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IDENTIFYING FACTORS OF SUCCESS FOR RENEWABLE ENERGY GROWTH IN THE UNITED STATES OF AMERICA

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IDENTIFYING FACTORS OF SUCCESS FOR RENEWABLE ENERGY GROWTH
IN THE UNITED STATES OF AMERICA

BY
ALAA MASRAHI

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
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UNIVERSITY OF RHODE ISLAND

2019

DOCTOR OF PHILOSOPHY DISSERTATION
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201

Abstract

Energy consumption has a complex relationship with its physical, demographic, and behavioral characteristics. The literature review showed that renewable energy is an increasingly important issue in energy security and sustainability. The research on renewable energy consumption identifies the driving and obstructing factors. Renewable energy growth is associated with complex, interacting variables and requires concerted, multidisciplinary efforts for effective research and development. Thus, the aim of this study is to demonstrate the importance of findings that influence renewable energy consumption among 22 states. Our study seeks to understand and assert the complex energy perspective via the relationship between factors and nature of causality. We considered 17 factors in our study that were proposed to identify and examine the relationship between each factor and renewable energy consumption among 22 states. A Vector Autoregressive model is used to evaluate this relationship. Therefore, this study demonstrates and discusses significant factors that Granger impacts in renewable energy consumption. The results demonstrated that the annual renewable energy consumption among 22 states can be predicted by relevant energy, and socio-economic factors. Most importantly, combining outcomes from PCA of energy consumption and socio-economic factors greatly improves the accuracy of prediction. At the state level, most states tend to share similar energy and socioeconomic patterns, as evidenced by the clustering analysis. Furthermore, MANOVA results illustrate total energy as the measure that differs between high-emission states and low-emission states. Moreover, academic research has recognized the role of social acceptance in the use of renewable energy. This study sought to understand how the user's

physical, demographic, socioeconomic, and behavioral characteristics impact their acceptance of using renewable energy in the residential sector in the United States. Twenty-two states, responsible for 20% or more of the energy production generated from renewable sources, were included in the study. This study tested the Theory of Planned Behavior (TPB) research model and included the construct “willingness to pay” to predict consumers’ intention to use renewable energy. The study found that the average household income in the residential sector has an important impact on consumers’ intention to use renewable energy per the TPB model. The study’s results were found consistent with the theory of the TPB structure equation modeling where the subjective norm (perceived behavioral control) and willingness to pay significantly affected consumers’ intention to use renewable energy, while the attitude toward behavior was not. The study concluded that the average household income affected and explained consumers’ behavior path which predicted their intention to use renewable energy in the residential sector in the US. Limitations of the study and suggestions for future research were discussed.

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Chapter 1: Introduction and Background

1.1. Energy Overview

Energy is the most important driving force for economic growth and human activities in modern societies. Since the first oil crisis in the early 1970s, energy has come to the attention of policymakers due to the limitation of energy sources. Energy researchers have been attempting to meet the energy demand despite limited natural sources (U 2002). Figure 1 shows that energy supplies have grown significantly in the past thirty years to meet the needs of economic growth. According to the International Energy Outlook 2016, the “Total world consumption of marketed energy expands from 549 quadrillion British thermal units (Btu) in 2012 to 629 quadrillion Btu in 2020 and to 815 quadrillion Btu in 2040—a 48% increase from 2012 to 2040” (the international energy agency EIA n.d.). Figure 1 shows the rising level of demand over the next three decades. In addition, figure 1 explains how much the energy consumption growing from countries outside Organization for Economic Cooperation and Development (OECD).

Figure 1: Primary energy growth (EIA t. i., 2017)

Fossil fuel has contributed to enhancing the role of energy in economic growth. According to World Bank (Bank n.d.), the total fossil fuel consumption worldwide (representing all fossil energy forms) is approximately 81% of total world consumption. At the end of 2015, the Organization of the Petroleum-Exporting Countries (OPEC) proved that its crude oil reserve was 1,213.4 billion barrels (bbl) which comprised of 81% of the global crude oil reserve. The non-OPEC proven crude oil reserve was 279.2 billion bbl, or 19% of the global crude oil reserve (OPEC n.d.).

According to Larry Hughes and Jacinda Rudolph (2011), world oil production will have exceeded 2000 giga (billion) bbl in the span of 135 years. The total world primary energy supply from 1971 to 2014 was composed of 31.3% oil, 28.6% coal, 21.2% natural gas, 10.3% biofuels and waste, 4.8% nuclear, 2.4% hydro, and 1.4% other (geothermal, solar, wind, heat, etc.) (IEA 2016). Peak oil refers to the maximum oil (fossil fuels) production of finite resources, which then gradually declines to zero (MK. 1956) . According to Shahriar Shafiee, Erkan Topal (2009), the fossil fuels for” oil, coal, and natural gas will run out in approximately 35, 107, and 37 years”, respectively. In contrast, Saria and Akkayab (2016) expect that “natural gas will run out in 60 years” based on the last proven reserve. According to the World Fact Book published by CIA in 2017, the proven world crude oil reserve was 1.662 trillion bbl in 2016 (CIA n.d.). Therefore, increasing of gas and oil prices could cause increased shale oil production (Lev n.d.) . According to Institute of Energy Research IER (2017) , the US has 1 trillion bbl of oil equivalent “(four times the Saudi Arabian proven oil reserve)” that could be recoverable from shale oil (IER n.d.). Figure 2 below shows that US has the largest amount of shale oil proven reserved, with Venezuela and Saudi Arabia coming in second and third, respectively.

U.S. OIL SHALE TECHNICALLY RECOVERABLE RESOURCES VS. FOREIGN OIL RESERVE ESTIMATES

Figure 2: Oil shale oil technically recoverable resources vs. foreign oil reserve

Therefore, in terms of sustainability and diversification of energy sources, energy experts, economists, and policymakers, are working to mitigate the risk of diminishing fossil energy and the impact of fossil energy to the environment by investing in a variety of energy forms that can be classified as follows:

- Conventional energy (finite resources): energy dependent on fossil fuels, including oil, coal, and natural gas. The Department of Energy defines nonrenewable sources as those that formed when prehistoric plant and animals died and were gradually buried by layers of rock. Conventional energy sources such as oil, coal, and natural gas have proven to be highly effective drivers of economic growth. However, massive usage of conventional energy has caused damage to the environment and human health.
- Renewable energy (non-conventional energy): this refers to all energies produced from natural processes “ (e.g., hydropower, solar, wind, geothermal, ocean)”.

Renewable energy has contributed to low carbon transmissions and to meeting the rapid growth in energy demand. According to Arif Saria and Murat Akkayab (2016), renewable energy contributed to 13% of the total global energy needs in 2012. According to International Energy Agency (2018), renewable energy accounted for almost 25% of global electricity generation in 2018 (EIA n.d.). Even though development and improvement of renewable energy technologies cuts renewable energy costs, public policy has a significant role in developing renewable energy capacity (ILO 2011).

The world is aware of the importance of energy. The availability, reliability, and security of energy has become strategic challenges. The intensive use of conventional energy that depends on fossil fuels (coal, oil, and natural gas) has led to an increase in environmental pollution (greenhouse gases (GHGs) air pollution, and hazardous water) and caused global warming and climate change. In addition to the problems of environment damage, fossil energy is a non-renewable resource, which presents a risk in long-term strategies due to energy supply depletion. A monumental global challenge is determining how to obtain a sustainable energy supply that balances economic growth and environmental and social impact. The earth has undergone an increase in temperature. The majority of climate scientists now believe that there is a direct link between this warming and GHG emissions because the warming trend of 0.23 °F over the last 50 years is twice that of the last 100 years (Amber Jenkins 2009; Anjali Goel and Ranjana Bhatt 2012)

In particular, carbon dioxide (CO₂) emissions are responsible for 50% of the greenhouse effect (Anjali Goel and Ranjana Bhatt 2012). The Intergovernmental Panel on Climate

Change IPCC (2007), the global atmospheric concentration of carbon dioxide has increased from the pre-industrial value of 280 ppm to 379 ppm in 2005 (IPCC 2007).

The effects of global warming have been represented as increased global temperatures caused by a broad range of changes. In fact, the global average temperature was increased 0.8 Celsius above the average global temperature since 1880 (NASA n.d.) . Since 1968, Hardin illustrated the importance of sustainability by describing the role of society and human activities in managing finite resources globally (Graedel 2010). The world has been more serious about sustainability since 1987, when the World Commission on Environment and Development published the “Our Common Future” report. The report raised the issue of growth overshoot in the volume of goods traded internationally, production of synthetic organic chemicals, and global rate of fossil fuel consumption (Brundtland 1987).

Certain factors have boosted world energy consumption due to advances in technology and rapid economic growth in countries such as China and India (energy4m n.d.). In addition, the United Nations estimates that the population will increase from 7.3 billion to 9.2 billion by 2040, which will increase energy, demand further (world nuclear association World-nuclear n.d.). According to Graedel Braden R. Allenby (2010), the causes of overshoot are categorized into three parts: rapid growth (population, economic, and technological), the limitations of finite energy resources, and delays or errors regarding perceptions of the Earth system. Although fossil fuels will endure to dominate the energy market over the next few decades, fossil fuels will account for more than 90% of total primary energy demand in 2020 (Painuly 2001). It is crucial to consider renewable energy as one option

to diversify energy sources which could allow fossil fuels sources to be used for longer periods.

1.2. US Energy Overview

The “US primary energy consumption” was 98.98 quadrillion Btu, equal to 18% of world total primary energy consumption in 2014 (PennState n.d.). In fact, US energy consumption has changed significantly over time as new energy sources and technologies have been developed. According to Nicholas Apergis, Payne, Menyah, & Wolde-Rufael (2010), the US is the single largest emitter of CO₂. Figure 3 below illustrates the significant energy changes in different categories from 1776 to 2015 in the US. Energy Information Administration (2017), the US primary energy consumption in 2017 was 97.7 quadrillion Btu (28.0% petroleum, 31.8% natural gas, 17.8% coal, 12.7% renewable energy, and 9.7% nuclear) (U.S. Energy Information Administration EIA 2018). According to the Institute for Energy Research (IER) approximately 25 percent of our oil product supply in 2010 was purchased from OPEC and the US has 198 billion bbl of recoverable conventional oil – “enough to power the country for the next 29 years at its 2010 rate of oil use (Energy 2012)”. Figure 3 shows different types of energy sources grouped into fossil fuel (petroleum, natural gas, and coal), renewable energy, and nuclear electric power for the USA’s primary energy consumption from 1949 to 2015. Figure3 illustrates how the mix of US primary energy consumption has changed over time. Petroleum is recorded as the first largest type of primary energy consumption. US energy information administration, coal peaked in 2008 and declined because the decreased coal consumption for electricity generation. In addition, we can observe in figure 3 that natural gas consumption was recorded as the second largest type of primary energy consumption over the time in the US. Figure 3 shows a slight growth in renewable energy consumption from

1963 until 1977. The US renewable energy consumption generally increased each year between 2001 and 2015.

Figure 3:US Primary Energy Consumption

According to Energy Information Administration EIA (2017), the primary energy sources in the US are natural gas, coal , petroleum, nuclear electric power , and renewable energy. The EIA reported the total primary energy consumption share among five sectors in 2016 as 38.1% electric power, 28.8% transportation, 22.4% industrial, 6.2% residential, and 4.5% commercial in 2017 (E. I. A. EIA n.d.).

The use of renewable energy is considered one of the most significant alternative solutions for overcoming and reducing “GHG emissions”, mitigating oil price fluctuations, and improving environmental conditions and sustainable energy. Furthermore, renewable energy provides sustainable energy for subsequent generations. In fact, the federal government of the US has established a roadmap to mandate that the states produce energy from renewable sources as alternatives to fossil fuel (NREL n.d.). Many states in the US have established a renewable portfolio standard (RPS).According to Energy Information

Administration EIA (2012), the RPS or renewable standards (RES) are defined as policies to encourage energy production and generation from renewable sources (e.g., solar, wind, geothermal, biomass, and other sources as hydroelectricity) (U. S. E. I. A. EIA n.d.). In Figure 4, the EIA shows which states have a mandatory RPS and (voluntary) goals.

Figure 4:US Renewable Energy Standards RES (EIA e. i., 2012)

Since 2000, US renewable energy growth has been approximately half of that of renewable electricity. Berkeley Lab reports that “Nationally, the role of RPS policies has diminished over time, representing 44% of all U.S. RE capacity additions in 2016. However, within regions, RPS policies continue to play a central role in supporting RE growth, constituting 70–90% of 2016 RE capacity additions in the West, Mid-Atlantic, and Northeast. Meeting RPS demand growth will require roughly a 50% increase in U.S. RE generation by 2030, equating to 55 GW of new RE capacity”(Barbose 2017:3) . Figure 5 shows the US RPS renewable energy policy targets for the percentage of electricity to be generated from renewable energy sources (e.g., CA is targeted to have 50% of its electricity from renewable energy sources by 2030.)

Figure 5:US RPS renewable energy policies (Barbose, 2017)

1.3. Natural Systems

Natural systems refers to a natural process (e.g., solar system, rain cycle). Human-made systems refers to human intervention through elements of the natural system (components, logical relationships, attributes) to create and achieve human needs and objectives. To show the complexity of the relationship between human-made and natural systems, it could use the industrial revolution as an example. Since the industrial revolution, human activities have added a large volume of greenhouse gases into the atmosphere by burning fossil fuels for energy. When greenhouse gases are released into the atmosphere, many greenhouse gases, such as carbon dioxide, remain for periods ranging from decades to millennia (Climate 2014; U.S. Environmental Protection Agency 2016)

According to Arrhenius (1896), he realized that the amount of carbon dioxide being released into the atmosphere was increasing. Arrhenius thought carbon dioxide and air pollution (greenhouse gases) concentrations would continue to increase due to world's consumption of fossil fuels. This led him to predict the doubling of carbon dioxide levels

in the atmosphere, thus increasing global warming, in the next 100 years (NASA, Global Warming, 1998).

1.4. Sustainability Overview

Sustainable development has been defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Sahota 2013). In the quest for a sustainable future, sustainability is examined from biological, political, physical, and spiritual perspectives. It is also necessary to consider sustainability’s effects on everything from social communities to ecosystems. International Council for Science (2010), “The balance of nature is very delicate and easily upset”. Thus, the global institutions have been concerned for sustainable global systems (2010). One such famous institution is the International Council for Science (ICSU), which was founded in 1931. According to Science (2010), “The ICSU is a non-governmental organization representing a global membership that includes national scientific bodies” (International Council for Science ICSU 2010:2). The ICSU includes four global environmental change programs: the World Climate Research Programme, the International Geosphere-Biosphere Programme, the International Human Dimensions of Global Environmental Change Programme, and DIVERSITAS (International Council for Science ICSU 2010). The ICSU defines five significant challenges to the Earth system and global sustainability: forecasting, observing, confining, responding, and innovation. The ICSU defines the Earth system as “the social and biophysical components, processes and interactions that determine the state and dynamics of the Earth including its biota and human occupants” (International Council for Science ICSU 2010:4). For the world to achieve global sustainability, the social, natural, health, engineering sciences, and humanities are all required to overcome significant challenges individually and collectively

(International Council for Science ICSU 2010). The growth of renewable energy is inspiring the world to establish sustainable energy resources that clue and stratify the present without compromising the needs of future generations.

1.4.1. Grand Challenges

Figure 6 shows five significant challenges that need integrated research to find solutions for the Earth's systems and global sustainability. The concentric circles represent the disciplinary research needed in the social, natural, health and engineering sciences, and the humanities that must be carried out alongside interdisciplinary and transdisciplinary research in order to address the challenges.

The lines linking the grand challenges show that progress in addressing any challenge will require progress in addressing each of the others (International Council for Science ICSU 2010).

Figure 6::Grand Challenges (Science, 2010)

1.4.1.1. Forecasting

“Improve the usefulness of forecasts of future environmental conditions and their consequences for people” (International Council for Science ICSU 2010:10). The aim of forecasting is to provide society and decision makers with reliable temporal and spatial information. Forecast challenging refers to an Earth system that interacts with sets of human actions or conditions (e.g., population size, macroeconomic variables of countries, levels of consumption of food, energy, water (life standards) and greenhouse gas emissions.

1.4.1.2. Observing

“Develop, enhance and integrate the observation systems needed to manage global and regional environmental change” (International Council for Science ICSU 2010:12). The ICSU has been seeking to identify what is needed to observe social environmental systems characteristics until the response and influence of global change are well identified.

1.4.1.3. Confining

“Determine how to anticipate, recognize, avoid and manage disruptive global environmental change” (International Council for Science ICSU 2010:13). The aim of confining is to find optimal ways for enhancing resilience to disorderly change by the identification, analysis, and tracking of significant risks for social environmental systems.

1.4.1.4. Responding

“Determine what institutional, economic and behavioral changes can enable effective steps toward global sustainability” (International Council for Science ICSU 2010:14).

Responding seeks to identify the ways organizational structure and economic systems based on the tradeoff between social needs and global environmental concerns contribute to global sustainability development.

1.4.1.5. Innovation

“Encourage innovation (coupled with sound mechanisms for evaluation) in developing technological, policy, and social responses to achieve global sustainability”(International Council for Science ICSU 2010:15) .Innovation seeks to identify system strengths among policy, technology and institutional innovation to respond to global sustainability due to social demands. Researchers are looking to understand how ecosystem service (e.g., provisioning services, regulating services, supporting services, and cultural services (TEEB n.d.) can meet human and society needs to improve standards of living in the framework of global sustainability.

1.5. Aims and objectives

The aim of this study is to investigate the important factors that influence renewable energy consumption and growth. These objectives will need to be sequentially completed:

- Identify, based on previous literature, the critical major dimensions for factors that influence renewable energy consumption and growth.
- Develop a model by using data mining (secondary data) of factors that examine and weigh the factors that influence the renewable energy consumption.
- Develop a model to cluster factors that influence renewable energy consumption.

- Develop a model by using social data (primary data) of online surveys of householders to examine the factors that influence them toward renewable energy consumption.

1.6. Research Motivation

As we have mentioned in the introduction and background, energy is crucial in advancing economic and social development, which contributes to the increase in national income and sustainable resources as well as exerting a strong influence on the process of civilization and social progress and development. However, renewable energy growth is associated with complex, interacting variables and requires concerted, multidisciplinary efforts for effective research and development. This dissertation investigates the factors that influence renewable energy growth. Successful factors are the key to renewable energy growth. For this, successful strategy implementation and the growth of renewable energy require a comprehensive understanding of which factors are required for sustainable growth. Hence, this research will conduct an analysis to identify the relationships between macroeconomics, global oil prices, population growth factors, and electricity demand-enhanced renewable energy growth to develop a model that focuses more on macroeconomic factors using an oversimplified representation of major oil and gas exporting and pricing. It seeks to model and develop a framework of renewable energy issues, including growing local demand, and a domestic economy that considers global oil price fluctuations. Renewable energy has been historically employed to support the diversification of the economy through renewable energy growth by state. A survey questionnaire will be conducted to determine what are the factors influencing the

behavioral intention among green energy consumers of renewable energy growth in 22 states.

1.7. Research Questions

- What are the vital aspects and factors that influence renewable energy consumption?

Identify and determine the key factors that have an influence on renewable energy consumption in the USA by using systematic literature review and identify the significant factors of renewable energy consumption.

- What are the Granger causality effect among the factors identified and renewable energy consumption in the USA?

Find significant and influential factors and grouping the factors based on the relative field.

- Do high-emission states versus low-emission states differ in at least one of the measures-- renewable energy consumption and fossil energy consumption?

Identify the impact of renewable energy consumption and fossil energy consumptions on the states' emission level.

- Could US annual total energy consumption be predicted accurately based on the principle components analysis score derived from a set of highly correlated socio-economic predictors?

The purpose is to apply Principal Component Analysis (PCA) because that technique allows finding correlations among variables represented by a set of observations stored in a matrix. These data were collected have a high degree of multicollinearity among predictors.

- Do those states sharing similar energy consumption and macroeconomics profile tend to cluster in the energy and economic landscape?

Cluster and separate the states into subgroups, based on macroeconomics and energy consumption. States within the same cluster are considered homogenous at the macroeconomic and energy consumption level.

- What are the factors influencing the behavioral intention among green energy consumers?

Identify the existing unobserved latent factors that explain the consumers' intention and how likely the consumers will perform their behavior

This study will conduct a survey to identify and explain the consumers' intention and how they will change their behavior to use renewable energy in the 22 states. Additionally, the survey seeks to identify the attributes and behavior of expected renewable energy consumers in 22 states. In addition, the survey seeks to tackle the challenges of renewable energy growth based on consumer perspectives in 22 states.

1.8. Expected Contribution

The proposed research employs two approaches: the top-down and the bottom-up approaches. This (1) offers an integrated approach to identify the factors that will enhance and develop renewable energy by designing and mapping a conceptual framework for renewable energy growth, and we will achieve this quantitatively by tracking and identifying real data; (2) delineates the relationships among factors that influence renewable energy growth; (3) clusters the states that are contributing to renewable energy production from 20% to above 80% based on social, economic, and energy consumption

per capital; and (4) builds a model to forecast renewable energy growth. This integrated model is a robust combination of multiple approaches to identify and analyze factors needed for renewable energy growth.

Principal Components Analysis (PCA), a multivariate technique that combines aspects of factor analysis and multiple regressions, can lead to the determination of significant factors that influence renewable energy growth.

Primary and secondary data analysis, statistical tools, time series methods, and a multivariate technique will be applied to identify and evaluate success factors for identification, evaluation, measurement, and optimization to allow decision makers to invest in renewable energy. In this study, we hypothesized the measured variables of income as a “manifest factor”. We also investigated some mediation effects including the effect of the manifest factor on the attitude towards, subjective norm, and PBC to predict intention to use. This study may help predict and explore the consumer attitude, intention, and actual behavior. In addition, this study may conduct the challenges and opportunities for policymakers and researchers to understand their behavior decision. To the best of the author’s knowledge, no studies have been found to integrate a conceptual framework and combined top-down and bottom-up approaches related to the renewable energy growth usage of homeowners in the US. Additionally, there are no approaches that show how these factors could encourage, enhance, and cause renewable energy growth. From this point on, the research will investigate how a top-down approach using econometric variables and a bottom-up approach using end-user samples can enhance and contribute to knowledge of renewable energy growth.

1.9. Dissertation organization and structure

The remainder of this dissertation is organized as follows: Chapter 2 presents a literature review of the relevant studies in renewable energy that used three components of the sustainability systems: economic, environment, and social. Chapter 3 discusses the study methodologies and each hypothesis. Chapter 4 presents the findings and results. Chapter 5 discusses the important findings and discusses the possible future extensions of the work. Chapter 6 restates the study conclusion and discusses the study limitations and possible future extensions of the work

Chapter 2. Systematic Literature Review

Chapter 2 of this study will identify existing studies related to the factors of success for renewable energy growth in order to evaluate those studies to synthesize the factors that enhance renewable energy consumption growth. “In this guide to systematic literature reviews, the methods of conducting systematic reviews are discussed in relation to minimizing bias, searching the literature and investigating heterogeneity (Nightingale 2009)”. The systematic literature review helps the researcher to identify specific questions to research, give guidance to the study’s planning, and target study gaps which contribute to the significant value of novel research (Piper 2013).

2.1. Glance to Systematic literature review

In reviewing previous literature and research, we noted that the intensity of renewable energy has contributed to achieving a lower carbon transmission and meeting the rapid growth in energy demand. According to Renewable Energy Policy Network for the 21st century REN21 (2017), the global insights have driven the evolution of renewable energy over the past decade. Several factors have enhanced and catalyzed the rapid growth of renewable energy such as the energy crisis in the 1970s, national energy security, population, and energy demand. Even though the development and improvement of renewable energy technologies contributed to cutting renewable energy costs, public policy plays a significant role in continuing to drive renewable energy development (ILO 2011). The ren21, report refers to the role of continuing technology advances and the rapid deployment of many renewable energy technologies (REN21 2017). There are various studies have been seeking to understand the relationship between economic activities and energy consumption sources (Altunbas and Kapusuzoglu 2015; Asafu-Adjaye 2000; Wang, Wang, and Wang 2011).

2.2. Systematic literature review strategy

A systematic review was conducted in the field's current research to determine which factors influence the implementation and growth of renewable energy. This systematic literature procedure attempts to determine the key factors that influence renewable energy implementation strategy. For this study, a systematic search process was carried out using the combination of the following keywords: renewable energy*, growth*, and implementation*; growth* and renewable energy*; and forecast*, renewable energy*, and success*. Below, figure 7 defines systematic procedures as the following: keywords, relative subject areas, removing duplication, reviewing title and abstract, and analysis.

Figure 7: Systematic Literature Review Stages Procedures

To achieve and attain a sustainable renewable energy growth, we must build and develop a scientific approach to understand the vital factors that help the growth of renewable energy based on sustainability system. Thus, the researchers seek to identify the success factors, barriers and obstacles that could limit or drive the consumption and production of renewable energy. Consequently, the researchers must consider a variety of factors at the level of governments and societies. It should also identify the economic and environmental benefits resulting from the growth of renewable energy. Several studies examined the

reasons for the use of renewable energy and the reasons for success. Recently, a study was conducted by means of a literary review of the study. The study concluded that are several factors that play main role in sustainability systems (i.e., economic, environment, social). Figure 8 depicts systematic review keywords which were used in the current research to analyze literature in the field to determine which factors influence the implementation, growth, and consumption of renewable energy.

Figure 8: Words accounts

Systematic literature synthesis is defined as system design that converts the systematic literature conceptual design into three constructions or components based on the sustainability system (economic, environment, and social). In general, system analysis refers to the procedures that break down systematic literature into 5 stages to gain related articles to our topic. Figure 9 shows five stages from three academic research engines to show how the systematic literature review procedures outcome was obtained.

Figure 9:systematic literature review stages outputs

The three academic Systems we used to gain systematic literature review were Scopus, Web of Science, and Science Direct. The total number of articles that were related to research keywords were reduced from 8486 to 621 through evaluation of relevant content. We evaluated 621 articles based to exclude articles published after 2006. In stage 3 duplicate articles were eliminated reducing the sample size to 616. In stage 4, the titles and abstracts were reviewed to further reduce the number of articles from 616 to 214. In stage 5, 126 articles were read and determined to be relevant. By following the synthesis, analysis, and evaluation process these results comprise a comprehensive systematic literature review.

2.4. Previous systematic literature review

Howes et al. (2017) did a systematic literature review to identify the reasons behind environmental policy failure in general. They identified research that included factors for achieving environmental sustainability. This reduced the number of their articles from 8339 to 94. They conclude that causes of environmental policy failure include interrelated structural causes (e.g., economic, social, environmental, political, technical, legal, and discursive) implementation traps (e.g., incomplete specification, inappropriate agency, conflicting objectives, incentive failures, conflicting directives, limited competence, inadequate administrative resources, communication failure) and knowledge/scoping issues (e.g., incomplete understanding of problem, a reading of issues that is too narrow, lack of evaluation.) “In terms of the relationships between structural causes, the prevalence of economic and political factors appears in 71 of the 94 papers (76%) including both the case-study and more general articles. Of these 71 papers, economic and political factors appear together 24 times (34%) while economic factors appear independently 29 times (41%) and political factors 18 times (25%).” The authors said “the policies need to be more comprehensive in terms of the area and recommended for future research to identify context-specific reasons for failure and exploration of the complexities in developing and implementing sustainability policies”.

Other researchers seeking to identify the factors that could influence and drive the renewable energy path (Can Şener, Sharp, and Anctil 2018) have done systematic literature reviews to identify that factors drive and influence the path of renewable energy. They selected 60 qualitative and quantitative academic studies from 1431 by using a multistage selection process. They identified from this systematic literature process seven main factors

(i.e., economic, environment, political social, technical potential, regulatory, and technologies) that influence renewable energy usage.

Economic (national income and price of non-renewables), environmental, and social factors were found to be drivers while political, regulatory, technical, technical potential, and technologies factors were undetermined as drivers or a barrier. “However, the price of non-renewable energy source subcategory was found to be a driver in 12 studies and a barrier in nine studies, and, overall, was classified as a factor that has an undetermined impact on the renewable energy deployment of countries” and national income was found to be a positive impact. According to Mirza, Ahmad, Harijan, & Majeed (2009), they declared the barriers to development of renewable energy can be seen broadly in Pakistan. They classified these barriers “as policy and regulatory barriers, institutional barriers, fiscal and financial barriers, market-related barriers, technological barriers and information and social barriers” (Mirza et al. 2009:927).

Furthermore, they conclude the poor or low levels of policy integration were predictors of policy failure. Another study sought to analyze renewable energy factors found five criteria (i.e., technology, market, economic, environmental and policy) that play a role for a successful renewable energy dissemination program. This study identified these main five-criterial factors based of Korean government goals to increase renewable energy share to 11% in the overall primary energy mix. The study assigned classified experts into two groups. The first group consisted of policy makers who were members of the government. The second group consisted of specialists in the energy sector as members of universities (Korea Maritime University , Yonsei University, Inha University), civil groups, government funded institutes, and Korea New Renewable Energy Association) . Using a

fuzzy analytical hierarchy process (AHP) to estimate a factor's weight, they identified four major conclusions that are “the importance of economic feasibility, the advancement of the target technology in the global market, the disagreement between the policymaker and the specialist group, and the application of the results” (Heo, Kim, and Boo 2010:2214).

2.5. Systematic literature review based on the components of sustainability systems

System theory (ST) provides a set of powerful integrated tools that can be used to integrate and shape the sustainability system structure in the multidisciplinary areas such as physical, life, engineering, and social science. System theory also describes the interaction and interrelationship between the social, ecological, and economic systems as group (Pappas 2012). System theory collectively studies systems from the perspective of the whole system and its various subsystems to predict and analyze the patterns resulting from the interaction and interrelationship between these subsystems. In addition, systems theory has a great influence in understanding how organizations change. Sustainability researchers focus on studying and understanding obstacles and traps that cause systems to overshoot.

Figure 10: Three perils of sustainability systems

According to Center of Sustainable Systems University of Michigan (CSS, 2016), the role of sustainable systems is to develop and implement systems analysis and transform systems to meet human need. Sustainable systems seek to design and optimize alternative projects to avoid the three perils of sustainability systems (social, economic, and environment) (CSS n.d.). Figure 10 above depicts the interconnection of the three perils of cross disciplinary sustainability: social, environmental, and economic factors (McNulty n.d.)

2.6. Systematic literature for Components of sustainability systems

Systematic literature Systems of sustainability is composed of and a combination of three main components: economic, environmental, and social. Component refers to parts of a system. However, components can be subdivided into smaller levels known as attributes. Attributes refer to factors of the components such as fossil energy prices, and GDP. Relationships of components are investigated vis a vis renewable energy consumption. In real situations, the systems cannot be isolated but are interrelated.

2.6.1. Economic and Energy consumption

Macroeconomics describes economic activities and processes which related to aggregate economic processes that deal with large activities and components of the economy. Macroeconomic indicators include variables such as a measure of Gross product per capital GDP, unemployment rate, and average income.

The energy is a key of the world economy. Energy sources are considered one of most important influence on economy growth. According to Bloch, Rafiq, and Salim (2015), they classified the relationship between energy consumption and economic growth into four hypothesis: growth hypothesis, feedback hypothesis (bidirectional causality), conservation hypothesis (unidirectional, directional) and neutrality.

According to Stern (2011), there are numerous researchers examined and investigated the relationship between economy activities and types of energy sources. Studies are based on the methodology for system research, aiming for an integrated consideration of all aspects and directions of the relationship between the economy and the energy resources growth (Stern 2011). According to Stern (2011), energy scarce is a strong constraint and important driver of economic growth. Stern shows through literature review that there is relationship between energy and economic growth such as GDP and energy. Stern illustrates and concludes the relationship among the energy abundance and economic growth shows a significant and positively relationship.

2.6.1.1 Gross Domestic Product GDP

The Gross Domestic Product (GDP) provides a measure of the economic value of the goods and services produced in a specific time period. GDP is very important to each country as it exhibits the strength of the country's economy and has a significant impact on country's stock and currency markets, and energy demand. As Stern (2011) mentioned, there are numerous studies have been investigated to identify the relationship between economic growth and energy consumptions such as (Altunbas and Kapusuzoglu 2015; Asafu-Adjaye 2000; Wang et al. 2011). According to Soytas and Sari (2003) Investigated the causal relationship between GDP and energy consumption in 16 countries. They found that GDP and energy consumption were stationary but became stationary with the first lag (first difference) for all countries (Soytas and Sari 2003). They found a causality relationship from GDP to energy consumption in Italy and Korea. Also, they reported there was a causality relationship from energy consumption to GDP in Turkey, France, Germany and Japan. In addition, they found a bi-directional causality between energy consumption and

GDP in Argentina. According to Lee (2005), he investigated the causal relationship between energy consumption and Gross Domestic Product GDP in 18 developing countries from 1975 to 2001. This study found that energy consumption had a significant influence on the income change in developing countries and energy conservation may have harmed economic growth. Lee and Chang (2008) investigated the relationship between energy consumption and economic growth in 16 Asian economies from 1971 to 2002, the paper result concluded that the GDP cannot be affected badly by the reducing energy consumption in the short-run but the GDP could be affected badly in the long-run.

Essentially, the energy shift warrants further study to ensure a smooth shift from the conventional to non-conventional energy. Therefore, the researchers have investigated what affects the shift in energy related to economy. Thus, the relationship between the economic variables such as GDP and renewable energy has been studied in some countries. Malik et al (2014) investigated the relationship between the macroeconomic and renewable energy in Pakistani. He found a significant relationship among them. Similarly, Pao and Fu (2013) studied the relationship between energy consumption and real GDP from 1980 to 2010 in Brazil. Their study divided energy consumption into four types: total renewable energy consumption, non-hydroelectric renewable energy consumption, total primary energy consumption, and non-renewable energy consumption (defined by the OECD (Organization for Economic Cooperation and Development) as “the direct use at the source, or supply to users without transformation”). They found that there is a positive relationship between economic growth and non-hydroelectric renewable energy consumption. Additionally, the results demonstrated that the impacts on non-renewable energy consumption and total primary energy consumption were insignificant. Many

researchers have become more interested in studying the relationship between the macroeconomic variables and renewable energy sources. This attention sprang from aspects such as the global environmental footprint, crucial economic considerations, and diversification of energy sources. According to Ohler and Fethers (2014), their paper's purpose was to study the relationship between GDP growth and renewable electricity generation in 20 OECD countries from 1990 to 2008. This paper investigated the following sources of energy: wind, hydroelectricity, waste, and biomass. The wind energy results show a positive long-term relationship with GDP growth. While the hydroelectricity has the largest positive Granger-causing influence the GDP in the short term. Also, GDP growth has a positive effect on biomass and solar energy. Similarly, Salima, Hassanb, and Shafiei (2014) investigated the relationship between renewable energy and nonrenewable consumption in 29 OECD countries from 1980 to 2011. The paper findings give evidence the relationship between non-renewable energy consumption and GDP growth indicated as bidirectional in short-term. However, their results indicated there was unidirectional causality exists between renewable energy consumption and GDP growth. According to Yildirim, Sarac, and Aslan (2012) ,who studied US energy from 1949 to 2010 for total renewable energy, 1960 to 2010 for geothermal energy, and 1970 to 2010 for biomass energy consumption. This study found no causal relationships between all types of renewable energy sources except biomass waste-derived energy consumption, which exhibited a causal relation to real GDP. According to Al-Mulali (2013), investigated the bi-directional long run relationship between renewable energy consumption and GDP growth based on classification of income in 108 countries into high income, high High-income countries , upper middle income, and lower middle income. Remarkable, they

found a positive bi-directional relationship between renewable energy consumption and GDP in 79% of the countries in the long run. Also, they reported approximately 19% of the countries that indicated no long run relationship between the variables. Finally, they reported approximately 2% of the countries showed a one-way long run relationship between GDP growth and renewable “energy consumption”.

2.6.1.2. Income

Salim & Rafiq (2012) examined influencing of renewable energy consumption on the economic activities in six countries (China, Brazil, Indonesia, Philippines ,India, and Turkey) over 1980-2006. This study indicated the renewable energy consumption is considerable “significantly “determined by “income and pollutant emission “in Brazil, China, India and Indonesia within long term”. Nevertheless, the renewable energy consumption can be determined by income only in the Philippines and Turkey. In addition, they found there is a causal relationship between income and renewable energy that indicated to be bidirectional in the short run. According to Can Şener et al. (2018), they studied national income and the price of non-renewables and national income was found to positively drive paths of renewable energy. Sadorsky (2009b), investigated the relationship between the renewable energy consumption and real per capital income over 1993 – 2003 for 18 emerging countries. This study found that the income has a positive impact on renewable energy consumption. Sadorsky (2009b), cited ” that Pfeiffer and Mulder found that income, education, democracy and implementation of economic and regulatory instruments have significant positive effect on renewable energy diffusion” whereas Sebri & Ben-Salha (2014), identified the causal relationship among the renewable energy consumption and economic growth in BRICS countries (India, Russia, Brazil,

China and South Africa) over 1971-2010. They found the increase of income obviously supporting and driving the growth of the renewable energy sector. Clearly, we can conclude the income has positive impact and there is a consensus that the increase of income positively influences renewable energy. The relationship between energy consumption and income in emerging economies has been a very active area of study to determine whether the relationship between renewable energy and national income has a positive impact or not.

2.6.1.3. Crude oil, coal, and gas prices related to economic variables and renewable energy

The world economy has been induced to study the relationship between macroeconomic factors “variables” and crude oil price fluctuations since the Arab oil ban of 1973–1974. According to Akella, Saini, & Sharma (2009), the traditional energy sources “conventional “such as natural gas, oil, and coal found to be extremely effective drives and enhances the economic progress. Traditionally, the price of energy generated from conventional energy sources is lower than the price of energy generated from RE sources (Kilinc-Ata 2016). According to Lin & Omoju (2017), investigated over forty-six developed and developing countries from 1980-2011 to identify which factors could influence the share of renewable energy, specifically “non-hydro renewable energy sources”. This study found the fluctuations in oil price “increases” has a positive influence on the share of “non-Hydro renewable energy sources”. In fact, most countries that are seeking to speculate in renewable energy not solely wish to cut back dependence on imported oil, however additionally prefer to extend the terms of secure energy and decrease the volatility of the fuel prices and imports (Kilinc-Ata 2016).

On the other hand, several academic and industrial studies show that crude oil constitutes a large portion of energy consumption. According to Energy Information Administration (EIA), the global economy has been highly correlated with oil price (E. I. A. EIA n.d.). Crude oil price become volatile relative to other crude commodities such as natural gas, refined petroleum (Al-Mulali et al. 2013). Thus, the oil price volatility encourages countries to have alternative energy sources such as renewable energy. According to Akay and Uyar (2016), the macroeconomic variables that have a relationship to the oil price are GDP and CPI. That means the oil price fluctuation is significant to macroeconomic variables. Thus, we ask, does the oil price influence the renewable energy growth?

According to Shafiee & Topal (2009), crude oil price volatility has been influenced by macroeconomic factors “variables: such as GDP growth in modern economy. In fact, the main exogenous variables in the econometric model effecting”oil, coal and gas reserve trends are their consumption and respective prices between 1980 and 2006” (Shafiee and Topal 2009:Abstract). The empirical evidence from academic literature and economic reports obviously indicates the growths of the economic activities “macroeconomic” due to the increasing the oil price can show a negative influence the macroeconomics (González and Nabiyeu 2009)”. Therefore, researchers pay more attention to the relationship between crude oil price and macroeconomic performance. This has been widely accepted since “Hamilton’s work indicating that oil price increases reduced US output growth between 1948 -1980 (Anton n.d.)” .Similarly, a study in Nigeria found that oil price volatility has significant negative impact on macroeconomics (Agri, Kennedy, and Nnandi 2016). An important indicator to forecast and predict the oil production according to M. King Hubbert (1956) is the world’s oil production rate. The fluctuation of oil price

could have a significant influence on developed and under-developed countries according to Brown and Yücel (2002). There are many agencies dedicated to predicting crude oil price, for instance OPEC, OECD, and USA energy information administration (EIA).

On other hand, the coal consumption causes pollution whereas oil consumption shows no significant impact on emissions. The growth of renewable energy consumption could be contributed to a reduction in emissions. Also, the volatility of oil and natural gas prices increases the uncertainty of energy or the electricity prices (Aguirre and Ibikunle 2014). Thus, renewable energy has become more significant due to conventional energy depletion, greenhouse emission mitigation, volatility of crude oil prices, and increasing of energy demand. We will examine the impact of the influencing of oil prices and the growth of renewable energy in terms vis a vis the ability of renewable energy growth. A study in “11 South American countries” over the period of 1980 to 2010 investigated the long run relationship of causal dynamic between renewable energy consumption per capita, and carbon dioxide emissions per capita, and oil prices, The study concluded that the long run estimations had a positive impact with respect to “GDP per capita, carbon emissions per capita, and oil prices” (Apergis and Payne 2015).

According to Bloch et al. (2015); Reboredo (2015), “oil price dynamics contributes around 30% to downside and upside risk of renewable energy companies”. In contrast, technology developments led to increased renewable energy “Solar PV module prices in Europe decreased by 83% from the end of Q1 2010 to the end of Q1 2017. Module costs declined 80% between the end of 2010 and the end of 2016, a period over which 87% of the cumulative global PV capacity installed at the end of 2016 occurred (Renewable Energy Agency 2018:61)”. “Sadorsky (2009a), there is debate about the volatility of oil prices and

the growth of renewable energy in the short, medium, and long terms and whether renewable energy growth will fall due to cheap crude oil price pressures”. Some studies have indicated that the rise of oil prices will be beneficial for the financial performance and stock prices of alternative or clean energy companies (Henriques and Sadorsky 2008; Kumar, Managi, and Matsuda 2012). Sadorsky (2014:73) showed “correlations and volatility spillovers between oil prices and the stock prices of clean energy and technology companies by using multivariate GARCH models”. In contrast, technological development led to increased renewable energy efficiency and more competition. According to Sadorsky (2009a), oil prices showed smaller “negative” impact on renewable energy consumption for the Group of Seven countries (G7) “Canada, France, Germany, Italy, Japan, the UK, and the US” from 1980 to 2005. In fact, global oil prices have fallen from approximately \$110 to the current level of approximately \$50 per bbl (OPEC 2017). “The oil price has to dip as low as \$15 for onshore wind and \$30 for solar for the technologies to be uncompetitive under current feed-in-tariffs (Macamericas n.d.).” Despite crude oil volatility and the global interest to invest in renewable energy, the world energy market will depend on conventional energy for at “least the next 50 years” (Shafiee and Topal 2009).

2.6.2. Environment and Global Warming

Since the industrial revolution, human activities have been added a large amount of greenhouse gases into the atmosphere by burning fossil fuels for energy. When “greenhouse gases” are released into the atmosphere, many gases (e.g., carbon dioxide) remain for long time periods of time (USEP; IPCC, 2007). In addition, Arrhenius (1896) thought carbon dioxide and air pollution (greenhouse gases) concentrations could endure

to growth due to world's consumption of fossil fuels which led him to predict the doubling of carbon dioxide in the atmosphere.

There are many chemical compounds found in the Earth's atmosphere that perform as "greenhouse gases". In fact, these gases absorb and emit infrared radiation in the Earth's atmosphere that reflects from Earth surface, which causes global warming and climate change (U.S. Energy Information Administration EIA n.d.). The earth has been increased in temperature change and majority of climate scientists now believe that there is a direct link between this warming and emissions of greenhouse gases because over the last 50 years as the warming trend of 0.23 F is twice that of the last 100 years (Anjali Goel and Ranjana Bhatt 2012). Carbon dioxide emissions (CO₂) are responsible for 50% of the greenhouse effect (Anjali Goel and Ranjana Bhatt 2012). Oceans levels are increasing due to thermal growth and oceans showed warming 0.302 F. Furthermore, amounts and patterns of precipitation are changing in USA. Precipitation has been increased since 1900, and the total number of annual of hurricanes has been increased since 1975 (E. O. NASA n.d.; United States Environmental Protection Agency EPA n.d.)

2.6.3. Social

Center of Sustainable Systems University of Michigan CSS, the role of sustainable systems is to develop and implement systems analysis and transform systems to meet human needs (CSS n.d.) Sustainable systems seek to design and optimize alternative projects to avoid the three perils of sustainability systems (i.e., social, economic, environment). The governments of many countries are striving to increase renewable energy sharing, work to increase social acceptance, and increasingly recognize that social acceptance may be an important factor in achieving these targets (Wüstenhagen, Wolsink,

and Bürer 2007). In this framework, we seek to investigate and identify the social factors and attributes relative to community acceptance of renewable energy by consumers in the residential sector. Academic research has recognized the role of social acceptance to renewable energy (Zoellner, Schweizer-Ries, and Wemheuer 2008). There are numerous studies that address the cultural, social, climatic, and psychological factors in customers' demand of green electricity (Bock et al. 2017; Sovacool 2009). Some studies measured by quantitative analysis the relationship between social acceptance, demographics, and economic characteristics. According to Joshi & Rahman, 2015 (2015a), there are two main factors that cause green purchasing behavior: the consumer's environmental concerns and the products' functional attributes. To understand the consumers' intention and their behavior is not a simple task since to explain human behavior in all its complexity is a difficult task (Ajzen 1991). The environmental consciousness and behavior changes that encourage the consumers to use and consume green energy is unrelated to the age and gender of the consumer (Singh & Bansal, 2012; Hartmann & Apaolaza-Ibáñez, 2012; Chen & Chai, 2010). According to, Bang, H., Ellinger, A.E.; Hadjimarcou, J. and Traichal, P.A. (2000), investigated the relationship between the concern for the environment, the knowledge about renewable energy, and the salient consequences of using renewable energy with consumer attitude. They found a positive relationship between consumers' willingness to pay a premium for renewable energy, their concern for the environment, and knowledge about renewable energy. According to Klick & Smith (2010), investigated public opinion about wind power in the United States in 2008 and they found the public's understanding of wind power is relatively weak. Klick & Smith found that only 18 percent of the survey responses recognized that wind generated electricity is more expensive than

electricity generated from conventional sources (Klick and Smith 2010). However, some studies declared the American public's support for renewable energy (solar energy) development and that they would pay more for clean energy (Carlisle et al. 2015; Farhan n.d.; Klick and Smith 2010) response to large scale renewable energy technologies (Batel and Devine-Wright 2015).

Attitudes and behaviors need to modify and change for a secure and sustainable energy future (Owens and Driffill 2008). In contrast, a study in Slovenia confirmed that age, income, and attitude play import roles to accepting green electricity (Zorić and Hrovatin 2012). In addition, residential consumers in the Cape Peninsula study showed the positive relationship between household income and willingness to pay for green electricity (Oliver, Volschenk, and Smit 2011). In general, "income positively affects consumers' acceptance of renewable energy projects in the residential sector and the results suggested the consumers status and gender are not significant" (Sardianou and Genoudi 2013).

But, consumers' attitudes played a significant role in a study of Swedish household consumers who have positive attitudes and willingness toward green electricity (Hansla et al. 2008). According to Laroche et al. (2001), there are five factors that influence the consumers' willingness to pay more for environmentally friendly products: demographics; knowledge; values; attitudes; and behavior. In addition, studies in the past few years examined and identified social contributions to the attitude and behavioral.

Thus, the Theory of Planned Behavior has strong predictions for wide range of human behavior (Han, Hsu, and Sheu 2010). Many researchers were using the Theory of Planned Behavior to explore and identify the consumer attitude, intention, and actual behavior (Joshi and Rahman 2015a) . According to Frederiks, Stenner, & Hobman (2015), the

empirical evidence shows the consumer's choices and actions usually deviate from neoclassical economic assumption. Essentially, Theory of Planned Behavior is strong predictor of human behavior (Han et al. 2010). According to Yadav & Pathak (2017), the Theory of Planned Behavior is one of most useful tools to identify human intention and behavior. Research dealing with social psychology often uses the theory of planned behavior to predict intentions and behavior (Madden, Ellen, and Ajzen 1992). In fact, "the theory of planned behavior is an extension of the theory of reasoned action" (Ajzen 1991:181). The purpose of the theory of planned behavior used to support and perform intention to behavior that can predict the intention attitude toward a behavior. There are three dimensions of the theory of planned behavior: social norms; subjective norms; and perceived behavioral control that account for considerable variance in actual behavior (Ajzen 1991). Ajzen declared that the three dimensions of the theory of planned behavior are related to salient behavior. Hence, the Theory of Planned Behavior includes core predictors (three dimensions) of behavior: that an individual hold a favorable attitude toward the behavior; individual perception norms; and the extent to which the individual perceived (Oreg and Katz-Gerro 2006). Ajzen asserts, "Intentions are assumed to capture the motivational factors that influence a behavior," and Ajzen & Fishbein (2000), defines it as " Intention is thus assumed to be the immediate antecedent of behavior, and to guide behavior in a controlled and deliberate fashion." Intention is explained as how much the people will perform their behavior. According to Tan (2013), intentions are subjective judgements which explain how the individual will behave in the future. According to Cheon, Lee, Crooks, & Song (2012), defined the three dimensions of theory of planned behavior as an attitude toward the behavior of an individual which could be positive or

negative regarding their feeling to perform actual behavior. According to Yadav & Pathak (2017) defined attitude as the result of individual beliefs. The second dimension is subjective norms that relate to “the individual’s perception that people important to the individual should perform the behavior in question.” (Yadav and Govind S. Pathak 2017). According to Oreg & Katz-Gerro (2006), social norms emphasize new issues such as freedom, self-expression, and the quality of life. Cheon, Lee, Crooks, & Song defined perceived behavior control, the third dimension of the theory of planned behavior, as an individual’s perception of the struggle or comfort of performing a behavior. The Theory of Planned Behavior has been useful in several perspectives (e.g., psychological, green products, environmental, behavior, human decision processes and hotel choice.) (Ajzen 1991; Fielding, McDonald, and Louis 2008; Han et al. 2010; Madden et al. 1992). According to Tan (2013), the attitude towards green housing has a positive influence on the behavioral intention to purchase green homes with perceived behavior control, and perceived self-identity . Some studies investigated the attitudes and intentions towards renewable energy such as (Yazdanpanah, Komendantova, and Ardestani 2015). They found the moral norms, attitudes, and perceived behavioral control of consumers significantly influenced public acceptance and their willingness to use renewable energy. Similarly, the positive attitudes towards green electricity indicate an increase in willingness to pay for green electricity that related to environmental awareness (Hansla et al. 2008). The majority of consumers understand the direct impact on several ecological and environmental problems in their purchasing behavior (Laroche et al. 2001). According to Stone, Barnes, & Montgomery (1995), referred to the growing numbers of consumers in the US and Western Europe that are becoming more environmentally concerned based on

their habits and lifestyles. Green consumerism has expanded quickly in the developed nations (Yadav and Govind S. Pathak 2017). In spite of renewable energy advantages for sustainable energy and environmental issue, certain shortcomings exists and there is gap between customers' favorable attitudes and actual purchasing (Joshi and Rahman 2015a). According to Chan (2001), the USA spends on the average 2.5% of its GDP on environmental concerns. Australia spends 5% of its GDP and China spends 1% of its GDP on environmental concerns. Understanding the consumers' perception of green products helps planners understand the obstacles to purchasing green products (Welsch and Kühling 2009). According to Cheon et al. (2012), energy consumption in the residential sector is complex vis a vis the socio-technical contents that can be clarified using a combination of physical, demographic and behavioral characteristics. Furthermore, recent empirical studies indicate that intention behavior is not just function of independent of psychological variables but it's a complex set of interdependences (Tan 2013). Tan refers to studies that found significant relationships between individuals who are concerned about the environment and attitudes to behave and participate to have an environmental impact. The residential sector and household energy conservation has been a major challenge and opportunity for policymakers and researchers to understand their behavior decision (Frederiks et al. 2015). Frederiks claims "the number of individuals willing to purchase green products has increased in the last few years." To encourage and help the green electricity market grow, our research will test the Theory of Planned Behavior in explaining household customers' intention to purchase green electricity. A high degree of consumers' concern for environmental and ecological issues is important to help motivate profit-driven enterprises to be green markets (Chan 2001). Specific objectives of this study were to

identify the predictors of intention to purchase green electricity (attitude, subjective norm, and perceived.) This study will help build a better understanding of green/renewable electricity consumers. We can clearly observe from the previous studies there is a complex of components used to identify a customer's motivation to purchase renewable electricity. In this study we will use the Theory of Planned Behavior to identify customers' attitude towards to use renewable energy to explain the consumers' green purchasing behavior (e.g., using renewable energy) in the residential sector. The Theory of Planned Behavior is a strong predictive for wide range of human intention and behavior. According to Stone et al. (1995), "there are several studies suggested the attitude is one of important element to exhibit environmental responsibility".

2.6.3.1 US Residential sector

The US population accounts for 4.5% of the global population but consumes approximately 20% of its energy (worldpopulationbalance, 2017). According to Bureau (2017), the US receives one birth every 7 seconds and one international migrant every 32 seconds. The US population on July 4, 2017 was 325,365,189 (bureau, 2017).

According to Bilgen (2014), the energy of the residential sector is that energy which is consumed by household energy use in the residential sector. It is defined as the energy consumed by households which includes heating, cooling, lighting, water heating, and other household demands, excluding transportation uses. The residential sector accounts for approximately 28% of global energy consumption (Hens, Verbeeck, and Verdonck 2001; Nejat et al. 2015b). Bilgen (2014) suggested that the residential sector accounts for 16 to 50 % by all energy sectors and averages approximately 30% of energy consumption worldwide. The residential sector accounts for approximately 17% of CO₂ emissions

(Nejat et al. 2015b). The American Council for an Energy Efficient Economy (ACEEE) found that the residential sector in the United States consumed approximately 80% for single-family homes, 15 % for multifamily homes, and 5% for mobile homes of the total energy consumed (The American Council for an Energy Efficient Economy n.d.). In addition, the ACEEE shows that the residential sector energy has steadily increased over the past 25 years. The most common types of energy used in the residential sector are natural gas and electricity (U.S. Energy Information Administration EIA n.d.). According to the United States Environmental Protection Agency, the USA residential sector accounts for more than a third of the electricity used nationwide (United States Environmental Protection Agency EPA n.d.). In 2004 the commercial and residential sectors accounted for 39% of the CO₂ in the United States and consumed 70% of the electricity load in the USA (U.S. Green Building Council usgbc n.d.). These commercial and residential buildings consumed approximate 40% of the total energy consumption of the United States in 2016 (U. S. E. I. A. EIA n.d.).

2.6.3.2. Green Electricity (electricity generation by renewable energy sources)

Globally, countries seek to increase the percentage of renewable electricity (i.e., green electricity) to reduce environmental pollution and reduce dependence on conventional energy sources. According to Aguirre & Ibikunle (2014), the United States has become interested in renewable energy as an import aspect of the electrical generation mix vis a vis the environment, energy security, and price volatility issues. Electricity generation accounted for approximately 35% of the carbon dioxide emissions in the US in 2016 (U.S. Energy Information Administration EIA n.d.). The volatility of oil and natural gas prices has pushed the United States to increase its use of green energy (Aguirre and Ibikunle 2014).

According to the Center of Sustainable Systems University of Michigan, fossil fuels dominate the production electricity in the United States which indicates a lack of production diversity(UCSUSA n.d.). In the US, coal and nuclear power account for approximately two-thirds of the net electricity generation and renewable energy sources (excluding hydropower) has remained at about 2 percent over the past decade (Menz 2005). The government seeks to support the growth of renewable energy. Federal agencies in the United States will have to use renewable energy for at least 30% of the total amount of building energy consumed by fiscal year 2025 (Energy Offices n.d.). There has been a significant growth of renewable energy in the United States increasing by 67% from 2000 to 2016 and accounting for 15% of the United States electricity generation (Center for Climate and Energy Solutions C2ES n.d.).Meanwhile, Menz (2005) suggested some factors that influence the green power market include economic issues, public support, external costs and the regulatory environment.

According to Marques, Fuinhas, & Pires Manso (2010), there are increasing literature reviews on renewable energy but the “drivers promoting renewable energy remain rare”. Thus, we believe the social role is essential to promote and encourage society or the public to accept the renewable electricity.

Therefore, we must understand the factors that could encourage the public to use renewable electricity. In 2003, the Union of Concerned Scientists Reports graded the 50 States based on their commitment to support renewable energy generation. Figure 11 summarizes the UCSUSA report on the 50 US states’ efforts to enact standards to increase renewable energy usage. Figure 12 shows “Only California and Nevada received A- grades for enacting standards that increase renewable energy sales by one percentage point per year

for at least 10 years” and thirty four states received failing grades of D or F for their lack of commitment to renewable energy (UCSUSA 2003:Executive Summary)”. UCSUSA found that the State of Maine ranks the highest, generating nearly 30 percent of its electricity from renewable energy and those 30 states were at or below 1.8 percent of their electricity from renewable energy. Renewable energy can help stabilize energy prices in the future because its prices can be very stable over time (UCSUSA 2003).

Figure 11:Renewable Energy Report Card Map

According to Devine-Wright (2011a, 2011b), the public’s acceptance of the government’s goals to mitigate climate change by increasing renewable energy technologies is important. Research investigating the public acceptance of renewable energy as a replacement for fossil fuels in electricity production has focused on the correlation of socioeconomic characteristics of household, age, gender, and education (Stigka, Paravantis, and Mihalakakou 2014). Public opinion varies from one place to another. Researchers found

public acceptance and support for biomass energy in UK, and strong resistance to wind energy application in Greece and Germany (Liu, Wang, and Mol 2013).

Thus, we will consider that the social role is an important factor that could impact the deployment or success of renewable energy. Some scholars have suggested investigating and identifying individual's intention and behavior because they believe public acceptance is critical for successful renewable energy technologies (Huijts, Molin, and Steg 2012). According to Office Nebraska Government website NEO (2016), Hawaii had the highest electricity rate (26 cents) and Washington had the lowest electricity rate (7.41 cents) in terms of the average electricity rate for all sectors (cents per kilowatt-hour (kWh)) in 2015 (NEO 2016). The State of Rhode Island was ranked by NEO as having the 45th highest rate with 17.05 cents per kWh (average electricity rate for all sectors). In contrast, Rhode Island showed the lowest total energy consumption per capita (ranked 50th) with 192 million Btu in 2015 (U. S. E. I. A. EIA n.d.) . Additionally, EIA ranked the State of Louisiana as having the highest total energy consumed per capita with 912 million Btu and the State of New York as having the lowest total energy consumed per capita with 189 million Btu in 2015 (U. S. E. I. A. EIA n.d.) . According to Energysage (n.d.), “residential electricity rates have increased nationally” by approximately 20% in the last 10 years “from about 10.8¢ per kWh in 2007 to about 13¢/kWh in 2017.” Also, EnergySage showed the fluctuation of utility electricity rates throughout the year. On the other hand, in the long term, the rates are predicted to rise. The fluctuations of utility electricity rates are the consequence of factors such as fuel costs.

2.6.3.4. Policy and Social acceptance of renewable energy

There are many of researchers have investigated and identified the strategic choices to “invest” in renewable energy and implement “public policies” to play a significant role in encouraging investors to invest and increase the renewable energy share (Wüstenhagen and Menichetti 2012). On the other hand, to ensure a stable and applicable policy, policymakers should understand that consumer behaviors are based on rational choices (Simon 1952). According to Frederiks et al. (2015), achieving household energy efficiency has been a major challenge and opportunity, and in their study, the consumer seemed aware of the benefits of sustainable energy, but many “failed to take noticeable steps towards sustainable energy.” This illustrates the distinction between the knowledge–action gap and value–action gap of renewable energy consumers.

According to traditional economic theory, human decision-making features rational choice as a set of alternatives that are open to choose, relationships that determine the payoffs as a function of alternative choices, and preferences.

Public policy plays a significant role in continuing to drive renewable energy development (ILO 2011). Howes et al. (2017), has done a systematic literature review to seek out the reasons behind environmental policy failure in general. Howes concluded the reasons for environmental policy failure are interrelated to structural causes (e.g., economic, social, environmental, political, technical, legal, and discursive.) .Mirza et al. (2009), identified the barriers to the development of renewable energy in Pakistan. They classified these barriers into policy and regulatory barriers, institutional barriers, fiscal and financial barriers, market-related barriers, technological barriers and information and social barriers. They found that poor or low levels of policy integration led to the policy failure.

2.7. Kyoto Protocol

The world is becoming concerned enough to protect the environment. Dogan & Seker (2016), 196 countries have joined the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol was the first outcome.

In 1992 the Kyoto Protocol was an initiative by the Earth Summit Convention in Brazil. The Protocol's main assertion was that there is an obligation and a global responsibility to combat and to reduce the greenhouse emission gases (GHG) level by the mandatory targets in developed and the developing countries. The Kyoto Protocol aims to solve the long international environment problems by reducing GHG level in participating countries. The Kyoto Protocol identifies the reduction of GHG level as a mandatory requirement not for just the developed countries but also for developing countries such as China and India. The Kyoto Protocol has listed clear GHG level reductions for several countries such as Canada, Japan and Hungary by 6% and USA by 7%.

Dogan & Seker (2016), investigated how the world can reduce the level of emissions. They found some empirical studies that suggested the aggregate of energy consumption and gross domestic production can influence the level of carbon dioxide. In addition, they showed that a variety of energy sources could have different impact on the level of emissions. Nicholas Apergis, Payne, Menyah, & Wolde-Rufael (2010), identified the causal relationship between the carbon dioxide and some types of clean energy sources consumption (i.e., nuclear, renewable) and economic growth. They used a panel error correction model for 19 countries from 1987 to 2007. They found, “The long-run estimates indicate that there is a statistically significant negative association between nuclear energy consumption and emissions (Apergis et al. 2010b:Abstract)”. However, the Granger

causality for short run indicated the renewable energy consumption does not contribute to reductions in emissions. According to Menyah & Wolde-Rufael (2010), investigated the relationship between the clean energy sources (renewable and nuclear) carbon dioxide emission, and real GDP. They found that renewable energy does not cause carbon dioxide emissions. Previous studies, they used Granger causality between the renewable energy consumption and carbon dioxide emission based on the national level. In our study, we will consider carbon dioxide emission and renewable energy consumption at the state level in the US.

2.8. Conclusion

The literature review showed that renewable energy is an increasingly important issue in energy security and energy sustainability. The research on the renewable energy consumption identifies the drivers and barriers factors related to renewable energy that became more important in the last two decades and covered multiple aspects. Through this systematic review, we can clearly identify the major area of drivers and barriers of renewable energy that are economic, social, and environmental. We found multiple gaps in the literature. One of these is that most previous works had no integrated approaches for primary data and secondary methodology. However, few researchers have focused on individual states as independent study subjects. In addition, none used methods including qualitative and quantitative methodology. Therefore, we are seeking to develop and present an integrated approach to identifying the critical factors dimensions within US states with consideration of the gaps in and shortcomings of previous literature. The study takes the macroeconomics of individual US states and global and local energy prices into account as well as the attributes and social behaviors that influence renewable energy consumption.

The literature review summarized some indicators that showed the relationship between renewable energy and those factors (macroeconomic, environmental, and social) and identified the drivers and barriers associated with a successful implementation of sustainable renewable energy in practice. To the best of the author's knowledge, no studies have been found to integrate a conceptual framework and combined top-down and bottom-up approaches related to the renewable energy growth of the residential sector in the US. However, to the best knowledge of the author, there is no approaches that show how these subsystems of sustainable energy could encourage, enhance, and cause renewable energy growth. From this point on, the research will investigate how a top-down approach using econometrics.

Chapter 3. Methodology

This chapter discusses the research method of this study and the comprehensiveness of the research aims for the top down approach and the bottom up approach. To answer all research questions and research hypothesis, a mixed method approach is adopted through the use of primary and secondary data (top down approach and bottom up approach methodology). It briefly introduces the systematic literature review and systems (e.g., system elements, system classification, process, and sustainable system) Then, it explains the primary and secondary data used, including the critical literature review process, data and collection, analysis, model weighting and qualities by designing survey, sampling, analysis and possible limitations.

3.1. Methodology Stages

The first stage is the development of the conceptual framework for renewable energy growth by using a systematic literature review and analysis of the actual data collection for mapping and categorizing the factors that influence renewable energy growth by

- Reviewing what has been done and the extraction of the factors that contribute to the sustainability of renewable energy growth.
- Categorizing and grouping the US states by their renewable energy consumption and growth percentage based on macroeconomic and social variables

The United States Environmental Protection Agency (EPA) helps meet the internal goals for federal sustainability requirements through strategic plans to reduce GHG emissions and other environmental impacts (United States Environmental Protection Agency EPA n.d.). The US Department of Energy provides and maps renewable energy production information by state (DOE). According to Engineering Department , the United States of

Americas is categorized into five segments that produce renewable energy (Energy.Gov n.d.). Figure 12 shows the maps of renewable energy production information by state. These segments illustrate those that produce between 80% and 100%, 60% and 80%, 40% and 60%, 20% and 40%, and less than 20%. In this study, we focus on all states that produce 20% or more in our analysis.

Figure 12: Maps of renewable energy production information by state

There are the vital factors that influence renewable energy consumption (e.g., macroeconomic, energy consumption, and environmental factors). This systematic literature review strategy will be an investigation of current research in the field to determine key factors that have an influence on the renewable energy implementation strategy. In this research, a systematic search process was carried out using the combination of the following keywords: renewable energy*, growth*, and implementation*; growth* and renewable energy*; and forecast*, renewable energy*, and success* that has been done in previous chapter 2.

The second stage is primary data. It seeks to develop a survey to facilitate understanding of the factors that influence renewable energy growth in the US by conducting a survey of residential householders to identify their views that can enhance and sustain renewable energy growth. This survey delineates and examines the factors influencing behavioral intention among green energy consumers

Finally, this study uses improved model forecasting by using a variety of forecasting techniques. The International Council for Science Unions (ICSU), defines forecasting as one of five significant challenges regarding improving “the usefulness of forecasts of future environmental conditions and their consequences for people” (International Council for Science ICSU 2010:10). The aim of forecasting is to help society and decision makers obtain temporal and spatially reliable information. The challenge of forecasting includes the Earth’s systems interacting with certain sets of human actions or conditions, such as the population size or macroeconomic variables of countries, levels of consumption of food, energy, and water (life standards) and GHG emissions.

For instance, there are techniques to predict energy demand through models, such as time series, regression, econometrics, and ARIMA, which are broadly used for energy demand management. Support vector regression, vector autoregression, and the Long-range Energy Alternatives Planning (LEAP) system, are also used for national- and regional-level energy demand (Suganthi and Samuel 2012).

To the best of the author’s knowledge, no studies have been found to integrate a conceptual framework and combined top-down and bottom-up approaches related to the renewable energy growth in the US. From this point on, the research will investigate how a top-down

approach using econometrics variables and a bottom-up approach using end-user samples can enhance and contribute to knowledge of renewable energy growth.

3.2. Mixed Method approach

To determine the success and other impacts that renewable energy could influence, primary and secondary data types of research were combined to identify the success of renewable energy growth in US. The integrated approach to investigate and identify factors which influence renewable energy has been limited to the use of primary and secondary data.

3.3. Study Hypotheses

We addressed the above research questions of this study. To answer the questions, we state five hypotheses in the next five sub-sections.

3.3.1. Hypothesis 1

Null hypothesis, H_0 – Factor i does not Granger cause the renewable energy consumption in 22 states (see table 1)

Alternative hypothesis, H_1 - Factor i does Granger cause the renewable energy consumption in 22 states

Factor i	Factor Description	Unit
1	The annual gross domestic product (GDP)	Billion
2	Crude oil, average	\$/bbl
3	Total energy consumption per capita.	Million Btu
4	Total energy consumption per capita in the residential sector.	Million Btu
5	Fossil fuels, total consumption.	Billion Btu

6	Coal total consumption.	Thousand short tons
7	Income	\$ Per capita personal income
8	Natural gas total consumption	Million cubic feet
9	Natural gas consumed by the residential sector	Million cubic feet
10	Electricity total consumption	Billion Btu
11	Electricity consumed by the residential sector.	Billion Btu
12	Primary energy average price, all sectors.	Dollars per million Btu
13	Primary energy average price in the residential sector.	Dollars per million Btu
14	Natural gas average price, all sectors	Dollars per million Btu
15	Coal average price, all sectors.	Dollars per million Btu
16	Electricity average price, all sectors.	Dollars per million Btu
17	Electricity price in the residential sector.	Dollars per million Btu

Table 1:Factors list for hypothesis 1

The Vector Autoregressive model and Granger causality test will be used to evaluate the factors that impact and influence renewable energy consumption in 22 states.

After that, we will weigh the factors that affect the 22 states in the United States by using exploratory factor analysis to load each factor.

We will test 17 Granger causality for each state and in total we will investigate the correlation between 374 factors (17 factors * 22 States). Causality for each state between factors and renewable energy consumption will be determined using Vector Autoregression and the Granger causality test. We will be reported a significance level of 5%, and 10% for rejecting the null hypothesis.

According to Beldjazia & Alatou (2016), and Mukaka (2012), suggested that the effect size correlation categories for absolute r are the following:

- .00–.19 “very weak”
- .20–.39 “weak”
- .40–.59 “moderate”
- .60–.79 “strong”
- .80–1.0 “very strong

Strong correlation does not imply a causal link between the variables, so we must test causality using the Vector Autoregression and Granger causality test.

3.3.1.1 Model Fitting (Vector Autoregression)

Vector autoregression (VAR) is “an econometric model used to capture the evolution and the interdependencies between multiple time series, generalizing the univariate AR models”. All the variables in a VAR are treated symmetrically by including an equation

explaining each variable's evolution based on its lags and the lags of all the other variables in the model.

A VAR model defines the a dynamic of a set of k factors “variables” (called “endogenous variables”) over the same sample period ($t = 1, \dots, T$) as a linear function of their past evolution. “Suppose that the variables of a VAR are categorized into two groups. The variables are collected in a $n \times 1$ vector Y_t , which has as the i th element $Y_{i,t}$ which is the time t observation of variable Y (Lu and Xin 2010:12)”. Therefore, if we have an example the i th variable is GDP, then $Y_{i,t}$ is the value of GDP at t . A (reduced) p -th order VAR, denoted VAR(p) is $(n1 \times 1)$ vector $Y1$, and the $(n2 \times 1)$ vector $Y2$. The VAR may then be written as

$$\begin{bmatrix} y_{1,t} \\ y_{2,t} \end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} + \begin{bmatrix} \alpha_{1,1} & \alpha_{1,2} \\ \alpha_{2,1} & \alpha_{2,2} \end{bmatrix} \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \end{bmatrix} + \begin{bmatrix} u_{1,t} \\ u_{2,t} \end{bmatrix} \quad \text{Equation 3.1}$$

Where:

y_t : ($y_{1,t}, y_{2,t}, \dots, y_{n,t}$) an $(n \times 1)$ vector of time series variables.

b_n : an $(n \times 1)$ vector of intercepts.

α : coefficient matrix of bivariate VAR(2) Model.

$u_{n,t}$: vector of white noise variable

To see the stationarity of the series, an augmented, Dickey-Fuller Test is performed on both series. The tests do not reject the unit roots that mean non-stationary process. The null hypothesis of subsector Y_{1t} does not Granger cause $y_{2,t}$. In R statistical software, the best VAR model was selected by using the Akaike information criterion (AIC).

3.3.1.2. Granger causality test

“The Granger causality test is a technique for determining whether a one time series is useful in forecasting another and detecting the causal relationship between two variables (Asafu-Adjaye 2000:41)”. According to Pfaff and Taunus (2007), the Granger Causality test is the most common method to test the causal relationship of variables. The Granger causality test can be applied in a multivariate context. According to Phillips and Perron (1988), Granger’s causality test requires that the series of variables be stationary. Bressler and Seth (2011) state “Suppose that we have two variables X, and Y, and we try to predict X_{t+1} using only past terms of X. We also try to predict X_{t+1} using past terms of both X and Y. If the second prediction is significantly more successful, then the past of Y contains information useful for predicting X_{t+1} that is not in the past of X. In this case, Y is said to G-cause X.”. Thus, “two variables are first transformed to covariance stationary processes through their first differences in the bivariate model” (Yang 2000). According to Pfaff and Taunus (2007), if we seek to examine if X factor “variables is “a Granger-cause” factor “variable” Y for prediction purpose , and “two variables assumed to be causal are remaining variables in the Vector Autoregressive VAR(p) process where p indicates the number of lags”. The statistical test is distributed as

$$F = \left(\frac{\frac{RSS_r - RSS_{ur}}{m}}{\frac{RSS_{ur}}{T - 2m - 1}} \right) \quad \text{Equation 3.2}$$

where T is the total number of observations used to estimate unrestricted model, RSS_r and RSS_{ur} are the residual sum of squares of the restricted and unrestricted models, and m refers to number of models lags. “The F statistic approximately follows an F distribution with degrees of freedom m and $(T - 2m - 1)$. The unrestricted model provides a better

prediction than does the restricted mode, and in that case Y is said to Granger cause X (Bressler and Seth 2011)”. We will be reported the significance at the 5% and 10% levels. In this study, we considered two level of significance value that are 5% and 10 % related to similar studies in field such as (Aslan 2012; Bowden and Payne 2009; Huang, Hwang, and Yang 2007; Ohler and Fетters 2014; Pao and Fu 2013). We then conducted the correlated and causal factors of renewable energy consumption in each state to weigh each significant factor that influenced the consumption of renewable energy by finding the eigenvalues for each factor. The regression coefficients are factor-loading when we explained these factors.

3.3.1.3. Exploratory Factor Analysis

For exploration, exploratory factor analysis is performed in the significant Granger Causality metrics from 22 states. Therefore, we supposed that this is due to the default maximum likelihood method MLE method for sufficient factors since data normality can affect factor extraction in factors. The Chi square statistic is used for the total factor numbers in model fitting. Once the number of factors is determined, the loadings of each resultant factor are examined, and implications of each factor are interpreted in the theoretical framework.

$$x_1 = \lambda_{11}F_1 + \lambda_{12}F_2 + \dots + \lambda_{1k}F_k + u_1$$

$$x_2 = \lambda_{21}F_1 + \lambda_{22}F_2 + \dots + \lambda_{2k}F_k + u_2$$

$$x_q = \lambda_{q1}F_1 + \lambda_{q2}F_2 + \dots + \lambda_{qk}F_k + u_q$$

$$\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_q \end{bmatrix} = \begin{bmatrix} \lambda_{11} & \lambda_{12} & \dots & \lambda_{1k} \\ \lambda_{21} & \lambda_{22} & \dots & \lambda_{2k} \\ \vdots & \vdots & \ddots & \vdots \\ \lambda_{q1} & \lambda_{q2} & \dots & \lambda_{qk} \end{bmatrix} \begin{bmatrix} F_1 \\ F_2 \\ \vdots \\ F_k \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ u_q \end{bmatrix} \quad \text{Equation 3.3}$$

Where :

$F_1, F_2, \dots, F_k$: *Causal factors of variables*

$\lambda_{q1}, \lambda_{q2}, \dots, \lambda_{qk}$: loading of variable q cause by F_k

This can be rewritten as

$$X = \Lambda F + U$$

Where:

X : Vector of q variables

Λ : loading matrix (lamda value)

F : Vector of *causal factors* (unobserved latent variables F_k)

U : Vector of error terms for q variables.

According to Gentleman, Hornik, & Parmigiani (2011), we have observed that factors “variables” x_q are linked to the “unobserved latent variables” F_k where $F < q$ in the regression model (Gentleman, Hornik, and Parmigiani 2011).

3.3.1.4. Forecast Error Variance Decomposition (FEVD)

A dynamic system, by definition, is its output when presented with a proportion of variance due to shocks to itself (endogenous variable) as well as to other variables (exogenous variables), and this system is called Forecast Error Variance Decomposition (FEVD). More generally, FEVD refers to the reaction of any dynamic system in response to some external change. According to McKenzie, Goodwin, & Carreira (2009), FEVD is a technique used to perform, generate and forecast an error of variance of the autoregressive model. In fact, the FEVD technique is considered to compute proportion of errors due to each shock at different horizons. FEVD is a simple transformation of an impulse response function. Therefore, the FEVD aim is to allow “a tracing out of the time path of the various shocks on the variables contained in the VAR (Sheng and Tu 2002:361)”.

3.3.2. Hypothesis 2

Null hypothesis (H_0): There are no differences between the socio-economic and energy variables among different states influencing the low and high emission level.

Alternate hypothesis (H_1): There are differences between the socio-economic and energy variables among different states influencing the low and high emission level.

Multivariate Analysis of Variance (MANOVA) will be employed here in the analysis. Renewable energy and total energy are the two dependent variables that we will use in MANOVA. The categorical factor variable is the state emission level (level0: low emission; level1: high emission). With two dependent numerical variables and one factor variable, this is a classic one-way MANOVA problem. Before applying MANOVA, we will check if our dataset satisfied the multivariate normal assumption inherent in

MANOVA. Transformation and outlier removal will be done if data do not meet the multivariate normal criteria. Four different tests will be used to determine the significance of the one-way MANOVA, including Hotelling's trace test, Wilk's lambda test, Roy's largest root test, and Pillai's trace test. Significant MANOVA results are followed with ANOVA tests to identify which dependent variable contributed to the MANOVA outcome. We consider the significance at the 5%.

3.3.3. Hypothesis 3

Null hypothesis (H0):

Principal Component Analysis does not provide a more accurate model than time series analysis such as the Autoregressive model

Alternate hypothesis (H1):

Principal Component Analysis provides a more accurate model than time series analysis such as the Autoregressive model.

Previous studies were conducted and captured some predictors that positively correlated with “energy consumption”, such as “population” (Ismail and Abdullah 2016). States & Olatubi (2003), examined the dynamics of energy consumption within the “Southern States” of USA and the socio-economic impact of energy “(energy price and income per capita)”.

This section examined U.S. Energy Consumption over a 45-year span, from 1970 through 2015. The authors will utilize quantitative methods via a multiple regression model to predict USA energy consumption annually. The Principal Component Analysis (PCA) will

be applied since that technique allows correlations could be found among variables represented by a set of observations stored in a matrix.

To validate the model's accuracy, we will compute and measure the model error using Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (MSE).

Energy consumption is associated with multiple socio-economic variables, such as GDP, unemployment rate, and Consumer Price Index. High correlations among these predictors pose a challenge to typical regression, therefore, we will be adopted PCA to reduce data dimensions. PCA is carried out on the correlation matrix so that results are less susceptible to the effect of variables with high variance. Once the principle components are selected, PCA scores are entered into a multiple regression as predictors for annual energy consumption. We used PCA until the independent variables (x 's) will be decomposed on an orthogonal basis (the principal components) which allows predictor dependencies to be represented in a lower dimension space. A subset of those components will be selected as the variables to predict y . First, we sought to better understand renewable energy consumption factors/variables and study how they are related to total energy consumption. Thus, we must conduct a descriptive and exploratory analysis of data variables. We will then determine how to combine multiple regression analysis and PCA to feed and improve the prediction and model accuracy (from unsupervised to supervised). The aim of using multiple regressions with a PCA technique is to check the impact of the model accuracy on prediction models multiple regression analysis with PCA by using validation techniques such as Mean Square Error.

Finally, this study uses improved model forecasting by using a variety of forecasting techniques. For instance, there are techniques that predict energy demand using models such as time series, regression, econometrics, ARIMA, and neural networks, which are broadly used for energy demand management.

Thus, multiple regression models must be run to determine if there is a multicollinearity issue. The multicollinearity results will be used to identify the high multicollinearity except, and which has low multicollinearity value. According to Keith Ord (n.d.) to compute the[multicollinearity value defined the Variance Inflation Factor (VIF)

where

$$VIF = \frac{1}{1-R^2} \quad \text{Equation 3.4}$$

If the number of observations is less than 30, we should drop variable if its VIF is greater than 5.

If number of observations is greater than or equal 30, we should drop variable if its VIF is greater than 10.

We seek a better understanding of renewable energy consumption factors/variables by studying how they are related to total energy consumption by conducting descriptive and exploratory analyses of data variables. We consider how multiple regression and PCA could be combined to feed and improve the prediction and model accuracy (from unsupervised to supervised).

Thus, we will use PCA to decompose the independent (x) variables on an orthogonal basis (the principal components) that allows predictor dependencies to be represented in uncorrelated components.

3.3.4. Hypothesis 4

Null hypothesis (H0):

There are not complicated natures of economic/social context at the state level; the states do not share similar energy and socio-economic pattern.

Alternate hypothesis (H1):

There are complicated natures of economic/social context at the state level; most states tend to share similar energy and socio-economic patterns

The nature of the economic/social context at the state level is complex; most states share similar energy and socio-economic patterns.

It is important to analyze economic/social development while taking into account the multivariate feature of the economic/social context, as evidenced by the clustering analysis.

According to Gentleman et al. (2011), “Cluster analysis is a generic term for a wide range of numerical methods with the common goal of uncovering or discovering groups or clusters of observations that are homogeneous and separated from other groups.”

The main use of cluster analysis is to investigate relationships between the states in order to establish whether a small number of groups (clusters) of similar objects can validly summarize the data. Clustering algorithms identify the objects collected in data $X_{n \times p}$, where p denotes the number of variables, and n denotes the number of observations selected for

similarity and dissimilarity measures to obtain the distance matrix. We then begin the N cluster, where each cluster contains a single entity, and find the near pairs of clustering from the distance matrix.

We aimed to separate the objects into subgroups based on a series of macroeconomic features. Objects within the same cluster are considered homogenous at a macroeconomic level. For this, we used two major clustering techniques: K-means algorithm and hierarchical method. In K-means clustering, one focus of our clustering analysis is the determination of the appropriate number of clusters (N). “A combination of the Elbow and Silhouette method are used to identify an appropriate numbers of clusters (Gentleman, Hornik, & Parmigiani, 2011)” . In a hierarchical clustering, we explore both the complete linkage and average linkage algorithm. K-means determines the appropriate number of clustering for the initialized total within sum of squares error (Yim 2015). As a result, we are able to compare the correspondence between K-means and hierarchical clustering.

All data used in this research will be obtained from open and published sources. GDP per capita were collected from the World Bank Group, total energy consummation was recorded by the U.S. Energy Information Administration (EIA) and unemployment data was obtained from the Bureau of Labor Statistical (BLS). Remaining data will be obtained from the Bureau of Economic Analysis (BEA).

3.3.5. Hypothesis 5

What are the factors influencing the behavioral intention among green energy consumers?

To answer this research question, we will address four hypothesizes to identify the existing unobserved latent factors that explain the consumers' intention and how frequently the consumers will perform their behavior. These are vital factors influencing the behavioral intentions of green-energy consumers.

Null hypothesis, H_0 – Factor i (see table 2) does positively related to use renewable energy for homes electricity

Alternative hypothesis, H_1 - Factor i does positively related to use renewable energy for homes electricity

The below table show the factors

Factor i	Factors names
1	Attitude towards the behavior
2	Subjective norm
3	Perceived control behavior
4	Independent factors of income, and gender

Table 2:Factors list for hypothesis 5

Figure 14 below depicted the three dimensions of theory of planned behavior.

The theory of planned behavior drives the individual behavior by measuring the behavior intentions, where behavior intentions are a function of three determinants: an individual's attitude toward behavior, subjective norms, and perceived behavioral control (Services

1998). Actually, figure 13 visualized the theory of planned behavior which consist one outcome, one mediator, and three independent variables. The three independent latent variables are attitude toward the behavior, subjective norm, and perceived behavioral control assumed that the residuals for the three independent are most likely related. The mediator is the intention that causes the behavior as results of intention prediction in this study.

Figure 13: Theory of Planned Behavior (Ajzen, 1991)

3.4. Pilot study

A pilot study contributes an important in many research fields “(e.g., health research, social research)” that could help obtain a good study finding. According to Van Teijlingen & Hundley (2001), a pilot study is a pretest of the particular research. Leon, Davis, & Kraemer (2012), defined the pilot study as,” Pilot studies represent a fundamental phase of the research process. The purpose of conducting a pilot study is to examine the feasibility of an approach that is intended to be used in a larger scale study”.

3.4.1. Purpose of Pilot study

Pilot or feasibility studies estimate parameters such as variance, response rate (recruitment rate) , calculation of a sample size, and testing study procedures (Arain et al. 2010; Lancaster, Dodd, and Williamson 2004). Thabane et. al. classified the reasons and purposes of pilot study into four rational reasons (Thabane, Ma, and Chu 2010). The process “assesses the feasibility of the steps that need to take place as part of the main study”, resources that related to build and time issues, management that deals with the potential human and data problems such as “Do data show too much or too little variability?” In addition, one pilot study’s advantage is to pretest and identify in advance study design flaws such as research protocols, and inappropriate proposed methods (van Teijlingen and Hundley 2001). While the pilot study can enhance the likelihood of study success, it is seldom used in scientific research (Thabane et al. 2010). According to Van Teijlingen & Hundley (2001), corrections of pilot study limitations are no guarantee of the success of the full scale survey.

3.4.2. Pilot study sample size

As we mentioned above, we would like to do the pilot study to enhance the likelihood of study success. In order to do so, we need to determine and estimate the appropriate pilot study sampling size. According to Horgas, Yoon, Nichols, & Marsiske (2008), the general “sample size should be 10% of the full sample size” and they claimed the adequate sample size for “each group should be ranging from 10 to 40 responses.” Johanson & Brooks (2010), reviewed and summarized some articles related to the social science, they suggested that the pilot study sampling size for social science should be between 10 to 30 participants.

3.5.3. Pilot study Analysis

According to Johanson (2010), researchers are encouraged to address any specific concern of the pilot study such as internal consistency and response rate .

3.5.3.1 Descriptive Analysis

We will use descriptive statistical methods to analyze components of the pilot study such as the sample average and variation of data demographic.

3.5.3.2. Content validation

According to Horgas et al. (2008), content validation indicates to the degree to which the sample items measure and test the construct of the interest. “Content validation uses the expert panel to evaluate the questionnaire’s items of the theoretical construct.” There are several procedures to compute the content validation that let the experts to evaluate the questionnaires items such as using the terms of dichotomies (yes or no) or they could use the ordinary terms or ranks such as “(high validity-moderate validity-low validity)” (Aiken

1980; Horgas et al. 2008). According to Horgas (2008), a good context validation is 0.78 or higher for three experts or more.

3.5.3.3 Response rate

We will compute the response rate of pilot study. According to Fincham (2008), response rate refers to “dividing the number of usable responses returned by the total number eligible in the sample chosen”.

3.5.3.4 Internal questionnaire validation

The internal consistency computing when we have several participations who respond to our survey items. According to Diane Suhr (2006) , "To measure the internal consistency of the items in the questionnaire, each subscale will use Cronbach's alpha, and the higher the coefficient, the higher the indication that the scale is reliable.

3.5. Qualitative Data

The qualitative data in this study is collected by conducting a full survey questionnaire to identify the intentions of green energy consumers in the 22 states. The survey seeks to identify the attributes and behaviors of expected renewable energy consumers in the 22 states by determining the attributes of consumers who buy renewable energy from the grid and install micro-renewable energy systems in their homes. In addition, the survey seeks to tackle the challenges of renewable energy growth based on consumer perspectives from the 22 states.

3.5.1. IRB Approval

Approval has already been received from the Institutional Review Broad Governance and Operating Policies (IRB) at the University of Rhode Island to conduct this survey. The IRB requested the survey aims, design, sample and other details to investigate and to be

responsible for the highest ethical standards and ensure that all research met the federal regulations, policies, and procedures.

3.5.2. Participants

We will use an online survey to collect randomly respondents from residential households in the 22 states and choose an instrument that allows us to obtain respondents in enough time to reach the maximum number of respondents.

3.5.3. Sample size

To obtain vigorous results from this survey design, we will follow a systematic approach.

The sample size will be based on the number of items in the survey.

It is desirable to have a minimum of three variables for each component and the sample size for the principle component analysis should be large enough to obtain reliable results.

The responses should be five times the number of items in questionnaires (for example a 50 item questionnaire needs at least 250 responses (50*5) (O'Rourke 2013). According to Paul, Modi, & Patel (2016), there is a desirable level of 15 to 20 observations per studied variable. Thus, our study will have 19 variables the theory of planned behavior has a single-measure IV of income; plus 4 factors, three mediator factors of attitude with 6 item parcels (attitude1, 2,4,5 & 6), subjective with 6 item parcels (subjective 1, 2,4,5 & 6), and perceived with 3 item parcels (perceived 1, 2 & 3); and a dependent factor of intention with 4 item parcels (intention1, 2 ,3& 4). Using these 19 items means that 380 respondents (19*20) are needed for the sample size. However, structural equation modeling recommends at least 400 respondents (A Boomsma 1988; Paul et al. 2016). According to Han, Hsu, & Sheu (2010), multi-item scales are used to measure variables to sufficiently capture the constructs. In this study, we will use the measurement scale for all items in this

study for a 5 point scale that has been validated in previous researches (Chan 2001; Hartmann and Apaolaza-Ibáñez 2012; Paul et al. 2016).

3.5.4. Data analysis through CFA model

The Structural Equation Modeling (SEM) evaluates the measurement model (Confirmatory Factor Analysis; CFA) and the estimation of the structural coefficient (path model) at the same time. According to Furr, 2011; D Suhr (2003); Diane Suhr (2006), CFA is a powerful statistical technique to test a clear hypothesis (theory) about a scale with a number of latent (unobserved) factors or dimensions underlying its items to determine the relationship between the observed variables and their underlying latent constructs. The CFA statistical technique is used to link specific items and factors and the association between them. Thus, to test and conduct the CFA, there are two preliminary steps after determining a clear hypothesis for a specific theory. The study must be conducted on a scale that describes conceptually oriented item generation and produces an evaluation process. In the second step, the researchers collect the responses to the item scale. The CFA requires an appropriate sample size that varies from a minimum of 50 participants to 300 or more (Furr 2011). According to Suhr and Ph (2006), a sufficient sample size for CFA is 5 to 20 cases per parameter estimate. Therefore, to test a certain theory using CFA, a sufficient sample size must be secured, a measurement instrument must be chosen, multivariate normality must be present, and missing data, outliers, and model fit must be assessed. Finally, the results must be interpreted. According to Diane Suhr (2006), “CFA specifically relies on several statistical tests to determine the adequacy of model fit to the data. The chi-square test indicates the amount of difference between expected and observed covariance matrices. A chi-square value close to zero indicates little difference between the expected

and observed covariance matrices. In addition, the probability level model Chi square must be greater than 0.05 when chi-square close to zero (Suhr and Ph 2006:2)". Furr (2011), suggested that additional tests may be necessary if the model is not formal inferential, and that these tests may include the "Goodness of Fit Index (GFI), the Incremental Fit Index (IFI), the Normed Fit Index (NFI), the Comparative Fit Index (CFI), the Non-normed Fit Index (NNFI, also known as the Tucker-Lewis Index or TLI), the Root Mean Square of Approximation (RMSEA), the Root Mean Square Residual (RMR), and the Standardized Root Mean Square."

3.5.5. CFA Model Adequacy

The aim of the measurement model is to test the model's adequacy and whether it meets the requirements of certain indexes. According to Bock et al. (2016), there are three types of measurement model validity: content validity, convergent validity, and discriminant validity. Bock et al. defined content validity as the consistency of the measurement items and the extant literature. Convergent validity defines the reliability. "Internal consistency is a procedure to estimate the reliability of a test from a single administration of a single form. Internal consistency depends on the individual's performance from item to item based on the standard deviation of the test and the standard deviations of the items" (Bock et al. 2016; Suhr 2003:94). To measure the internal consistency of the items in the questionnaire, each subscale will use Cronbach's alpha, and the higher the coefficient, the higher the indication that the scale is reliable. To validate the discriminant validity, we measured the Root Mean Square Error (RMSEA). Table 3 below shows the Measurement Model (Conformity Factor Analysis) and critical value for each index.

Indices	Critical value	References
Reliability of the scale (Cronbach's) alpha	A good-to excellent for all scales of reliability 0.6 to 0.9	(Yazdanpanah, Komendantova, and Ardestani 2015)
Chi-square normalized by degrees of freedom	Ratio less than 5	(Paul R. Pintrich, David A. F. Smith, Teresa Garcia 1993; Yazdanpanah, Komendantova, and Ardestani 2015) (Bentler 2006)
The Comparative Fit Index (CFI)	Acceptable model fit is indicated by a CFI value of 0.90 or greater	(Liao, Chen, and Yen 2007a; Suhr and Ph 2006; Yazdanpanah, Komendantova, and Sha 2015)
Root Mean Square Error of Approximation (RMSEA)	Diane Suhr suggested RMSEA should be less than 0.06 and Yazdanpanah suggested the acceptable RMSEA is less than 0.010.	(Liao et al. 2007a; Suhr and Ph 2006; Yazdanpanah, Komendantova, and Sha 2015)

	Besides, Liao, Chen, & Yen, supported RMSEA less than 0.010.	
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Table 3: Measurement model

3.6. Path Analysis Model

An adequate measurement model uses structural equation modeling (Path Analysis) to assess the relationship between the latent variables (Hartmann and Apaolaza-Ibáñez 2012). We will conduct the path analysis to reveal that a significant positive or negative influence of the path analysis with the standardized regression coefficients . We considered the significance level at the 5%.

3.7. Survey Design

This study conducts scientific research to identify the factors influencing consumer's behavioral intention to use renewable electricity in the United States. In this study, we reviewed the previous studies that were applied and aimed at the unobserved factors such as (intention). The scientific theory that will be used in this study is called Theory of planned behavior. This theory helps predict and explore the consumer attitude, intention, and actual behavior in the residential sector in US. The residential sector accounts for approximately 28% of global energy consumption (Nejat et al. 2015a) .

The American Council for an Energy Efficient Economy (ACEEE) found that the residential sector in the United States consumed approximately 80% by single-family homes, 15 % by multifamily homes, and 5% by mobile homes of the total energy consumed (The American Council for an Energy Efficient Economy, n.d.). In addition,

the ACEEE shows the residential sector energy has steadily increased over the past 25 years. Based on EIA, the most common types of energy used in the residential sector are natural gas and electricity (U.S. Energy Information Administration EIA n.d.) . Hence, we are interested in this research to predict and explore the consumers' attitude, intention, and actual behavior by using Theory of planned behavior to associate consumer's intention to use Renewable Electricity. Thus, we designed a survey to identify the factors influencing consumer's behavioral intention to use green energy in the United States. Our sample target is residential sector in the United States and combinations of demographic and socioeconomic variables will be used in this study. Each survey should take approximately 15 to 20 minutes. In this study, there is not any probable risk or discomfort related with the study. The decision to participate and contribute to this study is completely voluntary. All responses will be kept completely anonymous.

3.7.1. Benefits of this study

Essentially, there is no direct benefit to participants for taking part in this study, the researcher may conduct more studies to investigate and identify the social factors and attributes relative to consumer attitude, intention, and behavior. Thus, the research findings will help recognize the role of social acceptance to renewable energy and help improve policy regarding of renewable electricity.

3.7.2. Summary of Scientific Background & Literature Review

Some scholars have suggested investigating and identifying individual intention and behavior because they believe the public acceptance is critical for successful renewable energy technologies (Huijts et al. 2012). In this framework, we seek to investigate and identify the social factors and attributes relative to community acceptance of renewable

energy consumers in the residential sector. Academic research has recognized the role of social acceptance to renewable energy (Zoellner et al. 2008). There are numerous studies that address the cultural, social, climatic, and psychological factors in customers' demand of green electricity (Batel and Devine-Wright 2015; Bock et al. 2017; Sovacool 2009). Some studies were measured by quantitative analysis on the relationship between social acceptance, demographics, and economic characteristics (Joshi and Rahman 2015b; Zhai and Williams 2012). According to Joshi & Rahman (2015), there are two main major factors that cause green purchasing behavior: the consumer's environmental concerns and the products' functional attributes. To understand the consumers' intention and their behavior is not a simple task; to explain human behavior in all its complexity is a difficult task (Ajzen 1991). The Theory of Planned Behavior has strong predictions for wide range of human behavior ((Han et al. 2010). Many researchers were using the Theory of Planned Behavior to explore and identify the consumer attitude, intention, and actual behavior (Joshi and Rahman 2015a).

3.7.3. Survey Objectives

Research dealing with social psychology has widely used theory of planned behavior to predict intentions and behavior (Madden et al. 1992). We are interested in this research to predict and explore the consumer attitude, intention, and actual behavior by using the Theory of planned behavior in the United States regarding consumer's intention to use renewable energy. Hence, we addressed three hypotheses to identify the existing unobserved latent factors that explain the consumer's intention and how much the consumers will perform their behavior. The latent factors of consumer's attitude, subjective norms, and perceived behavior control are tests to find out if they positively influenced a consumer's intention to use renewable energy. This study may help predict and explore the

consumer attitude, intention, and actual behavior. In addition, this study may present the challenges and opportunities for policymakers and researchers to understand consumers' behavior decision. In conclusion, this study may lead to a better understanding of green/renewable energy consumers in the USA.

3.7.4. Survey question items

In this study, we designed a questionnaire including 6 items for attitude towards renewable energy, 6 items for subjective norm, 3 items for perceived behavioral control, and 4 items for intention. Thus, we have totally 19 items that means 380 respondents (19*20) are needed for the sample size. However, structural equation modeling recommends at least 400 respondents (A. Boomsma 1988; Paul, Modi, and Patel 2015). According to Han, Hsu, & Sheu (2010), multi-item scales are used to measure variables to sufficiently capture the constructs. In this study, we will use a 5 point scale measurement scale for all items (Chan 2001; Hartmann and Apaolaza-Ibáñez 2012; Paul et al. 2016; Xu et al. 2018). Our sample target is residential sector in the United States and combinations of demographic and socioeconomic variables will be used in this study. Any participant decides to participate in and contribute to this study, he or she will be asked to complete research questionnaires and this research questionnaire could take approximately between 10 to 15 minutes. The survey will be administered through Survey Monkey (Online survey) which is a private company that enables users to create their own Web-based surveys.

3.8. Recruitment process

The SurveyMonkey allows us to have target respondents based on specific attributes such as gender, age, income, and more by send the survey randomly to SurveyMonkey Audience in USA. SurveyMonkey (n.d.-a), defines audience panel as “US survey respondents from

the 30+ million people who completed SurveyMonkey surveys each month. They volunteer to join our panel “. The identity of the respondents will be protected by making changes to the Survey Monkey settings so that responses collected from the surveys are completely anonymous. The SurveyMonkey will review the survey content to ensure the survey content meets audience privacy, confidentiality, and legal requirements. The survey must meet the SurveyMonkey Audience Survey Content Policy and SurveyMonkey Terms of Use prior to the survey launched by SurveyMonkey. Below are some of the SurveyMonkey consent policy:

- “Don't add additional reward incentives.
- Don't use SurveyMonkey Audience for marketing or recruiting efforts.
- Don't link to content outside of the survey, and then ask respondents to come back to the survey to answer questions about it Don't collect personal information from respondents.” (SurveyMonkey n.d.)

3.8.1 Potential benefits

Renewable energy can help meet the rapid growth in the energy demand. Renewable energy will help the world to have availability, reliability, and security of energy. The increase of renewable energy social acceptance will help the world and policymakers to face the global warming and climate change, global population explosion, and limited natural resources challenges. The researcher may conduct more studies to investigate and identify the social factors and attributes relative to community regarding to consumer attitude, intention, and behavior. Thus, the research findings will help recognize the role of social acceptance to renewable energy and help improve policy regarding of renewable energy.

Chapter 4. ANALYSIS

Chapter 4 discusses how the data analysis is carried out from the primary and secondary data. This chapter is organized by sections and subsections for each hypothesis that was proposed in chapter 3. We present our results as concisely as possible and deliver enough detail to appropriately defend each section, as well as enable the reader to understand precisely what we did in terms of data analysis regarding of each of the five-hypothesis introduced in chapter 3.

4.1. Results of Hypothesis One

Section one shows the results of the vital aspects and factors that influence renewable energy consumption and determine the key factors that have an influence on renewable energy consumption among 22 states.

First, we computed the variability of renewable energy consumption for each state from 1970 to 2015. Then, we introduced an approach to test and examine the stability of the growth rate among the 22 states by a statistical approach not just graphical technique. The 17 subsections are based on hypothesis one factors examined in each of the 22 states (see table 4 below).

Each factor was used in a subsequence analysis based on a six-stages procedure to report significant and influential factors among the 22 states. The first stage delineated the descriptive analysis for each factor. Then, we classified the states into groups for classification purpose. In this stage, we introduced the results of grouping analysis according to the overall average of the 22 states into subgroups for each factor. On this way they should represent the average by subgrouping states of each factor (e.g., low level

states: less than or equal overall average and high-level states: greater than overall average).

To implement states groups, first, we dichotomize the factor based on its average, create a categorical variable factor-index (level 0: low level; level 1: high level), and use this as the response factor variable to illustrate the impact of factor according to states grouping. To groups states into subgroups we used this approach to classify GDP, INCOME, TETPB, TERPB, FFTCB, CLTCP, CLTCD NGTCP, NNRCB, ESTCB, and ESRCB. These factors have high variability among 22 states, whereas the most prices of energy have not large variation among states. In the third stage, the stationary order of the factors was checked using ADF for unit test root for all states. Then, we reported the results of Granger Causality tests using the bivariate Vector Autoregressive (VAR) model which was the fourth stage. In fifth stage, we introduced the Forecast Error Variance Decomposition (FEVD) technique to preform and generate forecasting of variance VAR for only significant factors based on the Granger Causality tests in each state. Finally, the Exploratory Factor Analysis (EFA) was performed for the significant Granger Causality metrics for the 22 states.

Factor i	Factor Description	Unit	Abbreviation
1	Crude oil, average	\$/bbl	Oil
2	Total energy consumption per capita.	Million Btu	TETCB
3	Total energy consumption per capita in the residential sector.	Million Btu	TERPB
4	Fossil fuels, total consumption.	Billion Btu	FFTCB
5	Coal total consumption.	Thousand short tons	CLTCP
6	Natural gas total consumption	Million cubic feet	NGTCP

7	Natural gas consumed by the residential sector	Million cubic feet	NNRCB
8	Electricity total consumption	Billion Btu	ESTCB
9	Electricity consumed by the residential sector.	Billion Btu	ESRCB
10	Income	\$ Per capita personal income	Income
11	Primary energy average price, all sectors.	Dollars per million Btu	PETCD
12	Primary energy average price in the residential sector.	Dollars per million Btu	PERCD
13	Natural gas average price, all sectors	Dollars per million Btu	NGTCD
14	Coal average price, all sectors.	Dollars per million Btu	CLTCD
15	Electricity average price, all sectors.	Dollars per million Btu	ESTCD
16	Electricity price in the residential sector.	Dollars per million Btu	ESRCD
17	The annual gross domestic product (GDP)	Billion	GDP

Table 4:Abbreviation of Factors list for hypothesis 1

4.1.1. Variability of Renewable Energy Consumption among 22 states

The table 5 provides a summary of data variability of renewable energy consumption among 22 states from 1970 to 2015. We found IA has the maximum average growth rate (10.03%) and NY has the minimum average growth rate (0.74%). The growth rate was calculated by considering the average growth rate and change in the absolute level of renewable energy consumption series for 22 states. The results demonstrated that average growth and absolute average growth (see equations 4.1 and 4.2) have much variability. By looking at average growth rate and absolute growth rate, we observed a high fluctuation of renewable energy consumption across 22 states. In contrast, IA was more stable with less fluctuation of renewable energy consumption. Also, all states have a positive average renewable energy growth which shows the 22 states have growth for renewable energy consumption from 1970 to 2015 (see table 5 below). Using the ranking method to rank renewable energy consumption among 22 states to illustrate the highest average growth

rate of renewable energy consumption over time we found IA, NV, NE, and FL have the highest percentage growth respectively.

$$\text{Average Growth Change} = 100 * \frac{\sum_{i=1}^N \left(\frac{Y_t - Y_{t-1}}{Y_{t-1}} \right)}{N} \quad \text{Equation 4.1}$$

$$\text{Absolute Average Growth Change} = 100 * \frac{\sum_{i=1}^N \left(\frac{|Y_t - Y_{t-1}|}{Y_{t-1}} \right)}{N} \quad \text{Equation 4.2}$$

State	Average	Median	Standard deviation	Average Growth Change %	Absolute Average Growth% change
ID	126521.6	123549	3610.27	2.50%	13.15%
MI	112008.8	112900	39378.92	3.40%	7.50%
MN	99338.93	75379.5	65934.11	4.90%	6.33%
MO	49299.02	42863	20832.45	4.60%	17.18%
NE	45763.34	24774.5	41017.13	5.79%	8.60%
NY	393929.91	395948	34575.66	0.74%	5.37%
RI	5243.8	5072.5	1264.359	4.00%	15.04%
WA	914385.69	908084.5	103851.84	1.13%	10.14%
CA	686131.65	690641	136825.13	2.7%	13.97%
DE	4559.54	2846	2973.81	3.75%	16.78%
FL	166256.58	188024.5	81800.07	5.13%	9.82%
GA	194705.39	214486.5	56096.12	3.20%	8.07%
IA	118084.97	80466.5	113398.92	10.03%	13.25%
ME	130769.1	147058.5	37386.02	2.6%	7.00%
MA	65583.36	66497.5	8821.3	1.00%	7.00%
NV	39469.52	40443	17158.55	5.84%	13.94%
NC	153949.6	147518.5	25885.53	2.60%	11.92%
OR	444806.76	434189.5	62769.5	1.20%	10.19%
SD	73878.52	63933.5	28606.52	3.49%	15.74%
TN	168886.41	172330.5	21577.4	1.78%	12.56%

VT	22724.71	21785.5	5587.62	2.66%	9.82%
WI	130682.84	126194.5	44341.42	3.55%	9.36%

Table 5: Average growth of renewable energy consumption among 22 states

4.1.1.1 Stability Growth Test

The next step was to commence with formal tests to examine the stability of renewable energy consumption growth across time and among the 22 states. We proposed an approach that examined the stability of growth over time among the 22 states that included their average growth rate and average absolute growth rate. Note that the average growth rate could be negative. After we computed two values of the average growth and average absolute growth for each state, we used a Paired t-test to compare whether the average growth and average absolute growth have stable values over time (see table 6 below). The table 6 provides evidence the states have unstable and heterogeneous rates of renewable energy growth when we reject null hypothesis. The results met our expectation regarding of unstable average growth among 22 states. Therefore, the results of stability were confirmed to use the bivariate VRA model to examine the Granger Causality test for all factors of the renewable energy consumption for each state. Moreover, we will provide more suggestions in chapter 5 on how we could use the stability time series approach to examine the stability growth in some application.

t-Test: Paired Two Sample for Average s	
	Average Change %
Average	3.481818182
Variance	4.346472727
Observations	22
Pearson Correlation	0.291882402
Hypothesized Average Difference	0
Df	21
t Stat	-10.04382136
P(T<=t) two-tail	1.79451E-09
t Critical two-tail	2.079613845

Table 6: Stability growth Model Test

4.1.2. Factors of Hypothesis one

This subsection is carried out the methodology and results used to test and examine hypothesis one that was proposed in chapter 3 (section 3.3.1.1 to section 3.3.1.4), the 17 subsections which are based on hypothesis one factors examined in each of the 22 states.

Null hypothesis, H_0 – Factor i does not Granger cause the renewable energy consumption in 22 states

Alternative hypothesis, H_1 - Factor i does Granger cause the renewable energy consumption in 22 states

4.1.2.1 Impact of Average Annual Oil Price on Renewable Energy Consumption (RETCB) among 22 states.

In this part of the analyses, we investigated the relationship between the impact of average annual oil price on renewable energy consumption among 22 states. We used the bivariate VAR model to test the Granger Causality test results between the average annual oil price and renewable energy consumption among 22 states over the period of 1970 to 2015. The renewable energy total consumption (measured in Billion Btu) was measured for total consumption of all types of renewable energies. Annual data from 1970 to 2015 on renewable energy consumption was obtained from the US Energy Information Administration. Average crude oil annual price in \$/bbl. data was obtained from World Bank Commodity Price Data (World Bank n.d.).

We used a diagnostic test to check if the variables time series were stationary. To provide a rational diagnostic of stationary process, we considered and used the ADF test approach to the decision on the differences that are provided in Table 7. The ADF test null hypothesis of nonstationary could not be rejected at even 10% level in the level form for renewable energy consumption for all states in this study. Reject the null hypothesis average s the series could have a unit root. Thus, the results for non-stationarity using ADF test are summarized in Table 7. The results show the second difference of all renewable energy consumption among 22 states appear stationary process at p value 1%. The first difference results of ADF test show 7 states are stationary at p value 1%, 4 states are stationary at p value 5%, 6 states are stationary at p value 10%, and 6 states are nonstationary process. However, we glean from our diagnostics of nonstationary process that uses the ADF test. That is considered the second difference used to diagnose the bivariate VAR model to examine the Granger causality test between the renewable energy consumption of 22 states

and average crude oil annual price. Because the states' series were stationary with the second difference, we implemented the regression methodology. The stationarity of the data was checked by computing the roots of the characteristic polynomial of the model; the results indicated the series in all models were stationary with second differences.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-3.7297**	-3.5926**	-4.286***
MI	-1.8801	-2.6314	-5.1531***
MN	-0.4099	-2.6804	-3.9471**
MO	-1.0408	-4.2676**	-6.307***
NE	-0.0903	-3.2735*	-4.5612***
NY	-2.9526	-3.256*	-4.1956***
RI	-2.188	3.3072*	-4.6186***
WA	-4.0729***	-4.629***	-5.2456***
CA	-3.3915*	-4.5637***	-5.9118***
DE	-1.4043	-4.1107***	-5.5365***
FL	-2.2458	-2.9623	-5.106***
GA	-1.8611	-3.4603*	-5.8541***
IA	-0.8912	-2.2457	-4.2636***
ME	-1.7218	-3.7746**	-4.8895***
MA	-2.1822	-2.0571	-4.1199***
NV	-2.7184	-4.3007***	-5.4549***
NC	-2.4525	-6.2583***	-8.2642***
OR	-2.9179	-3.363*	-4.1724***
SD	-1.896	-3.6529**	-4.8815***
TN	-2.9363	-6.512***	-7.6761***
VT	-1.0694	-3.252*	-6.5037***
WI	-2.6624	-2.3019	-4.6268***

Table 7:RETCB Augmented Dickey-Fuller

Significance at the level, the 0.05% level and the 0.10% level. *, **, ***represents 0.10, 0.05 and 0.01

In this section of empirical results, we are probing more deeply to recognize, based on the Lag Length Selection in VAR, additional models that could provide rigorous procedures. Thus, we have looked at two approaches of the bivariate VAR to examine the Granger causality test among 22 states.

In approach 1, we used symmetric lags in which the same lag length is used for renewable energy consumption and oil average price among 22 states. In approach 2, we considered the causality results from estimating the bivariate VAR model regarding the number of lags on the renewable energy consumption variable and the average oil price for each state. To select optimal lag selection, R software provides a set criteria that are by the Schwarz information criteria. In the short term, deviation criteria considered included Akaike's information criterion (AIC), Schwarz's information criterion (SIC), and Phillips' posterior information criterion (PIC). In applying the lag selection criteria, a maximum of 10 lags was used. To demonstrate and clarify our analysis approach we provided an example of approach 1 and approach 2 that investigated the impact of average annual oil price on renewable energy consumption among 22 states.

Approach 1: Symmetric Bivariate VAR of renewable energy consumption and average oil price. The result of temporal Granger causality is reported in Table 8. Wald F statistic and in 22 states having symmetric lag selected from the information criterion, t statistic used the significance at p value 5%, and 10%. We clearly notice the annual global oil price average, not Granger, causes the renewable energy consumption in 21

states. The results show in NE had a significant impact of average annual oil price average Granger causes renewable energy consumption.

State	The bivariate VAR Test		
	F-Test	p-value	Conclusion
ID	0.7957	0.5048	Oil Not G-Cause RETCB
MI	0.2693	0.847	Oil Not G-Cause RETCB
MN	0.7019	0.5575	Oil Not G-Cause RETCB
MO	1.4235	0.2529	Oil Not G-Cause RETCB
NE	5.791	0.00261	Oil G-Cause RETCB
NY	0.3164	0.8134	Oil Not G-Cause RETCB
RI	0.3273	0.8056	Oil Not G-Cause RETCB
WA	0.356	0.7851	Oil Not G-Cause RETCB
CA	1.3243	0.2825	Oil Not G-Cause RETCB
DE	0.356	0.7851	Oil Not G-Cause RETCB
FL	0.2965	0.8276	Oil Not G-Cause RETCB
GA	1.1085	0.3591	Oil Not G-Cause RETCB
IA	0.5962	0.6219	Oil Not G-Cause RETCB
ME	1.6231	0.2022	Oil Not G-Cause RETCB
MA	0.6498	0.5885	Oil Not G-Cause RETCB
NV	1.6191	0.2031	Oil Not G-Cause RETCB
NC	2.0403	0.1267	Oil Not G-Cause RETCB
OR	0.4649	0.7087	Oil Not G-Cause RETCB
SD	1.1616	0.3387	Oil Not G-Cause RETCB
TN	0.8128	0.4957	Oil Not G-Cause RETCB
VT	2.2021	0.1058	Oil Not G-Cause RETCB
WI	0.9197	0.4417	Oil Not G-Cause RETCB

Table 8: Approach 1 Oil G_Causality the bivariate VAR Test

Approach 2: The result of temporal Granger causality is reported in Table 9. Wald F statistic and in 22 states having Asymmetric lag selected from the information criterion, t statistic used the significance at p value 5% and 10% for Asymmetric Bivariate VAR of renewable energy consumption and average oil price. The Asymmetric Bivariate VAR that used optimal lags selection shows in 12 states that the annual global oil price average Granger caused renewable energy consumption significance at p value 5%, and 10% while in 10 states, the statistical test of F test has low critical values, the null hypothesis is failing to reject. We will use Asymmetric lags technique for all factors that we consider using bivariate VAR method.

State	The bivariate VAR Test		
	F-Test	p-value	Conclusion
ID	1.0545	0.3534	Oil Not G-Cause RETCB
MI	3.2261	0.00748	Oil G-Cause RETCB
MN	0.73205	0.688	Oil Not G-Cause RETCB
MO	4.2529	0.00148	Oil G-Cause RETCB
NE	3.433	0.00481	Oil G-Cause RETCB
NY	0.66752	0.7442	Oil Not G-Cause RETCB
RI	2.6757	0.02443	Oil G-Cause RETCB
WA	1.3728	0.2379	Oil Not G-Cause RETCB
CA	2.1247	0.0547	Oil G-Cause RETCB
DE	3.3209	0.03368	Oil G-Cause RETCB
FL	0.38572	0.9423	Oil Not G-Cause RETCB
GA	1.2951	0.07205	Oil G-Cause RETCB
IA	0.5112	0.4767	Oil Not G-Cause RETCB
ME	2.6467	0.04021	Oil G-Cause RETCB
MA	0.59754	0.5527	Oil Not G-Cause RETCB
NV	2.356	0.1017	Oil G-Cause RETCB

NC	3.1949	0.04653	Oil G-Cause RETCB
OR	1.7532	0.1159	Oil G-Cause RETCB
SD	3.6965	0.00299	Oil G-Cause RETCB
TN	0.76376	0.6203	Oil Not G-Cause RETCB
VT	3.5675	0.00381	Oil G-Cause RETCB
WI	0.7124	0.6932	Oil Not G-Cause RETCB

Table 9: Approach 2 Oil G_ Causality

After we illustrated and reported two approaches to examine the Granger causality of factors among states and confirmed the sensitivity of lags on the Granger causality results, we determine how much of the forecast error variance regarding of average annual oil price have significant Granger causality on renewable energy consumption in MI, MO, NE, RI, CA, DE, GA, ME, NV, NC, SD, and VT.

Table 10 below provides the FEVD results to determine how much of the forecast error variance of oil price can be explained exogenous shocks to the renewable energy consumption in MI, MO, NE, RI, CA, DE, GA, ME, NV, NC, SD, and VT after 6 and 12 years. A complete list of the “FEVD determines how much “of the forecast error variance of the factor can be explained is found in Appendix D (from appendix D.1 to appendix D12).

Oil price		
State	6 Years	12 Years
MI	0.4458	0.4613
MO	0.2774	0.6098
NE	0.5409	0.7136
RI	0.3353	0.3934
CA	0.2227	0.3407

DE	0.2635	0.2665
GA	0.2123	0.2318
ME	0.2124	0.2151
NV	0.2223	0.2297
NC	0.4916	0.6258
SD	0.3236	0.4724
VT	0.3236	0.4724

Table 10:FEVD results of oil price

4.1.2.2 Impact of Total Energy Consumption per Capita in Million Btu (TETCB) on Renewable Energy Consumption (RETCB) in 22 states.

The empirical analysis presented in this subsection was based on the total energy consumption per capita in million Btu and the renewable energy consumption in 22 states.

The total energy consumption per capita gives us an average of how much energy each person is consuming in each state. The total energy consumption per capita represents the amount of energy, produced from various types of fuels, that is consumed per capita in a year. Table 10 provides a summary of data variability of the total energy consumption per capita in 22 states from 1970 to 2015. We noted the total energy consumption per capita among the 22 has less variability over the time from 1970 to 2015 (see table below 11).

State	Min.	1st Qu.	Median	Average	3rd Qu.	Max.
ID	317.0	351.2	378	378.7	410.8	438
MI	272	290	305	303.1	315.5	337
MN	286	315	329	329.3	348.2	369
MO	276	289.5	306	305	322.2	337
NE	303	332.8	357	369.8	392	470
NY	179	200.2	209	209.5	217.5	243
RI	175	189.5	211	207.5	222	245

WA	278	313.2	384.5	368.3	403.8	431
CA	196	229.2	237	242.8	259.2	290
DE	278	336.2	367.5	357.8	381.8	427
FL	206	230.2	242.5	238.6	248	257
GA	278	303.2	321	322	342.8	370
IA	300	333.8	361	382.6	418.2	496
ME	301	336.8	349	350.7	371.8	403
MA	204	221	233	232.9	239	274
NV	225	287	320.5	318	341	410
NC	251	275	239	291.5	309	326
OR	238	288	334	324.4	358	381
SD	253	279.2	315	332.8	366.8	464
TN	322	358.2	369	367.1	380.8	402
VT	208	234.2	242.5	243.3	254.8	272
WI	286	301	312.5	316.4	334.5	356

Table 11:Descriptive Analysis of TETCB

Figure 14 is the ranking of the average total energy consumption per capita in 22 states and shows that IA has the highest average total energy consumption per capita (382.6 Million Btu). The state with the lowest average total energy consumption per capita is RI (207.5 Million Btu).

Figure 14: Ranking the average total energy consumption per capita

4.1.2.2.1. Grouping States based on TETCB

Table 12 provides a summary of states classification into two subgroups due to their average of total energy consumption per capita in Million Btu for each state. The overall average of 22 states due to TETCB average was 308.7318 Million Btu. Approximately 41% of states fell into low -level which the average of low-level group due to their TETCB was 252.688 Million Btu, and approximately 59% of states fell into high- level group of TETCB which the average of high-level group was 347.530 Million Btu. In addition, this subsection provides the results of average growth of TETPB from 1970 to 2015. The results show the highest average growth of TETPB was in SD which represented the average growth was increased by 1.34%. Also, the results show the lowest average growth of TETPB in NV that shows the average of TETPB declined by 1.15%.

State	Average Growth of TETPB	Average	Level of TETPB
ID	-0.52%	378.7	1
MI	-0.14%	303.1	0
MN	0.30%	329.3	1
MO	0.21%	305	0
NE	0.75%	369.8	1
NY	-0.44%	209.5	0
RI	-0.27%	207.5	0
WA	-0.62%	368.3	1
CA	-0.71%	242.8	0
DE	-0.53%	357.8	1
FL	-0.16%	238.6	0
GA	0.07%	322	1
IA	1.10%	382.6	1
ME	0.18%	350.7	1
MA	-0.36%	232.9	0
NV	-1.15%	318	1
NC	-0.05%	291.5	0
OR	-0.86%	324.4	1
SD	1.34%	332.8	1
TN	-6%	367.1	1
VT	-0.26%	243.3	0
WI	0.17%	316.4	1

Table 12: Grouping states based on TETPB

level 0: low level states; level 1: high level states

Even at the 10% significance level, the ADF test null hypothesis of non-stationary could not be rejected in the level form for total energy consumption per capita for all states in this study. Failure to reject the null hypothesis average s the series could have a unit root.

Thus, the results for non-stationarity using ADF test are summarized in Table 13. The

results show the all-time series of the total energy consumption per capita across 22 states were generated by a stationary process with second difference.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-2.0154	-2.8529	-4.2536***
MI	-2.4081	-3.2706*	-5.2253***
MN	-1.618	-3.4246*	-5.3394***
MO	-2.3258	-3.4686**	-4.5111***
NE	-2.0689	-3.2089*	-4.4376***
NY	-2.7572	-2.6968	-4.8642***
RI	-2.2826	-3.3763*	-5.7706***
WA	-1.3068	-4.3289***	-5.2557***
CA	-1.3256	-3.501*	-4.3109***
DE	-2.0078	-3.6362**	-5.8547***
FL	-0.716	-3.0636	-4.3851***
GA	0.10399	-2.7518	-5.3949***
IA	-2.1122	-3.0065	-4.527***
ME	0.05443	-4.6858***	-8.1358***
MA	-3.0965	-3.0992	-5.6217***
NV	-0.9019	-3.0047	-5.0564***
NC	-0.4129	-3.3392*	-5.4682***
OR	-1.4675	-4.2929***	-4.4407***
SD	-1.6521	-2.8073	-4.2105***
TN	-1.741	-2.5584	-4.9601***
VT	-0.7909	-3.3198*	-6.593***
WI	-1.7463	-3.6165**	-6.144***

Table 13:Augmented Dickey-Fuller (ADF) of TETCB

Significance at the level, the 0.05% level and the 0.10% level. *, **, ***represents 0.10, 0.05 and 0.01

Due to the sensitivity of the Granger causality test to number of lags to apply, we considered to apply the information criterion to select the appropriate number of lags for two series in the bivariate VAR model. The results show insufficient evidence that the total energy consumption per capita in the most states, except MI, MN, MO, CA, and SD, show a significant impact of the total energy consumption per capita to the renewable energy consumption (see table 14 below).

State	The bivariate VAR Test		
	F-Test	p-value	Conclusion
ID	1.9142	0.1545	TETCB Not G-Cause RETCB
MI	5.5207	0.00017	TETCB Not G-Cause RETCB
MN	6.0008	0.0143	TETCB G-Cause RETCB
MO	3.2004	0.07362	TETCB G-Cause RETCB
NE	1.3363	0.251	TETCB Not G-Cause RETCB
NY	1.5257	0.224	TETCB Not G-Cause RETCB
RI	0.81784	0.4452	TETCB Not G-Cause RETCB
WA	0.67294	0.5132	TETCB G-Cause RETCB
CA	2.1997	0.05528	TETCB G-Cause RETCB
DE	1.1345	0.327	TETCB Not G-Cause RETCB
FL	0.07983	0.9233	TETCB Not G-Cause RETCB
GA	1.215	0.3024	TETCB Not G-Cause RETCB
IA	0.01622	0.9839	TETCB Not G-Cause RETCB
ME	1.2522	0.3031	TETCB Not G-Cause RETCB
MA	0.60633	0.7951	TETCB Not G-Cause RETCB
NV	0.52007	0.5966	TETCB Not G-Cause RETCB
NC	1.3388	0.2683	TETCB Not G-Cause RETCB
OR	1.3988	0.2532	TETCB Not G-Cause RETCB
SD	3.9964	0.00589	TETCB G-Cause RETCB
TN	0.90798	0.5088	TETCB Not G-Cause RETCB
VT	0.70464	0.5524	TETCB Not G-Cause RETCB

WI	1.4279	0.2199	TETCB Not G-Cause RETCB
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Table 14:The bivariate VAR G_Causality of TETCB

Table 15 below provides the FEVD results to determine how much of the forecast error variance regarding of the total energy consumption per capita significantly Granger causality on renewable energy consumption in MI, MN, MO, CA, and SD after 6 and years.

TETCB		
State	6 Years	12 Years
MI	0.69497	0.67834
MN	0.25609	0.25447
MO	0.11897	0.12026
CA	0.27539	0.32354
SD	0.18996	0.3346

Table 15:FEVD results of total energy consumption per capita

4.1.2.3. The impact of Total Energy Consumption per Capita in the Residential Sector (TERPB) on Renewable energy Consumption (RETCB) among 22 states.

In this subsection, we examine and show the results of Granger-type causality tests the total energy consumption per capita in the residential sector of 22 states and renewable energy.

There are several measures of descriptive analysis data of the 22 states, as summarized in Table 16. The average is a simple way to represent the observation over time. Looking at the average for height of observation from 1970 to 2015 across 22 states, the height average around 83.76 Million Btu as NE is the height category with the highest total energy consumption per capita in the residential sector.

Several of the states with the highest residential electricity sales per capita, are TN (83.24 Million Btu), MO (81.96 Million Btu), MI (79.46 Million Btu), and IA (79.02 Million Btu).

State	Min.	1st Qu.	Median	Average	3rd Qu.	Max.
ID	67	76	78.5	78.8	82	89
MI	71	77.25	79	79.46	81.75	87
MN	68	74	77	76.35	79	85
MO	69	76	83	81.96	87	93
NE	76	81	84	83.76	87	92
NY	52	57	59	58.85	61	65
RI	57	61	66	65.26	69	75
WA	62	76	79.5	79.89	84.75	93
CA	35	41.25	45	45.87	49.75	58
DE	58	70	74	74.28	78	85
FL	50	58.25	62.5	63.13	68.75	73
GA	57	66	69	70.17	76	84
IA	69	77	80	79.02	81	87
ME	60	68.25	73	74.67	81	99
MA	61	66	70	70.83	70.75	84
NV	52	65.25	69	68.67	73.75	81
NC	63	69	72.5	72.63	76	84
OR	56	69	72.5	72.85	76.75	84
SD	66	75	78.5	78.5	83.75	91
TN	74	80	82.5	83.24	87	95
VT	58	68	73	75.8	80.5	103
WI	69	76	78	77.87	79.75	86

Table 16: Descriptive Analysis of TERPB

In addition to examining the data visually and mapping in Figure 15, average of the total energy consumption per capita in the residential sector in each state was calculated and the average value for each state was described.

Figure 15: Average of the total energy consumption per capita in the residential sector

Table 17 provides a summary of states classification into two subgroups due to their average of total energy consumption per capita in Million Btu for each state. The overall average of 22 states due to TERPB average was 73.266 Million Btu. Remarkably, we found the same percentage for each group which the percentage of low-level of TERPB was approximately 41% (average of low level TERPB was 65.36 Million Btu) and high-level of TERPB was 59% as classification of TETPB (average of low level TERPB was 78.73 Million Btu). However, it was interesting that the states did not necessarily fall into the same groups of TETPB. We found for example MI fell into low -level group according to TETPB whereas MI association to TERPB fell into high level group vice versa OR state based on average of TETPB fell into high level group whereas OR fell into low level association to TERPB. Table 17 provides more details for states classification in relation of TETPB and TERPB factors.

State	Average of TETPB	Level of TETPB	State	Average of TERPB	Level of TERPB
MI	303.1	0	NY	58.85	0
MO	305	0	RI	65.26	0
NY	209.5	0	CA	45.87	0
RI	207.5	0	FL	63.13	0
CA	242.8	0	GA	70.17	0
FL	238.6	0	MA	70.83	0
MA	232.9	0	NV	68.67	0
NC	291.5	0	NC	72.63	0
VT	243.3	0	OR	72.85	0
ID	378.7	1	ID	78.8	1
MN	329.3	1	MI	79.46	1
NE	369.8	1	MN	76.35	1
WA	368.3	1	MO	81.96	1
DE	357.8	1	NE	83.76	1
GA	322	1	WA	79.89	1
IA	382.6	1	DE	74.28	1
ME	350.7	1	IA	79.02	1
NV	318	1	ME	74.67	1
OR	324.4	1	SD	78.5	1
SD	332.8	1	TN	83.24	1
TN	367.1	1	VT	75.8	1
WI	316.4	1	WI	77.87	1

Table 17: Grouping states based on TETPB and TERPB

level 0: low level states; level 1: high level states

The Augmented Dickey-Fuller test has been calculated. For bivariate time series the null hypothesis H_0 of non-stationarity can be rejected at a 5% and 10 % level. As shown in Table

18 , a unit root can be rejected for the second difference all states at the 5% and 10% , and the 1% significance level.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-3.2695*	-3.6635**	-5.0424***
MI	-2.4303	-3.8352**	-4.9876***
MN	-2.4794	-4.3767***	-5.0614***
MO	-2.5551	-3.9911**	-6.0604***
NE	-2.9884	-5.7299***	-6.0262***
NY	-1.8523	-3.2908**	-5.98***
RI	-3.1392	-3.0451	-4.2053***
WA	-1.988	-4.1615***	-6.0477***
CA	-2.0781	-3.7402**	-6.1055***
DE	-2.3404	-4.9769***	-6.4761***
FL	0.878	-3.9625**	-6.5163***
GA	-0.1147	-3.9718**	-6.1663***
IA	-2.4975	-4.4107***	-6.0674***
ME	-3.1393	-3.6854**	-4.3182***
MA	-2.5278	-3.3625**	-5.233***
NV	-1.2711	-4.4213***	-5.5985***
NC	-1.4107	-4.2976***	-5.864***
OR	-2.2183	-4.7888***	-6.0625***
SD	-3.1286	-5.3683***	-5.6965***
TN	-2.5427	-4.0095**	-5.6263***
VT	-2.0164	-3.9857**	-7.0871***
WI	-3.2345	-4.3989***	-5.0316***

Table 18:Augmented Dickey-Fuller of TERPB

Significance at the level, the 0.05% level and the 0.10% level. *, **, ***represents 0.10, 0.05 and 0.01

The Augmented Dickey-Fuller test has been calculated. For bivariate time series the null hypothesis H_0 of non-stationarity can be rejected at a 5% and 10 % level. The bivariate VAR model applied the Granger-causality test to examine the relationship between the total energy consumption per capita in the residential sector and renewable energy consumption across 22 states. Evidence from the Granger-causality test results are shown in Table 19. It shows that 9 out 22 states of the total energy consumption per capita in the residential sector are causing renewable energy consumption, significant at 5% and 10 % level.

State	The bivariate VAR Test		
	F-Test	p-value	Conclusion
ID	1.0545	0.3534	TERPB Not G-Cause RETCB
MI	3.6742	0.02998	TERPB G-Cause RETCB
MN	2.5375	0.08574	TERPB G-Cause RETCB
MO	0.92461	0.4011	TERPB Not G-Cause RETCB
NE	0.11084	0.8952	TERPB Not G-Cause RETCB
NY	1.0709	0.4156	TERPB Not G-Cause RETCB
RI	3.1599	0.0079	TERPB G-Cause RETCB
WA	0.19336	0.8246	TERPB Not G-Cause RETCB
CA	5.9437	0.00017	TERPB G-Cause RETCB
DE	2.072	0.06617	TERPB G-Cause RETCB
FL	0.61957	0.737	TERPB Not G-Cause RETCB
GA	1.241	0.3092	TERPB Not G-Cause RETCB
IA	0.09068	0.913	TERPB Not G-Cause RETCB
ME	2.6218	0.02027	TERPB G-Cause RETCB
MA	1.2002	0.3267	TERPB Not G-Cause RETCB
NV	1.887	0.1006	TERPB G-Cause RETCB
NC	1.1614	0.3412	TERPB Not G-Cause RETCB

OR	1.2002	0.3068	TERPB Not G-Cause RETCB
SD	3.9255	0.00261	TERPB G-Cause RETCB
TN	0.76343	0.6205	TERPB Not G-Cause RETCB
VT	0.3962	0.93	TERPB Not G-Cause RETCB
WI	1.974	0.08369	TERPB G-Cause RETCB

Table 19:The bivariate VAR G_Causality of TERPB

Table 20 below provides the FEVD results to determine how much of the forecast error variance of Total energy consumption per capita in the residential sector (TERPB) can be explained exogenous shocks to the renewable Energy Consumption (RETCB) in MI, MN, RI, CA, DE, ME, NV, SD, and WI after 6 and 12 years.

TERPB		
State	6 Years	12 Years
MI	0.50878	0.54826
MN	0.12748	0.13051
RI	0.24292	0.25528
CA	0.61858	0.62108
DE	0.18541	0.27593
ME	0.18541	0.27593
NV	0.3407	0.35946
SD	0.47873	0.70182
WI	0.38015	0.40997

Table 20:FEVD results of TERPB

4.1.2.4. Impact of the Total Consumption of Fossil Fuels (FFTCB) on Renewable Energy Consumption (RETCB) among 22 states.

The key question, we seek to address was the relationship between the total consumption of fossil fuels and renewable energy consumption among 22 states. The empirical analysis presented in this section based on the total consumption of fossil fuels in Billion Btu. Table 21 provides a summary of data variability of the total consumption of fossil fuels among 22 states from 1970 to 2015.

State	Min.	1st Qu.	Median	Average	3rd Qu.	Max.
ID	146999	174752	202194	208076	247568	284344
MI	2164233	2357544	2547700	2543061	2695826	2843661
MN	918747	1092271	1187534	1206411	1336606	1453089
MO	1283516	1373354	1525676	1541819	1701373	1852077
NE	403672	454227	484927	523127	577526	706731
NY	2593298	2868491	3044712	3112838	3212806	3999224
RI	118472	158727	177753	175448	188885	230553
WA	670832	840168	1045943	1000805	1138218	1248464
CA	4613211	5246088	5558618	5538518	5797061	6334957
DE	171411	220936	229501	226916	237786	250191
FL	1533027	2092849	2614648	2683087	3310734	3634166
GA	1089764	1537593	1872166	1872166	2144102	2450179
IA	744482	831984	908306	946831	1054979	1209120
ME	186169	248585	265339	269390	284857	364609
MA	982320	1125463	1193400	1200944	1252531	1477303
NV	164602	322088	444656	449022	570039	709629
NC	2593298	2868491	3044712	3112838	3212806	3999224
OR	388126	427752	534750	526986	616538	680909
SD	138952	159857	180765	181464	199188	232194
TN	1043737	1327564	1371222	1417119	1592667	1693741

VT	58709	78757	85579	85086	92809	104101
WI	1077423	1192818	1268005	1295488	1427192	1535462

Table 21::Descriptive Analysis of FFTCB

Figure 16 Below is the mapping and ranking of the average total consumption of fossil fuels from 1970 to 2015 among 22. It shows the CA state has the highest average total consumption of fossil fuels and VT state shows the lowest average total consumption of fossil fuels .

Figure 16:The average of total consumption of fossil fuels

Table 22 provides a summary of states classification into two subgroups due to their average of Total Consumption of Fossil Fuels (FFTCB) for each state. The overall average of 22 states due to FFTCB average was 1368974.54 Million Btu. We found approximately 63.63% of states fell into low- level which the average of low-level group due to their FFTCB was 592571 Million Btu, and approximately 41% of states fell into high level group of FFTCB which the average of high-level group was 2727680.75 Million Btu. In addition,

this section provides the results of average growth of FFTCB from 1970 to 2015. The results show the highest average growth of FFTCB was in NV which represented the average growth was increased by 3.05%. Also, the results show the lowest average growth of FFTCB were in NC and NC with the average of FFTCB declined by 0.75%.

State	Average Growth of FFTCB	Average of FFTCB	Level of FFTCB
ID	1.39%	208076	0
MN	0.57%	1206411	0
NE	0.99%	523127	0
RI	0.26%	175448	0
WA	1.31%	1000805	0
DE	0.22%	226916	0
IA	0.65%	946831	0
ME	0.60%	269390	0
MA	-0.56%	1200944	0
NV	3.05%	449022	0
OR	1.05%	526986	0
SD	1.04%	181464	0
VT	0.58%	85086	0
WI	0.37%	1295488	0
MI	-0.19%	2543061	1
MO	0.53%	1541819	1
NY	-0.75%	3112838	1
CA	0.50%	5538518	1
FL	1.90%	2683087	1
GA	1.44%	1872166	1
NC	-0.75%	3112838	1
TN	0.73%	1417119	1

Table 22: Grouping states based on FFTCB

level 0: low level states; level 1: high level states

The Augmented Dickey-Fuller test has been calculated. For bivariate time series the null hypothesis H_0 of non-stationarity can be rejected at a 5% and 10 % level. Thus, the results for non-stationarity using ADF test are summarized in Table 23. The results show the all-time series of the total consumption of fossil fuels across 22 states were generated by a stationary process with second difference.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-2.1211	-2.8496	-4.795***
MI	-2.8937	-2.9232	-4.5174***
MN	-2.0479	-2.7476	-5.1858***
MO	-1.8893	-2.7957	-4.5133***
NE	-2.3285	-3.6303**	-6.1412***
NY	-3.0077	-2.6056	-4.5226***
RI	-2.151	-2.8214	-5.5954***
WA	-1.3553	-3.3483	-4.7983***
CA	-2.4364	-3.5215**	-4.5832***
DE	-2.4549	-4.7419***	-5.9944***
FL	-1.7956	-3.6329**	-4.8794***
GA	-0.287	-3.5186**	-6.02***
IA	-2.5278	-2.497	-4.6904***
ME	-1.9879	-3.0622	-6.3199***
MA	-2.8518	-3.2265*	-5.881***
NV	-0.556	-2.776	-7.1315***
NC	-3.0077	-2.6056	-4.5226***
OR	-1.9843	-3.9831**	-5.23***
SD	-2.2132	-3.1948*	-4.4282***
TN	-0.7501	-3.0189	-5.3151***

VT	-2.3325	-3.2616**	-5.3288***
WI	-2.6151	-3.6719**	-6.0121***

Table 23: Augmented Dickey-Fuller of FFTCB

Significance at the level, the 0.05% level and the 0.10% level. *, **, *** represents 0.10, 0.05 and 0.01

Evidence from the Granger-causality test results was given in Table 24. Evidence results show 6 out of 22 states of the total consumption of fossil fuels are causing renewable energy consumption, significant at 5% and 10% level.

State	The bivariate VAR Test		
	F-Test	p-value	Conclusion
ID	0.45418	0.6367	FFTCB Not G-Cause RETCB
MI	3.4606	0.00404	FFTCB G-Cause RETCB
MN	1.385	0.2566	FFTCB Not G-Cause RETCB
MO	0.24017	0.6554	FFTCB Not G-Cause RETCB
NE	0.09327	0.9843	FFTCB Not G-Cause RETCB
NY	0.7329	0.4839	FFTCB Not G-Cause RETCB
RI	0.20559	0.8146	FFTCB Not G-Cause RETCB
WA	1.0466	0.3561	FFTCB Not G-Cause RETCB
CA	2.2701	0.04277	FFTCB G-Cause RETCB
DE	0.55682	0.5754	FFTCB Not G-Cause RETCB
FL	0.40937	0.6655	FFTCB Not G-Cause RETCB
GA	7.328	0.00826	FFTCB G-Cause RETCB
IA	0.14154	0.8682	FFTCB Not G-Cause RETCB
ME	3.6208	0.03148	FFTCB G-Cause RETCB
MA	1.0738	0.3468	FFTCB Not G-Cause RETCB
NV	0.23679	0.9166	FFTCB Not G-Cause RETCB
NC	1.1543	0.3394	FFTCB Not G-Cause RETCB

OR	1.4812	0.2271	FFTCB Not G-Cause RETCB
SD	2.3372	0.03753	FFTCB G-Cause RETCB
TN	0.82655	0.6071	FFTCB Not G-Cause RETCB
VT	2.9142	0.01246	FFTCB G-Cause RETCB
WI	0.75013	0.6312	FFTCB Not G-Cause RETCB

Table 24:The bivariate VAR G_Causality of FFTCB

Table 25 below provides the FEVD results to determine how much of the forecast error variance of the Total Consumption of Fossil Fuel (FFTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) in MI, CA, GA, ME, SD, and VT after 6 and 12 years.

FFTCB		
State	6 Years	12 Years
MI	0.21488	0.23189
CA	0.4957	0.55553
GA	0.34357	0.34349
ME	0.16161	0.16639
SD	0.16331	0.39663
VT	0.3053	0.27297

Table 25:FEVD results of FFTCB

4.1.2.5. Impact of the Total Coal Consumption in thousand short tons (CLTCP) on Renewable Energy Consumption (RETCB) for 22 states.

The results of the analysis are presented using the bivariate relationship between the total coal consumption in thousand short tons and renewable energy consumption for each state. This consists of the results of the descriptive data of total coal consumption for each state from 1970 to 2015, unit root tests, and the VAR bivariate mode to test the Granger Causality test.

Outlined in Table 26 are some descriptive data for 22 states presented in the form of descriptive statistics that provide basic information such as the minimum, average, median, mode, maximum of a data set of total coal consumption from 1970 to 2015.

State	Min.	1st Qu.	Median	Average	3rd Qu.	Max.
ID	192	430.5	503.5	495.4	547	772
MI	28519	31817	341817	34611	36969	39870
MN	7884	13030	17139	16054	19085	21998
MO	12863	23967	26978	31572	42804	47033
NE	1174	5414	9080	8978	13092	16953
NY	1761	10926	12054	11508	12955	23936
RI	0	2	4	9.522	7	175
WA	245	4418	5446	5006	5924	7427
CA	1334	2166	2733	2649	2976	4062
DE	276	946.2	1819.5	1698.2	2292.5	2859
FL	5124	9974	24022	20424	28573	31100
GA	8131	21452	28266	26630	32884	42317
IA	5896	13146	19117	17872	24298	28393
ME	25	84.25	245	245.7	303	1093
MA	131	1039	3956	3047	4492	5229
NV	680	3982	5914	5764	7928	8865
NC	16364	21878	24628	25381	30193	33606
OR	101	284.2	1317.5	1281.1	2121	2672
SD	312	2010	2490	2200	2701	3036
TN	16661	22734	24752	24418	26776	30412
VT	0	1	10	23.48	39.25	110
WI	12632	16364	20680	20614	25158	26727

Table 26:Descriptive Analysis of CLTCP

Figure 17 below is the ranking of the average total coal consumption among 22 states. It shows MI state has the highest average total energy consumption per capita (34611 thousand short tons) and the lowest state due to the average total energy consumption per capita is RI.

Figure 17: Ranking the average total coal consumption among 22

The Augmented Dickey-Fuller test has been calculated. For bivariate time series the null hypothesis H_0 of non-stationarity can be rejected at a 5% and 10 % level. Thus, the results for non-stationarity using ADF test are summarized in Table 27.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-2.5778	-3.2974*	-5.4684***
MI	-1.9953	-3.4576**	-4.6238***
MN	-0.9831	-3.2775*	-4.7518***
MO	-1.6815	-2.8213	-4.3775***
NE	-2.7855	-3.3619*	-5.2025***
NY	-0.1767	-2.7737	-4.2453***
RI	-3.1022	-4.7921***	-6.1848***
WA	-1.9852	-4.2131***	-7.1142***
CA	-1.652	-2.8204	-5.1742***
DE	-1.8896	-3.0126**	-4.1856***
FL	0.07226	-2.1509	-3.8468**

GA	-1.4635	-2.9008	-3.9792**
IA	1.1848	-1.5313	-3.9754***
ME	-1.6091	-3.9495**	-4.8652***
MA	-0.9974	-3.4596**	-5.2628***
NV	-0.6016	-4.2586***	-6.6735***
NC	-0.2152	-1.8151	-5.4158***
OR	-2.9048	-3.915**	-4.5309***
SD	-3.5794**	-3.7061**	-5.3194***
TN	-0.1349	-3.368**	-5.554***
VT	-3.8702**	-3.8584**	-4.9232***
WI	-1.4395	-3.5388**	-4.6444***

Table 27: Augmented Dickey-Fuller (ADF) of CLTCP

Significance at the level, the 0.05% level and the 0.10% level. *, **, *** represents 0.10, 0.05 and 0.01

The results show insufficient evidence that the total coal consumption in common states, except FL and GA, show a significant impact of the total energy consumption per capita to the renewable energy consumption (see table 28 below).

State	The bivariate VAR Test		
	F-Test	p-value	Conclusion
ID	0.89771	0.4118	CLTCP Not G-Cause RETCB
MI	1.6828	0.1328	CLTCP Not G-Cause RETCB
MN	1.7208	0.1858	CLTCP Not G-Cause RETCB
MO	0.57696	0.564	CLTCP Not G-Cause RETCB
NE	0.57626	0.6809	CLTCP Not G-Cause RETCB
NY	0.89217	0.5529	CLTCP Not G-Cause RETCB
RI	0.20705	0.8134	CLTCP Not G-Cause RETCB
WA	2.0298	0.08776	CLTCP G-Cause RETCB
CA	0.44089	0.8712	CLTCP Not G-Cause RETCB
DE	0.95685	0.4181	CLTCP Not G-Cause RETCB

FL	2.7803	0.06834	CLTCP Not G-Cause RETCB
GA	2.427	0.09511	CLTCP G-Cause RETCB
IA	1.0426	0.3792	CLTCP Not G-Cause RETCB
ME	1.613	0.1509	CLTCP Not G-Cause RETCB
MA	1.5631	0.206	CLTCP Not G-Cause RETCB
NV	0.72377	0.5789	CLTCP Not G-Cause RETCB
NC	0.8845	0.4784	CLTCP Not G-Cause RETCB
OR	1.2788	0.2888	CLTCP Not G-Cause RETCB
SD	2.1309	0.1258	CLTCP Not G-Cause RETCB
TN	0.73002	0.6904	CLTCP Not G-Cause RETCB
VT	0.99118	0.3759	CLTCP Not G-Cause RETCB
WI	0.87617	0.4205	CLTCP Not G-Cause RETCB

Table 28:The bivariate VAR G_Causality of CLTCP

Significance at the level, the 0.05% level and the 0.10% level. *, **, ***represents 0.10, 0.05 and 0.01

Table 29 below provides the FEVD results to determine how much of the forecast error variance of the Total Consumption of Total Coal Consumption in thousand short tons (CLTCP) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) in FL and GA after 6 and 12 years.

CLTCP		
State	6 Years	12 Years
FL	2.10E-01	2.63E-01
GA	0.20319591	0.21060775

Table 29:FEVD results of CLTCP

4.1.2.6. Impact of the Natural Gas Total Consumption in million cubic feet (NGTCP) on the Renewable Energy Consumption (RETCB) among 22 states.

The empirical analysis presented in this section based on the natural gas total consumption in million cubic feet and the renewable energy consumption among 22 states. Table 30 provides a summary of data variability of natural gas total consumption among 22 states from 1970 to 2015.

State	Min.	1st Qu.	Median	Average	3rd Qu.	Max.
ID	34721	45896	56768	61942	75136	104784
MI	657396	777826	863263	845151	915929	1026867
MN	239991	302120	343459	340791	368247	474520
MO	231941	260557	276298	296205	296829	429526
NE	104732	121981	135443	150720	170757	229632
NY	561698	730962	999571	962686	1199218	1354084
RI	20559	27691	75218	64147	93604	130766
WA	107193	149084	209643	211718	270648	318292
CA	1531323	1837329	2147829	2084442	2307311	2509130
DE	15787	29393	41780	44451	49746	102693
FL	280095	312771	351810	563084	723131	1334286
GA	261320	315554	342772	378128	408167	693875
IA	203063	231718	250848	270131	311338	367595
ME	1299	2350	5158	27028	62806	121540
MA	147307	185019	334979	292844	390326	449195
NV	33790	63877	84543	131475	208540	299973
NC	72527	149297	183390	203409	228485	498569
OR	67045	92802	130461	153577	224322	268484
SD	21087	25858	34860	39528	41654	81985
TN	184048	217954	236443	241862	264816	313299
VT	2663	4373	7266	6642	8371	11949
WI	278848	331201	367739	362358	391979	463185

Table 30: Descriptive Analysis of NGTCP

Remarkably we found most of the states had a huge average growth of NGTCP. For example, the average growth in ME was increased by 18.59% from 1970 to 2015. We found two states had a declined in their average growth of NGTCP (MO average growth of NGTCP declined by 0.85% and NE declined by 0.44). Table 31 provides a summary of states classification into two subgroups due to the Natural Gas Total Consumption in million cubic feet (NGTCP) for each state. The overall average of 22 states due to NGTCP average was 351469.04 million cubic feet. We found approximately 63.72% of states fell into low-level which the average of low-level group due to their NGTCP was 158529.375 million cubic feet, and approximately 27.27% of states fell into high-level group of NGTCP which the average of high-level group was 865974.83 million cubic feet.

State	Average Growth of NGTCP	Average of NGTCP	Level of NGTCP
ID	2.25%	61942	0
MN	0.73%	340791	0
MO	-0.85%	296205	0
NE	-0.44%	150720	0
RI	4.77%	64147	0
WA	2.18%	211718	0
DE	4.15%	44451	0
IA	0.09%	270131	0
ME	18.59%	27028	0
MA	2.76%	292844	0
NV	4.96%	131475	0
NC	3.42%	203409	0
OR	2.65%	153577	0
SD	2.27%	39528	0
TN	0.69%	241862	0

VT	3.85%	6642	0
MI	0.30%	845151	1
NY	1.63%	962686	1
CA	0.48%	2084442	1
FL	3.48%	563084	1
GA	1.93%	378128	1
WI	0.88%	362358	1

Table 31: Grouping states based on NGTCP

level 0: low level states; level 1: high level states

The Augmented Dickey-Fuller test has been calculated. For bivariate time series the null hypothesis H_0 of non-stationarity can be rejected at a 5% and 10 % level. Table 32 summarized the results of Augmented Dickey that show the all-time series of the natural gas total consumption across 22 states were generated by a stationary process with second difference.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-1.7508	-3.6401**	-6.1281***
MI	-2.1483	-3.4033*	-5.6848***
MN	-2.4395	-4.1753**	-6.1178***
MO	-2.5178	-3.3438*	-5.6988***
NE	-2.2266	-3.5453**	-5.3709***
NY	-3.1397	-2.7804	-4.5703***
RI	-1.7527	-2.709**	-5.3574***
WA	-2.4729	-3.6081**	-6.9126***
CA	-3.1254	-3.6103	-5.2685***
DE	-1.7051	-3.1245	-5.1815***
FL	-0.648	-3.5835**	-5.1852***

GA	0.37397	-3.7382**	-6.0889***
IA	-2.0212	-4.5922***	-5.8724***
ME	-2.173	-3.5101	-4.7622***
MA	-2.346	-3.8127**	-6.332***
NV	-2.081	-2.4256	-4.2374***
NC	-1.1177	-3.2701	-4.686***
OR	-2.328	-3.373	-5.7938***
SD	-0.8658	-4.1562**	4.8721***
TN	-3.482	-3.082	-5.3623***
VT	-2.4268	-2.8742	-5.0699***
WI	-1.6623	-3.9159**	6.2231***

Table 32:Augmented Dickey-Fuller of NGTCP

Significance at the level, the 0.05% level and the 0.10% level. *, **, ***represents 0.10, 0.05 and 0.01

After we checked the DF test stationary process for each state, the bivariate VAR model was applied to the Granger causality test to examine the relationship between the total consumption of fossil fuels and renewable energy consumption across the 22 states. Evidence from the Granger causality test results are given in Table 33, which show that in 3 of the 22 states, natural gas total consumption causes renewable energy consumption with 5% and 10 % significance levels.

State	The bivariate VAR Test		Conclusion
	F-Test	p-value	
ID	0.024587	0.975	NGTCP Not G-Cause RETCB
MI	0.84188	0.4349	NGTCP Not G-Cause RETCB
MN	1.5248	0.2242	NGTCP Not G-Cause RETCB
MO	2.0936	0.1303	NGTCP Not G-Cause RETCB
NE	0.29472	0.7456	NGTCP Not G-Cause RETCB
NY	0.39895	0.6724	NGTCP Not G-Cause RETCB

RI	0.23419	0.7918	NGTCP Not G-Cause RETCB
WA	0.17207	0.6793	NGTCP Not G-Cause RETCB
CA	0.22721	0.6348	NGTCP Not G-Cause RETCB
DE	0.29738	0.7436	NGTCP Not G-Cause RETCB
FL	0.43681	0.6477	NGTCP Not G-Cause RETCB
GA	3.2544	0.04405	NGTCP G-Cause RETCB
IA	1.0576	0.3849	NGTCP Not G-Cause RETCB
ME	1.387	0.2561	NGTCP Not G-Cause RETCB
MA	0.76547	0.4687	NGTCP Not G-Cause RETCB
NV	0.056287	0.9453	NGTCP Not G-Cause RETCB
NC	8.8746	0.00034	NGTCP G-Cause RETCB
OR	0.030368	0.8621	NGTCP Not G-Cause RETCB
SD	0.46917	0.4953	NGTCP Not G-Cause RETCB
TN	1.5871	0.1885	NGTCP Not G-Cause RETCB
VT	1.3503	0.2653	NGTCP Not G-Cause RETCB
WI	3.4736	0.00454	NGTCP G-Cause RETCB

Table 33: The bivariate VAR Causality of NGTCP

4.1.2.7. The Impact of Natural Gas Consumed by the Residential Sector (NNRCB) on Renewable Energy Consumption (RETCB) for 22 states.

The results of the analysis presented the bivariate relationship between the natural gas consumed by the residential sector and renewable energy consumption for each state. This consists of the results of the descriptive data of the natural gas consumed by the residential sector for each state from 1970 to 2015, unit root tests, and the VAR bivariate mode to test the Granger causality test.

Table 34 outlines descriptive data for 22 states presented in the form of descriptive statistics that provide basic information such as the minimum, average, median, mode, and maximum of a data set of total coal consumption from 1970 to 2015.

STATE	Min.	1st Qu.	Median	Average	3rd Qu.	Max.
ID	6816	8849	13130	15162	21400	28197
MI	281450	337086	352590	352668	370776	404058
MN	89854	106651	116124	118216	130291	151383
MO	83790	113740	122519	126768	138096	162078
NE	31875	40555	43423	44922	48143	60861
NY	317250	346142	369947	375121	401964	473621
RI	11599	14154	17300	16792	18601	20711
WA	27113	34338	51300	54900	75740	87884
CA	408754	494489	520341	534049	564474	669746
DE	6310	7231	8272	8612	10080	11943
FL	13740	15083	15880	16139	16711	23125
GA	78329	93269	107419	108281	121189	143380
IA	50103	60498	64830	70264	80982	97373
ME	527	610.2	895	971.2	1189.8	2782
MA	81605	91605	110935	108115	120062	136948
NV	7857	12828	20546	23558	35730	43115
NC	27499	33449	46396	47777	61031	77048
OR	10517	21421	29593	30464	39890	47640
SD	9409	11350	12284	12254	13154	14863
TN	40767	45441	54749	56860	68137	80605
VT	1055	1272	2356	2213	3004	3928
WI	103992	117235	124914	126016	132969	155974

Table 34:Descriptive Analysis of NNRCB

We provide Table 35 below to show a summary of states classification into two subgroups due to their average natural gas total consumption in million cubic feet (NGTCP) and sublevel which represented the natural gas consumed by the residential sector (NNRCB). The results show the overall average of 22 states of NNRCB average was 102278.281

million cubic feet. Notably, we found that the percentage for each group of low level of NNRCB was approximately similar to NGTCP (percentage of low-level group for NNRCB was 63.63% whereas the percentage of low-level group of NGTCP was 72.72%). Likewise, we found the high-level group due to the NNRCB was 36.36% and the high- level group due to NGTCP was 27.27%. However, the states were grouped into each classification based on NGTCP and NNRCB not necessarily they placed in the same as classification. But our result demonstrated each state represented different classification based on sublevel of factor. For example, MA fell into low level of NGTCP whereas MA fell into high- level group due to NNRCB factor.

State	Growth OF NGTCP	Average of NGTCP	Level of NGTCP	State	Growth OF NNRCB	Average of NNRCB	Level of NNRCB
ID	2.25%	61942	0	ID	3.34%	15162	0
MN	0.73%	340791	0	NE	-0.54%	44922	0
MO	-0.85%	296205	0	RI	1.45%	16792	0
NE	-0.44%	150720	0	WA	2.29%	54900	0
RI	4.77%	64147	0	DE	1.23%	8612	0
WA	2.18%	211718	0	FL	0.62%	16139	0
DE	4.15%	44451	0	IA	-0.45%	70264	0
IA	0.09%	270131	0	ME	4.31%	971.2	0
ME	18.59%	27028	0	NV	4.01%	23558	0
MA	2.76%	292844	0	NC	2.44%	47777	0
NV	4.96%	131475	0	OR	2.83%	30464	0

NC	3.42%	203409	0	SD	0.30%	12254	0
OR	2.65%	153577	0	TN	1.32%	56860	0
SD	2.27%	39528	0	VT	3.19%	2213	0
TN	0.69%	241862	0	MI	0.13%	352668	1
VT	3.85%	6642	0	MN	0.84%	118216	1
MI	0.30%	845151	1	MO	-0.75%	126768	1
NY	1.63%	962686	1	NY	0.82%	375121	1
CA	0.48%	2084442	1	CA	-0.47%	534049	1
FL	3.48%	563084	1	GA	1.24%	108281	1
GA	1.93%	378128	1	MA	1.23%	108115	1
WI	0.88%	362358	1	WI	0.82%	126016	1

Table 35: Grouping states based on NGTCP and NNRCB

level 0: low level states; level 1: high level states

The results of the panel unit root tests are shown in Table 36 below. Based on the result, all of the variables are non-stationary at levels, and the first differences of most of the states (13 states) are stationary at the 1% and 5% significance levels. The second differences of all states are stationary at the 1% and 5% significance levels.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-2.0402	-2.391	-5.5584***
MI	-2.4686	-4.3122***	-5.2392***
MN	-2.4236	-5.6862***	-6.5253***

MO	-2.2567	-4.4466***	-5.7993***
NE	-2.4918	-5.4455***	-6.345***
NY	-2.591	-3.5698**	-5.7651***
RI	-1.5003	-2.587	-5.9344***
WA	-2.232	-2.7748	-5.4718***
CA	-2.1774	-3.5389**	-6.7054***
DE	-2.2837	-3.4626	-4.9423***
FL	-2.5508	-4.3322**	-6.9992***
GA	-2.082	-5.5873***	-7.5764***
IA	-1.3074	-4.5135**	-6.598***
ME	0.66138	-0.026161	-3.6906***
MA	-2.4403	-4.2757**	-5.4056***
NV	-1.6318	-2.0125	-5.227***
NC	-1.9051	-4.6556***	-7.5356***
OR	-2.2048	-3.2507*	-5.6645***
SD	-2.5006	-4.8957***	-5.0479***
TN	-2.2565	-4.5325	-7.5632***
VT	-2.2049	-1.9943	-4.8173***
WI	-2.991	-4.7014***	-6.1864***

Table 36:Augmented Dickey-Fuller of NNRCB

Significance at the level, the 0.05% level and the 0.10% level. *, **, ***represents 0.10, 0.05 and 0.01

The results of the bivariate of VAR model among the 22 states show evidence that the natural gas consumed by the residential sector in MI, MN, NY, RI, GA, NV, and VT had a significant impact on the natural gas consumed by the residential sector to the renewable energy consumption at the 5 % and 10% significance levels (see table 37 below).

State	The bivariate VAR Test		Conclusion
	F-Test	p-value	
ID	1.3209	0.273	NNRCB Not G-Cause RETCB
MI	2.2577	0.1116	NNRCB Not G-Cause RETCB
MN	8.0576	0.0006704	NNRCB G-Cause RETCB
MO	0.37762	0.6868	NNRCB Not G-Cause RETCB
NE	0.071493	0.9311	NNRCB Not G-Cause RETCB
NY	2.0937	0.06037	NNRCB G-Cause RETCB
RI	5.0822	0.0003134	NNRCB G-Cause RETCB
WA	0.0006713	0.9794	NNRCB Not G-Cause RETCB
CA	0.083945	0.7727	NNRCB Not G-Cause RETCB
DE	0.15129	0.9285	NNRCB Not G-Cause RETCB
FL	0.018909	0.9813	NNRCB Not G-Cause RETCB
GA	3.1833	0.02909	NNRCB G-Cause RETCB
IA	0.10722	0.8985	NNRCB Not G-Cause RETCB
ME	0.81804	0.4451	NNRCB Not G-Cause RETCB
MA	0.73409	0.4832	NNRCB Not G-Cause RETCB
NV	2.0855	0.09299	NNRCB G-Cause RETCB
NC	1.7524	0.1491	NNRCB Not G-Cause RETCB
OR	1.6357	0.1889	NNRCB Not G-Cause RETCB
SD	0.21914	0.6409	NNRCB Not G-Cause RETCB
TN	1.0026	0.4129	NNRCB Not G-Cause RETCB
VT	4.1133	0.002894	NNRCB G-Cause RETCB
WI	1.343	0.2569	NNRCB Not G-Cause RETCB

Table 37: The bivariate VAR G_Causality of NNRCB

Table 38 below provides the FEVD results to determine how much the Total Consumption of Natural Gas consumed by the Residential Sector (NNRCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) in MI, MN, NY, RI, GA, NV, and VT after 6 and 12 years.

NNRCB		
State	6 Years	12 Years
MI	0.42018	0.44875
MN	0.36144	0.37862
NY	0.55196	0.56493
RI	0.56959	0.75819
GA	0.32317	0.35085
NV	0.38907	0.4343
VT	0.09421	0.36676

Table 38:FEVD results of NNRCB

4.1.2.8. Impact of the Electricity Total Consumption (ESTCB) on Renewable Energy Consumption (RETCB) among 22 states.

The empirical analysis presented in this section based on the electricity total consumption in Billion Btu and the renewable energy consumption among 22 states. Table 39 outlines descriptive data for 22 states presented in the form of descriptive statistics that provide basic information such as the minimum, average, median, mode, and maximum of a data set of total electricity consumption from 1970 to 2015.

STATE	Min.	1st Qu.	Median	Average	3rd Qu.	Max.
ID	35804	53892	64364	63146	77249	82598
MI	188657	246892	293615	297616	353365	376837
MN	70680	116405	167129	164837	215901	234726
MO	87957	145558	196422	199592	255279	293722
NE	33291	47702	63727	68230	88273	105185
NY	299574	363058	442846	426688	490729	512304
RI	13401	17353	22123	21613	26056	27464
WA	162443	257196	287048	271748	308231	337891
CA	404818	573465	722828	708090	856273	914946
DE	15644	19496	30123	29424	38798	42990

FL	171346	316288	511387	517256	744782	803865
GA	107480	179055	294426	302653	436895	479971
IA	52792	87615	107283	111563	140339	161053
ME	17292	28529	39026	34880	40463	42198
MA	84069	116812	155459	150707	185755	195261
NV	19426	35561	61749	68935	105831	122899
NC	138037	219201	330918	321026	426207	465448
OR	87509	122699	150518	140936	160723	171727
SD	9564	17387	23185	24796	31324	42154
TN	176513	243519	270258	280969	330293	364118
VT	8912	12823	16986	15836	18918	20073
WI	162443	257196	287048	271748	308231	337891

Table 39:Descriptive Analysis of ESTCB

We found all states had increased average growth of Electricity total consumption and (ESTCB) from 1970 to 2015. We found the overall average of average growth increased by 2.25% from 1970 to 2015. Table 40 provides a summary of states classification into two subgroups due to the ESTCB for each state. The overall average of 22 states due to ESTCB average was 204194.95 Billion Btu. We found approximately 59% of states fell into low-level which the average of low-level group due to their ESTCB was 84191.92 Billion Btu, and approximately 41% of states fell into high -level group of ESTCB which the average of high -level group was 377532.66 Billion Btu.

State	Average Growth of ESTCB	Average of ESTCB	Level of ESTCB
ID	1.87%	63146	0
MN	2.69%	164837	0
MO	2.65%	199592	0
NE	2.53%	68230	0
RI	1.54%	21613	0

DE	2.16%	29424	0
IA	2.55%	111563	0
ME	1.97%	34880	0
MA	1.82%	150707	0
NV	4.26%	68935	0
OR	1.46%	140936	0
SD	3.36%	24796	0
VT	1.80%	15836	0
MI	1.45%	297616	1
NY	1.21%	426688	1
WA	1.59%	271748	1
CA	1.82%	708090	1
FL	3.55%	517256	1
GA	3.36%	302653	1
NC	2.75%	321026	1
TN	1.54%	280969	1
WI	1.59%	271748	1

Table 40: Grouping states based on ESTCB

level 0: low level states; level 1: high level states

The results of the unit root tests are shown in Table 41 below. Based on the results, all the variables are non-stationary at all levels. Most of the states had non-stationary first differences but ID, MN, MO, WA, CA, VT, and WI were stationary at the 1% and 5% significance levels. The second differences of all states are stationary at the 1% and 5% significance levels.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-1.5274	-3.7196**	-4.8817***

MI	-0.8171	-3.461	-6.4509***
MN	0.70952	-4.048**	-5.8537***
MO	-0.7052	-3.5514**	-6.5164***
NE	-1.5776	-2.8861	-5.7466***
NY	-2.9526	-3.256	-4.1956***
RI	-2.1883	-3.3072	-4.6186***
WA	-2.0109	-4.443***	-5.1427***
CA	-1.2095	-3.6351**	-4.3703***
DE	-1.4716	-2.9013	-6.4339***
FL	-2.0698	-2.3876	-4.9698***
GA	-1.1325	-1.967	-5.3325***
IA	-2.0602	-3.8986	-6.6141***
ME	-1.1225	-3.0437	-4.9799***
MA	-0.9103	-3.0972	-5.3312***
NV	-2.1865	-2.578	-4.9211***
NC	0.35466	-2.7809	-5.4928***
OR	-1.9417	-3.4693	-5.4243***
SD	-1.4793	-3.4687	-6.2085***
TN	-2.0882	-2.3917	-4.9476***
VT	0.28765	-4.1343**	-6.901***
WI	0.31617	-3.6818**	-6.1788***

Table 41:Augmented Dickey-Fuller of ESTCB

Significance at the level, the 0.05% level and the 0.10% level. *, **, ***represents 0.10, 0.05 and 0.01

The results of the bivariate of VAR model among the 22 states show evidence that in 27% of states total electricity consumption was a significant Granger cause of renewable energy consumption at the 5 % and 10% significance levels (see table 42 below).

State	The bivariate VAR Test		Conclusion
	F-Test	p-value	
ID	1.9525	0.1661	ESTCB Not G-Cause RETCB
MI	2.4648	0.03417	ESTCB G-Cause RETCB
MN	2.0207	0.102	ESTCB G-Cause RETCB
MO	2.3936	0.1257	ESTCB Not G-Cause RETCB
NE	1.3255	0.2717	ESTCB Not G-Cause RETCB
NY	2.7188	0.01801	ESTCB G-Cause RETCB
RI	3.7818	0.02718	ESTCB G-Cause RETCB
WA	0.83169	0.4808	ESTCB Not G-Cause RETCB
CA	2.5948	0.02263	ESTCB G-Cause RETCB
DE	1.2568	0.2959	ESTCB Not G-Cause RETCB
FL	0.10859	0.8972	ESTCB Not G-Cause RETCB
GA	4.6909	0.03323	ESTCB G-Cause RETCB
IA	4.2299	0.0429	ESTCB G-Cause RETCB
ME	1.8335	0.09783	ESTCB G-Cause RETCB
MA	0.52877	0.715	ESTCB Not G-Cause RETCB
NV	0.94931	0.3915	ESTCB Not G-Cause RETCB
NC	2.4121	0.09646	ESTCB G-Cause RETCB
OR	2.9439	0.05869	ESTCB G-Cause RETCB
SD	3.8681	0.007079	ESTCB G-Cause RETCB
TN	2.8738	0.06264	ESTCB G-Cause RETCB
VT	0.69963	0.5554	ESTCB Not G-Cause RETCB
WI	1.1838	0.3117	ESTCB Not G-Cause RETCB

Table 42: The bivariate VAR G _Causality of ESTCB

Table 43 below provides the FEVD results to determine how much of the forecast error variance of Electricity Total Consumption (ESTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) in MI, MN, NY, RI, CA, GA, IA, ME, NC, OR, SD, and TN after 6 and 12 years.

ESTCB		
State	6 Years	12 Years
MI	0.31352	0.26123
MN	0.2677	0.2661
NY	0.3455	0.5914
RI	0.6016	0.6249
CA	0.3293	0.3422
GA	0.3066	0.3115
IA	0.1197	0.1197
ME	0.0562	0.3647
NC	0.1454	0.1874
OR	0.1696	0.1734
SD	0.347	0.5077
TN	0.1018	0.1037

Table 43:FEVD results of ESTCB

4.1.2.9. Impact of Electricity Consumed by the Residential Sector in Billion Btu (ESRCB) on Renewable Energy Consumption (RETCB) in 22 states.

The results of the analysis of the bivariate relationship between the electricity consumed by the residential sector in Billion Btu and renewable energy consumption for each state. Table 44 outlines descriptive data for 22 states presented in the form of descriptive statistics that provide basic information such as the minimum, average, median, mode, and maximum of a data set of total electricity consumption from 1970 to 2015.

state	Min.	1st Qu.	Median	Average	3rd Qu.	Max.
ID	8033	17618	20752	20686	24764	29409
MI	58355	74963	91322	92936	113600	123156
MN	30814	42323	53316	55168	70305	77963
MO	33000	58523	80938	82229	107883	127275
NE	13926	19320	24506	24744	30470	34484

NY	86980	104561	134885	133439	161433	174830
RI	4742	6258	8168	8150	10178	10821
WA	52390	88561	101613	98104	112532	125453
CA	122071	179182	231129	229306	284058	311280
DE	3988	6200	10012	10084	14472	16545
FL	83969	154835	255928	261572	382772	418855
GA	42562	68793	107925	118495	172280	210024
IA	22109	33630	37817	38048	43955	49903
ME	5878	10476	12676	12299	14682	15908
MA	31850	40204	53837	53315	66745	73048
NV	6788	12674	21061	23667	36131	42275
NC	50021	83644	122778	127613	174871	212090
OR	33610	46357	55042	53595	62008	67932
SD	5411	8978	10490	10881	12754	16471
TN	61217	87452	102027	107657	132028	154192
VT	3945	5276	6616	6226	7091	7468
WI	33524	47071	59237	59025	72767	76628

Table 44: Descriptive Analysis of ESRCB

Remarkably we found the increased average growth of Electricity total consumption and (ESTCB) and the average growth of electricity consumed by the residential sector in Billion Btu (ESRCB) from 1970 to 2015 had approximately the same growth (ESTCB = 2.25%, and ESRCB = 2.37%) . The table 45 below shows the highest increase on ESRCB was in NV 4.26% from 1970 to 2015 and the lowest increase of average growth of ESRCB was in OR 1.45% (Please see Table 38 below).

State	Average Growth of ESRCB	Average of ESRCB	Level of ESRCB
ID	2.89%	20686	0
MI	1.55%	55168	0
MN	2.02%	24744	0
MO	3.00%	8150	0
NE	1.97%	10084	0
NY	1.56%	38048	0
RI	1.88%	12299	0
WA	1.90%	53315	0
CA	2.10%	23667	0
DE	3.44%	53595	0
FL	3.72%	10881	0
GA	3.53%	6226	0
IA	1.78%	59025	0
ME	2.30%	92936	1
MA	1.80%	82229	1
NV	4.26%	133439	1
NC	3.19%	98104	1
OR	1.45%	229306	1
SD	2.48%	261572	1
TN	2.03%	118495	1
VT	1.46%	127613	1
WI	1.78%	107657	1

Table 45: Grouping states based on ESRCB

level 0: low level states; level 1: high level states

The results of the unit root tests are shown in Table 46 below. Based on the results, all the variables are non-stationary at levels. Most states have first differences that are non-stationary with only five states (NY, RI, CA, DE, IA) stationary at the 10% and five states

(MA, NC, SD, VT, WI) stationary at the 5% significance levels. The second differences of all states are stationary at the 1% and 5% significance levels.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-2.6792	-2.7713	-5.0634***
MI	-1.215	-2.7397	-6.079***
MN	-1.503	-2.8623	-5.562***
MO	-0.7364	-3.0441	-8.0352***
NE	-1.2542	-4.061	-7.4825***
NY	-2.9526	-3.256*	-3.256***
RI	-2.1883	-3.3072*	-4.6186***
WA	-1.9081	-3.1661	-4.2983***
CA	-1.5969	-3.3292*	-4.6652***
DE	-2.8478	-3.5061*	-4.7205***
FL	-1.6032	-2.8609	-6.309***
GA	-1.667	-2.3876	-6.7831***
IA	-2.3949	-3.3985*	-6.6448***
ME	-2.6398	-2.4744	-3.5072**
MA	-3.1614	-3.8321**	-5.99***
NV	-2.2181	-2.637	-4.4947***
NC	-1.9611	-3.5562**	-6.4081***
OR	-0.9412	-3.7829**	-5.5084***
SD	-1.9492	-3.7367**	-6.3221***
TN	-1.8861	-3.1057	-5.8366***
VT	-2.864	-3.9424**	-5.9339***
WI	-0.0399	-3.8255**	-6.1245***

Table 46: Augmented Dickey-Fuller of ESRCB

Significance at the level, the 0.05% level and the 0.10% level. *, **, *** represents 0.10, 0.05 and 0.01

The results of the bivariate of VAR model among 22 state show evidence that 27% of states that show the total electricity consumption are a significant Granger cause of renewable energy consumption at the 5 % and 10% significance levels (see table 47 below).

State	The bivariate VAR Test		Decision
	F-Test	p-value	
ID	0.30869	0.7353	ESRCB Not G-Cause RETCB
MI	2.2366	0.09155	ESRCB G-Cause RETCB
MN	0.44078	0.6452	ESRCB Not G-Cause RETCB
MO	0.42083	0.793	ESRCB Not G-Cause RETCB
NE	0.25604	0.7748	ESRCB Not G-Cause RETCB
NY	2.4144	0.03917	ESRCB G-Cause RETCB
RI	2.9655	0.05753	ESRCB G-Cause RETCB
WA	0.26187	0.7703	ESRCB Not G-Cause RETCB
CA	2.5516	0.0233	ESRCB G-Cause RETCB
DE	0.064409	0.9377	ESRCB Not G-Cause RETCB
FL	0.18096	0.9809	ESRCB Not G-Cause RETCB
GA	2.9937	0.01126	ESRCB G-Cause RETCB
IA	0.80001	0.4531	ESRCB Not G-Cause RETCB
ME	3.5578	0.003321	ESRCB G-Cause RETCB
MA	0.76339	0.553	ESRCB Not G-Cause RETCB
NV	1.0285	0.3625	ESRCB Not G-Cause RETCB
NC	0.99934	0.4146	ESRCB Not G-Cause RETCB
OR	2.1898	0.119	ESRCB G-Cause RETCB
SD	4.6329	0.0343	ESRCB G-Cause RETCB
TN	1.1937	0.3347	ESRCB Not G-Cause RETCB
VT	0.3251	0.7234	ESRCB Not G-Cause RETCB
WI	1.4992	0.2298	ESRCB Not G-Cause RETCB

Table 47: The bivariate VAR G_Causality of ESRCB

4.1.2.10. Impact of Personal Income per capita (dollars) on Renewable Energy Consumption (RETCB) in 22 states.

The empirical analysis presented in this section is based on personal income per capita (dollars) and renewable energy consumption among the 22 states. Table 48 provides a summary of data variability of the total energy consumption per capita in 22 states from 1970 to 2015. We noted the total energy consumption per capita among the 22 states has less variability over the time from 1970 to 2015.

State	Min.	1st Qu.	Median	Average	3rd Qu.	Max.
ID	3649	9604	17953	18872	27939	38848
MI	4178	11051	20637	21666	31952	43074
MN	4099	11421	21602	24003	36580	51146
MO	3936	10615	19978	21155	31224	42381
NE	3905	11052	20252	22586	33146	49567
NY	4935	12507	25317	27152	29155	58537
RI	4298	11113	21550	23521	35386	49759
WA	4379	12214	22442	24467	36113	53064
CA	4966	13279	22804	25268	36972	54718
DE	4736	12087	23173	24622	38797	47071
FL	4160	11514	21417	22615	33583	45441
GA	3533	9695	19624	20622	31554	41020
IA	3649	9604	17953	18872	27939	38848
ME	3541	9529	18861	20657	31721	42821
MA	4575	12152	25063	28339	42343	62846
NV	5138	12930	22965	23348	35111	43118
NC	3386	9388	19540	20361	30092	41378
OR	4033	10932	19902	21271	31035	44335
SD	3394	9776	18520	21342	31696	47665

TN	3262	9273	19097	20097	30102	42128
VT	3696	9948	19691	22136	33584	48874
WI	3979	11004	20535	22193	32955	45960

Table 48:Descriptive Analysis of income

Below Figure 18 is mapping the average the personal income per capita (dollars) in the 22 states.

Figure 18:Average the personal income per capita

Table 49 provides a summary of states classification into two subgroups due to their average of personal income per capita (dollars) for each state. The overall average of 22 states due to income average was 22507.5 dollars. Approximately 55% of states fell into low -level which the average of low-level group due to their income was 20770 dollars, and approximately 45% of states fell into high- level group of income which the average of high-level group was 24592 dollars.

State	Average Growth of INCOME	Average of income	Level of income
ID	5.45%	18872	0
MI	5.37%	21666	0
MO	5.47%	21155	0
GA	5.65%	20622	0
IA	5.65%	18872	0
ME	5.74%	20657	0
NC	5.78%	20361	0
OR	5.52%	21271	0
SD	6.18%	21342	0
TN	5.89%	20097	0
VT	5.94%	22136	0
WI	5.63%	22193	0
MN	5.82%	24003	1
NE	5.88%	22586	1
NY	5.69%	27152	1
RI	5.64%	23521	1
WA	5.76%	24467	1
CA	5.53%	25268	1
DE	5.29%	24622	1
FL	5.52%	22615	1
MA	6.04%	28339	1
NV	4.90%	23348	1

Table 49: Grouping states based on income

level 0: low level states; level 1: high level states

The first step in this analysis concerns the stationarity of personal income per capita (US dollars) across the 22 states. The Augmented Dickey-Fuller test has been calculated. For

bivariate time series the null hypothesis H_0 of non-stationarity can be rejected at a 5% and 10 % significance levels (see Table 50 below).

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-1.9739	-3.6083**	-4.4761***
MI	-2.4313	-2.409	-4.6575***
MN	-1.79	-3.0753	-4.8684***
MO	-2.9912	-3.0586	-4.2128***
NE	-0.1524	-4.7824***	-5.6711***
NY	-1.3908	-4.0208**	-4.8116***
RI	-1.8606	-2.7569	-5.1379***
WA	-1.1975	-3.2264*	-3.3744**
CA	-0.5682	-2.7016	-3.7454**
DE	-2.6628	-2.8006	-5.1388***
FL	-2.8313	-3.1468	-4.301***
GA	-2.7924	-2.8341	-4.215***
IA	-2.7924	-2.8341	-4.215***
ME	-2.3454	-2.0437	-3.5097**
MA	-1.7366	-3.1244	-4.0925***
NV	-2.3971	-3.0036	-4.2015***
NC	-3.0682	-3.0084	-2.9932
OR	-1.6261	-2.959	-3.7008**
SD	-1.5269	-2.1314	-5.7253***
TN	-3.2796*	-3.2137*	-4.9529***
VT	-1.5863	-3.2609*	-5.0041***
WI	-2.1745	-3.6181***	-4.8945***

Table 50: Augmented Dickey-Fuller of income

Significance at the level, the 0.05% level and the 0.10% level. *, **, ***represents 0.10, 0.05 and 0.01

Table 51 below provides the Granger causality test between the personal income per capita and renewable energy consumption for each state considered to apply the information criterion to select the appropriate number of lags for two series in the bivariate VAR model.

State	The bivariate VAR Test		Decision
	F-Test	p-value	
ID	0.21171	0.6466	Income Not G-Cause RETCB
MI	2.4374	0.02925	Income G-Cause RETCB
MN	2.5943	0.02265	Income G-Cause RETCB
MO	1.9906	0.1065	Income G-Cause RETCB
NE	5.5808	0.0006442	Income G-Cause RETCB
NY	1.4273	0.2196	Income Not G-Cause RETCB
RI	0.29662	0.8277	Income Not G-Cause RETCB
WA	0.96559	0.4577	Income Not G-Cause RETCB
CA	2.1735	0.08194	Income G-Cause RETCB
DE	4.6279	0.0007968	Income G-Cause RETCB
FL	0.34853	0.7068	Income Not G-Cause RETCB
GA	3.4505	0.06682	Income G-Cause RETCB
IA	11.695	0.0009792	Income G-Cause RETCB
ME	2.3239	0.03758	Income G-Cause RETCB
MA	3.2644	0.04379	Income G-Cause RETCB
NV	0.0017756	0.9665	Income Not G-Cause RETCB
NC	1.2271	0.3081	Income Not G-Cause RETCB
OR	0.15617	0.6937	Income Not G-Cause RETCB
SD	2.4658	0.02834	Income G-Cause RETCB
TN	3.6495	0.009686	Income G-Cause RETCB
VT	15.697	1.97E-06	Income G-Cause RETCB
WI	0.13064	0.8777	Income Not G-Cause RETCB

Table 51: The bivariate VA Causality of income

Table 52 below provides the FEVD results to determine how much the personal income per capita (dollars) can be explained by exogenous shocks to the renewable energy consumption in MI, MN, MO, NE, CA, DE, GA, IA, ME, MA, SD, TN, and VT after 6 and 12 years .

Income		
State	6 Years	12 Years
MI	0.18907085	0.51711094
MN	0.2227229	0.40159409
MO	0.2519344	0.26814971
NE	0.2701353	0.27560368
CA	0.2184556	0.27178856
DE	5.07E-01	5.83E-01
GA	0.0584024	0.05887185
IA	0.2928697	0.2928769
ME	0.3706067	0.56365047
MA	0.2494702	0.25074875
SD	0.1490259	0.4955708
TN	0.2293637	0.2667527
VT	0.5373608	0.53964724

Table 52:FEVD results of Income

4.1.2.11. Impact of the Primary Energy Average Price, all sectors in dollars per million Btu (PETCD) and Renewable Energy Consumption (RETCB) in 22 states.

The empirical analysis presented in this section is based on the primary energy average price with all sectors in dollars per million Btu and the renewable energy consumption among 22 states. Table 53 provides a summary of data variability of the primary energy average price with all sectors in dollars per million Btu among 22 states from 1970 to 2015.

State	Min.	1st Qu.	Median	Average	3rd Qu.	Max.
ID	1.49	5.643	6.56	8.225	10.08	19.32
MI	1.13	4.245	4.51	5.587	6.8	11.92
MN	1.28	4.147	4.845	5.957	7.395	13.41
MO	1.17	3.82	4.565	5.385	6.383	11.61
NE	1.21	3.703	4.28	5.024	5.88	11.05
NY	1.17	4.822	5.65	6.868	8.665	15.5
RI	1.42	6.005	6.92	8.439	11.172	18.58
WA	1.38	4.585	5.75	7.437	9.14	19.15
CA	1.21	4.893	6.155	7.778	10.175	18.36
DE	1.06	4.103	5.085	6.714	8.473	16.55
FL	1.19	3.925	4.65	6	7.242	14.1
GA	1.24	3.768	4.17	5.398	6.455	12.38
IA	1.2	3.92	4.535	5.48	6.577	12.2
ME	1.34	4.202	5.27	7.026	8.877	18.13
MA	1.25	5.14	6.175	7.849	9.852	18.59
NV	1.06	3.685	4.69	6.16	7.798	15
NC	1.2	3.82	4.435	5.529	6.445	12.57
OR	1.61	5.005	6.38	7.875	9.908	18.7
SD	1.59	5.06	6.095	7.479	9.08	17.52
TN	1.03	3.79	4.19	5.322	6.053	12.86
VT	1.87	5.077	5.765	7.275	9.035	16.14
WI	1.16	4.133	4.695	5.727	7.15	12.75

Table 53:Descriptive Analysis of PETCD

Figure 19 Below ranks the average of the primary energy average price, all sectors, in dollars per million Btu among 22 states from 1970 to 2015.

Figure 19: Average of the primary energy average price, all sectors among 22

Even at the 10% significance level, the ADF test null hypothesis of non-stationary could not be rejected in the level form for the primary energy average price, all sectors in dollars per million Btu. Failure to reject the null hypothesis average s the series could have a unit root. Thus, the results for non-stationarity using ADF test are summarized in Table 54. The results show the all time series of the primary energy average price, all sectors in dollars per million Btu across 22 states were generated by a stationary process with second difference.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-2.2415	-2.3016	-3.5546**
MI	-2.3292	-2.4845	-3.7387**
MN	-2.0472	-3.1323	-4.4264***
MO	-2.0975	-2.9455	-4.2048***
NE	-2.0521	-2.9303	-4.2465***

NY	-2.1254	-2.4665	-4.1231***
RI	-2.1506	-3.0847	-3.9008***
WA	-2.2122	-2.8012	-4.5619**
CA	-1.789	-3.0812	-4.3942**
DE	-2.6868	-1.9683	-4.2728**
FL	-2.1888	-2.6566	-4.2958***
GA	-2.3068	-2.4798	-4.0589**
IA	-2.2177	-3.2198*	-4.0268**
ME	-2.064	-3.1023	-4.1355**
MA	-2.0097	-3.3498*	-4.3193***
NV	-1.8625	-2.9835	-4.7068***
NC	-2.1339	-2.783	-4.1309***
OR	-2.1192	-2.782	-3.9583**
SD	-2.0968	-3.2942*	-4.3589***
TN	-2.3897	-2.7081	-3.9974**
VT	-1.2649	-3.6414**	-6.1006***
WI	-2.1277	-2.4943	-3.4704**

Table 54:Augmented Dickey-Fuller of PETCD

Significance at the level, the 0.05% level and the 0.10% level. *, **, ***represents 0.10, 0.05 and 0.01

Table 55 below provides the Granger causality test between the primary energy average price, all sectors in dollars per million Btu, and renewable energy consumption for each state that was considered to apply the information criterion to select the appropriate number of lags for two series in the bivariate VAR model.

State	The bivariate VAR Test		Conclusion
	F-Test	p-value	
ID	1.9039	0.09768	PETCD G-Cause RETCB
MI	2.3351	0.03589	PETCD G-Cause RETCB
MN	8.2022	2.10E-05	PETCD G-Cause RETCB
MO	6.0404	7.57E-05	PETCD G-Cause RETCB
NE	24.503	6.13E-09	PETCD G-Cause RETCB
NY	1.1089	0.3352	PETCD not G-Cause RETCB
RI	2.5486	0.03074	PETCD G-Cause RETCB
WA	1.1241	0.3303	PETCD not G-Cause RETCB
CA	0.71113	0.5486	PETCD not G-Cause RETCB
DE	0.53337	0.5888	PETCD not G-Cause RETCB
FL	0.33415	0.717	PETCD not G-Cause RETCB
GA	1.1772	0.3329	PETCD not G-Cause RETCB
IA	2.1836	0.04966	PETCD G-Cause RETCB
ME	1.8809	0.1595	PETCD not G-Cause RETCB
MA	2.0121	0.141	PETCD not G-Cause RETCB
NV	0.23267	0.793	PETCD not G-Cause RETCB
NC	0.59737	0.702	PETCD not G-Cause RETCB
OR	1.5416	0.1768	PETCD not G-Cause RETCB
SD	3.3492	0.04037	PETCD G-Cause RETCB
TN	1.8306	0.101	PETCD G-Cause RETCB
VT	5.7045	0.004918	PETCD G-Cause RETCB
WI	0.022467	0.9778	PETCD not G-Cause RETCB

Table 55: The bivariate VA Causality of PETCD

Table 56 below provides the FEVD results to determine how much the Primary Energy Average Price, all sectors in dollars per million Btu (PETCD) can be explained exogenous

shocks to the Renewable Energy Consumption in ID, MI, MN, MO, NE, RI, and VT after 6 and 12 years.

PETCD		
State	6 Years	12 Years
ID	0.23526	0.44274
MI	0.4167	0.4189
MN	0.8201	0.9578
MO	0.1057	0.6172
NE	0.6592	0.6604
RI	0.2113	0.2684
VT	0.03705	0.03782

Table 56:FEVD results of PETCD

4.1.2.12. Impact of the Primary Energy Average Price in the Residential Sector in dollars per million Btu (PERCD) on Renewable Energy Consumption (RETCB) in 22 states.

The empirical analysis presented in this section is based on the primary energy average price in the residential sector, in dollars per million Btu, and renewable energy consumption in 22 states. Figure 20 provides a summary of data variability of the primary energy average price in the residential sector in dollars per million Btu in 22 states from 1970 to 2015.

Figure 20: Variability of the primary energy average price in the residential sector

The results for non-stationarity using ADF test are summarized in Table 57. The results show the all-time series of the primary energy average price in the residential sector in dollars per million Btu across 22 states were generated by a stationary process with second difference.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-2.0612	-2.5656	-5.2843***
MI	-2.9808	-1.9453	-3.6381**
MN	-2.3531	-2.8174	-4.6032***
MO	-1.9775	-2.6835	-5.6211***
NE	-2.1034	-2.6368	-4.8214***
NY	-2.1181	-1.9357	-4.2421***
RI	-1.9854	-2.0622	-3.8799**
WA	-2.2732	-1.9232	-4.1511**

CA	-2.6603	-3.5293**	-5.4003***
DE	-2.4472	-1.1928	-3.354*
FL	-2.0628	-2.3448	-4.5922***
GA	-2.3452	-2.0498	-4.4422***
IA	-2.1265	-2.5829	-4.7227***
ME	-1.6716	-2.8537	-4.1123**
MA	-2.065	-2.8078	-4.0758**
NV	-2.6844	-2.6319	-4.1787**
NC	-2.2511	-2.3985	-4.8411***
OR	-2.4383	-2.6215	-4.7994***
SD	-2.0055	-2.6654	-5.012***
TN	-2.4264	-2.6623	-4.7879***
VT	-1.6851	-2.39	-4.0476**
WI	-2.4814	-2.2066	-3.9974**

Table 57: Augmented Dickey-Fuller of PERCD

Significance at the level, the 0.05% level and the 0.10% level. *, **, ***represents 0.10, 0.05 and 0.01

Table 58 below shows the Granger causality test between the primary energy average price in the residential sector, in dollars per million Btu, and renewable energy consumption for each state that was considered to apply the information criterion to select the appropriate number of lags for two series in the bivariate VAR model.

State	The bivariate VAR Test		Conclusion
	F-Test	p-value	
ID	0.079396	0.9238	PERCD not G-Cause RETCB
MI	3.8519	0.0255	PERCD G-Cause RETCB
MN	5.5266	0.0006937	PERCD G-Cause RETCB
MO	3.5421	0.005146	PERCD G-Cause RETCB

NE	6.4375	0.002614	PERCD G-Cause RETCB
NY	1.5463	0.2197	PERCD not G-Cause RETCB
RI	3.1	0.0151	PERCD G-Cause RETCB
WA	1.1998	0.3069	PERCD not G-Cause RETCB
CA	0.33038	0.8034	PERCD not G-Cause RETCB
DE	0.51456	0.5998	PERCD not G-Cause RETCB
FL	0.40961	0.6654	PERCD not G-Cause RETCB
GA	1.3307	0.2704	PERCD not G-Cause RETCB
IA	2.7146	0.01816	PERCD G-Cause RETCB
ME	0.76461	0.4691	PERCD not G-Cause RETCB
MA	2.9154	0.06027	PERCD G-Cause RETCB
NV	2.4286	0.09498	PERCD G-Cause RETCB
NC	4.326	0.01662	PERCD G-Cause RETCB
OR	3.159	0.01021	PERCD G-Cause RETCB
SD	2.7893	0.06776	PERCD G-Cause RETCB
TN	0.55654	0.695	PERCD not G-Cause RETCB
VT	5.2651	0.002474	PERCD G-Cause RETCB
WI	0.19435	0.8238	PERCD not G-Cause RETCB

Table 58: The bivariate VAR G_Causality of PERCD

Significance at the level, the 0.05% level and the 0.10% level. *, **, *** represents 0.10, 0.05 and 0.01

4.1.2.13. Impact of the Natural Gas Average Price, all sectors in dollars per million Btu (NGTCD) on Renewable Energy Consumption (RETCB) in 22 states.

The empirical analysis presented in this section is based on the natural gas average price, all sectors in dollars per million Btu, and the renewable energy consumption of 22 states. Figure 21 provides a summary of data variability of the natural gas average price, all sectors in dollars per million Btu, in 22 states from 1970 to 2015.

Figure 21: Variability of the natural gas average price, all sectors in 22 states

Below Figure 22 ranks the average of the natural gas average price, all sectors in dollars per million Btu, in 22 states from 1970 to 2015.

Figure 22: ranks the average of the natural gas average price, all sectors

The Augmented Dickey-Fuller test has been calculated. For bivariate time series the null hypothesis H_0 of non-stationarity can be rejected at a 5% and 10 % level. The results for non-stationarity using ADF test are summarized in Table 59. The results show the all-time

series of the natural gas average price, all sectors across 22 states were generated by a stationary process with second difference.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-2.2264	-2.7234	-5.1166***
MI	-3.9138**	-2.7669**	-3.2778*
MN	-3.0091	-2.791	-4.2436***
MO	-2.4195	-2.6649	-5.2799***
NE	-2.4095	-2.618	-4.5161***
NY	-2.5345	-2.4657	-4.9828***
RI	-3.2401	-2.9715	-4.1491**
WA	-2.1985*	-2.0256	-4.3321***
CA	-2.0785	-3.3182*	-5.7968***
DE	-2.6027	-2.3023	-5.2467***
FL	-2.9052	-2.7449	-4.3597***
GA	-2.8856	-2.4769	-4.7634***
IA	-2.4425	-2.6777	-4.2404***
ME	-3.7162	-3.9147**	-3.5511**
MA	-2.8835	-3.1106	-4.4309***
NV	-2.1444	-2.7885	-5.1676***
NC	-2.4667	-2.6914	-5.1314***
OR	-3.1735	-2.8117	-4.1455***
SD	-2.4949	-3.0212	-4.4819***
TN	-2.6849	-2.8615	-4.8548***
VT	-2.3275	-2.4106	-4.7048***
WI	-2.4983	-2.2878	-4.2**

Table 59:Augmented Dickey-Fuller of NGTCD

Significance at the level, the 0.05% level and the 0.10% level. *, **, ***represents 0.10, 0.05 and 0.01

Table 60 below provides the Granger causality test between the natural gas average price, all sectors dollars per million Btu, and renewable energy consumption for each state considered to apply the information criterion to select the appropriate number of lags for two series in the bivariate VAR model.

State	The bivariate VAR Test		Conclusion
	F-Test	p-value	
ID	0.84287	0.4345	NGTCD not G-Cause RETCB
MI	2.9813	0.03713	NGTCD G-Cause RETCB
MN	5.727	0.0005279	NGTCD G-Cause RETCB
MO	2.8729	0.0171	NGTCD G-Cause RETCB
NE	14.652	2.51E-09	NGTCD G-Cause RETCB
NY	3.264	0.04366	NGTCD G-Cause RETCB
RI	1.6108	0.1947	NGTCD not G-Cause RETCB
WA	0.2951	0.7453	NGTCD not G-Cause RETCB
CA	0.29213	0.8309	NGTCD not G-Cause RETCB
DE	0.53342	0.8506	NGTCD not G-Cause RETCB
FL	0.75619	0.473	NGTCD not G-Cause RETCB
GA	3.9851	0.001836	NGTCD G-Cause RETCB
IA	0.84101	0.476	NGTCD not G-Cause RETCB
ME	0.0038916	0.9504	NGTCD not G-Cause RETCB
MA	1.9342	0.1516	NGTCD not G-Cause RETCB
NV	0.9596	0.3876	NGTCD not G-Cause RETCB
NC	2.7791	0.06841	NGTCD G-Cause RETCB
OR	0.52082	0.4725	NGTCD not G-Cause RETCB
SD	2.668	0.021	NGTCD G-Cause RETCB

TN	0.66494	0.7003	NGTCD not G-Cause RETCB
VT	3.5511	0.005064	NGTCD G-Cause RETCB
WI	0.72763	0.4864	NGTCD not G-Cause RETCB

Table 60:The bivariate VAR G_Causality of NGTCD

Table 61 below provides the FEVD results to determine how much the Natural Gas Average Price, all sectors in dollars per million Btu (NGTCD) can be explained exogenous shocks to the Renewable Energy Consumption in MI, MN, MO, NE, NY, GA, SD, and VT after 6 and 12 years.

NGTCD		
State	6 Years	12 Years
MI	0.48665	0.5338
MN	0.3228	0.401
MO	0.1837	0.264
NE	0.4685	0.8604
NY	0.2185	0.2569
GA	0.8875	0.7845
SD	0.238	0.4853
VT	0.2551	0.445

Table 61:FEVD results of NGTCD

4.1.2.14. Impact of the Coal Average Price, all sectors in dollars per million Btu (CLTCD), on Renewable Energy Consumption (RETCB) in 22 states.

The empirical analysis presented in this section is based on the coal average price, all sectors in dollars per million Btu, and the renewable energy consumption among 22 states. Figure 23 provides a summary of data variability of the coal average price, all sectors, of 22 states from 1970 to 2015.

Figure 23: Variability of coal average price

A prior step in this analysis concerns to check the stationarity process of the coal average price, all sectors in dollars per million Btu, across the 22 states. The Augmented Dickey-Fuller test has been calculated. For bivariate time series the null hypothesis of non-stationarity can be rejected at a 5% and 10% level. Thus, the results for non-stationarity using ADF test are summarized in Table 62.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-1.8792	-2.3573	-6.0206***
MI	-3.7464**	-2.689	-3.7875**
MN	-2.8495	-2.1716	-4.3852***
MO	-3.2136	-1.8101	-3.2017*
NE	-3.2345*	-2.471	-4.6478***
NY	-1.9427	-3.048	-4.6192***
WA	-2.4421	-3.2296*	-4.0664**
CA	-2.0783	-2.4439	-4.8491***
DE	-2.2147	-2.3695	-5.3612***
FL	-4.2392	-1.7611	-3.1082

GA	-3.1645	-1.9976	-3.1003
IA	-3.6659**	-1.8747	-5.1862***
ME	-2.2176	-2.769	-4.4782***
MA	-1.3008	-2.666	-4.7694***
NV	-2.7159	-2.134	-4.442***
NC	-3.1027	-1.5446	-2.7065
OR	-2.2378	-2.8637	-5.065***
SD	-2.2132	-3.1948*	-4.4282***
TN	-3.6221**	-2.2841	-3.2268***
VT	-1.6038	-4.0383**	-5.6041***
WI	-3.6279**	-1.9253	3.5094

Table 62: Augmented Dickey-Fuller of CLTCD

Significance at the level, the 0.05% level and the 0.10% level. *, **, *** represents 0.10, 0.05 and 0.01

Below Table 63 provides the Granger causality test between the coal average price, all sectors in dollars per million Btu, renewable energy consumption for each state considered to apply the information criterion to select the appropriate number of lags for two series in the bivariate VAR model.

State	The bivariate VAR Test		Conclusion
	F-Test	p-value	
ID	8.4692	0.004649	CLTCD G-Cause RETCB
MI	2.9904	0.01005	CLTCD G-Cause RETCB
MN	2.9161	0.04018	CLTCD G-Cause RETCB
MO	2.658	0.0766	CLTCD G-Cause RETCB
NE	11.014	6.31E-05	CLTCD G-Cause RETCB
NY	0.66322	0.5181	CLTCD not G-Cause RETCB

WA	0.44076	0.6452	CLTCD not G-Cause RETCB
CA	3.4732	0.004479	CLTCD G-Cause RETCB
DE	0.027517	0.9729	CLTCD not G-Cause RETCB
FL	0.48881	0.6912	CLTCD not G-Cause RETCB
GA	0.95257	0.3903	CLTCD not G-Cause RETCB
IA	0.13061	0.7187	CLTCD not G-Cause RETCB
ME	2.052	0.1355	CLTCD not G-Cause RETCB
MA	2.6255	0.07896	CLTCD G-Cause RETCB
NV	3.5484	0.03363	CLTCD G-Cause RETCB
NC	2.7978	0.01959	CLTCD G-Cause RETCB
OR	3.2257	0.07618	CLTCD G-Cause RETCB
SD	2.4987	0.0407	CLTCD G-Cause RETCB
TN	3.4103	0.00511	CLTCD G-Cause RETCB
VT	7.5705	0.0001862	CLTCD G-Cause RETCB
WI	0.78476	0.5064	CLTCD not G-Cause RETCB

Table 63: The bivariate VAR G_Causality of CLTCD

Table 64 below provides the FEVD results to determine how much the Coal Average Price, all sectors in dollars per million Btu (CLTCD) can be explained exogenous shocks to the Renewable Energy Consumption in ID, MI, MN, MO, NE, CA, MA, NV, NC, OR, SD, TN, and VT after 6 and 12 years.

CLTCD		
State	6 Years	12 Years
ID	0.25067	0.25044
MI	0.2019	0.3002
MN	0.1456	0.1608

MO	0.1363	0.1415
NE	0.4694	0.4721
CA	0.1218	0.3478
MA	0.2117	0.2373
NV	0.2112	0.2147
NC	0.0738	0.1499
OR	0.2331	0.2378
SD	0.1158	0.2841
TN	0.2926	0.253
VT	0.2102	0.2381

Table 64:FEVD results of CLTCD

4.1.2.15. Impact of the Electricity Average Price, all sectors in dollars per million Btu (ESTCD) on Renewable Energy Consumption (RETCB) in 22 states.

The empirical analysis presented in this section based on the electricity average price, all sectors in dollars per million Btu, and renewable energy consumption in 22 states. Table 65 provides a summary of data variability of electricity average price, all sectors in dollars per million Btu, in 22 states from 1970 to 2015.

State	Min.	1st Qu.	Median	Average	3rd Qu.	Max.
ID	2.95	8.178	11.38	11.642	14.783	23.7
MI	5.55	17.57	20.58	19.59	21.23	32.89
MN	6.1	14.82	16.35	16.49	18.16	28.08
MO	6.17	14.98	17.85	16.92	18.93	27.67
NE	5.12	13.33	15.75	15.21	16.66	26.1
NY	6.7	24.96	29.81	29.5	36.7	48.27
RI	6.85	23.31	27.5	27.45	33.2	49.86
WA	2.02	5.82	10.55	11.28	17.25	21.85

CA	4.76	19.36	27.04	25.54	34.48	45.3
DE	4.94	18.55	20.27	20.92	22.29	36.35
FL	5.67	20.11	20.78	20.69	23.59	33.68
GA	4.58	14.61	18.64	17.7	19.68	29.38
IA	6.39	16.27	17.56	16.73	19.19	24.47
ME	5.92	18.27	26.59	23.86	30.77	42.77
MA	7.29	22.74	27.83	27.8	33.25	49.54
NV	3.89	14.24	16.96	17.79	25.08	30.52
NC	4.17	13.89	18.94	17.36	20.34	27.47
OR	2.9	9.04	13.03	13.51	18.43	25.63
SD	7.38	15.06	18.14	16.93	18.82	27.76
TN	2.85	13.25	15.59	15.48	17.81	27.59
VT	6.05	17.6	26.19	24.99	32.16	42.83
WI	6.02	15.19	16.25	17.54	20.05	31.47

Table 65:Descriptive Analysis of ESTCD

Figure 24 below ranks the average of the electricity average price, all sectors in dollars per million Btu, in 22 states from 1970 to 2015.

Figure 24:Ranks the average of the electricity average price, all sectors

The Augmented Dickey-Fuller test has been calculated. For bivariate time series the null hypothesis H_0 of non-stationarity can be rejected at a 5% and 10 % significant level, Thus, the results of the electricity average price, in all sectors, across 22 states, for non-stationarity using ADF test are summarized in Table 66.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-1.3556	-3.0693	-4.3637***
MI	-2.8097	-1.9542	-3.7599**
MN	-2.424	-2.5325	-5.0853***
MO	-2.9026	-1.394	-4.1524**
NE	-3.2816*	-1.8968	-2.9311
NY	-3.4681	-3.2559*	-4.2315***
RI	-3.2229*	-3.7692**	-4.6472***
WA	-2.5672	-3.764**	-5.815***
CA	-2.3191	-3.4433*	-5.5022***

DE	-2.8503	-3.4827*	-4.4392***
FL	-3.0945	-3.058	-5.2808***
GA	-3.4512*	-2.3285	-4.4208***
IA	-3.2861*	-1.9406	-4.0895**
ME	-2.9133	-4.1025**	-4.6884***
MA	-3.1412	-4.2327***	-5.0491***
NV	-2.8209	-3.3882**	-5.2112***
NC	-3.1675	-2.0201	-4.0692**
OR	-2.1812	-2.6951	-4.4022***
SD	-2.5247	-2.2758	-4.3028***
TN	-2.9171	-2.2919	-4.2793***
VT	-1.901	-3.1106	-5.7641***
WI	-2.1807	-2.2056	-4.349***

Table 66:Augmented Dickey-Fuller of ESTCD

Significance at the level, the 0.05% level and the 0.10% level. *, **, ***represents 0.10, 0.05 and 0.01

Table 67 below provides the Granger causality test between the electricity average price, all sectors dollars per million Btu, and renewable energy consumption for each state considered to apply the information criterion to select the appropriate number of lags for two series in the bivariate VAR model.

State	The bivariate VAR Test		Conclusion
	F-Test	p-value	
ID	5.0497	0.0002385	ESTCD G-Cause RETCB
MI	2.0536	0.0653	ESTCD G-Cause RETCB
MN	5.2014	0.02516	ESTCD G-Cause RETCB

MO	2.7422	0.07081	ESTCD G-Cause RETCB
NE	0.46608	0.6292	ESTCD not G-Cause RETCB
NY	0.34501	0.7093	ESTCD not G-Cause RETCB
RI	2.1413	0.08583	ESTCD G-Cause RETCB
WA	1.4686	0.229	ESTCD not G-Cause RETCB
CA	0.16286	0.921	ESTCD not G-Cause RETCB
DE	0.93591	0.3967	ESTCD not G-Cause RETCB
FL	0.26351	0.769	ESTCD not G-Cause RETCB
GA	1.3763	0.2587	ESTCD not G-Cause RETCB
IA	3.0016	0.05564	ESTCD G-Cause RETCB
ME	5.581	0.005476	ESTCD G-Cause RETCB
MA	1.9175	0.154	ESTCD not G-Cause RETCB
NV	1.8946	0.1574	ESTCD not G-Cause RETCB
NC	0.7718	0.5476	ESTCD not G-Cause RETCB
OR	2.8659	0.09427	ESTCD G-Cause RETCB
SD	0.0005219	0.9818	ESTCD not G-Cause RETCB
TN	3.0424	0.0166	ESTCD G-Cause RETCB
VT	2.7587	0.01546	ESTCD G-Cause RETCB
WI	1.6064	0.1835	ESTCD not G-Cause RETCB

Table 67: The bivariate VAR G_Causality of ESTCD

Significance at the level, the 0.05% level and the 0.10% level. *, **, *** represents 0.10, 0.05 and 0.01

Table 68 below provides the FEVD results to determine how much the Electricity Average Price, all sectors in dollars per million Btu (ESTCD) can be explained exogenous shocks to the Renewable Energy Consumption in ID, MI, MN, MO, RI, IA, ME, OR, TN, and VT after 6 and 12 years.

ESTCD		
State	6 Years	12 Years
ID	0.47191	0.32534
MI	0.1905	0.3798
MN	0.2068	0.2069
MO	0.1271	0.1347
RI	0.188	0.204
IA	0.1939	0.1976
ME	0.2337	0.2342
OR	0.0778	0.0795
TN	0.172	0.198
VT	0.1379	0.2491

Table 68:FEVD results of ESTCD

4.1.2.16. Impact of the Electricity Price in the Residential Sector in dollars per million Btu (ESRCD) on Renewable Energy Consumption (RETCB) in 22 states.

The empirical analysis presented in this section based on the electricity price in the residential sector in dollars per million Btu and renewable energy consumption in 22 states.

Table 69 provides a summary of data variability of electricity price in the residential sector in dollars per million Btu in 22 states from 1970 to 2015.

State	Min.	1st Qu.	Median	Average	3rd Qu.	Max.
ID	4.81	9.377	14.54	14.485	18.275	29.1
MI	6.99	18.86	23.84	23.24	25.34	42.76
MN	7.3	17.56	20.66	20.46	23.02	35.51
MO	7.85	16.7	20.75	19.57	21.64	32.84
NE	6.21	14.52	18.34	17.83	20.34	31.07
NY	8.83	29.4	37.52	35.2	42.45	58.83

RI	8.44	25.32	30.94	30.32	35.69	56.53
WA	3.12	7.095	13.275	13.538	18.633	26.65
CA	6.53	19.5	31.46	28.3	36.45	49.8
DE	7.53	23.98	25.61	25.85	28	41.24
FL	6.1	21.35	23.03	22.62	26.06	36.3
GA	5.18	15.79	22.22	20.4	23.02	34.14
IA	7.75	18.78	23.5	21.91	25.98	34.1
ME	8.08	21.17	33.42	29.38	38.43	48.43
MA	8.59	24.5	30.67	30.35	36.02	58.11
NV	4.46	15.03	19.18	20.74	28.21	37.9
NC	5.45	16.59	23.39	20.98	24.67	33.06
OR	3.65	10.57	14.58	15.73	21	31.26
SD	7.75	16.78	20.58	19.32	22.29	32.47
TN	3.34	13.21	16.8	16.71	19.95	30.26
VT	6.68	18.54	28.43	28.59	37.84	51.21
WI	6.75	17.72	20.2	21.87	26.29	41.37

Table 69:Descriptive Analysis of ESRCD

Figure 25 below is mapping the average of the electricity average price, all sectors in dollars per million Btu, in 22 states from 1970 to 2015.

Figure 25: The average of the electricity average price, all sectors.

Even at the 10% significance level, the ADF test null hypothesis of non-stationary could not be rejected in the level form for the electricity average price, all sectors in dollars per million Btu. Failure to reject the null hypothesis average s the series could have a unit root. Thus, the results for non-stationarity using ADF test are summarized in Table 70. The results show the most time series of the electricity average price, all sectors in dollars per million Btu across 22 states were generated by a stationary process with second difference.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-1.085	-2.3752	-4.2869***
MI	-3.3429*	-2.13*	-3.1413
MN	-3.0604	-2.5707	-3.9515**
MO	-2.3936	-1.3267	-4.755***
NE	-2.8225	-1.8581	-3.3749**
NY	-3.1289	3.0658	-4.0114**
RI	-3.0293	-3.5748**	-4.3246***
WA	-1.9524	-3.1064	-5.023***

CA	-2.0604	-3.4372*	-5.5926***
DE	-2.8815	-3.5217*	-4.4193***
FL	-3.1002	-3.1537	-5.083***
GA	-3.0557	-2.0085	-4.0672**
IA	-2.8305	-2.3083	-4.7742***
ME	-2.3209	-3.7031**	-4.0042**
MA	-3.3649*	-4.2412***	-4.391***
NV	-2.4103	-3. **	-5.4001***
NC	-3.031	-2.2778	-4.9902***
OR	-0.9148	-2.7031	-5.0757***
SD	-2.3388	-2.1833	-4.6778***
TN	-2.5404	-2.7045	-4.8069***
VT	-2.4122	-3.6846	-5.2966***
WI	-1.5906	-2.1878	-4.4576***

Table 70: Augmented Dickey-Fuller of ESRCD

Significance at the level, the 0.05% level and the 0.10% level. *, **, *** represents 0.10, 0.05 and 0.01

Table 71 below provides the Granger causality test between the electricity price in the residential sector dollars per million Btu and renewable energy consumption for each state considered to apply the information criterion to select the appropriate number of lags for two series in the bivariate VAR model.

State	The bivariate VAR Test		Conclusion
	F-Test	p-value	
ID	2.6485	0.02059	ESRCD G-Cause RETCB
MI	2.7014	0.07356	ESRCD G-Cause RETCB
MN	0.86215	0.3559	ESRCD not G-Cause RETCB
MO	1.4638	0.2236	ESRCD not G-Cause RETCB

NE	0.15349	0.858	ESRCD not G-Cause RETCB
NY	0.21979	0.8032	ESRCD not G-Cause RETCB
RI	0.49493	0.6116	ESRCD not G-Cause RETCB
WA	9.4183	0.002912	ESRCD G-Cause RETCB
CA	0.91503	0.4607	ESRCD not G-Cause RETCB
DE	1.1284	0.3289	ESRCD not G-Cause RETCB
FL	0.25436	0.7761	ESRCD not G-Cause RETCB
GA	1.1333	0.3274	ESRCD not G-Cause RETCB
IA	7.5411	0.001029	ESRCD G-Cause RETCB
ME	6.9445	0.01001	ESRCD G-Cause RETCB
MA	1.631	0.19	ESRCD not G-Cause RETCB
NV	1.6677	0.2001	ESRCD not G-Cause RETCB
NC	1.0898	0.3691	ESRCD not G-Cause RETCB
OR	2.9073	0.02832	ESRCD not G-Cause RETCB
SD	1.0334	0.3124	ESRCD not G-Cause RETCB
TN	2.5591	0.03685	ESRCD G-Cause RETCB
VT	0.72513	0.5404	ESRCD not G-Cause RETCB
WI	1.2859	0.2849	ESRCD not G-Cause RETCB

Table 71: The bivariate VA G_Causality of ESRCD

4.1.2.17. Impact of the Annual Gross Domestic Product (GDP) in millions of current dollars on Renewable Energy Consumption (RETCB) in 22 states

The empirical analysis presented in this section is based on the annual Gross Domestic Product (GDP) in millions of current dollars and the renewable energy consumption in 22 states. Table 72 provides a summary of data variability of GDP in 22 states from 1970 to 2015.

State	Min.	1st Qu.	Median	Average	3rd Qu.	Max.
ID	3015	10680	21866	27460	42890	66274
MI	46178	114799	219212	240553	371777	473730
MN	18700	55921	116233	141078	226501	328455
MO	22230	58497	117097	137187	211666	294750
NE	6907	20964	38784	46759	69321	115270
NY	112349	266936	528604	632640	942714	1488201
RI	4311	10902	23116	26346	42502	56844
WA	18112	59922	138484	176124	267152	469944
CA	111985	375053	816903	1012158	1605986	2557132
DE	3166	9004	23208	29287	50527	70918
FL	30691	114696	294538	367277	622576	895004
GA	19365	64926	165860	211468	358294	513101
IA	12957	37337	62628	75621	113758	177875
ME	29052	79319	170481	210219	326827	502817
MA	3959	11470	24766	27535	43854	57515
NV	3262	13373	38045	56098	101010	144379
NC	22840	66645	163671	204390	323358	503467
OR	9798	31591	66400	84034	133982	203173
SD	2438	7673	15495	18892	29083	47778
TN	16100	50710	115614	134870	214474	322893
VT	1980	5516	12783	13994	22282	30673
WI	20193	57993	116498	135515	212138	304764

Table 72:Descriptive Analysis of GDP

Table 73 provides a summary of states classification into two subgroups due to their average of GDP in millions of current dollars for each state. The overall average of 22 states due to GDP average was 182250.22 million of current dollars. Approximately 68%

of states fell into low -level which the average of low-level group due to their GDP was 75386.67 million of current dollars, and approximately 32% of states fell into high- level group of GDPs which the average of high-level group was 411243.6 million of current dollars.

STATE	Average Growth OF GDP	Average of GDP	Level of GDP
VT	6.34%	13994	0
SD	6.96%	18892	0
RI	5.95%	26346	0
ID	7.21%	27460	0
MA	6.18%	27535	0
DE	7.23%	29287	0
NE	6.50%	46759	0
NV	8.90%	56098	0
IA	6.08%	75621	0
OR	7.05%	84034	0
TN	6.94%	134870	0
WI	6.26%	135515	0
MO	5.96%	137187	0
MN	6.63%	141078	0
WA	7.57%	176124	0
NC	7.17%	204390	1
ME	6.59%	210219	1
GA	7.67%	211468	1
MI	5.41%	240553	1
FL	7.87%	367277	1
NY	5.95%	632640	1
CA	7.26%	1012158	1

Table 73: Grouping states based GDP

level 0: low level states; level 1: high level states

Figure 28 below is mapping the average of the GDP in millions of current dollars among 22 states from 1970 to 2015.

Figure 26: Mapping the average of the GDP

The Augmented Dickey-Fuller test has been calculated. For bivariate time series the null hypothesis H_0 of non-stationarity can be rejected at a 5% and 10 % significant level, Thus, the results for non-stationarity using ADF test are summarized in Table 74. The results show the all-time series of the GDP across 22 states 22 states were generated by a stationary process with second difference.

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-1.3987	-4.4173***	-5.897***
MI	-2.7265	-3.1657	-5.6422***
MN	-1.6299	-3.1962*	-4.0838***

MO	-2.2786	-3.3341*	-3.9818**
NE	1.3985	-3.2682*	-4.622***
NY	-0.424	-3.8685**	-5.2393***
RI	-2.2582	-2.8895	-3.7776**
WA	-0.0975	-6.0462***	-5.7368***
CA	-0.614	-4.2177***	-4.3676***
DE	-2.123	-2.9536	-4.9659***
FL	-1.8684	-3.4773*	-4.2386***
GA	-1.9208	-3.0165	-4.4177***
IA	0.00317	-3.5105*	-4.3132***
ME	-0.8876	-3.0279	-3.9973**
MA	-2.5565	-2.3752	-3.4039*
NV	-1.8568	-3.1768	-4.3581***
NC	-1.6463	-4.3351***	-4.5872***
OR	-1.3304	-2.736	-2.8644
SD	0.67078	-3.6552**	-5.087***
TN	-1.0544	-2.5941	-3.8762**
VT	-2.5707	-2.2914	-4.6657***
WI	-1.641	-3.1792	-4.8736

Table 74:Augmented Dickey-Fuller of GDP

Significance at the level, the 0.05% level and the 0.10% level. *, **, ***represents 0.10, 0.05 and 0.01.

Table 75 below provides the Granger causality test between the GDP in millions of current dollars and renewable energy consumption for each state considered to apply the information criterion to select the appropriate number of lags for two series in the bivariate VAR model.

State	The bivariate VAR Test		Conclusion
	F-Test	p-value	
ID	0.32547	0.5699	GDP not G-Cause RETCB
MI	2.7665	0.01739	GDP G-Cause RETCB
MN	2.6682	0.04006	GDP G-Cause RETCB
MO	2.582	0.08225	GDP G-Cause RETCB
NE	5.2041	0.002655	GDP G-Cause RETCB
NY	7.6778	9.23E-06	GDP G-Cause RETCB
RI	1.1357	0.3266	GDP not G-Cause RETCB
WA	1.1707	0.2824	GDP not G-Cause RETCB
CA	2.291	0.1081	GDP G-Cause RETCB
DE	0.017549	0.9826	GDP not G-Cause RETCB
FL	1.0366	0.3596	GDP not G-Cause RETCB
GA	1.7337	0.1916	GDP not G-Cause RETCB
IA	10.672	0.00159	GDP G-Cause RETCB
ME	2.2409	0.04514	GDP G-Cause RETCB
MA	0.21499	0.8857	GDP not G-Cause RETCB
NV	0.076886	0.7823	GDP not G-Cause RETCB
NC	1.3436	0.2498	GDP not G-Cause RETCB
OR	0.58091	0.4481	GDP not G-Cause RETCB
SD	1.3335	0.2672	GDP not G-Cause RETCB
TN	2.3299	0.06539	GDP G-Cause RETCB
VT	1.7885	0.142	GDP not G-Cause RETCB
WI	0.16362	0.8494	GDP not G-Cause RETCB

Table 75: The bivariate VAR Causality of GDP

Table 76 below provides the FEVD results to determine how much the Annual Gross Domestic Product (GDP) in millions of current dollars can be explained exogenous shocks to the Renewable Energy Consumption in MI, MN, MO, NE, NY, IA, ME, and TN after 6 and 12 years.

GDP		
State	6 years	12 Years
MI	0.33892	0.34197
MN	0.11552	0.1217
MO	0.1596	0.1653
NE	0.2444	0.2489
NY	0.6196	0.7946
IA	0.3242	0.3249
ME	0.0554	0.6781
TN	0.1754	0.1705

Table 76:FEVD results of GDP

4.1.3. Exploratory Factor Analysis

We address this section to identify unobserved latent factors that underlie a diversity of energy and macroeconomic indices we directly observe. For exploration, exploratory factor analysis is performed in the significant Granger Causality metrics from 22 states. The state-by-state energy-macroeconomic dataset from EPA is performed in the macroeconomic dataset consisting of significant factors for each state that derived from Granger Causality. Chi square statistic is used for the total factor numbers in model fitting. The first step was to standardize the raw data to form the average and the standard deviation, respectively, computed from the N observations of the ith variable, then the jth observation of the ith

variable is expressed in standardized units as, “Standardization tends to increase the influence of variables whose variance is small and reduce the influence of variables whose variance is large. Furthermore, the standardization procedure eliminates the influence of different units of measurement, and makes the data dimensionless” (Venkaiah, Brahmam, and Vijayaraghavan 2011). Then, we conducted the correlation matrix among the set of variables for each state.

Factor analysis is the multivariate statistical technique. We used factor analysis to identify the underlying factors in a set of measurements variables. Data normality can affect the process of extracting factors. Therefore, we applied the principal Component Analysis technique to derive the suitable number of factors. Thus, PCA was used for extraction of factors and orthogonal rotation (varimax option) to derive non-correlated factors. The results are presented in the Table 77 for the 16 states (explained below) used in this section. Three factors were explored which are capable to explain the cumulative variance between 93% to 99% percent of the variance among variables (see table 63 below, of which more than 70% is explained by factor-1 and 7 percent is explained by factor- 2 and 3% to 8% explained by factor 3).

State	Comp.1	Comp.2	Comp.3	Cumulative Variance
MI	70%	18%	6%	93%
MN	75%	16%	4%	94%
SD	86%	5%	4%	95%
MO	77%	14%	5%	97%

CA	82%	1%	5%	97%
GA	77%	13%	7%	97%
ME	72%	15%	7%	94%
VT	74%	15%	8%	97%
RI	79%	13%	6%	97%
NE	80%	14%	4%	98%
IA	92%	4%	3%	99%
OR	77%	14%	6%	97%
TN	90%	7%	2%	99%
NY	83%	9%	6%	97%
NC	81%	9%	8%	98%
NV	86%	7%	4%	93%

Table 77: Cumulative Variance of PCA

We started with the exploratory factor analysis (EFA) on the state-by-state dataset. One problem we have is the suitability of this dataset in producing factors. According to Gentleman, Hornik, & Parmigiani (2011), we observed that variables x_q are linked to the unobserved latent variables F_k where $F < q$ in the regression model (Gentleman et al. 2011). In this regard, we excluded from this analysis WA, DE, FL, WI, ID, and MA.

As an exploration, particularly for the factor analyses, we have built a new data set, still from the same 22 states in the previous hypothesis 1 analysis, but with focus on the results of significant Granger causality variables matrices for each state. Therefore, table below groups the variables that had caused renewable energy for each state. Table 78 represented the loadings for two underlying latent variables for 16 states in the rotated component matrix.

State	Variables	Factor1	Factor2
MI	OIL	0.551	0.579
	TETPB	-0.197	-0.943
	TERPB		-0.681
	FFTCB		-0.984
	INCOME	0.979	0.195
	NNRCB		-0.444
	ESTCB	0.985	
	ESRCB	0.983	
	PETCD	0.837	0.427
	NGTCD	0.787	0.45
	CLTCD	0.531	0.769
	ESTCD	0.817	0.529
	ESRCD	0.845	0.49
State	Variables	Factor1	Factor2
MN	OIL	0.226	0.97
	TETPB	0.908	0.171
	TERPB	0.14	-0.109
	FFTCB	0.953	0.195
	INCOME	0.794	0.512
	NNRRCB	0.817	0.23
	ESTCB	0.834	0.422
	ESRCB	0.815	0.496
	PETCD	0.535	0.798
	NGTCD	0.652	0.555
	CLTCD	0.264	0.729
	ESTCD	0.556	0.635
	ESRCD	0.597	0.596

	GDP	0.788	0.535
State	Variables	Factor1	Factor2
SD	OIL	0.341	0.898
	TETPB	0.795	0.559
	TERPB	0.729	0.278
	FFTCB	0.825	0.411
	INCOME	0.847	0.517
	ESTCB	0.863	0.502
	ESRCB	0.849	0.517
	PETCD	0.629	0.774
	PERCD	0.707	0.672
	NGTCD	0.678	0.5
	CLTCD	0.655	0.655
State	Variables	Factor1	Factor2
MO	OIL	0.72	0.314
	TETPB		0.816
	INCOME	0.636	0.77
	PETCD	0.772	0.549
	PERCD	0.658	0.701
	NGTCD	0.617	0.693
	CLTCD	0.997	
	ESTCD	0.887	0.386
	GDP	0.607	0.793
State	Variables	Factor1	Factor2
CA	OIL	0.274	0.703
	TETPB	-0.634	-0.672
	TERPB	-0.701	-0.623
	FFTCB	0.786	0.294

	INCOME	0.654	0.755
	ESTCB	0.829	0.555
	ESRCB	0.786	0.614
	CLTCD	0.371	0.668
	GDP	0.608	0.792
State	Variables	Factor1	Factor2
GA	OIL	0.218	0.337
	FFTCB	0.899	0.398
	CLTCP	0.986	
	INCOME	0.631	0.708
	NGTCP		0.878
	NNRCB	0.64	0.572
	ESTCB	0.699	0.664
	ESRCB	0.644	0.685
	NGTCD	0.796	0.291
State	Variables	Factor1	Factor2
ME	OIL	0.282	0.654
	TERPB	-0.624	-0.194
	FFTCB	0.145	0.394
	INCOME	0.6	0.798
	ESTCB	0.827	0.398
	ESRCB	0.702	0.608
	ESTCD	0.795	0.599
	ESRCD	0.806	0.588
	GDP	0.544	0.837
State	Variables	Factor1	Factor2
VT	OIL	0.955	0.186
	FFTCB		0.879

	INCOME	0.586	0.808
	NNRCB	0.408	0.904
	PETCD	0.799	0.589
	PERCD	0.837	0.542
	NGTCD	0.792	0.537
	CLTCD	-0.469	
	ESTCD	0.535	0.812
State	Variables	Factor1	Factor2
RI	OIL	0.963	0.148
	TERPB	-0.545	-0.428
	NNRCB	0.161	0.859
	ESTCB	0.447	0.892
	ESRCB	0.527	0.847
	PETCD	0.872	0.484
	PERCD	0.843	0.528
	ESTCD	0.651	0.673
State	Variables	Factor1	Factor2
NE	OIL	0.656	0.459
	INCOME	0.53	0.845
	PETCD	0.695	0.646
	PERCD	0.775	0.629
	NGTCD	0.862	0.444
	CLTCD	0.294	0.29
	GDP	0.509	0.858
State	Variables	Factor1	Factor2
IA	INCOME	0.865	0.497
	ESTCB	0.844	0.524
	PETCD	0.699	0.556

	PERCD	0.786	0.526
	ESTCD	0.478	0.875
	ESRCD	0.622	0.78
	GDP	0.862	0.469
State	Variables	Factor1	Factor2
OR	OIL	0.522	0.537
	ESTCB	0.965	
	ESRCB	0.974	0.217
	PERCD	0.807	0.489
	CLTCD		0.672
	ESTCD	0.826	0.56
	ESRCD	0.832	0.551
State	Variables	Factor1	Factor2
TN	INCOME	0.841	0.537
	ESTCB	0.843	0.416
	PETCD	0.618	0.683
	CLTCD	0.385	0.848
	ESTCD	0.587	0.808
	ESRCD	0.656	0.753
	GDP	0.753	0.509
State	Variables	Factor1	Factor2
NY	NNRCB	0.568	0.576
	ESTCB	0.892	0.422
	ESRCB	0.824	0.562
	NGTCD	0.77	0.421
	CLTCD	0.362	0.776
	GDP	0.688	0.723
State	Variables	Factor1	Factor2

NC	OIL	0.512	0.701
	NGTCP	0.264	0.85
	ESTCB	0.719	0.539
	PERCD	0.784	0.617
	NGTCD	0.951	0.301
	CLTCD	0.526	0.795
State	Variables	Factor1	Factor2
NV	OIL	0.638	0.464
	TERPB	-0.72	-0.601
	NNRCB	0.468	0.857
	PERCD	0.611	0.731
	CLTCD	0.887	0.456

Table 78:loadings for two underlying latent variables for 16 states

A list of the 16 MLR models integrated with EFA components to predict renewable energy consumption is found in Appendix E (from appendix E.1 to appendix E.16).

4.2. Results of Hypothesis Two

We seek in this section two to identify the impact of renewable energy consumption and fossil energy consumption on the high-emission states versus low-emission states. Thus, this section addressed the results to identify if there are differences between the socio-economic and energy variables among different states influencing the low and high emission.

Null hypothesis (H_0): There are no differences between the socio-economic and energy variables among different states influencing the low and high emission level.

Alternate hypothesis (H_1): There are differences between the socio-economic and energy variables among different states influencing the low and high emission level.

4.2.1. MANOVA

Renewable energy and total energy are the two dependent variables we used in MANOVA. The categorical factor variable is the state emission level (level 0: low emission; level 1: high emission). With 2 dependent numerical variables and 1 factor variable, this is a classic one-way MANOVA problem. Before applying the MANOVA, we check if our dataset satisfies the multivariate normal assumption inherent in MANOVA. Transformation and outlier removal are needed if data doesn't meet the multivariate normal criteria. Four different tests are used to determine the significance of one-way MANOVA, including Hotelling's trace test, Wilk's lambda test, Roy's largest root test, and Pillai's trace test. Significant MANOVA results are followed with ANOVA tests to identify which dependent variable contributes to the MANOVA outcome.

Initial multivariate normal tests suggest the data is not multivariate normally distributed. In order to comply with the normal distribution assumption of MANOVA, the dataset has preparation steps. A square-root transformation has been applied to the dataset and outliers in the transformed data were removed using the 'MVN' package. Following square-root transformation and outlier removal, the data satisfied the Mardia's multivariate normal tests (p-value for skewness =0.11; p-value for kurtosis=0.43). In the MANOVA, all 4 tests, Hotelling's trace test, Wilk's lambda test, Roy's largest root test, and Pillai's trace test, have confirmed a significant MANOVA, with $F(1,19)=14.79$, and $p=0.0001$. In the follow-up MANOVA, the measure of total energy significantly differs between low-emission and high-emission states ($F(1,19)=11.0$, $p=0.003$), but not the measure of renewable energy ($F(1,19)=1.79$, $p=0.19$).

4.3. Results of Hypothesis Three

This section represented the results regarding of hypothesis 3.

Null hypothesis (H_0):

Principal Component Analysis does not provide a more accurate model than time series analysis such as the Autoregressive model

Alternate hypothesis (H_1):

Principal Component Analysis provides a more accurate model than time series analysis such as the Autoregressive model.

The method is to apply Principal Component Analysis (PCA) because that technique allows finding correlations among variables represented by a set of observations stored in a matrix. The data collected have a high degree of multicollinearity among predictors.

This section examines the U.S Energy Consumption over a 46 year span from 1970 through 2015. We utilized the quantitative methods to predict U.S Energy Consumption annually.

The method utilized a multiple regression model to predict U.S. Energy Consumption. The regression model forecasts with U.S Energy Consumption as the Y, dependent or output.

The purpose is to apply Principal Component Analysis (PCA) because that technique could find correlations among variables represented by a set of observations stored in a matrix.

These data have a high degree of multicollinearity among predictors.

4.3.1. Data Structure

We used the causality test for 17 variables in hypothesis 1 (section 3.3.1). We found 12 variables were significant and caused the U.S. Energy Consumption. The results of the total energy consumption (USA) Granger causality are available in Appendix F while a

table including results of unit root test is included in Appendix F.1 and The bivariate VAR test results are found in Appendices F.2 and F.3 .

One variable is represented as dependent variable that U.S. Energy Consumption expressed as “Quadrillion.Btu”. In this model consider Y is an $n \times 1$ vector of responses, and $X = [x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12}]$ is an $n \times p$ as full matrix of predictors. The predictor’s variables represent the independent variables..

This model depends on 12 inputs or predictor variables:

1. “Oil”: Crude oil, average. (\$/bbl)
2. “TETPB”: Total energy consumption per capita. (Million Btu)
3. “CLTCP”: Coal total consumption. (Thousand short tons)
4. “Income”: Per capita personal income (dollars)
5. “NNRCB”: Natural gas consumed by the residential sector. (million cubic feet)
6. “ESTCB”: Electricity total consumption .(billion Btu)
7. “PETCD”: Primary energy average price, all sectors. (dollars per million Btu)
8. “PERCD”: Primary energy average price in the residential sector. (dollars per million Btu)
9. “NGTCD”: Natural gas average price, all sectors. (dollars per million Btu)
10. “CLTCD”: Coal average price, all sectors. (dollars per million Btu)
11. “ESRCD”: Electricity price in the residential sector. (dollars per million Btu)
12. “GDP”: The annual gross domestic product

4.3.2. Data Sources

All data collected from 1970 to 2015 as observation (n) for USA were obtained from open and published sources. Population collected based on World Bank Group. GDP per capita

data collected from World Bank. Average household income is Bureau of Economic Analysis (BEA). Remaining data are obtained from recorded by the U.S. Energy Information Administration (EIA).

4.3.3. Dataset Issues

Dataset contains 12 variables and 46 observations. Also, there are no missing values in the dataset and descriptive analysis is represented (table 79 below) of variables

State	Min.	1st Qu.	Median	Average	standard deviation	3rd Qu.	Max.
Oil	5.21	22.41	30.48	40.6	26.00	53.81	95.30
TETPB	300.0	325.0	336.5	333.5	15.48	344.0	360.0
CLTCP	501575	713339	901863	865943	192959.9	1035213	1127912
Income	4196	11433	21379	23094	13531.84	33910	48451
NNRCB	4237541	4691904	4890998	4852958	252168.4	5016277	5350229
ESTCB	4750527	7191168	9595956	9547828	2614227	12058217	12845157
PETCD	1.080	3.987	4.605	5.753	3.49	7.105	13.0
PERCD	1.220	5.315	6.350	7.377	4.185	10.645	15.930
NGTCD	0.590	3.505	4.145	4.611	2.59	6.265	10.830
CLTCD	0.380	1.282	1.450	1.508	0.546	1.700	2.590
ESRCD	6.51	18.66	24.00	22.56	8.525	26.05	37.08
GDP	1073	3241	6689	7821	5268.614	12025	18219

Table 79:Descriptive Analysis OF U.S. Energy Consumption Factors

Figures 27 & 28 show that the distribution of NNRCB, CLTCP, PERCD, INCOME, and NGTCD have kind of a symmetric distribution. The ESTCB, CLTCD, and GDP histograms show positively skewed distribution (could be used log).

Figure 27:Histograms Plots of U.S. Energy Consumption Factors Set 1

Figure 28:Histograms Plots of U.S. Energy Consumption Factors Set 2

4.3.4. Normality test for univariate

In this part, we examine normality test for each variable by using Shapiro-Wilk normality test. The null hypothesis for this test is data are normally distributed, and alternative hypothesis is data are not normally distributed (see below table 80)

Variables	P value	Decision
Oil	0.00061	Data are not normally distributed
TETPB	0.06527	Data are normally distributed
CLTCP	0.00869	Data are not normally distributed
Income	0.01733	Data are not normally distributed
NNRCB	0.3309	Data are normally distributed
ESTCB	0.00267	Data are not normally distributed
PETCD	0.00011	Data are not normally distributed
PERCD	0.00305	Data are not normally distributed
NGTCD	0.06497	Data are normally distributed
CLTCD	0.00977	Data are not normally distributed
ESRCD	0.01962	Data are not normally distributed
GDP	0.00472	Data are not normally distributed

Table 80:Normality test for univariate of U.S. Energy Consumption Factors

Figures 29 & 30 shows the qqnorm plots for 12 variables.

Figure 29:qqnorm plots of U.S. Energy Consumption Factors Set 1

Figure 30:qqnorm plots of U.S. Energy Consumption Factors Set 2

4.3.5. Preprocessing PCA

Below Figure 31 shows there are high correlation among the variables.

Thus, multiple regression models were run to find if there was a multicollinearity issue.

Figure 31:Correlation among the variables Matrix of U.S. Energy Consumption Factors

4.3.6. Applicability of PCA

This section seeks to obtain a few important predictor variables by reducing the number of variables because we find there are multicollinearity among the variables. We used a principal component analysis (PCA) to decompose the independent (x) variables into an orthogonal basis (the principal components) that allows representing predictors dependencies in lower dimension space, then selected a subset of those components as the variables to predict y .

Prior to performing PCA, we scaled all variables to standardize the variables that can help avoid the large variance among variables (see Appendix G).

Below Figure 32 shows the Scree Plot which plots the eigenvalue (total variance explained) by the component number.

Figure 32:Scree Plot which plots the eigenvalue

Figure 33 below shows the results of PCA that provide the proration of variance for each component and also the cumulative proportion of variance. We can clearly notice components one and component two explained approximately 87% from the total variation

Importance of components:

	Comp.1	Comp.2	Comp.3	Comp.4	Comp.5	Comp.6	Comp.7
Standard deviation	2.9821387	1.2407897	0.89131982	0.62506375	0.43915522	0.36682759	0.189990313
Proportion of Variance	0.7410959	0.1282966	0.06620425	0.03255872	0.01607144	0.01121354	0.003008027
Cumulative Proportion	0.7410959	0.8693925	0.93559676	0.96815549	0.98422693	0.99544047	0.998448496
	Comp.8	Comp.9	Comp.10	Comp.11	Comp.12		
Standard deviation	0.1034101433	0.0690065859	0.0459995258	2.809488e-02	1.603742e-02		
Proportion of Variance	0.0008911381	0.0003968257	0.0001763297	6.577688e-05	2.143324e-05		
Cumulative Proportion	0.9993396344	0.9997364602	0.9999127899	9.999786e-01	1.000000e+00		

Figure 33:The principal components number and total variance

PCA are derived from a correlation matrix, which yields 2 prominent components, PC1 and PC2, when combined, account for 87% of variance. This way, the 12 socio-economic

variables are mapped onto 2 uncorrelated components while retaining most of the variance.

Table 81 below provides the loading of variables according to two components that explained 87% of variance.

Factors	PC1	PC2
Oil	0.274	-0.2369
TETPB	-0.20	0.517
CLTCP	0.263	0.359
Income	0.323	0.143
NNRCB	-0.056	0.587
ESTCB	0.313	0.242
PETCD	0.322	-0.088
PERCD	0.331	0.041
NGTCD	0.307	0.132
CLTCD	0.296	-0.278
ESRCD	0.325	0.011
GDP	0.321	0.131

Table 81:Uncorrelated components loading of U.S. Energy Consumption Factors

Then we used the 2 uncorrelated components to predict the total energy consumption (see appendix for details E). Results in Appendix E show the r square has good fit of 95% and global p value is significant.

For prediction: $Y_{t+1} = 86.75 + 2.95PC1_{t+1} + 4.218PC2_{t+1}$;

In this regard, we measured the model accuracy by using the Average Absolute Percentage Error criteria.

$$MAPE = 100 * \left(\frac{\sum_{i=1}^N \frac{|Actual - Forecast|}{|Actual|}}{N} \right) \quad \text{Equation 4.3}$$

Table 82 below shows the Mean Absolute Percentage Error criteria MAPE. We noticed the residual error from PCA prediction model accounts 2.75%.

Year	Actual Y	prediction	Absolute error	MAP
2008	98.82495	104.25138	5.42643	0.05491
2009	94.02275	96.40825	2.3855	0.025372
2010	97.6077	98.28274	0.67504	0.006916
2011	96.9488	97.12787	0.17907	0.001847
2012	94.47746	89.11316	5.3643	0.056779
2013	97.21844	98.06068	0.84224	0.008663
2014	98.38127	101.40243	3.02116	0.030709
2015	97.48356	94.07301	3.41055	0.034986
<i>MAPE</i>				2.752257%

Table 82: Absolute Percentage Error criteria MAPE

4.4. Results of Hypothesis Four

In this section, we address the results regarding of hypothesis 4.

Null hypothesis (H_0):

There are not complicated natures of economic/social context at the state level; the states do not share similar energy and socio-economic pattern.

Alternate hypothesis (H_1):

There are complicated natures of economic/social context at the state level; most states tend to share similar energy and socio-economic patterns

To identify economic/social context at the state level and cluster and separate the states into subgroups States within the same cluster are considered homogenous at the macroeconomic and energy consumption level.

4.4.1. Clustering

One focus of our clustering analysis is to determine the appropriate number of clusters (N).

In the first trial, we have used elbow method by plotting the total within-cluster sum of squares of N=1 to 15(see below Figure 34).

Figure 34:Elbow Plot

N=2 is the critical elbow location point, based on the above plot (below Figure 35).

Visual checking the elbow points has been a common practice in K-average s clustering. But to further confirm our preliminary choice of N=2, we have applied the Silhouette method to optimize our selection of cluster number. A high average silhouette width has proven to be a reliable indicator of good clustering. As shown in figure 35 below, N=2 reaches the climax of average silhouette width when N ranges from 1 to 10. This corresponds very well with the elbow method. The convergence between Silhouette and elbow method has provided us solid ground conclude that there exist 2 clusters in the state-by-state dataset.

Figure 35: optimize our selection of cluster number

To be more specific, cluster 1 consists of 18 states, including Rhode Island, Vermont, Nevada, Massachusetts, Oregon, Delaware, North Carolina, Maine, Idaho, Missouri, Wisconsin, Georgia, Michigan, Washington, Minnesota, Tennessee, Iowa, South Dakota, and Nebraska. In contrast, cluster 2 includes only 3 states: New York, Florida, and California. Below Figure 36 maps the two clustering and specify and names the states according to two clusters.

Figure 36:Clustering

According to Clatworthy et al. (2005); Jain, A, Murty, M, and Flynn, (1999), clustering techniques are used as typical data abstraction and compacted description of each cluster. In this regard, we provided table 83 & 84 below to show univariate descriptive analysis for cluster 1 and cluster 2 respectively.

Descriptive analysis of Cluster 1

Factors	Min.	Median	Average	SD	Max.
TETPB	209.5	324.4	321.2211	49.45922	382.6
TERPB	58.85	76.35	75.66316	5.937407	83.76
FFTCB	85086	1000805	1143178	952816	3112838
CLTCP	23.48	8978	12494.68	11715.22	34611
Income	18872	21666	22303.21	2533.525	28339

NGTCP	6642	211718	264244.5	254699.1	962686
NNRCB	971.2	54900	88586.43	106132.4	375121
ESTCB	15836	150707	170806.8	123823.4	426688
ESRCB	6226	53595	59379.53	43110.35	133439
PETCD	5.024	6.16	6.437737	1.036983	8.225
PERCD	6.057	7.289	7.726	1.205514	10.064
NGTCD	4.105	5.236	5.372632	0.842315	7.61
CLTCD	0.9254	1.505	1.627021	0.401786	2.507
ESTCD	11.28	17.36	18.48642	4.971505	29.5
ESRCD	13.538	20.74	21.90279	5.732335	35.2
GDP	13994	134870	137038.1	141285.6	632640

Table 83:descriptive analysis of Cluster 1

Descriptive analysis of Cluster 2

Factors	Min.	Median	Average	SD	Max.
TETPB	209.5	238.6	230.3	18.13532	242.8
TERPB	45.87	58.85	55.95	8.988014	63.13
FFTCB	2683087	3112838	3778148	1539594	5538518
CLTCP	2649	11508	11527	8887.515	20424
Income	22615	25268	25011.67	2279.336	27152
NGTCP	563084	962686	1203404	788727.7	2084442
NNRCB	16139	375121	308436.3	265316.5	534049
ESTCB	426688	517256	550678	143647.3	708090
ESRCB	133439	229306	208105.7	66645.38	261572
PETCD	6	6.868	6.882	0.889083	7.778
PERCD	6.553	8.762	8.848333	2.339695	11.23

NGTCD	3.982	4.723	4.917667	1.046666	6.048
CLTCD	1.87	1.936	1.914667	0.038695	1.938
ESTCD	20.69	25.54	25.24333	4.412486	29.5
ESRCD	22.62	28.3	28.70667	6.299852	35.2
GDP	367277	632640	670691.7	324120.1	1012158

Table 84:descriptive analysis of Cluster 2

4.5. Results of Hypothesis Five

In this section, we addressed the results regarding of hypothesis 5 to answer which factor influencing the behavioral intention among green energy consumers. Thus, we address four hypothesizes to identify the existing unobserved latent factors that explain the consumers' intention and how frequently the consumers will perform their behavior. These are vital factors influencing the behavioral intentions of green-energy consumers.

Null hypothesis, H_0 – Factor i (see table 85 below) does not positively related to use renewable energy for home electricity

Alternative hypothesis, H_1 - Factor i does positively related to use renewable energy for homes electricity

Table 85 below shows the factors

Factor i	Factors names
1	Attitude towards the behavior
2	Subjective norm
3	Perceived control behavior
4	Willingness to Pay
5	Independent factors of income, and gender

Table 85:Factors list for hypothesis 5

4.5.1. Research Objectives

The objective of this part of study is to understand and identify the factors influencing a consumer's behavioral intention to use renewable electricity in 22 states of the U. S. Specifically, this study sets out to investigate the following three research objectives: First, understand the consumer's behavioral intention to use renewable electricity in 22 states the U.S.; Second, identify the important factors and how these factors contribute to the consumer's behavioral intention to use renewable energy in 22 states of the U.S. Third,

investigate the impact of an individual's average household income on their intention to use renewable energy based on the Theory of Planned Behavior (TPB).

4.5.2. Proposed Frame Work

We addressed three models to identify the existing unobserved latent factors that explain the consumer's intention and how often the consumers will perform their behavior. We use three models, which are detailed below, to reduce the complexity of the TPB. It is also important to note that constructs were gradually added into the TPB model in two steps.

4.5.2.1 Hypothesis Testing: Model 1 TPB and Model 2 : Extended TPB

The first model is considered as the main TPB, which includes the three latent factors: consumer's attitude, subjective norms, and perceived behavior control tests. These factors will determine if they positively influence a consumer's intention to use renewable electricity in the U.S. In the second model, the *Willingness to Pay* construct was added to extend the TPB model. The four proposed hypotheses are listed in Table 86.

ID	Hypotheses
H1	Attitude of TPB and Extended TPB models positively affects Intention
H2	subjective norms of TPB and Extended TPB models positively affects Intention
H3	Perceived control behavior of TPB and Extended TPB positively affects Intention
H4	Willingness to pay of Extended TPB model positively affects Intention

Table 86:Hypotheses Model 1: TPB and Mode 2: Extended TPB

Based on the hypotheses, Figure 37 below not only illustrates the proposed paths of the TPB but also extends the TPB model hypotheses.

Figure 37: The Extended TPB model

4.5.2.2 Hypothesis Testing Model 3: Extended TPB with individual average income

To assess a consumer's intention to use renewable energy, the Extended TPB model was developed in this study to include the individual average household income, the reason being we wanted to take into account the Model 2: Extended TPB constructs. The nine proposed hypotheses from Model 3 are listed in Table 87.

ID	Hypotheses
H1	Individual income positively affects Intention
H2	Individual income positively affects attitudes toward behavior
H3	Individual income positively affects subjective norms
H4	Individual income positively affects perceived behavior control
H5	Individual income positively affects willingness to pay
H6	Attitudes toward behavior positively affects intention
H7	Subjective norms positively affects intention
H8	Perceived behavior control positively affects intention

H9	Willingness to pay positively affects intention
----	---

Table 87:Hypotheses Model 3: Extended TPB with individual average household income

Figure 38:The Extended TPB model with individual average household income

Based on the hypotheses, Figure 38 above illustrates the proposed paths of the Extended TPB with individual average income hypotheses.

The proposed constructs were measured with multiple items which were adapted from existing studies. The items were randomized to minimize question order bias and improve overall data quality. Through the use of a Survey Monkey online questionnaire, all of the items used a 5 point Likert scale that had been validated in previous research studies (Chan 2001; Hartmann and Apaolaza-Ibáñez 2012; Paul et al. 2016). Table 88 presents the study constructs with measurement items.

Construct	Items	Item statement	References
Attitude toward using renewable energy	ATT1	Using renewable energy is a good idea to supply my home's electricity	(Francis et al. 2004; Yazdanpanah, Komendantova, and Ardestani 2015)
	ATT2	I like the idea of using renewable energy for my home's electricity	
	ATT3	I have a positive attitude toward using renewable energy instead conventional energy for my home's electricity	
	ATT4	Using renewable energy helps prevent global warming	
	ATT5	Using renewable energy helps to reduce dependence on imported fuels	
	ATT6	Using renewable energy could help meet the social, economic and other needs of present and future generations	
Subjective norms	SN1	Most people who are important to me would like to use renewable energy for their home's electricity	(Cheon et al. 2012; Francis et al. 2004; Paul et al. 2016; Yazdanpanah, Komendantova, and Ardestani 2015)
	SN2	I think other friends in my community would be willing to use renewable energy for their home's electricity	
	SN3	People whose opinions I value would favor and support the use of renewable energy for their home's electricity	
Perceived behavioral control	PB1	I believe I can use renewable energy for my home's electricity	(Cheon et al. 2012; Francis et al. 2004; Paul et al. 2016; Yazdanpanah, Komendantova, and Ardestani 2015)
	PB2	If it were exclusively up to me, I would use renewable energy for my home's electricity	
	PB3	If I wanted to, I could easily use renewable energy for my home's electricity	
Willingness to pay	WTP1	I would be able to spend extra money to use renewable energy	(Bang, H., Ellinger, A.E., Hadjimarcou, J. and Traichal, P.A. 2000)
	WTP2	I am willing to pay more to use renewable energy	
	WTP3	It is OK to pay more to support and use renewable energy	

Intention to use renewable energy	IN1	I plan to use renewable energy resources rather than conventional energy for my home's electricity	(Paul et al. 2016)
	IN2	I definitely want to use renewable energy for home electricity in the near future	
	IN3	I intend to switch the source of my electricity supply from conventional energy to renewable energy	
	IN4	I expect to use renewable energy for my home's electricity in the near future	

Table 88:Study constructs with measurement items

4.5.3. Methodology

The sample target in this study is the residential sector in the United States. Various combinations of demographic and socioeconomic variables will be considered in this study. The survey was administered through Survey Monkey (Online survey) which is a private company that enables users to create their own Web-based surveys. The eligible participants in this study are people living in the United States in the residential sector. Participants signed an informed consent form for the study, as approved by the Institutional Review Board (IRB) at the University of Rhode Island. Approval were received from the Institutional Review Broad Governance and Operating Policies (IRB) at the University of Rhode Island to conduct this survey. The IRB requested the survey aims, design, sample and other details to investigate and to be responsible for the highest ethical standards and ensure that all research met the federal regulations, policies, and procedures. An online survey was used to collect responses from randomly chosen participants in the residential households in the 22 states.

4.5.3.1 Sample size

The sample size was determined based on the number of items in the survey. According to Paul R. Pintrich, David A. F. Smith, and Teresa Garcia, W. J. M.(Paul R. Pintrich, David

A. F. Smith, Teresa Garcia 1993) ,there is a desirable level of 15 to 20 observations per studied variable. However, structural equation modeling recommends at least 400 respondents (A. Boomsma 1988; Paul et al. 2015) . Harlow (2014), asserted the structural equation modeling analysis needs at least 200 to 400 respondents or more. It is desirable to have a minimum of three variables for each component and the sample size should be large enough to have and obtain reliable results. The responses should be five times the number of items in the questionnaire (for example a 50 item questionnaire needs at least 250 responses (50*5) (O'Rourke 2013). According to Paul, Modi, and Patel (Paul et al. 2016), there is a desirable level of 15 to 20 observations per studied variable. Thus, our study will have 18 variables, but the theory of planned behavior has three main dimensions therefore it will have 6 items for attitude towards renewable electricity, 3 items for subjective norm, 3 items for perceived behavioral control, willingness to pay, 3 items and 4 items for intention. Using these 19 items average s that 380 respondents (19*20) are needed for the sample size.

The target sample of this study was residential consumers in 22 states in the United States. The stratified sampling strategy was used to divide the study target sample into subgroups based on the 22 states' population using the Survey Monkey website. Figure 39 shows the maps of stratified sampling into subgroups based on the 22 states' population using the Survey Monkey website by state.

Country: United States

Region: California, Delaware, Florida, Georgia, Idaho, Iowa, Maine, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, Nevada, New York, North Carolina, Oregon, Rhode Island, South Dakota, Tennessee, Vermont, Washington, Wisconsin

Figure 39: The maps of stratified sampling by state (SurveyMonkey)

4.5.4. Results

4.5.4.1 Descriptive Analysis on the Responses

Of a total of 802 responses, 770 agree to participate in this study (96.01% response rate) and 32 declined (3.99%). When questioned about gender and age, 762 participants responded, and 40 participants skipped these questions. 435 participants were female (57.09%), and 327 participants were men (42.91%). Broken down by regional groups, the participants 215 (28.22%) Pacific, 171 (22.44%) South Atlantic, 94 (12.34%) Middle Atlantic, 82 (10.76%) East North Central, 79 (10.37%) West North Central, 52 (6.82%) New England, 17 (2.23%) Mountain, and 5 (0.66%) West South Central. Table 89 summarizes the demographic characteristics of the sample. An online survey data summary is found in Appendix H.

Items	Classification	Sample amount	Percentage
Agree to participate	Yes	770	96.01%
	No	32	3.99%
Gender	Female	435	42.91%
	Male	327	57.09%
Age	18-29	224	29.40%
	30-44	180	23.62%
	45-60	216	28.35%
	> 60	142	18.64%
Average Household Income	\$0-\$9,999	57	7.48%
	\$10,000-\$24,999	91	11.94%
	\$25,000-\$49,99	130	17.06%
	\$50,000-\$74,999	170	22.31%
	\$75,000-\$99,999	100	13.12%
	\$100,000-\$124,999	73	9.58%
	\$125,000-\$149,999	37	4.86%
	\$150,000-\$174,999	21	2.76%
	\$175,000-\$199,999	12	1.57%
	\$200,000+	17	2.23%
	Prefer not to answer	54	7.09%

Table 89:Descriptive statistics of raw data

4.5.4.2. Reliability and construct validity

To measure the internal consistency of the items in the questionnaire, Cronbach's alpha was used for the four latent constructs to assess each subscale, and the higher the coefficient, the higher the indication that the scale is reliable. Cronbach's alpha will be used to measure the internal consistency of the items in the questionnaire for each subscale (Suhr and Ph n.d.). Yazdanpanah, Komendantova, and Sha (2015) recommended a good-

to-excellent scale of reliability between 0.6 to 0.9. Per the Cronbach's alpha, there was internal consistency for the six measurement for the six measurement constructs. Table 90 below shows Composite Cronbach's alpha value for all constructs ranging from 0.6 to 0.84. There are two levels to test and determine the measurement scale that can examine the study constructs. According to Campbell et al. (Campbell et al. 1959), the two levels to test the measurement scale are convergent and discriminant validity. The Average Variance Extracted (AVE) of constructs is commonly used to examine the convergent validity of the measurement scales. Fornell and Larcker (Fornell and Larcker 2006) recommended that the Average Variance Extracted (AVE) for each construct should be 0.5 or higher.

The discriminant validity test, which refers the measurement scales, should be not related. According to M. Chen and Tung (2014); Yadav and Pathak (2017), discriminant validity refers to the Average Variance Extracted (AVE) for each construct that should exceed the square root of the correlation value of each construct. Table 77 provides the details of the convergent validity and discriminant validity. Table 77 shows that the Variance Average Extracted (VAE) was examined on all constructs greater than 0.5 except two constructs slightly lower than 0.5, the perceived behavioral control and the intention to use renewable energy reveals 0.446, and 0.474 respectively. Table 90 shows that the discriminant validity of each of the Average Variance Extracted (VAE) exceeded the square root of the correlation value of each construct.

Construct	Indicator	Item to total items correlation	Composite Cronbach's alpha value	Standardized factor loading	Average Variance Extracted
Attitude toward using	ATT1	0.463		0.717	
	ATT2	0.299 (delete)			

renewable energy	ATT3	0.54	0.81	0.672	0.521
	ATT4	0.46		0.713	
	ATT5	0.289 (delete)			
	ATT6	0.490		0.783	
Subjective norms	SN1	0.131(delete)	0.68		0.525
	SN2	0.378		0.655	
	SN3	0.421		0.789	
Perceived behavioral control	PB1	0.56	0.6	0.636	0.446
	PB2	0.322		0.699	
	PB3	0.357 (delete)			
Willingness to pay	WTP1	0.637	0.82	0.730	0.612
	WTP2	0.718		0.830	
	WTP3	0.672		0.784	
Intention to use renewable energy	IN1	0.6249	0.84	0.861	0.474
	IN2	-0.0029 (delete)			
	IN3	0.579		0.826	
	IN4	0.521		0.724	

Table 90:Constructs Validity

4.5.4.3. Univariate Analysis

The sample data, excluding the missing data, were independent with normality, linearity, and homoscedasticity. Table 91 provides a univariate analysis for all measurement items. All measurements met the skewness value, which should be less than 1 in the absolute value, and the kurtosis, which should be less than 2 in the absolute value. In addition, the largest standardized residuals were checked and all measurement items were no greater than 0.2 in the absolute value (Harlow 2014).

Items	Average	Standard Deviation	Skewness	Kurtosis
ATT1	4.05	0.89	-0.93	0.89
ATT3	4.09	0.89	-0.94	0.87
ATT4	3.95	1.02	-0.83	0.19
ATT6	4.09	0.92	-0.98	0.79
SN2	3.79	0.92	-0.57	0.18
SN3	3.84	0.92	-0.5	-0.06
PB1	3.65	0.98	-0.43	-0.31
PB2	3.02	1.13	0.14	-0.8
WTP1	3.11	1.12	-0.08	-0.76
WTP2	3.16	1.14	-0.12	-0.87
WTP3	3.34	1.13	-0.25	-0.78
EC1	3.95	0.95	-0.83	0.19
EC2	4.09	0.88	-0.86	0.72
IN1	3.5	0.98	-0.14	-0.55
IN3	3.36	0.99	-0.08	-0.45
IN4	3.48	1.04	-0.22	-0.7

Table 91:Descriptive analysis of variables

4.5.4.5. Measurement Model

The Structural Equation Modeling (SEM) evaluates the measurement model (Macro fit indices) and the estimation of the structural coefficient (path model as Micro fit indices) at the same time As suggested by Harlow (2014), we have to conduct two sets of tests, the macro level and the micro level test. Indices of macro level, including the χ^2 test, measure the differences between the expected and observed covariance matrices (Miller 1995; Suhr

2008). The CFI is equal to the discrepancy function adjusted for sample size, and Root Average Square Error of Approximation measures the residual error in the model. The χ^2 should be close to zero (Harlow 2014). The CFI should be 0.90 or greater. The RMSEA should be less than 0.06, which is the acceptable model fit (Suhr 2006; Yazdanpanah, Komendantova, and Ardestani 2015); (Liao, Chen, and Yen 2007b). According to Browne, M.W., and Cudeck (1993), RMSEA should have a range from 0.05 to 0.08 to 0.1; these values should be considered as good, fair and acceptable fit, respectively.

The table 92 below shows the Measurement Model (Macro fit indices) and critical value for each index.

Indices	Critical value	References
Reliability of the scale (Cronbach's) alpha	A good-to excellent for all scales of reliability 0.6 to 0.9	(Yazdanpanah, Komendantova, and Ardestani 2015)
Chi-square normalized by degrees of freedom	less than 5	(Paul R. Pintrich, David A. F. Smith, Teresa Garcia 1993; Yazdanpanah, Komendantova, and Ardestani 2015) (Bentler 2006)
The Comparative Fit Index (CFI)	Acceptable model fit is indicated by a CFI value of 0.90 or greater	(Suhr 2006; Yazdanpanah, Komendantova, and Ardestani 2015) (Liao et al. 2007b)
Root Average Square Error of Approximation (RMSEA)	Range from 0.05 to 0.08 to 0.1; these values should be considered as good, fair and acceptable fit.	(Liao et al. 2007b), (Browne and Cudeck 1993)

Table 92:Macro fit indices

4.5.4.6. Micro Fit

An adequate measurement model uses structural equation modeling (Path Analysis) to assess the relationship between the latent variables (Hartmann and Apaolaza-Ibáñez 2012). The Path analysis reveals that a significant positive or negative influence of the path analysis with the standardized regression coefficients. Harlow (2014) offers two guidelines regarding the micro-level fit interpretation: (1) determine the significance of constructs parameter by estimating the z value at p-value <0.05, and (2) the standardized loadings should be calculated. With the p-values, statistical conclusion is assessed by testing the null hypothesis for each path coefficient. The path model (Micro fit) of regression coefficients is displayed as Beta (Regression coefficients among latent constructs), and Gamma (Regression coefficients among independent variable and latent constructs) (Harlow 2014; Heath et al. 1989; Iacobucci 2009). Crooks and Chen (2011) recommended the standardized loadings, which gauge the magnitude of a relationship between variables, and the values should be 0.5, 0.3, and 0.1. Respectively, these values should be considered as large, medium and small loadings

4.5.4.7. Macro fit: the TPB and Extended TPB

Table 93 presents all macro fit indices for both models in this study. It suggested both models have adequate fit indices for the empirical data.

Model	X^2	df	X^2/df	P value of X^2	CFI	RMSEA	90% CI, RMSEA
TPB	118.28	38	3.11	0	0.977	0.054	[0.043,0.065]
Extended TPB	248.17	67	3.704	0	0.962	0.061	[0.053,0.069]

Table 93:Models' evaluation overall fit measurements.

4.5.4.8. Micro fit of the TPB

In the micro level of original TPB, the results indicate that attitude toward the behavior in H1 is not statistically significant ($\beta = 0.043$ p-value = 0.677) but the subjective norms in H2 ($\beta = 0.259$, p-value = 0.018), and perceived behavior control in H3 ($\beta = 0.713$, p-value < 0.01) are statistically significant. The R^2 indicates that 86% of variance could be explained by the original TPB for the intention to use renewable energy in residential sector in the US. In the TPB model, we found the perceived behavior control identified as the most important construct factor of the intention, followed by subjective norms. Remarkably, we found the attitude toward the behavior is not statistically significant to capture the intention to use renewable energy.

4.5.4.9. Micro fit of the Extended TPB

In the micro level of extended TPB, the results indicate that: attitude toward the behavior in H1 is not statistically significant ($\beta = 0.011$, p-value = 0.913), but the subjective norms in H2 ($\beta = 0.228$, p-value = 0.037), perceived behavior control in H3 ($\beta = 0.699$, p-value < 0.01), and willingness to pay in H4 ($\beta = 0.105$, p-value = 0.028) is statistically significant. The R^2 indicates that 87% variance could be explained by the extended TPB for the intention to use renewable energy on residential sector in the USA.

In the Extended TPB model, we found that the perceived behavior control is consistently identified by the TPB model as the most important construct factor of the intention, followed by subjective norms then willingness to pay but the attitude toward the behavior in the Extended TPB is not statistically significant to capture the intention to use renewable energy.

4.5.5. Model Comparisons

There are several indices used to assess the best model fitting such as the Akaike Information Criterion (AIC), the Consistent AIC (CAIC), or BIC to assess the models (Harlow 2014). In this study, we use AIC to assess the best fitting model regarding smaller AIC value (Schermerle-Engel, Moosbrugger, and Müller 2003). The AIC value shows that the TPB (24434.81) has slightly smaller AIC value than extended TPB (25118.37). However, we considered to assess the TPB and extended TPB constructs with individual household income. Both TPB and extended TPB were assessed since both models have adequately macro fit indices. Moreover, the extended TPB model identifies the willingness to pay has a positive influence to intention to use renewable energy. Therefore, we involve both models to explore the individual household income to see whether the model is likely to behave similarly in different latent construct.

4.5.6. Model 3: Extended TPB with Individual household income

Research investigating public acceptance focused on the correlation of socioeconomic characteristics of average household income, age, gender, and education (Stigka et al. 2014). Therefore, the proposed model is the preferred hypothesized model that posits from individual average income to the four latent (attitudes toward behavior, subjective norms, perceived behavior control, and willingness to pay) to the consumer intention. The paths for this model are shown with solid lines in Figure 39. In addition, this model included the direct path coefficient from individual average household income to the consumer intention.

4.5.7. Macro fit: extended TPB with individual household income

Table 94 shows the set of macro fit indices for both models. The macro fit indices for both models did not provide a good fit to the data. The χ^2 values for the model was very large,

more than five times of the degree of freedom for each model. The CFI values were less than 0.9, and RMSEA values were over 0.1. Harlow (2014) suggests that even though the macro fit indices did not provide a good fit to the data, it is useful to examine the micro fit level aspects.

Model	χ^2	df	Scaled χ^2/df	χ^2 prob	CFI	RMSEA	90%CI
Extended TPB	1126.6	82	13.73	0	0.779	0.132	[0.125,0.139]

Table 94:Model evaluation overall fit measurements.

In the micro level of extended TPB, the results indicated that H1: the path from the individual household income to the intention to use renewable energy, is not significant (Gamma = -0.052, p-value =0.148), and individual household income in H4 → perceived behavior control (Gamma = 0.046, p-value =0.324). However, the extended the TPB model has three direct paths related to H2, H3, and H5 which are all supported (H2: individual household income → attitude toward the behavior: Gamma = 0.107, p-value = 0.009; H3: individual household income → subjective norms: Gamma = 0.152, p-value < 0.01; H5: individual household income → willingness to pay: Gamma = 0.109, p-value = 0.007) are statistically significant. The result from H6: attitude toward the behavior is statistically significant (β =0.282, p-value <0.01), as well as toward H7: subjective norms (β = 0.310, p-value < 0.01), H8: perceived behavior control (β = 0.766, p-value <0.01), and H9: willingness to pay (β = 0.225, p-value <0.01). Moreover, the extended TPB (individual household average income model) has four indirect paths via associated extended construct of TPB. Table 72 shows the results of indirect paths of the micro fit indices that revealed

the standardized path coefficients indicate the strengths of relationships between the variables.

The indirect path of income to perceived behavior control construct is not statistically significant (Gamma = -0.052, p-value =0.148). R^2 indicates that approximately 81% of the variance in intention to use renewable energy can be explained by this model. In the micro level, H1, H2, H3, H4, H5, H6, H7, H8, and H9 were tested. All the mentioned hypothesizes are supported except H1, and H4. (see Table 95 below).

Path	Z value	P value	Indirect effect via associated Original TPB	Relationship
H2: Income To attitude toward the behavior To intention	2.483	0.013	0.030	Supported
H3: Income To subjective norms To intention	3.104	0.002	0.047	Supported
H4: Income To perceived behavior control	0.984	0.325	0.035	Not Supported
H5: Income To willingness to pay To intention	2.489	0.013	0.025	Supported

Table 95:Models' evaluation of indirect paths.

Chapter 5. Discussion

The aim of chapter 5 is to demonstrate and discuss the important findings that influence renewable energy consumption among 22 states. This chapter provides sequential sections. More details are involved in this chapter, along with five sections that reflected the study hypotheses proposed in chapter 3. Section one seeks to discuss this study approach, known as VAR Granger Causality results. More details discuss the factors that could impact renewable energy consumption based on the national level (aggregate level) as well as state levels (disaggregate level). Furthermore, section one discusses the results of the Forecast Error Variance Decomposition (FEVD) and discusses the integrated approach of Exploratory Factor Analysis (EFA) to explain renewable energy consumption in each state. The second section explains the findings of hypothesis 2 that investigates the impact of total fossil fuel consumption and renewable energy consumption on the low and high emission levels among 22 states. The third section demonstrates the results that show the combined multiple regression analysis and Principal Components Analysis (PCA) to feed and improve the prediction and model accuracy, for the purpose of predicting the total energy consumption in the USA. Furthermore, we seek to validate the PCA results by the ARIMA. Meanwhile, section four determined which states tend to share similar energy the most as well as socioeconomic patterns, as evidenced by clustering techniques. The fifth section revives the social aspect which included a questionnaire that conducted results of Theory of Planned Behavior (TPB) to determine what factors are influencing the behavioral intention among green energy consumers of renewable energy in the residential sector in 22 states. As a reminder, we first addressed and demonstrated each study objective that was proposed in chapter 1, section 1.5. and reflected on the results according to

previous studies findings that were conducted in chapter 2 (from section 2.4 to section 2.7) and, additionally, we discussed our findings that could provide a robust methodology and framework to estimate the impacts of these factors on renewable energy consumption that was restated in chapter 2 (section 2.8).

5.1. Discussion of Hypothesis One

Specifically, section one provides seven subsections to demonstrate and address our analysis approach that represented and confirmed that we don't have stable renewable energy growth as well as heterogeneous renewable energy growth among 22 states

Therefore, the first subsection discussed the stability of renewable energy growth among 22 states and reflected on the descriptive results with a statistical approach to test and examine the growth of renewable energy consumption that was conducted in chapter 4 (section 4.1.1.1). Then, we discussed VAR with regards to the asymmetric lags and not the symmetric lags approach in subsection 3 that was conducted in chapter 4 (section 4.1.2.1). The fourth subsection discussed the comparisons between Asymmetric lag and not symmetric lag. Then, we discussed the impact of regional and spatial economic analysis regarding the VAR in subsections five and six. Finally, we discussed the results of Exploratory Factor Analysis (EFA) that was conducted in chapter 4 (section 4.1.2.1 to section 4.1.2.17).

5.1.1. Test Stability of Growth

The result findings demonstrated that according to the mean growth and absolute mean growth, much variability existed. We found IA has the maximum mean growth rate (10.03%). In contrast, NY has a minimum mean growth rate (0.74%). In this regard, our study created and introduced an approach to test and examine the stability of growth over

time among 22 states in chapter 4 (section 4.1.1) which was rejected by the null hypothesis of stable growth.

5.1.2. Discuss the Use of Bivariate VAR not the Panel VAR model

In this subsection, we have to put into our account the regional and spatial economic analysis which there is little attention paid to the impact of regional and spatial economic analysis regarding the VAR approach (Giacinto 2010). According to Sharmin and Khan (2016), the specific heterogeneity of counties can lead to conflict and create dissimilar findings and definitions of the variables concerned. Huang et al. (2007) asserts, "If we pool every country's data together as a whole, the statistical testing power of estimation is greatly enhanced, but the heterogeneity among countries is neglected."

Thus, in line with the reasons of this study, we should consider using the bivariate VAR approach to identify factors that influence renewable energy consumption and determine the key factors that have an influence on renewable energy consumption among 22 states to capture the heterogeneities related to renewable energy consumption growth among 22 states.

5.1.3. Discuss the Use of Asymmetric Lag and Not Symmetric Lag

In this subsection, we are probing more deeply to recognize the results based on Lag Length Selection in Bivariate VAR Models that could provide rigorous procedures. Thus, we have looked at two approaches of the bivariate VAR to examine the Granger causality test among 22 states. In approach 1, we were using symmetric lags that have the same lag length for all variables. In the second approach, we proposed for consideration the causality results from estimating the bivariate VAR model regarding

the optimal number of lags on the renewable energy consumption in terms of the exogenous variables.

The subsection below demonstrated the results of Granger Causality for both approaches to examine the relationship between renewable energy consumption and average oil prices among 22 states by using symmetric lags and asymmetric lags that was conducted in chapter 4 (section 4.1.2.1). We clearly notice the annual global oil price average, not the Granger, impacts the renewable energy consumption in 22 states, except in NE. In approach 2, the Asymmetric Bivariate VAR that use optimal lags selection shows that the annual global oil price average Granger impacts the renewable energy consumption significance at p value 5%, and 10% in 12 states.

5.1.4. Finding Results related to Comparison between Asymmetric Lag and Not Symmetric Lag

According to the Symmetric Bivariate VAR approach, our findings show the results to examine the impact of average oil prices on renewable energy consumption among 22 states, and we found average oil prices had a significant impact on renewable energy consumption only in NE. However, we also considered the asymmetric lag approaches to examine average oil prices on renewable energy consumption among 22 states; the results show the oil had an impact in 12 states. According to Ozcicek and Mcmillin (2010), “Most VAR models are estimated using symmetric lags, i.e. the same lag length is used for all variables in all equations of the model. This lag length is frequently selected using an explicit statistical criterion such as the AIC or SIC. Symmetric lag VAR models are easily estimated”. Thus, we should use and estimate the variables by using asymmetric lag VAR models. In fact, our findings show the results are sensitive to the region and the lag length selection could differ across states and factors. Thus, we selected approach 2 to have an

optimal lag selection; R software provides set criteria by the following: “Schwarz information criteria, Akaike’s information criterion (AIC), Schwarz’s information criterion (SIC), and Phillips’ posterior information criterion (PIC).” In addition, the relationship between economic growth and energy consumption is classified into four hypotheses: growth hypothesis, feedback hypothesis (bidirectional causality), conservation hypothesis (unidirectional, directional) and neutrality.

This subsection seeks to discuss the study framework which is broken down into sublevels to explain what factors can impact renewable energy consumption at the national level, and at the state level that was proposed in chapter 1 (section 1.8). This approach can help policymakers to design and manage uncertainty in a complex energy context to identify factors that impact renewable energy consumption. In addition, this framework breaks down factors to the sublevel. For example, total energy consumption per capita and total energy consumption per capita in the residential sector. We used the topology in the figure in Appendix I to illustrate the study approach to identify factors that could show a contribution for renewable energy consumption growth among 22 states. Thus, the figure in Appendix I is used to illustrate the steps in an exam process for factors that were proposed in chapter 3. Then, the second step discusses the results that investigated the influencing factors on renewable energy consumption at the national level first and then at the state level.

5.1.5. National Level

The aim of this subsection is to discuss our study approach which demonstrates the Granger Causality test techniques between renewable energy consumption and 17 factors, according to the aggregate level (national level) that was proposed in chapter 1 (section

1.8). Our findings show most of the factors from the Granger causality test show no statistically significant impact on renewable energy consumption in the USA that was conducted in chapter 4 section (see appendix C).

Payne (2009), investigated the relationship between renewable energy and real GDP in the USA from 1949 to 2006. Payne declared there was “not a Granger causality impact between them”. In addition, according to Yildirim, Sarac, and Aslan (2012) who studied US energy from 1949 to 2010 , “unidirectional causality exists between GDP growth and total renewable energy (Yildirim et al. 2012)”.

In this regard, “Most of the related research utilizes aggregate data which may not indicate the relative strength or explanatory power of various energy inputs on output (Ewing, Sari, and Soytas 2007).”

In addition, “In an attempt to provide reasons for the disparate and often conflicting empirical findings on the relationship between energy consumption and economic growth, Asafu-Adjaye (2000) blamed it on the variety of approaches and testing procedures employed in the analyses. According to him, several studies employed simple loglinear models estimated by ordinary least squares without any regard for the nature of the time series properties of the variables involved (Osigwe and Arawomo 2015)”.

In this respect, this study used a disaggregate approach (Top-Down Approach) based on a state and other factors level (for example Electricity average price, all sectors ESTCD and Electricity price in the residential sector ESRD) to contribute in-depth analysis regarding of spatial level and disaggregate of factors level. This approach could help avoid variability among states and heterogeneity of factors such as consumptions pattern.

5.1.6. States Level

In this subsection, we discuss the results regarding the examination of the 17 factors for each state to clarify our top-down approach, which takes into account three principles, (1) national level, (2) state level and (3) other factors broken down that were analyzed in chapter 4 (from section 4.1.2.1 to 4.1.2.17) . In addition, we break down the 17 factors into three aspects that were proposed in chapter 1 section 1.7.

5.1.6.1 Aspect one

The first aspect demonstrates and discusses the findings of the macroeconomic factors (GDP and income per capita) .

5.1.6.1.1. Gross Domestic Product (GDP)

We demonstrated and reviewed many studies that investigated the relationship between energy sources and economic activities. In chapter 2, many literature reviews have considered the macroeconomic factors that play a significant role in order to enhance and increase energy consumption were discussed. “Sarac and Aslan (2012) studied US energy from 1949 to 2010 for total renewable energy, 1960 to 2010 for geothermal energy, and 1970 to 2010 for biomass energy consumption (Yildirim et al. 2012)”. This study found no causal relationships between all types of renewable energy except biomass. However, this study only considered the national level, it did not consider the state level.

Therefore, our study’s contribution seeks to investigate the relationship between total renewable energy consumption and GDP in 22 states. This subsection has discussed the results that examined the relationship between GDP and total renewable energy consumption in 22 states over a 45-year span from 1970 through 2015. We found the GDP factor had a significant impact on the total renewable energy consumption in 40.91% of

the 22 states. In addition, our findings demonstrate the significant impact of GDP is due to the average GDP classification. Therefore, we classified the states into low average GDP states and high average GDP states (level 0: low GDP; level 1: high GDP). In the category of low average GDP states, we found 15 states fell into this category. Their range of average GDP was from 13994 to 176124 million in current dollars, an average of 75386.67 million in current dollars, and with a standard deviation of 55278.76 million in current dollars.

In the low average GDP states category, we found in 46.66% of states that their GDP had no Granger significant impact on renewable energy consumption. Although, we did find in the second category (high average GDP states), we found 7 states fell into this category, and the average equaled 411243.6 million in current dollars, and the standard deviation equaled 306673.7 million in current dollars). We found in 28.57% of this high average level of GDP that there was no statistically significant impact on renewable energy consumption. Generally, the relationship between economic growth and energy consumption is classified into four hypotheses: growth hypothesis, feedback hypothesis (bidirectional causality), conservation hypothesis (unidirectional, directional) and neutrality (Bloch et al. 2015). Thus, in this discussion section, we classified our findings based on the types of four hypotheses that specify the causal direction between GDP and total renewable energy consumption.

Further, we broke down the states that had a statistically Granger causality results into four hypotheses, which maintained their statistical significance into three hypotheses which include: growth hypothesis (31.818%), feedback hypothesis (9.090%), conservation hypothesis (13.636%) and neutrality (45.45%) which shows no Granger causality statistical significance.

5.1.6.1.2. Income

As we mentioned in chapter 2 section 2.61.2, there are some studies have been investigated the relationship between the energy consumption sources and some economic factorsys such as income per capital. “Several studies have been investigating the relationship between income and energy consumption. Sadorsky (2009), investigated the relationship between renewable energy consumption and income per capita between 1993 – 2003 for 18 emerging countries. This study found that income per capita has a positive impact “influence” on renewable energy consumption”. Also, we noticed there are limited studies that have investigated the relationship between income and total renewable energy consumption. Thus, our study considered examining this relationship to provide more details about how we can identify this relationship. This study classifies the states based on their income level. Thus, we investigated the two levels of states where the average of all states was 22507.5 dollars. We considered the low state average income which had average income less than or equal to 22507.5 dollars, and the high states income level had average income greater than 22507.5 dollars. We found 54.54% of the states studied fell into the low average income category, and 45.45% of states fell into the high average income category. Remarkably, we found 75% of states in the low average income category had a significant relationship between the average income per capita and renewable energy consumption. While 60% of the states which fell into the category of high average income had a significant impact between average income per capital and renewable energy consumption which shows 45.45% of states have statistically significant Granger causality. In addition, we broke this percentage down into four hypotheses, which maintained their statistical significance into three hypotheses. Our findings show a relationship between average income per capita and total renewable energy consumption is classified into four

hypotheses: growth hypothesis (40.90%), feedback hypothesis (18.18%), conservation hypothesis (9.090%) and neutrality (31.819%) which shows no Granger causality statistically significant between them. In addition, we decompose the variance of the forecast-error of GDP and income into proportions attributable to future changes of renewable energy consumption over a 12-period horizon. Remarkably, GDP in MI, MN, MO, NE, NY, IA, ME, and TN and income in MI, MN, MO, NE, CA, DE, GA, IA, ME, MA, SD, TN, and VT, explained approximately the same percentage 36% and 37% respectively of the future change of renewable energy consumption.

5.1.6.2 Aspect 2: Impact of Energy and Electricity Prices on Renewable Energy Consumption

The second aspect includes the energy and electricity prices, for example, average oil price, primary energy average price, all sectors, and coal average price, all sectors.

Our findings show the Primary Energy Average Price, all sectors (PETCD Granger impacts 40.91% of renewable energy consumption among 22 states. PETCD results motivated us to investigate sub energy prices and how these subfactors of energy prices impact renewable energy consumption. Therefore, we examined the impact of average oil on renewable energy consumption among 22 states. Our findings enhance our view that annual average oil price impact renewable energy consumption in approximately 59% of 22 states. There is the debate about the volatility of oil prices and the growth of renewable energy in the short, medium, and long term and whether renewable energy growth will fall due to cheap crude oil price pressures (Sadorsky 2009a). “According to Shafiee and Topal (2009), crude oil price volatilities have been influenced by macroeconomic variables such as GDP growth in the modern economy”.

In this regard, we examined the impact of natural gas and total coal consumption prices on renewable energy consumption. “According to EIA (Administration, n.d.), natural gas accounted for the largest source, about 32% of U.S. electricity generation, and coal accounted for the second largest energy source for U.S. electricity generation in 2017”. We found the natural gas average price, all sectors including supplemental gaseous fuels NGTCD, Granger impacts 40.91% of renewable energy consumption among 22 states. However, we found the coal consumption price (CLTCD) Granger impacted 59.09 % of states. We have to consider the majority of coal, approximately 93%, “consumed in the United States is used to generate electricity”, and 30% of the total U.S. electricity generation was from coal in 2017 (U.S. Energy Information Administration EIA n.d.) In addition, this study investigated the electricity prices. We found the ESTCD Granger impacted 45.45% of the states while the ESRCD Granger impacted 27.27% of the states.

To illustrate the Granger Causality relationship between PETCD and total renewable energy consumption, we reflected and classified the significant states into three hypotheses: growth hypothesis (31.818%), feedback hypothesis (9.090%), conservation hypothesis (13.636%). In this regard, we classified the states that have a statistically significant Granger causality relationship between CLTCD, and total renewable energy consumption into three hypotheses: growth hypothesis (36.363%), feedback hypothesis (22.72%), conservation hypothesis (4.545%). Likewise, we examined the states that have statistically a significant Granger Causality relationship between the NGTCD, and Total Renewable Energy Consumption which fell into three hypotheses: growth hypothesis (22.727%), feedback hypothesis (18.181%), conservation hypothesis (9.90%) .Similarly, our findings show the states have statistically significant Granger Causality relationship

between ESTCD and total renewable energy consumption among 22 states fell into three hypotheses: growth hypothesis (27.27%), feedback hypothesis (18.181%), conservation hypothesis (13.63%).

In this respect, we reported the results of the variance decomposition of energy price factors impact future change in renewable energy consumption. We found all the energy sources and electricity prices (PETCD, NGTCD, CLTCD, and ESTCD) had increased of variance decomposition of the forecast error within the long run period. The results show NGTCD had the largest growth of variance over time, approximately 38% over a 6-year period of future changes, and increased to explain approximately 50 % of the future changes in renewable energy consumptions in MI, MN, MO, NE, NY, GA, SD, and VT over a 12-year period of future changes. The results also show PETCD had the second largest variance which can explain approximately the 36% to 49% increase in renewable energy consumption in ID, MI, MN, MO, NE, RI, and VT from year 6 to year 12 of future changes.

In line of energy prices, the forecast error variance decomposition in ID, MI, MN, MO, NE, CA, MA, NV, NC, OR, SD, TN, and VT results of CLTCD show the small percentage of variance growth over time which CLTCD can approximately explain between 20% to 25% from 6 to 12 years the renewable energy consumption of the future change. We found ESTCD had the lowest variance decomposition of forecast error, and the lowest growth over time, too. ESTCD can explain approximately between 19% to 20% from 6 to 12 from year 6 to year 12 of future changes of renewable energy consumption in ID, MI, MN, MO, RI, IA, ME, OR, TN, and VT.

5.1.6.3 Third aspect: Impact of Energy and Electricity Consumption factors on Renewable Energy Consumption among 22 states.

This aspect discusses the results of energy consumption factors such as Total energy consumption per capita TETPB, Fossil Fuel Total Consumption (FFTCB), Coal total consumption (CLTCP), Natural gas total consumption (NGTCP), Natural gas consumed by the residential sector (NNRCB) on the Renewable Energy Consumption (RETCB).

5.1.6.3.1. Total energy consumption per capita TETPB

The First factor we examined was the total energy consumption per capita among 22 states. Thus, our research question was asked: how total energy consumption per capital impact renewable energy consumption over time could. Thus, we discuss total renewable energy consumption per capital based on the national level and states level. Our findings in total show primary energy consumption per capital Granger impacts 22.75 % from 22 states. In contrast, the primary energy consumption per capital did not Granger impacts renewable energy consumption in the USA. In this respect, we investigated the impact of Total energy consumption per capita on renewable energy due to states group. The average of average of the total energy consumption per capita among 22 states (TETPB) was 308.73 Million Btu. Thus, we grouped TETPB into two categories: low TETPB which fell into less than or equal than average of high TETPB states which fell into category had greater than TETPB grand average. Low states TETPB accounted 40.90% of our study sample, and high states TETPB accounted 59.09% of our states sample. We found 44.44% of states which fell into low TETPB category had the significant relationship between the TETPB and renewable energy consumption. Although, we found 53.84% of states which fell into category of high TETPB had the significant impact between TETPB and total renewable energy consumption. The study finding noticed the states which produced from their total

renewable energy consumption approximately 20% or more from hydropower, the TETPB average growth becomes negative, for example, Growth of TETPB in ID (-0.52%), NY(-4.39%), WA (-0.62%),and NV (-1.15%).

In this line, we reported the states have statistically significant Granger Causality between primary energy consumption per capital and renewable energy consumption into three hypotheses: growth hypothesis (9.090%), feedback hypothesis (4.545%), and conservation hypothesis (31.818%).

According to EIA (U.S.Energy Information Administration EIA n.d.), “In 2017, total U.S. primary energy consumption per person (or per capita consumption) was about 300 million British thermal units (Btu). According to Asif & Muneer (2007), there are four countries (China, India, UK and USA) heavily dependent on imports of energy to sustain their demand”.

Thus, we noticed in Figure 40 below that the gap between primary energy consumption per capita (97. 806) quadrillion Btu and primary energy production per capital (88. 258) quadrillion Btu by approximately (-9.548) quadrillion Btu in 2017. The data show the renewable energy consumption per capita was increased from 4.0700 to 11.298 quadrillion Btu from 1970 to 2017. In addition, we noticed based in below Figure the gaps between Primary Energy Net Imports decreased from 11.2589 Quadrillion Btu in 2016 to 7.506779 Quadrillion Btu in 2017 whereas Primary Energy Exports increased from 14.119207 Quadrillion Btu in 2016 and 17.959917 Quadrillion Btu in 2017. Therefore, the renewable energy consumption impacted by primary energy consumption per capital which can play a significant role of energy transition in terms of energy balance.

Figure 40 U.S. Primary Energy Overview from 1950 to 2017

5.1.6.3.2. The impact Total energy consumption per capita in the residential sector (TERPB)

EIA (U.S. Energy Information Administration EIA n.d.) , defines the energy consumed per capital which divides the total energy consumption in each state by the population residing in this state: “The energy consumed per person residing in each state and in the United States is estimated by dividing the total energy series (“TE”) by the resident population”. According to the United States Environmental Protection Agency, the USA residential sector accounts for more than a third of the electricity used nationwide (United States Environmental Protection Agency EPA n.d.). Earlier, we demonstrated and discussed our finding to explore and emphasizes the role of total energy consumption per capita in the residential sector on energy. Jones (1991), emphasizes and asserts on the role and relationship between the urbanization effects of energy- use in developing communities which defines the importance of urbanization as “urbanization exerts a number of independent influences on energy-use.” Jones discussed “Higher residential density puts a

premium on the compactness and portability of domestic fuels”. Ewing, Rong, and Ewing (2010), declared “the urban form on the residential energy consumption is a new area of inquiring”. Thus, our study seeks to understand and realize the importance of this factor and demonstrate the relationship and impact of total energy consumption per capita in the residential sector on energy on renewable energy consumption. Based on our findings we found approximately 72.72% of states had declined in the average growth rate of TERPB whereas approximately 27.27% of states show the average growth rates of TERPB increased. In terms of TERPB, many factors can drive this decline over time such as annual consumption fluctuations, energy efficiency improvements and economic factors (U.S. Energy Information Administration EIA n.d.) . As aforementioned, TERPB is defined as the total energy consumption divided by population. Thus, the growth of population in each state should be taken into account. For example, in CA the TERPB average growth rate declined by 0.8% but the population in CA grew, by several percentage points. In fact, CA accounts for 12% of the total population of the country. We strongly believe the role of renewable consumption growth over time has contributed to this decline of TERPB. Thus, we keep CA as an example to discuss the relationship between TERPB and renewable energy consumption. CA had a positive renewable energy consumption growth from 1970 to 2015 which was 2.7%. In addition, the correlation between renewable energy consumption and TERPB in CA was - 0.75. Therefore, the negative correlation among renewable energy consumption and TERPB along with the results that show TERPB had significant Granger Causality impact on renewable energy consumption in CA that could enhance our view of the role of TERPB in relationship with some factors such as population, intensity of energy consumption to impact on renewable energy consumption.

In general, we found TERPB Granger Causality significant in approximately 41% of states examined from 22 states. In this respect, we found that the percentage of low-level of TERPB states group was approximately 41% (average of low level TERPB was 65.36 Million Btu) and high-level states group of TERPB was 59% as classification of TETPB (average of low level TERPB was 78.73 Million Btu). Approximately we found that the TERPB was significant for 33% Granger Causality significant fell into low level group of TERPB and approximately 56% of the TERPB was significant for 56% Granger Causality renewable energy fell into high level of TERPB. Therefore, the results indicate TERPB can enhance the role of renewable energy consumption as a significant impact and long-term concerted transition of energy sources.

5.1.6.3.3. The Impact of Fossil Fuel Total Consumption (FFTCB), Coal total consumption (CLTCP), Natural gas total consumption (NGTCP), Natural gas consumed by the residential sector (NNRCB) on the Renewable Energy Consumption (RETCB)

In this part, we discuss various types of conventional energy sources (finite resources) according to the aggregate level as Fossil Fuel Total Consumption (FFTCB) and the disaggregate levels such as coal and natural gas on renewable energy consumption. First, fossil fuel is still dominant and contributed to the percentage of “total world consumption at approximately 81% in 2015” (BANK, 2016).

Thus, we investigated and discussed the impact of various types of fossil fuels on renewable energy consumption over time. In general, the FFTCB, CLTCP, NGTCP, and NNRCB had positive average growth over time in most states. A few states were shown to have an average growth rate of FFTCB declined such as MI, NY, MA, and NC. Also, the CLTCP average growth rate declined in MI, NY, DE, and NC. Similarly, the NGTCP

average growth rate declined in MO and NE, and the NNRCB average growth declined in MO, NE, CA, and IA.

Later, we examined Granger Causality for each of these factors among 22 states. We found the FFTCB significantly Granger impacts approximately 27.27% of states. Remarkably, we found the FFTCB had the same percentage of significantly Granger impacts (50%) for both high FFTCB level states and low FFTCB level states. Furthermore, we investigated the correlation between average growth of FFTCB and the current percentage of renewable energy consumption in significant states. We found that most states which currently producing on average approximately 36.85% of their energy production from renewable energy sources show the FFTCB had significant impact on renewable energy except TN and WI. Whereas for most of the states which had current percentage of renewable energy production greater than 40%, the FFTCB had no Granger impacts for renewable energy consumption. Remarkably, we found the CLTCP had approximately Granger impacts 13.64% (WA, FL, GA) and the NGTCP had approximately Granger impacts 13.64% (GA, NC, WI). However, the NNRCB found Granger impacts in approximately 31.82% of states.

As with any energy resource, there are limitations to identifying what factors of energy sources can enhance renewable energy consumption. Furthermore, we found the Electricity Total Consumption (ESTCB) had Granger impacts of approximately 55% in renewable energy consumption in 22 states.

In addition, we reported the results of the variance decomposition of renewable energy consumption and determined the Forecast error variance of oil price on renewable energy consumption in MI, MO, NE, RI, CA, DE, GA, ME, NV, NC, SD, and VT over 12-years

period forecasting horizon. We found the renewable energy variations are explained due to their changes from approximately 70% over a 6-year period of future changes while decreasing to 60% over a 12- year period of future changes .The renewable energy consumption is affected by annual average price over a 6- year period of future changes by approximately explained 32%, while over a 12- year period of future changes is increased to be approximately 42%, except the impact of annual oil price on renewable energy consumption in GA which is approximately zero variability. Thus, we can notice the variance of annual oil price increases from a short period to long period by approximately 10% which indicates the importance of annual oil price for the long-run period on renewable energy consumption change.

In this respect, the results of forecast error variance of total energy consumption per capita (TETCB) can be explained as exogenous shocks to the Renewable Energy Consumption (RETCB). Over a 6- year period of future changes, approximately 31% of the variability on renewable energy consumption change, and at a longer period over a 12- year period of future changes is still explained approximately 34% of the variability due to change of renewable energy consumption. Regarding forecast error variance of Total Energy Consumption per capita in the Residential Sector (TERPB) approximately 34% over a 6- year period of future changes explained by exogenous shocks to the renewable in MI, MN, RI, CA, DE, ME, NV, SD, and WI while TERPB approximately explained 40% over a 12- year period of future changes. Thus, we noticed the variance of TERPB jumps up over the long run period more than the variance of TETCB

In general, renewable energy consumptions in MI, CA, GA, ME, SD, and VT are affected by Total Consumption of Fossil Fuel (FFTCB), approximately on average, 28% with a 6

year-period forecasting horizon of the variability in renewable energy consumption changes and is explained by FFTCB shock. The highest variability is shown as 33% over a 12 year- period forecasting horizon that is explained by FFTCB shock. Moreover, we decompose the variance of the forecast-error of NNRCB in MI, MN, NY, RI, GA, NV, and VT and ESTCB in MI, MN, NY, RI, CA, GA, IA, ME, NC, OR, SD, and TN. We found that a shock of NNRCB and ESTCB would shock a 47% and 10% change over 12 year-period forecasting horizon in the future change of the renewable energy consumptions respectively.

5.1.7. Exploratory Factor Analysis

This section presents and discusses our findings to identify the linear combination between macroeconomics, fossil fuels consumptions, and electricity consumption that enhance renewable energy consumption that was conducted in chapter 4 (section 4.1.3). To understand how these factors correlate to each other, we focus more on underlying factors using an oversimplified representation to explain renewable energy consumption. Multiple linear regression analysis is widely used for prediction and forecasting. Regression analysis is basically used to know that a dependent variable (renewable energy consumption for each state) is related to which independent variable (Orthogonal factors extracted from EFA). In this regard, the Multiple Linear regression is integrated with EFA to estimate the relationships between variables by fitting an equation to given data for each state. In addition, the Multiple Linear Regression is used to predict the value of Y which is dependent on X (explanatory variable or independent). Hence, we consider one independent variable (renewable energy consumption for each state), and predictors to indicate the orthogonal linear combination for each latent variable.

After we conducted MLR for 16 states the results show regression models are useful and statistically significant. Therefore, we found that the global p-value for 16 MLR models of EFA components is statistically significant. In this regard, these results demonstrated the significant linear combination of orthogonal predictors for all 16 states were shown to have a positivity coefficient. Of 16 MLR models, we found the proportion of variance explained approximately as: 87% in MI; 86% in MN; 77% in ME; 76% in NE; 75% in VT; 73% in IA ; 66% in MO; 64% in NV; 62% in GA; 54% in CA; 50% in SD; RI in 38% for renewable energy consumptions. However, the proportion of variance explained approximately decreased to 29% in NC; 24% in NY; 19% in TN; and 15% in OR. There are several reasons for this decline in the proportion of variance explained of renewable energy consumption in NC, NY, TN, and OR. The first reason could be due to the number of significant factors in each state prior to the performed and extracted EFA underlying components. The number of significant factors is 6 in NC; 6 in NY; 7 in TN; and 7 in OR. The second reason is due to the nature of factors which we noticed in these states there were absent of significant factors of TETPB, TERPB, and FFTCB. The third reason is behind the covariance and correlation matrix for original data for each state. Finally, the loading of factors according to the number of underlying components which varies from state to state.

5.2. Discussion of Hypothesis Two

In this section, we discussed the results of hypothesis two that was conducted in chapter 4 (section 4.2). One research question we addressed was if there are no differences between the socio-economic and energy variables among different states influencing the low and high emission levels. Thus, MANOVA results illustrate the total energy is the measure that differentiates high-emission states from low-emission states. In the following MANOVA,

the state emission level is used as a variable factor in the prediction of both renewable energy and total energy. MANOVA indicates that total energy differs among states based on the emission levels. But this pattern is not evident in renewable energy. This suggests that, in spite of the promotion of renewable energy consumption, it accounts for only a small proportion in the energy sector. Thus, we explore to demonstrate the impact of biomass renewable energy regarding an environmental issue such as emission. We mentioned in chapter one that renewable energy refers to all energies produced from natural processes (e.g., hydropower, solar, wind, geothermal, ocean). But the majority of the percentage of renewable energy share of biomass was 62.1% of total renewable energy sources in 1995 (Demirbas 2005). In fact, biomass can pollute the air when it is burned, though not as much as fossil fuels (Biomass 2013). According to (Partnership For Policy Integrity PFPI n.d.) , “Despite the frequent depiction of biomass as ‘clean’ energy, data from air permit applications and real smokestack tests demonstrate quite clearly that biomass is a heavily polluting technology.”.

In addition, our findings confirm the Apergis et al. (2010a) study which identified the causal relationship between the carbon dioxide and some types of clean energy sources consumption (i.e., nuclear, renewable) and economic growth. They used a panel error correction model for 19 countries from 1987 to 2007. They found, the Granger causality for short run indicated the renewable energy consumption does not contribute to reductions in emissions.

5.3. Discussion of Hypothesis Three

In this section, we discussed the results of hypothesis three that was conducted in chapter 4 (section 4.3). The concentration of this study is to seek to forecast the annual total energy consumption in the USA based on the time series statistical analysis. Two different models were applied: ARIMA with yearly; and integrated MRL with PCA components, both were fitted to predict the response variable annual total energy consumption in the USA. The time series is fitted by an ARIMA model and forecasting is performed for the model. Basically, we used the aggregate method which explains the dependent variable (annual) based on the independent variable (time period). In this case, we seek to have the best model which is fitted with ARIMA by using the R software. Several cases in the table indicate that based on the least value for AIC, best model fitted to the time. The results of the ARIMA model analysis is presented in Appendix J while the ARIMA best fitting model is found in Appendix J.1. The residual diagnostic test of the ARIMA model is found in Appendix J.2 while Appendix J.3 is presented the Results of ARIMA forecasting model.

The best model for our time series displays the following ARIMA (0,1,0), with a first drift based on the lowest AIC (157.8934). As a result of the ARIMA, the yearly time series of the ARIMA (0,1,0) model resulted in an accuracy model MAPE of the holdout with an accuracy of 8.46%. In contrast, our model, which integrated the regression model with PCA components forecast result, was a good predictor of the regression model and improved the accuracy MAPE holdout data with an accuracy of 2.75%. Moreover, multicollinearity has not existed between model predictors.

5.4. Discussion of Hypothesis Four

In this section, we discussed the results of hypothesis three that was conducted in chapter 4 (section 4.4). We seek to validate our clustering technique results in chapter 4 by using the K-means clustering Method. In K-means clustering, one focus of our clustering analysis is the determination of the appropriate number of clusters (N). Thus, our findings regarding the hierarchical clustering, complete linkage, and average linkage algorithm indicate a similar pattern with NY, CA and FL from the first cluster. Dendrograms are presented in figure 41 below.

Figure 41: hierarchical clustering complete linkage

Figure 42: hierarchical clustering average linkage

Therefore, we can notice from the two clustering techniques applied similarities and differences due to state-by-state datasets. The rationale for clustering and of both techniques applied is that our selected socio-economic and energy consumptions variables are known for their important roles in current energy supply-demand balance and in the future renewable energy transition.

5.5. Discussion of Hypothesis Five

In this section, we discussed the results of hypothesis two that was conducted in chapter 4 (section 4.5). In regards to renewable energy acceptance, empirical studies to date have shown strong evidence that the attitude toward behavior, subjective norms, and perceived behavior control have influences on the intention to use green products (Bang, H., Ellinger, A.E., Hadjimarcou, J. and Traichal, P.A. 2000; Han et al. 2010; Madden et al. 1992; Paul et al. 2016; Yazdanpanah, Komendantova, and Ardestani 2015). Moreover, some studies have recognized that to extend the TPB and present the willingness to pay in the TPB could help better understand the influences on the intention to use green products such as organic

food and renewable energy consumption (Bang, H., Ellinger, A.E., Hadjimarcou, J. and Traichal, P.A. 2000; Hansla et al. 2008). However, this study investigated and evaluated the theoretically justified original TPB and extended the TPB by adding the willingness to pay construct. Few studies have shown the influence of willingness to pay to use renewable electrical supply.

Indeed, the results augmented those of past studies using TPB to predict intention to use renewable energy. The results show that both models that proposed in Figure 37 have shown attitude toward behavior is not statistically significant. A reason for this could be due to its large sample size that could impacts the declining relationship between measurement properties and constructs (Fornell and Larcker 2006). Even so, H2 (the subjective norms) and H3 (the perceived behavior control) are consistent with the previous study in the original model of TPB and the extended TPB model. Our results suggest that willingness to pay had a significant positive relationship with the intention to use renewable energy value which is consistent with previous findings (Bang, H., Ellinger, A.E., Hadjimarcou, J. and Traichal, P.A. 2000; Hansla et al. 2008). Indeed, the regression models of effect size did not account for a high proportion changing from original TPB and extended TPB of variance. Moreover, this study investigated and assessed the effect of the individual household average income to intention to use renewable energy that the model proposed in figure 39. The figure shows the extended model of TPB examined the hypothesized model that posits from individual household average income to four latent mediators with the extended model of TPB constructs, and from mediators to the intention to use renewable energy (attitude toward the behavior, subjective norms, perceived control behavior and willingness to pay behavior control). In line with the proposed model in

Figure 38, the extended model of TPB was tested to assess the nature of the relationship for these data. The extended TPB tested that show the mediational path between individual household income affected the dependent latent of extended TPB except perceived control behavior, intention to use to use renewable energy. A few studies suggest an individual's income has a positive effect on the willingness to pay (Rowlands, Scott, and Parker 2003). In contrast, the relationship between income and willingness to pay was not significant (Hansla et al. 2008). Therefore, this study seeks to verify the relationship between the income and willingness to pay construct.

To the best of the authors' knowledge, no study has used and presented any relationship between the individual household average income regarding TPB constructs.

The extended TPB with individual household income tested the macro level fit indices including χ^2 , CFI, RMSEA but were not indicative of a well-fitting model. Interestingly, the effect of the individual household income in the extended TPB models' paths of intention to use renewable energy found most of hypotheses are accepted and supported except H1 and H4 which represented the direct path from individual household average, and path from individual household average to perceived control behavior respectively. In addition, the attitude toward the behavior intention to use renewable energy was significant with the inclusion and addition of the individual household average income path to the mediational paths. Also, the results of this study had verified the positive effect between the income and willingness to pay. The proportion of variance explained for intention in the extended TPB with inclusion and addition of the individual household average income path to the mediational paths and the extended TPB was high but slightly decreased that

model TPB, and Model Extended TPB without individual household average income (86% to 87%, 81% respectively).

Chapter 6. Conclusion

6.1. Conclusion

A great deal of research is based on empirical observations. Studying energy, economic and social phenomenon is known to be a difficult task. Particularly, energy is more than likely under the influence of a series of energy consumption patterns, economic, social and environmental dimensions, which can be correlated with each other as well. The complicated nature of energy, economic and social context, makes it a better choice to develop an integrated approach to simplify the energy context. It is important to analyze energy, economic, and social development while considering multivariate factors. Thus, this research takes advantage of different techniques to address a wide range of questions as to renewable energy consumption and penetration in relation to influential socio-economic forces. Our finding might enhance the understanding of the potential generalizability factors that impact on renewable energy consumption. Our research approach should be judged on its ability to generalize correctly. Thus, the finding of this study is ranking the highest frequencies of significant factors that Granger impacts renewable energy consumption among 22 states. Using the method of Granger causality, annual average price of Oil and Coal (CLTCD) impacts 59.09% of renewable energy consumption from 22 states. However, Per capita personal Income (dollars) and Electricity total consumption (ESTCB) impacts approximately 54.55% of renewable energy consumption from 22 states. The rest of the ranking list of frequent significant factors was reported in Appendix K. By breaking down 17 factors into three aspects, which were introduced in chapter 5, we found Income and GDP in macroeconomic factors aspect Granger impacts approximately 54.55%, and 40.91% respectively. According to the Energy Prices aspect, we found that Annual Average Oil Price is the most frequent factor.

Granger impacts renewable energy consumption approximately 59%, followed by Primary energy average price in the residential sector (PERCD) impacts with 54.55% of states. Moreover, Electricity Average Price for all sectors (ESTCD) approximately impacts 45.45% of the states. Finally, in respect to the Energy Consumption aspect, we found that Electricity Total Consumption (ESTCB) factors and Total Energy Consumption per capita in the Residential sector (TERPB) are the most frequent factors in energy consumption aspect. Granger impacts renewable energy consumption by approximately 54.55% and 40.91% of the 22 states respectively.

In addition, our study demonstrated the impact of significant factors for each state in the short and long run by analyzing and reporting the Forecast Error Variance Decomposition (FEVD). In general, most of the significant factors show the proportion variance of FEVD grows from a short period to a long period. This indicates the importance of these factors for a long-run period on renewable energy consumption change.

Thus, the EFA is derived from the empirical evidence obtained from the Granger Causality test for each state that had significant factors which impact the renewable energy consumption. Again, the EFA results demonstrated that energy consumption is associated with many aspects of factors that correlated among each other. Thus, our approach integrated EFA along with MRL to identify the linear combination between macroeconomics, fossil fuels consumptions, and electricity consumption. This approach could help and enhance to understand how these factors correlated with each other. Purposely, we seek to focus more on the underlining factors, using an oversimplified representation to explain renewable energy consumption. For approximately 69% of the states, we found that the R^2 explains more than 50% of the variance by using the linear

combination for orthogonal components that were exacted and that we proposed from EFA and integrated with MRL to explain renewable energy consumption for each state.

In this regard, the data that were collected have a high degree of multicollinearity among predictors. Thus, this application is driven by the fact that many of the socio-economic variables in predicting energy generation and consumption are highly correlated with each other. Ultimately, we expected improved accuracy in using PCA components for prediction in the following multiple linear regression. Validation has been achieved for comparison purposes between the ARIMA model and the PCA model which was integrated with the MRL model. The results confirmed a better accuracy in regressions with PCA scores.

Clustering techniques have been applied to state-by-state datasets. The rationale for clustering is that our selected 17 factors in this study are known for their important roles in current energy supply-demand balance, and in future renewable energy transition. In this regard, we argue that the state-by-state energy production and consumption pattern is heavily dependent on the energy and socio-economic factors. We found that the majority of states fell into one cluster (19 states out of 22), suggesting that most of states are, to a large extent, homogenous in terms of the pattern of macroeconomic energy, and energy consumption.

In the MANOVA, we seek to identify the impact of renewable energy consumption and fossil energy consumption on the states' emission levels. Each state's emission level is used as a variable factor in prediction of both renewable energy and total energy consumption. MANOVA indicates that total energy differs among states based on the emission levels. This suggests that, in spite of the promotion of renewable energy, it accounts for only a small proportion in the energy sector. In fact, twenty-two states,

responsible for 20% or more of the energy production generated from renewable sources, were included in the study. By investigating each state's energy profiles, we can notice that most states generated more than 20% of renewable energy from biomass. Therefore, this result pushes us to understand the relationship between emission levels and growth of biomass renewable energy.

6.2. Limitations

There are limitations to our analysis. The conclusion we have made should be considered as preliminary and warrants further replications, especially with a broader selection of energy consumption and production patterns and social-economic variables.

Thus, this section has introduced some limitations that might help introduce future research. The current study does not include the expert's view. The expert's viewpoints such as (political, econometrics, and energy) should be engaged to enhance and provide new insights into renewable energy production and consumption growth. Therefore, the qualitative approaches should be integrated with the current study (such as experts group comparisons, Delphi studies, or Fuzzy Logistic Regression).

Second, this study examined factors across 22 states and focused on these states which produce 20% of renewable energy. That is, not the complete dataset for all USA states. Moreover, this study does not consider the variation of significant factors that impact renewable energy consumption from one state to another. Also, what are common reasons that can be explained by variations among states? Third, we did not consider data of reserved energy sources and fossil fuel production in each state. Furthermore, this study ignored to identify renewable energy consumption growth due to modern technology development. In this regard, in terms of preparing for market readiness, studying types of

fuels is known to be a difficult task because fit and cost are more than likely to influence renewable energy consumption (International Gas Union IGU 2015). Also, the diversity energy production and consumption among 22 states were not considered, such as the growth of the percentage of mixed energy in each state over time. In addition, we ignored the impact of environmental policy and regulations from one state to another. Moreover, we did not consider the impact of the international and federal policies and investments to support and enhance renewable energy consumption for USA states. As well, we do not consider the impact of renewable energy consumption enabling it to provide society without severe price effects.

6.3. Recommending and Future Work

Based on our analysis, future research can develop a scale to capture the renewable energy growth in respect to the causal inference of significant factors. As well, we suggest developing an approach to compute a probability of each factor due to similarity and dissimilarity of clustering results (see Appendix L). Future studies can also utilize more sophisticated techniques, such as the neural network in accurately predicting energy production and consumption. Furthermore, future studies could identify the impact between the export and import of energy in relation to renewable energy consumption growth. In addition, designing rigorous policies should take into account environmental impacts, such as emission levels regarding types of renewable energy consumption (wind, geothermal, and solar). Moreover, we strongly recommend applying scenarios regarding significant factors that impact renewable energy consumption growth.

Clustering, MANOVA, and EFA techniques have been applied to state-by-state datasets, within macroeconomics. Thus, a future study could integrate the results with

microeconomic factors. “We believe the state-by-state energy production and consumption patterns are heavily dependent on energy, socioeconomic variables, as well as microeconomic factors”.

In fact, the cross-sectional data is not guaranteed to be representative and nor is it a causal relationship. Harlow suggested a future research study using cross-sectional data in which it would be meaningful to collect sample data over time (L. L. Harlow, 2014). Thus, the longitudinal data could help provide a better understanding for research study models across two or more time points (temporal ordering) by using a latent growth curve model to verify the causal paths and specific behavior change outcome. In addition, using a large and homogeneous sample size could be valuable to investigate the research study model based on invariance analyses across income groups. That might enhance the understanding of the potential generalizability, and a model should be judged on its ability to generalize correctly.

Appendix A Study Questionnaire

Dear Participants,

You are invited to enroll in a study that deals to identify the factors influencing consumer's behavioral intention to use renewable electricity in the United States of America. If you have questions please contact Professor Jyh-Hone Wang at 4018745195. You must be at least 18 years old to take part in this research project.

The procedure includes completing an online survey that will take approximately 10-15 minutes. You are encouraged to participate in the survey and your response is vital in identifying the important indicators from the public's point of view. The data collected will be used for scientific research purposes only.

Risks or discomfort

In this study, there is not any probable risk or discomfort related with the study. The decision to participate and contribute in this study is completely voluntary. Your responses will be completely anonymous.

Benefits of this study:

Essentially, there is no direct benefit to you for taking part in this study, the researcher may conduct more studies to investigate and identify the social factors and attributes relative to consumer attitude, intention, and behavior. Thus, the research findings will help recognize the role of social acceptance to use renewable electricity and help improve policy regarding of renewable electricity.

Confidentiality:

All information and response are totally private and confidential. In this study, it will not identify or ask about your name and the researchers will not be able to access your email or IP address in Survey Monkey. Please, read and review the privacy agreement of Survey Monkey before participating. Data will be assessed, analyzed, and reserved on password protected computers in protected offices at the University of Rhode Island. All data will be analyzed and reported in aggregate no individual response will be reported.

Rights and Complaints:

Please, if you feel not satisfied with this study performed, you may discuss your concerns with Professor Jyh-Hone Wang at 4018745195 , anonymously, if you choose. In addition, you may contact the office of the Vice President for Research and Economic Development, 70 Lower College Road, Suite 2, University of Rhode 106 Island, Kingston, Rhode Island, telephone: (401) 874-4328

Please, if you are have read and understand this above, and now agree to participate in this study, please indicate your consent and please complete this survey.

1. What is your age?

.....years

2. What is your gender?

☐ male ☐ female

3. What is the highest education that you completed successfully?

Not a high school graduate ☐

High school graduate ☐

College ☐

Associate/technical degree ☐

Bachelor's degree ☐

Post-graduate ☐

4. What is your average annual income?

.....\$

5. What was your average monthly electricity bill?

.....\$

6. How many people, including you, currently live in your house?

.....

7. When was your house built?

Before 1920 ☐

1920-1940 ☐

1940-1949 ☐

1950-1959 ☐

1960-1979 ☐

1980-1989 ☐

1990-1994 ☐

1995-1999 ☐

2000-2004 ☐

2005-later ☐

Do not know

Note: Likert Scale in this survey stands for:

1 = strongly disagree

2 = disagree

3 = don't know

4 = agree

5 = strongly agree

8. Using renewable energy is a good idea for my home's electricity

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

9. I like the idea of using renewable energy for my home's electricity

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

10. I have a positive attitude toward

to using renewable energy instead conventional energy for my home's electricity

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Note: Likert Scale in this survey stands for:

1 = strongly disagree

2 = disagree

3 = don't know

4 = agree

5 = strongly agree

11. Most people who are important

to me would like to use renewable energy for their home's electricity

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

12. I think other friends in my community

would be willing to use renewable energy for their home's electricity

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

13. People whose opinions I value would

favor and support the use of renewable energy for their home's electricity

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

14. I believe I can use renewable energy for my home's electricity

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

15. If it were exclusively up to me, I

am assured that will use renewable energy for homes electricity

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

16. If I wanted to, I could easily use renewable energy for homes electricity

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Note: Likert Scale in this survey stands for:

1 = strongly disagree

2 = disagree

3 = don't know

4 = agree

5 = strongly agree

17. I plan to use renewable electricity

and environmental electricity resources rather than conventional energy

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

18. I definitely want to use renewable energy for home electricity in near future

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

19. I intend to adopt an electricity from conventional energy to renewable energy

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

20. The federal government USA has ambitions targets to share of renewable energy
and reduce greenhouse gas emission

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

21. The federal government of USA renewable energy policy or initiative has
appropriate incentives to

encourage me to switch to using renewable electricity in residential sector

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Note: Likert Scale in this survey stands for:

1 = strongly disagree 2 = disagree

3 = don't know

4 = agree 5 = strongly agree

22. The federal government of USA has powerful support to have
reasonable and competitive renewable electricity prices

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

23. Using renewable electricity helps to prevent global warming causes

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

24. Using renewable electricity helps to have stable electricity prices

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

25. Using renewable energy growth

will meet human need that permit fulfilling the social, economic and other requirements of present and future generations

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Note: Likert Scale in this survey stands for:

1 = strongly disagree 2 = disagree

3 = don't know

4 = agree 5 = strongly agree

26. I would be able to spend extra money to use renewable electricity

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

27. I am willing to pay more to use renewable electricity

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

28. It is satisfactory to pay more to support and use renewable electricity

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

29. I support the renewable energy policies to protect the environment

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

30. I would be willing to buy and use green products

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

31. I am extremely worried

about the environmental issues such as global warming

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

32. On scale 1 to 5 (5 begin the strongest) ,

Could you rate how strongly you feel each below is considered as obstacles to
develop and growth the renewable energy in the state

- State policy

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

- Public support and sharing

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

- Business and commercial support and sharing

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

33. On 1 to 4 (begin 1 the highest),

Could you rank what factors you consider

as obstacles to switch from conversional electricity (fossil electricity sources) to

renewable electricity Expensive prices ☐

Low government support ☐

Low suppliers competitions ☐

Less family and friends support ☐

34. On 1 to 5 (begin 1 the highest),

35. Could you rank what long-term strategies you considers
the energy priorities to encourage the world, policy makers,
industry, and consumers to be more sustainable practices:

- Reduce Conventional Energy ☐
- Improve Energy efficiency and technology development ☐
- Using Low carbon technologies ☐
- Growth of Renewable Energy and Sustainable resources ☐
- Energy Saving and reducing demand ☐

36. What would be the main reason you would **not**
support paying for use of renewable electricity?

- It's too expensive ☐
- I don't think there are energy problems at present ☐
- I think it's the government's responsibility ☐
- It doesn't help the State economy enough ☐

37. My choice for home electricity

- I prefer to buy/use renewable electricity for grid
☐
- I prefer build my own small-scale
renewable electricity (such as solar panel) ☐
- I prefer the buy/ use ONLY electricity from conventional sources ☐

Appendix B Assessing questionnaire's items _Content Validity

Research Topic

Identify the factors influencing consumer's behavioral intention to use renewable electricity in the United States of Americas

In my research, we interested to predict and explore the consumer attitude, intention, and actual behavior to identify which factors could be influencing consumer's behavioral intention to use renewable electricity in the United States of Americas. Actually, some scholars have suggested investigating and identifying individual intention and behavior because they believe the public acceptance is critical for successful renewable energy technologies (Huijts, Molin, & Steg, 2012). . Academic research has recognized the role of social acceptance to renewable energy (Zoellner, Schweizer-Ries, & Wemheuer, 2008).

Objective

According to (Horgas et al. 2008), content validation refers to the degree to which the sample items measure and test the construct of the interest. Content validation uses the expert panel to evaluate the questionnaire's items of the theoretical construct.

IRB Approval

Approval Number: 1718-166

Expert's Name

.....

Expert's Signature

Date

Part one: Reference Index for Theoretical Study Constructs

Constructs	Definition	Number of Redundant Items
Attitude towards purchasing /using renewable energy	The result of individual beliefs to	8,9, and 10
Subjective norm	“The individual’s perception that people important to the individual should perform the behavior in question.” (Yadav and Govind S. Pathak 2017).	11,12, and 13
Perceived behavioral control	An individual’s perception of the struggle or comfort of performing a behavior	14,15, and 16
Intention	Intention is this assumed to be the immediate antecedent of behavior and to guide behavior in a controlled and deliberate fashion”. (Ajzen and Fishbein 2000)	17,18, and 19
Policy	Degree of individual consumer view to current federal policy that supports renewable energy	20, 21, and 22
Belief of Benefit Expectation	A degree of individual to belief about the renewable electricity benefits	23, 24, and 25

Willingness to pay	Willing of individual to pay more for renewable electricity	26, 27 and 28
Environment Concern	A degree of individual consumer to the environment issues	29, 30, 31

Table B1:Theoretical Study Constructs 1

We appreciate your help in evaluating this survey.

Please, to evaluate the questionnaire items circling the appropriate terms of dichotomies (yes or no) in the categories below

PART ONE: A Whole questionnaire

Is the questionnaire constructs relevant the intention to use green electricity?

[] Yes

[] No, “purpose of constructs not clearly articulated”

[] No, “questionnaire constructs irrelevant to stated purpose”

[] No, purpose irrelevant to the intention to use green electricity

- Does the scaling of 5-point liker’s scale give appropriate to measure the internal consistency of survey item?

[] Yes

[] No, please specify an appropriate scaling

- Do questionnaire items avoid grammatical messiness?

[] Yes

[] No, please specify a number of item/items

- Do questionnaire items keep a language simple and direct (clarified content)?

[] Yes

[] No, please specify a number of item/items

- Does length of time take to respond this questionnaire less than 15 minutes?

[] Yes

- [] No, please specify a number of item/items
- Does a whole questionnaire content appropriate for intended audience?
- [] Yes
- [] No, please provides some comments

PART TWO: Construct items redundantly

Construct 1: Attitude using renewable energy

- Are items questions from 8, 9, and 10 the content associated with attitude to use renewable electricity?
- [] Yes
- [] No, please specify a number of item/items
- Are items questions from 8, 9, and 10 redundantly?
- [] Yes
- [] No, please specify a number of item/items

Construct 2: Subjective norm

- Are items questions from 11, 12, and 13 the content associated with attitude to use renewable electricity?
- [] Yes
- [] No, please specify a number of item/items
- Are items questions from 11, 12, and 13 redundantly?
- [] Yes
- [] No, please specify a number of item/items

Construct 3: Perceived behavioral control

- Are items questions from 14, 15, and 16 the content associated with perceived behavioral control to use renewable electricity?
- [] Yes
- [] No, please specify a number of item/items
- Are items questions from 14, 15, and 16 redundantly?
- [] Yes
- [] No, please specify a number of item/items

Construct 4: Belief about federal Policy

- Are items questions from 20, 21, and 22 the content associated with policy to use renewable electricity?

[] Yes

[] No, please specify a number of item/items

- Are items questions from 20, 21, and 22 redundantly?

[] Yes

[] No, please specify a number of item/items

Construct 5: Willingness to pay

- Are items questions from 26, 27, and 28 the content associated with wiliness to pay to use renewable electricity?

[] Yes

[] No, please specify a number of item/items

- Are items questions from 26, 27, and 28 redundantly?

[] Yes

[] No, please specify a number of item/items

Construct 6: Belief of Benefit Expectation

- Are items questions from 23, 24, and 25 the content associated with intention to use renewable electricity?

[] Yes

[] No, please specify a number of item/items

- Are items questions from 23, 24, and 25 redundantly?

[] Yes

[] No, please specify a number of item/items

Construct 7: Belief of Benefit Expectation

- Are items questions from 29, 30, 31 the content associated with intention to use renewable electricity?

[] Yes

[] No, please specify a number of item/items

- Are items questions from 29, 30, and 31 redundantly?

[] Yes

[] No, please specify a number of item/items

Construct 8: Intention

- Are items questions from 17, 18, and 19 the content associated with intention to use renewable electricity?

[] Yes

[] No, please specify a number of item/items

- Are items questions from 17, 18, and 19 redundantly?

[] Yes

[] No, please specify a number of item/items

Comments

.....

ACKNOWLEDGEMENT

"We would like to thank the experts who were involved in the validation survey for this research. Without their passionate participation and input, the validation survey could not have been successfully conducted."

Appendix C: Granger causality results of the total renewable energy consumption in the USA

Appendix C.1: Unit test root

State	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
ID	-2.0154	-2.8529	-4.2536***
MI	-2.4081	-3.2706*	-5.2253***
MN	-1.618	-3.4246*	-5.3394***
MO	-2.3258	-3.4686**	-4.5111***
NE	-2.0689	-3.2089*	-4.4376***
NY	-2.7572	-2.6968	-4.8642***
RI	-2.2826	-3.3763*	-5.7706***
WA	-1.3068	-4.3289***	-5.2557***
CA	-1.3256	-3.501*	-4.3109***
DE	-2.0078	-3.6362**	-5.8547***
FL	-0.716	-3.0636	-4.3851***
GA	0.10399	-2.7518	-5.3949***
IA	-2.1122	-3.0065	-4.527***
ME	0.05443	-4.6858***	-8.1358***
MA	-3.0965	-3.0992	-5.6217***
NV	-0.9019	-3.0047	-5.0564***
NC	-0.4129	-3.3392*	-5.4682***
OR	-1.4675	-4.2929***	-4.4407***
SD	-1.6521	-2.8073	-4.2105***
TN	-1.741	-2.5584	-4.9601***
VT	-0.7909	-3.3198*	-6.593***
WI	-1.7463	-3.6165**	-6.144***

Table C1: USA Granger causality of REBC 1

FACTOR	Augmented Dickey-Fuller (ADF)		
	Level	First difference	Second difference
Oil	-2.097	-2.8941	-4.5205***
TETPB	-1.9458	-3.7803**	-5.6192***
TERPB	-1.2937	-3.9082**	-5.9333***
FFTCB	-2.0213	-3.2219	-5.2552***
CLTCP	1.9104	-1.8111	-5.7269***
Income	-1.7866	-3.6645**	-4.2561***
NGTCP	-2.494	-3.1481	-6.3953***
NNRCB	-2.1428	-4.3222***	-6.1282***
ESTCB	0.20799	-3.145	-5.9599***
ESRCB	-1.1098	-2.7219	-7.2893***
PETCD	-2.131	-2.6883	-4.0871**
PERCD	-2.2429	-2.38	-4.5286***
NGTCD	-2.748	-2.6916	-4.5675***
ESTCD	-2.8441	-2.8206	-4.9262***
ESRCD	-2.7375	-2.9344	-4.7863***
GDP	-1.2165	-4.1116***	-4.7204***
RETCB	-1.9889	-4.0559**	-4.0559**

Table C2: USA Granger causality of REBC 1

FACTOR	The bivariate VAR Test		Conclusion
	F-Test	p-value	
Oil	1.0605	0.3513	OIL not G-Cause RETCB
TETPB	1.0111	0.3175	TETPB not G-Cause RETCB
TERPB	0.30063	0.5849	TERPB not G-Cause RETCB
FFTCB	0.08999	0.914	FFTCB not G-Cause RETCB
CLTCP	1.1713	0.3155	CLTCPnot G-Cause RETCB
Income	2.6708	0.1061	Income not G-Cause RETCB
NGTCP	1.1004	0.338	NGTCP not G-Cause RETCB
NNRCB	0.39591	0.6744	NNRCB not G-Cause RETCB
ESTCB	0.39648	0.6741	ESTCB not G-Cause RETCB
ESRCB	1.6259	0.1587	ESRCB not G-Cause RETCB
PETCD	2.1999	0.1178	PERCD not G-Cause RETCB
PERCD	2.0985	0.1297	PERCD not G-Cause RETCB
NGTCD	2.1497	0.1236	NGTCD not G-Cause RETCB
ESTCD	0.45583	0.7678	ESTCD not G-Cause RETCB
ESRCD	0.33631	0.5636	ESRCD not G-Cause RETCB
GDP	1.3181	0.2543	GDP not G-Cause RETCB

Table C3: USA Granger causality of REBC 1

Appendix D: Forecast Error Variance Decomposition (FEVD)

Appendix D.1: FEVD of annual oil price

“FEVD determines how much” of the forecast error variance of oil price can be explained
exogenous shocks to the renewable energy consumption in MI.

\$RETCBMI.2

OIPID.2 RETCBMI.2

[1,]	0.0001077262	0.9998923
[2,]	0.0606958950	0.9393041
[3,]	0.4134149408	0.5865851
[4,]	0.4364003843	0.5635996
[5,]	0.4167607108	0.5832393
[6,]	0.4457969975	0.5542030
[7,]	0.4544414628	0.5455585
[8,]	0.4498412618	0.5501587
[9,]	0.4409800358	0.5590200
[10,]	0.5181300879	0.4818699
[11,]	0.4674315030	0.5325685
[12,]	0.4613418265	0.5386582

“FEVD determines how much” of the forecast error variance of oil price can be explained
exogenous shocks to the Renewable energy consumption in MO.

RETCBMO.2

OIPID.2 RETCBMO.2

[1,]	0.1157127	0.8842873
[2,]	0.1308143	0.8691857
[3,]	0.2147839	0.7852161
[4,]	0.2090715	0.7909285
[5,]	0.2177362	0.7822638
[6,]	0.2773737	0.7226263
[7,]	0.4073086	0.5926914
[8,]	0.4182458	0.5817542
[9,]	0.5897336	0.4102664
[10,]	0.6106134	0.3893866
[11,]	0.6104883	0.3895117
[12,]	0.6098380	0.3901620

“FEVD determines how much” of the forecast error variance of oil price can be explained
exogenous shocks to the renewable energy consumption **in NE.**

\$RETCBNE.2

OIPID.2 RETCBNE.2
[1,] 0.05537075 0.9446292
[2,] 0.54325985 0.4567402
[3,] 0.58414503 0.4158550
[4,] 0.59761425 0.4023858
[5,] 0.60411556 0.3958844
[6,] 0.54091791 0.4590821
[7,] 0.32454339 0.6754566
[8,] 0.46828175 0.5317183
[9,] 0.45940819 0.5405918
[10,] 0.54925159 0.4507484
[11,] 0.42559510 0.5744049
[12,] 0.71357032 0.2864297

“FEVD determines how much” of the forecast error variance of oil price can be explained
exogenous shocks to the renewable energy consumption **in RI.**

\$RETCBRI.2

OIPID.2 RETCBRI.2
[1,] 0.12607638 0.8739236
[2,] 0.06908721 0.9309128
[3,] 0.06776177 0.9322382
[4,] 0.07124230 0.9287577
[5,] 0.10816909 0.8918309
[6,] 0.33528976 0.6647102
[7,] 0.38916513 0.6108349
[8,] 0.36740326 0.6325967
[9,] 0.36592061 0.6340794
[10,] 0.38761546 0.6123845
[11,] 0.39151326 0.6084867
[12,] 0.39343987 0.6065601

“FEVD determines how much” of the forecast error variance of oil price can be explained
exogenous shocks to the renewable energy consumption **in CA.**

\$RETCBCA.2

OIPID.2 RETCBCA.2
[1,] 0.010586458 0.9894135
[2,] 0.009836602 0.9901634

[3,] 0.014003093 0.9859969
 [4,] 0.197577290 0.8024227
 [5,] 0.219727362 0.7802726
 [6,] 0.222744585 0.7772554
 [7,] 0.228337190 0.7716628
 [8,] 0.288004311 0.7119957
 [9,] 0.284281379 0.7157186
 [10,] 0.296942378 0.7030576
 [11,] 0.307215313 0.6927847
 [12,] 0.340739551 0.6592604

“FEVD determines how much” of the forecast error variance of oil price can be explained

exogenous shocks to the renewable energy consumption **in DE.**

\$RETCBDE.2

OIPID.2 RETCBDE.2

[1,] 0.05965383 0.9403462
 [2,] 0.14021497 0.8597850
 [3,] 0.23480344 0.7651966
 [4,] 0.22858486 0.7714151
 [5,] 0.25438202 0.7456180
 [6,] 0.26345885 0.7365412
 [7,] 0.26353358 0.7364664
 [8,] 0.26582745 0.7341726
 [9,] 0.26633700 0.7336630
 [10,] 0.26635607 0.7336439
 [11,] 0.26645867 0.7335413
 [12,] 0.26647734 0.7335227

“FEVD determines how much” of the forecast error variance of oil price can be explained

exogenous shocks to the renewable energy consumption **in GA.**

\$RETCBGA.2

OIPID.2 RETCBGA.2

[1,] 3.393629e-05 0.9999661
 [2,] 4.465003e-02 0.9553500
 [3,] 9.162229e-02 0.9083777
 [4,] 1.228162e-01 0.8771838
 [5,] 1.392354e-01 0.8607646
 [6,] 1.464857e-01 0.8535143
 [7,] 1.492067e-01 0.8507933
 [8,] 1.500641e-01 0.8499359
 [9,] 1.502799e-01 0.8497201
 [10,] 1.503166e-01 0.8496834
 [11,] 1.503174e-01 0.8496826
 [12,] 1.503156e-01 0.8496844

“FEVD determines how much” of the forecast error variance of oil price can be explained

exogenous shocks to the renewable energy consumption **in ME.**

\$RETCBME.2

OIPID.2 RETCBME.2

[1,] 0.2880354 0.7119646
[2,] 0.2079125 0.7920875
[3,] 0.2082711 0.7917289
[4,] 0.2019784 0.7980216
[5,] 0.2109780 0.7890220
[6,] 0.2122940 0.7877060
[7,] 0.2175117 0.7824883
[8,] 0.2273912 0.7726088
[9,] 0.2293287 0.7706713
[10,] 0.2296728 0.7703272
[11,] 0.2311995 0.7688005
[12,] 0.2317524 0.7682476

“FEVD determines how much” of the forecast error variance of oil price can be explained
exogenous shocks to the renewable energy consumption **in NV.**

\$RETCBNV.2

OIPID.2 RETCBNV.2

[1,] 0.02152729 0.9784727
[2,] 0.14232002 0.8576800
[3,] 0.18363186 0.8163681
[4,] 0.18233614 0.8176639
[5,] 0.20473499 0.7952650
[6,] 0.21243922 0.7875608
[7,] 0.21244756 0.7875524
[8,] 0.21407694 0.7859231
[9,] 0.21495571 0.7850443
[10,] 0.21500035 0.7849997
[11,] 0.21503571 0.7849643
[12,] 0.21510637 0.7848936

“FEVD determines how much” of the forecast error variance of oil price can be explained
exogenous shocks to the renewable energy consumption **in NC.**

\$RETCBNC.2

OIPID.2 RETCBNC.2

[1,] 0.002840289 0.9971597
[2,] 0.117005856 0.8829941
[3,] 0.170113255 0.8298867
[4,] 0.169651836 0.8303482
[5,] 0.202905245 0.7970948
[6,] 0.222341030 0.7776590
[7,] 0.222881487 0.7771185
[8,] 0.225634482 0.7743655
[9,] 0.228886883 0.7711131
[10,] 0.229460065 0.7705399
[11,] 0.229488321 0.7705117
[12,] 0.229749303 0.7702507

“FEVD determines how much” of the forecast error variance of oil price can be explained

exogenous shocks to the renewable energy consumption **in SD**

\$RETCBSD.2

OIPID.2 RETCBSD.2

[1,]	0.05219237	0.9478076
[2,]	0.25189696	0.7481030
[3,]	0.25829524	0.7417048
[4,]	0.49054122	0.5094588
[5,]	0.48574438	0.5142556
[6,]	0.49164903	0.5083510
[7,]	0.49274423	0.5072558
[8,]	0.52155317	0.4784468
[9,]	0.54808840	0.4519116
[10,]	0.57884917	0.4211508
[11,]	0.58936938	0.4106306
[12,]	0.62579844	0.3742016

“FEVD determines how much” of the forecast error variance of oil price can be explained

exogenous shocks to the renewable energy consumption **in VT**.

\$RETCBVT.2

OIPID.2 RETCBVT.2

[1,]	0.008858972	0.9911410
[2,]	0.002678912	0.9973211
[3,]	0.041436979	0.9585630
[4,]	0.071805647	0.9281944
[5,]	0.249704182	0.7502958
[6,]	0.323628296	0.6763717
[7,]	0.316656376	0.6833436
[8,]	0.371410539	0.6285895
[9,]	0.377613051	0.6223869
[10,]	0.437994200	0.5620058
[11,]	0.492871854	0.5071281
[12,]	0.472389907	0.5276101

Appendix D.2: FEVD results of TETCB

“FEVD determines how much” of the forecast error variance of Total Energy Consumption per Capita (TETCB) can be explained exogenous shocks to the renewable Energy Consumption (RETCB) **in ML**.

\$RETCBMI.2

TETPBMI.2 RETCBMI.2

[1,]	0.006362529	0.9936375
[2,]	0.055443033	0.9445570
[3,]	0.277360806	0.7226392
[4,]	0.611639571	0.3883604
[5,]	0.645995756	0.3540042
[6,]	0.694968417	0.3050316
[7,]	0.733959676	0.2660403
[8,]	0.735020427	0.2649796
[9,]	0.698640381	0.3013596
[10,]	0.708023508	0.2919765
[11,]	0.684461011	0.3155390
[12,]	0.678341640	0.3216584

“FEVD determines how much” of the forecast error variance of Total Energy Consumption per Capita (TETCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in MN**.

\$RETCBMN.2

TETPBMN.2 RETCBMN.2

[1,]	0.1780822	0.8219178
[2,]	0.1968416	0.8031584
[3,]	0.1816360	0.8183640
[4,]	0.1833308	0.8166692
[5,]	0.2410401	0.7589599
[6,]	0.2560889	0.7439111
[7,]	0.2552778	0.7447222
[8,]	0.2549969	0.7450031
[9,]	0.2547921	0.7452079
[10,]	0.2551388	0.7448612
[11,]	0.2546410	0.7453590
[12,]	0.2544664	0.7455336

“FEVD determines how much” of the forecast error variance of Total Energy Consumption per Capita (TETCB) can be explained exogenous shocks to the renewable Energy Consumption (RETCB) **in MO.**

\$RETCBMO.2

TETPBMO.2 RETCBMO.2
 [1,] 0.08148512 0.9185149
 [2,] 0.11865145 0.8813485
 [3,] 0.12408051 0.8759195
 [4,] 0.10482190 0.8951781
 [5,] 0.11472087 0.8852791
 [6,] 0.11897053 0.8810295
 [7,] 0.11515473 0.8848453
 [8,] 0.11815852 0.8818415
 [9,] 0.11978620 0.8802138
 [10,] 0.11899808 0.8810019
 [11,] 0.11976713 0.8802329
 [12,] 0.12025774 0.8797423

“FEVD determines how much” of the forecast error variance of Total Energy Consumption per Capita (TETCB) can be explained exogenous shocks to the renewable Energy Consumption (RETCB) **in CA.**

\$RETCBCA.2

TETCBCA.2 RETCBCA.2
 [1,] 0.01526988 0.9847301
 [2,] 0.01702294 0.9829771
 [3,] 0.08238858 0.9176114
 [4,] 0.08785372 0.9121463
 [5,] 0.17496217 0.8250378
 [6,] 0.27539043 0.7246096
 [7,] 0.30190284 0.6980972
 [8,] 0.30179354 0.6982065
 [9,] 0.30367338 0.6963266
 [10,] 0.30943467 0.6905653
 [11,] 0.32112753 0.6788725
 [12,] 0.32353769 0.6764623

“FEVD determines how much” of the forecast error variance of Total Energy Consumption per Capita (TETCB) can be explained exogenous shocks to the renewable Energy Consumption (RETCB) **in SD.**

\$RETCBSD.2

TETCBSD.2 RETCBSD.2
 [1,] 0.03597339 0.9640266
 [2,] 0.05282217 0.9471778
 [3,] 0.05311118 0.9468888
 [4,] 0.05903661 0.9409634
 [5,] 0.05738468 0.9426153
 [6,] 0.18995944 0.8100406
 [7,] 0.27747182 0.7225282
 [8,] 0.27519455 0.7248054
 [9,] 0.30625820 0.6937418
 [10,] 0.32916132 0.6708387
 [11,] 0.33195161 0.6680484
 [12,] 0.33460487 0.6653951

Appendix D.3: FEVD results of TERPB

“FEVD determines how much” of the forecast error variance of Total Energy Consumption per capita in the Residential Sector (TERPB) can be explained exogenous shocks to the renewable Energy Consumption **in MI.**

\$RETCBMI.2

TERPBMI.2 RETCBMI.2
 [1,] 0.2206536 0.7793464
 [2,] 0.3454520 0.6545480
 [3,] 0.3457730 0.6542270
 [4,] 0.4448359 0.5551641
 [5,] 0.5072669 0.4927331
 [6,] 0.5087772 0.4912228
 [7,] 0.5228839 0.4771161
 [8,] 0.5398650 0.4601350
 [9,] 0.5421944 0.4578056
 [10,] 0.5432858 0.4567142
 [11,] 0.5469190 0.4530810
 [12,] 0.5482562 0.4517438

“FEVD determines how much” the forecast error variance of Total Energy Consumption per capita in the Residential Sector (TERPB) can be explained exogenous shocks to the renewable Energy Consumption **in MN.**

```
$RETCBMN.2
  TERPBMN.2 RETCBMN.2
[1,] 0.07289476 0.9271052
[2,] 0.05568463 0.9443154
[3,] 0.10240957 0.8975904
[4,] 0.12570877 0.8742912
[5,] 0.12456234 0.8754377
[6,] 0.12747787 0.8725221
[7,] 0.12740390 0.8725961
[8,] 0.12786344 0.8721366
[9,] 0.12986226 0.8701377
[10,] 0.13015782 0.8698422
[11,] 0.13028749 0.8697125
[12,] 0.13050713 0.8694929
```

“FEVD determines how much” of the forecast error variance of of Total Energy Consumption per capita in the Residential Sector (TERPB) can be explained exogenous shocks to the renewable Energy Consumption **in RI.**

```
$RETCBRI.2
  OIPID.2 RETCBRI.2
[1,] 0.0007966708 0.9992033
[2,] 0.0708041976 0.9291958
[3,] 0.0868245903 0.9131754
[4,] 0.0952845262 0.9047155
[5,] 0.1039362796 0.8960637
[6,] 0.2429210905 0.7570789
[7,] 0.2462974791 0.7537025
[8,] 0.2580347884 0.7419652
[9,] 0.2750749778 0.7249250
[10,] 0.2672910047 0.7327090
[11,] 0.2569005311 0.7430995
[12,] 0.2552842100 0.7447158
```

“FEVD determines how much” of the forecast error variance of Total Energy Consumption per capita in the Residential Sector (TERPB) can be explained exogenous shocks to the Renewable Energy Consumption **in CA.**

\$RETCBCA.2

TETCBCA.2 RETCBCA.2

[1,] 0.2388974 0.7611026
[2,] 0.4995424 0.5004576
[3,] 0.5683133 0.4316867
[4,] 0.5903114 0.4096886
[5,] 0.6535942 0.3464058
[6,] 0.6185845 0.3814155
[7,] 0.5974207 0.4025793
[8,] 0.5933727 0.4066273
[9,] 0.5958061 0.4041939
[10,] 0.5961803 0.4038197
[11,] 0.6166755 0.3833245
[12,] 0.6210848 0.3789152

“FEVD determines how much” of the forecast error variance of Total Energy Consumption per capita in the Residential Sector (TERPB) can be explained exogenous shocks to the Renewable Energy Consumption **in DE**

\$RETCBDE.2

TETCBDE.2 RETCBDE.2

[1,] 0.08606814 0.9139319
[2,] 0.08134078 0.9186592
[3,] 0.08645732 0.9135427
[4,] 0.16073801 0.8392620
[5,] 0.15297973 0.8470203
[6,] 0.18540621 0.8145938
[7,] 0.22657470 0.7734253
[8,] 0.22707721 0.7729228
[9,] 0.24416479 0.7558352
[10,] 0.24562481 0.7543752
[11,] 0.26215297 0.7378470
[12,] 0.27593175 0.7240682

“FEVD determines how much” of the forecast error variance of Total Energy Consumption per capita in the Residential Sector (TERPB) can be explained exogenous shocks to the Renewable Energy Consumption **in ME.**

RETCBDE.2

TETCBDE.2 RETCBDE.2

[1,] 0.08606814 0.9139319
[2,] 0.08134078 0.9186592
[3,] 0.08645732 0.9135427
[4,] 0.16073801 0.8392620
[5,] 0.15297973 0.8470203
[6,] 0.18540621 0.8145938
[7,] 0.22657470 0.7734253

[8,] 0.22707721 0.7729228
 [9,] 0.24416479 0.7558352
 [10,] 0.24562481 0.7543752
 [11,] 0.26215297 0.7378470
 [12,] 0.27593175 0.7240682

“FEVD determines how much” of the forecast error variance of Total Energy Consumption per capita in the Residential Sector (TERPB) can be explained exogenous shocks to the Renewable Energy Consumption **in NV**

\$RETCBNV.2
 TETCBNV.2 RETCBNV.2
 [1,] 0.09315498 0.9068450
 [2,] 0.12610116 0.8738988
 [3,] 0.12901457 0.8709854
 [4,] 0.16461921 0.8353808
 [5,] 0.33471495 0.6652850
 [6,] 0.34070290 0.6592971
 [7,] 0.34134614 0.6586539
 [8,] 0.34157217 0.6584278
 [9,] 0.33898079 0.6610192
 [10,] 0.33824033 0.6617597
 [11,] 0.33764239 0.6623576
 [12,] 0.35945886 0.6405411

“FEVD determines how much” of the forecast error variance of Total Energy Consumption per capita in the Residential Sector (TERPB) can be explained exogenous shocks to the Renewable Energy Consumption **in SD.**

\$RETCBSD.2
 TETCBSD.2 RETCBSD.2
 [1,] 0.1626802 0.8373198
 [2,] 0.1651898 0.8348102
 [3,] 0.2967011 0.7032989
 [4,] 0.3730019 0.6269981
 [5,] 0.4050185 0.5949815
 [6,] 0.4787279 0.5212721
 [7,] 0.6803566 0.3196434
 [8,] 0.7083420 0.2916580
 [9,] 0.6957106 0.3042894
 [10,] 0.6990748 0.3009252
 [11,] 0.7047557 0.2952443
 [12,] 0.7018181 0.2981819

“FEVD determines how much” of the forecast error variance of Total Energy Consumption per capita in the Residential Sector (TERPB) can be explained exogenous shocks to the Renewable Energy Consumption **in WI.**

```
$RETCBWI.2
      TETCBWI.2 RETCBWI.2
[1,] 0.07327201 0.9267280
[2,] 0.26948701 0.7305130
[3,] 0.33629671 0.6637033
[4,] 0.36262044 0.6373796
[5,] 0.37131343 0.6286866
[6,] 0.38014740 0.6198526
[7,] 0.34196131 0.6580387
[8,] 0.41838017 0.5816198
[9,] 0.41657251 0.5834275
[10,] 0.41357437 0.5864256
[11,] 0.40913636 0.5908636
[12,] 0.40996559 0.5900344
```

Appendix D.4: FEVD of FFTCB

“FEVD determines how much” of the forecast error variance of Total Consumption of Fossil Fels (FFTCB) can be explained by exogenous shocks to the Renewable Energy Consumption (RETCB) **in MI.**

```
$RETCBMI.2
      FFTCBMI.2 RETCBMI.2
[1,] 0.0004953753 0.9995046
[2,] 0.0008389741 0.9991610
[3,] 0.1187604824 0.8812395
[4,] 0.1264516239 0.8735484
[5,] 0.1185021361 0.8814979
[6,] 0.2148842687 0.7851157
[7,] 0.2265301155 0.7734699
[8,] 0.2267091869 0.7732908
[9,] 0.2455428990 0.7544571
[10,] 0.2489782888 0.7510217
[11,] 0.2575638047 0.7424362
[12,] 0.2318886218 0.7681114
```

“FEVD determines how much” of the forecast error variance of the Total Consumption of Fossil Fels (FFTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in CA.**

```
$RETCBCA.2
  FFTCBCA.2 RETCBCA.2
[1,] 0.2844091 0.7155909
[2,] 0.2734594 0.7265406
[3,] 0.2903093 0.7096907
[4,] 0.3404964 0.6595036
[5,] 0.5012929 0.4987071
[6,] 0.4957035 0.5042965
[7,] 0.5007997 0.4992003
[8,] 0.5023124 0.4976876
[9,] 0.4904255 0.5095745
[10,] 0.5326796 0.4673204
[11,] 0.5335551 0.4664449
[12,] 0.5555292 0.4444708
```

“FEVD determines how much” of the forecast error variance of the Total Consumption of Fossil Fels (FFTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in GA.**

```
$RETCBGA.2
  FFTCBGA.2 RETCBGA.2
[1,] 0.07139186 0.9286081
[2,] 0.22690140 0.7730986
[3,] 0.30672295 0.6932771
[4,] 0.33575291 0.6642471
[5,] 0.34280943 0.6571906
[6,] 0.34357007 0.6564299
[7,] 0.34343992 0.6565601
[8,] 0.34341285 0.6565871
[9,] 0.34344918 0.6565508
[10,] 0.34347635 0.6565236
[11,] 0.34348623 0.6565138
[12,] 0.34348822 0.6565118
```

“FEVD determines how much” of the forecast error variance of the Total Consumption of Fossil Fels (FFTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in ME.**

\$RETCBME.2

FFTCBME.2 RETCBME.2

[1,] 0.01782244 0.9821776
[2,] 0.01337124 0.9866288
[3,] 0.06728820 0.9327118
[4,] 0.14169273 0.8583073
[5,] 0.16152113 0.8384789
[6,] 0.16161186 0.8383881
[7,] 0.16426074 0.8357393
[8,] 0.16593498 0.8340650
[9,] 0.16596162 0.8340384
[10,] 0.16620061 0.8337994
[11,] 0.16638449 0.8336155
[12,] 0.16638967 0.8336103

“FEVD determines how much” of the forecast error variance of Total Consumption of Fossil Fels (FFTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in SD.**

\$RETCBSD.2

FFTCBSD.2 RETCBS.2

[1,] 0.03451906 0.9654809
[2,] 0.03350711 0.9664929
[3,] 0.02938369 0.9706163
[4,] 0.03208942 0.9679106
[5,] 0.03837827 0.9616217
[6,] 0.16331113 0.8366889
[7,] 0.39582981 0.6041702
[8,] 0.39920937 0.6007906
[9,] 0.36989027 0.6301097
[10,] 0.38166236 0.6183376
[11,] 0.39404392 0.6059561
[12,] 0.39662883 0.6033712

“FEVD determines how much” of the forecast error variance of Total Consumption of Fossil Fels (FFTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in VT.**

\$RETCBVT.2

FFTCBVT.2 RETCBVT.2

[1,] 0.00020623 0.9997938
[2,] 0.18543252 0.8145675
[3,] 0.29778718 0.7022128
[4,] 0.27258796 0.7274120
[5,] 0.27252381 0.7274762

[6,] 0.30529553 0.6947045
 [7,] 0.32640971 0.6735903
 [8,] 0.26449685 0.7355031
 [9,] 0.25148721 0.7485128
 [10,] 0.27989109 0.7201089
 [11,] 0.28991073 0.7100893
 [12,] 0.27296718 0.7270328

Appendix D.5: FEVD of CLTCP

“FEVD determines how much” of the forecast error variance of the Total Consumption of Total Coal Consumption in thousand short tons (CLTCP) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in MI**

\$RETCBFL.2
 CLTCPFL.2 RETCBFL.2
 [1,] 4.684306e-05 0.9999532
 [2,] 6.515257e-04 0.9993485
 [3,] 4.753331e-02 0.9524667
 [4,] 1.685578e-01 0.8314422
 [5,] 2.108799e-01 0.7891201
 [6,] 2.102232e-01 0.7897768
 [7,] 2.344728e-01 0.7655272
 [8,] 2.548864e-01 0.7451136
 [9,] 2.571406e-01 0.7428594
 [10,] 2.581644e-01 0.7418356
 [11,] 2.614197e-01 0.7385803
 [12,] 2.628375e-01 0.7371625

“FEVD determines how much” of the forecast error variance of the Total Consumption of Total Coal Consumption in thousand short tons (CLTCP) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in GA**

\$RETCBGA.2
 CLTCPGA.2 RETCBGA.2
 [1,] 0.03945617 0.9605438
 [2,] 0.13743146 0.8625685
 [3,] 0.17402786 0.8259721
 [4,] 0.17382327 0.8261767
 [5,] 0.19517630 0.8048237
 [6,] 0.20319591 0.7968041
 [7,] 0.20372046 0.7962795
 [8,] 0.20826657 0.7917334
 [9,] 0.20900492 0.7909951
 [10,] 0.20958619 0.7904138
 [11,] 0.21058578 0.7894142
 [12,] 0.21060775 0.7893923

Appendix D.6: FEVD of NNRCB

“FEVD determines how much” the Total Consumption of Natural Gas consumed by the Residential Sector (NNRCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in MI**

\$RETCBMI.2

NNRCBMI.2 RETCBMI.2

[1,] 0.2984099 0.7015901
[2,] 0.3092933 0.6907067
[3,] 0.3239536 0.6760464
[4,] 0.4015450 0.5984550
[5,] 0.4137153 0.5862847
[6,] 0.4201755 0.5798245
[7,] 0.4390948 0.5609052
[8,] 0.4412620 0.5587380
[9,] 0.4436388 0.5563612
[10,] 0.4477580 0.5522420
[11,] 0.4479829 0.5520171
[12,] 0.4487544 0.5512456

“FEVD determines how much” the Total Consumption of Natural Gas consumed by the Residential Sector (NNRCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in MN**

\$RETCBMN.2

NNRCBMN.2 RETCBMN.2

[1,] 0.06831801 0.9316820
[2,] 0.08523258 0.9147674
[3,] 0.28062358 0.7193764
[4,] 0.35829368 0.6417063
[5,] 0.35434407 0.6456559
[6,] 0.36144198 0.6385580
[7,] 0.36078967 0.6392103
[8,] 0.36574162 0.6342584
[9,] 0.37539470 0.6246053
[10,] 0.37619717 0.6238028
[11,] 0.37742072 0.6225793
[12,] 0.37861548 0.6213845

“FEVD determines how much” the Total Consumption of Natural Gas consumed by the Residential Sector (NNRCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in NY**

\$RETCBNY.2

NNRCBNY.2 RETCBNY.2

[1,] 0.2291317 0.7708683
[2,] 0.4552117 0.5447883
[3,] 0.5290092 0.4709908
[4,] 0.5600821 0.4399179
[5,] 0.5576306 0.4423694
[6,] 0.5519563 0.4480437
[7,] 0.5340074 0.4659926
[8,] 0.5282420 0.4717580
[9,] 0.5590634 0.4409366
[10,] 0.5601246 0.4398754
[11,] 0.5600109 0.4399891
[12,] 0.5649291 0.4350709

“FEVD determines how much” the Total Consumption of Natural Gas consumed by the Residential Sector (NNRCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in RI**

\$RETCBRI.2

NNRCBRI.2 RETCBRI.2

[1,] 0.03467849 0.9653215
[2,] 0.02594717 0.9740528
[3,] 0.31882900 0.6811710
[4,] 0.57156065 0.4284393
[5,] 0.56808160 0.4319184
[6,] 0.56959227 0.4304077
[7,] 0.65862222 0.3413778
[8,] 0.73358476 0.2664152
[9,] 0.74674628 0.2532537
[10,] 0.75738779 0.2426122
[11,] 0.76126477 0.2387352
[12,] 0.75819486 0.2418051

“FEVD determines how much” the Total Consumption of Natural Gas consumed by the Residential Sector (NNRCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in GA**

\$RETCBGA.2

NNRCBGA.2 RETCBGA.2

[1,] 0.06496174 0.9350383
[2,] 0.09207445 0.9079256
[3,] 0.21711800 0.7828820

[4,] 0.31399036 0.6860096
 [5,] 0.31707427 0.6829257
 [6,] 0.32317337 0.6768266
 [7,] 0.32556971 0.6744303
 [8,] 0.34736382 0.6526362
 [9,] 0.35101258 0.6489874
 [10,] 0.35057297 0.6494270
 [11,] 0.34943753 0.6505625
 [12,] 0.35085065 0.6491494

“FEVD determines how much” the Total Consumption of Natural Gas consumed by the
 Residential Sector (NNRCB) can be explained exogenous shocks to the Renewable Energy
 Consumption (RETCB) **in NV**

\$RETCBNV.2
 NNRCBNV.2 RETCBNV.2
 [1,] 0.02529064 0.9747094
 [2,] 0.02215339 0.9778466
 [3,] 0.10726192 0.8927381
 [4,] 0.19825446 0.8017455
 [5,] 0.29432507 0.7056749
 [6,] 0.38907062 0.6109294
 [7,] 0.39451862 0.6054814
 [8,] 0.39914861 0.6008514
 [9,] 0.41872463 0.5812754
 [10,] 0.43300569 0.5669943
 [11,] 0.43643671 0.5635633
 [12,] 0.43430311 0.5656969

“FEVD determines how much” the Total Consumption of Natural Gas consumed by the
 Residential Sector (NNRCB) can be explained exogenous shocks to the Renewable Energy
 Consumption (RETCB) **in VT**

\$RETCBVT.2
 NNRCBVT.2 RETCBVT.2
 [1,] 0.016263264 0.9837367
 [2,] 0.006226016 0.9937740
 [3,] 0.031783099 0.9682169
 [4,] 0.073912681 0.9260873
 [5,] 0.094448914 0.9055511
 [6,] 0.094207143 0.9057929
 [7,] 0.170412731 0.8295873
 [8,] 0.295551876 0.7044481
 [9,] 0.297004666 0.7029953
 [10,] 0.310406518 0.6895935

[11,] 0.310812624 0.6891874
 [12,] 0.366764341 0.6332357

Appendix D.7: FEVD of ESTCB

“FEVD determines how much” the forecast error variance of Electricity Total Consumption (ESTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) in MI where Y.2 is represented the Renewable energy consumption and X.2 is represented ESTCB

\$Y.2

	X.2	Y.2
[1,]	0.01703414	0.9829659
[2,]	0.05860403	0.9413960
[3,]	0.05758191	0.9424181
[4,]	0.15359514	0.8464049
[5,]	0.31350982	0.6864902
[6,]	0.31352477	0.6864752
[7,]	0.30507039	0.6949296
[8,]	0.33896578	0.6610342
[9,]	0.27860412	0.7213959
[10,]	0.30096795	0.6990320
[11,]	0.27857975	0.7214202
[12,]	0.26122901	0.7387710

“FEVD determines how much” the Electricity Total Consumption (ESTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) in MN where Y.2 is represented the Renewable energy consumption and X.2 is represented ESTCB

\$Y.2

	X.2	Y.2
[1,]	0.04747766	0.9525223
[2,]	0.08836911	0.9116309
[3,]	0.11099691	0.8890031
[4,]	0.10651778	0.8934822
[5,]	0.16014447	0.8398555
[6,]	0.26766439	0.7323356
[7,]	0.27252267	0.7274773
[8,]	0.27269255	0.7273074

[9,] 0.26660067 0.7333993
 [10,] 0.26448001 0.7355200
 [11,] 0.26732554 0.7326745
 [12,] 0.26610648 0.7338935

“FEVD determines how much” the Electricity Total Consumption (ESTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) in NY where Y.2 is represented the Renewable energy consumption and X.2 is represented ESTCB

\$Y.2
 X.2 Y.2
 [1,] 0.05112538 0.9488746
 [2,] 0.03026102 0.9697390
 [3,] 0.08833656 0.9116634
 [4,] 0.09507327 0.9049267
 [5,] 0.17771406 0.8222859
 [6,] 0.34546841 0.6545316
 [7,] 0.53046226 0.4695377
 [8,] 0.59836622 0.4016338
 [9,] 0.58883764 0.4111624
 [10,] 0.62499965 0.3750003
 [11,] 0.63682492 0.3631751
 [12,] 0.59139337 0.4086066

“FEVD determines how much” the Electricity Total Consumption (ESTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) in RI where Y.2 is represented the Renewable energy consumption and X.2 is represented ESTCB

\$Y.2
 X.2 Y.2
 [1,] 0.2784686 0.7215314
 [2,] 0.3748327 0.6251673
 [3,] 0.5488683 0.4511317
 [4,] 0.5911744 0.4088256
 [5,] 0.5896925 0.4103075
 [6,] 0.6015833 0.3984167
 [7,] 0.6181212 0.3818788
 [8,] 0.6164244 0.3835756
 [9,] 0.6290001 0.3709999
 [10,] 0.6190137 0.3809863
 [11,] 0.6147353 0.3852647
 [12,] 0.6249051 0.3750949

“FEVD determines how much” the Electricity Total Consumption (ESTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in CA** where Y.2 is represented the Renewable energy consumption and X.2 is represented ESTCB

\$Y.1

	X.1	Y.1
[1,]	0.003180777	0.9968192
[2,]	0.002291162	0.9977088
[3,]	0.101409394	0.8985906
[4,]	0.102190336	0.8978097
[5,]	0.146473220	0.8535268
[6,]	0.329283516	0.6707165
[7,]	0.329445418	0.6705546
[8,]	0.326829486	0.6731705
[9,]	0.310000826	0.6899992
[10,]	0.347081698	0.6529183
[11,]	0.342198104	0.6578019
[12,]	0.342229662	0.6577703

“FEVD determines how much” Electricity Total Consumption (ESTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in GA** where Y.2 is represented the Renewable energy consumption and X.2 is represented ESTCB

Y.2

	X.2	Y.2
[1,]	0.05114735	0.9488526
[2,]	0.15462547	0.8453745
[3,]	0.23201842	0.7679816
[4,]	0.27612453	0.7238755
[5,]	0.29748744	0.7025126
[6,]	0.30656878	0.6934312
[7,]	0.30997317	0.6900268
[8,]	0.31108624	0.6889138
[9,]	0.31139313	0.6886069
[10,]	0.31145803	0.6885420
[11,]	0.31146484	0.6885352
[12,]	0.31146290	0.6885371

“FEVD determines how much” the Electricity Total Consumption (ESTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in IA** where

Y.2 is represented the Renewable energy consumption and X.2 is represented ESTCB

\$Y.2

	X.2	Y.2
[1,]	0.03495798	0.9650420
[2,]	0.06779245	0.9322075
[3,]	0.10332256	0.8966774
[4,]	0.11637584	0.8836242
[5,]	0.11931492	0.8806851
[6,]	0.11972646	0.8802735
[7,]	0.11974893	0.8802511
[8,]	0.11974689	0.8802531
[9,]	0.11974788	0.8802521
[10,]	0.11974882	0.8802512
[11,]	0.11974916	0.8802508
[12,]	0.11974923	0.8802508

“FEVD determines how much” the Electricity Total Consumption (ESTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in ME**

where Y.2 is represented the Renewable energy consumption and X.2 is represented ESTCB”

\$Y.2

	X.2	Y.2
[1,]	0.02140880	0.9785912
[2,]	0.03328880	0.9667112
[3,]	0.03387443	0.9661256
[4,]	0.03297861	0.9670214
[5,]	0.04513917	0.9548608
[6,]	0.05617009	0.9438299
[7,]	0.08725999	0.9127400
[8,]	0.12436349	0.8756365
[9,]	0.20893533	0.7910647
[10,]	0.21028100	0.7897190
[11,]	0.30783979	0.6921602
[12,]	0.36473056	0.6352694

“FEVD determines how much” the Electricity Total Consumption (ESTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in NC**

where Y.2 is represented the Renewable energy consumption and X.2 is represented ESTCB”

\$Y.2

	X.2	Y.2
[1,]	0.10439129	0.8956087
[2,]	0.08926783	0.9107322
[3,]	0.10552672	0.8944733
[4,]	0.13489925	0.8651007
[5,]	0.14447699	0.8555230
[6,]	0.14538766	0.8546123
[7,]	0.16753617	0.8324638
[8,]	0.18260486	0.8173951
[9,]	0.18327105	0.8167289
[10,]	0.18271463	0.8172854
[11,]	0.18498380	0.8150162
[12,]	0.18735753	0.8126425

“FEVD determines how much” the Electricity Total Consumption (ESTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in OR** where Y.2 is represented the Renewable energy consumption and X.2 is represented ESTCB”

\$Y.2

	X.2	Y.2
[1,]	0.04394204	0.9560580
[2,]	0.13359157	0.8664084
[3,]	0.13935159	0.8606484
[4,]	0.14496811	0.8550319
[5,]	0.16657980	0.8334202
[6,]	0.16958731	0.8304127
[7,]	0.17076591	0.8292341
[8,]	0.17275893	0.8272411
[9,]	0.17276175	0.8272382
[10,]	0.17318589	0.8268141
[11,]	0.17340476	0.8265952
[12,]	0.17341173	0.8265883

“FEVD determines how much” Electricity Total Consumption (ESTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) **in SD** where Y.2 is represented the Renewable energy consumption and X.2 is represented ESTCB”

\$Y.2

	X.2	Y.2
[1,]	0.0001500917	0.9998499
[2,]	0.0165325015	0.9834675
[3,]	0.0735260842	0.9264739
[4,]	0.2350158705	0.7649841
[5,]	0.2585760492	0.7414240
[6,]	0.3470135292	0.6529865
[7,]	0.4388416246	0.5611584
[8,]	0.4522662972	0.5477337
[9,]	0.4510066493	0.5489934
[10,]	0.4654013797	0.5345986
[11,]	0.5029556512	0.4970443
[12,]	0.5076573760	0.4923426

“FEVD determines how much” the Electricity Total Consumption (ESTCB) can be explained exogenous shocks to the Renewable Energy Consumption (RETCB) in TN where Y.2 is represented the Renewable energy consumption and X.2 is represented ESTCB

\$Y.2

	X.2	Y.2
[1,]	0.10256606	0.8974339
[2,]	0.05588507	0.9441149
[3,]	0.05087657	0.9491234
[4,]	0.06008174	0.9399183
[5,]	0.09051509	0.9094849
[6,]	0.10181931	0.8981807
[7,]	0.10150549	0.8984945
[8,]	0.10302690	0.8969731
[9,]	0.10348387	0.8965161
[10,]	0.10350336	0.8964966
[11,]	0.10359653	0.8964035
[12,]	0.10373531	0.8962647

Appendix D.8: FEVD of Income

“FEVD determines how much” the personal income per capita (dollars) can be explained exogenous shocks to the renewable energy consumption in MI where Y.2 is represented

the Renewable energy consumption and X.2 is represented personal income per capita (dollars)

Y.2

	X.2	Y.2
[1,]	0.02712875	0.9728712
[2,]	0.03681648	0.9631835
[3,]	0.05112400	0.9488760
[4,]	0.05133162	0.9486684
[5,]	0.18819341	0.8118066
[6,]	0.18907085	0.8109292
[7,]	0.30338158	0.6966184
[8,]	0.34058274	0.6594173
[9,]	0.39824504	0.6017550
[10,]	0.47700961	0.5229904
[11,]	0.51604563	0.4839544
[12,]	0.51711094	0.4828891

“FEVD determines how much” the personal income per capita (dollars) can be explained exogenous shocks to the renewable energy consumption in MN where Y.2 is represented the Renewable energy consumption and X.2 is represented personal income per capita (dollars)

\$Y.2

	X.2	Y.2
[1,]	0.03370307	0.9662969
[2,]	0.02811669	0.9718833
[3,]	0.06203017	0.9379698
[4,]	0.13414101	0.8658590
[5,]	0.12419718	0.8758028
[6,]	0.22272293	0.7772771
[7,]	0.29741960	0.7025804
[8,]	0.27315338	0.7268466
[9,]	0.30249056	0.6975094
[10,]	0.40092781	0.5990722
[11,]	0.41382236	0.5861776
[12,]	0.40159409	0.5984059

“FEVD determines how much” the personal income per capita (dollars) can be explained exogenous shocks to the renewable energy consumption in MO where Y.2 is represented

the Renewable energy consumption and X.2 is represented personal income per capita (dollars)

\$Y.2

	X.2	Y.2
[1,]	0.08470293	0.9152971
[2,]	0.27705140	0.7229486
[3,]	0.25783459	0.7421654
[4,]	0.23560229	0.7643977
[5,]	0.24678883	0.7532112
[6,]	0.25193440	0.7480656
[7,]	0.25151475	0.7484853
[8,]	0.26396150	0.7360385
[9,]	0.27230901	0.7276910
[10,]	0.27032737	0.7296726
[11,]	0.26870208	0.7312979
[12,]	0.26814971	0.7318503

“FEVD determines how much” the personal income per capita (dollars) can be explained exogenous shocks to the renewable energy consumption **in NE** where Y.2 is represented the Renewable energy consumption and X.2 is represented personal income per capita (dollars)

\$Y.2

	X.2	Y.2
[1,]	0.02508242	0.9749176
[2,]	0.18149930	0.8185007
[3,]	0.23024163	0.7697584
[4,]	0.26412441	0.7358756
[5,]	0.26744760	0.7325524
[6,]	0.27013533	0.7298647
[7,]	0.26838623	0.7316138
[8,]	0.27184037	0.7281596
[9,]	0.27184502	0.7281550
[10,]	0.27130579	0.7286942
[11,]	0.27500990	0.7249901
[12,]	0.27560368	0.7243963

“FEVD determines how much” the personal income per capita (dollars) can be explained exogenous shocks to the renewable energy consumption **in CA** where Y.2 is represented

the Renewable energy consumption and X.2 is represented personal income per capita (dollars)

\$Y.2

	X.2	Y.2
[1,]	0.07741281	0.9225872
[2,]	0.17058324	0.8294168
[3,]	0.16930354	0.8306965
[4,]	0.19281973	0.8071803
[5,]	0.20243001	0.7975700
[6,]	0.21845558	0.7815444
[7,]	0.23694071	0.7630593
[8,]	0.24268479	0.7573152
[9,]	0.25270913	0.7472909
[10,]	0.26659385	0.7334062
[11,]	0.27047136	0.7295286
[12,]	0.27178856	0.7282114

“FEVD determines how much” the personal income per capita (dollars) can be explained exogenous shocks to the renewable energy consumption **in DE** where Y.2 is represented the Renewable energy consumption and X.2 is represented personal income per capita (dollars).

\$Y.2

	X.2	Y.2
[1,]	9.839896e-05	0.9999016
[2,]	3.950743e-01	0.6049257
[3,]	4.625372e-01	0.5374628
[4,]	4.897905e-01	0.5102095
[5,]	4.999554e-01	0.5000446
[6,]	5.067234e-01	0.4932766
[7,]	5.591364e-01	0.4408636
[8,]	5.756072e-01	0.4243928
[9,]	5.746243e-01	0.4253757
[10,]	5.780150e-01	0.4219850
[11,]	5.816922e-01	0.4183078
[12,]	5.832380e-01	0.4167620

“FEVD determines how much” the personal income per capita (dollars) can be explained exogenous shocks to the renewable energy consumption **in GA** where Y.2 is represented

the Renewable energy consumption and X.2 is represented personal income per capita (dollars)

\$Y.2

	X.2	Y.2
[1,]	0.02280306	0.9771969
[2,]	0.03931181	0.9606882
[3,]	0.05098387	0.9490161
[4,]	0.05579343	0.9442066
[5,]	0.05767087	0.9423291
[6,]	0.05840241	0.9415976
[7,]	0.05868859	0.9413114
[8,]	0.05880088	0.9411991
[9,]	0.05884500	0.9411550
[10,]	0.05886235	0.9411377
[11,]	0.05886917	0.9411308
[12,]	0.05887185	0.9411281

“FEVD determines how much” the personal income per capita (dollars) can be explained exogenous shocks to the renewable energy consumption in IA where Y.2 is represented the Renewable energy consumption and X.2 is represented personal income per capita (dollars)

\$Y.2

	X.2	Y.2
[1,]	0.1965691	0.8034309
[2,]	0.2582159	0.7417841
[3,]	0.2895077	0.7104923
[4,]	0.2928423	0.7071577
[5,]	0.2928672	0.7071328
[6,]	0.2928697	0.7071303
[7,]	0.2928760	0.7071240
[8,]	0.2928768	0.7071232
[9,]	0.2928769	0.7071231
[10,]	0.2928769	0.7071231
[11,]	0.2928769	0.7071231
[12,]	0.2928769	0.7071231

“FEVD determines how much” the personal income per capita (dollars) can be explained exogenous shocks to the renewable energy consumption in ME where Y.2 is represented

the Renewable energy consumption and X.2 is represented personal income per capita (dollars)

\$Y.2

	X.2	Y.2
[1,]	0.02354446	0.9764555
[2,]	0.03723422	0.9627658
[3,]	0.07560555	0.9243944
[4,]	0.30267270	0.6973273
[5,]	0.38100501	0.6189950
[6,]	0.37060668	0.6293933
[7,]	0.39037883	0.6096212
[8,]	0.49415766	0.5058423
[9,]	0.49491601	0.5050840
[10,]	0.54547481	0.4545252
[11,]	0.56672526	0.4332747
[12,]	0.56365047	0.4363495

“FEVD determines how much” the personal income per capita (dollars) can be explained exogenous shocks to the renewable energy consumption in MA where Y.2 is represented the Renewable energy consumption and X.2 is represented personal income per capita (dollars)

\$Y.2

	X.2	Y.2
[1,]	0.06422388	0.9357761
[2,]	0.18685737	0.8131426
[3,]	0.19672503	0.8032750
[4,]	0.21802811	0.7819719
[5,]	0.24759005	0.7524099
[6,]	0.24947020	0.7505298
[7,]	0.24972823	0.7502718
[8,]	0.25074422	0.7492558
[9,]	0.25090344	0.7490966
[10,]	0.25081634	0.7491837
[11,]	0.25075949	0.7492405
[12,]	0.25074875	0.7492513

“FEVD determines how much” the personal income per capita (dollars) can be explained exogenous shocks to the renewable energy consumption in SD where Y.2 is represented

the Renewable energy consumption and X.2 is represented personal income per capita (dollars)

\$Y.2

	X.2	Y.2
[1,]	0.1109893	0.8890107
[2,]	0.1315352	0.8684648
[3,]	0.1388971	0.8611029
[4,]	0.1548016	0.8451984
[5,]	0.1451520	0.8548480
[6,]	0.1490259	0.8509741
[7,]	0.1499206	0.8500794
[8,]	0.1675079	0.8324921
[9,]	0.3028460	0.6971540
[10,]	0.3250317	0.6749683
[11,]	0.4774246	0.5225754
[12,]	0.4955708	0.5044292

“FEVD determines how much” the personal income per capita (dollars) can be explained exogenous shocks to the renewable energy consumption in TN where Y.2 is represented the Renewable energy consumption and X.2 is represented personal income per capita (dollars)

\$Y.2

	X.2	Y.2
[1,]	0.1644667	0.8355333
[2,]	0.1118268	0.8881732
[3,]	0.1299658	0.8700342
[4,]	0.1466631	0.8533369
[5,]	0.1581197	0.8418803
[6,]	0.2293637	0.7706363
[7,]	0.2499639	0.7500361
[8,]	0.2379302	0.7620698
[9,]	0.2394677	0.7605323
[10,]	0.2443713	0.7556287
[11,]	0.2439905	0.7560095
[12,]	0.2667527	0.7332473

“FEVD determines how much” the personal income per capita (dollars) can be explained exogenous shocks to the renewable energy consumption in VT where Y.2 is represented

the Renewable energy consumption and X.2 is represented personal income per capita (dollars)

\$Y.2

	X.2	Y.2
[1,]	0.12741162	0.8725884
[2,]	0.07682674	0.9231733
[3,]	0.36711977	0.6328802
[4,]	0.50196834	0.4980317
[5,]	0.50099408	0.4990059
[6,]	0.53736075	0.4626393
[7,]	0.54410698	0.4558930
[8,]	0.53923322	0.4607668
[9,]	0.53929677	0.4607032
[10,]	0.53943887	0.4605611
[11,]	0.53835213	0.4616479
[12,]	0.53964724	0.4603528

Appendix D.9: FEVD of PETCD

“FEVD determines how much” the Primary Energy Average Price, all sectors in dollars per million Btu (PETCD) can be explained exogenous shocks to the Renewable Energy Consumption in ID where Y.2 is represented the Renewable energy consumption and X.2 is represented PETCD.

\$`Y.2`

	Y.2	X.2
[1,]	1.0000000	0.0000000
[2,]	0.9868421	0.01315786
[3,]	0.9269582	0.07304185
[4,]	0.7838564	0.21614361
[5,]	0.7709261	0.22907392
[6,]	0.7647438	0.23525616
[7,]	0.7330451	0.26695492
[8,]	0.6046762	0.39532382
[9,]	0.6043508	0.39564924
[10,]	0.5710882	0.42891179
[11,]	0.5628727	0.43712735
[12,]	0.5572617	0.44273826

“FEVD determines how much” the Primary Energy Average Price, all sectors in dollars per million Btu (PETCD) can be explained exogenous shocks to the Renewable Energy

Consumption in MI where Y.2 is represented the Renewable energy consumption and X.2 is represented PETCD.

\$Y.2

	X.2	Y.2
[1,]	0.002011928	0.9979881
[2,]	0.059159539	0.9408405
[3,]	0.333285366	0.6667146
[4,]	0.330190976	0.6698090
[5,]	0.397381905	0.6026181
[6,]	0.416687179	0.5833128
[7,]	0.412323667	0.5876763
[8,]	0.423847901	0.5761521
[9,]	0.432369418	0.5676306
[10,]	0.485396904	0.5146031
[11,]	0.458295202	0.5417048
[12,]	0.418943976	0.5810560

“FEVD determines how much” the Primary Energy Average Price, all sectors in dollars per million Btu (PETCD) can be explained exogenous shocks to the Renewable Energy Consumption in MN where Y.2 is represented the Renewable energy consumption and X.2 is represented PETCD.

\$Y.2

	X.2	Y.2
[1,]	0.3881738	0.61182623
[2,]	0.4537371	0.54626290
[3,]	0.5937059	0.40629412
[4,]	0.5902288	0.40977122
[5,]	0.6541043	0.34589566
[6,]	0.8200655	0.17993452
[7,]	0.8524389	0.14756114
[8,]	0.8906769	0.10932305
[9,]	0.9299262	0.07007376
[10,]	0.9402593	0.05974073
[11,]	0.9462923	0.05370766
[12,]	0.9578364	0.04216359

“FEVD determines how much” the Primary Energy Average Price, all sectors in dollars per million Btu (PETCD) can be explained exogenous shocks to the Renewable Energy

Consumption **in MO** where Y.2 is represented the Renewable energy consumption and X.2 is represented PETCD.

\$Y.2

	X.2	Y.2
[1,]	0.007299659	0.9927003
[2,]	0.003453651	0.9965463
[3,]	0.095635912	0.9043641
[4,]	0.089290381	0.9107096
[5,]	0.101697872	0.8983021
[6,]	0.105663290	0.8943367
[7,]	0.202570486	0.7974295
[8,]	0.273106556	0.7268934
[9,]	0.601603335	0.3983967
[10,]	0.612691997	0.3873080
[11,]	0.631389976	0.3686100
[12,]	0.617208649	0.3827914

“FEVD determines how much” the Primary Energy Average Price, all sectors in dollars per million Btu (PETCD) can be explained exogenous shocks to the Renewable Energy Consumption **in NE** where Y.2 is represented the Renewable energy consumption and X.2 is represented PETCD.

\$Y.2

	X.2	Y.2
[1,]	0.04651177	0.9534882
[2,]	0.58880492	0.4111951
[3,]	0.60310819	0.3968918
[4,]	0.63444549	0.3655545
[5,]	0.65817989	0.3418201
[6,]	0.65921686	0.3407831
[7,]	0.65990723	0.3400928
[8,]	0.66036926	0.3396307
[9,]	0.66037807	0.3396219
[10,]	0.66039296	0.3396070
[11,]	0.66039712	0.3396029
[12,]	0.66039716	0.3396028

“FEVD determines how much” the Primary Energy Average Price, all sectors in dollars per million Btu (PETCD) can be explained exogenous shocks to the Renewable Energy

Consumption **in RI** where Y.2 is represented the Renewable energy consumption and X.2 is represented PETCD.

\$Y.2

	X.2	Y.2
[1,]	0.0008053462	0.9991947
[2,]	0.0235139121	0.9764861
[3,]	0.0354433754	0.9645566
[4,]	0.1267355073	0.8732645
[5,]	0.1657592823	0.8342407
[6,]	0.2113413889	0.7886586
[7,]	0.2418930782	0.7581069
[8,]	0.2450273298	0.7549727
[9,]	0.2450673872	0.7549326
[10,]	0.2705926720	0.7294073
[11,]	0.2685183955	0.7314816
[12,]	0.2683634176	0.7316366

““FEVD determines how much” the Primary Energy Average Price, all sectors in dollars per million Btu (PETCD) can be explained exogenous shocks to the Renewable Energy Consumption **in VT** where Y.1 is represented the Renewable energy consumption and X.1 is represented PETCD.

\$Y.1

	X.1	Y.1
[1,]	0.01548769	0.9845123
[2,]	0.01599627	0.9840037
[3,]	0.03642457	0.9635754
[4,]	0.03646510	0.9635349
[5,]	0.03736050	0.9626395
[6,]	0.03705254	0.9629475
[7,]	0.03767366	0.9623263
[8,]	0.03766968	0.9623303
[9,]	0.03778473	0.9622153
[10,]	0.03778637	0.9622136
[11,]	0.03781603	0.9621840
[12,]	0.03782285	0.9621771

“FEVD determines how much” the Natural Gas Average Price, all sectors in dollars per million Btu (NGTCD) can be explained exogenous shocks to the Renewable Energy

Consumption in MI where Y.2 is represented the Renewable energy consumption and X.2 is represented NGTCD.

\$Y.2

	X.2	Y.2
[1,]	0.1652738	0.8347262
[2,]	0.3376419	0.6623581
[3,]	0.3555586	0.6444414
[4,]	0.3796787	0.6203213
[5,]	0.4628409	0.5371591
[6,]	0.4866509	0.5133491
[7,]	0.4857006	0.5142994
[8,]	0.4962614	0.5037386
[9,]	0.5173910	0.4826090
[10,]	0.5278869	0.4721131
[11,]	0.5255381	0.4744619
[12,]	0.5338031	0.4661969

Appendix D.10: FEVD of NGTCD

“FEVD determines how much” the Natural Gas Average Price, all sectors in dollars per million Btu (NGTCD) can be explained exogenous shocks to the Renewable Energy Consumption in MN where Y.2 is represented the Renewable energy consumption and X.2 is represented NGTCD.

\$Y.2

	X.2	Y.2
[1,]	0.05914094	0.9408591
[2,]	0.18055266	0.8194473
[3,]	0.18739852	0.8126015
[4,]	0.19535900	0.8046410
[5,]	0.20423709	0.7957629
[6,]	0.32284550	0.6771545
[7,]	0.38202083	0.6179792
[8,]	0.40355684	0.5964432
[9,]	0.40546835	0.5945316
[10,]	0.40602353	0.5939765
[11,]	0.40279995	0.5972000
[12,]	0.40095596	0.5990440

““FEVD determines how much” the Natural Gas Average Price, all sectors in dollars per million Btu (NGTCD) can be explained exogenous shocks to the Renewable Energy

Consumption **in MO** where Y.2 is represented the Renewable energy consumption and X.2 is represented NGTCD.

\$Y.2

	X.2	Y.2
[1,]	0.07877905	0.9212210
[2,]	0.07331361	0.9266864
[3,]	0.13610967	0.8638903
[4,]	0.13914738	0.8608526
[5,]	0.15684682	0.8431532
[6,]	0.18373586	0.8162641
[7,]	0.21953895	0.7804610
[8,]	0.24999500	0.7500050
[9,]	0.25596622	0.7440338
[10,]	0.26945818	0.7305418
[11,]	0.26436412	0.7356359
[12,]	0.26403868	0.7359613

“FEVD determines how much” the Natural Gas Average Price, all sectors in dollars per million Btu (NGTCD) can be explained exogenous shocks to the Renewable Energy Consumption **in NE** where Y.2 is represented the Renewable energy consumption and X.2 is represented NGTCD.

\$Y.2

	X.2	Y.2
[1,]	0.1674550	0.8325450
[2,]	0.3007736	0.6992264
[3,]	0.2882894	0.7117106
[4,]	0.4198590	0.5801410
[5,]	0.4752450	0.5247550
[6,]	0.4684532	0.5315468
[7,]	0.6458896	0.3541104
[8,]	0.7071689	0.2928311
[9,]	0.8408428	0.1591572
[10,]	0.8474302	0.1525698
[11,]	0.8553615	0.1446385
[12,]	0.8603589	0.1396411

“FEVD determines how much” the Natural Gas Average Price, all sectors in dollars per million Btu (NGTCD) can be explained exogenous shocks to the Renewable Energy

Consumption **in NY** where Y.2 is represented the Renewable energy consumption and X.2 is represented NGTCD.

\$Y.2

	X.2	Y.2
[1,]	0.01561917	0.9843808
[2,]	0.01142724	0.9885728
[3,]	0.06997471	0.9300253
[4,]	0.18632457	0.8136754
[5,]	0.21579581	0.7842042
[6,]	0.21850209	0.7814979
[7,]	0.24108025	0.7589198
[8,]	0.24797947	0.7520205
[9,]	0.24886255	0.7511374
[10,]	0.25494192	0.7450581
[11,]	0.25628895	0.7437110
[12,]	0.25691730	0.7430827

“FEVD determines how much” the Natural Gas Average Price, all sectors in dollars per million Btu (NGTCD) can be explained exogenous shocks to the Renewable Energy Consumption **in GA** where Y.2 is represented the Renewable energy consumption and X.2 is represented NGTCD.

\$Y.2

	X.2	Y.2
[1,]	0.11312359	0.8868764
[2,]	0.09096987	0.9090301
[3,]	0.21865456	0.7813454
[4,]	0.77239785	0.2276022
[5,]	0.87230266	0.1276973
[6,]	0.88754522	0.1124548
[7,]	0.88622914	0.1137709
[8,]	0.88281558	0.1171844
[9,]	0.88396951	0.1160305
[10,]	0.84577592	0.1542241
[11,]	0.79996177	0.2000382
[12,]	0.78448034	0.2155197

“FEVD determines how much” the Natural Gas Average Price, all sectors in dollars per million Btu (NGTCD) can be explained exogenous shocks to the Renewable Energy Consumption **in NC** where Y.2 is represented the Renewable energy consumption and X.2 is represented NGTCD.

\$Y.2

	X.2	Y.2
[1,]	0.008436522	0.9915635
[2,]	0.094483072	0.9055169
[3,]	0.199104186	0.8008958
[4,]	0.211318730	0.7886813
[5,]	0.216265046	0.7837350
[6,]	0.241487324	0.7585127
[7,]	0.250256844	0.7497432
[8,]	0.250256969	0.7497430
[9,]	0.252539129	0.7474609
[10,]	0.254120148	0.7458799
[11,]	0.254252262	0.7457477
[12,]	0.254274171	0.7457258

“FEVD determines how much” the Natural Gas Average Price, all sectors in dollars per million Btu (NGTCD) can be explained exogenous shocks to the Renewable Energy Consumption **in SD** where Y.2 is represented the Renewable energy consumption and X.2 is represented NGTCD.

\$Y.2

	X.2	Y.2
[1,]	0.02234974	0.9776503
[2,]	0.02374048	0.9762595
[3,]	0.02965448	0.9703455
[4,]	0.25631666	0.7436833
[5,]	0.24407037	0.7559296
[6,]	0.23804899	0.7619510
[7,]	0.30741106	0.6925889
[8,]	0.44874382	0.5512562
[9,]	0.45185395	0.5481461
[10,]	0.47543617	0.5245638
[11,]	0.48142093	0.5185791
[12,]	0.48525836	0.5147416

“FEVD determines how much” the Natural Gas Average Price, all sectors in dollars per million Btu (NGTCD) can be explained exogenous shocks to the Renewable Energy Consumption **in VT** where Y.2 is represented the Renewable energy consumption and X.2 is represented NGTCD.

\$Y.2

	X.2	Y.2
[1,]	0.2004480	0.7995520
[2,]	0.2133043	0.7866957
[3,]	0.2069105	0.7930895
[4,]	0.2070336	0.7929664
[5,]	0.2021543	0.7978457
[6,]	0.2551063	0.7448937
[7,]	0.4008883	0.5991117
[8,]	0.4439146	0.5560854
[9,]	0.4342281	0.5657719
[10,]	0.4312733	0.5687267
[11,]	0.4332854	0.5667146
[12,]	0.4449514	0.5550486

Appendix D.11: FEVD of CLTCD

“FEVD determines how much” the Coal Average Price, all sectors in dollars per million

Btu (CLTCD) can be explained exogenous shocks to the Renewable Energy Consumption

in ID

	CLTCDID.2	RETCBID.2	CLTCDID.2
[1,]	0.01111453	0.9888855	
[2,]	0.06346822	0.9365318	
[3,]	0.15146516	0.8485348	
[4,]	0.21544607	0.7845539	
[5,]	0.24426875	0.7557312	
[6,]	0.25067416	0.7493258	
[7,]	0.24952614	0.7504739	
[8,]	0.24845778	0.7515422	
[9,]	0.24881178	0.7511882	
[10,]	0.24965401	0.7503460	
[11,]	0.25023153	0.7497685	
[12,]	0.25043530	0.7495647	

“FEVD determines how much” the Coal Average Price, all sectors in dollars per million

Btu (CLTCD) can be explained exogenous shocks to the Renewable Energy Consumption

in MI

	\$RETCBMI.2	CLTCDMI.2	RETCBMI.2
[1,]	0.1299037	0.8700963	
[2,]	0.1249177	0.8750823	
[3,]	0.1795531	0.8204469	
[4,]	0.1762165	0.8237835	
[5,]	0.1685120	0.8314880	

[6,] 0.2019073 0.7980927
 [7,] 0.2734150 0.7265850
 [8,] 0.3410506 0.6589494
 [9,] 0.3279936 0.6720064
 [10,] 0.3223072 0.6776928
 [11,] 0.3135400 0.6864600
 [12,] 0.3001943 0.6998057

“FEVD determines how much” the Coal Average Price, all sectors in dollars per million

Btu (CLTCD) can be explained exogenous shocks to the Renewable Energy Consumption

in MN

\$RETCBMN.2

CLTCDMN.2 RETCBMN.2
 [1,] 0.03393731 0.9660627
 [2,] 0.05084306 0.9491569
 [3,] 0.07472844 0.9252716
 [4,] 0.12610831 0.8738917
 [5,] 0.15212423 0.8478758
 [6,] 0.14560683 0.8543932
 [7,] 0.13827887 0.8617211
 [8,] 0.14787455 0.8521254
 [9,] 0.15809224 0.8419078
 [10,] 0.15849907 0.8415009
 [11,] 0.15813011 0.8418699
 [12,] 0.16076025 0.8392397

“FEVD determines how much” the Coal Average Price, all sectors in dollars per million

Btu (CLTCD) can be explained exogenous shocks to the Renewable Energy Consumption

in MO

\$RETCBMO.2

CLTCDMO.2 RETCBMO.2
 [1,] 0.003428626 0.9965714
 [2,] 0.100520168 0.8994798
 [3,] 0.110600971 0.8893990
 [4,] 0.118976856 0.8810231
 [5,] 0.138000455 0.8619995
 [6,] 0.136340931 0.8636591
 [7,] 0.139710973 0.8602890
 [8,] 0.140909156 0.8590908
 [9,] 0.140812876 0.8591871
 [10,] 0.141425203 0.8585748
 [11,] 0.141380147 0.8586199
 [12,] 0.141474517 0.8585255

“FEVD determines how much” the Coal Average Price, all sectors in dollars per million
Btu (CLTCD) can be explained exogenous shocks to the Renewable Energy Consumption

in NE

```
$RETCBNE.2
  CLTCDNE.2 RETCBNE.2
[1,] 0.0331005 0.9668995
[2,] 0.3816198 0.6183802
[3,] 0.4232542 0.5767458
[4,] 0.4390562 0.5609438
[5,] 0.4666275 0.5333725
[6,] 0.4693623 0.5306377
[7,] 0.4697648 0.5302352
[8,] 0.4710984 0.5289016
[9,] 0.4718486 0.5281514
[10,] 0.4718994 0.5281006
[11,] 0.4719831 0.5280169
[12,] 0.4721455 0.5278545
```

“FEVD determines how much” the Coal Average Price, all sectors in dollars per million
Btu (CLTCD) can be explained exogenous shocks to the Renewable Energy Consumption

in CA

```
$RETCBCA.2
  CLTCDCA.2 RETCBCA.2
[1,] 0.04587900 0.9541210
[2,] 0.02554651 0.9744535
[3,] 0.02951108 0.9704889
[4,] 0.03732404 0.9626760
[5,] 0.12250250 0.8774975
[6,] 0.12176179 0.8782382
[7,] 0.13039057 0.8696094
[8,] 0.13157535 0.8684246
[9,] 0.16907973 0.8309203
[10,] 0.18660060 0.8133994
[11,] 0.34322227 0.6567777
[12,] 0.34783799 0.6521620
```

“FEVD determines how much” the Coal Average Price, all sectors in dollars per million
Btu (CLTCD) can be explained exogenous shocks to the Renewable Energy Consumption

in MA

\$RETCBMA.2

CLTCDMA.2 RETCBMA.2

[1,] 0.01179307 0.9882069
[2,] 0.06041899 0.9395810
[3,] 0.05803481 0.9419652
[4,] 0.12260591 0.8773941
[5,] 0.20130525 0.7986947
[6,] 0.21167580 0.7883242
[7,] 0.21712619 0.7828738
[8,] 0.23243843 0.7675616
[9,] 0.23628942 0.7637106
[10,] 0.23636458 0.7636354
[11,] 0.23725447 0.7627455
[12,] 0.23733936 0.7626606

“FEVD determines how much” the Coal Average Price, all sectors in dollars per million

Btu (CLTCD) can be explained exogenous shocks to the Renewable Energy Consumption

in NV

\$RETCBNV.2

CLTCDNV.2 RETCBNV.2

[1,] 0.000284747 0.9997153
[2,] 0.110994780 0.8890052
[3,] 0.185519195 0.8144808
[4,] 0.179758198 0.8202418
[5,] 0.197324081 0.8026759
[6,] 0.211178039 0.7888220
[7,] 0.211948818 0.7880512
[8,] 0.212708646 0.7872914
[9,] 0.214218479 0.7857815
[10,] 0.214642965 0.7853570
[11,] 0.214636271 0.7853637
[12,] 0.214722073 0.7852779

“FEVD determines how much” the Coal Average Price, all sectors in dollars per million

Btu (CLTCD) can be explained exogenous shocks to the Renewable Energy Consumption

in NC

\$RETCBNC.2

CLTC DNC.2 RETCBNC.2

[1,] 0.002335612 0.9976644
[2,] 0.002570662 0.9974293
[3,] 0.004329273 0.9956707

[4,] 0.076814873 0.9231851
 [5,] 0.081299772 0.9187002
 [6,] 0.073838405 0.9261616
 [7,] 0.094814469 0.9051855
 [8,] 0.095071776 0.9049282
 [9,] 0.152538109 0.8474619
 [10,] 0.164619317 0.8353807
 [11,] 0.155111508 0.8448885
 [12,] 0.149895713 0.8501043

“FEVD determines how much” the Coal Average Price, all sectors in dollars per million

Btu (CLTCD) can be explained exogenous shocks to the Renewable Energy Consumption

in OR

\$RETCBOR.2

CLTCDOR.2 RETCBOR.2
 [1,] 0.03337545 0.9666245
 [2,] 0.12233898 0.8776610
 [3,] 0.18064768 0.8193523
 [4,] 0.21157866 0.7884213
 [5,] 0.22640812 0.7735919
 [6,] 0.23305183 0.7669482
 [7,] 0.23587870 0.7641213
 [8,] 0.23703420 0.7629658
 [9,] 0.23749204 0.7625080
 [10,] 0.23766913 0.7623309
 [11,] 0.23773636 0.7622636
 [12,] 0.23776152 0.7622385

“FEVD determines how much” the Coal Average Price, all sectors in dollars per million

Btu (CLTCD) can be explained exogenous shocks to the Renewable Energy Consumption

in SD

\$RETCBSD.2

CLTCDSD.2 RETCBSD.2
 [1,] 0.01857284 0.9814272
 [2,] 0.02418833 0.9758117
 [3,] 0.03319342 0.9668066
 [4,] 0.03196311 0.9680369
 [5,] 0.03967158 0.9603284
 [6,] 0.11583354 0.8841665
 [7,] 0.26802863 0.7319714
 [8,] 0.26383800 0.7361620
 [9,] 0.26840840 0.7315916

[10,] 0.27583155 0.7241685
 [11,] 0.28416746 0.7158325
 [12,] 0.28409714 0.7159029

“FEVD determines how much” the Coal Average Price, all sectors in dollars per million
 Btu (CLTCD) can be explained exogenous shocks to the Renewable Energy Consumption
in TN

\$RETCBTN.2
 CLTCDTN.2 RETCBTN.2
 [1,] 0.005397104 0.9946029
 [2,] 0.031118993 0.9688810
 [3,] 0.079950366 0.9200496
 [4,] 0.089887298 0.9101127
 [5,] 0.235148081 0.7648519
 [6,] 0.292551641 0.7074484
 [7,] 0.308034013 0.6919660
 [8,] 0.280420446 0.7195796
 [9,] 0.259750639 0.7402494
 [10,] 0.257649395 0.7423506
 [11,] 0.257139780 0.7428602
 [12,] 0.253015670 0.7469843

“FEVD determines how much” the Coal Average Price, all sectors in dollars per million
 Btu (CLTCD) can be explained exogenous shocks to the Renewable Energy Consumption
in VT

\$RETCBVT.2
 CLTCDVT.2 RETCBVT.2
 [1,] 0.17121379 0.8287862
 [2,] 0.06627960 0.9337204
 [3,] 0.06413126 0.9358687
 [4,] 0.06362886 0.9363711
 [5,] 0.10754848 0.8924515
 [6,] 0.21024929 0.7897507
 [7,] 0.21596301 0.7840370
 [8,] 0.22242791 0.7775721
 [9,] 0.22030755 0.7796924
 [10,] 0.23022831 0.7697717
 [11,] 0.23833924 0.7616608
 [12,] 0.23813577 0.7618642

Appendix D.12: FEVD of ESTCD

“FEVD determines how much” the Electricity Average Price, all sectors in dollars per million Btu (ESTCD) can be explained exogenous shocks to the Renewable Energy Consumption **in ID** where Y.2 is represented the Renewable Energy Consumption and X.2 is represented ESTCD.

where Y.2 is represented the Renewable Energy Consumption and X.2 is represented ESTCD.

```
$Y.2`
      Y.2    X.2
[1,] 1.0000000 0.0000000
[2,] 0.9205625 0.07943745
[3,] 0.8835610 0.11643898
[4,] 0.7954059 0.20459411
[5,] 0.5001687 0.49983128
[6,] 0.4719086 0.52809144
[7,] 0.4854898 0.51451019
[8,] 0.4368540 0.56314600
[9,] 0.3857894 0.61421060
[10,] 0.3282069 0.67179313
[11,] 0.3252254 0.67477455
[12,] 0.3253389 0.67466110
```

“FEVD determines how much” the Electricity Average Price, all sectors in dollars per million Btu (ESTCD) can be explained exogenous shocks to the Renewable Energy Consumption **in MI** where Y.2 is represented the Renewable Energy Consumption and X.2 is represented ESTCD.

```
$Y.2
      X.2    Y.2
[1,] 0.05661874 0.9433813
[2,] 0.13288765 0.8671124
[3,] 0.14977581 0.8502242
[4,] 0.15290550 0.8470945
[5,] 0.18720118 0.8127988
[6,] 0.19052336 0.8094766
[7,] 0.19104261 0.8089574
[8,] 0.23942249 0.7605775
[9,] 0.25652610 0.7434739
[10,] 0.34043621 0.6595638
[11,] 0.38009480 0.6199052
```

[12,] 0.37981221 0.6201878

“FEVD determines how much” Electricity Average Price, all sectors in dollars per million Btu (ESTCD) can be explained exogenous shocks to the Renewable Energy Consumption in MN where Y.2 is represented the Renewable Energy Consumption and X.2 is represented ESTCD.

\$Y.2

	X.2	Y.2
[1,]	0.02160498	0.9783950
[2,]	0.12893976	0.8710602
[3,]	0.18666990	0.8133301
[4,]	0.20447879	0.7955212
[5,]	0.20695617	0.7930438
[6,]	0.20675324	0.7932468
[7,]	0.20671849	0.7932815
[8,]	0.20680896	0.7931910
[9,]	0.20686083	0.7931392
[10,]	0.20687336	0.7931266
[11,]	0.20687401	0.7931260
[12,]	0.20687372	0.7931263

“FEVD determines how much” the Electricity Average Price, all sectors in dollars per million Btu (ESTCD) can be explained exogenous shocks to the Renewable Energy Consumption in MO where Y.2 is represented the Renewable Energy Consumption and X.2 is represented ESTCD.

\$Y.2

	X.2	Y.2
[1,]	0.007396649	0.9926034
[2,]	0.066760912	0.9332391
[3,]	0.097314647	0.9026854
[4,]	0.092452040	0.9075480
[5,]	0.123134350	0.8768657
[6,]	0.127073707	0.8729263
[7,]	0.127539763	0.8724602
[8,]	0.133534206	0.8664658
[9,]	0.133163531	0.8668365
[10,]	0.133938066	0.8660619
[11,]	0.134836357	0.8651636
[12,]	0.134661836	0.8653382

“FEVD determines how much” Electricity Average Price, all sectors in dollars per million Btu (ESTCD) can be explained exogenous shocks to the Renewable Energy Consumption in RI where Y.2 is represented the Renewable Energy Consumption and X.2 is represented ESTCD.

\$Y.2

	X.2	Y.2
[1,]	0.11367190	0.8863281
[2,]	0.07043243	0.9295676
[3,]	0.07217397	0.9278260
[4,]	0.10534856	0.8946514
[5,]	0.18265312	0.8173469
[6,]	0.18804389	0.8119561
[7,]	0.18592883	0.8140712
[8,]	0.18202990	0.8179701
[9,]	0.18612060	0.8138794
[10,]	0.19599260	0.8040074
[11,]	0.20378769	0.7962123
[12,]	0.20400929	0.7959907

“FEVD determines how much” the Electricity Average Price, all sectors in dollars per million Btu (ESTCD) can be explained exogenous shocks to the Renewable Energy Consumption in IA where Y.2 is represented the Renewable Energy Consumption and X.2 is represented ESTCD.

\$Y.2

	X.2	Y.2
[1,]	0.01926797	0.9807320
[2,]	0.03568616	0.9643138
[3,]	0.16079691	0.8392031
[4,]	0.16876455	0.8312355
[5,]	0.18703740	0.8129626
[6,]	0.19385059	0.8061494
[7,]	0.19514068	0.8048593
[8,]	0.19711555	0.8028844
[9,]	0.19713645	0.8028636
[10,]	0.19753767	0.8024623
[11,]	0.19754274	0.8024573
[12,]	0.19760760	0.8023924

“FEVD determines how much” the Electricity Average Price, all sectors in dollars per million Btu (ESTCD) can be explained exogenous shocks to the Renewable Energy Consumption **in ME** where Y.1 is represented the Renewable Energy Consumption and X.1 is represented ESTCD.

\$Y.1

	X.1	Y.1
[1,]	0.02326883	0.9767312
[2,]	0.21049233	0.7895077
[3,]	0.22553122	0.7744688
[4,]	0.23467663	0.7653234
[5,]	0.23327945	0.7667206
[6,]	0.23366475	0.7663353
[7,]	0.23353697	0.7664630
[8,]	0.23423938	0.7657606
[9,]	0.23423793	0.7657621
[10,]	0.23421122	0.7657888
[11,]	0.23422888	0.7657711
[12,]	0.23422941	0.7657706

“FEVD determines how much” the Electricity Average Price, all sectors in dollars per million Btu (ESTCD) can be explained exogenous shocks to the Renewable Energy Consumption **in OR** where Y.2 is represented the Renewable Energy Consumption and X.2 is represented ESTCD.

\$Y.2

	X.2	Y.2
[1,]	0.006070404	0.9939296
[2,]	0.028836073	0.9711639
[3,]	0.053529260	0.9464707
[4,]	0.068044139	0.9319559
[5,]	0.074947198	0.9250528
[6,]	0.077837280	0.9221627
[7,]	0.078941007	0.9210590
[8,]	0.079333661	0.9206663
[9,]	0.079465618	0.9205344
[10,]	0.079507911	0.9204921
[11,]	0.079520923	0.9204791
[12,]	0.079524782	0.9204752

“FEVD determines how much” the Electricity Average Price, all sectors in dollars per million Btu (ESTCD) can be explained exogenous shocks to the Renewable Energy Consumption in TN where Y.2 is represented the Renewable Energy Consumption and X.2 is represented ESTCD.

\$Y.2

	X.2	Y.2
[1,]	0.001455152	0.9985448
[2,]	0.033048695	0.9669513
[3,]	0.142984887	0.8570151
[4,]	0.180114760	0.8198852
[5,]	0.180654223	0.8193458
[6,]	0.172023996	0.8279760
[7,]	0.198037039	0.8019630
[8,]	0.189649743	0.8103503
[9,]	0.176720179	0.8232798
[10,]	0.176297176	0.8237028
[11,]	0.188507110	0.8114929
[12,]	0.198033007	0.8019670

“FEVD determines how much” the Electricity Average Price, all sectors in dollars per million Btu (ESTCD) can be explained exogenous shocks to the Renewable Energy Consumption in VT where Y.2 is represented the Renewable Energy Consumption and X.2 is represented ESTCD.

\$Y.2

	X.2	Y.2
[1,]	0.01779649	0.9822035
[2,]	0.01608372	0.9839163
[3,]	0.02609581	0.9739042
[4,]	0.03254989	0.9674501
[5,]	0.14558911	0.8544109
[6,]	0.13787581	0.8621242
[7,]	0.13235606	0.8676439
[8,]	0.27326144	0.7267386
[9,]	0.44655091	0.5534491
[10,]	0.45111343	0.5488866
[11,]	0.34844784	0.6515522
[12,]	0.24914645	0.7508536

Appendix D.13: FEVD of GDP

“FEVD determines how much” the Annual Gross Domestic Product (GDP) in millions of current dollars can be explained exogenous shocks to the Renewable Energy Consumption in MI where Y.2 is represented the Renewable Energy Consumption and X.2 is represented GDP

\$Y.2

	X.2	Y.2
[1,]	0.05642378	0.9435762
[2,]	0.22960690	0.7703931
[3,]	0.31250574	0.6874943
[4,]	0.30042742	0.6995726
[5,]	0.30117993	0.6988201
[6,]	0.33892437	0.6610756
[7,]	0.35038888	0.6496111
[8,]	0.35598282	0.6440172
[9,]	0.31609245	0.6839076
[10,]	0.31194487	0.6880551
[11,]	0.31117295	0.6888270
[12,]	0.34197135	0.6580287

“FEVD determines how much” the Annual Gross Domestic Product (GDP) in millions of current dollars can be explained exogenous shocks to the Renewable Energy Consumption in MN where Y.2 is represented the Renewable Energy Consumption and X.2 is represented GDP

\$Y.2

	X.2	Y.2
[1,]	0.0003479989	0.9996520
[2,]	0.0516436236	0.9483564
[3,]	0.0450751105	0.9549249
[4,]	0.0426441234	0.9573559
[5,]	0.0838648485	0.9161352
[6,]	0.1155263480	0.8844737
[7,]	0.1122006728	0.8877993
[8,]	0.1158496762	0.8841503
[9,]	0.1192050700	0.8807949
[10,]	0.1217715472	0.8782285
[11,]	0.1236822144	0.8763178
[12,]	0.1217493561	0.8782506

“FEVD determines how much” the Annual Gross Domestic Product (GDP) in millions of current dollars can be explained exogenous shocks to the Renewable Energy Consumption in MO where Y.2 is represented the Renewable Energy Consumption and X.2 is represented GDP

\$Y.2

	X.2	Y.2
[1,]	0.002266046	0.9977340
[2,]	0.066224185	0.9337758
[3,]	0.136922384	0.8630776
[4,]	0.120818685	0.8791813
[5,]	0.144583428	0.8554166
[6,]	0.159606135	0.8403939
[7,]	0.156116097	0.8438839
[8,]	0.162590034	0.8374100
[9,]	0.164194742	0.8358053
[10,]	0.163826756	0.8361732
[11,]	0.165320792	0.8346792
[12,]	0.165282886	0.8347171

“FEVD determines how much” the Annual Gross Domestic Product (GDP) in millions of current dollars can be explained exogenous shocks to the Renewable Energy Consumption in NE where Y.2 is represented the Renewable Energy Consumption and X.2 is represented GDP

\$Y.2

	X.2	Y.2
[1,]	0.002324589	0.9976754
[2,]	0.091572956	0.9084270
[3,]	0.109860130	0.8901399
[4,]	0.190090371	0.8099096
[5,]	0.197482706	0.8025173
[6,]	0.244415266	0.7555847
[7,]	0.243949216	0.7560508
[8,]	0.247654305	0.7523457
[9,]	0.247217503	0.7527825
[10,]	0.245989594	0.7540104
[11,]	0.248346007	0.7516540
[12,]	0.248928423	0.7510716

“FEVD determines how much” the Annual Gross Domestic Product (GDP) in millions of current dollars can be explained exogenous shocks to the Renewable Energy Consumption in NY where Y.2 is represented the Renewable Energy Consumption and X.2 is represented GDP

\$Y.2

	X.2	Y.2
[1,]	0.007291474	0.9927085
[2,]	0.084316683	0.9156833
[3,]	0.379941898	0.6200581
[4,]	0.372069966	0.6279300
[5,]	0.410040319	0.5899597
[6,]	0.619640240	0.3803598
[7,]	0.734651641	0.2653484
[8,]	0.777744789	0.2222552
[9,]	0.766435788	0.2335642
[10,]	0.771047539	0.2289525
[11,]	0.776424293	0.2235757
[12,]	0.794596111	0.2054039

“FEVD determines how much” the Annual Gross Domestic Product (GDP) in millions of current dollars can be explained exogenous shocks to the Renewable Energy Consumption in IA where Y.2 is represented the Renewable Energy Consumption and X.2 is represented GDP

\$Y.2

	X.2	Y.2
[1,]	0.1467542	0.8532458
[2,]	0.2179851	0.7820149
[3,]	0.2873789	0.7126211
[4,]	0.3140110	0.6859890
[5,]	0.3220828	0.6779172
[6,]	0.3242369	0.6757631
[7,]	0.3247627	0.6752373
[8,]	0.3248828	0.6751172
[9,]	0.3249088	0.6750912
[10,]	0.3249143	0.6750857
[11,]	0.3249153	0.6750847
[12,]	0.3249156	0.6750844

“FEVD determines how much” the Annual Gross Domestic Product (GDP) in millions of current dollars can be explained exogenous shocks to the Renewable Energy Consumption **in ME** where Y.2 is represented the Renewable Energy Consumption and X.2 is represented GDP

\$Y.2

	X.2	Y.2
[1,]	0.003988213	0.9960118
[2,]	0.003289429	0.9967106
[3,]	0.007695693	0.9923043
[4,]	0.051733701	0.9482663
[5,]	0.052273029	0.9477270
[6,]	0.055430622	0.9445694
[7,]	0.176232232	0.8237678
[8,]	0.243936802	0.7560632
[9,]	0.494162468	0.5058375
[10,]	0.657315462	0.3426845
[11,]	0.659913650	0.3400864
[12,]	0.678072403	0.3219276

“FEVD determines how much” the Annual Gross Domestic Product (GDP) in millions of current dollars can be explained exogenous shocks to the Renewable Energy Consumption **in TN** where Y.2 is represented the Renewable Energy Consumption and X.2 is represented GDP

\$Y.2

	X.2	Y.2
[1,]	0.01227345	0.9877266
[2,]	0.01261758	0.9873824
[3,]	0.07700762	0.9229924
[4,]	0.09766831	0.9023317
[5,]	0.11007685	0.8899232
[6,]	0.17540626	0.8245937
[7,]	0.17298822	0.8270118
[8,]	0.16607907	0.8339209
[9,]	0.16446735	0.8355327
[10,]	0.16603903	0.8339610
[11,]	0.17023191	0.8297681
[12,]	0.17051646	0.8294835

Appendix E 16 MLR models integrated with EFA components to predict renewable energy consumption.

Appendix E.1: MI state

```
pcar01=lm(TOTAL~PC1+PC2,data = pcar11)
> summary(pcar01)
```

Call:

```
lm(formula = TOTAL ~ PC1 + PC2, data = pcar11)
```

Residuals:

Min	1Q	Median	3Q	Max
-24450	-9490	531	7189	36711

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	112008.9	2124.0	52.736	<2e-16 ***
PC1	12062.2	704.8	17.115	<2e-16 ***
PC2	-767.5	1296.6	-0.592	0.557

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 14410 on 43 degrees of freedom

Multiple R-squared: 0.8721, Adjusted R-squared: 0.8662

F-statistic: 146.6 on 2 and 43 DF, p-value: < 2.2e-16

Appendix E.2 :MN state

Call:

```
lm(formula = TOTAL ~ PC1 + PC2, data = pcar11)
```

Residuals:

Min	1Q	Median	3Q	Max
-37734	-17388	-11849	21279	57851

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	99339	3669	27.08	< 2e-16 ***
PC1	18723	1153	16.24	< 2e-16 ***
PC2	7638	2512	3.04	0.00401 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 24880 on 43 degrees of freedom

Multiple R-squared: 0.8639, Adjusted R-squared: 0.8576

F-statistic: 136.5 on 2 and 43 DF, p-value: < 2.2e-16

Appendix E.3 :SD state

```
> summary(pcar01SDF)
```

Call:

```
lm(formula = TOTAL ~ PC1 + PC2, data = pcar11SDF)
```

Residuals:

Min	1Q	Median	3Q	Max
-29079	-14836	-3808	17560	38963

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	73879	3054	24.189	< 2e-16 ***
PC1	5597	1005	5.570	1.54e-06 ***
PC2	13813	4023	3.433	0.00133 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 20710 on 43 degrees of freedom

Multiple R-squared: 0.4989, Adjusted R-squared: 0.4756

F-statistic: 21.41 on 2 and 43 DF, p-value: 3.53e-07

Appendix E.4 :MO state

```
summary(pcar01MOF)
```

Call:

```
lm(formula = TOTAL ~ PC1 + PC2, data = pcar11MOF)
```

Residuals:

Min	1Q	Median	3Q	Max
-28368.7	-8340.5	19.8	5887.0	26267.2

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	49299.0	1829.0	26.954	< 2e-16 ***
PC1	5039.5	601.7	8.375	1.4e-10 ***
PC2	8939.8	2409.3	3.711	0.000589 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 12410 on 43 degrees of freedom

Multiple R-squared: 0.6612, Adjusted R-squared: 0.6454

F-statistic: 41.96 on 2 and 43 DF, p-value: 7.842e-11

Appendix E.5: CA state

```
summary(pcar01CAF)
```

Call:

```
lm(formula = TOTAL ~ PC1 + PC2, data = pcar11CAF)
```

Residuals:

Min	1Q	Median	3Q	Max
-247550	-55927	4170	59765	186647

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	686132	14050	48.833	< 2e-16 ***
PC1	32034	4622	6.930	1.63e-08 ***
PC2	-24442	18508	-1.321	0.194

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 95300 on 43 degrees of freedom
Multiple R-squared: 0.5365, Adjusted R-squared: 0.5149
F-statistic: 24.88 on 2 and 43 DF, p-value: 6.614e-08

Appendix E.6 : GA state

```
summary(pcar01GAF)
```

Call:
lm(formula = TOTAL ~ PC1 + PC2, data = pcar11GAF)

Residuals:

Min	1Q	Median	3Q	Max
-64785	-24415	-11205	36004	55482

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	194705.39	5242.17	37.142	< 2e-16 ***
PC1	16695.36	2009.58	8.308	1.74e-10 ***
PC2	-27.06	4938.93	-0.005	0.996

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 35550 on 43 degrees of freedom
Multiple R-squared: 0.6161, Adjusted R-squared: 0.5983
F-statistic: 34.51 on 2 and 43 DF, p-value: 1.147e-09

Appendix E.7 : ME state

```
summary(pcar01MEF)
```

Call:
lm(formula = TOTAL ~ PC1 + PC2, data = pcar11MEF)

Residuals:

Min	1Q	Median	3Q	Max
-27521	-14545	-3351	14443	32371

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	130769	2696	48.503	< 2e-16 ***
PC1	12738	1068	11.928	3.16e-15 ***
PC2	3998	2374	1.684	0.0995 .

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 18290 on 43 degrees of freedom
 Multiple R-squared: 0.7714, Adjusted R-squared: 0.7608
 F-statistic: 72.55 on 2 and 43 DF, p-value: 1.66e-14

Appendix E.8: VT state

summary(pcar01VTF)

Call:

lm(formula = TOTAL ~ PC1 + PC2, data = pcar11VTF)

Residuals:

Min	1Q	Median	3Q	Max
-7299.9	-1525.5	514.3	1996.9	5093.1

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	22724.7	420.2	54.076	< 2e-16 ***
PC1	1665.5	164.9	10.100	6.38e-13 ***
PC2	1910.0	361.3	5.286	3.94e-06 ***

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2850 on 43 degrees of freedom
 Multiple R-squared: 0.7514, Adjusted R-squared: 0.7398
 F-statistic: 64.97 on 2 and 43 DF, p-value: 1.01e-13

Appendix E.9: RI state

summary(pcar01RIF)

Call:

lm(formula = TOTAL ~ PC1 + PC2, data = pcar11RIF)

Residuals:

Min	1Q	Median	3Q	Max
-3238.1	-570.7	-128.4	541.8	2420.1

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	5243.80	149.59	35.054	< 2e-16 ***
PC1	113.03	60.26	1.876	0.0675 .
PC2	728.18	150.65	4.834	1.74e-05 ***

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1015 on 43 degrees of freedom
 Multiple R-squared: 0.3847, Adjusted R-squared: 0.3561
 F-statistic: 13.44 on 2 and 43 DF, p-value: 2.921e-05

Appendix E.10: NE state

summary(pcar01NEF)

Call:
lm(formula = TOTAL ~ PC1 + PC2, data = pcar11NEF)

Residuals:
Min 1Q Median 3Q Max
-33623 -11414 -4359 12858 64355

Coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) 45763 3036 15.075 < 2e-16 ***
PC1 15003 1297 11.564 8.76e-15 ***
PC2 4195 3073 1.365 0.179

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 20590 on 43 degrees of freedom
Multiple R-squared: 0.7592, Adjusted R-squared: 0.748
F-statistic: 67.8 on 2 and 43 DF, p-value: 5.064e-14

Appendix E.11: IA state

Call:
lm(formula = TOTAL ~ PC1 + PC2, data = pcar11IAF)

Residuals:
Min 1Q Median 3Q Max
-103064 -43194 -561 36176 144671

Coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) 118085 8823 13.38 < 2e-16 ***
PC1 38039 3510 10.84 7.08e-14 ***
PC2 17063 16252 1.05 0.3

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 59840 on 43 degrees of freedom
Multiple R-squared: 0.7339, Adjusted R-squared: 0.7215
F-statistic: 59.29 on 2 and 43 DF, p-value: 4.355e-13

Appendix E.12: OR state

summary(pcar01ORF)

Call:
lm(formula = TOTAL ~ PC1 + PC2, data = pcar11ORF)

Residuals:
Min 1Q Median 3Q Max
-122104 -43778 -6642 44614 114654

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	444807	8716	51.035	<2e-16 ***
PC1	3821	3804	1.004	0.3208
PC2	22772	8777	2.594	0.0129 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 59110 on 43 degrees of freedom
Multiple R-squared: 0.1525, Adjusted R-squared: 0.1131
F-statistic: 3.87 on 2 and 43 DF, p-value: 0.02849

Appendix E.13: TN state

```
> summary(pcar01TNF)
```

Call:
lm(formula = TOTAL ~ PC1 + PC2, data = pcar11TNF)

Residuals:

Min	1Q	Median	3Q	Max
-44708	-12309	1007	13251	36700

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	168886	2929	57.664	<2e-16 ***
PC1	1007	1177	0.856	0.3967
PC2	13403	4380	3.060	0.0038 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 19860 on 43 degrees of freedom
Multiple R-squared: 0.1902, Adjusted R-squared: 0.1525
F-statistic: 5.049 on 2 and 43 DF, p-value: 0.01073

Appendix E.14: NY state

```
summary(pcar01NYF)
```

Call:
lm(formula = TOTAL ~ PC1 + PC2, data = pcar11NYF)

Residuals:

Min	1Q	Median	3Q	Max
-48102	-20704	-4554	18456	97790

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	393929.91	4540.54	86.758	<2e-16 ***
PC1	7342.57	1981.91	3.705	0.0006 ***
PC2	-84.67	4572.70	-0.019	0.9853

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 30800 on 43 degrees of freedom
Multiple R-squared: 0.242, Adjusted R-squared: 0.2067
F-statistic: 6.863 on 2 and 43 DF, p-value: 0.00259

Appendix E.15: NC state

```
summary(pcar01NCF)
```

Call:

```
lm(formula = TOTAL ~ PC1 + PC2, data = pcar11NCF)
```

Residuals:

Min	1Q	Median	3Q	Max
-54620	-14621	4837	12669	45468

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	153949.6	3291.8	46.768	< 2e-16 ***
PC1	6009.4	1436.8	4.182	0.000139 ***
PC2	138.5	3315.1	0.042	0.966860

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 22330 on 43 degrees of freedom
Multiple R-squared: 0.2892, Adjusted R-squared: 0.2561
F-statistic: 8.747 on 2 and 43 DF, p-value: 0.0006497

Appendix E.16: NV state

```
> summary(pcar01NVF)
```

Call:

```
lm(formula = TOTAL ~ PC1 + PC2, data = pcar11NVF)
```

Residuals:

Min	1Q	Median	3Q	Max
-16965.4	-7615.1	242.8	4689.8	24752.4

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	39469.5	1545.8	25.533	< 2e-16 ***
PC1	5929.4	674.7	8.788	3.75e-11 ***
PC2	860.0	1556.8	0.552	0.584

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 10480 on 43 degrees of freedom
Multiple R-squared: 0.6432, Adjusted R-squared: 0.6266
F-statistic: 38.76 on 2 and 43 DF, p-value: 2.378e-10

Appendix F USA Granger causality test

Appendix F.1: UNIT ROOT TEST & Short Run Test

FACTOR	Augmented Dickey-Fuller (ADF)			p value		
	Level	First difference	Second difference	Level	First difference	Second difference
TotalPrimary	-1.8078	-3.3851	-5.2677		*	**
Oil	-2.097	-2.8941	-4.5205			***
TETPB	-1.9458	-3.7803	-5.6192		**	***
TERPB	-1.2937	-3.9082	-5.9333		**	***
FFTCB	-2.0213	-3.2219	-5.2552		*	***
CLTCP	1.9104	-1.811	-5.7269			***
Income	-1.7866	-3.6645	-4.2561		**	***
NGTCP	-2.494	-3.1481	-6.3953			***
NNRCB	-2.1428	-4.3222	-6.1282		***	***
ESTCB	0.20799	-3.145	-5.9599			***
ESRCB	-1.1098	-2.7219	-7.2893			***
PETCD	-2.131	-2.6883	-4.0871			**
PERCD	-2.2429	-2.38	-4.5286			***
NGTCD	-2.748	-2.6916	-4.5675			***
CLTCD	-4.047	-2.0557	-2.3905	**		
ESTCD	-2.8441	-2.8206	-4.9262			***
ESRCD	-2.7375	-2.9344	-4.7863			***
GDP	-1.2165	-4.1116	-4.7204		**	***
RETCB	-1.9889	-3.0138	-4.0559			**

Table F1. TETPB USA Granger test 1

Appendix F.2: The bivariate VAR test result (Factors X G-Cause TotalPrimary) of the USA total energy consumption factors

FACTOR	The bivariate VAR Test		Conclusion
	F-Test	p-value	
Oil	21.71	1.21E-05	OIL G-Cause Total Primary
TETPB	2.4455	0.09348	TETPB G-Cause Total Primary
TERPB	0.82072	0.6121	TERPB not G-Cause Total Primary
FFTCB	0.3201	0.727	FFTCB not G-Cause Total Primary
CLTCP	5.5902	0.005432	CLTCP G-Cause Total Primary
Income	2.102	0.0594	Income G-Cause Total Primary
NGTCP	1.7579	0.1794	NGTCP not G-Cause Total Primary
NNRCB	0.12416	0.8834	NNRCB not G-Cause Total Primary
ESTCB	1.2093	0.3041	ESTCB not G-Cause Total Primary
ESRCB	1.3367	0.2552	ESRCB not G-Cause Total Primary
PETCD	23.719	5.35E-06	PERCD G-Cause Total Primary
PERCD	9.8394	0.002372	OIL G-Cause Total Primary
NGTCD	8.9412	0.00368	NGTCD G-Cause Total Primary
CLTCD	9.4959	0.0002084	CLTCD G-Cause Total Primary
ESTCD	9.0091	0.003559	ESTCD G-Cause Total Primary
ESRCD	3.6108	0.06092	ESRCD G-Cause Total Primary
GDP	1.728	0.1543	GDP G-Cause Total Primary
RETCB	1.169	0.3513	OIL not G-Cause Total Primary

Table F2. TETPB USA Granger test 1

Appendix F.3 :The bivariate VAR test result (Total Primary G-Cause Factor X) of the USA total energy consumption factors

FACTOR	The bivariate VAR Test		Conclusion
	F-Test	p-value	
Oil	1.8472	0.09783	Total Primary Not G-Cause Oil
TETPB	1.7731	0.1768	Total Primary Not G-Cause TETPB
TERPB	1.2129	0.3251	Total Primary Not G-Cause TERPB
FFTCB	0.082082	0.9213	Total Primary Not G-Cause FFTCB
Income	0.82733	0.6065	Total Primary Not G-Cause Income
NGTCP	0.8514	0.4308	Total Primary G-Cause NGTCP
NNRCB	4.6849	0.01206	Total Primary G-Cause NNRCB
ESTCB	2.4508	0.09302	Total Primary G-Cause ESTCB
ESRCB	0.53892	0.8357	Total Primary Not G-Cause Oil
PETCD	18.339	4.99E-05	Total Primary G-Cause PETCD
PERCD	17.987	5.81E-05	Total Primary G-Cause PERCD
NGTCD	16.76	9.89E-05	Total Primary G-Cause NGTCD
CLTCD	0.61654	0.5425	Total Primary Not G-Cause CLTCD
ESTCD	5.5047	0.02138	Total Primary G-Cause ESTCD
ESRCD	2.8336	0.09611	Total Primary G-Cause ESRCD
GDP	2.5639	0.04599	Total Primary G-Cause GDP
RETCB	1.0239	0.4492	Total Primary Not G-Cause Oil

Table F3. TETPB USA Granger test 1

Appendix G: PCA

Appendix G.1 Standardize factors

Factor	Average	Standard Deviation
PCA.Oil	-5.263507e-17	1
PCA.TETPB	4.643214e-18	1
PCA.CLTCP	-8.649930e-17	1
PCA.Income	1.214306e-16	1
PCA.NNRCB	-6.476924e-16	1
PCA.ESTCB	1.520711e-16	1
PCA.PETCD	9.013020e-17	1
PCA.PERCD	5.602497e-17	1
PCA.NGTCD	-8.181248e-17	1
PCA.CLTCD	1.402439e-16	1
PCA.ESRCD	8.112661e-18	1
PCA.GDP	8.935240e-17	1

Table G1. Standardize factors 1

Appendix G.2 R output _Multiple linear regression with EFA components

```
lm(formula = TOTAL ~ PC1 + PC2, data = pcar0)
```

Coefficients:

(Intercept)	PC1	PC2
86.759	2.958	4.218

Call:

```
lm(formula = TOTAL ~ PC1 + PC2, data = pcar0)
```

Residuals:

Min	1Q	Median	3Q	Max
-----	----	--------	----	-----

-5.4264 -1.6745 0.0719 1.2821 5.3643

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 86.7587 0.3268 265.50 <2e-16 ***

PC1 2.9581 0.1108 26.70 <2e-16 ***

PC2 4.2183 0.2663 15.84 <2e-16 ***

Signify. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.216 on 43 degrees of freedom

Multiple R-squared: 0.9573, Adjusted R-squared: 0.9553

F-statistic: 481.9 on 2 and 43 DF, p-value: < 2.2e-16

Appendix H Data Summary

Identify the factors influencing consumers' willingness to use renewable energy in the United States

SurveyMonkey

Q1 Dear Participants, You are invited to participate in a study to identify the factors influencing consumers' willingness to use renewable energy in the United States. If you have questions, please contact Alaa Masrahi at 401-4597939 or Dr. Wang at 401-8745195. You must be at least 18 years old to take part in this research project. The procedure includes completing an online survey that will take approximately 5 to 8 minutes. You are encouraged to participate in the survey and your response is vital in identifying the important indicators from the public's point of view. The data collected will be used for scientific research purposes only. Risks or discomfort In this study, there is not any probable risk or discomfort related with the study. The decision to participate in and contribute to this study is completely voluntary. Your responses will be completely anonymous. Benefits of this study: Essentially, there is no direct benefit to you for taking part in this study, the researcher may conduct more studies to investigate and identify the social factors and attributes relative to consumer attitude, intention, and behavior. Thus, the research findings will help recognize the role of social acceptance to use renewable energy and help improve policy regarding renewable energy. Confidentiality: All information and responses are totally private and confidential. This study will not identify you by name or email. The researchers will not be able to access your email or IP address in Survey Monkey. Please read and review the privacy agreement of Survey Monkey before participating. Data will be assessed, analyzed, and reserved on password protected computers in protected offices at the University of Rhode Island. All data will be analyzed and reported in aggregates, no individual response will be reported. Rights and Complaints: Please if you have concerns about this study, you may contact Alaa Masrahi at 4015947939 or Dr. Wang at 401-8745195, anonymously if you choose. In addition, you may contact the office of the Vice President for Research and Economic Development, 70 Lower College Road, Suite 2, University of Rhode 106 Island, Kingston, Rhode Island, telephone: (401) 874-4328 Please, if you have read and understood the above and now agree to participate in this study, please indicate your consent by clicking Yes in the space below and please complete this survey.

Figure H.1. Data Summary 1

Q2 What is your approximate average household income?

Answered: 730 Skipped: 72

Figure H.2. Data Summary

Q3 Using renewable energy is a good idea to supply my home's electricity

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES	
Strongly agree	33.74%	247
Agree	44.67%	327
Neither agree nor disagree	16.12%	118
Disagree	4.10%	30
Strongly disagree	1.37%	10
TOTAL		732

Figure H.3. Data Summary

Q4 I like the idea of using renewable energy for my home's electricity

Answered: 732 Skipped: 70

Figure H.4. Data Summary

Q5 I have a positive attitude toward using renewable energy instead conventional energy for my home's electricity

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES	
Strongly agree	36.48%	267
Agree	42.08%	308
Neither agree nor disagree	16.67%	122
Disagree	3.42%	25
Strongly disagree	1.37%	10
TOTAL		732

Figure H.5. Data Summary

Q6 Most people who are important to me would like to use renewable energy for their home's electricity

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES	
Strongly disagree	8.74%	64
Disagree	14.07%	103
Neither agree nor disagree	37.70%	276
Agree	29.51%	216
Strongly agree	9.97%	73
TOTAL		732

Figure H.6. Data Summary

Q7 I think other friends in my community would be willing to use renewable energy for their home's electricity

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES	
Strongly agree	22.95%	168
Agree	42.49%	311
Neither agree nor disagree	27.19%	199
Disagree	5.60%	41
Strongly disagree	1.78%	13
TOTAL		732

Figure H.7. Data Summary

Q8 People whose opinions I value would favor and support the use of renewable energy for their home's electricity

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES	
Strongly agree	26.09%	191
Agree	39.34%	288
Neither agree nor disagree	27.87%	204
Disagree	5.33%	39
Strongly disagree	1.37%	10
TOTAL		732

Figure H.8. Data Summary

Q9 I believe I can use renewable energy for my home’s electricity

Answered: 732 Skipped: 70

Figure H.9. Data Summary

Q10 If it were exclusively up to me, I would use renewable energy for my home's electricity

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES	
Strongly agree	37.02%	271
Agree	37.98%	278
Neither agree nor disagree	17.90%	131
Disagree	5.33%	39
Strongly disagree	1.78%	13
TOTAL		732

Figure H.10. Data Summary

Q11 If I wanted to, I could easily use renewable energy for my home's electricity

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES	
Strongly agree	11.75%	86
Agree	21.72%	159
Neither agree nor disagree	30.60%	224
Disagree	28.42%	208
Strongly disagree	7.51%	55
TOTAL		732

Figure H.11. Data Summary

Q12 I plan to use renewable energy resources rather than conventional energy for my home's electricity

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES	
Strongly agree	17.49%	128
Agree	31.42%	230
Neither agree nor disagree	36.34%	266
Disagree	12.84%	94
Strongly disagree	1.91%	14
TOTAL		732

Figure H.12. Data Summary

Q13 I definitely want to use renewable energy for home electricity in the near future

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES
Strongly disagree	13.93% 102
Disagree	9.97% 73
Neither agree nor disagree	23.22% 170
Agree	34.43% 252
Strongly agree	18.44% 135
TOTAL	732

Figure H.13. Data Summary

Q14 I intend to switch the source of my electricity supply from conventional energy to renewable energy

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES	
Strongly agree	13.93%	102
Agree	28.96%	212
Neither agree nor disagree	39.34%	288
Disagree	14.89%	109
Strongly disagree	2.87%	21
TOTAL		732

Figure H.14. Data Summary

Q15 I expect to use renewable energy for my home's electricity in the near future

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES
Strongly agree	17.62% 129
Agree	33.61% 246
Neither agree nor disagree	29.78% 218
Disagree	16.67% 122
Strongly disagree	2.32% 17
TOTAL	732

Figure H.15. Data Summary

Q16 The federal government has ambitious targets to increase renewable energy production and reduce greenhouse gas emission

Answered: 732 Skipped: 70

Figure H.16. Data Summary

Q17 The federal government's renewable energy policy or initiative has appropriate incentives to encourage me to switch to using renewable energy in residential sector

Answered: 732 Skipped: 70

Figure H.17. Data Summary

Q18 The federal government has powerful support to set reasonable and competitive renewable electricity prices

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES	
Strongly agree	13.39%	98
Agree	23.36%	171
Neither agree nor disagree	35.25%	258
Disagree	19.67%	144
Strongly disagree	8.33%	61
TOTAL		732

Figure H.18. Data Summary

Q19 Using renewable energy helps prevent global warming

Figure H.19. Data Summary

Q20 Using renewable energy helps to reduce dependence on imported fuels

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES
Strongly disagree	12.98% 95
Disagree	7.38% 54
Neither agree nor disagree	17.49% 128
Agree	37.57% 275
Strongly agree	24.59% 180
TOTAL	732

Figure H.20. Data Summary

Q21 Using renewable energy could help meet the social, economic and other needs of present and future generations

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES	
Strongly agree	38.11%	279
Agree	40.16%	294
Neither agree nor disagree	16.12%	118
Disagree	4.10%	30
Strongly disagree	1.50%	11
TOTAL		732

Figure H.21. Data Summary

Q22 I would be able to spend extra money to use renewable energy

Answered: 732 Skipped: 70

Figure H.22. Data Summary

Q23 I am willing to pay more to use renewable energy

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES
Strongly agree	12.57% 92
Agree	29.64% 217
Neither agree nor disagree	26.91% 197
Disagree	23.36% 171
Strongly disagree	7.51% 55
TOTAL	732

Figure H.23. Data Summary

Q24 It is OK to pay more to support and use renewable energy

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES	
Strongly agree	16.12%	118
Agree	32.24%	236
Neither agree nor disagree	26.64%	195
Disagree	19.40%	142
Strongly disagree	5.60%	41
TOTAL		732

Figure H.24. Data Summary

Q25 I support renewable energy policies to protect the environment

Answered: 732 Skipped: 70

Figure H.25. Data Summary

Q26 I would be willing to buy and use green products

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES	
Strongly agree	30.87%	226
Agree	46.31%	339
Neither agree nor disagree	16.94%	124
Disagree	4.64%	34
Strongly disagree	1.23%	9
TOTAL		732

Figure H.26. Data Summary

Q27 I am extremely worried about the environmental issues such as global warming

Answered: 732 Skipped: 70

ANSWER CHOICES	RESPONSES
Strongly disagree	15.44% 113
Disagree	9.15% 67
Neither agree nor disagree	18.03% 132
Agree	31.69% 232
Strongly agree	25.68% 188
TOTAL	732

Figure H.27. Data Summary

Figure H.28. Data Summary

Figure H.29. Data Summary

Q30 Household Income

Answered: 762 Skipped: 40

ANSWER CHOICES	RESPONSES	
\$0-\$9,999	7.48%	57
\$10,000-\$24,999	11.94%	91
\$25,000-\$49,999	17.06%	130
\$50,000-\$74,999	22.31%	170
\$75,000-\$99,999	13.12%	100
\$100,000-\$124,999	9.58%	73
\$125,000-\$149,999	4.86%	37
\$150,000-\$174,999	2.76%	21
\$175,000-\$199,999	1.57%	12
\$200,000+	2.23%	17
Prefer not to answer	7.09%	54
TOTAL		762

Figure H.30. Data Summary

Figure H.31. Data Summary

Q32 Device Type

Answered: 762 Skipped: 40

ANSWER CHOICES	RESPONSES	
iOS Phone / Tablet	45.54%	347
Android Phone / Tablet	37.93%	289
Other Phone / Tablet	0.00%	0
Windows Desktop / Laptop	12.47%	95
MacOS Desktop / Laptop	3.02%	23
Other	1.05%	8
TOTAL		762

Figure H.32. Data Summary

Appendix I Study approach to identify factors that could show a contribution for renewable energy consumption growth among 22 states.

Figure I.1: Study approach 1

Research Approach

Figure I.2: Study approach 1

Study Framework

Figure I.3: Study approach 1

Secondary Data Analysis _ Flowchart

Figure I.4: Study approach 1

Primary Data Approach _ Proposed in future work

Figure I.5: Study approach 1

Appendix J :ARIMA model results

Appendix J.1: Best-fitting model

Best model: ARIMA(0,1,0) with drift

```
ARIMA(2,1,2) with drift      : Inf
ARIMA(0,1,0) with drift      : 157.8934
ARIMA(1,1,0) with drift      : 159.9563
ARIMA(0,1,1) with drift      : 158.9839
ARIMA(0,1,0)                  : 162.0618
ARIMA(1,1,1) with drift      : 162.1148
```

Best model: ARIMA(0,1,0) with drift

Appendix J.2: Residuals diagnostic test

Box-Pierce test

```
data: arimalfit0$residuals
X-squared = 1.5937, df = 1, p-value = 0.2068
```

```
> jarque.bera.test(arimalfit0$residuals)
```

Jarque Bera Test

```
data: arimalfit0$residuals
X-squared = 1.7388, df = 2, p-value = 0.4192
```

Figure J. 1. ARIMA model 1

Figure J. 2. ARIMA model 1

Figure J. 3. ARIMA model 1

Appendix J.3: Result of ARIMA Forecasts model

Figure J. 4. ARIMA model 1

Year	Actual Y	prediction	Absolute error	MEAP
2008	98.82495	101.911	3.08645	0.031231
2009	94.02275	102.808	8.78535	0.093439
2010	97.6077	103.705	6.0971	0.062465
2011	96.9488	104.601	7.6526	0.078934
2012	94.47746	105.498	11.02064	0.116648
2013	97.21844	106.395	9.17626	0.094388
2014	98.38127	107.291	8.91013	0.090567
2015	97.48356	108.188	10.70454	0.109809
				0.084685
				8.468528%

Table J.1. ARIMA model 1

Appendix K: Ranking list of frequent significant factors

State	Percentage	States
Oil	59.09%	MI,MO,NE,RI,CA,DE,GA,ME,NV,NC,OR,SD,VT
CLTCD	59.09%	ID,MI,MN,MO,NE,NY,CA,MA,NV,NC,OR,SD,TN,VT
Income	54.55%	MI,MN,MO,NE,CA,GA,IA,ME,MA,SD,TN,VT
ESTCB	54.55%	MI,MN,NY,RI,CA,GA,IA,ME,NC,OR,SD,TN
PERCD	54.55%	MI,MN,MO,NE,RI,IA,MA,NV,NC,OR,SD,VT
ESTCD	45.45%	ID,MI,MN,MO,RI,RI,IA,ME,MA,OR,TN,VT
TERPB	40.91%	MI,MN,RI,CA,DE,ME,NV,SD,WI
PETCD	40.91%	ID,MI,MN,MO,NE,RI,IA,SD,TN,VT
NGTCD	40.91%	MI,MN,MO,NE,NY,GA,NC,SD,VT
GDP	40.91%	MI,MN,MO,NE,NY,CA,IA,ME,TN
ESRCB	36.36%	MI,NY,RI,CA,GA,ME,OR,SD
NNRCB	31.82%	MI,MN,NY,RI,GA,NV,VT
FFTCB	27.27%	MI,CA,GA,ME,SD,VT
ESRCD	27.27%	ID,MI,WA,IA,ME,OR,TN
TETPB	22.73%	MI,MN,MO,CA,TN
CLTCP	13.64%	WA,FL,GA
NGTCP	13.64%	GA,NC,WI

Table K.1. Ranking list 1

Appendix L : Clustering Appendix

Appendix L.1: Theoretical framework

We summarized and discussed the frequentist of significant factors that Granger Causality among 22 states. Thus, we demonstrated the similarity and dissimilarity among of 22 states which found and reported the most of states were fell into one cluster, and the rest were fell into second cluster. In this section, we introduce an approach that integrated the clustering analysis and Granger Causality results for each factor to illustrate the probability of each factor can impact on renewable energy consumption regarding of the similarity and dissimilarity among of 22 states. So, the ideal behind this approach to address mathematical approach that integrated results of VAR model and clustering technique to compute a probability of each factor could occur regarding of clustering techniques.

We simply used event algebra which is a mathematical method to compute a probability of factors and clustering.

So, we called cluster 1 is A, and cluster 2 is B. As simple way to compute probability which each cluster has finite number of states. So, we denote N is total number of states (22 states). To find a probability of each factor that statistically Granger Causality renewable energy in specific sate we address it as following :

$$P(i_j) = \frac{SVAR_{ij}}{N_j}$$

Where

P_{ij} : Probability of i factor in cluster j

$SVAR_{ij}$: refers to number of significant factor i in cluster j

N_j : Number of states in cluster j

Appendix L.1: Reported frequent each factor found Granger Causes according into specific clustering.

Below Table is summarized the results of 17 factors we considered in our study into two clustering (cluster 1 includes 19 states ; cluster 2 includes 3 states) and reported frequent each factor found Granger Causes according into specific states.

FACTORS	Cluster 1	Cluster 2
Oil	11 out 19	1 out 3
TETPB	2 out 19	1 out 3
TERPB	7 out 19	1 out 3
FFTCB	5 out 19	1 out 3
CLTCP	2 out 19	1 out 3
Income	12 out 19	1 out 3
NGTCP	3 out 19	0 out 3
NNRCB	6 out 19	1 out 3
ESTCB	10 out 19	2 out 3
ESRCB	5 out 19	1 out 3

PETCD	10 out 19	0 out 3
PERCD	12 out 19	0 out 3
NGTCD	8 out 19	1 out 3
CLTCD	12 out 19	1 out 3
ESTCD	10 out 19	0 out 3
ESRCD	7 out 19	0 out 3
GDP	8 out 19	1 out 3

Table L. 1. Clustering 1

Thus, we seek to identify the probability of each factor that intersection between cluster 1 A and cluster 2 B. Thus, the factor probability could occur based on similarity and dissimilarity of states could be straightforward. Thus, we could compute probability by using the probability concept of the intersection of independent events because the probability. If we assumed the independent event refers to number of clusters that extracted by using two techniques. Thus, we can compute a probability of each factor can occur regarding of clustering techniques. We aimed to separate the objects into subgroups based on a series of macroeconomic features to find a probability of each factor regarding of subgroups of variables or objects. Objects within the same cluster are considered homogenous at a macroeconomic level. Thus, the probability of certain factor could vary from cluster to another cluster. For example what is a probability of oil price could be significant impact on renewable energy on certain

Below Figure shows if we increased a number of clustering among states based on the certain factors that Granger Causes renewable energy from to 3 clusters.

Appendix M Pilot study

R code

```
setwd("C:/Users/Alaa Masrahi/Desktop/New folder (4)/CONTENT VALIDITY/Survey  
Editing/Professor Editing/final of final/Pilot Study Analysis")
```

```
IAN=read.csv("Poilt Study Participants Analysis.csv")
```

```
##install.packages("psy")
```

```
library(psy)
```

```
names(IAN)
```

```
MNmodel=IAN[,c(-1,-2,-3)]
```

```
cronbach(MNmodel)
```

```
library(psych)
```

```
C1=data.frame(MNmodel$x3,MNmodel$x4,MNmodel$x5)
```

```
C2=data.frame(MNmodel$x6,MNmodel$x7,MNmodel$x8)
```

```
C3=data.frame(MNmodel$x9,MNmodel$x10,MNmodel$x11)
```

```
C4=data.frame(MNmodel$x12,MNmodel$x13,MNmodel$x14)
```

```
C5=data.frame(MNmodel$x15,MNmodel$x16,MNmodel$x17)
```

```
C6=data.frame(MNmodel$x18,MNmodel$x19,MNmodel$x20)
```

```
C7=data.frame(MNmodel$x21,MNmodel$x22,MNmodel$x23)
```

```
C8=data.frame(MNmodel$x24,MNmodel$x25,MNmodel$x26)
```

Pilot Study Analysis

```
> cronbach(MNmodel)  
$sample.size  
[1] 11
```

```
$number.of.items  
[1] 24
```

```
$alpha
```

```

[1] 0.8919234

> cronbach(C1)####0.66 attitude
$sample.size
[1] 11

$number.of.items
[1] 3

$alpha
[1] 0.6666667

> cronbach(C2)####0.737 subjective
$sample.size
[1] 11

$number.of.items
[1] 3

$alpha
[1] 0.7370242

> cronbach(C3)####0.527 percieved
$sample.size
[1] 11

$number.of.items
[1] 3

$alpha
[1] 0.5276382

> cronbach(C4)####0.78 intention
$sample.size
[1] 11

$number.of.items
[1] 3

$alpha
[1] 0.7967033

> cronbach(C5)####0.758 policy
$sample.size
[1] 11

$number.of.items
[1] 3

$alpha
[1] 0.7585227

> cronbach(C6)#####-0.0961 Degree of benefit belief
$sample.size
[1] 11

```

```
$number.of.items  
[1] 3
```

```
$alpha  
[1] -0.09615385
```

```
> cronbach(C7)#####0.76    willingness to pay  
$sample.size  
[1] 11
```

```
$number.of.items  
[1] 3
```

```
$alpha  
[1] 0.7678571
```

```
> cronbach(C8)#####0.638    E.concern  
$sample.size  
[1] 11
```

```
$number.of.items  
[1] 3
```

```
$alpha  
[1] 0.6387097
```

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