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Energy Companies Investment in Renewable Energy Production and its Effect on Financial Performance

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"A transition to clean energy is about making an investment in our future."

- Gloria Reuben

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by

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Submitted to The Department of Business and Economics

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I hereby recognize and pledge to fulfill my responsibilities as defined in the Honor Code and to maintain the integrity of both myself and the College as a whole.

Holden E. Phillips

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Acknowledgments

My deepest gratitude extends to my family. To my mom for pushing me to take risks, and to learn from it when those risks fail. To my dad for giving me direction and advice throughout this comprehensive project, alongside every other paper I have ever written. Finally, to my brother for being an ear to my stresses when things get difficult, and for being a best friend throughout it all

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Abstract

As the effects of climate change become more prevalent, the world must become more sustainable in order to combat them. One of the ways that energy companies are contributing to increasing sustainability is by increasing their renewable energy generation infrastructure to provide clean, emission-free energy. In the past, due to high upfront costs related to building renewable energy infrastructure, renewable energy investments had to be subsidized in order to achieve financial viability. This study performed a regression analysis to test whether recent developments in renewable energy technology, which have led to cost decreases, have made renewable energy investments financially viable. Using data collected from company documents and online databases to analyze renewable energy generation capacity and financial metrics for the year 2022, this study provides evidence that there is no statistically significant relationship between investment in renewable energy and financial performance. Resulting from a lack of evidence supporting an advantage for either green or non-green companies, a mixed asset base was recommended due to its ability to capture the advantages of both hydrocarbon and renewable electricity generation sources.

Chapter I - Introduction

As the world begins to face the consequences of global warming, many energy companies have started to invest in renewable energy production sources. Public opinion is a driving force behind many of these decisions, as energy companies must serve a consumer base whose support for renewable energy is consistently growing (Stokes & Warshaw, 2017). This support has grown in tandem with the growing intensity of natural disasters that have accompanied the worsening of global warming. As natural disasters have become more intense, they result in increased economic damage when they occur (Coronese et al., 2019), and more people are being affected. The economic damage these natural disasters cause is reflected in economic performance metrics like GDP per capita growth rate, which has been shown to be negatively correlated with natural disasters such as floods (Shabnam, 2014). This demonstrates the connection between people, the economy, and natural disasters, a connection which is projected to kill 150,000 to 250,000 people worldwide each year (Schiermeier, 2005).

Death, destruction, and economic turmoil do not have to be the norm, though, as we have developed tools and technological knowledge to combat global warming with science. One of the scientific pathways that has been explored to combat climate change is the production of energy through renewable sources. These sources include, but are not limited to, wind energy, solar photovoltaics (PV), hydroelectric, biomass, and geothermal energy. Biomass, while renewable, poses the problems of needing heavy resource inputs and producing greenhouse gas emissions when burned to generate electricity. Geothermal is both renewable and a great option for energy production as, with the exception of the high initial investment cost, it has a small environmental impact and low operating costs. Unfortunately, geothermal hotspots are located primarily along major tectonic plate boundaries (U.S. Energy Information Administration, 2022) and are scarce everywhere else, therefore, making it an unreliable option for renewable energy production. Solar PV, wind, and hydropower have generally shown worldwide promise, as they each are adaptable, based on scale and design, to fit many different areas and power generation needs.

Solar PV has emerged as one of the leading sources of renewable energy in many areas, as the advantages of the technology are extensive, and it boasts few pitfalls. While expensive upfront in comparison to hydrocarbon generation plants, specifically combined cycle (otherwise known as natural gas,) solar has the lowest levelized cost of energy or LCOE, rated at $36.49 per MWh while combined cycle sits at $39.94 MWh (Zientara, 2022). LCOE is the measure of the total lifetime costs of an energy source and divides it by its total lifetime production (U.S. Department of Energy, 2013). This allows for utilities and energy companies to make a net present value calculation which, in turn, allows them to assess the best investment based on the current and forecasted future costs of their investment choices. One of the reasons that the LCOE of solar PV is so low is due to the technology's low maintenance costs and the fact that solar is a free energy source. Alongside this, solar PV is widely available as literally nearly every area on Earth receives sunlight, poses no social costs as it is quiet and does not pollute, and is environmentally friendly as it produces clean energy without extensive environmental degradation or disruption (Sampaio & González, 2017).

Due to the aforementioned characteristics, solar PV is often the choice for utilities and energy companies, especially those in developing countries. For example, India is a world leader in solar PV power generation capacity installation, boasting a total generation capacity of 40 GW with a total annual production of 1.38 trillion kWh (Pandey et al., 2022). This is in part due to India's location and geography, as India's land territory has a relatively high solar irradiation level in comparison to other countries. India's level exists between 2000 to 2500 kWh per meter squared for most of its land territory, which is in the upper echelon of total solar energy availability (Nyah & Mukwekwe, 2015). India has existed, in recent years, as an example to developing countries that there is an affordable path to green energy, and that path is through investment in solar power generation capacity.

Onshore wind energy generation is a renewable energy alternative that shines in areas of low sunlight and high windspeeds, where solar energy fails to be a reliable energy source. While slightly more expensive than solar and combined cycle in terms of LCOE, sitting at $39.94 per MWh, the difference in price is relatively small compared to other power generation alternatives. The minimal cost difference solidifies onshore wind power as a viable alternative for renewable energy power generation in places where solar energy investments do not make sense, such as jagged mountain ranges or windy cliff edges. While solar energy investment is most effective closer to the equator due to a higher level of solar radiation, wind energy investment is most effective in territories further north and south, away from the equator (Jacobson, 2009). Because of this, wind energy has been a successful investment for more developed countries that exist far from the equator. One strong example of this is Ireland. Ireland produced 9.7 trillion kWh of wind energy annually through means of the country's 4.3 GW total installed wind capacity, which represents about 30% of Ireland's total energy consumption (International Energy Agency, 2021).

While solar PV and onshore wind represent great options for renewable energy generation, the technology is relatively new in comparison to other energy sources and is continuously being developed. Hydropower, however, has a long history of energy generation, with the world's first hydroelectric power plant beginning in 1882 in Appleton, Wisconsin (Fitzgerald, n.d.). Alongside this, Whiting, Wisconsin is home to the oldest hydroelectric facility still in operation today, which began operation in 1891, (Hydropower Reform Coalition, 2023) demonstrating that hydroelectric power generation is a long-developed renewable energy generation process and, consequently, has been used extensively in the U.S. and on a global scale. Because of the widespread implementation of hydroelectric power generation technology in the 20th century, many of the areas that lend themselves to the hydroelectric process have been exploited already. This has led to solar overtaking hydroelectric as the dominant emerging renewable energy source in countries such as the United States, first occurring in the U.S. in September of 2022 (U.S. Energy Information Administration, 2023).

However, even though hydroelectric capacity has been largely used up in many major areas such as China, Latin America, and Europe, (International Energy Agency, 2023) hydroelectric power generation has a key role to play in the transition to renewable energy. This is due to hydroelectric's ability to effectively store renewable energy for long durations of time, a feature that is only available for wind and solar power generation if expensive options, such as lithium-ion battery storage, accompany them. Because stored energy is available for release whenever the power is needed and at the rate of generation that is needed at that time, hydroelectric power serves as a key tool in compensating for the variability that comes along with relying heavily on solar PV and wind power generation (International Energy Agency, 2023).

Because of the previously mentioned characteristics of these renewable resources, some energy companies have begun to transition their power generation portfolios to include, and even emphasize, renewable energy sources. This transition is the focus of this study, as it is not quite yet clear whether or not this transition to renewable energy makes fiscal sense. In order to conduct such a study, 148 energy companies (63 green and 85 non-green) were compared under the lens of financial performance indicators in order to determine whether renewable energy investments are financially viable. This was done by means of a cross-sectional regression analysis, which took the most recent numbers for renewable energy and total energy generation capacity and ran them against financial data from the fiscal year ending 2022.

I will use financial performance metrics such as net income, return on assets (ROA), Financial Leverage, and return on equity (ROE) in order to conduct in-depth research into the financial performance of the chosen companies. The purpose of this study is to determine the financial viability of firm investment in renewable energy generation capacity and provide recommendations to energy companies for future investment. I will also address the previous literature on the subject, which provides both context and background on the importance of the research that I am conducting. In doing so, I will fill the gap of outdated datasets and financial reports that have been used in previous studies by using current data and information. Alongside this, I will discuss the role of government subsidies in the financial viability of renewable energy investment, and on the financial performance of renewable energy companies.

Chapter II - Background

In this chapter, I will explore and present the history of renewable energy as it has developed alongside the development of society in order to provide context to the contents of this study. In addition, I will also explore the different views concerning the effects of government subsidies following their implementation. The history of renewable energy is both long and intriguing, as renewable energy sources have been used since the 3rd century BCE when the first scientific watermill was invented in Byzantium (Angelakis et al., 2022). However, with the global demand for energy rising as societies grew larger, scientists and other great thinkers were incentivized to innovate and find new ways to harvest the world's resources. This led to the development of wind technology. According to the U.S. Energy Information Administration (2008), The first windmill was invented and put into action in 500 CE, further expanding society's ability to generate power and complete work with more than just human and animal energy output. Further into the future, Kerker (1961) states that Thomas Newcomen was the first to invent the steam engine in 1698, an invention that would eventually lead to the development of crucial technologies in world history, most predominantly the steam locomotive.

Steam technologies, however, were not fully renewable technologies as they relied on thermal energy in order to function, which included the use of coal and other combustible materials. As society progressed further, the need for constant sources of electricity developed, leading inventors to try and figure out how to satisfy this demand. The U.S. Energy Information Administration (2007) states that Charles Brush was the first to complete this task, patenting his open-coil dynamo in 1879 which allowed for the production of a steady stream of electricity. These developments in electricity production finally led to the first power plant being built in

New York City by Thomas Edison in 1882, as recorded by the National Grid Group (2022). This power plant was responsible for providing light to The New York Times and Wall Street and created the market for electricity production, resulting in the basis for this study of the viability of renewable energy sources in the modern day.

As the technology to harness the wind and the sun for electricity would not exist at a scale to meet the global demand for some time, hydrocarbon and hydroelectric power generation sources were the focus of research and innovation. Alongside the technology already existing at a scale that could meet demand, hydroelectric and hydrocarbon sources do not have the problem of intermittency, permitting them to provide a steady supply of electricity at all times. Originally, the focus was on coal-fired power plants, with the first coal power plant being the aforementioned plant built by Thomas Edison. This power plant used a low-efficiency steam engine, fueled by coal, to run a DC dynamo that was able to supply a steady stream of electricity as long as coal and water were continuously fed into the steam engine (Termuehlen & Emsperger, 2003). These power plants spread across major population centers globally, as the demand for electricity continued to grow. The included graph shows the global rise in demand for energy since 1800, which demonstrates exponential growth in the total global energy demand, especially within the past 70 years.

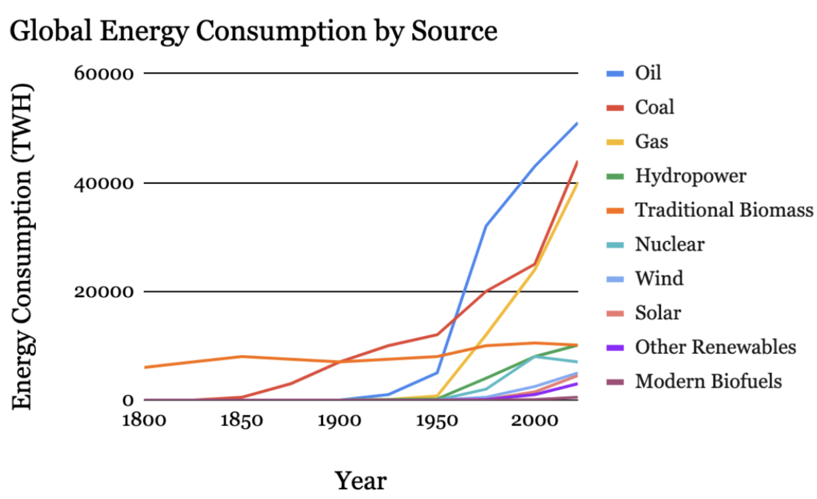

Figure 2.1 Source OurWorldInData (2023b)

However, the coal-fired power plant technology wasn’t efficient or clean enough to satisfy innovators within the energy production industry, and so the search for better technologies continued. Also in 1882, Jacob Schoellkopf built the world's first commercial-scale hydroelectric power plant in the world in Niagara Falls, using the local waterfalls to power the nearby town and proving that commercial-scale hydroelectric plants were a viable option (New York Heritage, 1956).

However, it soon became obvious that, while hydroelectric power plants are a great source of clean renewable energy, the locations that have the characteristics to host a commercially sized hydroelectric power plant are few and far between. Because of this, the search for a wide-scale solution to commercial power generation continued. The best successor to the coal-fired power plant was found to be the combined-cycle power plant, which used a combination of gas and steam turbines to produce cleaner, more efficient power. The first of these plants was built in the United States in 1952 and sparked the construction of similar plants globally, much like the construction of the first coal-fired plant (Chase, 2001). As the technology behind combined-cycle power plants and coal-fired power plants developed further, they emerged as the option with the lowest cost and the highest efficiencies when it came to turning fuel into electricity. Combined cycle power plants continue to be the cheapest power plant technologies when it comes to upfront cost, which is the reason why in 2022 they accounted for 57% of the United States’ in-service power plants (U.S. Energy Information Administration, 2023b).

Globally, both coal-fired and combined cycle power plants continue to be the dominant sources of energy production. This is due to the cheap upfront costs associated with building hydrocarbon energy sources, alongside their relatively low maintenance and input costs. As depicted in the graph, coal is the most dominant technology due to its longevity in the energy production market with natural gas, or combined cycle, closely in second.

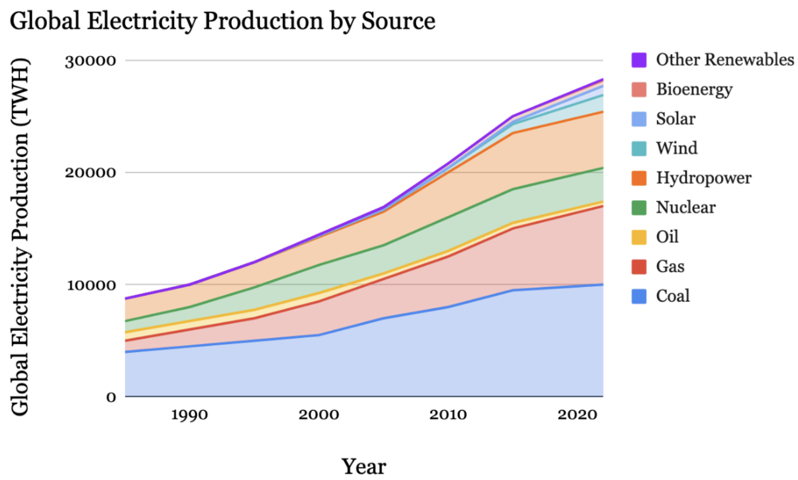

Figure 2.2 Source OurWorldInData (2023a)

These technologies did not come without problems, however, as pollution from hydrocarbon power plants and factories using engines fueled by non-renewable sources filled the air and water. Primarily, the burning of hydrocarbons in these power plants and factories led to increased levels of air pollution, which caused a major public health risk in large population centers such as London and New York City (Bulletin of New York Academy of Medicine, 1966). Alongside this, hydrocarbon power plants emitted and still emit large amounts of toxic wastewater from their operations which can harm local residents and the surrounding environment (U.S. Environmental Protection Agency, 2023).

Eventually, pollution concerns became too dire to ignore, and innovators and environmentalists began to look for newer, greener ways to supply the world's power demand. This led to the construction of the world's first commercial wind farm, built in 1980 and located on Crotched Mountain in New Hampshire, which boasted a total of 20 wind turbines at a total rated capacity of 30 kW per turbine and 600 kW for the farm in total (UMass Wind Energy Center, 2023). Soon to follow, as stated by Arnett et al. (1984), was the world's first commercial solar energy farm which operated at a capacity of 1 MW, or 1000 kW, and was located in

Hesperia, California. However, while these projects were steps in the right direction towards a renewable energy future, they were minuscule in terms of power generation when compared to the electricity demands of a small city, let alone the entire world. As renewable energy technology developed and became cheaper, larger installations have been built to satisfy new consumer demands for cleaner energy. As a result, solar power plants and wind farms have been built all over the world providing clean, renewable energy to seek it. One of the solar plants that was built is located in Bhadla, Rajasthan with a capacity of 2.2 GW or about 2,200 MW, making it the largest non-hydroelectric energy source in the world (Blackridge Research and Consulting, 2023).

The reason that solar and wind farms have been able to become as large as the solar farm located in Bhadla, Rajasthan is because of significant price decreases due to technological development over time and suppliers achieving economies of scale. As stated by Nemet (2019), these suppliers hailed from major global powers such as the United States, Germany, Australia, Japan, and China, with development in each country driven by global developments and each country's separate national innovation system. Because of this, according to Nemet (2019), the price of solar panels has decreased 10,000 fold since they were first offered on the commercial market. This, in turn, has allowed solar panels to become the cheapest source of electricity in areas where there is abundant sunlight. For wind power generation the same is true, as suppliers in the wind energy industry have also made heavy technological advancements and achieved economies of scale. Alongside the technological and economic advancements though, were developments in the decision-making process behind deciding optimal locations for wind farms. Vargas et al. (2019) discuss how advancements in weather forecasting and weather measurement technology have allowed for more accurate prediction of future wind speeds and weather types.

Furthermore, as the variables forecasted using the new technology affect the total production of electricity from the turbines, the more accurate forecasts allow for better decision-making with regard to wind farm location which, in turn, leads to more productive wind farms with a higher return on investment.

Another technology that has developed alongside wind and solar technology is battery storage techniques, primarily lithium-ion battery technology. The issue that comes with using renewable sources such as wind and solar is their intermittent nature, meaning that they cannot produce electricity at the same rate every hour of every day as hydrocarbon sources can. This means that when renewable sources are producing more electricity than the grid requires, excess energy must be able to be stored for times when the renewable plant is not producing electricity at its full capacity. The solution to this is building separate infrastructure devoted to storing the excess energy at the high points and releasing it into the grid at the low points.

Currently, one of the leading technologies in battery storage is lithium-ion batteries due to their ability to store and release energy very quickly. Similar to wind and solar technology, lithium-ion batteries have seen a decrease in price due to the industry achieving economies of scale according to Ziegler & Trancik (2021). Also in their research, Ziegler & Trancik, (2021) found that intensified R&D activities in the lithium-ion battery industry, due to higher demand, have led to cost decreases. The increase in demand for lithium-ion batteries and better lithium-ion technology is no coincidence, as renewable energy developers are aware that they are the best option for battery storage in a market with few commercially viable alternatives.

While lithium-ion battery storage is one of the most common energy storage systems, it is important to note that, while they are few in number, there are other alternatives. One of the alternatives currently in place globally is the pumped storage system. This energy storage system involves using excess energy generated from renewable sources operating at peak efficiency to pump water from a body of water at a lower elevation to one at a higher elevation. Then, once the grid demands energy at an off-peak generation time, the water can be used to run turbines in a similar manner to a hydroelectric dam, providing supplemental energy to the grid. China has been effectively using this technology for years, with their current installed storage capacity at 45.7 GW, according to a survey done by IRENA (2023). While this technology is promising, it is limited by the number of naturally occurring areas that can host the infrastructure needed, as each site needs bodies of water with differing levels of elevation within a close proximity to each other. In contrast, a new storage system has recently been developed using molten salt that is promising but widely untested in the commercial battery storage market. While less efficient than a lithium-ion battery by about 10%, salts are much more abundant than the rare metals necessary to build lithium-ion batteries. While less efficient, these batteries can still be up to 90% efficient according to Zhu et al. (2022) which solidifies them as a possible future alternative to lithium-ion batteries.

While renewable energy has been around since the dawn of organized civilizations, many of the developments and innovations in technology have occurred in recent years. In order for a full transition to renewable energy to happen, these developments must continue into the future. This includes innovations in battery storage technology, such as molten salt storage technology, that create a more reasonable solution to renewable energy's intermittency problem. Alongside this, technologies must continue to become cheaper, similar to the cost-decrease of solar panels since their initial offering to the market. Provided innovation and cost-decline continue to occur, hydrocarbon sources will likely become a thing of the past while renewable energy sources take their place as the majority producer of global electricity.

Chapter III - Literature Review

3.1 Introduction:

There has been a recent trend towards investment in renewable energy, driven by consumer tendencies to purchase goods and services from companies that operate in tandem with environmental health, rather than exploiting the environment. The goal of this chapter is to explore this trend, and the research conducted as a consequence of it. In doing so, I will highlight gaps in the literature that create an environment suitable for the research conducted in this study.

3.2 Influence of Green Consumerism on Market Trends:

Sangvikar et al. (2019) discuss the importance of corporate “green marketing” campaigns in swaying consumer decisions, especially those deemed green customers. This point is highlighted by Dangelico & Vocalelli (2017), who provide a framework for corporations building green marketing strategies, and those strategies’ importance in obtaining environmentally conscious consumers. Demonstrated by this is a consumer market trend towards corporations and suppliers who operate with environmental health as a top priority.

This trend has attracted the attention of investors for mutual and hedge funds, as clients have increased their demand for investment markets such as green technology and renewable energy sources, as mentioned by Climent & Soriano (2011). This has led to an outperformance of green portfolios compared to their non-green portfolio alternatives, as discussed by Cortez et al. (2022). Similar to these green portfolios is the practice of socially responsible investment or investment into SRI funds, which operate similar to green portfolios with respect to environmental health, but also include investment with consideration to ethical policies. As brought forth by Ballestero et al. (2012), the market is also trending towards SRI funds as portfolio managers show increasing levels of interest in SRI strategies. The recent trend towards environmental social governance investing (ESG) shows the culmination of green portfolios and SRI funds, with the added adjustment to account for corporate governance performance. Cerqueti et al. (2021) demonstrate that investment in ESG funds leads to lower market losses during periods of low market volatility, signaling the financial viability of ethical investments. Also brought forth by Cortez et al. (2022) is the fact that increased market performance is not solely due to increased customer demand for green companies, but can also be attributed to an increase in performance of those companies. Further discussion by Cortez et al. (2022) shows that this increase in performance compared to the market is likely due to the global transition to a low-carbon economy. This demonstrates the context for my research, as while market trends show an increased demand for green investment opportunities, there is little published financial analysis on these green investment opportunities with recent data.

3.3 Financial Viability of Renewable Energy Investments:

Research specific to individual firm financial performance independent of market implications largely comes from data collected from 2016 and before, which does not reflect the financial viability of modern investments in renewable energy. For example, it was found that renewable energy investment is not financially viable as discussed by Paun (2017), and that a negative relationship between renewable energy increase and short-term and long-term financial performance was found by Ruggiero & Lehkonen (2017). While this seems to clearly show that investment in renewable energy reflects negatively on financial performance, it is important to consider the decreases in costs and increases in efficiency that renewable energy technologies have experienced since 2017. For example, Timilsina (2021) explains that the average costs of electricity from utility-scale renewable power generation plants have decreased by 420% when solar PV is used and 150% when onshore wind is used, just over the past decade. This allows for renewable energy sources to be competitive with their hydrocarbon counterparts in terms of long-term financial viability. However, it must be noted that short-term financial viability is often negatively related to renewable energy investment, as the upfront investment costs can be more expensive in renewable power generation investments than in hydrocarbon power generation investments. This is demonstrated by the LCOE table presented by the U.S. Energy Information Administration (2022a), which shows that upfront capital costs represent 72% and 75% of the total system cost of wind and solar, respectively; whereas when considering hydrocarbon power generation, specifically combined cycle power generation investment, the upfront cost represents only 23% of the total system cost. This is further discussed by Hu et al. (2018), who state that the upfront capital costs of renewable power generation sources are much higher than their fossil-fuel counterparts, even with their respective decreases in average costs of electricity, as previously mentioned. The high upfront capital cost associated with renewable energy investment creates a barrier to the renewable power generation market, making it difficult for new companies to enter the market and be competitive.

While upfront capital costs are high in renewable energy investment, it is important to also consider the lifetime costs of the energy sources. This is represented by levelized variable cost, which falls under the operating-related costs in the calculation of LCOE, as discussed by Shen et al. (2020). These levelized variable costs represent the energy inputs required for operating a power plant, and they vary extensively between hydrocarbon sources and renewable sources. For example, the levelized variable cost for combined cycle power plants, the cheapest out of all of the hydrocarbon sources, represents 70% of the total system costs. Renewable energy sources such as solar PV and onshore wind, however, boast a levelized variable cost that represents 0% of the total system costs (U.S. Energy Information Administration, 2022a). This is due to wind and sunlight's status as public goods that do not have cost or tax associated with them, allowing the inputs of these renewable power generation plants to be free for their entire lifetimes. Taking this into account, it is easier to understand why the upfront capital cost of renewable energy sources is so high as, once installed, power generation is free outside of occasional or lifespan maintenance.

Energy companies have not overlooked the low-overhead structure of renewable power generation facilities, and use calculations such as the net present value calculation (NPV) to determine if renewable energy investment makes sense on an individual basis. Cucchiella et al. (2014) discuss the framework for the NPV calculation and use it to determine the financial viability of investment in renewable power generation facilities. Furthermore, Cucchiella et al. (2014) discuss the importance of NPV calculation in determining the correct scale of renewable power generation facilities, as different renewable technologies have higher or lower financial viability based on plant size. Through the use of the NPV formula, Cucchiella et al. (2014) determined that all of the renewable investments considered in the study had the possibility of becoming profitable investments. Dobrowolski & Drozdowski (2022) further this point by adding a variable discount rate to the NPV formula, which accounts for variable interest rates that change at a frequency of 1 or more times per year. This adjusts the formula to account for real-world interest rate change, a factor that has a large impact on the present value of future cash flows because of the time value of money. The adjustment to the formula by Dobrowolski & Drozdowski (2022) allows for more accurate forecasting of the financial viability of renewable energy investment, which leads to more informed decision-making by firms who want to invest in renewable energy sources.

Without the NPV calculation, combined cycle natural gas power plants will always seem like the more cost-effective choice. This is because, as previously mentioned, the upfront capital cost of combined cycle power plants is about one-third of the upfront capital cost of the next cheapest renewable energy source, which is solar PV. However, the levelized variable costs of renewable energy sources are zero while for combined cycle power plants it represents 70% of the total system cost. The NPV calculation allows companies to see past the initial investment cost, as well as make more informed decisions as it pertains to size and energy source type when designing a renewable energy power plant. This is important because smarter, more informed decisions made through financial modeling will, in turn, lead to increased financial performance. Because of this, when analyzing the financial performance of energy companies that invest in renewable energy, understanding the NPV calculation is key to understanding the determinants of that financial performance.

Another determinant of an investment's financial viability, and on a larger scale whole firm financial performance, is the time that it takes for an investment to generate enough cash flow to pay back the initial investment cost. This is called a simple payback time (SPB), as discussed by Chauhan & Saini, (2014) who state that the SPB of a renewable energy investment is a valuable metric when weighing the economic benefit of that investment. The value of this metric is further emphasized through its use in different renewable energy investment analyses put forth on a country scale by Ge et al., (2018) and on a community scale by Klein & Coffey, (2016). Because SPB takes into account the upfront cost of renewable energy investments, decreases in the upfront cost of renewable energy sources lead to a shorter SPB. Therefore, with the development of renewable energy technologies leading to a lower upfront cost, renewable energy investments become both more attractive and financially viable for energy companies.

Because of this, due to the decreases in upfront costs as discussed by Timilsina (2021), the financial viability of renewable energy investments has increased significantly in recent years, and SPB for renewable sources would appear to be greatly reduced, even in the past decade.

However, while both the NPV and SPB equations are important in determining the true economic cost of renewable energy investment, they lack consideration for the social benefits that renewable energy sources provide. Vergara et al. (2014) quantify these social benefits by labeling them as avoided costs, which allow for dollar values to be assigned to things such as the negative effects of pollution, low energy security, and climate change. The framework of avoided costs was then used by Ortega-Izquierdo & del Río (2016) in order to determine the viability of cycling plants that combine renewable energy sources with non-renewable sources to provide a continuous stream of electricity. Ortega-Izquierdo & del Río (2016) found that when the avoided costs associated with implementing renewable energy sources are included in the economic benefit calculation, renewable energy investments become more financially viable. This is due to renewable energy sources being zero-emission sources, preventing pollution that is harmful to members of society that come in contact with it. When the previously unquantifiable costs of hydrocarbon energy sources are included, they become much less attractive investments.

3.4 Effect of Private Investment on R&D Activity:

To continuously lower the costs of renewable energy technologies as a way of increasing the financial viability of renewable energy investment, it is crucial to attract private investment into research and development (R&D) activities associated with renewable technology. In their study on this topic, Prokopenko et al. (2023) found that investment in renewable technology R&D led to increased financial performance among the analyzed companies. Alongside this, Prokopenko et al. (2023) concluded that forecasted future investments in renewable technology also positively affected the financial performance indicators of the studied companies. This is important as there is uncertainty around the return on investment gained from investments and R&D into renewable energy technology as it is difficult to predict future cash flows of these investments. This issue is explored by Owens (2002) and is cited as one of the main barriers to attracting private investment into renewable technology R&D activities. Because of this, the positive performance indicators associated with R&D in renewable technology, as brought forward by Prokopenko et al. (2023), provide a solid basis for investment in renewable technology R&D. Moreover, it creates a financial environment that is conducive to generating private investment in renewable R&D activities. This is key to developing innovation within the renewable energy technology sector which, in turn, leads to cost reductions that increase the financial viability of renewable energy investments. The importance of innovation in cost reduction is discussed by Elia et al. (2020), who find that innovation, and the subsequent learning from previous innovation, drives cost reduction in all technology, including renewable energy technologies.

3.5 The Effect of Government Subsidies on Financial Performance:

One common theme across the history of renewable energy is that it has taken large amounts of R&D at no small expenditure in order to progress renewable technologies to the point that they are at today. One way that renewable energy companies and researchers were able to stay in business amongst high costs and slow returns was through the use of government subsidies. While private investment's positive effect on renewable energy firms' financial performance is significant and largely undisputed, the same cannot be said for government funding in the form of subsidies. There is debate within the literature on whether government subsidies positively or negatively impact overall firm financial performance.

For example, both Zhu & Liao (2018) and Zhang et al. (2022), found that the presence of government subsidies within the renewable energy generation market increases the prevalence of “rent-seeking behavior.” Rent-seeking behavior, as described by Henderson (2019), causes inefficiency within the market by taking some of the gains that the system creates from its beneficiaries which, in the case of the renewable energy market, is the general public. Alongside this, Wu et al. (2020) argue that non-R&D subsidies have an extensively negative impact on renewable energy investment that can be attributed to the inefficiencies that exist between government motivations and a private company's chosen development strategies.

A unique point presented by Zhu & Liao (2018) is that subsidies can also have the unintended effect of generating overcapacity in the market. This occurs as the government subsidies save companies, in this case in the renewable energy market, that would otherwise fail without their financial support. In doing so, this disturbs the natural progression of the market by artificially increasing competition levels, making it harder for firms in the market to achieve financial success, as discussed by Hao et al. (2019). Government subsidies have been found to have negative effects not just on individual firms, but also on the entire renewable energy market, and have the potential to disrupt and delay the global transition to renewable energy sources. This is due to their ability to negatively impact firm financial performance at a significant level, stunting corporate growth within the renewable energy market and continuing the competitive advantage that hydrocarbon power generation holds over renewable power generation.

In contrast to the evidence on the negative impact of subsidies on the market, Yang et al. (2019) argue that government subsidies do have a positive impact on renewable energy investment, a key driver for firm financial performance in the renewable energy sector. This research is in agreement with the information put forth by Yu et al. (2016), as both articles agree that government subsidies have a positive impact on individual firm R&D activities. This connection spurs innovation within the renewable technology sector, which leads to cost decreases in renewable technology. These cost decreases subsequently lead to increased financial performance of firms operating within the renewable energy field, as new investments are cheaper and, therefore, have the ability to generate higher profits than previous investments. This point is further supported by the research contributed by Chang et al. (2020), which analyzes the effect of government subsidies on total investment efficiency and pure technical efficiency. This is due to government subsidies' ability to decrease the amount of private financing that renewable energy companies need to obtain and use for renewable energy investments. In doing so, government subsidies provide funding that does not need to be returned, greatly increasing the financial viability of renewable energy investments.

Nicolini & Tavoni (2017) present an alternative to direct government subsidies by emphasizing the effectiveness of “feed-in tariffs” as a government financial tool aimed at supporting the renewable power generation industry. These feed-in tariffs provide long-term contracts for renewable energy producers that allow for greater stability in predicting future cash flows, which has been previously mentioned as a key component in generating private investments in renewable energy. It was found, in the study conducted by Nicolini & Tavoni (2017), that an increase in the amount of feed-in tariff incentives offered leads to an increase in renewable energy generation capacity, making it a viable alternative to government subsidies as a financial incentive.

Both contrasting views within the literature, pertaining to the effect of government subsidies on the financial performance of firms operating within the renewable energy sector, present sound research on the positive and negative effects that government subsidies can have. The connection within the literature that is agreed upon by both sides is that subsidies are only effective if used correctly, and if used incorrectly either have a negative or no effect on firm performance. This is discussed by Yang et al. (2019), who state that government subsidies are the main force supporting new entrants into the renewable energy market when they are used correctly. However, when used incorrectly, Zhu & Liao (2018) found that it can lead to subsidy funding increasing the rent-seeking behavior of firms which, consequently, leads to inefficiency and decreases firm financial performance. This point was furthered by Zhang et al. (2022), who found that firms tend to abuse subsidy payments due to imperfect subsidy standards and unreasonable subsidy structures.

This is not to say that government subsidies always lead to performance inefficiency, however, because when correctly used, Chang et al. (2020) found that subsidies increased total investment efficiency and pure technical efficiency. Alongside this, the connection found by Yu et al. (2016) linking government subsidies and R&D investment increases demonstrates the important role that government subsidies can play when used in a manner that supports innovation. Because of this, I agree that government subsidies play an important role in the renewable power generation sector. However, specifically stating what these subsidies are allowed to be spent on is an important regulation to include in the subsidies, as it is shown by Zhu & Liao (2018) and Zhang et al. (2022) that a lack of clear regulation leads to abuse of these funds.

3.6 Analysis of Financial Metrics:

While it is important to analyze the policies, calculations, and investments and their effect on financial performance, it is also important to understand and analyze the metrics that we use to measure financial performance. The examination of net income is fairly straightforward when it comes to analyzing financial performance, as it shows the firm's profitability at a given period. However, it is important to realize that this measure does not account for firm size, and therefore can provide a skewed analysis of financial performance if firm size is not accounted for. For this reason, it is important to supplement with key measures, as described by Almazari (2012), such as return on assets (ROA) and return on equity (ROE). Both metrics divide net income by total assets and total shareholder equity, respectively, in order to provide a number that measures net income, in a way that firm size is controlled for, so that financial performance and profitability can be measured. Another way to control net income for firm size is by looking at the net income growth rate, which allows for analysis of the percentage growth of net income between periods. Net income growth rate controls for firm size by expressing growth as a percentage rather than as its full value, which will show the difference in growth between analyzed companies with no influence from each firm's size.

Alongside net income, ROA, and ROE, financial leverage is an important financial performance metric. As stated by Ahmad et al. (2015), financial leverage is one of the key indicators of a firm's profitability due to its ability to measure how companies choose to finance their investments. This is important, March (1982) discusses, because each company has a target debt level that they will operate most efficiently at, with assets being financed by equity when above that debt threshold and by debt when below that threshold. Because of this, the financial leverage metric allows for analysis of how each company within the dataset handles its debt, allowing for clear trends in profitability between green and non-green companies to be seen.

3.7 Conclusion:

The included metrics, financial leverage, ROA, and ROE, were selected due to their ability to accurately define and analyze financial performance. Similar metrics were used in the studies conducted by Paun, (2017) and Ruggiero & Lehkonen, (2017), both of which, as previously mentioned, stated that investment in renewable power generation was not financially viable. However, with decreases in costs, as stated by Timilsina, (2021), I believe that there now is an economic environment that will allow for companies operating in the renewable power generation sector to be profitable. I will analyze whether this is, in fact, true or not through the use of the aforementioned metrics to analyze the financial performance of the selected firms and determine whether the financial viability of renewable energy investments has changed over the past seven years.

Chapter IV - Empirical Analysis

4.1 Introduction:

The purpose of this chapter is to introduce the methodology, variables chosen, data collection, and regression results that took place within the study. In doing so, I hope to accurately communicate the findings of this study, and explain why I believe some of the results presented as they did. Furthermore, I hope to draw connections between the data to accurately depict how the chosen variables affect firm financial performance.

4.2 Methodology:

The methodology I chose to analyze the accumulated data was a cross-sectional regression. This cross-sectional regression took the most recent energy generation capacity data and created a unique dummy variable labeled "green" or "not-green." This dummy variable was then run against financial indicators from the fiscal year of 2022, which was the most recent and widely available year that provided a complete dataset of financial information. In order to complete the cross-sectional data study by means of regression analysis, a dataset containing the necessary information first had to be constructed, as a pre-made data set containing the information needed did not exist.

4.3 Summary of Variables:

With the dependent variables explained, it is important now to present the explanatory variables chosen for this cross-sectional regression analysis. As previously stated, the purpose of this study is to determine the effect that investment in renewable energy generation has on financial performance, which is being done through the "green" and "non-green" dummy variables. However, it is important, for the predictability of the model, to include other variables called control variables. The control variables chosen for this study are total energy generation capacity (TEGC), total assets, total equity, number of employees, GDP per capita of the home country, company age, market capitalization, and whether the company operates in the US, EU, or another country. Following the gathering of these variables, a model was constructed to approximate how much these independent variables affect the dependent variables. These independent variables are listed and explained below.

Total Energy Generation Capacity (TEGC)

Total energy generation was chosen as an independent variable due to its close ties with the financial viability of electricity generation companies. With companies operating in this industry, it would be assumed that a higher total energy generation capacity would lead to a more profitable company in all aspects. Because of this, total energy generation capacity is a good indicator of a company's profit-generating capacity in the electricity generation industry and, therefore, an important variable to include.

Total Assets

Total asset value was chosen as an independent variable for similar reasons to total energy generation capacity. This is because the company's total asset base is a good indicator of its profit-generating capacity. The total assets variable and the total energy generation capacity variable are different, however, in that the total assets variable encompasses all assets under the company's ownership, while total energy generation capacity focuses solely on electricity-generating assets.

Total Equity

The investment flows of capital into a company are a strong indicator of company profitability and, because of this, total equity is an important variable to include in the study. This is because of the total equity variable's ability to measure external financing activities, which can, in turn, be used to fund new asset purchases and further expand the company's profit-generating capacity.

Number of Employees

Companies that have a larger amount of employees are predicted to have a better handle on managing the business operations of the company, as work can be delegated efficiently and allow for company expansion at a moment's notice. Because of this, the number of employees was chosen as an independent variable for the study, as it is a good indicator of a company's efficiency and, consequently, its profitability as well.

GDP Per Capita of Home Country

The GDP per capita of the home country was chosen as an independent variable because of its ability to demonstrate how developed the company's home country is. A higher GDP per capita usually means the country is more developed and, therefore, has more developed infrastructure. With more developed infrastructure, electricity companies operating in those more developed countries will have an increased opportunity to expand, likely leading to higher profitability.

Company Age

The experience of a company is extremely important to the operations of that company. Because of this, older companies are assumed to operate more efficiently and at a higher profit margin, due to an excess of experience in comparison to newer, less experienced companies. Consequently, company age was determined to be an important independent variable to include in the study.

Market Capitalization

The larger a company is the more assets that company will have at their disposal. These assets include labor, capital, and physical assets, which all increase the company's profit-generating capacity. Because of this, market capitalization was chosen as an independent variable for the study.

Company Location

Companies operating in different locations will be subject to different regulations and external forces, both of which heavily impact profitability. By including company location, we can monitor the profitability of the two global regions included in this study; the United States and the European Union. Because of this, company location was chosen as an independent variable for the study.

4.4 Empirical Models:

Now that the variables affecting financial performance have been listed and described, the empirical models used for the study can be presented. This study used four empirical models, one for each of the dependent variables: net income, ROA, financial leverage, and ROE. For the purpose of this study, a linear relationship between the independent and dependent variables was assumed as some of the dependent variables presented negative values which do not allow the use of logarithmic regression.

The linear models were presented as follows:

$$NI_i = \beta_0 + \beta_1 TEGC_i + \beta_2 TA_i + \beta_3 TE_i + \beta_4 NE_i + \beta_5 GDPPC_i + \beta_6 CA_i + \beta_7 MC_i + \beta_7 CL_i + \varepsilon_i$$

$$ROA_i = \beta_0 + \beta_1 TEGC_i + \beta_2 TA_i + \beta_3 TE_i + \beta_4 NE_i + \beta_5 GDPPC_i + \beta_6 CA_i + \beta_7 MC_i + \beta_7 CL_i + \varepsilon_i$$

$$FL_i = \beta_0 + \beta_1 TEGC_i + \beta_2 TA_i + \beta_3 TE_i + \beta_4 NE_i + \beta_5 GDPPC_i + \beta_6 CA_i + \beta_7 MC_i + \beta_7 CL_i + \varepsilon_i$$

$$ROE_i = \beta_0 + \beta_1 TEGC_i + \beta_2 TA_i + \beta_3 TE_i + \beta_4 NE_i + \beta_5 GDPPC_i + \beta_6 CA_i + \beta_7 MC_i + \beta_7 CL_i + \varepsilon_i$$

Where,

NI_i= Net income of company i

ROA_i= The return on assets of company i, measured as net income divided by total assets

FL_i= The financial leverage of company i, measured as total assets divided by total equity

ROE_i= The return on equity of company i, measured as net income divided by total equity

$TEGC_i$= Total energy generation capacity of company i

TA_i= Total assets of company i

TE_i= Total equity of company i

NE_i= Number of employees of company i

$GDPPC_i$= GDP per capita of the home country of company i

CA_i= The age of company i

MC_i= Market capitalization of company i

CL_i= The location of company i

ε_i= Error term

4.5 Summary of Data:

In order to build the data set, a conscious, step-by-step, approach was necessary. The first step to building this data set was gathering a list of electricity/energy companies that fit the necessary criteria for the analysis. These criteria stated that the included companies must have: a $1 billion total company valuation or higher, company-owned energy generation assets, and a public company designation. This created a database of 148 global companies that operate within the energy/electricity market. The reasoning behind the cutoff below a $1 billion total company valuation is due to the extreme financial volatility of the electricity/energy market (Geng et al., 2021), creating circumstances that are hard to absorb by newer players financially which, in turn, can create outliers in the data.

The other two criteria allow for the analysis of renewable energy generation capacity as a percentage, as well as the analysis of each individual company's financial data, allowing for a regression to be run to determine any connection between the two. There were many sources for the energy generation capacity data, but most data points were found in company sustainability documents or investor presentations as well as public databases such as *Statista* or the *World Benchmarking Alliance*. The financial information included in the data set was much more consolidated, coming from *Mergent Online* or the *Wall Street Journal*.

The data collected supports the four dependent variables that the regression model is testing: Net income, ROA, ROE, and Financial leverage. These variables provide an accurate picture regardless of firm size, with the exception of net income, of the financial performance of the companies that were selected within the database. These financial performance indicators will be run against the company's "green" or "non-green" designation, alongside the listed control variables, to determine connections between renewable energy generation capacity and financial performance. The “green” or “non-green” company designation was given based on the listed company's renewable energy generation capacity as a percentage of the company's total energy generation capacity. This variable was represented as a dummy variable with the “green” designation receiving a 1 in the dataset and “non-green” receiving a 0. The average renewable energy generation capacity percentage for the listed companies was calculated at 48.24%. Consequently, the threshold percentage for a company to receive a “green” designation was placed at 50%, as any company with a renewable energy generation capacity percentage equal to or greater than 50% represents an above-average company with regard to renewable energy generation capacity.

4.6 Hypotheses:

Prior to running the regression, I generated three hypotheses as to what the outcome of the regression may be. The first hypothesis states that there is no statistically significant correlation between “green” or “non-green” companies and their financial performance, signaling that, for companies entering the industry, the energy generation mix does not affect financial performance and companies should solely focus on business practice instead.

H0: There is no statistically significant correlation between “green” or “non-green” companies and their financial performance.

The second hypothesis states that there is a statistically significant positive correlation between a company's “green” designation and the listed financial indicators. This means that it is now financially viable to have a renewable energy generation mix due to changes in technology and market demand. In turn, this signals that companies should increase their investment into building renewable energy generation capacity and the infrastructure necessary to support it, as it will likely improve their financial performance in the long run.

H1: There is a statistically significant positive correlation between a company's "green" designation and its financial performance.

The third hypothesis states that there is a statistically significant positive correlation between a company's "non-green" designation and its financial performance and a statistically significant negative correlation between a company's "green" designation and its financial performance. This means that the financial viability of renewable energy sources has not changed and that non-renewable energy generation sources are still more financially viable than renewable energy sources. This signals companies to slow their investment into renewable energy sources and to keep their holdings in non-renewable energy sources rather than selling them in order to increase financial performance.

H2: There is a statistically significant positive correlation between a company's "non-green" designation and its financial performance and a statistically significant negative correlation between a company's "green" designation and its financial performance.

When the regression is completed, I predict that H1 will be proven true by positive, statistically significant, correlations between "green" company designation and the listed financial performance metrics. Specifically, I predict that the metrics net income and ROA will have a positive coefficient due to renewable infrastructure's low maintenance costs, and decreasing technology costs.

4.7 Regressions and Data Results

The regressions were run individually, starting with the regression that uses net income as the dependent variable of the test. This regression was the most statistically significant and explanatory regression, presenting an r-squared value of 0.306. This, in turn, means that, on average, 30.6% of the variation in net income is attributable to the independent variables included in the study.

R Squared	0.306
Adjusted R Squared	0.255
Significance F	1.433
TEGC (GW)	7.315 (0.212)
Green	348.555 (0.478)
Total Assets (Millions USD)	-0.029 (0.016) **
Total Equity (Millions USD)	0.105 (0.002) ***
Employees	-0.018 (0.494)
GDP Per Capita of Home Country	0.040 (0.004) ***
Company Age	7.844 (0.252)
Market Capitalization (Millions USD)	0.064 (0.001) ***
USA	-1846.185 (0.028) **
EU	114.005 (0.853)

(*) 90th threshold, (**) 95th threshold, (***) 99th threshold Table 4.1

When analyzing the net income regression results, there were many control variables that presented statistically significant values that were confident at the 95th and 99th thresholds. The total assets variable held a negative coefficient and was statistically significant at the 95th confidence threshold. This coefficient was unexpected but can be explained by the expenses that assets generate, especially in the electricity generation industry. These powerplants often have large amounts of overhead and, therefore, a company expanding their asset base might encounter a lower net income as a result of those expenses. The total equity variable held a positive coefficient and was statistically significant at the 99th confidence threshold. This relationship is logical and can easily be explained as increased levels of investment into a company allow for improvements to technology, R&D within the company, and expansion.

Following the total equity variable, the GDP per capita of the home country variable returned a positive coefficient and was statistically significant at the 99th confidence interval. Like total equity, this connection is both logical and can be easily explained. Countries that boast higher GDP per capita values are often seen as more developed countries, as more of their population lives above the poverty line and, therefore, has expendable income. Furthermore, these more developed countries often have more developed infrastructure that can support larger electricity production companies. These larger companies are able to make more profit compared to smaller companies and because of this, countries with a higher GDP per capita, on average, have more profitable electricity generation companies. Market capitalization also returned a positive coefficient and statistically significant p-value, which was significant at the 99th confidence threshold. The connection between larger market capitalization and higher net income is simple - larger companies often have more resources, such as assets, employees, and capital, at their disposal and, in turn, are able to generate a higher profit from these resources.

The final statistically significant variable in the net income regression was the US dummy variable, which presented a negative coefficient and was statistically significant at the 95th confidence threshold. This was surprising, as I would have predicted that companies operating in the United States would be more profitable than other countries. However, it could be attributed to the extensive corporate and human rights regulations that companies must follow in the United States. For example, an electricity generation company operating in the United States would have to pay their workers at least $7.25 USD an hour, whereas, in India, companies would only have to pay their workers $2.12 USD. These expenses add up for companies and, as shown in the regression, lead to a lower net income on average.

The second regression run used ROA as the dependent variable for the study. This second regression also yielded the second most statistically significant variables out of all the regressions, even though the r-squared value and significance-f value were much lower than the net income regression, as shown in Table 4.2. While the regression presented two statistically significant variables, significant at the 90th confidence threshold, the ROA regression can be described as not relevant to the explanatory variables due to these low values alongside low p-values associated with the majority of the control variables included in the regression.

R Squared	0.048
Adjusted R Squared	-0.021
Significance F	0.728
TEGC (GW)	0.0002 (0.503)
Green	-0.008 (0.755)
Total Assets (Millions USD)	-1.130 (0.071) *
Total Equity (Millions USD)	2.915 (0.093) *
Employees	-5.882 (0.663)
GDP Per Capita of Home Country	8.740 (0.220)
Company Age	5.587 (0.876)
Market Capitalization (Millions USD)	7.199 (0.460)
USA	-0.021 (0.623)
EU	0.002 (0.949)

(*) 90th threshold, (**) 95th threshold, (***) 99th threshold

Table 4.2

As shown in Table 4.2, only two variables reported statistically significant p-values following the running of the regression. These variables were total assets and total equity. The total assets variable returned a negative coefficient at the 90th confidence threshold, which can be explained relatively easily as a higher total asset value, proportionate to net income, will lead to a lower ROA percentage due to the relationship between total assets and net income. The total equity variable returned a positive coefficient and was also statistically significant at the 90th confidence threshold. This can be attributed to a higher level of financing available to companies that have a higher total equity value. This financing, if used correctly, can be turned into extra profit for the company which, in turn, raises the net income value of the company leading to an increased ROA percentage.

The third regression run used financial leverage as the dependent variable. Similar to the ROA regression, the financial leverage regression also returned low r-squared and significance-f values. Alongside this, the financial leverage regression returned no variables with statistically significant p-values. Because of the low r-squared and significance-f values, in tandem with the lack of statistically significant variables present in the regression, the financial leverage regression can be described as not relevant to the explanatory variables.

R Squared	0.028
Adjusted R Squared	-0.043
Significance F	0.948
TEGC (GW)	-0.053 (0.603)
Green	-9.377 (0.271)
Total Assets (Millions USD)	0.0001 (0.512)
Total Equity (Millions USD)	-0.0003 (0.545)
Employees	-0.0002 (0.583)
GDP Per Capita of Home Country	-0.0002 (0.291)
Company Age	-0.014 (0.908)
Market Capitalization (Millions USD)	-7.016 (0.827)
USA	1.668 (0.908)
EU	-6.089 (0.568)

(*) 90th threshold, (**) 95th threshold, (***) 99th threshold Table 4.3

Since the financial leverage regression returned no statistically significant variables, none of the variables presented showed a correlation with the financial leverage dependent variable. This can be explained by a multitude of different reasons, primarily, it can be explained by a limited sample size in the regression dataset. The companies included in the dataset were a small portion of the total electricity generation market, and, therefore, are a representative sample but not a fully complete picture of the market. This, in turn, could potentially affect the predictive power of the regression negatively, leading to lower-than-expected p-values.

The fourth and final regression used ROE as the dependent variable. Following the ROA and financial leverage regression, the ROE regression returned r-squared and significance-f values lower than what was expected of the regression. Similar to the financial leverage regression, the ROE regression also returned no statistically significant variables. Because of the combination of low predictability values and no statistically significant variables, the ROE regression can be described as not relevant to the explanatory variables.

R Squared	0.025
Adjusted R Squared	-0.046
Significance F	0.963
TEGC (GW)	-0.009 (0.630)
Green	-1.667 (0.285)
Total Assets (Millions USD)	1.746 (0.643)
Total Equity (Millions USD)	-4.623 (0.659)
Employees	-4.305 (0.599)
GDP Per Capita of Home Country	-4.088 (0.343)
Company Age	-0.003 (0.891)
Market Capitalization (Millions USD)	-8.818 (0.881)
USA	0.152 (0.954)
EU	-1.132 (0.562)

(*) 90th threshold, (**) 95th threshold, (***) 99th threshold Table 4.4

Similar to the financial leverage regression, the ROE regression returned no statistically significant variables. The result of no statistically significant variables can be attributed to many different things, one of them being sample size. Another reason that no statistically significant variables would be returned may be because there is no relationship between the independent variables and the dependent variables. This means that no increase or decrease in any of the independent variables would affect the dependent variable value.

In order to compare green versus non-green companies apart from the regression results, the averages of the dependent variables for both groups were taken. The net income variable was not averaged and represented graphically as, on its own, net income does not account for firm size like ROA, financial leverage, and ROE do, and therefore skews the analysis in favor of bigger firms. The dataset for these graphs omitted four companies that have values far outside of the normal range for energy companies deduced from the dataset. Because of this, the data in the graphical analysis depicts a slightly different picture than the regression results. The reasoning behind comparing the average values for the two company designation types was due to the fact that firm size was already controlled for by our selected financial indicators. Therefore, the averages could be compared to one another without a firm size bias, increasing the validity of the conclusions that could be drawn from them.

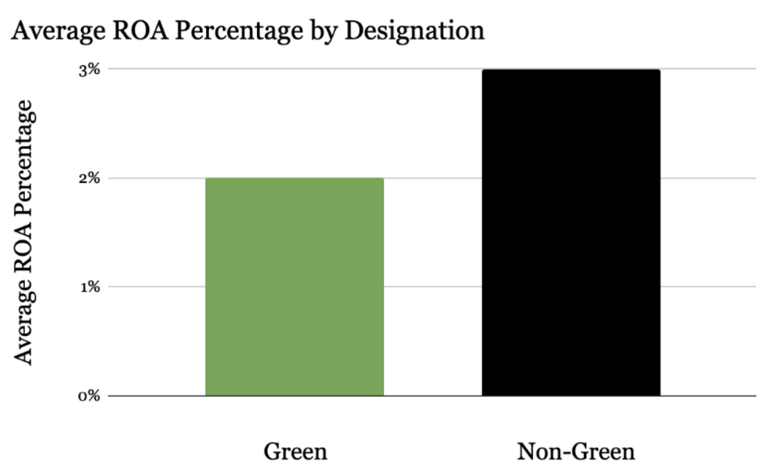

Figure 4.1

The first graph analyzed was the average ROA percentage graph which showed that the non-green companies held a 1% advantage over green companies. The ROA percentage metric was calculated by taking each company's net income and dividing it by their total asset base to show the percentage of total assets that net income made up. This data parallels the results received from the regression analysis and firmly backs up the claim that non-green companies perform better financially than green companies at this time. It does so by signaling that non-green companies are approximately 1% more efficient at generating profits from their asset base. This statistic is incredibly important in a market where income generation from a company's asset base is usually the company's sole source of revenue. Because of this, an advantage in ROA percentage signifies an important advantage that non-green companies hold over green companies.

The second graph analyzed was the financial leverage ratio graph. The financial leverage metric was calculated by dividing each company's total asset base by their total equity financing in order to show how much of each company's assets were financed by equity investment. The results indicated the same as the regression analysis, with green companies having a slightly lower average financial leverage when compared to non-green companies. This is likely due to higher levels of investment into technology companies following recent market trends which, as renewable energy companies act like technology companies, would lead to an increased amount of investment into renewable energy companies. This, in turn, would lead to higher levels of equity proportionate to the total asset base in renewable energy

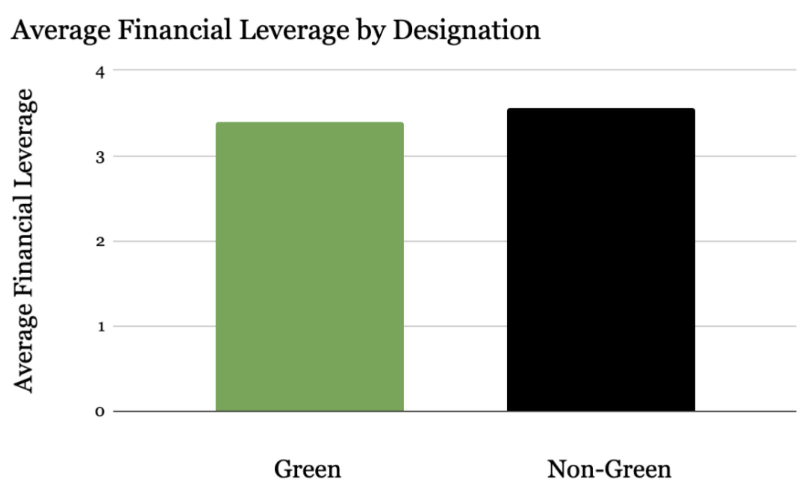

Figure 4.2

companies and would lead to a lower average financial leverage result for the green-designated companies.

The ROE graph when analyzed, coinciding with the previous graphs, followed the regression results. The regression results showed green companies with a lower, statistically insignificant, return on equity when compared to non-green companies, and the graph showed a sizeable advantage for non-green companies totaling around 3%. This advantage is shown clearly through the ommitance of outlier variables, allowing the average ROE calculated to accurately show the difference in efficiency between green and non-green companies. In this instance, the graph shows that non-green companies are 3% more efficient at generating profits from their equity financing activities when compared to green companies. This could also be due to non-green companies' lower total equity amount proportional to their net income, as previously deduced from the financial leverage graph.

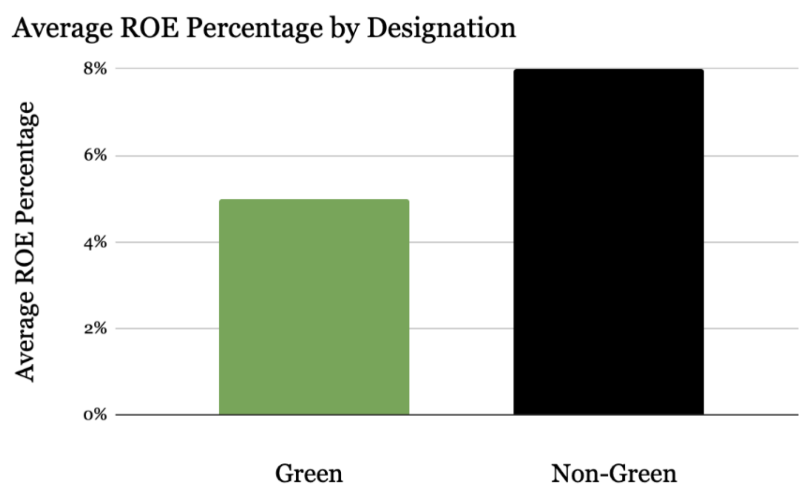

Figure 4.3

4.8 Conclusion:

Through means of a cross-sectional regression analysis, the relationship between the chosen independent variables and the chosen dependent variables was found. While only two of the four regressions run presented variables with statistically significant p-values, much can still be learned from the study. For example, in the net income regression, the total assets, total equity, GDP per capita of the home country, market capitalization, and one of the company location dummy variables presented as statistically significant. This shows that many of the selected variables demonstrated a correlation with the net income dependent variable. Because of this, we can conclude that these variables, based on the sign associated with their respective coefficients, are good predictors of net income either in a linear or inverse relationship.

Unfortunately, unlike the net income regression, the ROA, financial leverage, and ROE regressions were not relevant to the explanatory variables, hence why the financial leverage and ROE regressions had no statistically significant variables and the ROA regression only had two variables statistically significant at the 90th confidence threshold. This does not mean that ROA, financial leverage, and ROE are poor financial indicators, rather, they largely shared no relationship with the independent variables chosen for the study. Alongside this, the “green” dummy variable returned no statistically significant relationship with the dependent variables of any of the regressions, and therefore it cannot be stated that there is a correlation between investment in renewable energy and financial performance. However, in the net income regression, the “green” variable showed a large positive coefficient which, if statistically significant, would show a strong positive relationship between investment in renewable energy sources and financial performance.

Chapter V - Conclusion & Policy Recommendations

In a world threatened by environmental issues such as climate change, it is imperative that the world transitions from heavily polluting hydrocarbon power sources to renewable ones to reduce the global impact on our environment. The rationale behind this study was to determine if this full transition to renewable energy was a financially viable one, or if hydrocarbon sources still held a financial advantage.

I first began by introducing the severity of the global issue of climate change and presented renewable energy as a viable solution to a large portion of the world's pollution. There are many different types of renewable energy discussed in the study, but the most important of these technologies are solar PV, onshore and offshore wind, and hydropower.

In order to understand these technologies and where they came from, a background was presented on the history of renewable energy, extending from their primitive invention to recent developments in the different technologies. It is here that I presented depictions of the rise in both global electricity consumption and production, which set the stage for an expansion in fossil fuel electricity generation sources and a rise in pollution. This, in turn, lent itself to the rise of renewable energy as society searched for an answer to pollution-related problems. Also mentioned was the development of battery storage technologies, which hold an important role in the development of renewable energy infrastructure.

Following this, I discussed the literature pertaining to the renewable energy sector focusing on four main topics: the influence of green consumerism on market trends, the financial viability of renewable energy investments, the effect of private investment on R&D activity, and finally the effect of government subsidies on financial performance. Discussed first, the green consumerism trend framed the grounds for the study as consumers are increasingly looking for products that respect environmental health, including electricity generation. Consequently, there has been a recent increase in demand for electricity produced by renewable energy sources which has caused a market shift towards environmentally conscious electricity producers. In the past, these renewable energy investments have been found to not be financially viable and, therefore, have been tough investments to make. However, this was using data prior to 2017, which does not include the cost decreases and technological developments that have occurred since then, of which there have been many.

These technological developments have come as a result of R&D activities, which are typically funded through private investment and government subsidies. While private investment's effect on financial performance is largely undisputed, the same cannot be said for government subsidies. This is due to the fact that government subsidies have been said to cause market overcrowding and promote rent-seeking behavior. However, this only occurs when subsidies are used ineffectively, and, when subsidies are used correctly, they can be very effective at providing a financial advantage to renewable energy producers. The supposed financial advantage of renewable energy companies was the focus of this study and was analyzed through the use of financial metrics such as net income, ROA, financial leverage, and ROE.

The previously mentioned metrics were used as dependent variables, using each one for a different cross-sectional regression study. This study aimed to determine the correlation between these variables and the selected independent variables, which were total energy generation capacity, total assets, total equity, number of employees, GDP per capita of the home country, company age, market capitalization, and company location. In the study, 148 companies were analyzed in order to determine if a company's green designation had an impact on the firm's financial performance. Following the cross-sectional regression analysis, it was found that a company's green designation had no statistically significant relationship with any of the chosen dependent variables. However, there was a statistically significant relationship between net income and total assets, total equity, GDP per capita of the home country, market capitalization, and company location. Total equity, GDP per capita of the home country, and market capitalization were all significant at the 99th confidence threshold and held positive coefficients, signaling a strong positive relationship between the variables and net income. In addition, companies located in the United States were found, on average, to have net incomes that were around $1.8 billion less than companies operating in other countries.

Following the regression analysis, the averages of the dependent variables were analyzed through a set of graphs. These graphs were adjusted for outliers, eliminating 4 companies that had values well above or below the normal range for the companies selected. This, in turn, allowed the graphs to show accurate trends within the data without being skewed by extreme values that would otherwise invalidate the averages shown on the graphs. The ROA graph showed a non-green advantage of 1% over the green companies, signaling a greater skill at generating profits from their total asset base. The financial leverage graph showed a slightly higher value for non-green companies when compared to green companies, but this doesn't signal an advantage. The ROE graph showed a sizable 3% advantage of non-green companies over green companies, showing that non-green companies were more successful in turning profits from their equity financing activities. Net income was not included in the graphical analysis because it, as a financial indicator, does not control for firm size and, because of this, would provide a biased evaluation that favored bigger firms.

The results from the regression and graphical analysis can be interpreted most clearly in a way that supports a mixed asset base for energy companies. This is due to the lack of a statistically significant p-value for the “green” variable in any of the regressions run, and a perceived advantage when the averages of the financial indicators were compared between the green and non-green firms. Alongside this, the green variable provided a positive coefficient in the net income regression which, if statistically significant, would represent a strong positive relationship between investment in renewable energy generation capacity and net income. Because of the mixed results, not clearly favoring green or non-green companies, a mixed asset base is the most logical choice of asset base for firms in the electricity generation market.

A mixed asset base, in the case of energy companies, can be explained as an asset base containing both hydrocarbon and renewable energy sources. This is the best current option for many reasons, primarily, that the two energy production assets complement each other well, with renewable assets requiring very low levels of maintenance and hydrocarbon sources being able to generate power to solve renewable energy’s problem of intermittency. An example of this that is currently being used in the commercial energy generation market is renewable plants built in tandem with natural gas peaker plants. A peaker plant lies dormant during periods of renewable energy generation and only comes online during periods of low or nonexistent renewable energy generation, lowering the total emissions of the hydrocarbon fuel source drastically. Another advantage of energy companies diversifying their asset base is they get to cater to the green consumer trend as they are still investing in renewable energy sources. Among many benefits, discussed by Sangvikar et al. (2019), catering to the new generation of green consumers improves the company's public image and increases the likelihood of swaying undecided customers in the market. Alongside green marketing and problem-solving, a diversified asset base makes sure that the company will not fall behind in the energy generation market in the coming future. The world is trending towards renewable energy, with governments tightening their restrictions and fines placed on pollution, so investing in renewable energy sources alongside hydrocarbon energy sources can allow for a smooth transition to 100% renewable energy in the future. This is another reason why the renewable energy and natural gas peaker plant combination is a viable option for future investment, as once the world reaches a 100% renewable energy future, the hydrocarbon assets can simply be scrapped, leaving behind only a renewable energy source.

There is no doubt that the global energy market is headed toward a fully renewable future, and this study neither supports nor denies that. Following the results of the regression, there is not enough statistically significant evidence that supports full investment in either green or non-green sources. Instead, it is a study that must be run year after year until a fully renewable energy approach is proven to be positively related to the selected financial indicators in a statistically significant manner, giving green companies the advantage over non-green companies. This would likely include many panel regression studies using recent data, as cross-sectional regressions can often be skewed due to previous events affecting the market, and may not include recent developments in technology. Also, it may prove insightful to conduct further studies between differing renewable energy sources, rather than comparing them solely to hydrocarbon sources. This would allow one to determine the advantages and disadvantages, financially, of each renewable technology which would further aid investors in their decision-making process. Alongside this, a larger study including more control variables that provide statistically significant p-values for each financial indicator would result in a more fruitful analysis. The size of the study could also be improved by conducting a wider study of the market, one that included companies below a $1 billion market capitalization.

While this study concluded that there is no statistically significant relationship between investment in renewable energy sources and financial performance, it is important to note that a transition to renewable energy is imperative for global health, regardless of the financial viability of the matter. Because of this, many companies may choose to invest in renewable electricity generation sources purely as a result of altruistic motivation. However, making renewable energy investment into an investment that is financially viable is crucial in getting the companies studied to make the transition, as money is the greatest motivator for corporate change. Investment into R&D for renewable technologies is crucial in lowering the cost of renewable energy sources which, in turn, will create financially viable renewable energy investments and aid in finally making the transition to a fully renewable energy economy. While it cannot be said with absolute certainty that investment in renewable energy has a positive effect on financial performance, this study showed that society has made healthy advancements toward transitioning to a fully renewable future. However, only the future will tell if investment solely in renewable energy ever provides a statistically significant advantage over hydrocarbon sources, or if it will take outside aid from forces such as government subsidies or consumer pressure to put fuel on the fire of the renewable energy revolution.

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About the Author

Holden Phillips is a four-year undergraduate student at Allegheny College, where he obtained a BA with a major in business and a minor in energy and society. While attending Allegheny, Holden was a varsity-lettered athlete for the Allegheny Men's Basketball team four years in a row and a member of the Allegheny Wealth Management Club. During his tenure, the Allegheny Wealth Management Club started the Allegheny Student Managed Investment Fund, created with a $1 million donation from Patricia Tippie orchestrated by the members of the club. Following graduation, Holden will be joining UPMC's Financial Management Rotational (FMR) Program, where he hopes to learn more about the world of finance and wealth management through on-the-job training and experience. Alongside this, while in the FMR program, Holden hopes to earn a graduate degree from the University of Pittsburgh using UPMC's tuition reimbursement program.