the SEMS on other sites, the team assumed a general energy policy for three of the four sites of the case study organization. The policy states that the sites would comply with all applicable regional regulations, and achieve 50% energy efficiency in 2030 by increasing the renewable energy share in their energy mix to at least 50% and incorporate energy efficiency strategies.

4.3.2. Energy Review

The team has decided that an organization implementing an SEMS must record and maintain an energy review with certain documenting methodology and criteria. This review is based on data and measurements that could assist in identifying areas of improvements in energy performance that are part of the scope of the SEMS. The energy profile provides useful information for the 1) development of energy baseline, 2) selection of ENPI, and 3) establishing a monitoring mechanism for future improvements.

From the content analysis of databases documents, the team built a relatively full picture of the regional conditions. The conditions include a regional overview containing baseline data and energy potentials. This also includes regional incentives that help the deployment of renewable energy, energy efficiency, and synergy between renewable energy and energy efficiency strategies. This was done to include the missing critical element discussed in phase I. Data can be found in appendix A.

After receiving replies from the questionnaires the team was able to collect data for the site specifications to identify opportunities for improvement specific for each site. From this analysis, the team identified three improvement categories; lightings, electrification, and heating/cooling. The improvement categories are considered to be the most energy intense technologies utilized by the case study organization. Thus, improving the efficiency of any of the categories would help the organization achieve better energy performance. The questions and the design of questionnaires used were general to receive results as soon as possible to leave enough time for the team to continue the research and the study. For example, from the questionnaires, the team could not collect information about the number of lights and their specific types and this made the calculations difficult to find more efficient lighting practices. Yet, if organizations are using the SEMS, site surveys must be done to get proper assessments to better estimate costs and plan for strategies to improve their energy performance the categories. The questionnaires were designed and written to be replicable and can be used for multinational organization in other industries. Data can be found in appendix B.

Since energy intensity is an EKPI, the team has calculated the current energy intensity of each of the sites. This energy intensity data is considered the reference data for the comparison with the SHIFT case in 2030 after the implementation of SEMS. There are several kinds of energy performance indicators that can be used for different businesses in different regions, yet this indicator was used by the team because it's the most relevant and convenient in terms of monitoring and calculations, to be used on the case study organization. Data can be found in Appendix C.

During the process of collecting data from the different sites, the team has noticed that all the sites of the case study organization have been able to provide the data and information properly in due time. Yet, the site already implementing the EnMS sent back the questionnaires faster and provided more organized data. This highlights the importance of documenting and organizing the data periodically. It was also especially useful to receive more specific information from the contact person who had access to the database including energy key performance indicators and other data. The team also highlights the difficulty of researching for geographical and regional information for the site in Ras Al-Khaimah. This was true because of the lack of databases in the region. Thus, the team recognizes that information from regions with relatively weak databases can be more effectively collected by directly contacting the governmental entities.

4.3.3. REmap Tool for Businesses

In the following sections, calculations from the case study organization's site in Chicago are illustrated in the form of the three reference shift scenarios including the proposed actions. To better estimate the benefits and illustrate a more accurate Remap, organizations implementing the tool must survey the site to decide better on the kind of energy strategies to be used. For example, an organization can hire a consultant or a contractor to apply the strategies in a more efficient manner. The team could have proposed more energy actions, yet it was not possible due to lack of data and information from the sites to calculate feasibility and illustrate the REmap scenarios. The sustainability principles analysis done on the proposed actions under the three strategies shows the level of compliance or violation of the proposed actions against the three environmental sustainability principles through the production, use, and the end of life phases. Some actions show better compliance with the principles among the current practices and existing strategies nowadays to deliver the objective.

On the other hand, some partial violations of some of the sustainability principles are identified. Yet, this partial violation is negligible compared to their current practices which violate more sustainability principles. The analysis was done based on the team's understanding of the sustainability challenge and sustainability principles. The results of the SP analysis can be different with different perspectives.

For example, the installation of PV cells and relying on them instead of fossil fuels as a source of electricity generation would result in better compliance since there is no need for drilling or mining for fossil fuels and increasing their concentration (SP1&SP3), and also GHG emissions from the burning of fossil fuels are eliminated(SP2). However, although the action of installing PV cells proves better compliance mainly in the use phase, it could also be a source of violation in the production and the end of life phases. If the PV cells are installed on green areas contributing to the degradation and the deforestation violating SP3. Moreover, the production of PV cells includes silicon and other materials that might need to be mined for violating SP1. Yet these violations could be avoided by using recycled materials and installing PV on unused spaces such as rooftops and deserts.

Energy Efficiency

In this scenario, energy efficiency of two types of water heaters were compared to illustrate the cost savings of utilizing more efficient electric heaters instead of the ordinary gas water heaters. Baseline analysis showed that the Chicago site utilizes ordinary gas water heaters with primitive controls. Based on the comparison done on the water heating technologies, an action of replacing the current gas water heaters with electric heaters was proposed, and the results of the REmap Tool for Businesses energy efficiency scenario is as follows. Other actions that can be implemented regarding energy efficiency are the installation of L.E.D lightings, improving insulations in the sites, closing leakages, and replacement of windows.

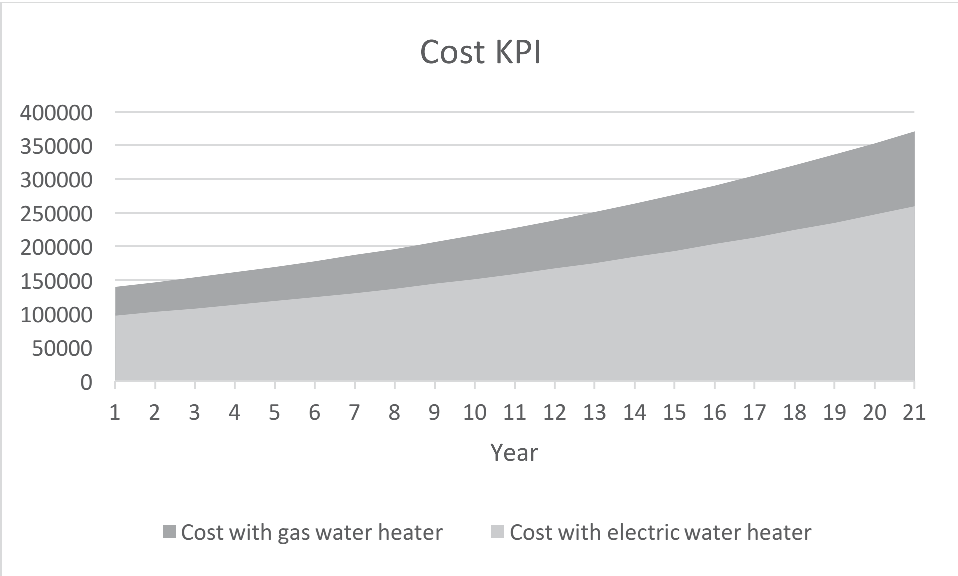

Figure 4.1: Energy efficiency scenario shows an energy saving off energy bills by 40%

Table 4.1: Table of Compliance of "installing electric water heaters" against the Sustainability Principles. Half-ticks mean partial violation, while a tick represents better compliance.

Phase of analysis	SP1	SP2	SP3
Production	✗	✓	✓
Use	✗	✓	✓
End of Life	✓	✓	✓

Renewable Energy

In this scenario, the impact of the installation of new PV cells are compared against the BAU case, where the site is purchasing electricity from the grid. As mentioned in the methods section 2.1.4. The site has already performed the PV cells installation return on investment analysis. Other actions that can be proposed for renewable energy strategies are solar water boilers, and small wind turbines.

The following calculations are included in their study:

1. The compound effect over years in terms of electricity prices
2. Initial cost of the purchase and installation of the PV cells and the inverter.
3. Electricity costs and consumption per quarter.
4. The replacement of the PV cells every 20 years and the inverter every 10 years.
5. The governmental incentive of 30% tax credit of the initial PV cells purchase.
6. Annual loss of efficiency
7. Solar irradiance program revenue provided by the state municipality.
8. PV cells efficiency variations per season.

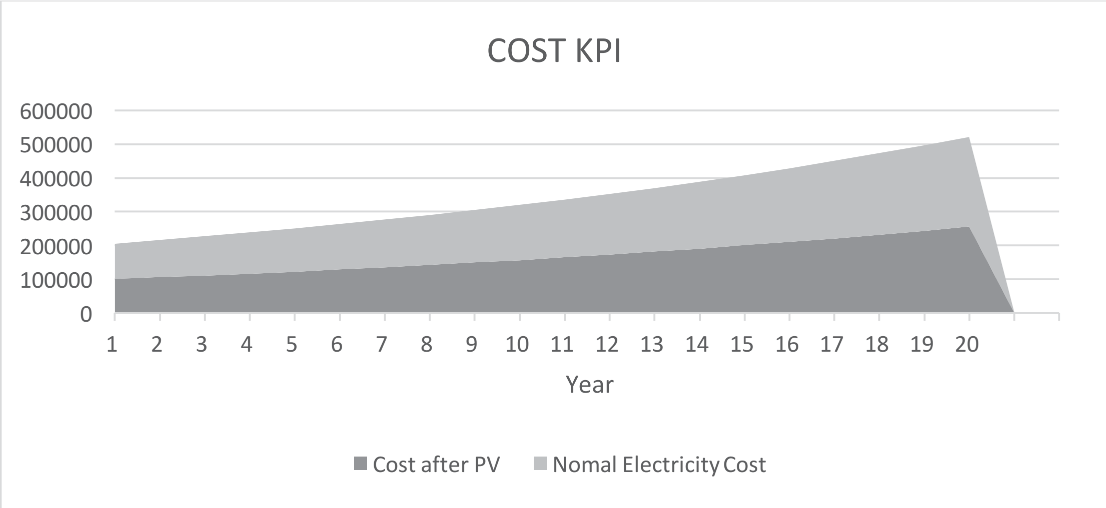

Figure 4.2: Comparison of costs in USD between a scenario of site using PV cells for power and without PV cells. Estimated savings are 40% off electricity bills.

Sustainability principles analysis on the recommended renewable energy action shows no violation of any of the sustainability principles.

Table 4.2: Table of Compliance of "installing PV cells" against the Sustainability Principles. Half-ticks mean partial violation, while a tick represents better compliance.

Phase of analysis	SP1	SP2	SP3
Production	✗	✓	✓
Use	✓	✓	✓
End of Life	✓	✓	✓

Synergy between renewable energy and energy efficiency

In this scenario, the impact of synergy between energy efficiency and renewable energy are compared to the BAU case where the site is purchasing gas for gas water heaters. The proposed action for this scenario is the installation of geothermal heat pumps. There are other actions that can be proposed of this scenario such as improvement of building natural lightings with renewable source of electricity and use of thermal mass. The results are as follows:

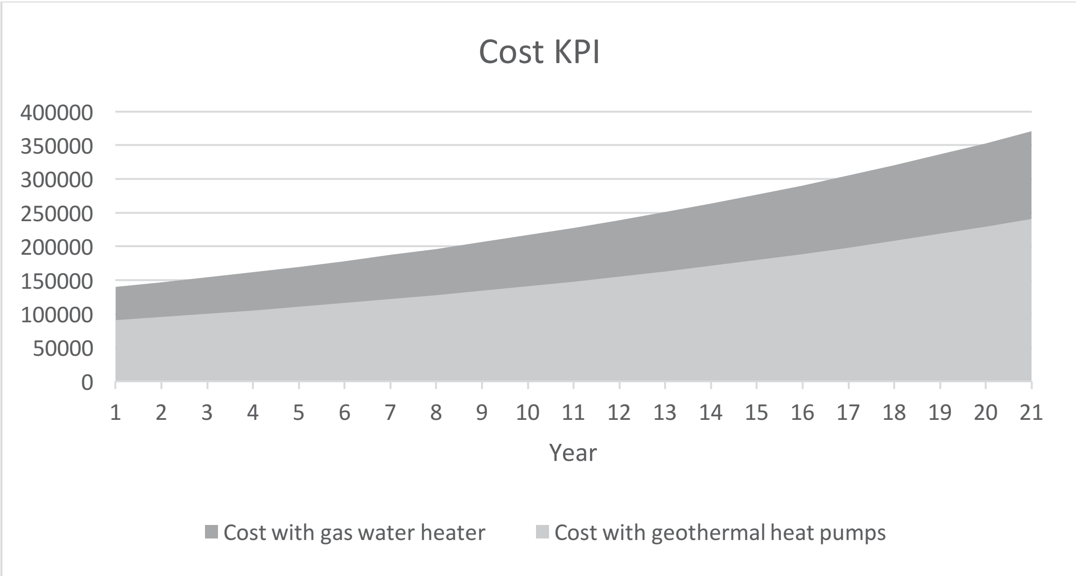

Figure 4.3: Synergy between renewable energy and energy efficiency shows an estimate cost savings off energy bills of 50%

Sustainability principles analysis on the synergy recommended action shows better compliance with the three environmental sustainability principles. Since

The team recognized that the synergy between renewable energy and energy efficiency is the most cost effective and convenient scenario compared to the renewable energy and energy efficiency alone. It is also noticeable from the research that to achieve the complimenting some energy efficiency strategies with renewable energy strategies in synergy helps achieve the targets faster and more feasibly.

Table 4.3: Table of Compliance of "installing geothermal heat pumps" against the Sustainability Principles . Half-ticks mean partial violation, while a tick represents better compliance.

Phase of analysis	SP1	SP2	SP3
Production	✗	✓	✓
Use	✓	✓	✗
End of Life	✓	✓	✗

The tool developed by the team addresses the three environmental sustainability principles (SP1, SP2, and SP3) mentioned in 1.3; unlike the commonly used energy management systems that only address the second sustainability principle regarding carbon dioxide emissions. By assessing the geographical conditions in different regions and incentives that facilitate the deployment of both renewable energy and energy efficiency in synergy, the tool promotes the strategic elimination of fossil fuel based energy resources. Consequently, reducing the extraction of materials from Earth's crust (SP1), the burning fossil fuels and thus decreasing GHG emissions (SP2), and eventually reducing the degradation of Earth's crust by avoiding mining and drilling processes (SP3).

The tool also covers the financial aspects of implementing the energy efficiency, renewable energy and the synergy between renewable energy and energy efficiency strategies by carrying out a cost benefit analysis for each proposed action. This analysis includes variables such as costs variations, costs savings, initial costs, replacement and maintenance costs, cost reductions by incentives, and the compound effect of increasing energy prices. Consequently, the strategies proposed by the tool fit neatly into the business case for sustainability.

5. Conclusion

In conclusion, organizations must always identify their own critical elements that would hinder or motivate their sustainability driven energy management systems. This was especially helpful in the case study organizations because of their resource limitation and the diversity of their site locations around the world. Keeping the critical elements in mind as the tool is implemented provides ease of access of renewable resources to organizations, hence, reducing the multinational manufacturers' environmental impact. Having a proper CSR communication and sustainability reports, which the case study organization already does, reflects the company's policies and attitude towards climate change, hence, attracting more customers and investors towards them. Also reputational incentives, such as carbon disclosure schemes and multi-regional GHG registries are key to build a "greener" company image. Many investors and other market participants are focused on the short term plans such as increasing profitability and reducing costs on the expense of longer term plans such increasing energy efficiency and shifting to renewable energy resources.

Renewable and energy efficiency are stepping stones of sustainable energy. The growth of the demand for energy must be within the sustainable range., so that renewable energy can start taking over and ultimately eliminate the need for fossil fuel. If energy consumption continues the at this current growth rate, then renewable energy alone may not be able to drastically reduce fossil fuel consumption. So energy efficiency together with renewable energy must be used simultaneously in a sustainable energy future.

With the scarcity of resources increasing every day, renewable energy plans are being implemented more and more in all countries. Governments and utility companies are always providing incentives and lobbying for regulations to increase the renewable energy generation rather than fossil fuel based energy. It is considered a best practice for organizations to research tools and systems that would assist them in incorporating energy efficiency plans and renewable energy deployments. The deployment can be more effective if the climate and geographical conditions, in terms of renewable potentials, are taken into consideration.

To implement the tool successfully, the energy management team and the energy manager must be competent enough to implement it effectively. Taking accurate and detailed measurements of the energy consumption in the sites implementing the tool is vital for successful implementation and achieving the best results possible. Also, documenting the processes and operations, and checking the results towards the energy objectives consistently is important.

It is vital to use governmental incentives to apply sustainability policies and actions to make them more feasible. It is also important for multinational organization to develop their economic performance, improve their brand image, and ensure the harmony of their policies and actions with the overall goals of the company. Thus, implementing sustainability-driven energy management systems and strategies of synergies between renewable energy and energy efficiency fits neatly into the business case for sustainability.

The Sustainability-Driven Energy Management System developed for this research is integrating FSSD concepts to facilitate its use in complex systems, where the relationship of organizations with the socioecological system is not developed enough. This done by incorporating the sustainability principles, backcasting, and other FSSD tools.

5.1. Further Improvements

The tool can be further improved by representing it using a software with a graphical user interface. The user would input the baseline data, while the software would access different databases to include incentives and governmental regulations. The tool would then illustrate best practices based on the data provided and would remind the user to monitor and measure the data periodically. The tool can also be connected directly to the sub meters in the sites energy consuming modules to ensure the periodic data collection and report the deviation from the expected energy objectives.

The scope could also be expanded to include the transportation sector and the lifecycle of the products that the manufacturers produce. Also, the scope can include the social sustainability principles (SP4 to SP8) in the baseline assessment and the proposed actions in the tool. This will help tool evolve to include all the socioecological aspects of sustainability.

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7. Appendices

Appendix A: Incentive for different region of chosen sites

Chicago U.S.

Incentive	Incentive Type	Administrator	Eligble Renewable/Other Technologies	Incentive amount	Maximum Incentives	Eligible System Size
1.Business Energy Investment Tax Credit	Corporate Tax Credit	U.S. Internal Revenue Service	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Municipal Solid Waste, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Tidal, Wind (Small), Geothermal Direct-Use, Fuel Cells using Renewable Fuels, Microturbines	30% for solar, fuel cells, small wind* 10% for geothermal, microturbines and CHP	Fuel cells: $1,500 per 0.5 kW Microturbines: $200 per kW Others: No limit	Small wind turbines: 100 kW or less Fuel cells: 0.5 kW or greater Microturbines: 2 MW or less CHP: 50 MW or less*
2.Renewable Electricity Production Tax Credit	Corporate Tax Credit	U.S. Internal Revenue Service	Geothermal Electric, Biomass, Hydroelectric, Municipal Solid Waste, Landfill Gas, Tidal, Wave, Ocean Thermal, Wind (Small), Hydroelectric (Small)	$0.023/kWh for geothermal, closed-loop biomass $0.012/kWh for other Eligible technologies Applies to first 10 years of operation	Not specified	Marine and Hydrokinetic: Minimum nameplate capacity rating of 150 kW Open-Loop Biomass Facilities Using Agricultural Livestock Waste: Minimum nameplate capacity of 150 kW
3. Special Assessment for Solar Energy Systems	Property Tax Incentive	Illinois Department of Commerce and Economic Opportunity	Solar Water Heat, Solar Space Heat, Solar Photovoltaics	Not specified	Not specified	Not specified
4. Green Building Permit Programs	Green building incentive	Chicago Center for Green Technology	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting, Wind (Small), Hydroelectric (Small) Rainwater Harvesting Systems	50% of Building Permit Fee amount up to $25,000. Varies by project type and sector.		Comprehensive Measures/Whole Building, Yes; specific technologies not identified
5.Property Valuation for commerial wind energy equipment	Property Tax Incentive	Illinois Department of Commerce and Economic Opportunity	Wind (All)	Valuation: $360,000 per MW (annually adjusted for inflation) Depreciation: Up to 70% of the trended real property cost basis		500 kW and larger
6. ComEd, Nicor Gas, Peoples Gas	Rebate Program	ComEd, Nicor Gas, Peoples	Equipment Insulation, Water Heaters, Lighting, Lighting Controls/Sensors, Furnaces, Boilers, Programmable	Free Measures Energy Assessments Compact Fluorescent Lamps (CFLs) Low-flow Showerheads/Aerators	Natural Gas incentives and measures may vary across territories. Program	Business must have peak electric demand of 100 kilowatts or less and less than 60,000 therms per year.

& North Shore Gas - Small Business Energy Savings Program		Gas, and North Shore Gas	Thermostats, Custom/Others pending approval, Other EE, Vending Machine Controls, LED Lighting	Vending Machine Controls Devices Pre-rinse Sprayers Incentives covered up to 70% of the cost T8 Fluorescent Lighting Upgrades Delamping Outdoor Lighting LED Exit Signs Occupancy Sensors Condensing Heating Equipment Incandescent to LED Upgrades Programmable Thermostats Pipe Insulation/Hot Water Boiler Guest Room Energy Management System Boiler Tune-up	incentives greater than $25,000 will require additional program review.	
7. USDA - High Energy Cost Grant Program	Grant Program	USDA Rural Utilities Service	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Wind (Small), Hydroelectric (Small)	$50,000-$3,000,000	$3 million	
8. Renewable Energy and Energy Efficiency Project Financing	Bond Program	Illinois Finance Authority	Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Combined Heat & Power, Daylighting, Wind (Small), Fuel Cells using Renewable Fuels, Other Distributed Generation Technologies Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Building Insulation, Windows, Custom/Others pending approval, Yes; specific technologies not identified, LED Lighting,	Varies by project		

France

Policy Type	Policy Sector	Policy target	Description
Policy Support, Economic Instruments>Fiscal/financial incentives>Feed-in tariffs/premiums	Electricity	Renewable energy→ power	"EOLE" Programme, designed to increase the supply of large-scale grid-connected wind electricity to at least 250 MW by 2005.
Regulatory Instruments, Regulatory Instruments>Other mandatory requirements, Economic Instruments>Fiscal/financial incentives>Feed-in tariffs/premiums	Electricity	Renewable energy→ power	One part of the Energy Law of 10 February 2000, addresses the obligatory purchase of electricity from renewable sources and cogeneration at fixed feed-in tariffs.
Wind, Bioenergy>Biomass for heat, Bioenergy>Biomass for power, Geothermal>Heat, Solar>Solar photovoltaic, Solar Thermal	Multi-sectoral Policy		- The Heat Fund's goal is to support 5.5 Mtoe production of renewable heat between 2009 and 2020. - supports the development of the use of biomass, geothermal energy, heat pumps and solar thermal. - managed by the ADEME at regional level with regional calls for projects.
financial incentives>Feed-in tariffs/premiums		Solar photovoltaic	- **A feed-in tariff**, adjusted every trimester, for building installation no bigger than 100 kW; and - **Tenders** for building installations larger than 100kW and ground mounted plants. - when **solar PV** installed capacity reaches or exceeds the **fixed cap** 100 MW/year for non residential caps, tariffs will drop by 2.6% each trimester - about 10% annually- and less so if the installation rate slows down.
financial incentives>Feed-in tariffs/premiums	Electricity	Hydropower	Under the Electricity Law 2000, a feed-in tariff was introduced on 1 March 2007 for hydropower installations with contracts of 20 years. The tariff comprises 6.07 Eur cents/kWh, together with a bonus of between 0.5 and 3.5 for small installations and a bonus of between 0 and 1.68 Eur cents/kWh in winter depending upon the regularity of production.
financial incentives>Loans, Economic	Multi-sectoral Policy	Solar, Bioenergy>Biomass	Agency:Directorate General for Energy and Raw Materials (Ministry of Ecology, Energy, Sustainable Development and Planning)

Instruments>Fiscal/financial incentives		for heat, Geothermal, Multiple RE Sources>Heating, Multiple RE Sources>Power	
Strategic planning	Electricity	Wind>Offshore, Wind	On 11th of July 2011 the French ministry of Ecology, Energy, Environment and Sustainable Development launched the French Offshore wind tendering programme. In a first stage, 3 GW of offshore installed capacity are tendered, with the deadline for project bidders fixed at January 11th 2012. The second round of tender, auctionning another 3 GW of installed capacity, is scheduled for April 2012. France aims at reaching a total installed capacity of 6 GW by 2020, and supporting the development of the manufacturing sector, in France.
financial incentives>Tax relief	Multi-sectoral Policy	Multiple RE Sources	The Finance law of 2003 extends the tax credit for acquiring energy production equipment which uses a renewable source of energy, and which is installed in new housing. The credit is equal to 15% of the amount of the purchase price.
financial incentives>Grants and subsidies	Framework Policy	All RE	In addition to available grants for surveys, pre-feasibility and feasibility studies, ADEME provides support for demonstration projects and diffusion in the renewable energy sector. Grants for demonstration projects can go up to 30 to 40% of project costs depending on the energy source and targeted sector. Assistance can also be provided for market diffusion of demonstrated technologies/projects, grants can reach 15 to 30% of the costs depending on sector they can also be calculated on the basis of avoided CO2-equivalent emissions (up to 400 Euro/t avoided carbon). Support is also available to increase market diffusion of mature and validated innovative technologies which still need to overcome cost barriers. The programme covers wood-energy for industrial boilers, collective and individual household heating; biogas recovery for energy production, electricity from renewables, geothermal heat and ground source heat pumps as well as solar energy.
Feed-in tariffs/premiums, Voluntary Approaches	Electricity	Biomass for power	A waste management company and the state-owned utility, Electricité de France (EdF), signed an agreement to develop renewable energy from landfill methane. The "biogas project" operating during 1999 was centred near the town of Plessis Gassot, home to Frances largest municipal waste landfill. The waste management company, which operates the landfill, invested FRF 200 million in the infrastructure to capture the methane gas and burn it to produce 10 MW of electricity. EdF agreed to buy all the electricity production for a term of 12 years at a guaranteed price. A second facility at the same site is expected in 2004.

Tax Relief	Electricity	RE power	Under the 2003 Finance Law, the reduced VAT rates applying to equipment for renewable energy production and use which is installed in primary or secondary residencies built for more than two years has been extended until 31 December 2003. The VAT rate is 5.5% in France and Corsica and 2.1% in Guadeloupe, Martinique and Reunion. The equipment must be bought from and installed by the same company.
Feed-in tariffs/premiums	Electricity	Biomass for power	As of January 27th 2011, new feed-in tariffs for electricity produced from biomass are in place. These apply to vegetable and animal agricultural waste, algae and some industrial biomass waste (pulp and paper, wood industries). It does not cover biogas, household or municipal waste. A fixed tariff of EUR cents 4.34/kWh is offered for a period of 20 years, equivalent to a 3.6% decrease from 2009 rates of EUR cents 4.5/kWh. In addition, a variable rate of EUR cents 8-13/kWh is added according to the level of power generation, energy efficiency, and the source of energy. In 2010, France tendered 250 MW of biomass installed capacity, distributed between 32 Combined Heat and Power (CHP) plants and another 200 MW for plants no smaller than 12 MW was closed in February 2011. France targets a total installed capacity of 2,300 MW by 2020. As of November 24th 2011 biomethane gas from waste is entitled a fedd-in tariff, ranging from EUR 0.45 to 0.125/kWh for biogas fed into the gas networks. Tariff vary according to the type of installation and the feedstock.
Regulatory Instrument→ Infrastructure investment	Electricity	Hydropower	The French Ministry announced in July 2008 a plan to boost hydropower as part of Frances goal of increasing the share of renewable sources of energy in its final energy consumption to 23% by 2020. The plan does not include the construction of new hydropower facilities, but seeks to improve the efficiency and capacity of the countrys hydropower dams. The plan has three components. The first component involves the renewable process for the concessions of the 400 largest dams, to be attributed on a competitive basis. The candidates who wish to exploit the dams must: - Meet stringent security requirements; - Meet energy efficiency requirements to maximise their production potential; - Meet requirements as to water quality and the impact on the environment and ecosystems. The call for candidacies will take place in 2009, with the renewal process being complete by 2012. The second aspect of the plan calls for large-scale public investment in hydropower dams, in compliance with the commitments undertaken as part of the Grenelle de lEnvironnement. These investments have the following primary aims: -To improve production capacity through new generation turbines, allowing for 30% more production; - To

			develop pumping stations, ensuring steady supply during peak hours without having recourse to fuel-powered electricity production. - To develop small- and micro-hydropower, including the standardisation of wind turbines. Lastly, the plan will undertake measures to ensure high water quality in streams and rivers. All aspects of the plan are to be discussed with relevant stakeholders. The planned investments will be financed through an increase in the fees paid by hydroelectric concession operating companies, which will be proposed to the parliament.
Regulatory Instruments	Electricity	RE power	On 29 January 2008, the French Ministry of Ecology, Energy, Sustainable Development and Planning signed a five-year agreement with the Federation of Retail and Distribution Enterprises, representing 26 500 outlets nationwide. The agreement commits the retail sector to establish packaging waste and greenhouse gas emission reduction goals. Retailers agreed to undertake detailed analysis of the CO2 emissions of all their activities, to better assess emissions from merchandise transportation and in-store activities. They also pledged to improve energy efficiency in stores, by switching to low-energy lighting and upgrading refrigeration and freezer systems. They also committed to acquiring at least 20% of their overall energy use from renewable energy sources by 2020.
Regulatory Instruments>Other mandatory requirements	Electricity	Multiple RE Sources>CHP	A decree on 5 May 1999 introduced a simplified procedure for classifying district heating using renewable energy or cogeneration, allowing local authorities to obligate new buildings in specified zones to be connected to the district heating grid.
financial incentives>Feed-in tariffs/premiums	Electricity	Wind>Onshore, Bioenergy>Biomass for power, Geothermal>Power, Solar>Solar photovoltaic, Wind>Offshore	Under the Electricity Law 2000, further feed-in tariffs were introduced on 10 July 2005. These apply for contracts of 15 years (except for off-shore wind power and photovoltaic, for which they apply to contracts of 20 years). They are as follows: - Biogas and methanisation: between 7.5 and 9 Eur cents/kWh, with an energy efficiency bonus of between 0 and 3 Eur cents and a methanisation bonus of 2 Eur cents/kWh; - Onshore windpower: 8.2 Eur cents/kWh for 10 years. For the following five years, between 2.8 and 8.2 Eur cents for 5 depending on the site; a low of 2.8 for a plant operating for an average of 3600 hours or more and a high of 8.2 for 2400 hours or less. - Offshore windpower (contracts for 20 years): 13 Eur cents/kWh for 10 years, then a variable rate for the next 5-10 years ranging from 3 Eur cents/kWh for a plant operating 3900 hours or more to 13 Eur cents/kWh for 2800 hours or less. Rates fall by 2% a year for plants built after 1 January 2008, while also adjusted to take account of inflation. Annulled in August 2006, the tariff for

			wind power was reinstated mid-December. **-** Photovoltaic: 30 Eur cents/kWh, with a construction bonus of 25 Eur cents/kWh for mainland France and 40 Eur cents/kWh, with construction bonus of 15 Eur cents in the outer French territories; **-** Geothermal: 12 Eur cents/kWh, with an energy efficiency bonus of between 0 and 3 Eur cents for mainland France and 10 Eur cents/kWh, with an energy efficiency bonus of between 0 and 3 Eur cents on Corsica;
Strategic planning	Electricity, Framework Policy, Heating and Cooling, Multi-sectoral Policy, Transport	Heating,cooling,CHP and power → RE sources	Under the EU Directive 2009/28/EC member countries of the European Union are obliged to draft and submit to the European Commission National Renewable Action Plans (NREAPs) outlining pathway which will allow them to meet their 2020 renewable energy, energy efficiency and GHG cuts targets. **France 2020 renewable energy targets:** 1 **Overall target**: 23% of share of energy generated from renewable sources in gross final energy consumption; 2 **Heating and cooling**: 33% of heat consumption met by renewable sources; 3 **Electricity**: 27% of electricity demand met by electricity generated from renewable energy sources; 4 **Transport**: 10.5% of energy demand met by renewable energy sources. In order to achieve above enlisted targets France runs following incentive schemes: Modifications of administrative procedures in order to overcome administrative barriers to the deployment of renewable energies; Tax reliefs (VAT, Measures improving energy efficiency and energy savings in buildings; Grants Financial aid to research, development and deployment of renewable and energy efficiency technologies; Investments in railway infrastructure with purpose of energy savings;
Strategic planning, Policy Support	Electricity, Framework Policy, Heating and Cooling, Multi-sectoral Policy	Heating and power	In mid-2014 France has revealed a draft of its Energy Bill (likely to be adopted in 2015) establishing climate and renewable energy targets to be reached by 2030. The split of the renewable energy target for 2030 follows NREAP model: **Overall target**: 32% of share of energy generated from renewable sources in gross final energy consumption;

			Heating and cooling: 38% of heat consumption me by renewable sources; **Electricity**: 40% of electricity demand met by electricity generated from renewable energy sources; **Transport**: 15% of energy demand met by renewable energy sources. In order to reach the above 2030 target France is planning to use mechanisms set by NREAP. The Bill set a goal to cut greenhouse gas emissions by 40% (compared to 1990 baseline) and to reduce overall fossil fuel consumption 30% by 2030. Also France is aiming at decreasing its reliance on nuclear energy power generation. The goal is to reduce the share of nuclear energy to 50% of electricity production by 2025, from around 75% in 2014.
financial incentives>Feed-in tariffs/premiums	Electricity	Power	The following feed-in tariffs were established under the Electricity Law of 2000. All sites benefiting from the mandatory buyback rates must be under 12 MW of nominal capacity: - Wind energy: production sites built after the law was published (November 2001) can sign a fifteen-year contract which guarantees a FF 0.55/kWh (0.0838) rate for the first five years for all sites. The tariff for the next ten years depends on wind conditions; plants working at full capacity for less than 2,000 hours continue to get EUR 0.0838, those at a full-capacity of 3,600 h/year receive 0.0541/kWh (tariffs in between are determined by a linear regression). These tariffs apply for the first 1,500 MW of nationally installed capacity, thereafter all tariffs decrease by 10% (only for new projects). These tariffs are applicable until December 2002, after they decrease by 3.3% annually to reflect technology learning. - Small hydro: production sites built after the publication of the law (or for the marginal production from retrofits increasing production by more than 10%) can sign a twenty-year contract which guarantees FF 0.40/kWh (0.0610) for sites with a capacity under 500 kW and FF 0.36/kWh (0.0549) for larger ones. An incentive for regularity of production of up to FF 0.10/kWh (0.0152) is available in winter (regularity and winter incentives can be separated). - Combustible waste: production sites built after the publication of the law are guaranteed rates of up to FF 0.299/kWh (0.0456) for medium-voltage connections and FF 0.274/kWh (0.0418) for high-voltage connections. - Solar (PV or any radiative technology): The rate is 0.305/kWh in the overseas departments and Corsica, and 0.0155/kWh on mainland France. It also provides a grant of 4.6/watt for direct grid-connected installations. - Biogas from landfills: production sites built after the publication of the law are guaranteed, in metropolitan France, rates up to 0.0572/kWh for

			small installations, up to 0.0450/kWh for large installations and linear interpolation for medium-sized installations. -Municipal solid waste (other than biogas): Rate of EUR 0.045 to EUR 0.05/kWh with a bonus for energy efficiency ranging from 0 to EUR 0.003/kWh. -Cogeneration: Rate of between EUR 0.061 and EUR 0.0915/kWh, according to the price of gas, running time and power.
Regulatory Instruments 1999	Electricity	Power	This policy provided the enabling conditions for EdF to purchase electricity produced from renewable sources such as hydro, co-generation, waste incineration and photovoltaics.
Feed-in tariffs/premiums	Electricity	Solar>Solar photovoltaic, Bioenergy>Biomass for power, Geothermal>Power, Multiple RE Sources, Multiple RE Sources>Power	In 2002, feed-in tariffs were set for the following renewable energy sources, completing the list of tariffs provided for in the Electricity Law, which came into force in 2001. The tariffs have been set for 15 years, except for solar PV which is for 20 years. All sites benefiting from the mandatory buyback rates must be under 12 MW of nominal capacity: - Biomass (Arreté of 16 April 2002): EUR 0.049/kWh, plus bonus for efficiency of between 0 and EUR 0.12/kWh. - Methanisation (Arreté of 16 April 2002): EUR 0.046/kWh, plus bonus for efficiency of between 0 and EUR 0.12/kWh. - Geothermal (Arreté of 13 March 2002): EUR 0.0762/kWh, with a bonus for efficiency between 0 and EUR 0.003/kWh. - Animal waste (Arreté of 13 March 2002): EUR 0.045 to EUR 0.05/kWh, with a bonus for efficiency between 0 and EUR 0.003/kWh. - Solar photovoltaics (Arreté of 13 March 2002): A tariff of EUR 0.305 per kWh has been set in the overseas departments (DOM), in the islands of Saint Pierre et Miquelon and Corsica and of EUR 0.152 per kWh for mainland France. New tariffs have subsequently been set for most of these technologies (see related entry).

Shanghai China

Incentive	Incentive Type	Administrator	Eligble Renewable/Other Technologies	Incentive description
The Notice on New Energy Demonstration City and Industrial Park	Policy Support, Policy Support>Strategic planning	National Energy Administration	Multiple RE Sources	Plans to construct demonstration city relaying extensively on renewable energy sources for heating and electricity needs. Project will be backed with financial support from governmental budget. In order to benefit from the support from the Fund, renewable energy consumption of projects must be higher than 3% of total energy demand. There are detailed specifications and requirements for the utilization of wind, solar, biomass and geothermal that were established by the National Energy Administration in May 2012.
Notice on promotion of PV industry by exert the price leverage effect	Fiscal/financial incentives>Grants and subsidies	National Development and Reform Commission	Solar, Solar>Solar photovoltaic	Since September 25, 2013, to other electricity levy charge renewable energy tariff except for residents living and agricultural production to 1.5 cents / kwh.
Energy saving and new energy automotive industry development plan 2012-2020	Policy Support>Strategic planning	State Council	Multiple RE Sources	Full transition to pure electric vehicles will be achieved by promotion campaign of such automobile, popularization of non-plug-in hybrid vehicles, energy-saving internal combustion engine vehicles. It is estimated that: 1) by 2015 total production and sales of pure electric cars and plug-in hybrid vehicles will reach 500,000 and more than 5 million by 2020; 2) by 2020 will be produced cars that will consume 5 litres/100km of fossil fuels, 3) new energy cars, power cells and key part produced in China will reach an international level of advancement.
12th Five Year Plan for National Strategic Emerging Industries	Policy Support	State Council	Wind, Solar, Bioenergy	The plan sets a goal to further develop new energy technologies such as: nuclear power, wind, solar PV, geothermal, biomass electricity generation and methane gas in order to actively advance the industrialization of renewable resource technology. Wind industry: ● Construction of the 100GW of wind power base with an expected annual

				generation capacity to be achieved 190 billion kwh by 2015; ● Accumulated installed capacity of 200GW; ● Establish generation quota system; ● Scale up commercialization of the wind offshore equipment production ; ● Increase wind equipment production standards to the international standards; ● Focus on technology innovation in the sector of onshore and offshore wind; ● Establish efficient grid operation and management system applicable for wind power development. **Solar industry**: ● Draft and implement standards and regulations overseeing solar power and solar heat utilization; ● Establish efficient grid operation and management mechanism for distributed power generation for solar photovoltaic technologies and suitable pricing mechanism. **Biomass industry**: ● Draft and implement standards and regulations overseeing biomass systems production and utilization; ● Improve biomass testing and certification system. ● Improve framework of incentives to trigger usage of forestry residue for biofuels and bioenergy production.
Special Fund for the Industrialization of Wind Power Equipment	Fiscal/financial incentives>Grants and subsidies	Ministry of Finance	Wind	The Ministry of Finance created the Special Fund for the Industrialization of Wind Power Equipment. The institution allocates funding to wind projects assessment and evaluation studies, related technology research and development and the construction of pilot demonstration projects. The fund also supports the production of new wind turbines equipments. Subsidies of an amount of CNY 600/kWh, equivalent to USD 87.41/kWh, are provided to domestic companies for the first 50 new turbines of a minimum capacity of 1.5 MW they produce.
Market entry standards for wind equipment manufacturing industry	Framework Policy	National Development and Reform Commission (NDRC)	Wind	The Chinese government introduced specific regulations to improve the efficiency and competitiveness of the local wind equipment manufacturing market. The new standard first restricts the wind turbine manufacturing market to entities of a minimum production capacity of 2.5 MW. New wind turbine manufacturing companies should also demonstrate a five years experience in large-scale mechanical and electrical industry and establish a professional Research and Development Team. Such regulations are applicable to grid-connected wind turbines generators and wind equipment manufacturing companies.

Appendix B   Questionnaire

Questionnaire I

Utilities

1. To which utility area does your site belong?	
2. From which electric utility provider/supplier do you buy your electricity?	
3. Does your site have any off-grid energy supply (e.g. solar cells, batteries , diesel, generators, heat pumps,….)?	

Policies and Incentives

1. What is your site's business license (Industrial or commercial) ?	
2. What internal energy policies do you implement on your site? (Regarding energy efficiency, lighting, heating/cooling systems, machines used in the manufacturing process,..)	
3. Does your site utilize any local/governmental incentives (e.g. policies, regulations, grants, loans, tax credits,)	

Site Specifications,cooling,heating and ventilation systems

1. Do they have any insulation standards or policies? (E.g. sound proofing, double glazing windows,…)	
2. What is the total size of the site? How much area is covered by buildings? What is the remaining area used for?	
3. Number of floors, rooms, and their sizes on the different operational buildings on your site?	
4. What are the specifications of the roof? - Orientation of the building (e.g. North, South, …) - What is the roof shape (e.g. flat, inclined, gabled, ….) - The material from which the roof is constructed? (e.g. metallic, cement ,…) - Is the roof used for other purposes? If yes, then how much area is covered and what is the size of the remaining area?	-
5. What kind of ventilation system do you have and please provide us with specifics? (e.g. extraction rate, ductwork, extract and exhaust locations, schematics)	
6. How is the cooling/air conditioning done on the site?	
7. Working hours of the site? (e.g. how many hours per day? How many days per week?) - Factory and machinery for the manufacturing process? - Cooling/heating and lighting in buildings?	

8. What kind of system do you use for heating purposes (e.g. space heating, water heating systems, air-to-air systems, district heating, heat pumps, electric heaters, ...)? -In case of electric heaters, how much electricity do they consume?	

Questionnaire II

Utilities

1. Kindly attach your utility bills from March 2015 till the current.	

Policies,regulations & incentives

1. What internal energy policies do you implement on your site? (Regarding energy efficiency, lighting, heating/cooling systems, machines used in the manufacturing process,..)	.
2. Does your site utilize any local/governmental incentives (e.g. policies, regulations, grants, loans, tax credits,….)	

Questionnaire III

Existing Lighting Systems

What type of light bulbs are used? Please highlight or check the one you are using.			
	Major Source	**Minor Source**	**None**
• Incandescent bulbs (General/ Reflectorized / Tungsten-halogen/ Xenon)			

			
• Fluorescent bulbs /Compact Fluorescent Lamps CFLs/ T8 bulbs 			
• High-intensity discharge (HID)			

			
• Light Emitting diodes (LED's) 			
• Other (Please Specify)			

Appendix C: Calculation for 3 scenarios

Renewable Energy

Year	1	2	3	4	5	6	7	8	9	10	11	12
Energy Cost	[redacted]											
Cost after PV												
Total Savings USD	3532.3	3704.2	3884.4	4073.4	4271.5	4479.3	4697.2	4925.7	5165.3	5416.5	5680.0	5956.2
Percentage Saving	3.4%	3.4%	3.4%	3.4%	3.4%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%

Energy Efficiency

Year	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0
Cost with gas water heate	[redacted]											
Cost with electric water h												
Total Saving USD	41900.0	43995.0	46194.8	48504.5	50929.7	53476.2	56150.0	58957.5	61905.4	65000.7	68250.7	71663.2
Percentage	42.9%	42.9%	42.9%	42.9%	42.9%	42.9%	42.9%	42.9%	42.9%	42.9%	42.9%	42.9%

Synergy

Year	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0
Cost with gas water heate	[redacted]											
Cost with geothermal hea												
Total Saving USD	48884.0	51328.2	53894.6	56589.3	59418.8	62389.7	65509.2	68784.7	72223.9	75835.1	79626.9	83608.2
Percentage	53.8%	53.8%	53.8%	53.8%	53.8%	53.8%	53.8%	53.8%	53.8%	53.8%	53.8%	53.8%

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