EXPLORING THE MARKET POTENTIAL FOR SUSTAINABLE STEAM TO ELECTRICITY GENERATION WITHIN THE UNITED STATES

Lappeenranta–Lahti University of Technology LUT
Master's Program in Business Analytics, Master's thesis
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Mikaela Peters
Examiner(s): Postdoctoral Researcher Jyrki Savolainen
Tenured Professor Pasi Luukka

ABSTRACT

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The threat of global climate change is driving CO2 emitting industries towards more environmentally sustainable means of production. This research will explore alternative ways of producing steam by renewable means rather than oil and gas. A case study will be carried out to examine market potential in the US for the Finnish company Elstor Oy. The company's technology both produces steam and acts as an electricity storage device. This research examines the steam and electricity markets, as well as preexisting research for market feasibility of similar products. The primary research will be carried out via semi-structured interviews with US-based industry and academia experts supporting sustainability in the steam and electricity industries. The findings derived from their expert opinions on a variety of best ways to penetrate the US market with further analysis of the modern-day industry environment concluded to be, collaborations with universities, applying for grants, and establishing a business presence in the US using a business plan.

ACKNOWLEDGEMENTS

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Thank you to Rutgers University, where I received my bachelor's level education, for providing me with a network as an alumnus, by which I was able to find and contact industry experts to interview for the purpose of this research. More specifically, thank you to those who participated in my interviews, both those who I contacted through the Rutgers Energy Institute directory and those I found through LinkedIn from both Rutgers and Miura, which allowed me to gain key insights into the US steam and electricity markets. Thank you also to the US-Finland Chamber of Commerce in Minnesota for its assistance in setting up an interview and offering itself as a resource for future business endeavors as Elstor considers expansion into a US market.

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1. Introduction

In the wake of the COVID-19 pandemic, it has become blaringly evident that the way in which human society interacts with the environment can have far-reaching, negative consequences for the entirety of humanity. Inconsistent weather patterns, natural disasters, and epidemics have been proliferated by increased deforestation, CO2 emissions, and the like. These issues spell out a need for a transition from the use of fossil fuels towards more sustainably fueled technologies to support the energy needs demanded by consumers today. In recognition of this challenge, governments and companies across the globe are striving to support and incentivize the use of sustainable resources in processes related to production and manufacturing across all energy sectors. Despite this shift, there are still many companies today continuing to use fossil fuels rather than sustainable resources due to their availability, relative cleanliness by comparison to other nonrenewable resources, and low price point. However, with the advent of sustainable energy-saving technologies, fueling power generation through more sustainable energy sources rather than fossil fuels needn't be seen as a penalty, but rather a means by which both long-term cost-savings and increased process efficiencies can be achieved. This case presents a recently developed sustainable technology targeted at eliminating the use of fossil fuels in industrial steam production.

Elstor Oy is a Finnish sustainable energy company based out of Lappeenranta, Finland, which was established in 2017 as the result of a research project related to clean energy alternatives. Elstor's solution provides emission-free power-to-heat storage that produces both steam and heat cost-efficiently with renewable electrical energy inputs via wind, solar, hydro, and nuclear power (Elstor, 2022). Elstor's product is compact, requires a low initial investment, and offers high-capacity energy storage, thus enabling customers to gain long-term cost savings.

As a young company, the overwhelming majority of Elstor's clients are in Finland, where the company has been enjoying great success. According to Pekka Koivisto, the Deputy CEO of Kaskein Marja Oy, a Finnish company, which produces freeze-dried fruits, "With the help of the Elstor solution, our company has been able to completely stop using natural gas in the production of steam" (Elstor, 2022). Kaskein Marja is merely one of numerous Finnish companies adopting and benefiting from this technology, as ongoing efforts for the expansion of Elstor's technology both within and beyond the scope of the Finnish market are being executed. Naturally, exploring the European market would be the next logical step. Working with other Nordic nations has been one project as of late, as has exploring market potential in specific European countries, such as Spain, to name a concrete example. Since market research efforts are currently of interest to Elstor, this research will consider US market potential for Elstor’s technology.

Since there are multiple components to Elstor’s product, there are several different categories of research that will be carried out to conduct a thorough market investigation, as per the request of the company and given the nature of the technology and how it relates to the needs of a US market. Since Finland and the US differ greatly with regards to many aspects, including size, population, public policy and natural resources, there are many areas of research that will need to be considered for the purpose of determining whether Elstor’s technology could be applicable to a US market. At a higher level, there will be four main topics considered in this research. The first will be the steam industry overall since that is the industry which Elstor primarily supports in Finland. This includes how steam is used, by which resources it is produced, and what quantity of it is used if it is quantifiable at all. The second will be the electricity market since Elstor’s technology doubles as an electricity storage unit. Whether the reserve market, where prices fluctuate and are stored in the device when prices are low and released on-demand when prices are high, exists and the extent to which this type of market exists in the US, will be explored. As a subtopic, attempts at understanding how these industries can be costed in a way that would provide insight as to whether the US market could be profitable will be discussed, but not yet calculated since calculations can be made only once a specific target region and market has been selected for further investigation. Rather, this research lays out the pros and cons for selecting certain regions and industries over others.

Since public policy towards sustainable efforts is of prime importance in Finland, the third topic will be related to public policy and sustainability, examining the extent to which policies and incentives supporting sustainable energy use exist in the US. This will be considered at both federal and state levels, thus reiterating the need for region specific efforts on the part of Elstor at a later point. Finally, the fourth topic will be an attempt at understanding what renewable resources are being used and are available in the US will be made. This will include renewable resources being used in either industry, either steam or heat, as well as what potential they may have for use in the future, if they are not being used already.

Through the consideration of these various market research topics from the perspective of general publicly available information, academic research, and interviews with industry experts, whether Elstor's technology stands a chance in a US market context will ultimately be revealed.

1.1. Motivation and Background

In Finland, the impetus to create and dispense a sustainable solution can be attributed both to Finland's overarching priority of creating a more sustainable nation and due to the nature of energy politics in the region. Following Russia's invasion of Ukraine in early 2022, an energy crisis ensued both in Finland and across Europe. However, according to a piece from the State Department of Finland discussing Finland's "Ruxit," or Russian exit, Finland was unique from other countries in Europe, namely Germany and the Czech Republic, in that rather than having many households directly connected to the flow of Russian gas, Finland was utilizing a much smaller amount of gas, meanwhile using sustainable technologies to supplement the rest. In fact, Finland boasts natural gas accounting for only six per cent of its total energy consumption (Tynkkyen, 2022). Despite these current advantages, it is worth noting that Finland had historically benefited from cheap gas prices from Russia. Because Finland ranks among the most energy-intensive countries in the world due to its cold climate and the amount of energy necessary in production for various industries, coupled with its practically non-existent domestic fossil fuel and uranium resources, the vast majority, at approximately two-thirds of imported energy, had been being supplied by Finland's neighbor in the east, Russia (Jääskeläinen et al., 2018). In 2006 and 2009, the crises associated with the supply of natural gas in Europe motivated the European Union (EU) to develop a European energy security strategy in 2014, with national policies and responses varying because of differing energy infrastructures and perceptions of threats and risks (Jääskeläinen et al., 2018). Given Finland's long-standing history with Russia, its reliance on it for gas, and the volatility of the political situation between Russia and the west, Finland's push towards sustainability has been as much about sustainability for the sake of it inasmuch as it has been for maintaining the status quo when international relations take a turn for the worst as they always have the potential to do in such a geopolitically volatile region. In the modern political climate, Finland views Ruxit and energy transition as essential to defending democracy, protecting the climate, and guaranteeing European security of supply and competitiveness (Tynkkyen, 2022). Nowadays, renewable energy accounts for more than 40% of Finnish energy consumption, making Finland one of Europe's top leaders in terms of sustainability (Tynkkyen, 2022).

For several years, Finland has consistently ranked among the top ten most sustainable nations in the world. In fact, most recently, it was ranked as the number one most sustainable UN member state as determined by the UN SDGs, or Sustainable Development Goals (Sustainable Development Report, 2022). In the same report, the United States ranks 41st out of 163 countries. While most developed nations may understand why the promotion and integration of greener forms of energy consumption is becoming increasingly necessary, the implementation of new and improved technologies required to promote said initiatives can still seem dubious at times, irrespective of the availability of resources within a given country. Since profit is typically the driving force behind why companies make certain decisions, the larger challenge surrounding the adoption of more sustainable technologies in lieu of preexisting methods primarily comes down to convincing companies that implementing more sustainable methods in the present will pay off in the future. However, some companies may not yet be willing to make these investments in the short-term if it means they will have to wait years to reap the benefits of their investments. This becomes a particular issue in the absence of proper incentives. Understanding whether the potential for cost savings could exist for US companies the same way it does for Finnish companies, particularly given the Finnish government's involvement in subsidizing more sustainable technology, will be one of the focal points of this research.

1.2.Thesis Focus and Research Questions

This research will be carried out in a case study fashion to support Elstor in its mission to produce emission-free steam and heat production with the goal of promoting a more sustainable future. Elstor as of the spring of 2023 conducts business primarily with companies based in Finland. However, since Elstor is interested in expanding its scope to countries outside of Finland, this research will focus primarily on the United States market as part of an exploratory effort to determine whether Elstor's sustainable technology has the potential to be successful in a US context. This will be carried out via a deep dive into the US steam and electricity markets, meanwhile simultaneously considering the availability of incentives offered by both governmental-wide and state-led programs for using sustainable resources in production, as well as identifying what those resources may be.

Due to the nature of Elstor's technology being multifaced with regards to both supporting the steam industry and utilizing the electricity market, this research will take several different directions, but can be summarized by four primary topics below (Figure 1).

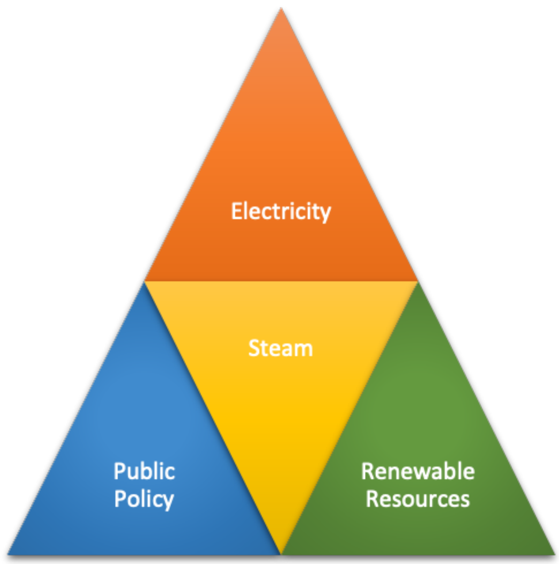

Figure 1. Research areas of this study.

Since Elstor primarily supports the steam industry, first the US steam industry will be explored in detail, from understanding how steam production works, what energy sources fuel it in a US context and whether it is possible to obtain readings on quantities used in US steam production in an industry context. If it is revealed that it is difficult to obtain steam readings from companies, the reasons as to why will be discussed. From the electricity standpoint, how electricity prices in Finland compare to those in the US will be considered as the second element. Likewise, the reserve market and the extent to which a similar market system exists in the US will be researched. The overall electricity market system and how it functions will be explored, as well as what renewable energy sources exist to support it. The third area will be public policy via governmental programs and incentives. While the discussion will begin with examining public policy on a governmental level, research will reveal that considering these policies at a state level as they relate to the steam and electricity industries may be more prudent. The fourth and final aspect to this research will be renewable energy resources and how they are used in the steam and electricity industries. These research topics will be considered both in conjunction with and in isolation from each other at various points throughout the thesis.

The way in which steam and electricity are handled in a US context differs from that of Finland. As one example, electricity prices are standardized throughout Finland, regardless of population density, whereas that is not the case in the US, where electricity prices differ considerably depending on population density, and, therefore, demand for a given location. The nuances behind costing in the US electricity steam market will be detailed. Likewise, from the steam perspective, the way in which steam is used, produced, and costed will be touched upon, as they, too, likely differ from European practices. As a result, public policies will likewise differ, as will renewable energy usage, since the two tend to be correlated.

Elstor's patented solution is an optimized remote-controlled energy storage technology that stores electricity as thermal energy (Elstor, 2022). To meet the needs of fluctuating heat and steam levels, this storage technology offers a high unloading power. Furthermore, loading and unloading in the system operate independently of each other, thus creating flexibility. This technology supports various load levels well due to its ability to regulate the discharge power anywhere between 0 and 100% of its total discharge power capacity, which is maximum 2.0 MW (Elstor, 2022).

In terms of system specifications, the charging power is from 0.5 – 2.5 MW. The storage capacity ranges from 5 – 15 MWh. Decomposition as steam or heat is supported up to 200 °C, or 16 Bar. Electricity to heat efficiency is supported at a 95% efficiency rate MW (Elstor, 2022). A visual representation of the product can be seen in Figure 2 below.

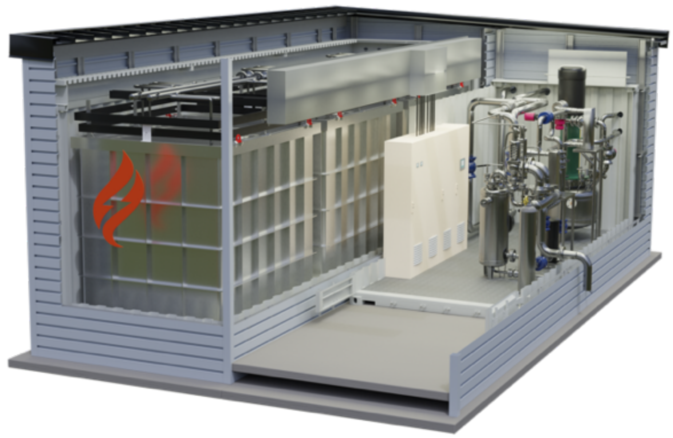

Figure 2. Model of Elstor’s solution (Elstor, 2022).

Since the technology doubles as an energy storage unit, input via electricity is then converted to heat energy to be stored for efficient discharge later. Therefore, efficient storage with limited heat losses is provided. With this technology, guided loading and unloading, in addition to modular and mobile support is offered. In terms of electricity storage, independent charging is optimized by storing electricity during the cheapest hours of the day (Elstor, 2022).

Elstor’s technology takes advantage of what is referred to in Finland as the electricity reserve market to store energy from electric grids when prices are low, later releasing the electricity on demand when it is needed, known as demand flexibility. This approach works well in Finland due to the cost of electricity being delivered from the grid, in which its electricity pricing fluctuates based on the time of day at which it is being used. Part of this research will be focused on assessing whether the US electricity market behaves similarly to understand whether potential cost savings could come to exist in instances where Elstor’s technology could be adopted.

Elstor’s technology is currently being used primarily to support small-scale industries that utilize steam and, to a lesser extent, heat in their production processes. Examples of clients who utilize steam are bakeries; breweries and distilleries; laundromats; food manufacturers specializing in dairy, fish, and meat processing; chemical and biofuel processing factories;

pharmaceutical manufacturers; cement mills and sawmills. Clients of Elstor who solely utilize heat production rather than steam are considerably less numerous and include district heating systems and large facilities. Therefore, another component of this market research will focus on the steam industry within the US in terms of how steam is used and produced to determine whether a customer profile in the US may look similar to that which exists in Finland.

As the many angles by which this research will be approached have been described above, the following research questions will provide some structure and assist in reiterating the main points surrounding this market research effort:

The first overarching research question is:

1. What is the market potential for Elstor's technology in the US market?

The topic-specific research questions are as follow:

2. How does the steam industry operate in the US? Which renewable resources are currently being used, or have the potential to be used, in the steam industry? Are companies measuring their steam usage? Why or why not? If so, are those usage rates easily obtainable from companies? If not, do companies have the capacity or any sort of financial incentive to measure steam?
3. How does the electricity market work in the US? How is electricity priced? Does the reserve market, or something similar under a different name, exist in the US? What opportunities would there be in terms of energy storage in a US context?
4. What is the economic feasibility of producing steam with electricity in industrial applications as indicated by the availability of incentive programs or other means of financial support? What governmental policies and incentives exist to support the use of renewable energy? Are these always via governmental incentive programs or do other support programs exist in the US?
5. What renewable resources are used in either the steam or electricity market? What is the potential of using renewable resources in a US market?

While the first and primary research question is related to overall market potential, the remaining research questions assist in answering the primary research question by looking at each of the contributing factors which need to be researched to provide a well-rounded answer as regards market potential for Elstor's technology.

1.3.Data and Methodology

The data for this thesis comes from multiple sources, including publicly available information, especially that which is provided from governmental agency websites, academic databases, and industry experts. Since current electricity prices are provided by electricity provider websites, these prices are compared from both a Finnish and a US company provider website. Additionally, explaining how the electricity markets are broken down by regions in the US is derived from information yielded from websites detailing the electricity market in the US. Background on the steam industry, currently available governmental policies, and information on alternative sustainable resources for the steam industry are also provided from publicly available information.

Once the background information on the four primary topics is covered, a literature review, which examines whether there are any similar works on case studies related to a technology like Elstor's will be conducted. Since Elstor's technology is relatively unique with the storage component being linked to the reserve market, but also possessing a steam component, it can be challenging to find previous research on the topic. For that reason, the bulk of the research practical for informing a market entry strategy will come from interviews with industry experts working in the steam and electricity industries and public policy research spaces. Based on the description provided to these interviewees about this technology, these experts speculate from which potential directions this technology could enter a US market from their own perspective based on what they've seen in industry, as well as by which funding opportunities, they know to be available, which could be utilized to support the technology's further development and ultimate market entry.

Overall, due to the specificity of this research request, limited information, which is applicable, has already been made available via academic publications. However, if this technology were to find itself in an academia space as part of a US market entry strategy, this could change and perhaps more academic research on the topic of this technology could continue to be conducted.

1.4.Thesis Structure

Prior to assessing and determining whether there is market potential in the US for Elstor's technology, it is imperative to understand how the electricity and steam markets operate in the

US, and potentially differ from those in Finland, as well as the extent to which the US government offers incentives and subsidies for more eco-friendly energy production. Where governmental policies may be potentially absent, it is likewise important to consider what other incentivizes US companies are being offered to reduce their CO2 emissions, such as those at the state-level. These topics will be discussed in the theoretical background, after covering the steam industry, its history, how steam boilers work, where they are used in the modern-day US steam Industry, and how the cost of steam can be calculated. The section following it will cover the US electricity market where the different markets across the US nation will be explained. Next, daily prices are compared in both a Finnish and US context. Then, the reserve market from the Finnish context is explained in greater detail as a precursor to finding a similarly functioning market in a US context.

To conclude the theoretical background section, renewable resource alternatives for the steam and electricity industries are explored, with geothermal being the most obvious and, therefore, being explained in detail. The concept of other renewable resources used in both industries will be expounded upon throughout the course of the research.

Finally, an overview of sustainable public policy is given, detailing the ways in which the Environmental Protection Agency (EPA) attempts to incentivize more eco-friendly behavior at a governmental level. Whether non-for-profits for environmental efforts exist in the US in the same way they do in Europe will likewise be considered. The politics surrounding sustainability in a US context will be highlighted in this section, as they tend to drive governmental policy. The new government initiative towards sustainability recently mandated by President Biden will be discussed. Although climate issues are moving towards becoming more of a partisan issue among both US parties, the divide between this issue still tends to be drawn in a modern-day setting. This shift towards both parties concerning themselves more will likewise be illustrated in this section. However, discussing the political leaning of a state will become an important aspect of this research task, as revealed later in the thesis.

This background information will be followed by a literature review designed to determine whether similar feasibility studies have been previously conducted. Furthermore, previously conducted research which attempts to answer any of the primary research questions will be considered. Therefore, this review will be broken down by the four major topics, concluding in a feasibility analysis to answer the research question regarding the market penetration potential.

The order in which these major topics will be considered is the cost of steam, the electricity market and grid, the electricity reserve market, and public policy. Since sustainability is the overarching theme considered within each of these topics, it does not have its own section, but rather, is considered in conjunction with each of them. This literature review concludes with Table 1, which gives an overview of all the literature pieces considered, followed by a conclusion documenting the challenges of finding research relevant enough to Elstor's specific case, thus exposing the research gap of market penetration for a specified technology. Some of these scientific studies can be reviewed to get an idea as to how these measurements are taken and whether those models could eventually apply to the Elstor case once a specific market segment is selected. As for how steam is being produced, the answer will vary widely, as will what alternatives are available for steam production via more sustainable means, which likewise shows a need for a targeted market related to steam production or electricity storage.

Although Elstor is interested in knowing these figures to be able to create financial models that will prove it can create cost savings for specific clients, before effort is expended, it is more valuable to know whether there is any market potential in the US to begin with. While prior research can be consulted to examine the feasibility of a technology like Elstor's, particularly in a US market, it is difficult to find prior research and information entirely targeted towards this specific case. For that reason, a considerable portion of the research for this paper will be derived from interviews with industry experts offering their opinions, and dispensing information regarding their experiences supporting the given research areas, for the purpose of determining whether this type of technology has any potential in the US market. From these interviewees, suggestions for how to proceed with market entry will likewise be given, potentially paving the way for future business ventures in the US well into the future.

The interview section will be prefaced with a more detailed case description. Then a data and methodology section will outline how the research was conducted, who the participants were and how they were selected, how their interviews were reported and what the interview process was like. This research will be carried out in a qualitative form via interviews and consideration of preexisting research with the prospect of economic models being created at a later point once sufficient research has contributed to a narrower market scope. The results outlined the discussions and the information gleaned from the interviewees, which proved very insightful. Based on this information, the final discussion and conclusion sections present future market entry strategies and opportunities, in addition to best- and worst-case scenarios for Elstor deciding whether to attempt to enter the industry or not.

After researching the answer to these questions, the culmination of these efforts will allow for the consideration of insights from previous work completed on the topic, coupled with expert opinions, to aid in guiding Elstor towards the best business decision with regards to whether an attempt at entering a US market with its technology should be undergone. Exploring whether climate change-combatting alternatives for the steam and electricity industries are already being used in the US, meanwhile considering their potential to be integrated at some point in the future, will likewise provide clearer insight into whether Elstor's product has potential within the US market (Figure 2).

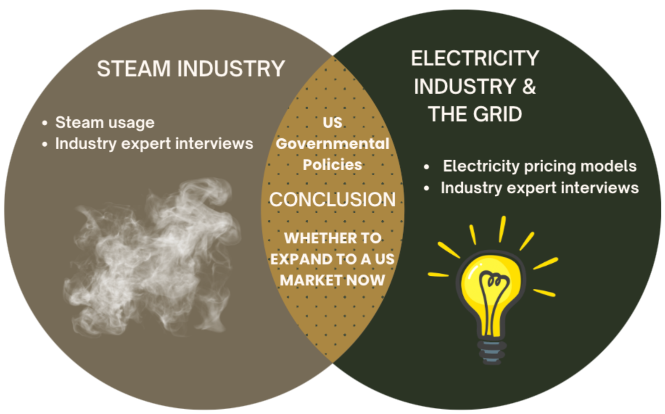

Figure 3: Simplified Venn diagram for research plan, displaying how the market research to be carried out for both the steam and electricity markets coincide to determine whether Elstor should consider expanding into the US market.

2. Theoretical Background

This section will lay the foundation for the research by providing thorough information about the markets in question. It will provide an overview of climate views in the US, followed by more detailed information about both the steam and electricity markets. How steam is manufactured and measured will be discussed, as well as the ways in which it can be manufactured more sustainably. The electricity market will be explored in terms of how it is broken down by region. This section will explain the reserve market and how it works in Finland. It will consider preexisting incentive programs for greenhouse gas emission reductions.

2.1. The Steam Industry

Given the multitude of energy generating technologies available today, it may at times be difficult for both companies and individuals to decide which forms of energy are best to use. While there may exist policies, regulations, and financial incentives established by governmental or local authorities as regards which sources of energy may be preferred over others, there are likewise a variety of complex factors to be considered when deciding which form of energy is best to use in any given situation. However, understanding the background behind how each of these forms of energy are used and produced, as well as the instances in which they are typically used, can allow companies to make more informed decisions about which method is best for a given industry. Therefore, to learn more about the US steam and electricity markets, it is beneficial to understand the background on these industries, how they emerged, and what the subsequent implications are for the industries as they exist today.

2.1.1. The History of Steam

For most of human history, the sun and wood were the main sources of energy available to humans. In the United States, wood became the first real source of energy beginning in 1775 and was later replaced by coal in the 1850s (Energy Information Administration, 2022). By the end of the 1900s, all known forms of energy production today had been brought into existence, including petroleum, natural gas, hydroelectric, nuclear, wind, and solar. Much of the advancement in the realm of energy began with Benjamin Franklin’s discovery of electricity in 1752, which served as a catalyst for the Industrial Revolution a mere decade later (Engineering and Technology History Wiki, 2015). The Industrial Revolution would transform the way various forms of energy were used in industry, marking an era during which agricultural societies began transitioning towards something both more industrialized and urbanized. The advent of the transcontinental railroad, the cotton gin, and electricity, to name a few, would change human society forever by making life considerably more convenient for human society (History, 2023).

Preceding the Industrial Revolution, the burning of traditional biomass, such as wood, crop waste, or charcoal, was the dominant source of energy across the world. These sources of energy would soon be replaced by coal, oil, and gas (Ritchie, Roser, and Rosado, 2022). The use of steam to generate energy was first introduced during the Industrial Revolution and was initially powered primarily by coal (Alberta Culture and Tourism, 2023). Meanwhile, later developed steam producing mechanisms would utilize all three nonrenewable resources, in addition to more renewable sources, such as solar. Nowadays steam power generators are typically powered by either fossil fuel power plants or nuclear power plants. "Less often seen, but growing in popularity today, are concentrated solar power systems (CSP, 2023) which use the sun's heat to heat water into steam" (TurbineGenerator, 2016). Since steam turbines use steam to produce electricity independently from the heat source, the energy sources used to produce the steam can come from a variety of sources. In addition to solar power, geothermal, biomass, hydrogen and waste-to-energy power plants all promote the use of carbon-neutral steam turbines in production (EU turbines, 2023). Europe, in particular, has many initiatives dedicated to the promotion of carbon-neutral steam turbines, which have the potential to create greater cost-effective, more easily dispatchable and more environmentally beneficial carbon-neutral power. Steam power today has its roots in the steam turbine, first invented by Englishman, Thomas Newcomen in 1712, prior to the start of the Industrial Revolution. His simple single-piston pump was the first machine to effectively direct steam to produce work (Alberta Culture and Tourism, 2023). The use of Newcomen engines quickly spread all over England to pump out water which regularly flooded the coal mines, thus allowing coal mines to delve deeper into the ground, resulting in the ultimate expansion of England's coal industry (Alberta Culture and Tourism, 2023). Although the first commercially successful engine was the one invented by Thomas Newcomen, James Watt's new and improved steam engine likewise contributed to the kickstarting of the Industrial Revolution in England (Encyclopedia Britannica, 2023). Although the steam engine was used primarily in the cotton mill industry during this time, it was quickly adopted across multiple industries.

Newcomen's design was later modified by James Watt in 1765 to separate the condenser to avoid heating and cooling the cylinder with each stroke, which he achieved by creating a new engine, which rotated a shaft instead of providing the simple up-and-down motion of the pump (Encyclopedia Britannica, 2023). This invention gave way to steam turbines, which have gone on to exist even into our era. By the end of the late nineteenth century, steam engines would outpace the use of water and wind power sources, continuing to do so into the early decades of the twentieth century. Preceding the Industrial Revolution, the burning of traditional biomass, such as wood, crop waste, or charcoal, was the dominant source of energy across the world (Ritchie, Roser, and Rosado, 2022). These sources of energy would soon be replaced by coal, oil, and gas. The turn of the 20th century brought about yet another new energy-generating technology – hydropower. By the 1960s, nuclear power appeared. Finally, in the 1980s, solar and wind came into existence (Ritchie, Roser, and Rosado, 2022). Many of these forms of energy are used to power steam boilers required to generate today, with CO2 emitting coal, oil, gas, and biomass remaining the most widely used sources of energy during this process (EUTurbines, 2023). Although steam boilers can likewise be heated via more renewable resources, these energy sources tend to be used less frequently due to the associated added cost of use (Inspire Clean Energy, 2023). Although steam is not mentioned directly in Figure 4 below, which provides a visual representation of the timeline for the introduction of each of these resources, steqm serves as a cleaner source of energy than that of using oil or coal alone (Saraniero and Young, 2022). Steam started out being produced from coal, which gradually shifted to oil and natural gas. Nowadays, steam can be produced from more sustainable methods, like wind and solar. Figure 4 shows the ways in which renewable energy makes up only a sliver of energy being used today, meanwhile gas, oil, and natural gas nearly equally make up the largest parts of energy consumption today. Oil and natural gas are often considered as better alternatives to coal due to their cost effectiveness and relative cleanliness and are most widely used in the steam industry today.

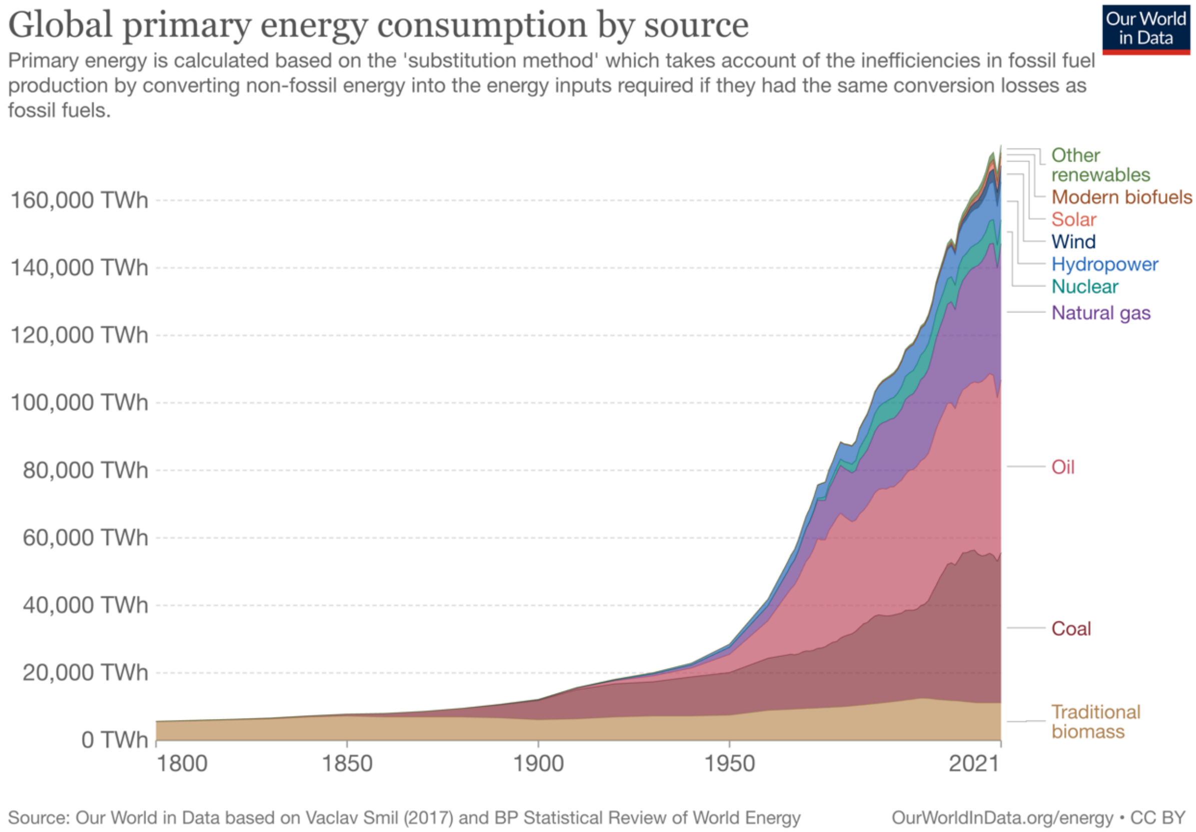

Figure 4: Energy consumption timeline (Ritchie, Roser, and Rosado, 2022).

2.1.2. Steam Boilers

Steam boilers are commonly used to generate steam required for steam turbines, and boilers can utilize a wide range of fuels, most commonly including natural gas, oil, coal, and biomass, while occasionally utilizing more sustainable methods of energy input, such as wind and solar. Steam turbines generate the majority of the world's electricity. In the US alone, steam turbines accounted for about 45% of U.S. electricity generation in 2021 (Environmental Impact Assessment, 2022).

In a traditional sense, a steam engine is a machine, which uses steam power to perform mechanical work through the agency of heat (steam engine summary, 2023). Steam engines have four basic parts. First, there is the boiler itself, which is often regarded as the heart of the steam system. It is a pressurized chamber heated by a system of burners, which most often tend to be gas-fueled. Next there is a steam distribution system, followed by a heat exchange system, and, finally, a condensation return system (Steam boilers, 2023).

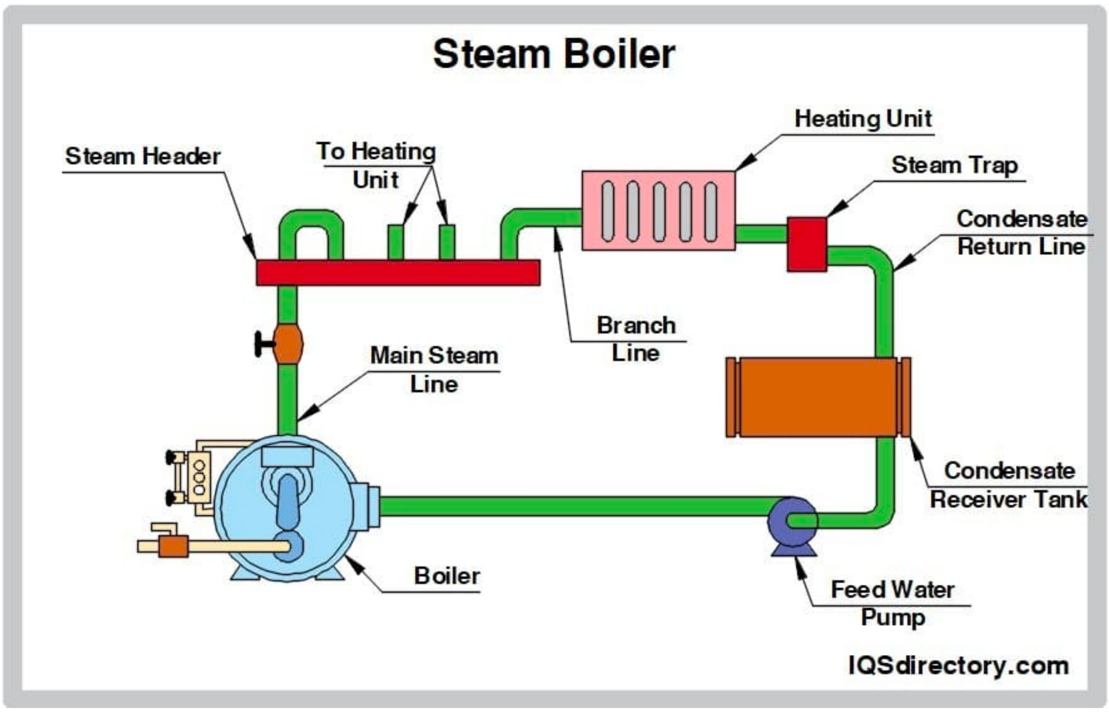

Figure 4: The above steam boiler diagram displays how fuel is burned to heat water, with the combination of heat and water producing steam (Steam boilers, 2023).

Hot steam supplied by the boiler expands under pressure with the resulting heat energy being converted into work. The remainder of the heat may escape. However, for maximum engine efficiency, the steam can be condensed in a condenser at a comparatively lower temperature and pressure. To promote higher efficiency, the temperature of the steam must substantially decrease as it expands within the engine. Therefore, the most efficient performance in which the greatest output of work is yielded relative to the amount of heat supplied is obtained by using a low condenser temperature and a high boiler pressure (steam engine summary, 2023). The steam may be further heated when it passes through a superheater when traveling from the boiler to the engine. An example of a common superheater design is one in which rows of parallel pipes have their surfaces exposed to the hot gases coming from the boiler furnace. The power of these superheaters enables the steam to be heated beyond the temperature at which it could be when merely boiling water (steam engine summary, 2023).

There are various types of steam boilers that exist today, including hot water boilers, electric boilers, gas boilers, low pressure boilers, high pressure boilers, oil boilers, water tube boilers, La Mont Boilers, Benson Boilers, Loeffler Boilers, fire tube boilers, and shell boilers. In addition, there are various ways to heat different boilers, including radiation, convection, and conduction (Steam boilers, 2023). Radiation uses electromagnetic waves. In a steam boiler, the tubes absorb radiant heat from the flame produced in the combustion chamber. Convection transfers the heat generated by a liquid of a gas and mixes it with a cooler liquid or gas, which in turns, heats the cooler liquid or gas, thus making the fluid lighter and less dense. Conduction occurs when heat is transferred from one surface to another through contact. “Conduction in a steam boiler takes place as the outer part of the tubing is heated, and the heat passes through to the inner part and to the cool water in the tube” (Steam boilers, 2023).

The variety of steam boilers can be attributed to the fuel sources used in the heating process, as well as the way in which the heating and cooling process occurs. Hot water boilers are tanks that transfer heat to water, which is then circulated for heating purposes. There are two types of hot water boilers – fire and water. The difference between them is determined by the way in which the tubes are heated. Fire tube hot water boilers have tubes immersed in water, whereas water tube boilers have water inside the tubes that circulate as the tubes are heated. As the name implies, electric boilers use electric elements to generate heat. This type of steam boiler is considered to be a faster, more efficient, and eco-friendlier heating method, as it does not necessitate the burning of fuel. “Electric boilers are longer lasting, require less cleaning, and are maintenance free” (Steam boilers, 2023). Furthermore, the efficiency of electric boilers is usually close to 99%, which is considerably higher than the 89%-95% range for even the most highly efficient condensing boilers (Greenmacth, 2023). While electric steam boilers may promote higher levels of environmentalism and be more efficient all around, CO2 emitting steam boilers tend to be used more for larger scale, industrial purposes, particularly because of their average lower costs. Gas steam boilers are powered by natural gas or propane and are still considered to be more efficient than standard boilers. Likewise, oil boilers operate similarly to gas boilers, where oil is ignited in the combustion chamber rather than gas. However, they can be more expensive than gas boilers, despite having a lifespan approximately twice that of gas boilers. Oil boilers have high efficacy rates, reaching over 90% efficiency. Other boilers include water tube boilers, which pass water through the tubes of the boiler, where fire is created in the combustion chamber and burns around the outside of the tubes, heating the tubes, and thus heating the water (Steam boilers, 2023). “La Mont, Benson, and Loeffler steam boilers use forced circulation and draught fans to produce large quantities of steam at high efficiency” (Steam boilers, 2023). Fire tube boilers work by heating the tubes of the boiler, after which the water circulates around the tubes. The heat inside the tubes is produced by gases heated by coal or oil (Steam boilers, 2023). Finally, shell boilers, also known as flue boilers, have their heat transfer surfaces enclosed in a shell that is usually made of steel. They have a long water tank configuration with fire tubes. Shell boilers are the simplest form of boiler that produces steam efficiently and economically (Steam boilers, 2023).

Although not every steam boiler is built the same since there are many different types of steam boilers, the basic elements of steam boilers include a burner, a combustion chamber, a heat exchanger, an expansion tank, a steam temperature control, a safety relief valve, a low water cutoff (Steam boilers, 2023). Industrial steam use can be applied in aquariums, laboratories, skyscrapers, power generation, and lumber kilns (Steam boilers, 2023). In addition, steam may be used in any large residence facilities, such as hospitals, prisons, campuses, or any other residence environment, which require temperature regulation.

2.1.3. The Modern-day US Steam Industry

Many industries and manufacturing processes use steam as a heat source and for cleaning and sterilization with the aim of producing steam efficiently to reduce water and energy consumption and save money (Hunter Water, 2023). Steam systems are commonly used today in manufacturing, food refining and meat processing, commercial laundries, hospitals, and the paper and cardboard manufacturing sectors. In some of these instances, steam systems can account for over half the total energy use (Hunter Water, 2023). Other industries that use steam include hospitals and healthcare facilities, universities and school campuses, breweries and distilleries, food and beverage processing plants, commercial laundry facilities, textile manufacturing facilities, and automotive manufacturing facilities (Eklind, 2020). Steam is used in also widely used in the space industry and is used to test space rocket engines (French, 2023). Steam creates the vacuum conditions experienced by the engines at launch, which was a method developed during the days of the Apollo Space Program in the 1960s and is still used today (French, 2023). In a more modern-day cube satellites, or mini satellites, that hop between extra-terrestrial objects, are propelled by steam (French, 2023).

In terms of determining US regions where steam energy is abundantly used, it may be beneficial to opt for densely populated region where the steam industry is already alive and well. To illustrate, it is a commonly known fact that New York is a city built on steam and with it being one of the largest cities in the US, this gives great evidence that steam isn't merely a relic of the past. Today New York has about 105 miles of steam pipes underneath its streets. "Some of New York City's most famous buildings are steam powered, including the Empire State Building, the Chrysler Building, Grand Central Terminal, the United Nations, Rockefeller Center (Saraniero and Young, 2022). Since heating water to create steam uses vast amounts of water and energy, producing steam as efficiently as possible can help reduce water and energy consumption and carbon pollution, thus reducing costs (Water quality management a multiple approach). In the 21st century most of the world's power is generated using steam, whether the fuel is coal, gas, geothermal, nuclear, or futuristic fusion reactors (French, 2023). The world's most advanced power plants still use a boiler, which heats water to make high pressure steam (French, 2023).

The leading US producer of steam boilers is Miura. On their company website, Miura very thoroughly describes the ways in which they meet customer needs and by what means their products service customers. In the example of college campuses, boilers are used on campus for heat and hot water, food preparation, and laundry (Miura America, 2022). The primary benefits of using such devices are that they start up quickly, cut fuel costs, create seamless operations, and leave a smaller environmental footprint (Eklind, 2020). Miura manufactures several different products, ranging in their ability to handle different pressure levels of steam. All products run off natural gas and propane. The Miura EX Boiler series also uses #2 fuel oil in addition to these fuel sources while simultaneously enjoying lower NOx ratings. The differences in these product offerings can be found in the charts below and are what can be used to help customers make decisions when choosing to invest in a boiler. In terms of considering the different industrial procedures that each of these boilers can support, the maximum pressures are included in the figures below. Where the first and last models support medium pressure, the high pressure naturally supports high pressure, at 300, whereas the standard and NOx boilers support 170. Furthermore, the efficiency of each of the models is around 85%, which is less than that of Elstor's technology, which claims 95% efficiency.

STANDARD PRESSURE

	UNIT	LX-50-12	LX-100-12	LX-150-07	LX-200-07	LX-250-16	LX-300-16
Utilization Horsepower	BHP	50	100	150	200	250	300
Maximum Pressure [1]	PSIG	170	170	170	170	170	170
Equivalent Output [2]	LB/HR	1,725	3,450	5,175	6,900	8,625	10,350
Heat Output	MMBTU/HR	1.674	3.348	5.002	6,695	8.369	10.043
Efficiency (fuel to stream) [3]		85%	85%	85%	85%	85%	87%
Operational Weight	LBS	4,600	6,600	8,800	8,800	12,700	12,600
Operational Water Content		45	60	95	95	135	130
Shipping Weight	LBS	4,200	6,000	8,000	8,000	11,500	11,500
Width	IN.	33 7/8"	33 7/8"	33 7/8"	33 7/8"	63"	63"
Length	IN.	96 7/8"	125 1/8"	138 3/4"	138 3/4"	157 7/8"	157 7/8"
Height	IN.	101 5/8"	110 3/4"	125 5/8"	125 5/8"	127"	127"
Power Supply		575,460,380,230, or 208V, 3 Phase, 60Hz	575,460,380,230, or 208V, 3 Phase, 60Hz	575,460,380,230, or 208V, 3 Phase, 60Hz	575,460,380,230, or 208V, 3 Phase, 60Hz	575,460,380,230, or 208V, 3 Phase, 60Hz	575,460,380,230, or 208V, 3 Phase, 60Hz
Fuel Type [4]		NG / LPG	NG / LPG	NG / LPG	NG / LPG	NG / LPG	NG / LPG
No. 2 Oil	GAL/HR						
Gas Supply Pressure	PSIG	3-5 PSIG	3-5 PSIG	3-5 PSIG	3-5 PSIG	3-5 PSIG	3-5 PSIG
Chimney Diameter (ID)	IN.	12" OD	12" OD	20" OD	20" OD	20" OD	20" OD

Figure 5. Standard Pressure (Miura America, 2022).

HIGH PRESSURE

	UNIT	LXH-200-07	LXH-250-16	LXH-300-16
Utilization Horsepower	BHP	200	250	300
Maximum Pressure [1]	PSIG	300	300	300
Equivalent Output [2]	LB/HR	6,900	8,625	10,350
Heat Output	MMBTU/HR	6.695	8.369	10.043
Efficiency (fuel to stream) [3]		84%	86%	86%
Operational Weight	LBS	9,100	13,000	13,000
Operational Water Content		100	140	140
Shipping Weight	LBS	8,200	11,800	11,800
Width	IN.	33 7/8"	63"	63"
Length	IN.	155 5/8"	156 1/4"	156 1/4"
Height	IN.	125 3/8"	127"	127"
Power Supply		575,460,380,230, or 208V, 3 Phase, 60Hz	575,460,380,230, or 208V, 3 Phase, 60Hz	575,460,380,230, or 208V, 3 Phase, 60Hz
Fuel Type [4]		NG / LPG	NG / LPG	NG /LPG
No. 2 Oil	GAL/HR			
Gas Supply Pressure	PSIG	3-5 PSIG	3-5 PSIG	3-5 PSIG
Chimney Diameter (ID)	IN.	20" OD	20" OD	20" OD

Figure 6. High Pressure (Miura America, 2022).

ULTRA LOW NOX

	UNIT	LX-100SGN-12	LX-150SGN-07	LX-200SGN-07	LX-250SGN-16	LX-300SGN-16
Utilization Horsepower	BHP	100	150	180	250	300
Maximum Pressure [1]	PSIG	170	170	170	170	170
Equivalent Output [2]	LB/HR	3,450	5,175	6,210	8,625	10,350
Heat Output	MMBTU/HR	3.348	5.022	6.026	8.369	10.043
Efficiency (fuel to stream) [3]		85%	85%	85%	87%	87%
Operational Weight	LBS	6,600	8,800	8,800	12,700	12,600
Operational Water Content		60	95	95	135	130
Shipping Weight	LBS	6,000	8,000	8,000	11500	11,500
Width	IN.	33 7/8"	33 7/8"	33 7/8"	63"	63"
Length	IN.	140 5/8"	154 3/4"	154 3/4"	157 7/8"	157 7/8"
Height	IN.	110 3/4"	125 5/8"	125 5/8"	127"	127"
Power Supply		575,460,380,230, or 208V, 3 Phase, 60Hz	575,460,380,230, or 208V, 3 Phase, 60Hz	575,460,380,230, or 208V, 3 Phase, 60Hz	575,460,380,230, or 208V, 3 Phase, 60Hz	575,460,380,230, or 208V, 3 Phase, 60Hz
Fuel Type [4]		NG / LPG	NG / LPG	NG / LPG	NG / LPG	NG / LPG
No. 2 Oil	GAL/HR					
Gas Supply Pressure	PSIG	3-5 PSIG	3-5 PSIG	3-5 PSIG	3-5 PSIG	3-5 PSIG
Chimney Diameter (ID)	IN.	12" OD	20" OD	20" OD	20" OD	20" OD

Figure 7. Ultra Low NOx (Miura America, 2022).

There are not too many companies like Miura operating in the US that are easy to find publicly available information on, which could ultimately point to a ripe opportunity for Elstor in a US market. Furthermore, steam is evidently still relevant and widely used in the US, particularly in places with a high population density, like New York or residency facilities.

2.1.4. Steam Calculations

According to one estimate, the average cost of steam in the US is $12.29 per 1,000 lbs (Paffel, 2013). The caveat to this number is that steam can easily be one to two and a half times the value of the unloaded steam cost. Regarding the measurement of steam, steam has a loaded and an unloaded cost. The unloaded cost accounts for only the cost of fuel necessary to produce steam with consideration towards the total steam used, whereas the loaded cost accounts for the combination of total costs associated with steam production. Costs which would make up the total of loaded steam costs include the unloaded cost of steam and costs associated with electrical power, chemical, water, and sewer; emission payments; labor (management, operations, and maintenance); waste disposal; maintenance; and new projects (Thermaxx Jackets, 2021).

One formula by which the cost of steam is estimated is as follows:

$$\textit{Total Steam Cost}\ (\$/MMBtu) = \textit{Fuel Cost}\ (\$/MMBtu) \times 130\% \quad (1)$$

Steam can be challenging to measure accurately. However, attempting to measure steam is of value to companies because it can make a difference in the evaluation of different energy, efficiency, and emission projects, thus leading to potential energy and cost savings (U.S. Department of Energy). The US Department of Energy offers a best practices guide for how to most accurately estimate the true cost of steam. The below two equations are from this guide, where the operating cost of the boiler is Co per hour and the process requires *S* pounds/hr (lb/h) of steam. Here *X* is a factor typically ranging from 5 to 20% (U.S. Department of Energy, 2023).

(a) generating cost C_G, \$/lb = $C_o /(1+X)S$

(b) consumption cost, C_G, \$/lb = C_o /S

These first two equations delineate between generation costs and consumption costs where generation costs are associated with efficiency and improvements. By comparison, consumption costs are related to the cost of process observation and rather than making the steam use more efficient, it seeks to conserve the use of steam altogether (U.S. Department of Energy, 2023).

When it comes to calculating the generation cost of steam, this part is relatively straightforward in that it involves adding all the different factors contributing to price together. Calculating the cost of generating steam includes the total variable cost of raising steam, as shown in the following equation and expressed per thousand pounds (\$/Klb).

$$C_G = C_F + C_W + C_{BFW} + C_P + C_A + C_B + C_D + C_E + C_M \quad (2)$$

Fuel cost is usually the dominant component, accounting for as much as 90% of the total. The equation to calculate this specific component is as follows:

$$C_F = a_F \times (H_s - h_w)/1000/\eta_B$$

a_F = fuel cost, (\$/*MMBtu*)

H_s = ethalpy of steam, *Btu*/lb

h_w = enthalpy of boiler feedwater, *Btu*/lb

η_B = overall boiler efficiency, fractional

Since fuel costs associated with steam production comprise such a high total amount of steam costing, fuel pricing would be one of the most influential components in terms of calculating the true steam cost. The below table is an example of a steam cost calculation, whereby different components are considered in the overall steam cost. To the point of the fuel source being the most expensive component, the fuel here very clearly accounts for the majority of the operating costs, where it is responsible for 6.70 out of 7.06, which is the summed total fuel cost.

Assumptions/Basis:

Required Power	8.32 MW	
Generated Power	7.80 MW (includes direct mechanical drives)	BD = Blowdown
Full Rate Operation	7680 h/yr	ST = Steam Turbine
Total Boiler Duty	370.8 MMBtu/h	
Gas Heating Value	1020 Btu/cubic foot	

	Psig	Klb/h	Comments
Process Steam Demand	200	15.6	
	80	13.3	
	12	250.5	
Parasitic Steam Demand	300	1.7	Sootblowing and losses
	12	21.3	Deaerator
	12	-5.4	BD flash vapor recovery
Total Steam Generation Required:	**300**	**297**	

Operating Costs:

	Quantity	Unit Cost, $ @	Unit	MM$/yr
Gas (fuel)	363.6 KCF/h	2.40	KCF	6.70
Purchased Power	0.52 MW	61.0	MWH	0.24
Softened Water	246.4 gpm	1.00	Kgal	0.11
Wastewater	47.4 gpm	0.25	Kgal	0.01
			Total	**7.06**

Operating Policy and Constraints

1. Boilers #1 through 6, capacity limits: Minimum = 30% of design
   Preferred Rate = 85% of design
   Maximum safe = 95% of design
2. Boiler #7 is operated independently of others; direct coupled to Steam Turbine #1 (steam demand for ST#1 depends on compressor load)
3. Steam flow capacity constraints on turbogenerators ST #2 and #3:

	Min	Max	
ST#2	20	60	Klb/h
ST#3	40	120	

Figure 8. Steam cost calculation table (U.S. Department of Energy, 2023).

The pressure of the steam can likewise contribute to the total cost, as there is a distinct correlation between the amount of steam pressure and the steam cost. Figure 9 below clearly depicts this correlation.

Steam, Klb/h Low-pressure to process	Total	Op Rate, % of cap Coal Boilers	Boiler #1	Steam Flow, Klb/h Turbo-generator #2	Turbo-generator #3	PRV Flow Klb/h	Cost MM$/yr	Δ(Cost) MM$/yr	Δ(Low-pressure steam) Klb/h	Steam Cost $/Klb
152.8	194	43	30	20	40	2.6	6.3	—	—	1.18
152.9										1.18
219.2	264	80	30	20	110	2.6	6.9	0.60	66.4	1.18
219.3										1.01
226.9	272	85	30	28	110	2.6	7.0	0.06	7.7	1.01
227.0										2.21
257.0	304	85	83	60	110	2.6	7.5	0.51	30.1	2.21
257.1										3.85
266.8	314	85	100	60	110	12.9	7.8	0.29	9.8	3.85
266.9										2.96
280.0	328	93	100	60	110	26.8	8.1	0.30	13.2	2.96

Figure 9. Results of Perturbation Analysis for Marginal Cost of Low-Pressure Steam (U.S. Department of Energy, 2023).

Since the steam pressure affects the cost of steam, different calculations must be made depending on the pressure of the steam. Figure 10 similarly depicts the cost to pressure correlation, but also marks a normal operating point for the given project in question in this example.

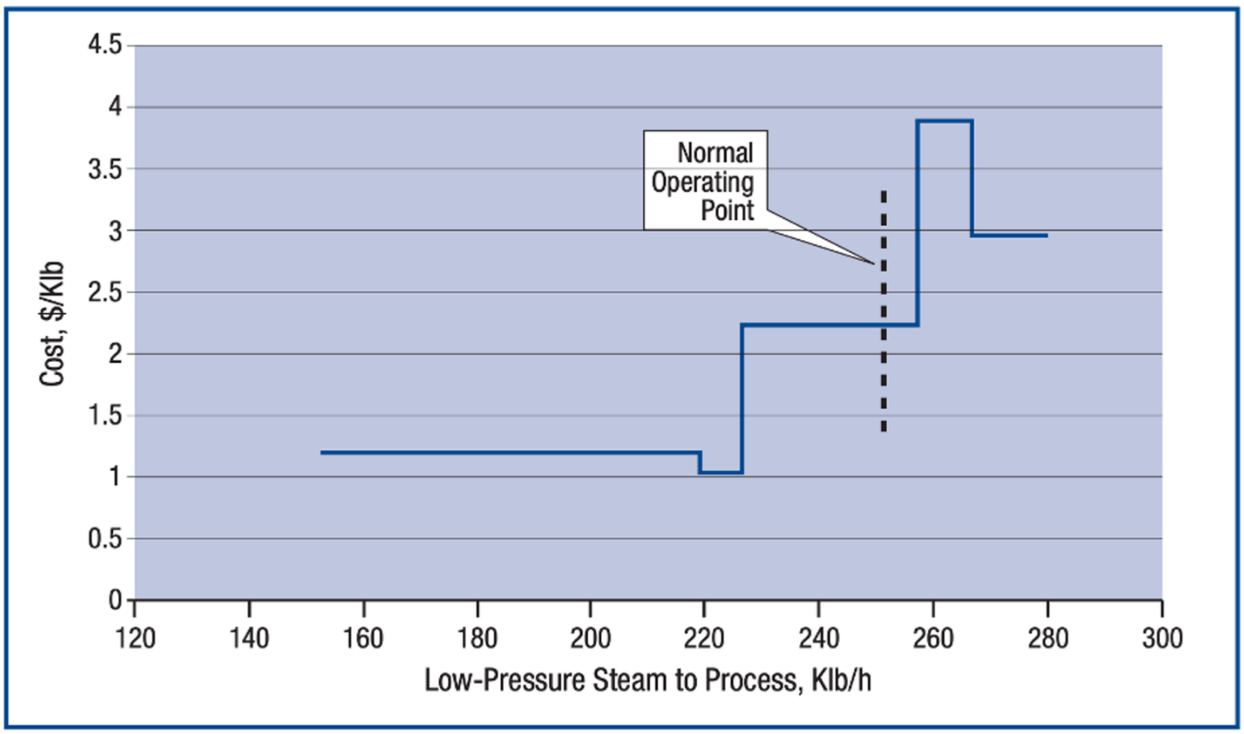

Figure 10. Low-pressure steam cost (U.S. Department of Energy, 2023).

Calculating the cost of steam in the US is not as straightforward as calculating the cost of steam in Finland due to the fluctuations in energy prices varying by region and the cost of oil and gas being heavily tied to US steam production. Since delving into the cost of steam in a US market requires a targeted approach towards a given US state or region, the purpose of this overview will be to depict the theoretical ways in which steam prices can be calculated, given relevant pricing data.

Steam prices generally consist of a market price, transfer price, and tax price. Market prices in the US will vary by state and regional locations rather than being standardized, regardless of location, the way they are in Finland. These prices are generally more expensive in the more densely populated regions, such as the northeast and California. The below table depicts the state market prices for electricity for a few different states, since electricity is involved in the cost of steam, at least in the case of Elstor's technology.

STATE	Sep 2021	Sep 2020
New York	**19.30¢ / kWh**	18.76¢ / kWh
North Carolina	11.24¢ / kWh	11.07¢ / kWh
North Dakota	12.07¢ / kWh	12.34¢ / kWh
Ohio	12.64¢ / kWh	12.67¢ / kWh

Figure 11. US electricity market price (Electric Choice).

The net component of the steam price, the transfer price, requires a calculation. "The equation used to establish the amount of heat required to raise the temperature of a substance can be developed to apply to a range of heat transfer processes" (U.S. Department of Energy, 2023).

The equation is:

$$Q = m\, c_P\, \Delta T \quad (3)$$

Where:

Q = Quantity of energy (kJ)

m = Mass of the substance (kg)

C_P = Specific heat capacity of the substance (kJ/kg °C)

ΔT = Temperature of the substance (°C)

The steam transfer price will vary depending on what level of steam is being used, or, in other words, where along the spectrum of low to high pressure the steam is. The third and final component is the tax price. Tax prices, like market prices, vary highly by location, even within states. Figures 12 and 13 below depict different energy tax rates and how they vary based on different counties, or municipalities, within a given state. Although these rates are for residential energy use tax rates, ranging from as low as 2% up to 7%, with many numbers in between, these rates portray the way in which US regional factors heavily into energy rate discrepancies.

Part 1 – Jurisdictions that tax residential gas, propane (100 pounds or more), electricity, and steam

Taxing jurisdiction (county names added for clarification)	**Tax rate %**
Albany School District *(Albany County)*	3
Cohoes School District *(Albany County)*	3
Watervliet School District *(Albany County)*	3
Allegany County	4½
Cattaraugus County (outside the following)	3
Olean (city)	3
Salamanca (city)	3
Auburn (city) *(Cayuga County)*	2
Chemung County	4
Norwich (city) *(Chenango County)*	3
Hudson School District *(Columbia County)*	3
Cortland County	4
Poughkeepsie School District *(Dutchess County)*	3
Erie County (outside the following)	4¾
Lackawanna School District	7¾
Franklin County	2
Gloversville School District *(Fulton County)*	3
Johnstown School District *(Fulton County)*	3
Batavia School District *(Genesee County)*	3
Watertown School District *(Jefferson County)*	3
Oneida (city) *(Madison County)*	2
Johnstown School District *(Montgomery County)*	3
Glen Cove School District *(Nassau County)*	3
Long Beach School District *(Nassau County)*	3
Niagara County (outside the following)	4
Lockport (city)	4
Niagara Falls School District	7
Utica School District *(Oneida County)*	3
Middletown School District *(Orange County)*	3

Taxing jurisdiction (county names added for clarification)	**Tax rate %**
Newburgh School District (outside city) *(Orange County)*	3
Newburgh School District (inside city) *(Orange County)*	6
Port Jervis (city) *(Orange County)*	3
Orleans County	4
Oswego (city) *(Oswego County)*	4
Rensselaer School District *(Rensselaer County)*	3
Troy School District *(Rensselaer County)*	3
Schenectady County (outside the following)	4
Schenectady School District	7
Hornell School District *(Steuben County)*	2½
St. Lawrence County (outside the following)	4
Ogdensburg School District (outside city)	7
Ogdensburg School District (inside city)	7
Suffolk County	2½
Tioga County	3
Tompkins County (outside the following)	4
Ithaca (city)	4
Westchester County (outside the following)	***4***
Mount Vernon School District (outside city)	***7***
Mount Vernon School District (inside city)	***7***
New Rochelle School District	***6***
Peekskill School District	***7***
Rye City School District	***7***
White Plains School District	***6***
Yonkers (city)	***4½***
New York City	4½

Figure 12. Taxes on residential gas, propane, electricity, and steam (New York State).

Part 2 – Jurisdictions that tax residential coal, fuel oil, and wood (for heating)

Taxing jurisdiction (county names added for clarification)	**Tax rate %**
Allegany County	4½
Cattaraugus County (outside the following)	3
Olean (city)	3
Salamanca (city)	3
Auburn (city) *(Cayuga County)*	2
Chemung County	4
Norwich (city) *(Chenango County)*	3
Cortland County	4
Erie County	4¾
Franklin County	2
Oneida (city) *(Madison County)*	2
Niagara County	4
Orleans County	4
Oswego (city) *(Oswego County)*	4
Schenectady County	4
St. Lawrence County (outside the following)	4
Ogdensburg (city)	4
Suffolk County	2½
Tioga County	3
Tompkins County (outside the following)	4
Ithaca (city)	4
Westchester County (outside the following)	***4***
Mount Vernon (city)	***4***
New Rochelle (city)	***3***
Yonkers (city)	***4½***
New York City	4½

Figure 13. Taxes on coal, fuel, oil, and wood (New York State, 2023).

Since the market price, the transfer price, and the tax price all contribute to the total cost of steam in Finland, comparing the ways in which these prices differ in a US market could theoretically assist in calculating estimates for more accurate steam prices in a US market context. As is the case with Finnish electricity prices, which do not vary by region, it is important to consider that nearly all US energy prices vary by region, with prices typically being higher the more densely populated an area is.

2.2.The US Electricity Market

In a broad sense, the electricity market facilitates the exchange of electricity-related goods and services. Similar to how the stock market is affected by external factors, which result in price volatility, the electricity market likewise experiences price fluctuations related to changes in demands for commodities, like natural gas. In addition, electricity prices are influenced by the cost to build, finance, maintain, and operate power plants and the electricity grid (Energy Price

Increases: How Does Electricity Pricing Work? 2023). As a result, electricity prices generally include both a use price and a transfer price.

Other factors, such as time of day and region can affect the cost of electricity at any given time. Pricing models can be broken down by units of time, such as minutes or hours. Electricity pricing is likewise determined by the buyers as different pricing structures exist for each type of customer. An example of a unit price for each customer can be seen in the figure below.

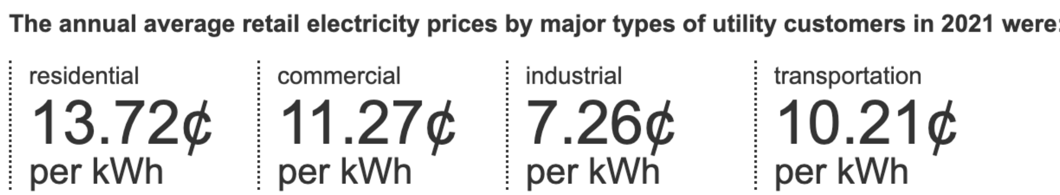

Figure 14. Energy prices by customer (U.S. Energy Information Administration, 2023).

Large scale customers, such as industrial use customers, receive lower rates than residential customers. This practice follows a typical economies of scale model, where customers who are purchasing electricity in greater quantities are given lower per unit rates. Within the US, electricity prices are likewise determined by the region. As aforementioned, the electricity market is affected by various supply and demand factors, meaning that in places where the demand is higher, the electricity prices will naturally follow suit and be higher as well. For example, since the northeast is one of the densest regions of the United States in terms of population, the demand for electricity in this region is increased and, therefore, the price of electricity will be higher. There are two different systems by which the US electricity market is broken up, including RTOs (Regional Transmission Organizations), which are also known as ISOs (Independent System Operators) and non-RTO regions. As regards RTOs and ISOs, there are seven regional transmission pools with wholesale electricity markets within the US, as depicted in Figure 15.

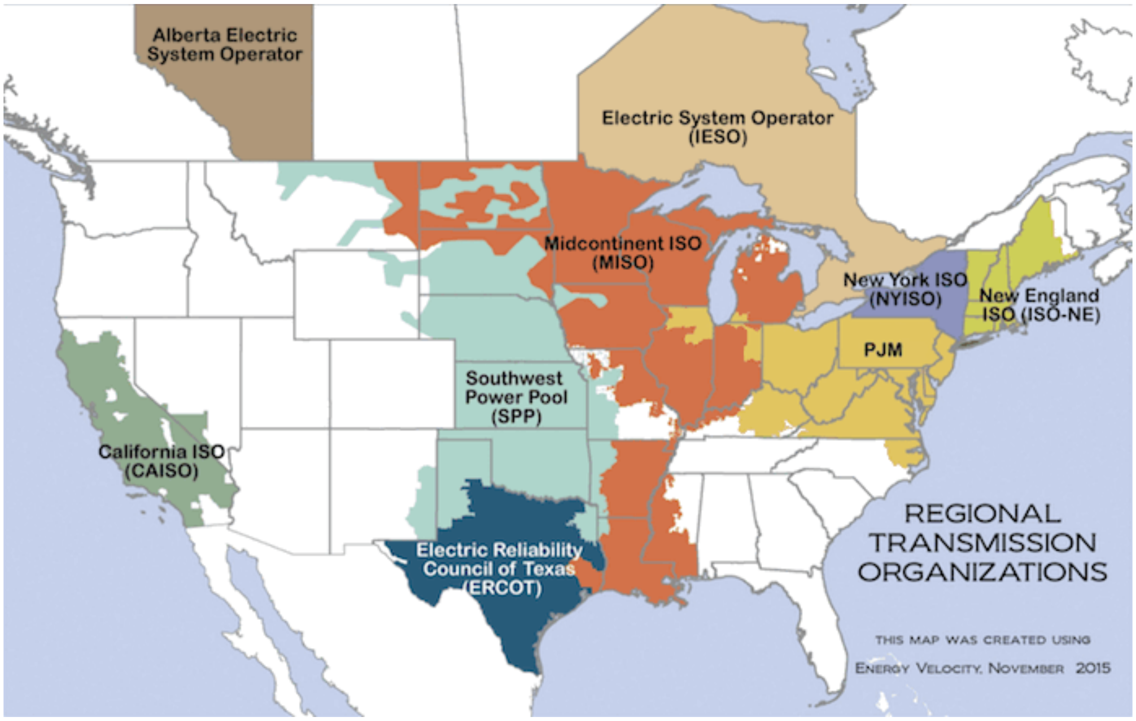

Figure 15. Regional Transmission Organizations (RTOs) (U.S. Electricity System, 2023).

An ISO/RTO does not own the transmission or generation assets it manages (U.S. Electricity System, 2023). Some RTOs have retail-level competition and consumer choice of electricity providers. Meanwhile, each ISO has its own FERC, or Federal Energy Regulatory Commission, approved governance structure.

The purpose of RTOs is to assure that there is non-discriminatory open access to transmission. They allow for forecasts and schedules, dispatching generation to meet predicted demand. They manage the interconnection of new electricity generation. They administer the region's competitive wholesale electricity markets, monitor the fairness and neutrality of markets for all participants, and provide reliability planning for the bulk of the entire electricity system (U.S. Electricity System, 2023). Therefore, ISO/RTOs serve as regulatory structures to promote a free, but fair electricity market for both consumers and suppliers.

In addition to ISO/RTO's, there are also non-RTO regions, which are operated by many individual regulated monopoly utilities (U.S Electricity System, 2023). In Figure 16 below, the non-RTO regions are the Southwest (marked in orange), the Northwest (gray), and the Southeast (brown), which are all federally operated by many individual vertically integrated utilities, where these utilities have been granted monopoly status over "ratepayers" in their territory and are regulated
by state Public Utility Commissions (PUCs or PSCs) (U.S. Electricity System, 2023). "Although these utilities don't participate in wholesale power markets, they must still comply with open transmission access" (U.S. Electricity System, 2023). However, since they retain control over their transmission system, this can lead to preferential treatment for their own generation over more affordable, cleaner, or local generation from competitive suppliers and marketers (U.S. Electricity System, 2023).

Figure 16. ISO/RTOs and non-RTO regions (U.S. Electricity System, 2023).

Understanding the concept of regulated versus deregulated electricity markets can help Elstor make a more informed decision about which regional market segment of the US it would like to attempt to penetrate with its technology. For example, since ISO/RTOs promote free and fair trade, it may be wise to consider US regions which have these types of electricity market structures in place.

Most electricity customers are served by utilities that are owned by investors and can be either regulated and operated as vertically integrated monopolies with oversight from public utility commissions or deregulated whereby electric energy prices are set by the market with some federal

oversight of wholesale market operations (Resources for the Future, 2023). Regulated, or vertically integrated, means the utilities own the electricity generators and power lines, used for distribution and transmission. "Today, only one third of US electricity demand is serviced by these integrated utility markets because many states have abandoned this system in favor of deregulation" (Resources for the Future, 2023). The purpose of deregulation has been to create competition and lower costs. As a result of deregulation, regional transmission organizations (RTOs) replaced utilities as grid operators and became the operators of wholesale markets for electricity (Resources for the Future, 2023). "RTOs typically run three kinds of markets that determine wholesale prices for these services: energy markets, capacity markets, and ancillary services markets" (Resources for the Future, 2023). Therefore, as a newly emerging business attempting to be competitive in the market, entering the market in a state that has deregulated utilities may offer the best business prospects due to the ability to compete in multiple different markets. One consideration, however, is that with some state having policies shifting towards the promotion of cleaner renewable sources of energy, like wind and solar power, complications may arise with the existing wholesale market structure in deregulated states as renewable generators become a larger portion of the grid's resources (Resources for the Future, 2023). Since renewables do not require fuel inputs to run, low bid costs could begin to significantly reduce wholesale prices for energy and capacity and discourage long-term investment for all resources. Therefore, there is the potential that the wholesale markets will gradually begin changing their structure to accommodate different types of resources in the future (Resources for the Future, 2023).

2.2.1. Electricity Pricing in Finland vs. the United States

With electricity pricing being one of the research tasks related to this thesis, electricity pricing which is publicly available and easily accessible will be considered in this section to depict the ways in which the electricity market in the US functions differently than that which exists in Finland. Thus, US electricity prices will be determined and subsequently compared with those in Finland. Electricity prices fluctuations during a 24-hour period for both the US and Finland will be graphed and shown. Finally, a brief comparison between electricity prices with those of oil and gas will be touched upon.

Since one of the primary benefits of Elstor's technology is storing electricity prices when prices are low, later releasing them on-demand when prices are high, one way to determine where in the US this technology could prove beneficial is by considering the electricity prices in different US regions. As has been mentioned, in Finland, electricity prices are the same regardless of the region. In fact, Finland has a total of 77 distribution network companies responsible for electricity distribution to customers, but regulation is used to ensure that electricity distribution prices are reasonable, and that the electricity distribution business remains efficient (Caruna, 2023). In this way, Finnish electricity distribution is operated by way of a natural monopoly, by which the operators are regulated by the Energy Authority under the Ministry of Economic Affairs and Employment (Caruna, 2023). The Finnish government has enacted the Electricity Market Act and the Act on Electricity and Gas Market Regulation to regulate the operations of electricity distribution companies. The Finnish Energy Authority, under the Ministry of Economic Affairs and Employment, has been deemed the regulator in this model.

Figures 17 through 19 display Finnish electricity prices. The first two figures have been calculated by Elstor and depict average spot prices in Finland, based on price history data from by Nord Pool, the leading power market in Europe, offering day-ahead and intraday markets to customers (Nord Pool, 2023.) Spot electricity prices are a market price determined by the supply and demand for electricity exchanges (True Energy, 2023). The spot pricing market is important to Elstor, because it is related to the reserve market, which is what Elstor uses to charge the component of its technology that functions as an energy storage device to store when prices are low and release electricity on demand when prices are high.

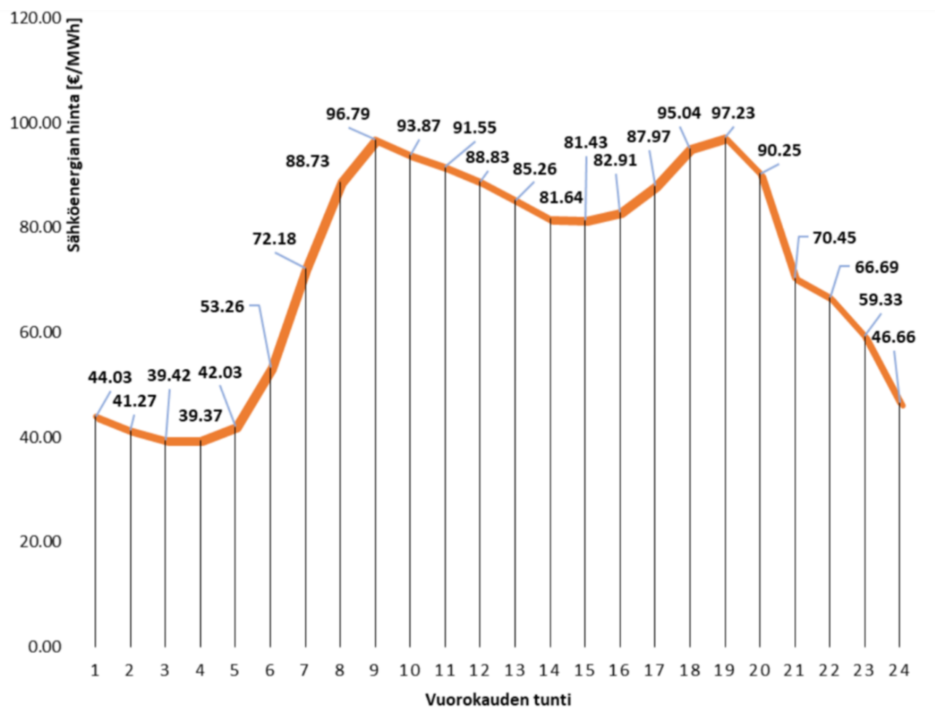

Figure 17. Average spot Finland regional prices for 2021 (Elstor, 2023).

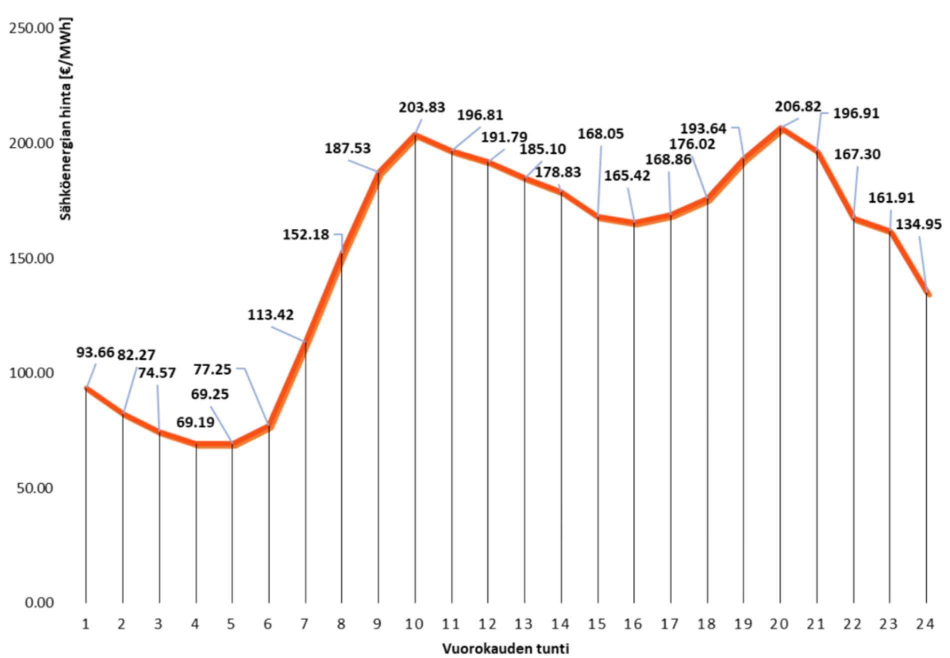

Figure 18. Average spot Finland regional prices for 2022 (Elstor, 2023).

The Figure 19 chart below, taken from Herrfors, a Finnish electricity company, shows the 24-hour cycle for price changes within a given day, using spot prices (Nykyiset spot-hinnat, 2023). Figure 19 shows that the electricity prices are higher during certain hours, which are the hours with an increased demand. Herrfors, the company recording these statistics, services both residential clients and corporate customers. Therefore, if considered from the residential perspective, clients are at home and using electricity most often during the morning hours and in the evening. Since corporate clients would also be using electricity in the morning, it can logically be deduced that between these two customer segments, overall prices would be highest in the morning. Accordingly, for the time-of-day electricity reading, 60% of the electricity consumption happens during the day and 40% during the night (True Energy, 2023).

Figure 19. By-the-hour electricity prices in Finland, VAT excluded (True Energy, 2023).

These electricity prices are based on the hourly rate of Nord Pool Spot Finland. At the time that this thesis is being published, Herrfors has its margin published at 0.400 for cost per kilowatt hour, which is a cost that gets added on to comprise the total electricity price. The average energy fee is 18.65 cents per kilowatt hour. The general fee is 2.03€ per month. The bill shows an average monthly price and the amount of energy consumed. The invoice breaks down the pricing by the price of the energy itself, the share of the margin, and the basic payment of the contract. Figure 19 above shows electricity prices, excluding VAT, while Figure 20 below includes it. The current VAT tax during the time that this is being published is 24% (True Energy, 2023). However, between December 1, 2022, and April 30, 2023, the VAT was only 10%, as part of an effort to alleviate the pressure brought on by inflation and rising energy costs due to the Russia-Ukraine conflict (Yle, 2022). This effort alone highlights one of the primary ways in which the Finnish market operates fundamentally differently than the US market in that the Finnish market is fully governmentally regulated, whereas the US market is broken down and regulated by region, rather than nationwide. Although Finland's electricity prices are governmentally regulated, the market still treats electricity as a commodity that is bought and sold, thus affecting the price as a direct function of supply and demand. Furthermore, different market factors that affect the electricity price can be weather, water conditions, disturbances in the production or distribution of electricity, and the global political climate (True Energy, 2023).

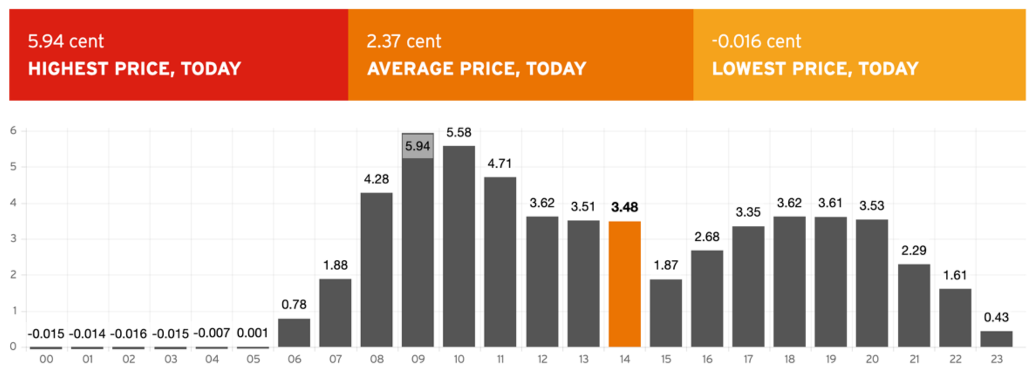

Figure 20. By-the-hour electricity prices in Finland, VAT included (True Energy, 2023).

In the US, there tends to be a correlation between population density and the price of electricity whereby in the states and regions where the population is denser, the price is higher. For context, Figure 21 below depicts the areas of the US where the population is denser, with the northeast, California, and Florida being the most notably dense areas, whereas the Midwest is much more sparsely populated.

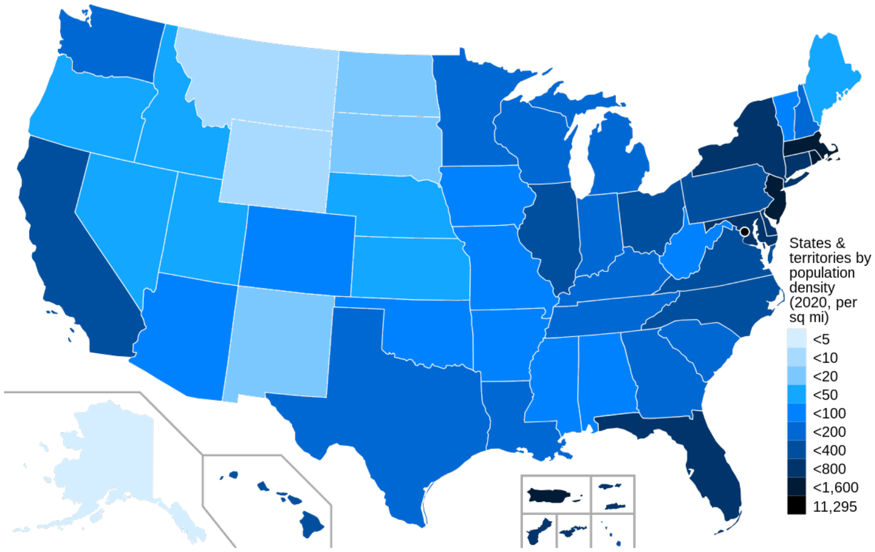

Figure 21. Population density map (Wikipedia, 2023).

Since greater demand means higher prices, more densely populated areas having higher prices is logical. Likewise, as discussed earlier, prices are also dependent on who the consumer is, with businesses usually receiving lower prices, whereas residential users are charged higher prices. Figures 22 and 23 below charts depict energy rates by state for both residential and business customers.

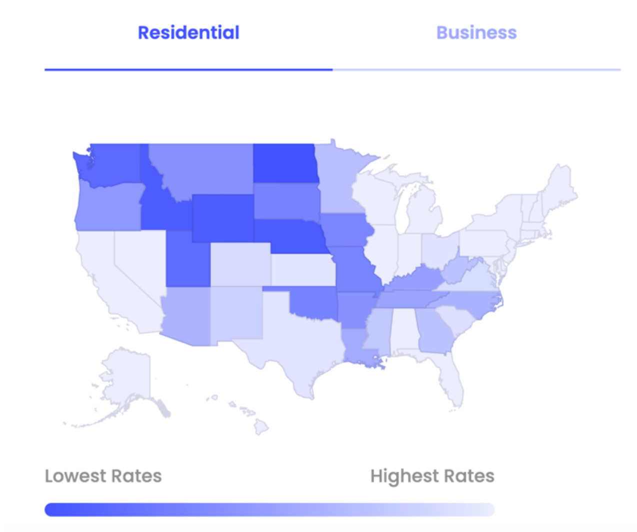

Figure 22. Electricity cost per kWh by state map for residential (EnergyBot, 2023).

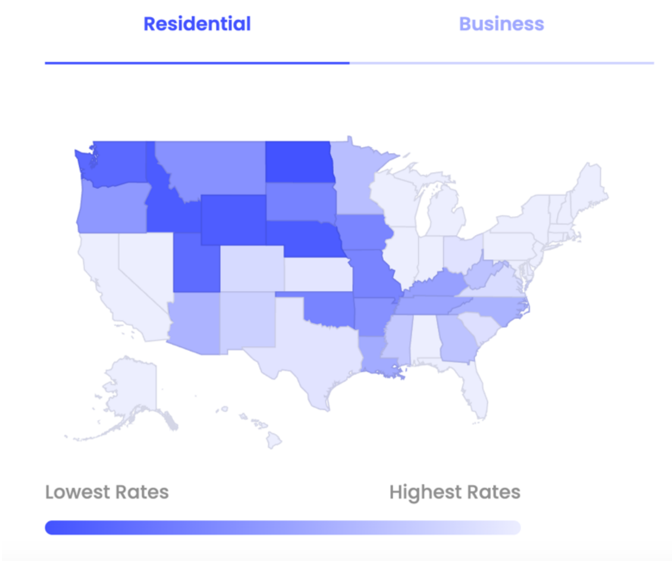

Figure 23. Electricity cost per kWh by state map for business (EnergyBot, 2023).

As can be seen from both heat maps, and despite some minor differences between residential and business pricing, it is evident that the lowest rates exist in the most sparsely populated areas. According to the source that publishes these charts, the average electricity rate in the U.S. is 10.42 cents per kilowatt-hour. Meanwhile, Hawaii has the highest average electricity rate of 30.55 cents per kilowatt-hour and Louisiana has the lowest average electricity rate of 7.01cents per kilowatt-hour (EnergyBot, 2023). Other reasons why electricity prices vary by state are the load factor, which companies and individuals have some control over, versus the types of energy generation in the state of operation and their accessibility (EnergyBot, 2023). In terms of load, the time of day that energy is being used is important. Energy suppliers use models to forecast demand throughout the day. Therefore, if more energy is being used at a time when demand is high, the cost of electricity to the supplier is more, thus driving up the cost paid by the consumer. Another factor that is somewhat unique to the United States market pertains to climate control and the subsequent use of air conditioning. The United States consumes more energy for air conditioning than any other country in the world (Noack, 2021). This stands in stark contrast to Europe, where most Europeans have grown up without any air-conditioning. Another key difference is that while Americans like to have their thermostats set at the same temperature all year, Europeans tend to set their thermostats higher in summer and lower in winter (Noack, 2021). Furthermore, Europeans on average, tend to be more sensitive to global climate change issues by comparison to Americans. “Cooling uses much more energy than heating, which is why many Europeans prefer sweating for a few days over continuously suffering under the effects of global warming in the future” (Noack, 2021). Another issue is that Europe is situated more northern than the US. Therefore, “the U.S. is somewhat unusual in being a wealthy nation much of whose population lives in very warm, humid regions” (Noack, 2021). The combination of these factors, however, creates a synergistic effect in terms of electricity use being high for the purpose of climate control in the US. For this reason, the time of year affects electricity prices. For example, in Southern states, summer rates can be higher than winter rates due to higher energy demand for cooling system, and vice versa for heating in cold northern states during winter (EnergyBot, 2023). US locations are important in determining electricity pricing not only based on climate and population, but also as related to the type of state. Energy rates vary from state to state and among utility areas in the same state, regardless of whether the state allows for energy choice, or, in other words, are deregulated. As mentioned above, the US is broken down by different regions for electricity servicing. Similarly, there are regulated and deregulated states, where regulated states have a lower average rate overall vs those with energy choice. To illustrate, Texas, a deregulated state, traditionally has had some of the lowest energy rates in the country (EnergyBot, 2023). Meanwhile, the northeast, where the demand, population density, and cost of living is high, has some of the highest rates in the country, both before deregulation and after. Lower rates are offered in the central states, where there the markets are regulated, and both the demand and cost of living of living are lower (EnergyBot, 2023). Therefore, states with energy choice, or that are deregulated, afford customers the ability to lower their electric bill by shopping around for better suppliers and rates.

Although it is evident that US prices, too, fluctuate on an hourly basis, the rates of these fluctuations are less publicly accessible than those types of per hour prices are in Finland. For example, monthly US electricity prices are publicly available and much more readily accessible. Figure 24 below details average energy prices for the United States regions, based on information on census divisions and selected metropolitan areas from statistics published by the U.S. Bureau of Labor Statistics. The differences in price per region can be clearly seen. The original data provided from the bureau is broken down by each area and smaller subsets. The four overarching regions are the Northeast, Midwest, South, and West. The Northeast includes New England and the Mid Atlantic. The Midwest includes East North Central and West North

Central. The South includes South Atlantic, East South Central, and West South Central. The West includes Mountain and Pacific (U.S. Bureau of Labor Statistics, 2023). Figure 24 is broken up by each of these smaller regions since these subdivided regions are arguably the most pertinent when considering electricity prices.

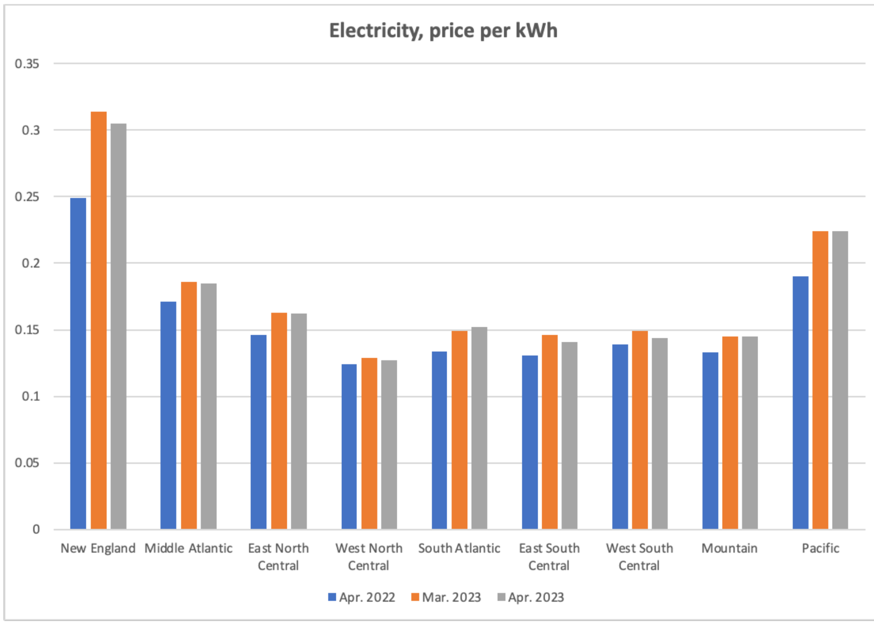

Figure 24. Monthly US average prices for electricity broken down by region.

In terms of population, it was already mentioned that the northeast is the most densely populated state. The northeast here includes New England and the Mid Atlantic, but New England is considerably more expensive than the Mid Atlantic. The Pacific, which includes the cities of the metropolitan areas of Los Angeles, Riverside, San Diego, San Francisco, Seattle, Urban Alaska, and Urban Hawaii is the runner up in terms of priciness. This is also fitting since Hawaii has the highest price of electricity in all the country. However, the general trend is that New England's electricity prices tend to be approximately double that of the remaining regions. When compared to Finland, however, and not considering the dollar to euro rate and its fluctuations, these prices are all cheaper than the VAT included estimates for Finnish daily prices as seen above, which stand at 5.94 cents. Meanwhile, the VAT excluded price for Finland stands at 3.56 cents, which is still more expensive than the US.

When discussing oil and gas versus electricity, the topic of electric vehicles (EV's) inevitably arises. Therefore, when considering the price of electricity versus that of gas and oil, EV's are a natural starting point. The infographic in Figure 25 below depicts the prices of gasoline versus the price required to power EV's, with the price per gallon of EV's versus gasoline-powered cars being up to more than one-fourth less. The concept of the electrification movement and the push towards going electric with more than simply electric vehicles will be discussed further in the research interview section.

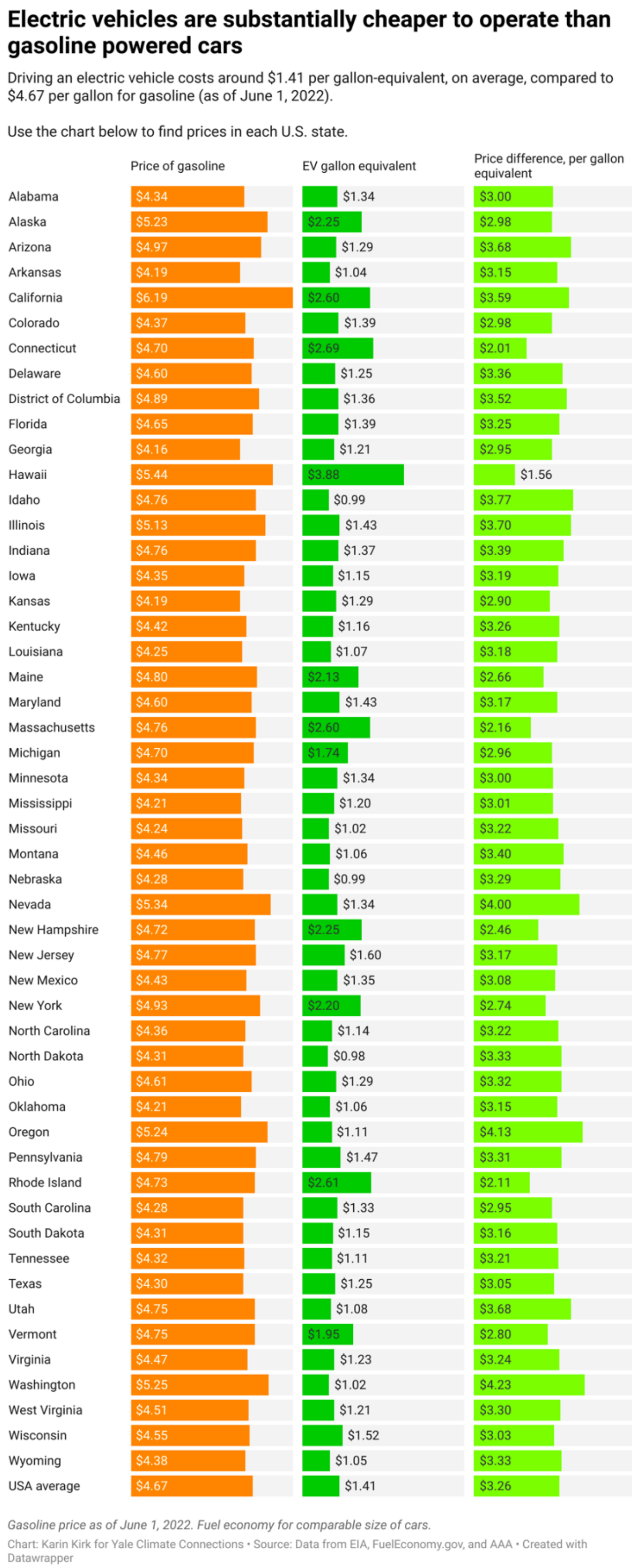

Figure 25. The price of gas versus the cost of using electric vehicles (Kirk, 2022).

When comparing the prices of oil versus electricity, it is important to consider that electricity prices tend to be stable over time since rates are regulated by each state's public utilities commission, whereas the price of oil fluctuates rapidly, driven by global pricing, geopolitics, refining capacity, and other market forces (Kirk, 2022). Therefore, bringing the discussion back to Finland and Finnish politics, it is natural that given Finland's geopolitical disposition, electric alternatives may be more attractive given the volatile gas and oil prices brought on by Russia. In the instance of EV's in Finland, Finland ranks among the top five European countries with the highest percentage of new electric cars behind its Nordic counterparts, Sweden, Norway, Denmark, and Iceland (Bello, 2023). Although EV's and EV charging is not necessarily part of Elstor's target market, as further research will indicate, EV's could spell out a ripe market opportunity, at least in the US context.

2.3.The Reserve Market

Electricity markets are designed to meet consumer needs on demand. However, because electricity must come from a supply that cannot be stored in the network itself, the supply must come from a type of intermediary, or market. For instance, as regards electricity, there are capacity markets and reserve markets. Where a capacity market ensures there is enough capacity to meet demand, a reserve market ensures that enough capacity is available to be called upon at a given time (Mujeeb, 2021). Capacity markets are designed to meet the potential peak demand with enough installed capacity. Meanwhile, reserve markets are designed to create a greater balance between supply and demand to be delivered more readily with less advanced notice. Since electricity demands can never be predicted with complete accuracy, reserve markets require some margin of error in these demand predictions. Where the capacity market considers overall installed capacity, measured in megawatts (MW), the reserve market is measured in megawatts per minute (MW/min), which denotes the possible change in input.

The purpose of the reserve market is to intervene and either increase or decrease production where realized demand is higher or lower than forecasted demand (Mujeeb, 2021). This type of electricity market is widespread in Finland and the Nordics in a way that it is not as visibly present in the US. For example, Fingrid Oyj is a Finnish national electricity transmission grid operator that maintains an electricity reserve market with the goal of balancing electricity consumption and production. Fingrid promotes energy cost savings for clients by providing flexible consumption, production, and energy storage through said reserve markets. Fingrid currently operates a joint Nordic grid system between Finland, Sweden, Norway, and East Denmark under the System Operation Agreement between the Nordic Transmission System Operators (TSOs) (Fingrid, 2017). Fingird plans to expand its grids with cross-border connections into continental Europe in coming years. Given this prospect, this could spell out greater opportunities for companies like Elstor to continue taking advantage of this grid control system, thus promoting cost savings for customers.

In the same way that standard electricity prices can be calculated, so too can electricity prices from the reserve market. "Reserve margin is (capacity minus demand)/demand, where "capacity" is the expected maximum available supply and "demand" is expected peak demand" (Mujeeb, 2021). It is interesting to note, however, that the reserve market does not stand in isolation from a capacity market, since in the absence of sufficient capacity, reserves cannot be supplied. While capacity markets are technically efficient enough to meet demand needs, they are slow in changing their output, which can make them less profitable than a reserve market. To illustrate, a capacity market can be likened to a large thermal generator, which can provide needed electricity but can only slowly change its output. Meanwhile, a small but flexible generator, which can instantaneously change its output level, but can only supply part of the total demand, would be the equivalent of the reserve market (Mujeeb, 2021). In an instance where the demand was to peak suddenly, both sufficient generation capacity and ramping capacity are necessary. Given the size limitation of the reserve market, however, in the instance where the demand was to peak suddenly, both sufficient generation capacity and ramping capacity are necessary. Given the size limitation of the reserve market, however, in the instance of Elstor, it is logical that its technology strives to meet the needs of small-scale customers. In addition, Fingrid, which operates in the Nordic countries, is likely servicing an altogether smaller demand base than what would be found in the US. For this reason, a very high-level overview on the reserve market topic makes it appear that the reserve market does not exist in the US the same way it does in Finland. However, further research in the form of interviews will reveal to what extent this supposition is true, in addition to assessing whether any type of structure resembling the Finnish reserve market exists in the US.

2.4.Geothermal as a Sustainable Energy Source for Steam

Geothermal energy as a sustainable energy source predominates areas where naturally occurring steam exists. Since one of the areas of this research is focused on sustainable alternatives by which electricity and steam are produced in the US, it would be remiss not to mention geothermal energy, especially since the US boasts considerably robust geothermal energy reserves by which steam production takes place in certain geographical regions. Therefore, as far as the topics of the steam industry and sustainable resources are concerned in the US, considering geothermal is an imperative in terms of unlocking the potential for renewable steam production in the US steam market.

Geothermal refers to any system that transfers heat from within the Earth to its surface, whereas hydrothermal is a subset of geothermal, denoting a transfer of heat involving water, either in a liquid or vapor state (Heasler, Jaworowski, and Foley, 2009). Geothermal energy finds its way to the earth's surface through volcanoes and fumaroles, which are holes in the earth where volcanic gases are released; hot springs; or geysers (EIA, 2022).

Most geothermal resources are near the boundaries of the earth’s tectonic plates where most volcanoes are located, with one of the most active geothermal areas in the world being the Ring of Fire, which encircles the Pacific Ocean, as seen in Figure 27 below. Most geothermal resources in the US are located in the pacific northwest (Figure 26). Furthermore, most geothermal plants within the US are located in Hawaii (EIA, 2022).

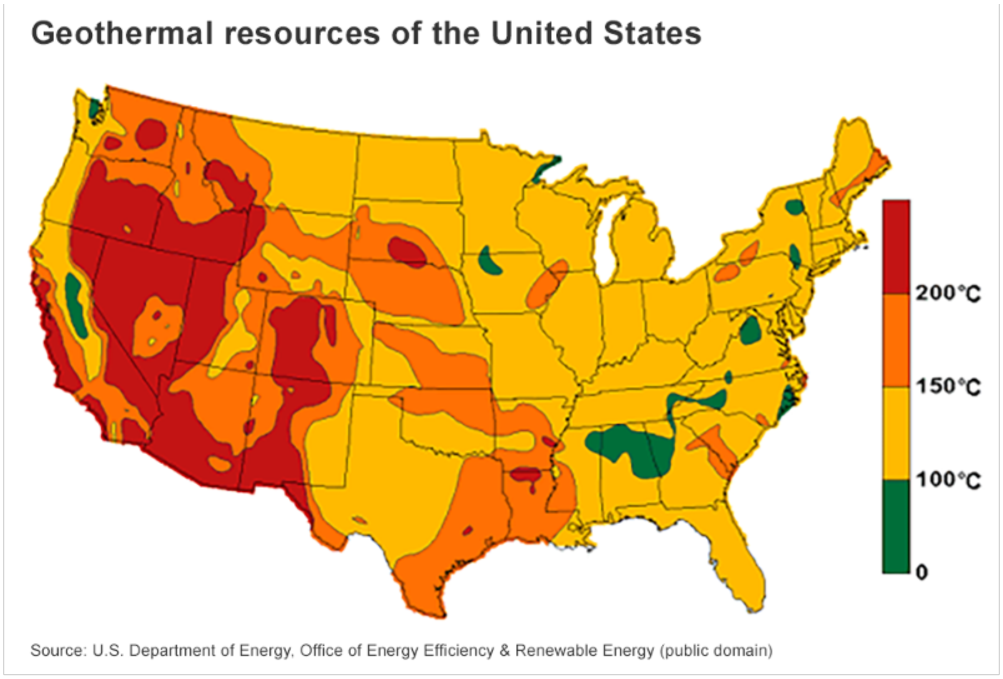

Figure 26. Geothermal resources in the US (EIA, 2022).

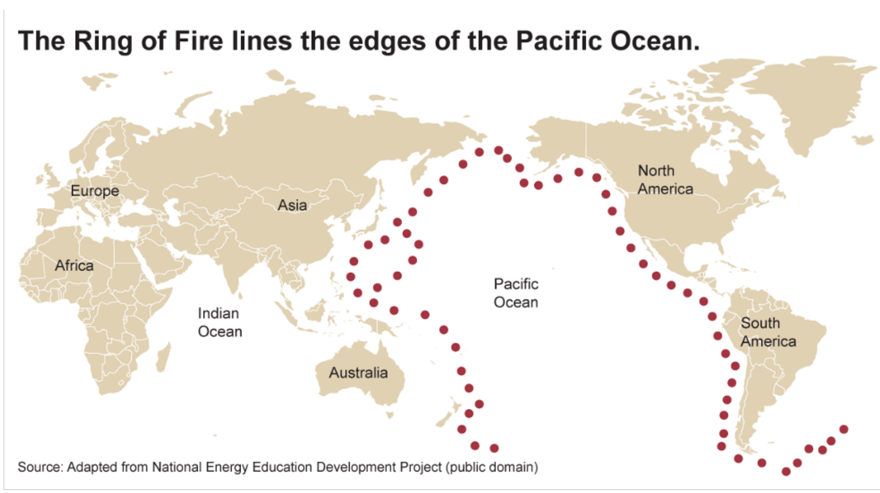

Figure 27. The Ring of Fire (EIA, 2022).

Geothermal power plants use steam to produce electricity. The steam comes from reservoirs of hot water found a few miles or more below the earth's surface. The steam rotates a turbine that activates a generator, which produces electricity. This process is illustrated in Figure 28.

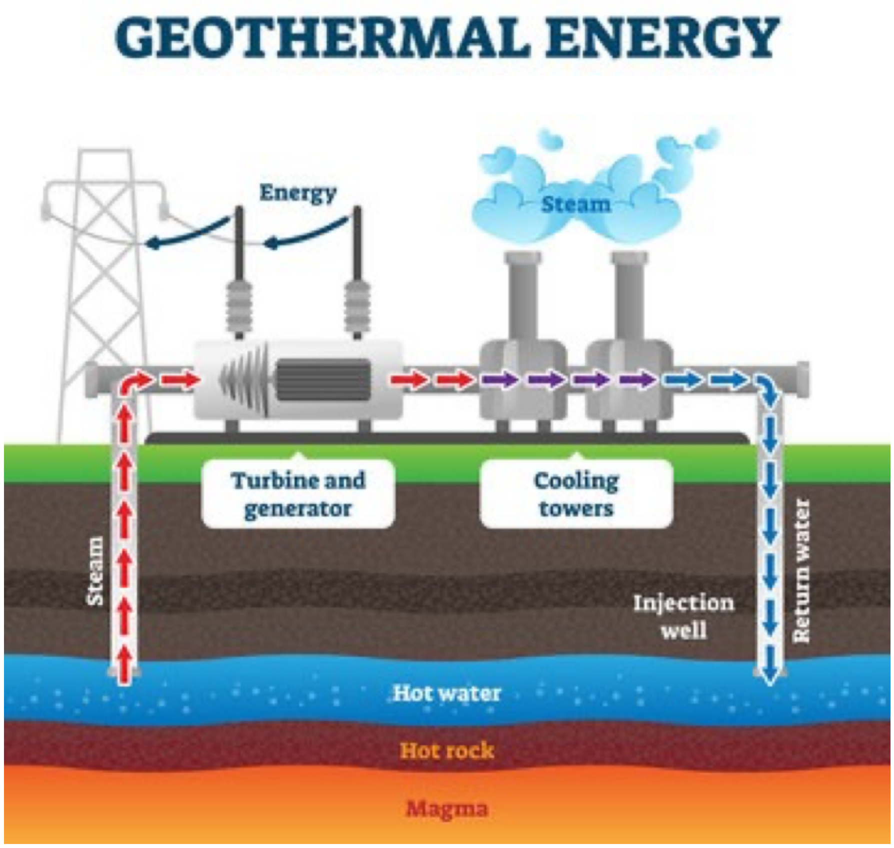

Figure 28. Geothermal Energy Process (Adobe Stock, 2023).

While Elstor's technology does not utilize geothermal energy in Finland, the availability of geothermal energy in the pacific northwest area of the United States could indicate an opportunity for sustainable energy sources to both power the electricity used in Elstor's technology and provide steam power in industry.

Working to green steam production processes could have far-reaching consequences, as steam wastewater often contains pollutants, like bioaccumulative pollutants, including selenium, mercury, arsenic, and nickel; halogen compounds, like bromide, chloride, iodide; and nutrient and total dissolved solids (EPA, 2023). Some unintended consequences could be cancer and non-cancer risks in humans, a lowered IQ among children, and deformities and reproductive harm in fish and wildlife (EPA, 2023). Therefore, the solution is to implement affordable technologies to reduce discharges. For that reason, understanding how public policy shapes the need for this steam use to be used in conjunction with cleaner forms of energy may lie at the crux of determining Elstor's best approach to US market penetration.

2.5.Sustainable Public Policy

Steam production in the US traditionally being produced by gas and oil is a trend that continues today. As regards the existence of the steam electric power generation industry in the US, about 1000 steam electric power generating plants currently operate in the country, out of which 35% generate in excess of 500 megawatts and 12% generate 25 MW or less (MW) (Climate Policy Watcher, 2023). Steam electric power generating plants represent 79% of the entire electric utility generating capacity and generate 85% of electricity produced by the entire electric utility industry, where plants built after 1970 represent 44% of the total capacity and those built before 1960 represent 26% of capacity (Climate Policy Watcher, 2023).

Amidst these norms, the US government still strives to encourage companies to behave more sustainably both through incentives and penalties (Environmental Protection Agency, 2022). To understand the potential that Elstor's technology has to be successful in a US market, a preliminary investigation into the overall US energy policy market must be conducted. One of the first areas to consider is the extent to which there are incentives for US companies to reduce CO_2 emissions in their processes. While this may exist in Finland on both governmental and company levels, it is necessary to investigate whether this is the case in the US. To illustrate, Motiva is a Finnish sustainable development company which provides public sector, businesses, municipalities and consumers with information, solutions and services that allow them to make resource-efficient, effective, and sustainable choices (Motiva, 2023). While it is possible that these types of intermediary companies exist to help production companies reduce their emissions, the extent to which sustainable energy alternatives are supported and available in the US market must be explored to further understand the market penetration feasibility for Elstor's product in the US.

According to the UN, fossil fuels, namely coal, oil, and gas, are the largest contributors to global climate change and account for greater than 75% of global greenhouse gas emissions and nearly 90% of all carbon dioxide emissions (United Nations, 2023). In the United States, fossil fuels are responsible for meeting most energy needs, including roughly two-thirds of US electricity generation (Union of Concerned Scientists, 2023). According to the Pew Research Center, Americans are largely in favor of the U.S. taking steps to become carbon neutral by 2050, although only approximately one-third want to phase out the use of fossil fuels completely (Tyson, Funk, and Kennedy, 2022). In other words, two-thirds of Americans think that fossil fuels should be retained as an energy source amidst the transition to greener methods of energy production. The most notable reason for this view can be attributed to economic concerns surrounding the way that these policies could directly impact the lives of individuals. According to the same study, 69% of U.S. adults prioritize developing alternative energy sources, such as wind and solar, over expanding the production of oil, coal, and natural gas, and simultaneously favor the U.S. taking steps to become carbon neutral by 2050, which has been sighted as a key component of President Joe Biden's climate and energy policy agenda. (Tyson, Funk, and Kennedy, 2022). Furthermore, another consideration is that climate issues tend to be a partisan issue in the US. While Democrats generally support climate issues, Republicans tend to deprioritize it as a relevant political issue (Figure 30).

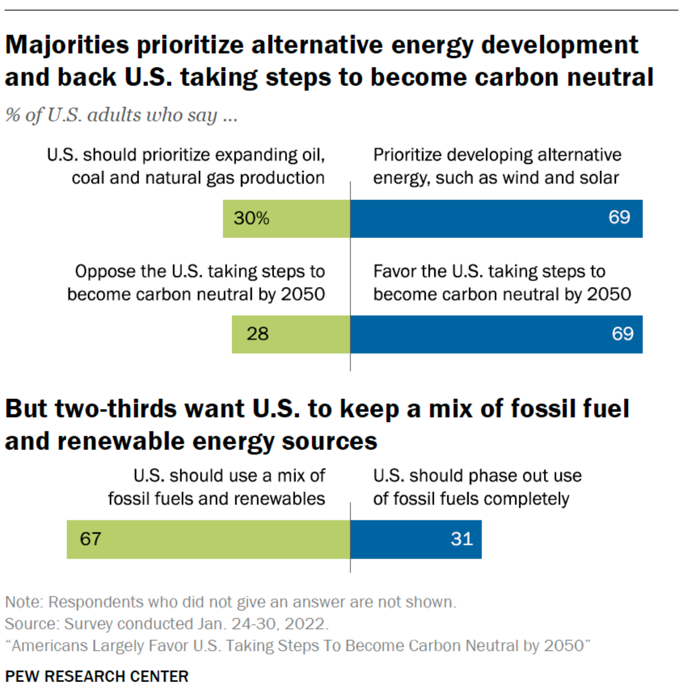

Figure 29. Survey of Americans' preferences towards the phasing out of fossil fuel use in energy production (Tyson, Funk, and Kennedy, 2022).

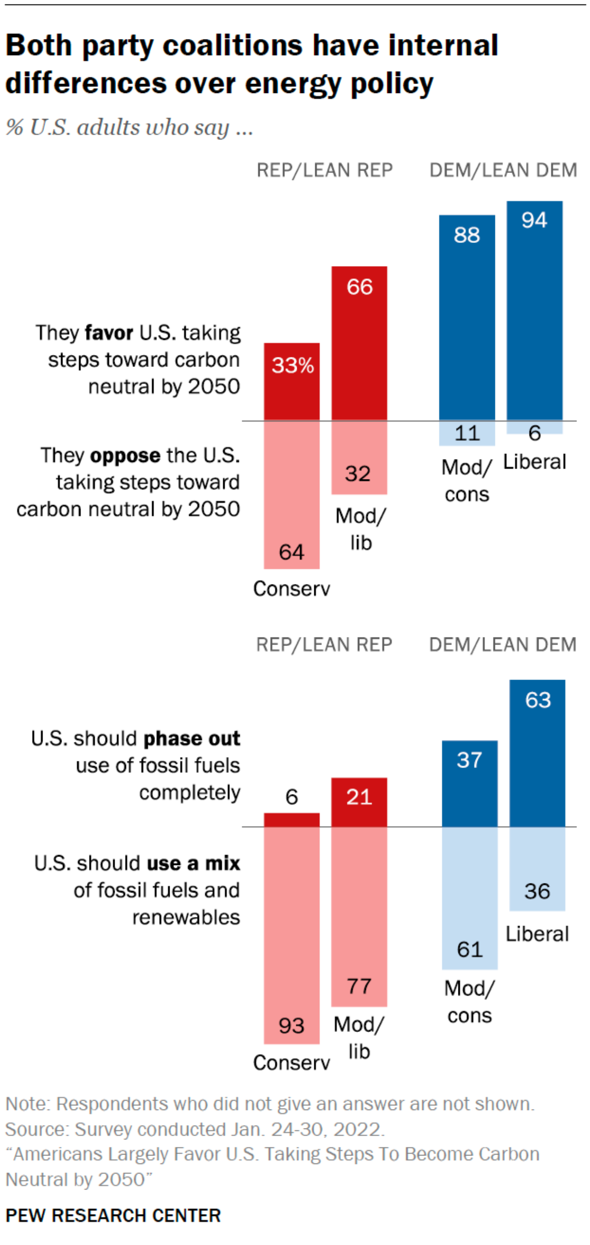

Figure 30. Illustration of the degree to which climate change is a partisan issue (Tyson, Funk, and Kennedy, 2022).

According to the White House, Biden has been actively working to support the vision that he originally campaigned for of tackling the climate crisis "with the urgency that science demands" (The White House, 2023). This shift stands in stark contrast with the environmental agenda taking place during the US's previous presidency, where on June 1, 2017, President Donald Trump's withdrew the US from the Paris Agreement, which was established in 2015 and was comprised of nearly 200 nations who came together for the first major worldwide agreement with the purpose of tackling global climate change (Cama and Henry, 2017). Not only did Biden rejoin the Paris Agreement after Trump's withdrawal, but he created the US's first-ever National Climate Task Force, with more than 25 Cabinet-level leaders from various government agencies (The White House, 2023). Their objectives are four-fold and include the following goals:

1. Reducing U.S. greenhouse gas emissions 50-52% below 2005 levels in 2030
2. Reaching 100% carbon pollution-free electricity by 2035
3. Achieving a net-zero emissions economy by 2050
4. Delivering 40% of the benefits from federal investments in climate and clean energy to disadvantaged communities

In addition to these longer-term aims, considering other methods by which President Joe Biden has already begun to implement more eco-friendly policies likewise aids in understanding the potential that the US has overall for cleaner energy adoption technologies. For example, the Inflation Reduction Act, which was passed in August 2022, has been "the most significant legislation in U.S. history to tackle the climate crisis and strengthen American energy security" (The White House, 2023). Its purpose is to generate cost savings for the general population by lowering energy costs for households, creating millions of well-paying jobs for American workers through manufacturing of solar panels, wind turbines, and electric vehicles, and delivering a healthier future for future generation through pollution reduction. In addition, the Bipartisan Infrastructure Law has the purpose of upgrading the power grid, improving public transit, creating greater accessibility for EV charging stations, cleaning up pollution, and enabling access to cleaner water. Natural disasters brought on by climate-change cost the US $150 billion in damages from the most large-scale 20 weather and climate disasters in 2022 alone (The White House, 2023).

While the current US administration is currently making considerable effort to promote a greener future for the US, and the world as a whole, whether greener technologies are adopted quickly remains an issue related in part to economics, rather than public policy alone. However, given that climate change and environmentally sustainable issues are a partisan issue in the US, the direction in which the US may be leaning with regards to said issues at any given time, is inevitably influenced by the president in power. In addition, certain states, dependent upon their political leaning and population density, may also be either more or less willing to invest in these technologies. One of the most important things to consider, however, from the perspective of a company, is what will bring the company, and as a result, the stakeholders, the greatest profit. Therefore, to determine the market potential of any sustainable technology product requires understanding the market from both a public policy and economic perspective and on a case-by-case basis per company.

The two notable ways in which the US government motivates countries to go green are via Emission Reduction Credits (ERCs) and Capped Allowance Systems. However, there are also market-based approaches, which include marketable permit systems; emission taxes, fees, and charges; subsidies; and tax-subsidy combinations. In addition to these, hybrid approaches, which combine aspects of command-and-control and market-based incentive policies, are becoming increasingly used. These tactics may be more flexible, however, they are not always the most economically efficient. Examples of hybrid approaches include combining standards and pricing approaches, liability rules, and information disclosure as regulation (Environmental Protection Agency, 2022). Furthermore, the EPA also offers a number of non-regulatory approaches that rely on voluntary initiatives with the goal of achieving improvements in emissions controls and management of environmental hazards. While most of these programs are not intended as substitutes for formal regulation, they support existing regulations. Many of EPA’s voluntary programs encourage polluting entities to go beyond what is mandated by existing regulation, while others have been developed to improve environmental quality in areas that policymakers have yet to regulate, such as greenhouse gas emissions and non-point source water pollution (Environmental Protection Agency, 2022). When policy makers are deciding which types of policies to enact, the most appropriate market-based incentive or hybrid regulatory approach must be approached from a wide variety of factors, including the type of market failure being addressed, the specific nature of the environmental problem, the degree of uncertainty surrounding cost and benefits, concerns regarding market competitiveness, monitoring and enforcement issues, potential for economy-wide distortions; and the ultimate goals of policy makers (Environmental Protection Agency, 2022).

Renewable energy requirements and incentives operate at the federal, state, and local governmental level. Electric utilities encourage investing in and using renewable energy and, in some cases, require it (EIA, 2023). Among government financial incentives, there are federal government tax credits, grants, and loan programs available for qualifying renewable energy technologies and projects. These include the Renewable Electricity Production Tax Credit (PTC), the Investment Tax Credit (ITC), the Residential Energy Credit, and the Modified Accelerated Cost-Recovery System (MACRS, 2023). Meanwhile, grant and loan programs are offered by government agencies, including the U.S. Department of Agriculture, the U.S. Department of Energy (DOE, 2023), and the U.S. Department of the Interior. However, many states provide financial incentives to encourage renewable energy production and use on a statewide level (EIA, 2023). There is also a Renewable Portfolio Standard (RPS), which requires that a percentage of the electric power sales in a state comes from renewable energy sources, whereby some states have specific requirements or voluntary goals for the share of electricity generation or sales in a state derived from renewable energy (EIA, 2023). Renewable Energy Certificates (RECs) allow a purchaser to pay for renewable energy production without directly producing or purchasing the renewable energy. “These products may also be called green tags, green energy certificates, or tradable renewable certificates, depending on the entity that markets them” (EIA, 2023). Many companies use RECs to meet their voluntary targets or goals to reduce greenhouse gas emissions in their operations. Net metering allows electric utility customers to install qualifying renewable energy systems on their properties and to connect them to an electric utility's distribution system or grid (EIA, 2023). These programs are mainly state-based and may vary, but in general, electric utilities bill their net metering customers for the net electricity their customers use during a defined period. Approximately 44 states and the District of Columbia have some form of state net metering policy (EIA, 2023). Most net metered systems are used for solar photovoltaic (PV) systems (EIA, 2023). A related example would be that of New York City, commonly known as the city built on steam, as was previously mentioned. New York state has set an ambitious target of transitioning to renewable electricity, with 70% of generation mandated to be renewable by 2030. A shift from conventional steam generators will transition towards a mix of wind, photovoltaic, and hydroelectric, supplemented by pumped hydro storage to ensure dispatchability (Murphy, 2020).

Feed-in tariffs (FITs) are the special rates for purchasing electricity from certain types of renewable energy systems in certain states and are intended to encourage new projects for specific types of renewable energy technologies (EIA, 2023). Consumer options for purchasing electricity generated with renewable energy sources depend on state regulations for retail electric power markets. "Consumers can also voluntarily purchase green power, even if retail electricity choice is not available" (EIA, 2023). Most voluntary programs generally involve contractual accounting for renewable electricity generation as opposed to the physical or contractual delivery of the electricity to the customer or utility (EIA, 2023). Biofuels and other fuels for vehicles are backed by incentives offered in several federal states where biofuels are used as alternative vehicle fuels. Federal law requires the use of biofuels, or qualifying substitutes, in the U.S. transportation fuel supply. In fact, the U.S. Environmental Protection Agency sets annual volume requirements for these fuels, meanwhile other federal programs provide financial support for biofuels producers (EIA, 2023). In addition, the DOE has an Alternative Fuel Data Center, which offers additional information on these types of programs (EIA, 2023). Many of these incentives and related programs must be broken down at the state level and are so numerous that it may be difficult to identify the best policy in each case. However, with enough research and trial and error, companies have the capacity to identify and utilize incentives, both on a state and federal level, that work for them in their quest to become more environmentally conscious.

In addition to government programs, there is also the discussion surrounding sustainable development companies and the extent to which they exist in the US. Sustainable development companies that operate on more of a non-for-profit basis do not exist in the US the same way they do in Finland in large part due to the fact that sustainability is not at the forefront of the government agenda in the US the same way it is in Finland. Furthermore, environmentalism tends to be a partisan issue. Nonetheless, companies that are designed to help other companies reduce their carbon footprint in their production processes exist. However, they are usually consultancy agencies which services clients with the intention to make profit. Rather, companies, and especially large corporations, generally tend to have some sort of Corporate Social Responsibility (CSR) policy built into their operations. Another example would be sustainable investing and environmental, social, and corporate governance (ESG, 2023). J.P. Morgan, an American multinational financial services company, helps companies with sustainable investing, whereby they help to manage the financially material ESG risks and opportunities of their clients (J.P. Morgan Asset Management, 2023). Therefore, when these types of companies exist, a lot of the corporate, for-profit offerings are dedicated to helping companies to become more sustainable, as opposed to them being not-for-profit. In addition to ESG investing, there is green software, also known as sustainable software, which is software that is designed, developed, and implemented to limit energy consumption and create minimal environmental impact (Rosencrance, 2022). Most of these companies operate for profit, like Accenture, of which 95% of its applications are running in the public cloud and which has trained more than 70,000 of its developers on green software engineering practices. However, one instance of not-for-profit sustainable technology efforts were made in May 2021, when Microsoft, Thoughtworks, Accenture and GitHub, together with the Joint Development Foundation Projects LLC and the Linux Foundation, established the Green Software Foundation, a nonprofit organization aimed at developing a network of people, standards, tooling and best practices for green software (Rosencrance, 2022). As this may be the exception, it is worth noting that most companies offering these types of technologies are for-profit. Ultimately, it is up to each individual company to choose to become more sustainable or not. However, many companies consider their appeal to stakeholders and investors through such efforts. Another key incentive for companies is that by going greener, companies can cut costs and improve efficiency, which can be an incentive in and of itself (Lavers, 2022). Furthermore, tax savings would likely be another large incentive for companies to behave more environmentally consciously. “Beyond credits, government tax breaks for green companies include grants and special or subsidized loans” (First Citizens Bank, 2023). Companies may also qualify for free or reduced-cost technical resources from the USDA, state development authorities, and other federal and state entities, which could assist with building or expanding certain types of energy-producing or conserving facilities (First Citizens Bank, 2023).

Therefore, researching what's available in a given state for a specific industry may be a more viable way by which to go about receiving funding rather than through nonprofit sustainable development companies. Ultimately, speaking with industry experts will likewise help to alleviate this research gap, as they offer insight into incentive programs and companies supporting green initiatives.

3. Literature Review

The purpose of this literature review is to explore preexisting research concerning the major market research objectives of this study. Topics covered are steam production and the electricity market, coupled with feasibility studies considering the potential for this type of technology in a US market. Previous research related to the steam industry, the cost of steam, complete with steam costing models, will likewise be considered, as will the topics the electricity market, the grid, and the electricity reserve market. The other research areas of public policy and sustainability are likewise considered, but to a lesser degree since the focus of the literature review is to understand whether market feasibility for this specific type of technology exists. Because the market is a US market, focusing on the technologies in the US was attempted, but often yielded too few results.

This literature review is the result of a systematic review yielded by searching for different combinations of keywords. It was conducted largely through EBSCO Host and, to a slightly lesser degree, through LUT Primo, both of which yielded a combination of peer-reviewed and journal articles and book sections. The first few pages of each search result were often considered. In addition to EBSO Host and LUT Primo, Google Scholar were also consulted for cross verification, especially where citations were concerned.

The research topics were searched for both together and in isolation from each other to generate a greater quantity of results in some cases, and to narrow results in others. To illustrate, a search for “electricity production with steam” and “electricity storage” was conducted on EBSCO, but yielded only three results, most of which were related to highly specialized technologies and were outside the scope of a US market. Therefore, they were not considered. The search was then expanded to include more general topics to yield a greater quantity of results.

Steam industry" yielded 3,205 results. This was too general. Therefore, different combinations of topics, based on keyword sets, were searched for to obtain a smaller, more specific set of results. "Cost of steam" and "steam industry" produced 23 results. The combination of "electricity storage" and "steam" yielded 152 results. "Feasibility analysis" and "steam" yielded 195 results. The exact key words used for each search will be mentioned prior to the explanation of the sources in question. Steam started as the primary research topic. For that reason, most of the initial searches included steam. Since Elstor's technology doubles as an electricity storage unit in addition to servicing the steam industry, this search theoretically allowed for the consideration of other similar types of models similar to Elstor's technology to be considered. However, it was discovered that
starting a search with too many terms may convolute results. For that reason, there are several sections below that are typically separated out by studies performed on steam or electricity since finding studies where both aspects were included didn't necessarily result in valuable results. Since there are many publications that appear to be only slightly related to the topic at hand, those that were most related to the topic, despite being only partially related in some instances, are referenced in this review below. While there may be additional resources which share some similarities, as the research continued, it became clearer that some of the specific market research necessary to inform Elstor of market potential and feasibility could not be provided through previously conducted studies. However, the ways in which these studies provided some insight or were related to the Elstor study will be referenced.

3.1.Cost of Steam

Using the EBSCOhost database, a search using the keywords "steam" and "cost" was initially conducted. This search yielded articles related to both pure steam costing and the cost savings generated by transitioning to renewable energy. To the topic of energy costing for renewables, one paper compares cost calculations for the adoption of greener technology in a few countries, including the US, Denmark and India. The study itself acknowledges the limitations behind the generation of cost estimations, especially because of fluctuations in fuel costs and the effects of subsidies and incentives for renewable generation (Patridge, 2017). It sites resources such as wind, coal, and natural gas being difficult to cost estimate. This study deals more with confound generation cost calculations and fuel costs. It exposes the potential pitfalls of reliable cost estimating when it comes to energy consumption. However, this study didn't relate specifically to steam energy, but rather considered some aspects of energy policy as it relates to energy consumption (Patridge, 2017).

While Elstor's product tends to use wind and solar in its production, the research depicts that these renewable energy input resources seem to be less common when it comes to steam production in the US. In fact, geothermal, biomass, and, in more recent times, hydrogen, are the more sustainable options related to steam production that the US has been shifting towards. Therefore, unsurprisingly, one study considers the technical and economic potential of biomass use for the production of steam (Saygin et al., 2014). Furthermore, this study does not focus on the US alone, but rather takes a global approach to the use of biomass in steam production. Likewise, this paper argues that among the six main renewable energy resources, namely bioenergy, solar, geothermal, hydro, wind, ocean, that bioenergy, or biomass, is projected to contribute the most to the economy-wide energy demand in the long term, also in the industry sector (Saygin et al., 2014). This prospect may seem practical given a long-term, broader approach to steam production. However, given Esltor's technology, which isn't currently using biomass in its processes, this research is limited in its ability to provide insight into relevant steam costing models that are specific to the Elstor case. Likewise, this preexisting research relates more to the production of plastics, rather than steam use in industries related to food production, bakeries, or breweries, for instance, which are the type of industries that have been identified as Elstor's primary target market. However, what this research does well is that it identifies and makes a case for the use of biomass generating long term cost savings into the future, despite this case being made more strongly for certain world regions over others, namely regions where low-cost biomass is available, such as Southeast Asia, South America and Africa (Saygin et al., 2014). Since these regions are not included in the current target market for Elstor, naturally a net profit of biomass use in these regions does not provide valuable insight to Elstor at this time.

Other sources discuss how to calculate the total cost of steam. For instance, one such case considers industrial steam systems and provides a strategic framework by which proxy measurements are used in the evaluation of the total cost of steam. However, as discussed, Elstor's technology is used in smaller scale steam production, as opposed to larger industrial scale steam usage, which is the industry type that this study considers. Nevertheless, research related to calculating the efficiency of boilers using a proxy metering device (PMD) depicts how steam estimates can be made without installing steam readers directly (Seiler, Donovan, and O'Donnell, 2019). While this source does not necessarily discuss more sustainable alternatives to steam production the way the first two sources did, it acknowledges that with steam systems accounting for approximately 30% of the energy used in manufacturing facilities, the steam industry offers high potential for improved efficiency, which has yet to be realized (Seiler, Donovan, and O'Donnell, 2019). This source cites lack of access to information regarding how to derive potential saving opportunities in steam systems as one of the largest barriers to both cost savings and subsequent reduced emissions. Metering devices are acknowledged as one of the ways to glean data regarding the use of steam in industry. However, the potential drawbacks are acknowledged as being the continuous maintenance that is needed to guarantee the accuracy of the meters and to replace broken devices (Liu et al., 2009). This is especially problematic due to meters being both costly and time-consuming to maintain. Therefore, meters are often not used well enough by companies to meet the full potential with regards to data that they could capture (Salonen and Deleryd, 2011). A byproduct of this lackadaisical approach is that too many meters go missing or are broken, thus preventing the accomplishment of metering audits, ultimately leading to missed efficiency improvements (Seiler, Donovan, and O'Donnell,, 2018). In essence, many companies are unwilling to put forth the work upfront in an attempt to gain some cost savings if those cost savings are either not guaranteed or are hard to come by.

With the clients that Elstor services in Finland, the use of steam meters being offered to companies to track steam usage has likewise been implemented. As the drawbacks of steam metering have just been discussed, coupled with the theoretical nature of this research, it could be deduced that potential US clients, too, would not make use of a meter when offered one. Therefore, this research offers an alternative by which steam calculation estimates can be made, not through the actual measuring of steam, but rather, through energy, or more specifically, electricity inputs and outputs. Therefore, the goal would be to estimate the true cost of steam through these adjacent means, rather than through the recording of the steam use itself through more traditional, direct steam metering means. In essence, gauging electricity and its pricing could prove more valuable to finding a market, rather than calculating isolated steam cost estimations. Nonetheless, considering the way in which the cost of steam is typically calculated through more accurate means provides evidence that this type of research exists, thus limiting the gap with regards to this research question slightly. However, as aforementioned, finding data specific to a US market is often what proves to be the most challenging. The reality is calculating steam usage and cost savings is very company specific. Therefore, this academic article, which discusses how steam can be produced through proxy metering, helps to lay the groundwork for alternative methods for steam cost estimation.

The article on measuring industrial steam systems through proxy metering makes a compelling case as to why proxy methods are preferred. It discusses three primary reasons why these methods are an attractive alternative for collecting steam use data, including a lower cost for implementation since there is no need for physical measuring devices. Likewise, the process is easier to implement, is less invasive, and offers real-time estimations of data, which are derived from online monitoring systems. These systems exist as part of the proxy meter system and differ from traditional meter means, which collect the data while in an offline state (Seiler, Donovan, and O'Donnell, 2019). Once the data has been collected, it must undergo traditional data analysis methods, including data cleaning and normalization to account for outliers, or potential inaccuracies in the data. The research carried out in this article includes a case study in which the data that was collected and analyzed was used to illustrate the performance of different devices and flows. A sample size of three boilers was used in this research. However, as regards the steam generation for each, Boiler 1 generated most of the steam, at 91%, during the observed time. Meanwhile, Boiler 2 and 3 remained mainly in standby mode as back up. The overall fuel to steam efficiency was calculated using separate equations for both steam generation and steam distribution, thus resulting in varying degrees of steam consumption per area for each of the different boilers to verify boiler efficiency and total steam generation contribution per load.

These cost of steam calculations primarily considered natural gas, electric energy, and water (Seiler, Donovan, and O'Donnell, 2019). Therefore, the potential for renewable energy to be used in this system and what those results could yield is not considered in this study and is, thus, a limitation. Nonetheless, the insight that is gleaned from this type of study is how to evade greater steam losses during production via new system reconfigurations. However, at the same time, the article likewise acknowledged that while the proxy metering approach saves time and money to create reports on data that could create cost savings, the pitfall is that this model is much more inaccurate by comparison to that data which is derived from a physical meter device (Seiler, Donovan, and O'Donnell, 2019). Ultimately, proxy metering, while having the potential benefits to create more efficient means of steam use, generate less waste, and, thus, help the environment, will likely continue to benefit from advancements being made in future field use as more sophisticated proxy meter models continue to be developed. This is especially true since industrial systems differ in terms of their levels of complexity. Furthermore, future knowledge transfer between academia and industrial facilities could likewise prove beneficial for the purpose of facilitating greater cost savings and environmental preservation where steam usage measurement and subsequent conservation is concerned.

In another study, which considers the estimation of renewable-based steam costs, current prices of steam are considered at the time the study was published (Pérez-Uresti, Martín, and Jiménez-Gutiérrez, 2019). The result of the study asserted that given the then current prices of natural gas, lignocellulosic biomass offers better perspectives to become a competitive resource to produce steam when compared with solar radiation and biogas of all the renewable methods (Pérez-Uresti, Martín, and Jiménez-Gutiérrez, 2019). For instance, it was concluded that solar-based and biogas-based steams are only competitive when obtained via a cogeneration scheme in conjunction with a credit to the power produced being assigned. For each renewable resource, correlations were developed to estimate both the cost of steam as a function of the raw material cost and the availability (Pérez-Uresti, Martín, and Jiménez-Gutiérrez, 2019). As aforementioned, while Elstor uses wind and solar as its renewable resources, it has yet to incorporate biomass into its portfolio of resources used by its technology. Therefore, while this study provides valuable insight into why biomass may be a superior form of renewable energy to be used in steam production, it does not necessarily help Elstor with discovering a market which could make use of its technology. However, insight into steam calculations can be gleaned from this study with one of the most noteworthy differentiations being made between different steam conditions, which is important because these conditions affect the calculations contributing to cost estimations. The four conditions are steam at very high pressure (VHP) steam at 165 bar or 550 °C, high pressure (HP) at 42.5 bar or 320 °C, medium pressure (MP) at 27.6 bar or 230 °C, and low pressure (LP), 2.07 bar or 122 °C (Pérez-Uresti, Martín, and Jiménez-Gutiérrez, 2019). To further divide up the calculations into groups, a piecewise function was used to make estimates for each specific type of equipment. In addition, each form of renewable energy was considered in the process between bio-, solar-, and biogas-based, with bio- ultimately proving to be the most economically competitive resource. Therefore, this study depicts how a proof-of-concept analysis and optimization model for different energy systems can be used to demonstrate the best potential source for steam generation.

Other resources concern the calculations of renewable energy in steam production, although without the direct application to an industry setting. For instance, one source makes a proposal for solar-aided coal-fired power generation system for direct steam generation and active composite sun-tracking (Wang, Sun, and Hong, 2019). The purpose is to propose a new technology for steam generation, known as a novel solar-aided coal-fired power generation system (SCPGS), which has a direct-steam-generation (DSG) solar field and active composite (AC), such as active off-focus plus double-axis, sun-tracking strategy. The purpose of the DSG, ordinarily, is to reduce the cost, and the purpose of the AC sun-tracking strategy is to improve performance. Through mathematical models, the way in which these cost savings and improved performance can be obtained are proven. However, due to the theoretical nature of these calculations and lack of application of this technology to industry, it is challenging to tell how these cost calculations can be made relevant in a definitive business case setting.

Another resource considers cheaper ways to develop steam in the absence of freshwater resources. For example, one report asserts that carbonized kelp can help fill this gap as it is cheap and has high solar absorption up to 93% (Lin, et al., 2019). Yet another source considers how a triple-pressure steam-reheat gas-reheat gas-recuperated combined cycle can use steam for cooling the first gas turbine in a way that promotes optimization relative to operating parameters (Bassily, 2008). Another source focusing on an integrated electricity and steam network in Australia considers advanced process control (APC) technology. The article cites, regarding APC technology, “although application of this technology has traditionally been focused on production units, the industry is now exploiting this technology on utilities, boilers, power generation and other ancillary systems” (Gray, La Grange, and Brew, 2019). The article speaks to some of the objectives of this transition being related to overall fuel gas use reduction being used to produce both steam and electrical power. This will be carried out via attempts at automating the optimization to reduce operator workload, minimizing both high-pressure (HP) and low-pressure (LP) letdown and the LP steam header condensing by adjusting the load on the steam-driven alternators and fan condensers. Attempts will likewise be made to balance the electrical system frequency using the gas-driven alternator load, balance the electrical generator power factors, and absorb system load disturbances regularly experienced due to changes in ambient temperature, process driver load demand, and electricity demand (Gray, La Grange, and Brew, 2019). This source goes onto describe the process involved in implementing this new technology, operational challenges, how the technology will be introduced, the benefits, and the way the project can continue to be improved into the future. In this way, this reference makes a business case for how optimization can be achieved in the industry. Similar to the article that discussed proxy metering methods, this article discusses how the resultant improved operability and energy efficiency of the plant was achieved through software alone, with the aim to optimize the existing equipment, without any process interruption or mechanical modifications (Gray, La Grange, and Brew, 2019). Therefore, multiple sources speak to the ability to make predicative calculations in the absence of metered readings, thus demonstrating that these types of calculations, while somewhat less accurate, could still have the potential to provide valuable insight towards what cost savings derived from more sustainable methods of steam, and in this case, electricity also, could look like.

One search that was conducted via LUT Primo was simply “steam industry US.” The first result discusses on-site electricity and steam generation technologies in the US paper, petroleum, and chemical industries in 1998, calibrated against several federal data sources. While it is a bit outdated, it makes the claim that improvement in energy efficiency of industrial processes is the most significant option for lowering greenhouse gas emissions (Ozalp and Hyman, 2006). The models created in this paper can be used to construct energy end-use models that depict the energy flows between inputs and end-uses, thus providing national energy usage patterns for these industries. Likewise, this study compares different types of steam production to determine which are most efficient. The results indicate that the chemical industry has the highest electricity conversion efficiencies for Internal combustion engines (ICEs) at 35%. “For gas turbines, the paper and chemical industries have similar electricity conversion efficiencies, 29% and 28% respectively. These three industries have steam turbine efficiencies that are very close, but substantially less than for either ICEs or gas turbines” (Ozalp and Hyman, 2006). The purpose of comparing these different models is to examine how efficiently energy is being used to help identify potential improvements in energy usage that lead to more profitable manufacturing. This is important because more efficient use of energy creates less pollutants, thus leading to more environmentally friendly manufacturing. Since Elstor services a variety of clients from several industries, this study is relevant in that it explores multiple industries. However, these clients all behave similarly with regards to the scale of steam. This article also focuses on large scale steam production. Therefore, research efforts towards smaller scale steam use, for the purpose of best supporting Elstor’s product, remains a research gap has yet to be bridged.

3.2.The Electricity Market and Grid

The keywords used in the EBSCO search to find information on this topic were “electricity market” and “grid.” The push for more sustainable technology use as it relates to the electricity grid is a concept that has been explored in previous research. However, related results were primarily derived from research carried out countries other than the US.

While electricity has the potential to be generated through many different forms, both renewable and non-renewable, there are careful considerations that must be made when both independent companies and governmental agencies are deciding which types of infrastructure to either invest in or subsidize. In the journal, Energy Policy, one section advocates for the shift of Brazil's electricity grid to expand to include that of nuclear energy, rather than relying on hydropower the way that it has traditionally. The arguments for this are related to pushes for longer term benefits towards reaching more sustainable goals and that electricity grid expansion is essential to supporting the country's economic growth and development, and to ensure the subsequent improvement in the quality of life of the surrounding population (dos Santos et al., 2013). The article also acknowledges that throughout the remainder of the 21st century, Brazil's electricity mix will continue to rely primarily on renewable sources of energy, mainly hydropower. Meanwhile a case is being made for the concept of transitioning to nuclear, the article still acknowledges that economic and environmental constraints will limit the progress of a nuclear transition, despite its practicality (dos Santos et al., 2013).

In the US’s neighbor to the north, Canada, the province of Alberta has planned to transform its electrical grid from being largely powered by coal to instead being powered by natural gas, hydroelectricity, wind and solar, and, most notably, hydrogen (Neff, 2021). With this article being relatively recent, it claims that Alberta can and will begin cleaning its grid by using hydrogen by 2030 (Neff, 2021). The paper acknowledges challenges surrounding fully decarbonizing Alberta's electric power sector as being related to a lack of significant hydroelectric or any nuclear power in the province (Neff, 2021). However, Canada, as a country, is working to achieve net-zero greenhouse gas emissions. This article makes a case for the benefits of switching to hydrogen in Canada specifically, given its vast amounts of natural gas that can be used to produce hydrogen and its ample geology for underground carbon capture and storage for the greenhouse gases emitted during hydrogen production (Neff, 2021). While this piece acknowledges that future adjustments will be necessary to make hydrogen investment and production a reality, it ends on a positive note, regarding hydrogen as the ultimate future solution to greening Albert's electric grid, thus promoting net-zero fuels and technologies now and into the future (Neff, 2021).

3.3.The Electricity Reserve Market

One search considered "reserve market" and "electricity." While preliminary research has conceded that the electricity reserve market does not exist in the US the same way that it does in Europe, one source references its existence in California. However, it is important to note that California ranks among the top three greenest states in the US along with Vermont and New York (Robertson, 2023). In one study, the efficiency of the California electricity reserves market is tested by examining systematic differences between its day- and hour-ahead prices (Metaxoglou and Smith, 2007). This study is of interest because it examines a model of pricing which behaves very similarly to the way that Elstor's technology works. The study considers demand through the establishment of a principal–agent relationship between the markets' buyers, known as the principal, and their supervisory authority, the agent (Metaxoglou and Smith, 2007). It was determined that the agent was not very incentivized to shift reserve purchases to the lower priced hour-ahead markets. By comparison, the supply side created barriers in the market through purely speculative trading, thus creating uncertainty and subsequent risk of regulatory scrutiny. The mathematical models used in this study were a high-dimensional vector moving average model to estimate the premia and conduct correct inferences and an Exact Maximum algorithm to obtain exact maximum likelihood estimates of the model, which worked in conjunction with each other to incorporate missing data from each other's model. While this study presents thorough data analysis for this specific case, it may be difficult to integrate a similar model towards the electricity reserve market data that Elstor is seeking to find, particularly because the reserve market operates differently in the US versus Europe. Similarly, this study is relatively outdated as it is from roughly a decade and a half ago. The case starts out by explaining that California's reserve markets were developed around the year 2000 as a means to ensure sufficient standby supply. One issue is that these reserve markets were not seen as very reliable (Metaxoglou and Smith, 2007). More recent information on the California electricity market for the state's ISO, or Independent System Operator, cites various market processes and products, including a day-ahead market, a real-time market, ancillary services, congestion revenue rights (CRRs), and convergence bidding (Market processes and products). Out of all of these, the closest concept to the reserve market described in this case would be the real-time market, or the spot market, which exists to meet electricity needs not covered by the day ahead schedules (Market processes and products). In this way, it acts similarly to a reserve market, storing and later releasing energy when it is needed.

3.4.Public Policy

One of the first few results, which was also found via the LUT Primo search for "steam industry US," and arguably one that may be most relevant to the research target of this paper, was a study, which covers the implementation and rejection of industrial steam system energy efficiency measures and goes into depth on public policy concerns in a US market. While this paper is a bit outdated by roughly a decade, it mentions the ways in which the US government via the US Department of Energy (US DOE) has attempted to reduce energy consumption via steam system energy assessments having been conducted on a wide range of industry types over the course of 5 years (Therkelsen and McKane, 2013). More specifically, it has done so through its Energy Savings Assessment (ESA) program. The ways in which assessments derived from this program result in energy efficiency measure recommendations via given potential energy, energy cost savings, and potential implementation cost values is discussed more thoroughly and modeled accordingly. The cost metrics under consideration are the payback period and measure implementation cost as a percentage of facility baseline energy cost, or implementation cost percentage. This study starts out by mentioning that the industrial sector accounts for 32% of the 105.5 EJ of energy applied within the United States in 2008 and which cost the industrial sector US$247.19 billion (US DOE, 2011). To increase industrial energy productivity and facilitate competitiveness, the US government promotes energy savings measures, and while the government can encourage facilities to adopt energy efficiency measures, ultimately, individual facilities decide whether or not to implement these measures (Therkelsen and McKane, 2013). This study measures energy efficiency measures, savings generated, and cost metrics. Energy savings metrics include a savings ratio and an energy cost savings ratio, while cost metrics include an implementation cost ratio and a payback period. Due to extraneous variables, such as repair costs, the extent to which cost savings exist is confounded. Additionally, different rates of implementation are considered by way of 6–24 months, 6–12 month, and 12–24 month periods. One assessment considers time dependence of implementation rate and its relationship to savings and cost metrics analyzed for all 606 recommended energy efficiency measures. The results pointed towards the likelihood that longer implementation periods are likely to receive the greatest cost savings based on the time dependence of energy efficiency measure implementation numerical results presented in the study (Therkelsen and McKane, 2013).

When it comes to installing Elstor’s technology, there is likewise a payback period, however, which tends to be in the years range, not the months range. However, this source is a quintessential example of how cost savings can be proven through partnership with the US Department of Energy's Energy Saving Assessment program. “This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Energy Efficiency Department, Advanced Manufacturing Office, of the US Department of Energy” (Therkelsen and McKane, 2013). This research explored which factors govern the implementation and rejection of recommended steam system energy efficiency measures. Given its US perspective and collaboration with a US agency dedicated to the reduction of waste, this type of study offers promise for what Elstor could hope to accomplish at some point in the future via collaboration with a US research institution to promote its technology in a US market. While this study considers the steam industry at large, which is broader than the type of research which would be pertinent to Elstor’s US expansion, it suggests a means by which Elstor could penetrate a US market, in some respect, via collaboration with a US agency conducting research within the scope of more economically friendly steam production as it relates to cost savings for companies.

3.5.Feasibility Analysis

One search was conducted on EBSCO host, which combined the key phrases "electricity production with steam" and "feasibility study." This search resulted in only a few sources, which were related primarily to eco-friendly energy systems and their general feasibility as functional systems, rather than the economics behind these technologies being feasible in a market setting. One source on the sustainability of hybrid system considers a hybrid energy system with production derived from solar, wind, biomass, or natural gas and utilization from electricity, heat, and hydrogen (Afgan and Carvalho, 2008). This study, which was conducted in Europe, contains a sustainability assessment method used to evaluate the quality of the selected hybrid systems. In this evaluation the following indicators are used: economic indicator, environment indicator and social indicator (Afgan and Carvalho, 2008). Therefore, the methods used in this research are targeted at defining and ranking various hybrid systems via a sustainability index with the purpose of advising which system should be used in a given situation. This study differs from the intent of the research to be carried out by Elstor in that it entertains multiple systems. However, the one hybrid system it reports on with solar PV, wind turbine and biomass steam turbine aimed to produce electricity, heat and hydrogen, would be most akin to Elstor's technology. However, this study relates only to perceived sustainability, which is quantified by metrics, rather than cost savings.

Another study on the utilization of deep geothermal energy for heating purposes is the most similar to the type of study required to answer Elstor's primary research questions related to steam feasibility in the marketplace. In fact, this article discusses the process of electricity production from low temperature steam or a plant for the supply of thermal heat and hot water (Kattenstein and Wagner, 2005). Although Elstor's technology does not support the use of geothermal, in particular, for the electricity generation portion of its product, and although geothermal has been discussed earlier as it relates to steam production and the steam industry overall, the focus of this study being on the use of geothermal energy is the portion of it that makes it least applicable to the Elstor case. However, this study is beneficial in that it offers a feasibility study, which speaks to not only the technical, but also the economic feasibility of this technology, which due to the cost-intensive and high annual load associated with the technology under investigation, was deemed an imperative.

The final study related to this search was a case study of energy systems with gas turbine cogeneration technology for an eco-industrial park, based in China. As with most sources, this study was not specific to the US, thus making it irrelevant to a US market. However, this study considers the feasibility of using gas turbine technology to increase electricity production and to generate steam. The gas turbine-based cogeneration system considered in this study has been compared with a baseline reference case that is defined as if all the energy to the industrial park is supplied from the local electricity grid, with results indicating that the gas turbine-based cogeneration system can reach a total efficiency of 58% and reduce CO2 emissions by up to 12,700 tons per year (Starfelt and Yan, 2008). A sensitivity analysis is likewise considered in conjunction with electricity prices. However, part of the conclusion stipulates that the economic feasibility of gas turbine-based systems is significantly dependent on current fuel prices. This study likewise factors the cost of natural gas into its calculations, which is a type of model that could potentially be beneficial to Elstor at the point at which calculating potential cost savings to interested parties becomes relevant. In this way, this paper creates models which consider the cost of steam to some extent, which is related to Elstor trying to understand the amount of steam used by companies and its associated cost. However, with this study being focused on a different world market and a specific set of geographical conditions with an altogether different technology, this study is limited in its relevance in helping Elstor to address its research questions related to steam production and cost. The study talks about the grid and calculates a pay-off time of 15 years with an interest rate of 6%. Furthermore, the concept of steam production through oil and gas is primarily discussed, although there are only some renewable methods mentioned. Furthermore, this study doesn’t calculate cost as much as it calculates efficiency through flow rates. Ultimately, the concept of this study, if it could be recreated for a different market segment and with a more financial costing-based approach, rather than an energy efficiency one, could prove relevant to Elstor in some respect in terms of assessing market feasibility. However, the main purpose of this research will be to uncover whether market potential exists, based on expert opinions. Costing out models for potential customers or organizations expressing interest will be a later project once the question on market potential has been assessed thoroughly.

3.6.Summary and Conclusion

Table 1 below provides a recapitulation of all the sources referenced in this literature review. It is meant as a high-level overview by which the details and main points for each source are presented briefly.

Table 1. Summary of works mentioned in literature review.

Title	Year	Author(s)	Topic	Data and Method	Findings
Utilisation of deep geothermal energy for heating purposes	2005	Thomas Kattenstein, Hermann-Josef Wagner	Feasibility study for geothermal as a sustainable source of heating	A Hot-Dry-Rock-(HDR) is considered for technical and economic feasibility by measuring demand, temperatures, and output.	Since this technology is cost-intensive, a high annual load duration of the energy system above the surface is needed for an economic operation. A process of electricity production by using low temperature steam or a plant for the supply of

					thermal heat and hot water could be installed. The average geothermal heat output amounts to approximately 7 MW and the investment costs are nearly 30 million EUR.
Calibrated models of on-site power and steam production in US manufacturing industries	2006	Nesrin Ozalp, Barry Hyman	Electricity and steam generation	Recovery and efficiency calculations based on estimates of energy inputs, thermal and electricity outputs, recovered waste heat for boilers, gas turbines and internal combustion prime movers	There are electric conversion and waste heat recovery efficiencies for each prime mover, and overall conversion efficiencies for on-site power and steam production.
Efficiency of the California	2007	Konstantinos Metaxoglou, Aaron Smith	Electricity reserve market	High-dimensional vector moving	There are significant day-ahead premia. The

electricity reserves market				average model to estimate the premia among electricity prices during different hours; algorithm using Kalman filter and a fixed interval smoother in the E step and least squares-type regressions in the M step	market design established a principal–agent relationship between the buyers (principal) and their supervisory authority (agent). The agent had limited incentives to shift reserve purchases to the lower priced hour-ahead markets.
Sustainability assessment of a hybrid energy system	2008	Nain H. Afgan, Maria G. Carvalho	Sustainability of hybrid energy systems	Piecewise function to calculate sustainability using each given type of renewable input	The multi-criteria method for the evaluation of hybrid energy system shows the potential possibility for the determination of the Sustainability Index rating to be used on the basis of executive decision-making.
Cost numerical optimization of	2008	A. M. Bassily	Cost optimization	Numerical optimization is	Cost savings are to be had through

the triple-pressure steam-reheat gas-reheat gas-recuperated combined power cycle that uses steam for cooling the first GT			in a steam system	used to analyze the cost aspects of a specific power cycle configuration. The methodology involves optimizing the cycle's parameters to minimize overall costs.	cost minimization and plant optimization. Optimizing the net additional revenue could result in an annual saving of 21 million U.S. dollars for a 439 MW power plant.
Case study of energy systems with gas turbine cogeneration technology for an eco-industrial park	2008	Fredrik Starfelt, Jinyue Yan	Feasibility analysis for eco-park complex using gas turbine cogeneration	Analysis of the cogeneration plant in terms of thermal efficiency, cost estimation, and greenhouse gas emission using a sensitivity analysis	"The investigated system is economically profitable at natural gas prices below 4.4 RMB m−3 with fixed electricity prices and at electricity prices above 736 RMB MWh−1 with fixed natural gas prices. The sensitivity analysis based on the interest rate

					showed that the proposed system is economically feasible with interest rates up to 16%" (Starfelt and Yan, 2008).
Virtual sensing techniques and their applications	2009	Lichuan Liu; Sen M. Kuo; MengChu Zhou	Sensors	Algorithms are used to determine the way that models are transferred between the source and the physical/virtual sensors.	Constraints limit the practical usability in real applications.
Cost of poor maintenance: A concept for maintenance performance improvement	2011	Antti Salonen, Mats Deleryd	Cost of poor maintenance (CoPM) in the manufacturing industry	Financial measure for maintenance by which maintenance costs are documented	Company higher-ups may be more inclined to make executive decision regarding maintenance if they are presented with evidence justifying why maintenance costs are a necessary evil in avoiding

					long-term higher maintenance costs.
The importance of nuclear energy for the expansion of Brazil's electricity grid	2013	Ricardo Luis Pereira dos Santos, Luiz Pinguelli Rosa, Maurício Cardoso Arouca, Alan Emanuel Duailibe Ribeiro	Electrity grid	Quantitative analysis and modeling makes use of data derived from historical energy production and consumption in Brazil, electricity demand projections, and nuclear energy capacity and generation.	Increasing the participation of nuclear energy in Brazil's electricity grid will ensure energy security along with other positive benefits.
Implementation and rejection of industrial steam system energy efficiency measures	2013	Peter Therkelsen, Aimee McKane	Steam energy efficiency assessment	Energy Savings Assessment (ESA) program data analysis for cost metrics via examining uptake/rejection of industrial steam system energy efficiency measures	Implementing steam system energy efficiency measures is driven primarily by cost metrics. Stated reasons for rejecting recommendations are typically based on economic concerns.

Assessment of the technical and economic potentials of biomass use for the production of steam, chemicals and polymers	2014	D. Saygin, D.J. Gielen, M. Draeck, E. Worrell, M.K. Patel	Steam production	Scenario analysis on biomass emissions and prices	Biomass is becoming an increasingly attractive energy resource. Steam production is already attractive and is more ecofriendly than biomass.
Cost comparisons for wind and thermal power generation	2017	Ian Partridge	Energy generation and costing	Financial calculations including the debt-equity ratios and the weighted average cost of capital (WACC)	Cost estimating as it is related to energy usage may not always be as reliable as it appears.
Dynamic optimization of integrated electricity and steam network	2019	S. Gray and G. La Grance, T. Brew	Integrated electricity and steam network	Mathematical optimization techniques were executed using historical plant production data	Optimizer technologies can help automate challenging operations, significantly reduce operator workload, and increase plant energy efficiency.

Low-cost carbonized kelp for highly efficient solar steam generation	2019	Yawen Lin; Weiping Zhou; Yunsong Di; Xiaowei Zhang; Lun Yang; Zhixing Gan	Renewable energy; solar	The efficiency of solar steam generation (SSG) is examined through mathematical models used to determine energy production.	Carbonized kelp is used to produce solar energy and offers potential for SSG generation.
Estimation of renewable-based steam costs	2019	Salvador I. Pérez-Uresti, Mariano Martín, Arturo Jiménez-Gutiérrez	Steam costing with renewable resources, such as biomass	Optimization for different levels of steam power using calculations based on a piecewise function for each level of steam use	Solar-based and biogas-based steams are only competitive when obtained via cogeneration along with an issued power credit.
Proposal of solar-aided coal-fired power generation system with direct steam generation and active	2019	Wang, Ruilin; Sun, Jie; Hong, Hui	Solar-generated steam	Solar output calculations for electricity generation	There is potential for smart and low-cost solar-aided coal-fired power generation systems (SCPGS) in future.

composite sun-tracking					
Industrial steam systems: Strategic framework with proxy measurements to evaluate the total cost of steam	2019	Dominik Seiler, Dan Donovan, Garret E. O'Donnell	Steam costing and measuring	Data from proxy metering device (PMD) used to estimate steam use with data analytics and steam cost calculations	Although meters could help both the planet’s and companies’ bottom line, they are both costly and time-consuming to maintain. Proxy metering is a viable alternative, although it isn’t as accurate.
The Energy Transition in New York: A Greenhouse Gas, Net Energy, and Life-Cycle Energy Analysis	2020	David J. Murphy, Marco Raugei	Renewable electricity in New York State	Common inventory analysis via a fully integrated approach via net energy analysis (NEA) and life-cycle assessment (LCA)	“The ambitious renewable energy targets set by the latest legislation in New York are very effective at reducing the carbon intensity of the state's electricity mix (by as much as 92%), while at the same time they clearly improve the state's energy

					sovereignty (by a factor of 2)" (Murphy and Raugei, 2020).
The Role of Hydrogen in Decarbonizing Alberta's Electricity System	2021	Neff, Jordan; Bataille, Chris; Shaffer, Blake;	Hydrogen-fueled electricity grid	Electricity sector, wind and solar, and carbon data analysis-based pricing to demonstrate cost savings	The potential for Alberta's electric grid to be greened using hydrogen provides an opportunity for hydrogen to support net-zero fuels and technologies.

The literature presented in this review provides an overview as to the type of research that already exists related to the steam industry, steam costing, electricity usage in steam generation, and the feasibility of related technology in terms of both use and financial sustainability. How cost savings can be gleaned through more efficient energy consumption processes was likewise discussed.

Although it is possible to find research that is loosely related to the research task proposed by Elstor, the pieces of literature summarized in this literature review make evident the need to conduct further research to meet the specific research needs presented by the company. Market research specific to both the steam industry and electricity market, coupled with the feasibility of Elstor's unique technology as it pertains to penetrating a US market, makes it difficult to find sufficient preexisting research specific to satisfy this research request. For this reason, an extensive feasibility study related to Elstor's technology in the US market context must be carried out via more specified means of research to address this most pertinent research question regarding market penetration feasibility. While considering mathematical and financial models could prove beneficial in better answering this question at a later point, the original and most important question as to whether Elstor has potential in a US market would best be examined first, prior to exerting effort into modeling feasibility calculations for a specific target market. Therefore, preexisting literature may provide quintessential examples of specified studies and their financial feasibility, as well as energy alternatives used in process. However, the replication of such models in the context of Elstor will likely require a more targeted approach towards a selected market segment prior to performing feasibility calculations. Thus, the research to be conducted in this study via discussions with interviewees will be focused primarily on determining the opportunities for market penetration in a US context based on different locations and subsequent, potential entry strategies. More specific calculations and case studies, like the ones considered above, may have greater potential as a future research prospect once initial market research on market entry strategies specific to Elstor's technology has already been conducted.

4. Case Description

Elstor Oy is a Finnish sustainable energy company based out of Lappeenranta, Finland. Elstor's unique technology focuses on solving problems related to current steam and heat production by providing an emission-free power-to-heat storage system that produces steam and heat cost-efficiently with renewable electrical energy inputs via wind, solar, hydro, and nuclear power (Elstor, 2022). The problems which Elstor's technology strives to solve are related to the high CO2 and particle emissions in heat and steam production with existing technologies and the current high cost of steam and heat. In addition, the expansion of clean energy sources indicates a need for a technology like Elstor's, which is compact, requires a low investment, and offers cost energy storage capability at a higher capacity. Furthermore, electric grids are continually requiring greater demand flexibility to manage the variation of energy production (Elstor, 2022). Elstor's technology resolves these issues through its elimination of CO2 and particle emissions in heat and steam production, thus reducing the cost involved in steam and heat generation. Elstor offers low-cost energy storage to support the expansion of clean energy sources. Its technology matches energy demand and low daily electricity prices, thus generating cost savings through greater demand flexibility for electric grids (Elstor, 2022).

Since many industries today primarily use fossil fuels in their steam production processes, Elstor's competitive advantage lies in its solution's ability to reduce or eliminate CO2 emissions in these processes, either during the entirety of the production process or as part of a hybrid system, which is performed by swapping CO2 energy production with that which is generated by renewable resources. Elstor's technology offers both cost and energy savings to clients, meanwhile simultaneously offering companies a practical way to reduce CO2 emissions in their energy consumption processes, which is increasingly relevant today as prices for CO2 emission allowances continue to climb. In Finland, this is particularly relevant since the government offers subsidies for companies opting to replace the burning of fossil fuels with CO2-free, or emission-free, solutions.

Exploring the extent to which the US government offers similar incentives will assist in understanding the potential for Elstor's product offering in a US market setting. Furthermore, it will be beneficial to investigate whether there are any US institutions, government affiliated or otherwise, who support companies in their efforts to greatly reduce or eliminate the use of fossil fuels in their production processes.

Elstor's patented technology takes advantage of the electricity reserve market to store energy from electric grids when prices are low, later releasing the electricity on demand when it is needed, known as demand flexibility. This approach works well in Finland due to the cost of electricity being delivered from the grid fluctuating based on the time of day at which it is being used. Part of this research will be focused on assessing whether the way in which the US electricity market behaves in this regard offers promise that Elstor's technology could be applied to the US market as well.

The objective of this research is multifaceted. Questions will be asked of interviewees, related to the following topics, which were likewise mentioned at the onset this thesis. Firstly, the research will seek to determine whether steam can be accurately measured and if it is possible to obtain these figures from companies which use steam. The steam market at large will be discussed, too, with regards to where in the market a product like Elstor's could fit well. The electricity market will likewise be considered to determine the extent to which the electricity reserve market exists in the US and in which ways this technology could be adopted from the electricity market perspective. Next, other renewable forms of energy being used in the US steam and electricity markets will be discussed. Finally, public policy and the way in which it would affect green technology adoption within the US will be investigated. Together these results will provide insight into these various topics to help inform Elstor as to the market potential of its product in a US context.

4.1.Elstor Oy Background

As aforementioned, Elstor Oy is a Finnish-based green energy technology company. Its primary product offering is a power-to-heat high temperature energy storage for industrial steam and heat production. The solution is designed to store energy in a way that generates emission-free steam and heat in a cost-effective manner. Elstor's technology is two-fold in that it does not only concern the steam industry and steam production, but also electricity, the grid, and the related reserve market. Elstor's technology captures electricity, generated through environmentally friendly ways, including wind and solar, to eliminate emissions. Elstor's technology stores electricity when prices are low, releasing it for use when prices are high, which is known in Finland as the reserve market, thus creating demand flexibility.

Since the purpose of this research is to determine whether Elstor's product offering has market potential in a US market, various factors will be considered before conjuring up a feasible market entry strategy or determining whether market penetration makes sense altogether. This process will involve consulting with industry experts working within the steam or electricity industry on the topics of environmentally sustainable US governmental incentives and regulations, regional variations in incentives and emissions regulations, and overall public policy. Therefore, the primary research method will be qualitative in nature, in which industry advice will be extracted from interviews. These experts will give advice based on which industry they specialize in, whether steam or electricity, offering additional suggestions for market entry strategies based on their own experience in industry and knowledge of additional programs and funding opportunities.

While proving to companies that cost savings exist for their company if they invest in Elstor's technology is of utmost importance when it comes to attracting clients, it is equally as important to understand the market and the way in which complex factors, such as politics, economics, population density, and natural resources vary by region, especially within a country as geographically large and dynamic as the US. For example, whether the state is Democratic or Republican can serve as an indicator as to which states would typically be quicker adopt greener methods of energy usage than others. Therefore, determining which US regions is a topic covered thoroughly within the interviews, as it is most beneficial to focus marketing efforts towards an area that would be most supportive of the technology.

Traditionally, when Elstor has gone about identifying potential clients, understanding the amount of steam or heat they need during their processes has been of critical importance. However, obtaining company-specific data related to steam usage can often be riddled with obstacles. Due to challenges surrounding the accurate measurement of steam, the simplified approach of companies to relay this information is to give outputs of how much electricity is used in their manufacturing processes. From these figures, it is possible to deduce estimates as to how much steam or heat may have been used in the process. However, obtaining these figures can at times likewise be challenging due to companies not carefully tracking this electricity input and output. Therefore, the act of finding companies who are either able or willing to provide this electricity consumption information often poses a challenge. One way in which Elstor has overcome this obstacle is by providing companies with measuring equipment, usually in the form of a meter, to measure steam use. Although this case study will not include sending meters to companies of interest in the US, inquiring as to what extent this strategy could be effective for gathering data on individual company steam usage, is a topic that will be covered in the interview discussions, as this research question related to quantifiable steam consumption was the one that Elstor was most concerned about at the inception of this research effort.

To conclude this case, attempts at determining a viable entry strategy for Elstor into the US market will be made, regardless of whether that route would lean more heavily towards the academia research and development route versus that of establishing an a business presence in industry. The culmination of this data collection will result in a prognosis as to what attempts at marketing Elstor's technology to any segment within the US seem feasible at this time.

5. Data and Methodology

The primary data collection method for this study was through interviews with individuals knowledgeable about some aspect of Elstor's technology or potential target market. This section will explain more about those who were interviewed while delving into the reasons for their selection as interviewees before documenting the process and outcomes of each interview. The conglomeration of the results based on each interview will ultimately serve as the advisory basis by which Elstor shall assess the feasibility of expanding into a US market at this time.

5.1.Research Methods

The research was obtained via interviews which were conducted in a semi-structured, organic manner. Most of the participants were asked similar questions, of which the prewritten questions can be found in Appendix 1. However, questions were not asked verbatim, but were tailored to each participant depending on the natural flow of the conversation and based on the area of expertise of each interviewee. Since the research grew to encompass many different aspects of the technology, consulting with experts from different industries meant that not all questions related to the various research topics were applicable to each of the interviewees. At times, some questions were asked, which were difficult for interviewees to answer, which resulted in a redirection of the interview towards other questions, which were more related to areas which were familiar to the industry that the interviewee specializes in. For example, since researching steam was one of the largest components of this research, asking whether it was possible to measure steam was at times asked of those who worked more with electricity and public policy. Some experts had some knowledge of how this was done if they knew more about energy production in general, although those working in the steam industry were best able to answer that question. However, most could answer in greater detail from the sustainability perspective to reveal which sustainable resources are predominately used in steam production used in steam production, or which could be used more often, in a theoretical sense. Most interviewees spoke to the knowledge they could provide, which was as related to the interview questions as possible. For that reason, most interviews took the shape of an organic discussion, rather than a strict question and answer dialogue.

While one set of questions was used for general interviewees, another set of questions was used for the couple of participants from the company Miura America Co., LTD (Appendix 2). Miura representatives were selected as target interviewees once it was determined that Miura was a company of interest, as it is one of the leading dispatchers of steam boilers in the US (About Miura America: Industrial Steam Boiler Manufacturer, 2023). Therefore, Miura was the most easily identifiable company involved in the US steam industry, which is most similar to that of Elstor. As a result, a couple of representatives from the company were contacted to learn more about the company's involvement in the steam industry.

5.2.Participants

To determine whether Elstor's technology has potential in the US market, industry experts who live and work within the US and specialize in topics related to the use of industrial steam, grid electricity, clean energy, and public policy related to energy use and consumption were consulted. Most of these experts were identified through the Rutgers Energy Institute directory (Rutgers Energy Institute, 2023). These persons included both academia folks, professors, and those with industry experience. Meanwhile others who were contacted were reached via LinkedIn. For example, the two Miura representatives who were interviewed were reached out to via LinkedIn. Meanwhile, those who were contacted via the Rutgers Energy Institute directory were typically contacted via email initially and were simultaneously added and messaged or followed up with on LinkedIn. At times, individuals who were contacted via email from their contact information having been listed on the Rutgers Energy Institute facilitated discussions with other Rutgers points of contacts who they perceived to be more knowledgeable about topics related to the research areas of interest. In a similar manner, one lone interviewee was contacted via the Minnesota Chamber of Commerce and was recommended by the secretary of the chamber. This individual was contacted by both email and LinkedIn.

Table 2 below provides an overview of the profiles of the individuals interviewed, their areas of expertise, their affiliation, and the type of interview they participated in. The table is indexed at zero since the first interviewee answered a questionnaire, rather than participating in a formal interview.

Table 2. Summary of interviewees selected for interviews.

Interview No.	**Interviewee Profile**	**Expertise/Research Area**	**Affiliation**	**Information Collection Type**
0	Engineering Department Representative	Engineering and Technical Support for Energy Companies	Miura America Co., LTD	Questionnaire
1	Electricity Industry Expert	Energy Policy and Electricity Markets	Rutgers Energy Institute	Phone Call
2	Regional Operations Representative	Nuclear Specialist with the US Navy; Experienced Sales and Accounts Manager	Miura America Co., LTD	Zoom Call
3	Professor	Agricultural, Food, and Resource Economics; Development, Energy, the Environment, Technology, and Trade	Rutgers Energy Institute	Zoom Call
4	Professor	Urban Planning, Planning and Public Policy, Green Building	Rutgers Energy Institute	Zoom Call

5	Professor	Supply Chain Management, Energy Systems, Operations Research	Rutgers Energy Institute	Zoom Call
6	Energy Industry Consultant	Traditional, Renewable, and Energy Efficiency Project Development	Rutgers Energy Institute	Zoom Call
7	Minnesota Chamber of Commerce Representative	Energy Market Expert in Distributed Energy Resources	Rutgers Energy Institute	Zoom Call
8	Technical Director	Physical Oceanography and Offshore Meteorology; Former Climate Change Researcher	Rutgers Energy Institute	Zoom Call

5.3.Information Collection

The primary method of data collection was via Zoom video conferencing interviews. One interview was conducted via phone call. Oral interviews were conducted either over phone call or Zoom call with similar questions being asked to each of the interviewees, regardless of whether their background and involvement with the steam industry was more academic- or industry-based, or both. One questionnaire was sent out with written answers having been received in response. The results of the questionnaire were collected via written surveys in which questions were sent out and responses were written down, recorded, and returned, with the results of which can be found in Appendix 3 below. Different sets of questions were developed for each set of interviewees, based on their affiliation and whether they were selected based on their employment at Miura or their affiliation with the Rutgers Energy Institute. The questions for general industry experts can be found Appendix 1, and the ones for both Miura representatives can be found in Appendix 2 below.

Only one employee from Miura was orally interviewed. However, this interviewee was likewise asked some of the general interview questions. The one Minnesota Chamber of Commerce representative, who was affiliated with neither Rutgers nor Miura, was asked questions from the more general set of research questions given in Appendix 1. Not all research questions listed in the appendix were used in every interview. Similarly, the two sets of interview questions have some similarities and overlap. Each interview lasted approximately forty minutes.

It is worth noting that the questions relate mostly to the steam industry, as this was Elstor's higher priority in terms of research. However, based on the research task expanding to encompass the electricity market as research efforts progressed, impromptu questions related to what is referred to in Finland as the reserve market were raised organically in the discussion, as were general questions related to electricity and sustainability, especially among those interviewees who were more well versed in the electricity market rather than the steam industry.

5.4.Interview Process

Each interview was initiated with a broad overview, or explanation, of the research project and the intended research task of determining a market entry strategy. The initial explanation included an overview of Elstor's technology and how it works and in which the typical client is depicted as a small-scale steam user like a bakery or a brewery. The introductory explanation concluded with the prompt of examining the market potential in a US market, requesting an opinion from the interviewee on what the best market penetration strategy would be. A few additional facts were mentioned, such as that Elstor's technology is most often powered by clean energy from wind and solar in Finland. An average payback period by which a company starts realizing returns after the installation of Elstor's technology, at least in a Finnish small business context, is roughly four years. It was also mentioned that gas and oil in the US is more of a self-contained resource, whereas in Finland specifically, gas and oil products have long been dependent on a supply from Russia, which can be volatile, depending on the political climate. Interviewees were prompted to offer their opinions in response to these additional pieces of information during various points in the conversation and given the natural flow of the interview.

Follow-up questions were asked both for clarification and to steer the conversation in a direction conducive towards answering more pertinent research questions. These questions may have varied based on the area of expertise of the professional being interviewed. However, they tended to be similar in nature. For example, these questions were mostly derived from the prewritten research questions contained in the first two appendices below, but they were not generally asked in order. The most common follow-up questions were related to inquiring whether the interviewee knew whether it was possible to uncover the quantity of steam used in production at a company level. Furthermore, there was a discussion around incentives versus disincentives on a governmental level, in addition to whether ERC's (Emission Reduction Credit's) exist and are utilized by companies.

At the end of each discussion, interviewees were thanked for their time and were requested to be followed up with later as needed. Following the interviews, each of the discussions were roughly transcribed, mostly based on the answers from the respondents and not including the questions asked or leading comments made. From these transcriptions, a written reports for each of the interviews transcribed. These transcriptions were edit and are contained in the section below.

Some of the interviewees reference similar concepts, meaning that there is some overlap.

Because the interviewees were oral interviews, the tone of the interview sections is written more in a colloquial style as opposed to a literary one.

Additionally, since many acronyms are used by interviewees, some of these acronyms are spelled out in parentheses for the sake of clarification. However, the following results section will begin by outlining some of the most commonly used acronyms and terms, complete with a table.

6. Results

Since the bulk of research efforts put forth in this thesis are derived from the industry expert interviews, this section contains detailed accounts from the discussions with the interviewees. Since each interviewee had different key points and a unique background, the information extracted from these interviews varied greatly in breadth and depth. Each interviewee and his background are introduced at the onset of each interview section. The interviews are labeled numerically in chronological order.

Interviewees are primarily broken down into two groups. There are those who work in academia and those who work in industry. Furthermore, the interviewees come from a variety of backgrounds and specializations. Some specialize in research related to the steam industry and steam production. Meanwhile, others have more experience regarding electricity and the electricity grid or market. Still others focus on renewable technology and public policy.

There was some overlap in the following interviews, mostly as regards the innerworkings of the electricity market and various governmentally ordained programs, as well as those at the state level, many of which were portrayed in acronyms. There were likewise some repeated terms that were used that were not necessarily related to either of these segments but were related to the energy market in some way. This section starts with an overview of the terms that require elaboration for clarity where additional information on these terms may not be thoroughly addressed in the interview portions.

Table 3. Key words, ideas, and organizations mentioned in interviews.

Term	Acronym	Definition
Anaerobic digesters		"Anaerobic digesters are simply an enclosed structure where anaerobic breakdown of manure organic matter

		takes place. The anaerobic microorganisms convert the organic matter into biogas, which then can be captured and utilized for energy as a flammable gas. Methane is the most commonly captured by-product from the digestion of organic matter, but carbon dioxide, hydrogen, hydrogen sulfide, nitrogen, and water vapor are also present" (ScienceDirect).
Ancillary services		Ancillary services refer to functions that help grid operators maintain a reliable electricity system. Ancillary services maintain the proper flow and direction of electricity, address imbalances between supply and demand, and help the system recover after a power system event. Ancillary services include synchronized regulation, contingency reserves, black-start regulation, and flexibility reserves (Greening the Grid, 2023).
Advanced Research Projects Agency–Energy	ARPA-E	"The Advanced Research Projects Agency-Energy (ARPA-E) advances high-potential, high-impact energy technologies that are too early for private-sector investment. ARPA-E awardees are unique because they are developing entirely new ways to generate, store, and use energy" (Arpa-E).
Build America Buy America Act	BABAA	"The Build America Buy America Act, enacted as part of the Infrastructure Investment and Jobs Act on November 15, 2021, established a domestic content procurement preference for all Federal financial assistance obligated for infrastructure projects after May 14, 2022. The domestic content procurement preference requires that all iron, steel, manufactured products, and construction materials used in covered infrastructure

		projects are produced in the United States" (U.S. Department of Commerce, 2023).
Business Finland		"Business Finland is Finland's official government agency for trade and investment promotion, innovation funding, travel promotion and talent attraction" (Business Finland).
Carbon Capture and Storage Norway	CCS Norway	"Various governments have worked to realize a full-scale project for capture, transport and storage of CO2 (CCS) in Norway. The Norwegian Parliament approved the full-scale CO2 management project in Meld. St. 33 (2019–2020) Longship - capture, transport and storage of CO2 in the state budget for 2021. A total of NOK 25.1 billion will be invested in the project. The government will cover approximately 2/3 and the industry will cover approximately 1/3 of the costs in the project's first phase" (Ministry of Petroleum and Energy).
Clean Energy Economy of Minnesota	(CEEM)	"Clean Energy Economy MN (CEEM) educates Minnesotans and policymakers about the significant economic opportunities provided by clean, reliable and affordable energy" (Clean Energy Economy of Minnesota).
Energy arbitrage		"Energy arbitrage is a simple concept: electricity is stored when kWh costs are low, and used or sold when kWh costs are high. This can be applied with small home batteries, medium-sized storage systems in commercial buildings, or utility-scale batteries" (Tobias, M 2022).

Electric vehicles	EV's	"All-electric vehicles, also referred to as battery electric vehicles (BEVs), have an electric motor instead of an internal combustion engine. The vehicle uses a large traction battery pack to power the electric motor and must be plugged in to a wall outlet or charging equipment, also called electric vehicle supply equipment (EVSE). Because it runs on electricity, the vehicle emits no exhaust from a tailpipe and does not contain the typical liquid fuel components, such as a fuel pump, fuel line, or fuel tank" (Alternative Fuels Data Center).
Heat pumps		"Heat pumps offer an energy-efficient alternative to furnaces and air conditioners for all climates. Like your refrigerator, heat pumps use electricity to transfer heat from a cool space to a warm space, making the cool space cooler and the warm space warmer. During the heating season, heat pumps move heat from the cool outdoors into your warm house. During the cooling season, heat pumps move heat from your house into the outdoors" (U.S. Department of Energy).

Inflation Reduction Act	IRA	"The Inflation Reduction Act (IRA) of 2022 makes the single largest investment in climate and energy in American history, enabling America to tackle the climate crisis, advancing environmental justice, securing America's position as a world leader in domestic clean energy manufacturing, and putting the United States on a pathway to achieving the Biden Administration's climate goals, including a net-zero economy by 2050" (U.S. Department of Energy).
Infrastructure Act		"This Bipartisan Infrastructure Deal will rebuild America's roads, bridges and rails, expand access to clean drinking water, ensure every American has access to high-speed internet, tackle the climate crisis, advance environmental justice, and invest in communities that have too often been left behind" (The White House).
Midcontinent Independent System Operator	MISO	"MISO (Midcontinent Independent System Operator) is an independent, not-for-profit, member-based organization focused on three critical tasks: - Managing the flow of high-voltage electricity across 15 U.S. states and the Canadian province of Manitoba - Facilitating one of the world's largest energy markets with more than $40 billion in annual transactions - Planning the grid of the future" (MISO).
National Science Foundation	NSF	"The National Science Foundation is an independent federal agency of the United States government that supports fundamental research and education across various fields of science and engineering. It plays a vital role in advancing scientific knowledge, promoting innovation, and fostering the development of a skilled workforce in STEM (science, technology, engineering,

		and mathematics) disciplines. The NSF funds research projects, provides grants to researchers and institutions, and collaborates with international organizations to promote scientific advancements and address global challenges” (Panchanathan, 2023).
New York State Energy Research and Development Authority	NYSERDA	“NYSERDA offers objective information and analysis, innovative programs, technical expertise, and support to help New Yorkers increase energy efficiency, save money, use renewable energy, and reduce reliance on fossil fuels. A public benefit corporation, NYSERDA has been advancing energy solutions and working to protect the environment since 1975” (NYSERDA).
Low Carbon Fuel Standard	LCFS	“The Low Carbon Fuel Standard is designed to decrease the carbon intensity of California's transportation fuel pool and provide an increasing range of low-carbon and renewable alternatives, which reduce petroleum dependency and achieve air quality benefits” (California Air Resources Board.).

Locational Marginal Price	LMP	“Locational marginal pricing is a way for wholesale electric energy prices to reflect the value of electric energy at different locations, accounting for the patterns of load, generation, and the physical limits of the transmission system” (ISO New England).
National Offshore Wind Research and Development Consortium	NOWRDC	“The National Offshore Wind Research and Development Consortium is a nationally focused, not-for-profit organization collaborating with industry on prioritized R&D activities to reduce the levelized cost of energy (LCOE) of offshore wind in the U.S. while maximizing other economic and social benefits” (National Offshore Wind, 2023).
Pennsylvania-New Jersey-Maryland Interconnection	PJM	PJM Interconnection LLC (PJM) is an American regional transmission organization (RTO) that operates within the Eastern Interconnection grid. It is responsible for managing the electric transmission system that covers areas in Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and the District of Columbia (PJM).
Public Service Enterprise Group Inc	PSEG	“Public Service Electric & Gas Company (PSE&G) PSE&G is one of the largest combined electric and gas companies in the United States and is also New Jersey's oldest and largest publicly owned utility” (PSEG).
Renewable Energy Certificates	RECs	“RECs are the accepted legal instrument through which renewable energy generation and use claims are substantiated in the U.S. renewable electricity market. RECs are supported by several different levels of government, regional electricity transmission authorities,

		nongovernmental organizations (NGOs), and trade associations, as well as in U.S. case law" (EPA).
Regional Greenhouse Gas Initiative	RGGI	"The Regional Greenhouse Gas Initiative (RGGI, pronounced "Reggie") is the first mandatory market-based program to reduce greenhouse gas emissions by the United States. RGGI is a cooperative effort among the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont and Virginia to cap and reduce carbon dioxide (CO_2) emissions from the power sector" (RGGI, Inc.)
Spot market		"The NordPool spot market operates both day ahead and intraday markets for the exchange of electricity. Prices are set using the merit order, scheduling electricity generation with the lowest marginal cost to meet electricity demand, ensuring the lowest cost of electricity for consumers. This is done for every hour of the year, 1 day ahead" (Clark et al., 2017).
Triple Bottom Line		"Triple bottom line theory expands conventional business success metrics to include an organization's contributions to social well-being, environmental health, and a just economy. These bottom line categories are often referred to as the three "P's": people, planet, and prosperity" (UW Extended Campus).
United States Department of Commerce	US DOC	"The Department of Commerce works with businesses, universities, communities, and the Nation's workers to promote job creation, economic growth, sustainable development, and improved standards of living for Americans" (USA Gov, U.S. Department of Commerce).

United States Department of Energy	US DOE	"The Department of Energy manages the United States' nuclear infrastructure and administers the country's energy policy. The Department of Energy also funds scientific research in the field" (USA Gov, U.S. Department of Energy).
United States Environmental Protection Agency	US EPA	"The Environmental Protection Agency protects people and the environment from significant health risks, sponsors and conducts research, and develops and enforces environmental regulations" (USA Gov, U.S. Environmental Protection Agency).

Rather than organizing the interviews in chronological order as they are in Table 2 above, the below interviews are categorized based on the four primary themes of the steam industry, the electricity market, public policy, and renewable energy alternatives, and depending on which of these themes is most predominant throughout the course of the interview.

6.1.Steam Industry Interviews

Questionnaire 1. MIURA AMERICA CO., LTD. Employee Supporting the Engineering Department.

The results of the first questionnaire are contained in the third appendix. The original questions asked are provided in the second appendix. Miura is a Japanese company, out of which it runs a larger product line. However, the responses provided relate to the US Miura branch only. Miura products sold in the US America produce steam using fuel gas in the form of either natural gas or propane, oil, or a combination of both. In the US space, Miura yet to attempt switching over to more sustainable forms of steam generation. However, Miura Japan manufactures a hydrogen-burning boiler product line and has explored other alternative fuels. However, these products have not been brought to the US market as there is not a present demand for them. However, Miura America has produced some biogas boilers.

The amount of steam used by Miura products is contingent upon the customer. However, Miura's product line ranges from approximately 1750 pounds (roughly 794 kilograms) of steam per hour to roughly 10,000 pounds (roughly 4535.924 kilograms). per hour per boiler. Modular solutions with multiple boilers are often provided to clients.

In terms of CO2 reduction efforts, salespeople generally handle this topic. However, most programs are regulated at the state and local level rather than at the federal level. In terms of ECR's (Emission Reduction Credits), Miura has provided boilers for projects based on these credits relatively often. However, Miura itself does not receive any of these benefits directly. However, Miura's technology often reduces emissions, particularly NOx. This also depends on the customer, and the project they are undertaking and whether it can be justified based on ECRs.

Interview 2. Zoom Call Interview Conducted May 3, 2023, with Regional Operations Representative from MIURA AMERICA CO., LTD.

This interviewee was an industry expert supporting Miura. His background is in the US Navy supporting nuclear power. Since he currently supports the steam industry, much of this interview was focused on steam and somewhat on public policy. This interviewee used many analogies and illustrations to make the information more palatable. Some of these will be retained below. It is worth noting that these questions were the most unique and can be found in the second appendix, whereas the other interviewees were asked questions from the first appendix.

The initial discussion was related to whether a more sustainably based steam boiler system could be something of value to a US market. One issue with renewables is, to illustrate, if 10 pounds (4.5 kg) of nuclear fuel can power a small city for thirty years, that fuel then becomes radioactive and needs to be stored. With steam production now being made from oil and natural gas, it's similar to knowing the life of combustion engines, which started with the Model-T. Locomotives had used coal, whereas the Model T used ethanol-alcohol and leaded gas. In the world of engineering, this was an innovation. In the case of engines, selecting a better fuel became the next step, because diesel burns, but it is considered a relatively dirtier fuel. Burning dirtier fuel means that the engine would eventually need more repair work. By comparison to diesel, gasoline and natural gas burn cleaner, meaning the engines will last longer.

Hydrogen is a fuel that can likewise be used as energy. With the trajectory of the growth of engines, at some point there was a switch to steam, which comes from water. It was originally used in boilers, like in the Titanic, where steam was being generated from burning coal. Next, steam boilers were powered by diesel in more of a flame thrower type of fashion, passing through with water to create steam. However, natural gas needs to be used precisely with this technology. In the example of Miura, the company wanted to make this process more compact. Rather than working with thousands of gallons (liters), it created a technology that works with 50 (189.2 liters) or 60 (227.1 liters) gallons. As mentioned in the questionnaire results, here it was also mentioned that Miura is trying to develop hydrogen cells in Japan. Tesla and EV's are a great example of making a process more sustainable. Although it is possible to make steam more sustainable, the next best question is why is the steam necessary? For each industry, the answer is different, meaning that each industry will have a more sustainable solution that is unique to that industry.

As an example, biodigesters take food waste and other forms of waste and store them in a container as they decompose. The gas produced can then be taken out and burned. In which industry are waste products being created that can then turn into usable energy to power another process? Another example is coffee grounds, which can be dried and compressed to make logs to kindle for fires. How much steam can be produced from making fire? Some components may be reusable, but how can they be reused? For instance, breweries use hops. Can hops be used in a biodigester? As an example, coffee ground recycling communities could be collaborated with. In the example of rubber tires, rubber requires a high temperature to melt the rubber into the needed forms. This is an instance where it would be harder to substitute the heat source. But electricity

can be either generated through solar, electrical, or gas turbines. An electric turbine is similar to an airline turbine but creates electricity and can generate a considerable amount of power. But the waste gas afterwards that the electricity makes is very hot. Could that gas be used in a steam boiler placed on the end of the turbine?

Steam generation and electricity generation can certainly coexist and move towards greater sustainability. A lot of it is based on the logistics of the manufacturers and is industry specific. The best way to get the most out of one cent of gas or fuel would be to have a city block, for instance, where an electrical turbine, a coffee shop, a brewery, and a pig farm all feed into each other from each other's waste products, creating an energy circle. There are no current incentives for reusing waste products. The most that's being done is by recycling and melting that waste down and reselling it. For instance, if Starbucks found a way to recycle their coffee grounds and then Dunkin Donuts found out, they wouldn't want that because now there is competition, unless it's to help the planet and we all agree that we should.

If Miura started making more sustainable steam boilers, it's fully possible that customers would buy them. But one concept that should be considered is the adoption curve (Figure 34).

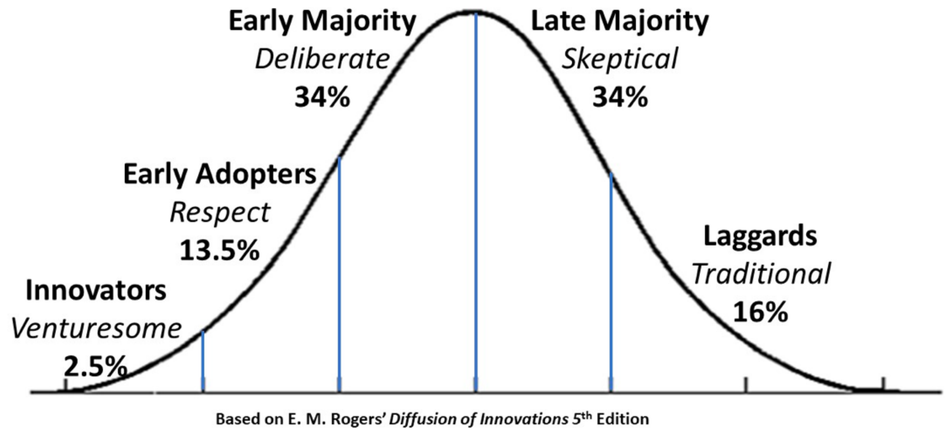

Figure 31. Adoption curve (CWBSA, 2021).

The adoption curve represents the hurdles needed to be overcome during the adoption process. In the adoption curve, there are early adopters who will adopt the product in the beginning, which will take years. Then there is the second wave of adopters who buy it. Several years after that, almost everyone has it. But there's always the 10-20% at the end who die saying they'll never adopt.

Will Miura invest in a more sustainable product? Now it's about specificity and trying to home in on profitability for a product that is already being produced. Since changing the power source would be a large-scale task, Miura could gain a competitive advantage by being the only company producing it. However, if Miura sees another company already invested in it, it might be more willing to follow suit, since it's less risky that way.

In terms of incentives, there are studies that cover the topic of incentives. To illustrate, sugar in 1960s and 1970s became a problem. The government started taxing it. The tobacco industry proved that you could tax these types of products highly and people still buy them. Incentives work, but they have to be simple and aligned with the goals of the tax. Nowadays it's necessary to write an easily understandable policy to prevent people from taking advantage of it. For that reason, a tax credit description would be very lengthy and riddled with qualifiers. Reduction is necessary, but it can be carried out by various means. It would have to be measured and verified by two independent third parties to keep companies honest. This creates an entire industry of people who take the time to read the hundreds of pages of the policy and will sell their consulting services to other companies to inform them as to what they can save.

In terms of incentives used by Miura's clients, it varies by state. New York and the surrounding region are more densely populated, meaning they have more emissions issues versus in North or South Dakota, where there's a lot of open space. Big industries will move to those sorts of places because the land is cheap and there aren't many regulations. They start polluting there and then a bigger city emerges around it. Then emissions regulations are created to manage what's going on.

Miura does not receive any of these types of emissions credits or incentives directly as a company. Their incentive is strictly the sales. California will start having stricter policies as they continue to lead the US in emissions restrictions. One target is to omit the sales of gasoline-emitting vehicles past 2030.

In terms of other industrial emissions, if California's policies are gravitating towards stricter emissions restrictions, Miura might be proactive about producing a boiler that could meet the restriction cap efficiently. There is a fine line of heat, temperature, and volume, where traditional boilers can't meet the demand. If Miura thinks it can, their new boiler would be the first one. Miura would benefit from that first mover strategy until a competitor caught up with them. Therefore, the government does not incentivize Miura, but Miura meeting their incentives brings in more business, thus attracting more clients and generating more sales.

With boiler steam generation, Miura has done a study from the last fifty to eighty years, where companies were roughly estimating how much steam they needed. If a company has four machines that need 100 pounds/hour (approximately 45 kg/h) of steam, then they need 400 pounds/hour (approximately 181 kg/h) total. Maybe the first few times, there wasn't enough steam, which are called steam losses, where steam leaks and heat is lost as it moves through the pipes. Engineering calculations are then made on this. There is head loss where, by the time the steam goes through to the end of the pipe, it's not the same amount as it was when it started. The next time the company goes to use the boilies, they double it and decide to get a machine that supports 800 pounds/hour (approximately 363 kg/h). The rule of thumb became that however much they need, they can just get more. Imagine now it's winter and they need 100 pounds/hour (approximately 45 kg/h). Once Miura started the study, it was quickly discovered that the machines were much larger than the facility could use. The machines would be inefficient because they were purchased to handle 1000 pounds (approximately 456 kg), but they are only being used for 400 (approximately 181 kg). It's like having a racecar engine only going five mph just in case it needs to go fast. Between the 1900s and up until the 1980s, that's how all companies were estimating. Miura went to about 8,000 customers to track how much they need versus how much they were using. Fifty percent of the customers were oversized. There's a management phrase: You can't manage what you can't measure. The reality was that there were not any companies making meters for easy measurement of steam calculations.

Steam is made from water and gas. Gas turns into fire and heats up the water. Steam tables are used in engineering. The hotter the steam, the more force and energy it has. There are different levels of pressure for steam. Low-pressure doesn't start until 15 psi. Standard is about 70-270 psi. High is 300-400 psi and can't go above that. But electrical generating steam is 400 psi and up. These different levels can be found in steam tables. A complex graph with a hump in the middle can be found. The amount of energy required to get to certain sections of that graph varies substantially. The amount of energy required to get to certain sections of that graph varies substantially.

When steam is contained and the pressure is raised, there is entropy. Between volume and temperature, it's harder to measure the steam. Between the 1980s and now, there have only recently been companies that have become relatively successful in measuring steam accurately. Previously,

the measurement would be taken from water and gas as a guesstimate to how much steam was being produced, but the actual amount of steam would be unknown since some would be escaping via leaks and steam traps. Steam usage is a hard thing to measure and when companies are offered expensive equipment to measure the steam, they usually choose not to. It's a cost to manage the cost. With this different process in house, a different expert is needed to run that. Adding measurements can be too complicated. Most companies would need a process as simple as a person going in, pressing a button, and walking out. Overall, they aren't interested in taking on the additional work to measure their steam usage.

The bigger clients may decide to invest in a technology like Elstor's if there are no machines that meet the need that Elstor does. While it is possible, the adoption rate is what's most concerning for investors. They want to know how soon they will get their money back.

It could be a while before Miura invests in something greener, like hydrogen, to sell to customers. In the realm of electricity, electricity is usually at a higher steam pressure, which takes more energy to produce. Electricity is a different industry than Miura's lower pressure steam generation, where the steam is generated, because steam is used in breweries, dry cleaning, or manufacturing tires, while electrical steam generation has different companies doing that. That would be more of cogeneration plants. There are companies that make cogeneration plants where a microgrid is created, like in Puerto Rico. Instead of having one grid that powers the whole island, which might cause all the power to go out during a storm, the cogeneration is a microgrid whereby small generators are all over the island and power ten to twenty blocks. When half of them go down during the storm, the other half can still supply people with power, thus providing power to 75% of the island. But co-generation had a different manufacturing process, industry, and goal behind it.

6.2.Electricity Market Interviews

Interview 1. Phone Interview Conducted on April 25, 2023, with Energy Policy and Electricity Markets Expert.

This field expert is an electricity market and policy researcher, educator, and director. His research interests include the reliability and economics of electricity markets, state energy policy, energy efficiency and renewable energy evaluation, and integrated energy modeling. He was contacted through the Rutgers University Energy Institute, even though he now works in industry, currently supporting an independent electricity consultant company.

Since this discussion was being conducted with an electricity expert, the discussion was more so focused on the topic of electricity, as opposed to steam, and started out with a question related to what is known as the reserve market in Finland. The question was whether the electric grid stability control reserve market exists in the US as it does in Finland. However, the interviewee hadn't heard of the like in the US. Rather he started off by providing more general information related to the electricity markets in the US. Something that he pointed out, and that continued to be a recurring theme throughout the duration of the remaining interviews, is that the electricity markets in the US vary by region, which, as previously mentioned, differs starkly from that of Finland where electricity prices are standardized, regardless of where in the country the electricity is being accessed. This interviewee described the two different market architectures, which were regulated versus deregulated markets, with the Regional Transmission Organization (RTO) or Independent System Operator (ISO) being one structure. He explained how there are five or six of these kinds of markets, covering over half of the US market, including New York, New England, Texas, California, the mid-continent, and the mid-Atlantic, which is called PJM. PJM includes Pennsylvania, New Jersey, and Maryland. Since the majority of the folks who were spoken to have lived or worked in New Jersey at some point in their career, due to the affiliation with Rutgers University, which is the state university of New Jersey, PJM was mentioned often, especially among the electricity specialist folks.

The second structure is a vertical utility structure, which accounts for roughly 45% of the remaining part of the US operations. It has no formal, transparent, operating energy reserve market. One issue is that at the wholesale market level, there are these two separations. Additionally, there is another layer given the focus on smaller scale customers. In the US, around 20 states participate

in the RTO market. Out of those, most have retail electricity markets, which allow a bakery, whether large or small, to directly or indirectly, more easily access an energy service company type of a market which, in turn, accesses these wholesale electricity markets. When a state has a wholesale electricity market, different opportunities emerge. Many of these states that have resale electricity markets also have natural gas electricity markets, which could be relevant based on how the steam is being generated and whether it's by natural gas. Therefore, the two layers that could be considered are wholesale and retail. For big states, like California, Texas, and New York, and

the industrial northeast, where the population is high, these RTO markets generally have retail electricity markets as well. For instance, with bakeries specifically, there are a lot in the New York City area.

Within the RTO-ISO market, they have two or three products that this technology could take advantage of since the technology allows storage. The RTO market breaks down electricity by megawatt hours or kilowatt hours. Anyone can buy and sell electricity in these RTO markets. Similar to the reserve market concept, this technology could buy when prices are low. When they're high, the steam could be sold as electricity. Rather than a reserve market, there is a real-time electricity market. It technically changes prices every five minutes. For every unit of time, be it every five minutes or an hour, a company could decide to buy or sell electricity and try to arbitrage those differences, whereby electricity is being stored in times of low and selling in times of high.

In states that have retail electricity markets, typically those states are within an RTO, and, therefore, this hourly energy market exists, plus at least one other market usually, anyone can become a retailer. Any company or business partner could hire a company to manage this type of arbitrage, or the company could become a member of the New York ISO or PJM (Mid-Atlantic) or MISO (Midwest) itself. Retailers don't necessarily provide better prices because anyone could become the retailer at a relatively low cost. In this scenario, a viable business partner, or service provider, would also be a member of the New York ISO, that would enable them to buy and sell power, even if those companies themselves don't physically own the power. This can be done speculatively without owning the generation or the demand. The company or partner company would be a member of the New York ISO. Prices vary by both unit of time and the city. For instance, in the case of New York City versus upstate New York, New York City has more demand and , therefore, higher prices. Prices vary by weekends and night hours. All these historical prices

are publicly available on the ISO's website and can be compared between New York and Manhattan. There are different zones, like Long Island and others. Examining these historical price differences and determining whether there is enough of a difference between the highs and the lows, could be one method by which Elstor could determine whether its technology would be profitable in this market. However, there is no guarantee that future prices will look similar, which is where some business analytics work might be required.

Trying to arbitrage electric energy is known as the energy market in the day ahead of the real time electricity market. Rutgers University could do this. It would produce its own electricity, or it could buy from PJM. They had a computer program, and they would see the spot price, or the real time price at their control center. They hired a company to help them do this. Then they had the person operating the cogeneration facility. They would look at that price and forecast that price. For example, on a hot summer day, the price will be higher, so they would produce more electricity. If the prices were low, because it was a mild weekend, such as the Sunday of Memorial Day Weekend (in late May), they wouldn't burn the gas and make electricity. That would be too expensive. They would just buy the electricity. They would do this on an hourly basis. They would know their price of gas and how much gas it takes to make electricity. They would compare their costs of making electricity given PJM's costs with buying it from the grid. Another product that Elstor could provide that is perhaps less valuable and more complicated is operating reserves, or the ability to provide that and other ancillary services to the grid. There is a market to do that, typically to provide operating users these ancillary services, it's based off the energy price. Buying and selling energy in the form of electric megawatt hours is the preferred option. Although it's more technical and complicated, ancillary services could be a viable option by which to provide additional revenue.

In terms of metering, if a company is using a lot of steam, then it's worth metering. Rutgers University, for instance, uses 20-25 megawatts. It can be thought of as being like a small town. As a massive campus, it essentially is. Large food processing or paper mills use a lot of steam, maybe in the order of 100 megawatts. A household or small bakery probably uses not even megawatts worth of electricity. It's probably being measured in kilowatts. For example, a bakery in the northeast is using a boiler to burn natural gas to make the hot water or steam they're using. They aren't measuring actual steam, but rather they'd be considering what they're getting billed for, which is the amount of natural gas being used. Although steam can be made from electricity, that's probably not the preferred way. Large entities using steam, like in food processing, at an industrial facility, or a paper mill, are more likely to have that information as to how much steam they're using, but whether they want to disclose that information to is a different story. They have a dedicated boiler making the steam where they are measuring the gas going in and the steam going out. Therefore, they usually want to know the temperature, the pressure, and the volume. A follow-up research strategy for Elstor could be finding examples of facilities that are in the sweet spot in

terms of energy usage. Entities that use a lot of steam are large hospitals, prisons, college campuses, or places where there are residents and a cold or very hot environment, like Singapore. Food processing facilities, papermills, and co-generation where steam is being used for heat are other examples.

In terms of incentives, at the federal level, there is the recent Inflation Reduction Act (IRA), which has been signed by Biden. There is the sister Infrastructure Act. Between those two pieces of legislation within the last year, there are a lot of incentives to reduce CO2 emissions, which means reducing the use of natural gas, greening the grid, and promoting energy storage. There are different tax incentives and grants. An integral part of the Infrastructure Act is clean energy. There are incentives for energy storage and for heat pumps to provide both heating and cooling, which use electricity. There could be benefits from Elstor's technology to the extent that it reduces the need for steam in heating.

Many states are pushing clean energy, like California and the northeast. You can look at states that are aggressive, like California and New York, which both have RTO markets. There are pushes to eliminate gas stoves in new facilities and for heat pumps to replace natural gas boilers. The third state to consider would be Massachusetts. But starting with New York and California could prove most advantageous. The northeast tends to follow California.

The northeast and California have markets for CO2 emissions that are based on a cap-and-trade model. Those are embedded. New York is a member of "Reggie," which stands for the Regional Greenhouse Gas Initiative (RGGI, pronounced "Reggie"). They have a cap for their northeast region, which is part of the Mid-Atlantic region, on CO2 emissions. If a company emits a copious amount of CO2, it would then have to buy an emissions allowance. This affects supply and demand and ripples through to the energy price. With the buying low and selling high model, those in the allowances that are purchased or avoided are embedded in part of the price already. In a state that wasn't part of RGGI, it wasn't part of the cap and trade. As an example, there is Ohio. To the extent that they value emission reduction as part of their state policy, they have enacted incentives to reduce emissions and have incentivized related technologies via grants, tax incentives, or rebates. This stresses the importance of considerations being made on a state level. Unlike Europe, the US does not have a national greenhouse gas treaty or price on CO2.

Cleaner or greener ways in which steam is being produced in the US could be due to forestry. For instance, if there is a paper mill where wood is being processed, waste wood is being used where possible. In the northeast, once electricity is sourced, the company doesn't usually turn around and make steam. Once solar or wind is sourced, that is then used that for electricity, because there is already enough of it, rather than taking the efficiency loss and using that electricity to then make steam. Typically, the electricity would be the higher value. Going from electricity to steam is nonsensical since the electricity market in the US is so large. The exception would be with agricultural waste products, like wood and forestry, which can be burned and used to produce steam. However, the most sustainable way that steam is currently being produced in the US is arguably by natural gas first since it's widely available, clean, and relatively cheap, whereas oil is to a lesser extent.

The problem is that biomass is expensive to transport, meaning that the agricultural, wood, or waste source needs to be located nearby. If natural gas or methane was coming from a landfill by rotting garbage or food waste, the energy coming from that is very diffused. You would need a lot of biomass to either turn into methane or to burn to get units of energy. It's expensive to transport because it's not energy dense. It doesn't make sense to take forest waste from the pacific northwest to the northeast to burn. More money would be spent on oil on the transportation costs alone because it's bulky and not energy dense. Therefore, for biowaste, there has to be a radius within which it can be used, like one to two miles, rather than a hundred miles from site. Burning biomass releases CO2, but if it is left in the woods to decompose, it releases methane. Therefore, burning it for fuel creates a net zero impact.

In terms of whether there is an issue with energy density and the cost associated with renewable sources, such as wind and solar, whether the steam can be replaced with electricity is a consideration. With respect to heating, with a heat pump process, it depends on the process. In some processes, the steam is entirely necessary and cannot be replaced.

Electricity is used to make hydrogen, which is then used directly to be burned as a gas. Hydrogen is difficult to transport. Therefore, it must be made into ammonia before doing so. That would be the other route, whereby hydrogen is made from electricity. Electricity is made from solar or wind to make it clean. Or another option is taking the CO2 emissions from oil or gas, capturing them, and storing them in the ocean or underground, which can be expensive. The other path is hydrogen. With the different federal legislations previously mentioned, there are large incentives for hydrogen.

Hydrogen can be obtained from wind when an H20 molecule is split and the hydrogen is retained. That molecule can then be burned to replace natural gas. But there are several steps. The hydrogen has to be converted, stored, and transported. It could be done on site with the use of a boiler that can handle hydrogen as opposed to natural gas. However, due to the complications of it, this would likely be a longer-term plan.

Currently, very little, if any, hydrogen is currently being used. It's being used in refinery processes as part of turning oil into products, like gasoline. People aren't using hydrogen today to make steam. They are using natural gas or oil. People have been arguing about whether we should switch over to hydrogen for 30 years, but it hasn't happened yet.

Interview 4. Zoom Call Interview Conducted on May 5, 2023, with Urban Planning Professor, Center Director, and Associate Research Dean.

This interviewee works in academia. He teaches public informatics and planning courses and performs research on how people interact with aspects of their environment which have been built for them. This discussion included topics related to both the steam and electricity markets and touched upon public policy, although electricity was the primary theme.

The discussion started off and largely continued to pertain to discussing market strategies and potential for battery storage devices for the electricity market. In his opinion, since the storage market is a highly differentiated market, it is imperative to select a specific niche. One consideration is the duration of storage and whether Elstor's device operates on a scale of hours, as opposed to milliseconds. Likewise, whether the storage is seasonal or at the capacitor level should be considered.

Thermal storage was the next discussion topic. Related to the topic of heat pumps, one viable submarket in the US could be ice storage rather than heat storage since electricity in the US is more expensive in the summer than in the winter due to the use of air conditioning. For that reason, it is more valuable to shave the cooling peak than the heating peak. However, this is starting to change as heat pumps are being used more often, which provide both heating and cooling, using electricity as the primary heating source. Therefore, in places that have begun to use heat pumps more often, there is now a summer peak and a winter peak. For this reason, determining whether there is seasonal storage could prove beneficial.

Although Elstor's target market is not necessarily involved in the wholesale market at this time, the next portion of the discussion was related to the wholesale electricity market. One US market segment for storage devices serves the purpose of helping the wholesale electricity market to function well. One example is related to the large hydro-pumped plants located where there is a reservoir present atop a mountain. These devices can store a large quantity of megawatt hours of energy at a time. Water is pumped up into the device during the cheap hours of the day and pumped down through the generators during the expensive hours with the purpose of stabilizing the overall wholesale electric grid at a regional level. While this technology may function similarly to that of Elstor's, since this technology concerns the wholesale market, which Elstor does not serve at this time, this segment may be one which Elstor should not consider in the immediate future. However, related to this topic, which is tied to grid stabilization, the concept of the spot market was mentioned. PJM, for instance, has a market for energy storage devices. Since investors are interested in storage technology, which could earn them money in the spot market by offering services, depending on the scale of Elstor's technology, this type of market entry strategy could present a future prospect.

The wholesale bulk power grid has transmission lines and large powerplants that funnel down to locally powered substations and distribution systems, which deliver power to households via utility poles and transformers. This smaller scale energy system at a household level via substations may be a more feasible market in the context of Elstor's technology. The need for this type of technology stems from an increase in more sustainable technologies, such as solar panels and EV's being used at a household level, which puts more stress on the grid, thus creating grid instability. Therefore, there is a clear market for energy storage at the local level, which could mean either on the customer side in a household basement or in the utility room of a small business, or on the utility side at a substation. An example of where there could be a need for any of these would be when there are power outages, caused by a natural disaster, as was the case with Hurricane Sandy in New Jersey in 2012, or for any other reason. For those households which were unable to obtain local generators and gas to power them, they didn't have access to electricity. But because obtaining gasoline became both limited and time-consuming during a hurricane power outage that lasted up to two weeks in some places, in that event, there is a need for a storage unit being powered by a source other than gasoline. The only other option would be a natural gas-powered generator. An example where something similar to this is being done already is with Tesla power walls, which are designed to work in harmony with solar systems. The solar on a roof generates electricity during the day during which some of it is transferred into a battery storage system, which will then discharge the battery during the night to provide electricity.

Another market opportunity would be that of the ancillary services market, in which there are attributes by which the presence of electricity can be adjusted. In North America, a typical load would be met using 60 cycles per second of alternating current. When a greater than standard load is added to the grid, such as charging an electric car or using fluorescent lights, the distribution pattern of electricity loses sync with the others by which one portion of the 60 cycles per second starts to lose phase with another portion. An alternating current system benefits from having a high level of electrical inertia in the system that keeps everything looping at the same 60 cycles per second at the necessary voltages. This is the difference between real power and reactive power. For instance, solar systems produce real power, but they don't produce the inertia needed to stabilize the grid. Therefore, there is a lot of interest in the kind of storage that can add inertia to the electric power grid system at the local level and offset that weakness of solar by providing reactive power to bring both the real and reactive components into sync together again. This could be market opportunity since this is something that utilities companies are willing to pay for.

Another type of ancillary market would be voltage support. In the US context, the objective is to be as close to 120 volts as possible. If too many items are using electricity at once, the voltage of each of them may collectively reduce by a few voltages. Therefore, the utility companies are willing to pay for locally provided voltage support. In the battery storage world, the battery storage devices are offering not only storage of the energy, but also ancillary services, such as voltage support and reactive power regulation. Therefore, it is possible with a technology like

Elstor's, competing in the ancillary services market may be an opportunity for a market entry strategy.

Segueing the discussion towards that of the steam market, Finland and the United States differ in terms of district energy systems, such as it relates to water pipes under the ground as an example. In terms of larger district heating systems, there tends to be economies of scale in a US market. In the United States, district heating only exists in very largest cities, like Chicago or almost every state capital. But in Finland, it is there by policy choice all the way down into villages of 1000 people, because there has been a collective decision to provide space heating on a community basis. Likewise, because there is a large biomass resource in Finland, at one point, there were a lot of wood-fired powerplants, or steam plants essentially. By comparison, in the US context, steam is widely used in the biggest cities, but it's increasingly being replaced by hot water as the distribution medium. New York still runs on steam, but most district energy systems at this point are hot water. Places that have district energy in addition to big cities and capitals are college campuses and hospital complexes. However, US density is different than European density in that European density is much higher, with New Jersey being an exception. As an example, the US on average has approximately 68 people per square mile, while NYC has 60,000 per square mile.

In terms of answering whether companies are motivated to reduce their CO2 emissions, New Jersey, New York, most of New England, California, Oregon, Washington, Minnesota, or any of the blue states, are pressing hard on solving global warming problems. Therefore, in these states, there are large scale plans, incentives, and regulations, which are usually more progressive than those that are administered by the federal government is. With Biden as president, more attempts are being made at catching up to where these states are. But in Alabama, Texas, or Kansas, these policies don't exist. Therefore, in terms of choosing a regional market, it makes the most select a market where there is stable support.

In terms of others forms of steam production which could come from more sustainable means, geothermal is a power source that is highly localized where there are guizers, such as in California and throughout the pacific northwest. In the European context, Italy, for example, has always used geothermal where there is Mount Etna, for instance, since the volcanism that is present means there is water in the grounds. The Philippines also has geothermal accessible, as does Japan, but to a lesser extent, since guizers in Japan tend to carry a religious significance tied to bath rituals, rather than using them for utilitarian purposes.

In terms of which organizations to consider, rather than the EPA, the DOE funds millions of dollars' worth of research programs per year. There are small business integrative research grant cycles, but because the DOE wouldn't fund a Finnish company directly, Elstor would need to find an American company to work with. The benefit of this path is that these funding opportunities are steadily funded and aren't subject to the political whims of who is in Congress or President.

In terms of ECR's, most US policies today are set up on the incentive model rather than the disincentive model. At the federal level, there are tax credits, production tax credits, and investment tax credits. That was a source of contention between President Biden and Senator Manchin of West Virginia, who was unwilling to support legislation that imposed a carbon tax. Ultimately, what passed as a law was the incentive-based framework. Several major US jurisdictions, with New York City being the largest of them, have had benchmarking programs where every building for several years has sent a report on CO2 emissions related to their electricity, natural gas, and water consumption. New York passed a law that by 2030, buildings must cut their emissions in half. And by 2040, they must cut their emissions to 0. This can be seen as an aggressive timetable since buildings can last for hundreds of years and heating and cooling systems for decades. However, it is likely that there will be a lot of pushback and probably many exemptions granted on the grounds of economic hardship. However, this is one of the first real regulatory hammers trying to change things. Berkely, California and New York City are the only two jurisdictions to have passed this into law. However, it's likely that these types of programs will become more commonplace in the coming years.

In terms of addressing trying to penetrate a new market during a potential recession, either academia or selecting a supportive regional market could be viable market entry strategies in which entering via a small pilot program would be most feasible towards introducing the company into a US context. Collaborating with a local partner would be most beneficial if pursuing governmental funding is the end goal.

Buy America is a program by the DOC with pursuing governmental funding as the end goal. Buy America is a program by the DOC which has returned in recent years and would be worth considering if working with a US partner.

In terms of regional efforts, Minnesota could be advantageous since it has reasonably progressive energy policies. The state restructured its utilities early on, implemented district energy systems, and have attempted wind farms. In terms of culture, it might be the best fit given that is has a Finnish American Chamber, along with a Finnish population to support it. The only drawback could be a limited market due to Minnesota only having a couple of big cities, with most of the state being suburban and rural. However, once the company can obtain one or two customers from an installation, the business will naturally grow from that point forward.

Interview 6. Zoom Call Interview Conducted May 8, 2023, with Energy Specialist and Consultant.

This interviewee works in industry as Vice President for an energy, environmental and public utility consulting firm. He has over a decade of experience supporting complex energy issues related to traditional, renewable, and energy efficiency project development, regional transmission

related to organizations, economic and tariff analyses, and energy procurement. Based on his experience, this discussion primarily focused exclusively on electricity markets.

In terms of market potential, it depends on the US region since energy markets in the US differ by region. There is the typical energy market where energy is bought and sold. There are also capacity markets, which are a type of reliability market, where companies are paid for being online and available in the event of a future need. There are different types of ancillary markets, like regulation, reactive, black start, synchronized, and non-synchronized reserve.

What Elstor would consider the reserve market sounds similar to what would be called demand response in the US. Within PJM and most of the markets, companies can participate as a demand response resource in several ways, such as aggregating thermostats or turning boilers on and off using a generator at a facility. Within PJM and most of the other markets, guaranteeing participation for a set period of time is a requirement. The device needs to be able to be turned on in a certain amount of time, like 5 minutes, 15 minutes, or an hour. The provider would make revenue simply from being available, regardless of whether its energy was used or not during that period.

Charging during low price times and discharging while they are high is referred to as energy arbitrage in a US market context. Since Elstor's technology is likely being installed at sites that use the steam, it is important to keep in mind that retail customers aren't always directly exposed to energy markets. There's a price every 5 minutes technically, but residential customers only see a flat price, as do some commercial customers, meanwhile other commercial customers have exposure to the market. Energy arbitrage requires market exposure, which is possible depending on the state and whether it is regulated or not. Deregulated means that the delivery utilities don't own the generation, meaning that customers are free to shop. If a state is deregulated, or vertically integrated, meaning the utility owns the generation and the distribution, the market is likely inaccessible. The regulation of the state is related to its political leaning, where regulated tend towards the right and deregulated tend toward the left. However, Texas is the exception in that it is deregulated, but right leaning.

In terms of steam, if the technology produces steam by electricity, and the electric grid being used to produce the steam is cleaner, then the steam production process itself would have a lower emissions profile. If the grid is dirtier, the emissions would be, too. This fits with the guise of electrification that is a popular movement of electrifying everything. Within the movement, there

is a push for EV's, and electrifying all equipment by eliminating gas boilers, for example, and replacing them with electric heat pumps. Electric induction stoves are replacing gas stoves. Switching all site-based equipment to electric promotes the idea that as the grid shifts and becomes cleaner, the power that is sourced to run all that equipment will be cleaner, and eventually 100% renewable.

In terms of grants available, there is the DOE loan office and, and at the state level, NYSERDA. New Jersey has its own R&D programs, too, whereby the state offers incentives to end users to purchase energy efficient equipment. All the utilities companies in New Jersey have energy efficiency programs, where there are incentives for, or money towards, upgrading equipment.

Not every state has these types of incentives, as it can be politicly leaning with New Jersey, New York, and Massachusetts being some of the primary states that have them, along with most of the northeast. California and Maryland the Midwest have incentives, too, but to a lesser degree.

In the northeast, “Reggie” exists as a cape and trade program for electric generators, where companies are required to buy credits. In the bakery context, and based on the scale, the small business is only thinking about carbon if they want to. The people who push the electrification movement are of the mindset that it shouldn’t be a choice. They want to eliminate all carbon forms of power and don’t want the bakery to have an option other than purchasing the electric source piece of equipment. But as it stands now, people can do what they want. There are codes and standards that each state is required to abide by, but there are no minimum efficiency standards at the federal level.

On the electric sourcing side, there are programs where electricity can be purchased via RECs (Renewable Energy Certificates), whereby a company buys the rights to production through solar or wind. A company can then claim that their electricity is being produced by renewable means.

Priot to entering the market, it would be wise to consider demand response and energy efficiency programs, which vary by state or by utility within a state. Furthermore, involvement in an R&D program could likewise be a plausible market entry strategy, but this depends on whether Elstor itself is already commercialized or still at the R&D phase itself. If Elstor only has a few customers in Finland now versus tens of thousands throughout Europe, it is likely that going the R&D route is feasible, which would allow the technology to be tested out and further developed. In terms of

Elstor making use of energy reduction credits once it has become established, there are a plethora of energy consultants out there that help companies take advantage of US incentive programs. Elstor would either pay out of pocket for the consulting or the consulting company would receive a percentage of the income once Elstor begins taking on clients. Energy efficiency is of greater concern in the wholesale market, meanwhile the emissions reductions path is largely voluntary.

From a business perspective, it can be challenging to run a business and build a product that people want to buy. In the instance of the electrification movement, which has taken hold among the environmental community, the state government assists in influencing this. However, at the federal level, the IRA (Inflation Reduction Act) has passed, providing a large sum of money for emission reduction. Therefore, the timing of entering the market fits well in that regard.

At the end of the interview, the interviewee mentioned it could be beneficial to consider pairing up with a US-based startup, called Enduring Planet, which helps small companies that are combatting climate change to raise capital to expand. However, as is the case with some other funding opportunities already mentioned, this strategy would likely prove plausible only once Elstor has already established a US presence.

Interview 7. Zoom Call Interview Conducted May 17, 2023, with Energy Market Expert and Finnish American Chamber of Commerce Representative

This interviewee was contacted through the Finnish American Chamber of Commerce Representative located in Minnesota. He also works in energy consulting, providing policy and testimony support, business development, and training in wholesale energy markets.

In terms of selecting a viable market, identifying and selecting states and utilities that have a high peak rate and low off-peak rates could prove advantageous. Likewise, considering the states that are most committed to sustainability efforts is imperative. For instance, that would include California, New York, and Hawaii, and considering their time of use rates for electricity would be beneficial. Coupled with that, data from the Department of Commerce (DOC) or the Business Industry Consortium may reveal how much steam most businesses use. Therefore, combining steam use information with where there is potential for high renewable energy penetration, such as in states like Minnesota or California, may make it clearer where in the US to first attempt to enter the market. Deciding on a definitive region is the first step, however.

In the instance of selecting Minnesota as the target state for market entry, Elstor could become a member of the Finnish American Chamber of the state and work with Business Finland and the Finnish ambassador. The next step would be networking by attending related events, speaking with potential partners, explaining the technology, and setting up meetings with contacts established from these events. This route would allow Elstor to finetune its market entry strategy and determine whether there are potential candidates for a partnership. Meetings could be held both in person and via Zoom, depending on what is most convenient. Most people these days are willing to join a quick Zoom call.

The eventual business objective here would be to have at least one company, industry, bakery, or brewery adopt Elstor's technology. One consideration is that a Finnish bakery or brewery operating in the US is more likely to want to buy this technology from a fellow Finnish company. Thus, attempts at selling this technology to Finnish companies in the US may be a viable market entry strategy.

Once Elstor has one client in the US and the proof of concept is there, obtaining other clients has will have a snowball type of effect. Marketing to new customers via a referral program, which offers a reduced rate could likewise be an attractive option. If efforts start out more experimental, through a pilot program, for example, once that proves effective, mainstream adoption with expansion, scaling outside of Minnesota will occur naturally. Only a mere one to two clients are needed for expansion and scaling. If the technology is already ready to enter the market, it may not be necessary to go the academia route at all. In that event, starting with a pilot in industry would be the bare minimum of what is needed to enter the market. The issue with going the academia route is that the technology could remain in an academia circle in which research continues and papers are being written about the technology, but the technology is never taken to market. This is because academia people often have a vested interest in the academia route and the proliferation of this technology throughout the academic world could result in grants, which will benefit universities and research. By comparison to working with other companies directly, companies want to turn a profit to make money to pay employee salaries and pay out stakeholders. Going directly to market with clients in industry with a unique selling proposition is likely more advantageous. However, it is a matter of time, resources, and personnel. Theoretically, doing both is possible with enough resources. But if either of those resources are limited, going the business or industry route is more feasible. Focusing on small scale bakeries or breweries first would be a

wise move before starting to scale. Once cash flows are built up and additional people are hired, scaling is much more plausible. Getting involved in the academia route, if anything, should happen organically.

In terms of holding off because of the impending recession, an argument can be made for this current time period providing a prime opportunity for market entry, since the present administration is in favor of climate reduction. There are a lot of strong signals from the White House policy wise with their net zero goals by 2040 and in states like New York and California, this timetable is being sped up even further.

In terms of a time frame, starting these conversations takes time and people take time to react. They won't jump on the bandwagon with this type of new technology right away. Rather, they'll proceed with caution. It usually takes somewhere between three and six months during which people think about new information before they act. Therefore, the sooner Elstor's technology is present in people's minds, the sooner they'll begin adopting the technology. Information about the technology could be spread via a one-pager targeted at the target market, detailing the cost and function associated with the technology via graphics. Partnering with a Finnish American Chamber would help to expedite this process. Furthermore, Minnesota isn't the only chamber. They are also located in San Diego, the Bay Area, and New York, all of which would be all willing to help. These chambers can help with getting Elstor's logo on the pamphlets used by different organizations to get the idea into the minds of prospective clients. In this case, Elstor becomes a familiar company. However, there needs to be an initial proof of concept needs to be evident. Once it is, people and organizations will be more inclined to do business with this company. Meetings with the chambers likewise do not involve membership. Therefore, they can be set up at any time.

Another organization worth considering in terms of prospective clients is the Clean Energy Economy of Minnesota (CEEM). Furthermore, there is Finn Fest in Duluth happening at the end of July and this year's theme is sustainability-focused, thus providing an opportunity to meet with the Minnesota utilities companies. In fact, 60-80% of Finns in the US live in the Duluth area.

In terms of the electricity market, this interviewee was familiar with Fingrid as he had previously partnered with them on a project. Since the idea of the reserve market comes from Fingrid technology, the verdict was that something akin to the reserve market does exist in the US, although it is not necessarily called that. However, these types of reserve markets include energy storage, as was previously in other interviews. The potential for this type of storge in the US would be most related to pump storage, as previously discussed, too. Since there are a lot of batteries and interconnected queues waiting to be connected to the transmission system, the need for increased capacity related to this energy storage makes an energy storage device an attractive option. California is the leader in terms of using energy storage for capacity purposes. However, determining a market depends on both capacity and granularity of the product. Likewise, some markets are pricier than others. For example, where PJM may charge $300 for a given amount of electricity, that same amount may only cost $100 for MISO. Furthermore, some states, or regions, aren't in any organized market. As an example, the city of Atlanta in the state of Georgia doesn’t belong to an organized market. Instead, there is an LMP (Locational Marginal Price) for this region. Based on these differences, Elstor needs to decide whether to provide services in a wholesale market and if so, in which regional market. In a wholesale market context, there are ancillary services, energy market services, and capacity services. Therefore, choosing one or more of those would likewise need to be considered.

In the retail context, Elstor, as the vendor, would enter into a retail contract with a bakery, where it would attempt to reduce the price associated with their distribution utility and not the transmission. Since the bakery operates off the distribution system, it would be categorized as a distribution level connection. At the distribution level, Elstor could have an advantage in the wholesale market, where these organized markets exist. However, this opportunity could only be pursued once the technology has been tested as a pilot or proof of concept with one or two other clients.

Elstor’s product offerings could also grow and expand along with the clients’ needs. If a bakery wants to expand, for example, it would then have a higher energy need, thus providing an opportunity for Elstor’s technology to help them offset their higher energy cost. Elstor could scale along with the bakery and get paid for it, too. Dedicating separate funds towards expansion would not be necessary, thus making expansion a net zero cost.

In terms of logistics of establishing a business in the US, Finnish workers at Elstor do not necessarily need to come directly from Finland to the US. However, that is an option. The chamber would be able to help make business sponsorship visas available along with immigration lawyers and whatever other resources are needed to make that a possibility.

However, another option is contracting out through a company that already exists in the US, or you can work with an individual
contracting out through a company that already exists in the US, or you can work with an individual, who sets up a small home office from your home initially. This is a relatively cheap option for starting off. Once the business begins to expand and attracts customers, it might prove beneficial at that point to invest in a physical office space and hire more people to support the US expansion project.

6.3.Public Policy Interviews

Interview 3. Zoom Call Interview Conducted May 3, 2023, with Professor at the Department of Agricultural, Food, and Resource Economics, Focusing on Development, Energy, the Environment, Technology, and Trade.

This interviewee's background is in academia and is related to the food industry and working with different economic policies to promote sustainability. The discussion started off by addressing market potential in terms of the most important driver from a business perspective – money. How much does Elstor's technology cost? If companies move towards investing in that system, what do the carbon offsets look like? How are they being compensated for? If the amounts are small for carbon offsets, there are other ways to compensate. However, if the differences are large, this creates a challenge, which is seen in most technologies and as is the case with oil, gas, and coal, which are the leading sources of steam for electricity. However, there is a drive to find alternatives. There is a lot of money going into research and development, creating opportunities for sustainable projects.

As a company, Elstor should start by developing a business plan to demonstrate its potential in a US market. For example, Finland could be used as a case study. If there are certain food processors or retail suppliers that benefit from these systems in Finland, demonstrate how their benefit would impact the US. If the path is viable, other companies will be interested in adopting this technology.

Although the perception may widely be that steam is primarily produced by oil and gas, geothermal plays a considerable role. In fact, geothermal, by nature, is all about steam. However, it exists only in certain states and depends on what resources are available locally.

In terms of what renewable resources are most popular in a US context in, biomass is reasonably popular, but hydrogen is not since it's challenging to work with. Wind comprises 25% of energy use in Texas, with solar reaching similar percentages. In fact, 30% of US energy comes from renewables. However, most of it is not hydrogen, which has yet to be developed, mostly because hydrogen is logistically difficult to transport and can be dangerous. To illustrate, the hydrogen bomb is worse than the atomic bomb. While hydrogen may be part of a future solution, much more development needs to happen before it starts to be used widely. In contrast to the US and European markets, hydrogen is more common in Australia and Japan. In fact, Japan is betting on hydrogen. Japanese car manufacturers have much more fuel cell-built cars than EV's.

The best entry strategy would be to showcase those who have already adopted the technology, using secondary data to demonstrate a proof of concept. By showcasing these Finnish companies who have already adopted, this demonstrates that this technology is more than a pilot. It's already commercial. In fact, what exists already in Finland can act as a that proof of concept. The biggest challenge that exists is that US states are still conflicted as to whether climate change exists, with some states having strong pro-climate policies, while others do not.

ARPA-E (Advanced Research Projects Agency–Energy) funds company projects that are intended to be pilots or proofs of concept. Elstor could likely fall under some of their paths. Looking at the DOE (Department of Energy) could likewise be a feasible starting point, and especially in states that have geothermal, like Wyoming. California might be viable as well because electricity prices are high. If prices are higher and an alternative is offered, that could make the technology more attractive.

The current trend in the US right is to decarbonize the manufacturing sector, under which the food processing sector falls. Another approach could be the EPA (Environmental Protection Agency), which has regional projects, some of which may fit the Elstor technology well. The EPA grants support seed funding for industries with applications while fostering interactions between academia and industry. And in terms of regions, New York, New Jersey, California, Washington, Oregon are all states that are looking for these kinds of solutions.

In terms of how quickly to proceed to market, this current period is particularly challenging, because the world global economy is slowing down and there will be a recession soon. Interest rates will rise again. Banks are failing. For that reason, the academic grant system could be a better path now. But in the immediate future, I would assume the coming year is a good year to go into the market, since the current administration is pro-climate, which could change again in 2024. But regardless of the governmental policies, pro-climate states consistently have stronger incentives. However, industries would still like to see a proof of concept to understand what is in it for them.

It is true that the difference between Europe and the US is that politics with Russia create uncertain gas prices in Europe as opposed to the US which is more stable since it has its reserves. It's one of the primary reasons why Europe is, on average, more concerned with sustainability than the US. Europe doesn't have resources the same way the US does. It depends on a country that is very unstable and aggressive, and it wants to separate form it. It needs to find alternatives. It's a good fit with the climate issue. As a European example, because of the rising sea level in the Netherlands, the government transitioned to the use of offshore wind and built barricades to prevent flooding. The US had a good fit with the climate but has since moved more towards energy security.

Steam and geothermal could be a great entry angle for Elstor's technology, but breaking down the technology to see the advantage is necessary. Geothermal and steam are valuable for this industry and this technology. However, it might be more valuable in the west coast, rather than the east coast, considering the way the plates are structured, since that's where the Ring of Fire is located along the west coast in California up to Canada and Alaska and then down back down into the Pacific Ocean. Since that area has a lot of steam, it stands to benefit from this technology. By comparison, the Reggie region, where New Jersey is located, is not a region rich in in steam. In terms of renewable resources, New Jersey is better for wind or solar. California, Oregon, and Washington have also recently joined the LCFS (Low Carbon Fuel Standard), which incentivizes fuels. The LCFS has been expanded to include hydrogen fuel cell stations, which are being subsidized right now. Likewise, anaerobic digesters, which manage organic wastes, are worth considering.

Despite governmental challenges surrounding changing parties, there is some durability of policy since climate issues are arguably a partisan topic. Once a research grant is received from the government, the grant doesn't disappear as a result of a presidential party switch. Once the industry of interest is convinced that they won't lose money from investing in this technology, and it generates income and is sustainable, some customers may be willing to pay a premium as is done in some regions for sustainability. In these markets, the price of the technology can be raised. Once a market base is already established, the technology has the potential to become considerably profitable.

In terms of other programs or organizations that may be interested in supporting sustainable efforts, there are offset markets slowly being introduced, but this market is still emerging.

In terms of measuring steam use, companies often guestimate it since they typically aren't interested in paying money to measure it. But technically, it is possible to measure it. Some companies will pay for advising, while others won't, which is part of the sales component. However, if Elstor itself is bearing the cost of measuring steam, companies may be more willing to participate in it, especially if it's being used as an opportunity for companies to see that Elstor's technology could save them a given amount on money in their steam production. However, for some companies, if the steam is a polluting output, they may not want to measure in order to acquit themselves of any responsibility or billing associated with their steam production. But if there is a reusable output, such as circulating the steam back and reusing it and there is a benefit in this operation, that could be an additional selling point. In that way, the measuring equipment could work to generate an extra stream of cash. In the sense that Elstor would bear costs early on to demonstrate the legitimacy of the technology, if companies come to understand that taking on this technology is not a financial penalty to them, they will be more willing to invest in it. Client relationships are all about getting companies to trust and believe in you.

Depending on the company, some companies want to appear sustainable. Image can be important. Even the fossil industry is trying to create hydrogen in circularity to create value. For instance, BP is very different than Exxon Mobil. BP is trying to move to an energy company from a fossil company and become sustainable in that sense. Exxon prefers to stay with fossil fuels but is willing to clean them up. Therefore, there is a general understanding that something needs to be done. Some US companies care a lot but for others, it's beyond them.

It's important to note that companies won't do something for the good of the globe if it will hurt the company itself, because the stakeholders will throw out the CEO without a second thought. The government needs to support it. In that way, an example would be the CCS project that Norway is putting forth. Similar to this, investigating electricity distribution in certain states could prove beneficial and for those states that are deregulated, there is often a separation between distribution and supply, thus creating a need for a solution that creates storage easily. That makes consumption of wind and other intermittent sources much more viable. For instance, in New Jersey, PSEG has a problem with their grid and is currently updating it. Therefore, they might be interested in updating it with a technology that creates storage.

If one of the issues is scalability, it may be useful to keep in mind that the DOE supports companies

working in certain energy sectors, especially those that are greener. What are the renewable resources that can be used to save the company money in the long term?

As another example, United, the airline company, has started using biofules in its planes because they are cleaner than aviation fuels. Another option could be to approach terminals in airports. The small shops there are paying a lot for electricity, and they have the capacity to withstand an initial investment that won't pay back until several years out.

If the regional goal is to stay in the northeast, food bakeries could be the best fit. As long as a proof of concept can be presented, it can later be scaled. In addition to a proof of concept, working out pricing models is one of the most compelling ways to prove to companies that the technology is worth investing in.

Interview 5. Zoom Call Interview on May 8, 2023, with Professor of Supply Chain Management, Energy Systems, Operations Research

This interviewee is an assistant professor of supply chain management. His research focuses on energy systems and operations research, examining ways in which operations research models can be used to determine the best investment strategy to expand the electric power grid in a way in which total societal costs are minimized, including market costs and health damages, and whereby capacity is expanded to mitigate disruption and intermittency of renewable sources.

The first resource which was mentioned during this interview was that Rutgers has a Center for Energy, Economic and Environmental Policy, from where more folks who might be more knowledgeable about the market related to a technology like that of Elstor's could be contacted. However, as there were many willing participants for interviews already, this proved unnecessary.

Since Elstor's technology is unique for a US market, a market entry strategy must be considered from an operational perspective versus a long-term planning perspective. Therefore, what type of infrastructure already exists today and how this new technology could be integrated into the US centralized grid as a support to distributive energy resources must first be considered.

In terms of long-term planning for the grid, some questions to consider are: How is this product going to be competitive from an investment or capital expenditure perspective? What is the lifecycle of the product? If you make an investment, what does this look like in reality and how is it managed? How big of a load, depending on scalability, can that satisfy?

In a day-ahead electricity market, electricity markets are balanced every day or planned every day in terms of their operational balance. They're balanced in real time as they come on and offline, known as the capacity market, which has a reserve capacity as well. Companies submit their bids as to how much they can generate for what price point, after which a centralized planner selects a bidder based on a combination of cost and capacity. However, one bidder may be selected for a certain block of hours versus another based on how much capacity is required at that time. Given this model, could Elstor compete in that kind of market and at what price point? Is the technology competitive enough from both a financial and a capacity perspective for a centralized planner to choose Elstor's technology over another? Is it scalable enough to serve that kind of load?

Over the past few years, EV and electric storage adoption has started to become more commonplace and, therefore, more affordable. Charging batteries of any type using electricity most commonly occurs at night when the demand is lowest, but at some point, depending on EV adoption or how many centralized energy storage facilities may come to exist, it may no longer be financially advantageous to charge batteries at night some years from now, because if charging electric cars at night soon becomes commonplace, the demand would gradually increase. Could Elstor's technology create optimization from this perspective? What do maintenance costs and operating costs look like for this technology? Is the technology competitive enough to compete with a biomass plant? From a distributed energy resources perspective, Elstor's technology might be a viable investment from a long-term perspective.

To speak to the policy side, every administration that comes in has their own political agenda. There are incentives for renewable energy and distributed energy resources and for both residential and commercial communities. One thing to consider is whether this technology emits in any way. From an energy storage perspective, there are different scopes or levels. Scope 1 is when the individual is emitting, such as a person driving their car. Scope 2 is when someone drives an electric vehicle, thus eliminating their immediate footprint, but the process by which the electric car came into existence through the manufacturing process is not emissions-free. Scope 3 is where the process for manufacturing the vehicle is clean, but the process by which the manufacturing parts are brought to the manufacturer is dirty. Although this product is reducing emissions from the grid, is the product itself carbon negative in any way? What scope does it fall under? Are there ancillary benefits to this product? The answer to these questions will help determine the business strategy.

When it comes to manufacturing and improving this technology to be sold in the US market, there are research and funding opportunities available from the DOE and the NSF. This technology fits in with the distributed energy resources market, which is linked to solving the climate crisis. Therefore, the funding for this type of technology exists now and will likely continue to exist into the future.

The best way to incentivize companies to adopt these types of technologies is through punitive measures. A carbon tax is often not the best way, because it incentivizes companies to do the bare minimum to avoid not paying the tax. For that reason, incentives work better. However, every business has different utility functions, but all of them seek to maximize profit. A lot of companies now are trying to strike a balance between all three elements of the triple bottom line (people, planet, and price or prosperity), but there are a lot who only want to provide value to their shareholders without regard for the planet. From a policy perspective, it can be challenging to create a policy that provides a sense of utility to all companies.

From a pure cost perspective, demonstrating the lifecycle of this product and the benefit it can provide to companies is necessary for marketing purposes. If it's an investment, there will be an upfront cost. To convince companies to invest, they need to understand how much money they will save in the future and over what span of time. While cost is important, some may be willing to invest more in the present if it means savings in the future. It likewise depends on the utility and what they are using the product for.

In terms of more sustainable methods of steam production, one of the biggest misconceptions with sustainable resources is that they don't emit at all. In the instance of biomass, burning it emits NOx (nitrogen oxides) and methane, which are some of the worst, most dangerous pollutants in the atmosphere. With making the switch to renewables, there could be dangers, or what an economist might call unintended consequences. From a supply chain perspective, and depending on the type of fuel in question, there may be challenges surrounding how to deliver that resource or raw materials to the energy source. Therefore, companies will often need to consider their current carbon emissions profile before making the switch to something renewable.

When it comes to whether the electricity storage capacity or the steam component of this technology is more marketable, it depends on the companies in question. Elstor needs to think about what its competitive dimensions are. An example based on Walmart would be price and availability. For Amazon, it would be flexibility, convenience, and price. Some other examples are

quality and reliability. Everything should be aligned to whatever Elstor's company's strategy is. Business processes, investments, and the target audience, for instance, should be aligned to those competitive dimensions.

In terms of ERC's, they are successful in some cases. However, they are highly subjective and volatile depending on who is in Congress. As an example, solar benefits used to be a lot better, or higher, than they are now. Previously, it had been possible to install solar panels using a specific government loan based on an artificially subsidized interest rate of a certain percent, and in addition to that, there were bonus incentives offered by the federal government.

Furthermore, you could save on energy consumption. This was a three-prong approach. Two of those three prongs are based on benefits from the federal government. But the last one is based on the solar panel company. Marketing to consumers as to why they should choose one company over another is the only influence to be had over consumer selection in this type of instance, thus demonstrating why marketing strategies are just as important as the technology itself when it comes to market penetration.

6.4.Alternative Energy Substitutes Interviews

Interview 8. Zoom Call Interview Conducted May 22, 2023, with Technical Director in Physical Oceanography and Offshore Meteorology and Former Climate Change Researcher.

This final interview was conducted with someone formerly working in academia who has since switched over to industry. He specializes in oceanography and offshore meteorology. However, his research during his time in academia largely dealt with renewable energy technologies targeted at reducing climatic change, including environmental connections, such as how the building of wind turbines interacts with the environment. In industry, he now supports various offshore wind projects with the intent of getting them approved for funding at both the state and federal levels. This interview was the most unique in that the expert was not as knowledgeable about the steam or electricity markets or industries. However, due to his knowledge related to climate policy, he was able to suggest several different funding opportunities, which had not been mentioned in previous interviews. Furthermore, he had some knowledge of storage devices. However, his perspective was quite different compared to that of previous interviewees. This interviewee likewise mentioned some organizations to check with which were mentioned in previous interviews, such as those offered by the DOE or NYSERDA. One of the new ones he mentioned, and which is related to his own line of research, was the National Offshore Wind Research & Development Consortium (NOWRDC), which was previously part of NYSERDA, but now functions as its own organization. It typically has funding calls a couple of times a year and has an advisory committee, which helps to decide what types of funding objectives will have priority for the upcoming year. Although the NOWRDC came out of New York, other states have now bought into the consortium. Essentially, every state is pursuing its own offshore wind portfolio, is a member of the consortium, and, therefore, contributes funds to the organization. However, the NOWRDC determines where those funds get spent with the ultimate goal being to bring down the levelized cost of energy for offshore wind, including costs, such as those related to maintenance and storage. NOWRDC's research programs tend to support either private enterprises pursuing new ideas relevant to the industry or partnerships between academia and industry. One NOWRDC-funded project he was a part of considered maintenance scheduling based on weather and the environmental need where an AI algorithm considered these factors to predict when maintenance would be needed. As long as the product is related to offshore wind and how to better integrate offshore wind with the need for it in the United States, funding opportunities are available. Since Elstor's technology supports electricity being produced by wind energy, funding through this organization could be an option worth exploring.

The NOWRDC has three different levels of funding, depending on the maturity of the work involved, who is behind it, and what needs to be done. For example, the first type of grant would be geared towards a technology that needs to be brought up to the next level of readiness. Those grants are around \$250,000 – \$300,000. The second level offers funding in the amount of roughly \$800,000, which is meant for technologies that are already at a deployable stage, where testing may still need to be undergone for the product. Finally, there is a \$1.5 million level, which comes with the intent to turn something into production. Perhaps a smaller grant could initially be used for the purpose of creating an initial proof of concept. Since the past round of NOWRDC calls have been conducted this way, it is likely that the following will be conducted in a similar manner. As regards applying, proposals tend to be very regimented in that there are different levels of forms that need to be filled out, coupled with many different requirements. For instance, a business development plan may be needed.

NYSERDA could likewise be worth exploring since it has more money, and, therefore, funding opportunities available, relative to some of the other US state programs. The DOE contributed roughly 20 million USD to NYSERDA, who then matched that amount. In the last year, roughly twenty to twenty-five projects were funded by NYSERDA. NYSERDA has an annual symposium related to these projects.

In terms of wind energy and where the best region in the US could be for that, Elstor's technology could be deployed anywhere. Outside of the offshore wind space, there is land-based wind in states like Texas, Oklahoma, Kansas, and Nebraska. In fact, Texas, while it has a large oil industry, also produces more wind than other state in the US. However, as of late, the wind industry in Texas has been so successful, since renewables have been allowed to compete on the open market, that politicians have been pushing back by subsidizing oil. In terms of offshore wind, New York, New Jersey, Massachusetts, other states in New England, Maryland, and Virginia offer the most potential in the near future, with construction projects on the books in these states coming up in the next year or two. Funding in New Jersey can be more challenging to come by. For example, New York has NYSERDA, whereas New Jersey doesn't have anything too similar. However, New Jersey has NJDEA (New Jersey Economic Development Authority), which has renewable energy development efforts and offers grants. As part of this organization, there is the NJ Wind Institute, which is offshore wind focused but also explores other areas related to wind. Out of these states, Massachusetts has a strong renewable energy program. It has the Massachusetts Clean Energy Center (MassCEC) which supports a variety of clean energy areas. However, there is no utility scale for offshore winds in the US. There are only two small administration projects. However, this signifies room for growth in the industry. BOEM (Bureau of Ocean Energy Management), the federal agency which has oversight over offshore wind, leased areas from California last year and are talking about future initiatives to lease off the Gulf of Mexico, Maine, and the mid-Atlantic over the next two years.

In offshore wind, examining what financial support is available at a state level with respect to renewable energy tends to be more successful than governmental level incentives, as had been previously mentioned with regards to the steam and electricity markets in previous interviews. This is because the states themselves are driving the demand for the resource. Different states have different renewable energy goals, such as carbon neutrality targets by a certain year, which drive the demand more than federal goals. The federal government has goals for offshore winds, but because energy is being bought at the state level, state demands and state programs drive more of that demand. The states have the most incentive to find solutions that will help them reach their sustainability goals. Another consideration is that federal government policy is subject to the sustainability goals. Another consideration is that federal government policy is subject to the political elections. If in the next presidential election, there is a party change, the federal level programs can shift directions, with Republican presidents often giving less attention to climate issues, which usually impacts the agendas of climate change organizations to the degree that efforts state moving more slowly. However, at a state level, the sustainable efforts are built into the state law, meaning that even if the president changes, the state is still obligated to work towards those goals. Therefore, states are ultimately driving the demand, making their policies and incentives more pertinent than those coming from the federal level.

Since wind power is only a small equation of Elstor's technology, it may be necessary to consider how feasible it is to apply for these grants when there is only a loose connection to wind sourcing with the technology. However, if it is possible to pitch for there being a clear connection between the two topics, it makes the project potentially eligible for funding. One pitch could be that greening the grid by using a power source for steam other than natural gas or oil could require the use of wind, thus making the entire process that this technology is being used for more sustainable. With any sort of logical connection between the technology and wind, applying for a grant is possible. One example of a similar project would be using offshore wind to generate hydrogen, which would theoretically cater to two different markets. If a truck, for example, is powered by hydrogen, which was produced by wind, the truck is by power of deduction, powered by wind. Therefore, making an argument for a strong connection, even in the space of a tertiary type of development, is the most crucial to receiving funding.

In terms of partnerships to apply for grants, it may be enough to partner with a university to receive a grant, rather than needing to have a US business presence already. However, this may not be the case for all grants. Furthermore, offshore wind works a lot with companies that are both Scandinavian and European, thus indicating that a foreign company may not be a barrier. To illustrate, the biggest players in offshore wind are Ørsted, which is Danish, and Equinor, which is Norwegian. However, these companies have US presences and US staff supporting them locally in the US. Occasionally, some European folks are brought in.

In terms of other renewable energy sources, such as hydrogen, it can be difficult to know what will cause a pivot towards that source picking up speed in a market context. A similar thing can be said

for electric cars. While they may be doing well, gas vehicle sales still dominate the market. If hydrogen continues to get cheaper and more competitive, the price will naturally fall.

This interviewee was less knowledgeable about entering the market as a business or as a start-up, but rather knew more about the academia side and applying for grants to obtain funding. However, with this statement, it became clear that going both routes simultaneously could be an option, as previously discussed in other interviews. Meanwhile, looking into the start-up space for environmental technology companies in the US could provide new opportunities that hadn't been touched upon in depth in any of these interviews. With Finland being a hub for entrepreneurship, this could, in fact, be an attractive opportunity for Elstor as a market entry strategy.

6.5.Summary of the Interviews

The research carried out via these interviews was highly valuable in that answering the research questions which were more challenging to answer via the literature review were answered in greater detail throughout the course of the interviews. The experts came from diverse backgrounds and approached the market potential question from many different perspectives, offering ideas as to which organizations and agencies would be best to consider and consult in terms of funding. The answers related to this overarching research question related to market potential likewise served as the basis by which market feasibility can be predicted, even if offered from a non-quantitative perspective.

The innerworkings of the electricity industry were explained clearly and in greater depth than the preliminary research in this thesis provided insight into. As a result, the need for battery storage devices became clear through these discussions. The challenges surrounding steam measurements became somewhat clearer, although the steam market altogether remained a bit more ambiguous than the electricity market, due to the use of renewables in the steam industry not being commonplace. However, the need for more renewable energy production overall was discussed comprehensively in each of the interviews. Considering costs and the business end of market penetration was mentioned in a few of the interviews and reiterated the need to provide a proof of concept before attempting to penetrate the market, whether by predicting steam use figures for a target company or displaying the ways in which Elstor's current clients have already benefited from this technology in a financial way.

The culmination of these explanations and pieces of advice have created a new research task by which Elstor will need to think carefully about which target market would best suit its capabilities. Scope and scalability of the product are important considerations when deciding which US geographical regions, or types of companies, should be targeted. The most valuable insight gained from these interviews lies within the identification of more specified market considerations prior to any attempts at US market penetration on the part of Elstor.

6.6.Future Market Entry Strategies

There are two potential routes that Elstor could take for US market penetration. As the interviewed experts advised, from the public policy and incentives angle, the more feasible route would likely be to initially collaborate with a US research organization, such as the Environmental Protection Agency (EPA), National Science Foundation (NSF), or Department of Energy (DOE). These organizations could help Elstor to further assess market potential through further market research and feasibility studies. However, many of these grants are offered to research projects being carried out in conjunction with a university. As an example, research funding opportunities offered by the EPA include air research grants, climate change research grants, ecosystems research grants, health research grants, safer chemical research grants, sustainability research grants, and water research grants (EPA, 2023). In the example of Elstor, it could be worthwhile to consider climate change and sustainability research grants. These grants, however, have periods during which they can be applied for. The downside of going this route is that it may be too academic and research-focused, thus being too slow moving to affect any positive change in terms of timely market penetration for Elstor in a US market.

The other option, which was explored to a lesser degree in this research, and which could be approached with greater feasibility within the steam industry angle, is to contact individual small companies and businesses and offer them a "proof of concept" whereby it is proven that Elstor's technology has the potential to save the company a certain amount of money over a given payback period. This can be proven either from presenting examples in Finland where this has worked, drafting a set of figures that corresponds with the specific company in question, or creating another theoretical proof of concept model detailing the length of time required for the technology investment to finally become profitable for the company. Deciding which types of companies and in which regions to invest in would be the focal point of approaching the market penetration question. As aforementioned, and from the public policy angle, blue, or democratic states are likely to show more interest in green technology since climate change tends to be more of their political agenda than in red, or republican states. Likewise, the cost of gas, oil, and electricity tends to be higher in these blue states. To illustrate, "compared to the U.S. average, northeast residents pay 29% more for their natural gas and 44% more for their electricity. Additionally, the region has increased air emissions as a result of the increased use of other generation sources like coal to meet demand" (Anderson, 2022). When considering which small businesses to contact, many states have their own small business associations. For example, the New Jersey Small Business Development Centers (NJSBDC) network provides information on small businesses operating in the state and resources to support them (NJSBDC, 2022). As a relatively expensive state, which is also democratic, some small businesses may be looking to reduce their energy-related expenses, particularly if there are incentives available. Therefore, reaching out to local businesses, such as bakeries and breweries could be one avenue of operation. Furthermore, today the NJSBDC network has its headquarters located at Rutgers Business School - Newark and New Brunswick, which is the same entity by which some of the industry expert interviewed were contacted through. The NJSBDC likewise has appointed and paid directors and consultants stationed at this location. Therefore, circling back to the university points of contact to uncover potential market entry strategies has the potential to lead to both a research-academic route, as well as a pure business plan path.

6.7.Best Case Scenario

There are a few viable market entry strategies depending on whether Elstor wants to start by executing a more theoretical, and potentially academic route, or strictly enter the market through traditional business means via a business plan. During the interviews with experts, several market angles were discussed from the perspective of both the product itself and selecting an appropriate market type to that of determining a US region of interest. Many considerations must be made to decide what is most beneficial for Elstor in accordance with the risk level that the company is most comfortable with.

Applying for grants and different funding opportunities, while they may be time-consuming, can potentially be less risky than attempting to enter the market straight away as an established business. However, for some, if not most, of these grants, it is likely that Elstor will have to have some sort of established US presence prior to applying, whether that is an association with a university or an established business within the US. When considering establishing a business in the US, this can be as simple or as complex as Elstor wants to make it. As mentioned in one of the above interviews, establishing a business doesn't necessarily require a facility. It could start as a business run out of a singular person's home and expand to eventually include an office and full staff.

Connecting with other organizations, companies, and individuals operating in the space in which Elstor wants to expand is the most critical step towards expanding via the business plan. The Finnish American Chambers of Commerce are an invaluable resource by which Elstor could be supported in establishing its business presence in the US. These chambers likewise work to connect Finnish companies with other companies located in the US to facilitate new business opportunities. This path would require a proper business plan and thus, a decided, specified market segment.

As discussed in many of the interviews, considering which region to expand into can often be tied to political leanings and population density, as well as state incentives towards renewable energy. Some densely populated areas have larger scale steam production facilities, whereas more densely populated areas would have more bakeries or smaller scale steam users. Likewise, more densely populated states may tend to lean more democratic, or blue, meaning that the state legislature likely promotes and subsidizes the use of cleaner, renewable energy in a way that the republican, or democratic, states might not that. Therefore, choosing a densely populated, majority democratic state, or area within a state where a Finnish American Chamber of Commerce is present, is likely the most practical way to enter a US market within the scope of a business plan.

Although entering through a business plan strategy versus an academia and research plan type of strategy seem like two opposing paths, it is likewise possible to move in the direction of both routes and continue to develop Elstor's technology through a research grant, meanwhile

simultaneously establishing a business, attracting a few customers, and maintaining those partnerships and continuing to grow a customer base with whatever Elstor's current technology is at the given time of a sales agreement. If Elstor continues to develop and improve the technology
with the help of a grant, it could then offer upgrades to preexisting customers, meanwhile working to attract new customers with its new and improved technology. The drawback to this hybrid plan, however, is that it requires more resources altogether and especially in the form of employees and given that the US is a foreign country with a culture that is different than that of Finland's, there is always the potential for intercultural communication discrepancies. For that reason, scaling the rate of market entry is likewise important, indicating that it could be wiser and more manageable for Elstor to start with one plan versus the other, rather than trying to incorporate both plans simultaneously. However, if Elstor wants to move in both directions at the same time, it may need to slow the pace of both entry strategies to enter the market in a way that is both more manageable and sustainable long-term.

6.8.Worst Case Scenario

As one of the interviewees posited, the best strategy for now may be to wait to attempt to enter the US market, primarily due to the risk posed by the current recession now and into the future. The US economy is the world's strongest economy, thus eliciting a trickle effect into other countries' economies when a recession begins. According to Fortune, an American multinational business magazine, a recession in 2023 is now inevitable, with layoffs in the tech and finance sectors to spread to all other sectors (Sabrin, 2023). Since layoffs tend to begin early in the recession phase of the business cycle, and accelerate markedly as companies realize they must cut expenses to deal with the new economic reality of tight money and slowing demand, widespread layoffs from large companies like Goldman Sachs and Amazon are a key indicator of not only a recession, but also that companies would likely not be willing to dedicate funds towards innovative, novel tasks, like revamping already functioning systems. This suggests that smaller businesses, which are typically a target market for Elstor, and who are generally hit harder by recessions than larger corporations, could be especially unwilling to entertain a new technology installation at this point in a recession.

Likewise, government funding for various programs may be temporarily suspended, such as the research grants mentioned above, or simply more challenging to apply for and access. The reasoning behind this is that state support for higher education falls during recessions and federal government spending for higher education tends to match that of the state's (Aborn and Cahill, 2020). Since the EPA and NSF types of grants and the like tend to have some association with higher educational institutions, it is plausible that the programs offered by these types of organizations could become less readily accessible in upcoming years if the economic situation continues to decline.

6.9.Future Opportunities

All business ventures come with a degree of risk. Therefore, it may still be beneficial for Elstor to continue to entertain the idea of US market expansion into the future. As is the case with investing, the greater the risk, the greater the reward. Therefore, making efforts towards investing in a US market has the potential to result in positive, financially lucrative outcomes. While Elstor as a company will need to decide whether investing at this time is logical given the company's current financial standing, this research has laid the groundwork for market expansion potential by outlining several options related to market entry strategies, based on the culmination of research as it was approached from the steam industry, electricity market and related reserve market, renewable energy, and public policy perspectives.

Since Elstor is the product of a research project dating back to 2016 related to research efforts towards alternative solutions for energy storage, the company may be more willing than most to take a joint academia-research approach as a means by which to enter into the US market (Elstor, 2022). With this entry strategy, there is still much work to be done in terms of determining which organization and which grant within that organization would be most suitable to apply for. Likewise, deciding which university to collaborate with would also be an important decision, and like the concept of entering the business market cold, choosing a US region could be of critical importance. Making these decisions would require additional research into which academic partnerships and research grants would be the most sensical to apply to.

If Elstor decides to strictly go the business route, it would need to develop a business plan and identify and establish business relations with helpful contacts within the US. The most feasible route by which to do this would likely be working in agreement with the Finnish American Chamber of Commerce. Since there are several of these chambers spread out within different regions of the US, including in the states of Minnesota, New York, and California, deciding which region to establish itself in as a business would be the most critical decision for this market entry strategy, thus requiring more research geared towards delving into potential contacts and opportunities in each of these regions. For instance, if New York has more bakeries, it could be a

more viable market to start in. However, if the Midwest market has more small businesses run by Finns, who would be willing to support a fellow Finnish business, perhaps this spells out greater market opportunities in that region. For this reason, additional research regarding which region would be most ideal given this type of market entry strategy is imperative before any business expansion efforts are made in one region versus another.

7. Conclusion and Discussion

The culmination of research carried out thus far is best concluded in terms of reviewing each of the research questions and the answers to them.

1. What is the market potential for Elstor's technology in the US market?

This research has clearly demonstrated that there is ripe market potential for Elstor should it choose to expand its operations to a US market. There are many ways to penetrate the market, both through an academia, research grant route and through a proof-of-concept business plan strategy, or a combination of both, time and resources allowing.

2. How does the steam industry operate in the US? Which renewable resources are currently being used, or have the potential to be used, in the steam industry? Are companies measuring their steam usage? Why or why not? If so, are those usage rates easily obtainable from companies? If not, do companies have the capacity or any sort of financial incentive to measure steam?

How steam is being produced was a question which was much easier to answer as opposed to how much steam companies use, given that information on steam input sources is widely publicly available. The US steam industry is fueled primarily by oil and gas without many known renewable resources being used, despite there being great potential for such efforts, namely via wind, solar, and geothermal. Hydrogen was also widely discussed as it has been an energy source of interest in the US in recent decades. In the interviews, the experts were hopeful about the expansion of green technology into the future, especially given the current political climate in the US.

As regards to how much steam companies produce, the literature review section revealed that alternative means of steam metering to track a company's steam usage exist, such as through proxy metering devices (PMD), which calculate rough estimates of steam usage through predictive modeling. Where companies may be unwilling to install an actual meter, this could be an alternative method by which to obtain steam use estimates. It is important to note, however, that while the proxy metering approach saves time and money to create reports on data that could create cost savings, the pitfall is that this model is much more inaccurate by comparison to data which is derived by a physical meter device.

The research contained in the interviews revealed that many companies are unwilling to invest in measuring steam usage due to associated costs and mere inconvenience. According to one of the Miura employees, it is likely that many companies in the steam industry may be using steam boilers which are overfit for the company's necessary purposes. Although companies don't often measure steam, some could potentially be willing to if it could be done for free and could indicate cost savings. While it may not be easy to obtain these figures from companies, with enough work, it could be possible, especially if companies are incentivized with either free equipment or potential cost savings. Cost modeling for steam usage for companies could serve as a potential subject for further research as Elstor is keenly interested in these figures.

3. How does the electricity market work in the US? How is electricity priced? Does the reserve market, or something similar under a different name, exist in the US? What opportunities would there be in terms of energy storage in a US context?

The electricity market in the US has its own markets and experiences many price fluctuations related to the fuel which supplies the electricity and the demand of the electricity as often indicated by the location and the related population density. There are both regulated and deregulated markets, where deregulated markets allow for greater competition among providers. Although the reserve market is not called that in a US context, similar concepts exist, such as the spot electricity market, which operates similarly to Finland's reserve market, although perhaps by a different interval of time, like minutes instead of hours. Another similar market could be the ancillary services market, in which there are attributes by which the presence of electricity can be adjusted. There are different types of ancillary markets, like regulation, reactive, black start, synchronized, and non-synchronized reserve. Another similar concept to the reserve market would be known as demand response in the US. These alternative markets were not explored in depth and, therefore, could form the basis of future research to determine which one would be best for Elstor to compete in.

There is great potential in terms of electricity storage, especially since the electrification movement in the US is currently gaining momentum, and there is a strong push to replace gas power with electric.

All of these electricity market opportunities indicate that Elstor has the potential to be successful in the US electricity storage market.

4. What is the economic feasibility of producing steam with electricity in industrial applications as indicated by the availability of incentive programs or other means of financial support? What governmental policies and incentives exist to support the use of renewable energy? Are these always via governmental incentive programs or do other support programs exist in the US?

While economic feasibility related to Elstor's technology was challenging to assess directly, understanding which incentives, policies, and grants are available indirectly aided in the understanding of economic feasibility potential during a market entry into the US. These were mentioned to exist at both the state level and the federal level, as well as at the regional level for electricity markets in particular. There are also grants and incentives for certain types of markets and technologies, such as those related to wind, electricity, and green innovative technology.

Since this research was geared towards promoting a sustainable technology to support steam, learning which sustainable methods already support steam, as well as which resources have potential to do so in the future, was invaluable in determining market potential for Elstor's product. Throughout the process of the interviews, however, it became clear that there are many possible alternative angles with which incentive policies could have been approached. As an example, ECR's are sometimes used by companies. Miura has worked with companies which utilize them. Incentives tend to be highly based on state and region based. The suggestion to look at green incentives through a regional and state lens rather than at a national level was perhaps one of the most valuable takeaways since different regional markets tend to have their own sustainable programs, like New York having NYSERDA. Grants offered by different US governmental organizations were also mentioned, such as those offered through the EPA, DOE, and NSF.

5. What renewable resources are used in either the steam or electricity market? What is the potential of using renewable resources in the US market?

The electricity market makes use of renewable forms of energy with regards to production, which can include the traditional wind and solar means, as well as hydrogen. However, the ways in which oil and gas are slowly being replaced by electricity, such as in the instance of EV's, was discussed in greater detail. Due to this and the electrification movement at large, the potential for electricity storage devices in the US is on the incline.

While the connection to renewables in the steam industry was less clear, the potential for an increase in renewable resources in overall energy production became apparent through the sheer number of organizations and US agendas, or acts, in support of renewable shifts, which were mentioned, like NYSERDA, Reggie, and the Inflation Reduction Act. The current democratic presidency was also cited as a reason for which this current time period would be a favorable time to attempt to penetrate the US market.

Due to time and space limitations, not all research questions were answered in detail, indicating that future research efforts may be applicable. While more research may still be required to support efforts towards financial modeling and predictive analytics to best assess economic feasibility and steam use in the US and as a proof of concept to steer individual companies towards adoption, the research thus far yields indisputable evidence that continuing these research efforts is more than likely to lead to a potentially lucrative outcome for Elstor's technology in a US market.

While Elstor as a company still has many decisions ahead of it to make prior to attempting to expand into the US market, this research has proven that market potential for a technology like Elstor's in a US market is indisputable. Although the market penetration decision will require further research efforts and attempts at establishing meaningful connections with valuable organizations and interested parties, this research demonstrates that the question is no longer a matter of whether to expand into the US market, but rather: When?

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9. Appendices

9.1. Appendix 1

General Questions.

1. Is it possible to measure the amount of steam used by companies?
2. From an industry perspective, how is steam most often produced? Is it by burning gas or oil?
3. Are companies generally interested in reducing their CO2 emissions during this process?
4. Are there financial incentives or support available from the US government for companies to go greener? In other words, is the US taking any steps towards carbon neutrality, especially in the steam industry?
5. Do you know of any companies who currently receive any financial support or incentives from the US government or another institution for the purpose of reducing CO2 output?
6. Do companies in this industry ever make use of ERC's (Emission Reduction Credits)?
7. Do you believe that a technology like the one that Elstor offers has any longer-term, future market potential in the US? If so, what would eventually make that possible? If not, why?

9.2. Appendix 2

Miura Questions.

1. How is the steam produced by your technology? Is it by burning gas or oil?
2. To your knowledge, is Miura interested in alternative solutions that could reduce emissions during these processes?
3. What quantity of steam use used in the production process per year?
4. Is Miura aware of whether there are financial incentives and/or support available from the US government for companies to reduce their CO2 emissions?
5. To your knowledge, does Miura currently receive any financial support or incentives from the US government or another institution for the purpose of reducing its own CO2 output or that of clients?
6. Does Miura's technology make it possible for companies using it to make use of ERC's (Emission Reduction Credits)?

9.3.Appendix 3

Answers Received March 25, Provided by MIURA AMERICA CO., LTD. from Representative Employee Supporting the Engineering Department.

Miura is a global company based in Japan. The Japanese company has a larger product line, but I do not have much information on it, so I've provided the answers I can with regards to Moira America.

1. How is the steam produced by your technology? Is it by burning gas or oil?

   Miura America has models that produce steam using fuel gas, (natural gas or propane), oil, or a combination of the two.

2. To your knowledge, is Miura interested in alternative solutions that could reduce emissions during these processes?

   Miura Japan has hydrogen-burning boilers and has explored other alternative fuels. These products have not been brought to the US as there is not much market for it right now. Miura America has produced some biogas boilers and will consider producing more in the future.

3. What quantity of steam use used in the production process per year? (This may be client-specific and difficult to answer in the case of Miura.)

   This depends on the customer, so I can't give a good answer. Miura's product line ranges from approximately 1750 lbs of steam per hour to about 10,000 lbs per hour per boiler. We often provide modular solutions with multiple boilers.

4. Is Miura aware of whether there are financial incentives and/or support available from the US government for companies to reduce CO2 emissions?

   Our sales group and our representatives would have more knowledge than me on this topic, but I believe the majority (if not all) of ECRs are regulated at the state and local level, not at the federal level. We have provided boilers for projects based on these credits relatively often.

5. To your knowledge, does Miura currently receive any financial support or incentives from the US government or another institution for the purpose of reducing its own CO2 output or that of clients?

   We do not receive any benefits directly.

6. Does Miura's technology make it possible for companies using it to make use of ECR's (Emission Reduction credits)?

   Our technology does often reduce emissions (particularly NOx), depending on the customer, and projects are sometimes justified based on ECRs.