ABSTRACT

Clean Energy Convergence: One Solution Leads to another Problem,

Effective Policies can mitigate the Causality

by

Nick E. Gilewski, Doctor of Philosophy

Niagara University, 2019

Major Professor: Dr. Walter Polka

Department: Leadership and Policy

The security of the United States and the systems upon which all citizens rely are in peril.  An unpredictable electric grid and a volatile bulk power market are the results of the increasing use of clean energy and the decreasing use of dirty energy. This dissertation is an investigation and analysis of the carbon emissions crisis and the causality of the battles between clean and dirty energy sources.  Yes, clean energy is a boon to the environment, but when the sun goes down and the wind is becalmed, dirty energy must be employed to keep the power systems on and the energy trading floors stable.  Good policies must be engineered to mitigate the causality from the convergence of clean and dirty energies.  This study is focused to that end.

INTRODUCTION

Solar, wind, biomass, hydrogen, and geothermal power, or “Clean Energy,” have been the fastest-growing sources of electricity generation in the United States. According to the U.S. Energy Information Administration, in 2017 the United States generated 4,034.2 billion kilowatt-hours from clean energy sources. In total, the United States generated 623.8 billion kilowatt-hours; therefore, only 15.46% came from a clean renewable source. Electricity that is not generated from a clean energy source, is considered “dirty” energy, because a byproduct of carbon dioxide (CO2) is emitted into the environment during the process. Carbon dioxide enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees, and wood products, and also as a result of certain chemical reactions (EPA , n.d.). In 2017, the United States generated 2.039 billion tons of CO2 emissions from power plants generating electricity (EIA, 2018).

The global average atmospheric carbon dioxide on January 19th, 2018 was 411 parts per million (ppm) with a range of uncertainty of plus or minus .01 ppm (NASA, 2019). Carbon dioxide levels today are higher than at any point in at least the past 800,000 years (Lindsey, 2018). Carbon dioxide concentrations are rising mostly due to the fossil fuels that people are burning for energy. Electricity is a significant source of energy in the United States and is used to power homes, business, and industry. In 2016 the combustion of fossil fuels to generate electricity was the largest single source of CO2 emissions in the nation, accounting for about 34 percent of total U.S. greenhouse gas emissions (EPA, n.d.).

Clean energy convergence represents key challenges in the pathway, while maintaining a reliable and sustainable power grid, by the replacement of fossil fuels for clean energy sources (Berk, Kasman, & Kilinc, 2018). The convergence of clean energy is happening at an enormous rate and is more imperative now to minimize and or mitigate CO2 emissions. Unfortunately, the reliability of clean energy generation can be unpredictable and inconsistent, which has adverse effects on system conditions creating a grid imbalance. The convergence of unpredictable clean energy and predictable dirty energy, can create huge swings in bulk power generation/capacity making it more difficult and costlier to manage. The diffusion between state and federal policies paint an unclear realistic trajectory for clean energy.

**Purpose Statement**

The purpose of the study is to understand the impact clean energy convergence has to bulk power reliability, distribution, and market while recognizing the importance and necessity for clean renewable energy and grid stability. State and federal policies must be created and enforced succinctly to mitigate the effects clean energy has on the power grid.

**Background of the Problem**

In 1839 a 19-year-old French physicist, A.E. Becquerel discovered the photovoltaic effect, which at that time carbon emissions were not a concern (Energy Sage, n.d.). Clean energy was created as an alternative means to create electricity, not to reduce carbon emissions. However, an increase of CO2 emission and global temperatures have caused a sense of urgency to utilize an alternative form energy that when created does so with a carbon-free footprint.

Carbon dioxide concentrations are rising mostly due to the fossil fuels that people are burning for energy (EPA , n.d.). In fact, the global average atmospheric carbon dioxide on January 19th, 2018 was 411 parts per million (ppm) with a range of uncertainty of plus or minus .01 ppm (NASA, 2019). Carbon dioxide levels today are higher than at any point in at least the past 800,000 year (Lindsey, 2018). With such dire environmental concerns and conditions, state and federal involvement is required to curtail CO2 emissions.

Numerous state and federal institutions recognized the need for clean energy sources, due to rapidly increasing CO2 emissions and global temperature causing the creation of new regulations and policies. However, there are too many government bodies involved in the decision making towards the convergence of clean energy creating ambiguity. Listed below are state and federal organizations that have a stake in the clean energy regulation and policy making process:

The North American Electric Reliability Corporation, or NERC, is a not-for-profit international regulatory authority whose mission is to assure the effective and efficient reduction of risk to the reliability and security of the grid (NERC, n.d.).

The Federal Energy Regulatory Commission, or FERC, is an independent agency that regulates the interstate transmission of natural gas, oil, and electricity. In addition, FERC regulates natural gas and hydropower projects (FERC, 2019).

The National Conference of State Legislatures, or NCSL, was created on January 1, 1975 to:

* Improve the quality and effectiveness of state legislatures.
* Promote policy innovation and communication among state legislatures.
* Ensure state legislatures a strong, cohesive voice in the federal system.

The NCSL is a bipartisanship committee that servers both Republicans and Democrats, legislators and staff.

Regional Transmission Organizations, or RTO, in the United States in an electric power transmission system operator that coordinates, controls and monitors a multi-state electric grid.

Independent System Operator, or ISO, was formed by the recommendations of FERC. An ISO coordinates, controls, and monitors the operation of the electric power system, usually within a single U.S. state, but sometimes encompasses multiple states.

**Rationale for the Study**

Minimal research has been done towards minimizing or completely mitigating the causality of clean energy. Additionally, both state and federal energy policies must act succinctly to converge clean energy successfully. Policies are chosen by state representatives whom have different preferences, initiatives, goals and resources creating diffusion between state policies and federal regulations. The United States does not currently have any federal-level renewable energy policies that are formulated to include national renewable electricity targets, policies are only made at the state level (Okioga, Wu, Sireli, & Hendren, 2018). While the United States does not directly mandate federal policies; however, federal regulations are mandated which can indirectly and negatively influence state policies.

**Problem Statement**

Clean energy is required to reduce carbon dioxide emissions; however, the solution of one problem creates another. The convergence of clean energy creates frequency variations, capacity swings, and market fluctuations. Moreover, according to the International Energy Agency (IEA) the global average wind and solar penetration today is 5%, and will rise to 13-34% by 2040, depending on the ambition of energy policies adopted (Wnynn, 2018). That said, policies dictate how clean energy integrates onto the power grid; therefore, well thought out policies is critical.

**Conceptual Framework**

The researcher will be using a quantitative research approach, which is used for testing objective theories by examining the relationship among variables. These variables, in turn, can be measured, typically on instruments, so that numbered data can be analyzed using statistical procedures. The final written report has a set structure consisting of introduction, literature and theory, methods, results and discussion (Creswell & Creswell, 2018).

Multilevel modeling using independent and dependent variables to test the null hypothesis with clean energy convergence, the power grid and policies. Identify any correlations between clean energy sources, policies, and grid or market instability.

For example, the North American Electric Reliability Corp., which is the regulatory agency that ensures the security of the nation’s wholesale power supply, planned for more than a year to mitigate the effects of the solar eclipse that occurred on August 21st, 2017. The last solar eclipse occurred in 1991, and wasn’t a concern because solar was in its infancy states (Maykuth, 2017).

Dependent Variables

* Grid frequency
* Day ahead market pricing
* Real-time market pricing

Independent variables

* Federal Policies
* State Policies

**Research Questions**

1. How does the convergence of clean energy effect the Electric Grid?
2. How do current policies impact or impede the convergence of Clean Energy?

**Definition of Key Terms**

Clean Energy – Hydroelectric, Wind, Solar, Biomass, and Geothermal energy sources.

CO2 – Carbon Dioxide

Dirty Energy – Coal, Petroleum, Natural Gas, Nuclear, Wood, and Other Gases energy sources.

EIA – U.S. Energy Information Administration

EPA – Environmental Protection Agency

FERC – Federal Energy Regulatory Commission

IRENA – International Renewable Energy Agency

ISO – Independent System Operator

NASA – National Aeronautics and Space Administration

NERC – North American Energy Reliability Corporation

NOAA - National Oceanic and Atmospheric Administration

NREL – National Renewable Energy Laboratory

PURPA – The Public Utility Regulatory Policies Act

PRS – Renewable Portfolio Standards

SPSS – Statistical Package for Social Sciences

**Limitations**

Information and data relating to grid frequency swings may be proprietary and unavailable to the public. In addition, some financial information may be private regarding market pricing on clean energy generation . Policies are mostly created reactively versus proactively, therefore understanding the backdrop on why certain policies were created may be difficult to locate. Limited lack of resources for data collection. The researcher may face problems when in a controlled environment, during an interview, where the respondent is limited on answering the questions honestly. Quantitative research is difficult, requires a lot of time and can be expensive, which can become a limitation.

**Delimitations**

The focus of the research will be on the United States. Encompassing the world in this research paper would lead to an inaccurate representation data due to different regulations and policies. Europe will be used throughout the research to show similarities and correlations. Unlike the United States, Europe can and does mandate that countries within the EU to conform to clean energy goals. The United States does not currently have any federal-level renewable energy policies that are formulated to include national renewable electricity targets, policies are only made at the state level (Okioga, Wu, Sireli, & Hendren, 2018).

**Organization of the Study**

The following are the list of chapters that will be included in the proposed study:

1. Introduction
   1. Statement of the problem
   2. Rationale for the study
   3. Research question and hypothesis
   4. Definition of key terms
   5. Assumptions
   6. Limitations and delimitations of the study
2. Literature Review
   1. Clean energy causality
   2. State energy policies
   3. Federal energy policies
3. Research Methodology – Descriptive and inferential statistical non-experimental methodological approach
   1. Research question and hypothesis
   2. Data collection - Longitudinal
      1. Observational
      2. Exploratory
      3. Survey
      4. Case-control
      5. Correlation
      6. Interviews
      7. Document reviews
      8. Historical and proforma data review
   3. Instrumentation and software - SPSS
   4. Independent and dependent variables
   5. Data analysis and interpretation
   6. Statistical power of the study
4. Results
   1. Results analysis
5. Discussion and Conclusion
   1. Recommended future studies
6. References

**Research Methodology – Descriptive and Inferential Statistical non-experimental methodological approach**

The researcher is prepared to answer two research questions: (1) How does the convergence of clean energy effect the Electric Grid? (2) How do current policies impact or impede the convergence of Clean Energy?

The researcher will conduct interviews, explore, conduct research, review documents, collect data, and make observations on clean energy convergence and the current energy policies. The interviews and study abroad will take place in the United States and in Europe. The expectation from the interviews and study abroad, that are conducted in the U.S. and the UK, will be to show a correlation or relationship when converging clean energy and energy policies required to effectively do so. The data collection process will be difficult, longitudinal and expensive.

The first interview will be conducted in Athens Greece with the Minister of Energy. During the interview and whilst in Athens the researcher will explore, conduct research, review documents, and make observations on clean energy convergence and the current energy policies.

The second interview will be conducted in Budapest Hungary with the Minister of Foreign Affairs and a United States Diplomat responsible for foreign affairs and policy. During the interview and whilst in Budapest the researcher will explore, conduct research, review documents, and make observations on clean energy convergence and the current energy policies.

The third interview will be conducted in Budapest Hungary with the Minister of Foreign Affairs and a United States Diplomat responsible for foreign affairs and policy. During the interview and whilst in Budapest the researcher will explore, conduct research, review documents, and make observations on clean energy convergence and the current energy policies.

The fourth interview will be conducted in London England with the Minister of Energy and a Diplomat responsible for foreign affairs and policy. During the interview and whilst in London the researcher will explore, conduct research, review documents, and make observations on clean energy convergence and the current energy policies.

The fifth interview will be conducted in Washington D.C. with a member of the Department of Energy. During the interview and whilst in Washington the researcher will explore, conduct research, review documents, and make observations on clean energy convergence and the current energy policies.

The sixth, and last interview will be conducted in Golden, Colorado with a member of the National Renewable Energy Lab. During the interview and whilst in Golden the researcher will explore, conduct research, review documents, and make observations on clean energy convergence and the current energy policies.

The researcher will attend the 2018 Advanced Energy Conference in New York City in hopes to glean a look into the synergy surrounding clean energy. The Advanced Energy Center (AERTC) is located in the Research & Development Park at Stony Brook University and is a true partnership of academic institutions, research institutions, energy providers and industrial corporations. The Center's mission is innovative energy research, education and technology deployment with a focus on efficiency, conservation, renewable energy and nanotechnology applications for new and novel sources of energy (AEC, n.d.). Numerous observations and documentation will be obtained from attending clean energy classes enthralled with rich discussion and content.

Lastly, the researcher will obtain copious amounts of well-dispersed population statistical data from a myriad of internet sources. The data sources will include, but are not limited to: Data.Gov, National Renewable Energy Laboratory, Department of Energy, Environmental Protection Agency, National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, and Institute for Energy Economics and Financial Analysis.

Data.Gov is Data.gov is a U.S. government website launched in late May 2009 by the then Federal Chief Information Officer (CIO) of the United States, Vivek Kundra. Data.gov aims to improve public access to high value, machine readable datasets generated by the Executive Branch of the Federal Government. The site is a repository for federal, state, local, and tribal government information, made available to the public (Data.Gov, n.d.). The data collected from Data.Gov will be used and analyzed statistically.

The National Renewable Energy Laboratory focus on creative answers to today's energy challenges. From breakthroughs in fundamental science to new clean technologies to integrated energy systems that power our lives, NREL researchers are transforming the way the nation and the world use energy (NREL, n.d.). The NREL has an enormous amount of information and data on current and possible future renewable energy generation. The future renewable energy modeling will be used to demonstrate that the United States can utilize 100% clean energy, resulting in zero carbon emissions.

The Department of Energy mission is to ensure America’s security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions (DOE, n.d.). The DOE data and documents will be utilized from a policy perspective. Policies will be interpreted and converted to a numerical value having a specific numerical weight for analysis.

The Environmental Protection Agency is responsible for protecting human health and the environment. The EPA works to insure that:

* Americans have clean air, land and water;
* National efforts to reduce environmental risks are based on the best available scientific information;
* Federal laws protecting human health and the environment are administered and enforced fairly, effectively and as Congress intended;
* Environmental stewardship is integral to U.S. policies concerning natural resources, human health, economic growth, energy, transportation, agriculture, industry, and international trade, and these factors are similarly considered in establishing environmental policy;
* All parts of society--communities, individuals, businesses, and state, local and tribal governments--have access to accurate information sufficient to effectively participate in managing human health and environmental risks;
* Contaminated lands and toxic sites are cleaned up by potentially responsible parties and revitalized; and
* Chemicals in the marketplace are reviewed for safety.

When Congress writes an environmental law, we implement it by writing regulations. Often, we set national standards that states and tribes enforce through their own regulations. If they fail to meet the national standards, we can help them. We also enforce our regulations, and help companies understand the requirements (EPA , n.d.). Data and policies collected from the EPA will be interpreted and converted to a numerical value having a specific numerical weight for analysis.

The European Commission is responsible for the EU’s energy policy; secure, sustainable and competitively priced energy for Europe (European Commission, n.d.). Data and policies collected from the European Commission will be interpreted and converted to a numerical value having a specific weight for analysis.

National Aeronautics and Space Administration’s (NASA) vision: We reach for new heights and reveal the unknown for the benefit of humankind (NASA, 2019). NASA’s database will be utilized to analyze vital signs of the planet, specifically the United States and Europe. Historical, current and predicted future data will be used and analyzed regarding climate change and carbon dioxide emissions.

National Oceanic and Atmospheric Administration (NOAA), which is an agency that enriches life through science. NOAA’s reach goes from the surface of the sun to the depths of the ocean floor and works to keep the public informed of the changing environment around them. NOAA’s mission is to understand and predict changes in climate, weather, oceans, and coasts to share that knowledge and information with others, and to conserve and manage coastal and marine ecosystems and resources (NOAA, n.d.). The NOAA is considered to be America’s environmental intelligence agency. Historical, current and predicted future data will be used and analyzed regarding climate change and carbon dioxide emissions.

The Institute for Energy Economics and Financial Analysis conducts research and analyses on financial and economic issues related to energy and the environment. The Institute’s mission is to accelerate the transition to a diverse, sustainable and profitable energy economy (IEEFA, 2019). Historical, current and predicted future financial data will be used in an economic analysis.

The data collected from the said sources will be analyzed using SPSS identifying descriptive and inferential statistics. The IBM SPSS software platform offers advanced statistical analysis, a vast library of machine-learning algorithms, text analysis, open-source extensibility, integration with big data and seamless deployment into applications. Its ease of use; flexibility and scalability make IBM SPSS accessible to users with all skill levels and outfits projects of all sizes and complexity to help you and your organization find new opportunities, improve efficiency and minimize risk (IBM, n.d.).

Inferential statistics is the branch of statistics that deals with generalizing outcome from small samples to a much larger population. Some key concepts of inferential statics are:

* Statistical significance testing;
* Confidence intervals;
* Statistical power;
* Standard errors;
* Null hypotheses.

All the above-mentioned concepts are aimed at drawing conclusions, or inferences, on populations based on data from samples from those populations. The basic concept is that sample statistics such as means, correlations, proportions and others which may differ from their population counterparts (parameters). However, they do so in a predictable way which tells us how much our sample outcomes are likely to be off (SPSS, n.d.).

Descriptive statistics are brief descriptive coefficients that summarize a given data set, which can be either a representation of the entire or a sample of a population. Descriptive statistics are broken down into measures of central tendency and measures of variability (spread). Measures of central tendency include the mean, median, and mode, while measures of variability include the standard deviation, variance, the minimum and maximum variables, and the kurtosis and skewness (Kenton, 2018).

For example, the researcher will analyze direct and indirect variables pertaining to energy policies and clean energy convergence making correlations verifying a null hypothesis. Furthermore, if the null hypothesis is rejected the researcher can use results from inferential statistics to formulate and accept a null hypothesis towards a descriptive analysis. Specifically, this would be used to show that Europe has a greater integration of clean energy, why? Because, Europe has federal policies mandating the use of clean energy, whereas the United States does not. Hence, a lower clean energy penetration rate within the United States.

As mentioned in my original message/invitation, I am currently writing my dissertation for my Ph.D. at Niagara University. I have a couple of questions about my research question. Do you feel enough research has been done in identifying the deleterious affects renewable energy has on the power grid? More specifically, without load balancing area cooperation, renewable energy would be extremely difficult, and damn near impossible. So, there are physical constraints on a bulk power system that is being exacerbated by the introduction of more renewable energy. The convergence of renewable energy is made possible mostly by hydro, or peak plants that can quickly absorb the onset of renewable energy instabilities. Moreover, these peak plants and hydro plants are starting and stopping, hundreds, if not thousands of times a year. The degradation of the units themselves, due to thermal stresses, has not been quantified because renewable energy is relatively new in large quantities. Please note… I am pro renewable energy, because I do feel we have a global warming/climate change crisis on our hands. I am hoping that my research will spur more research on the causality of renewable energy, minimizing the affects, as we move forward to a greener future. Lastly, if you have any suggestions on research questions that you feel need to be answered, please let me know. You have traveled the world and have evolved with renewable energy; therefore, you may see it thru a different lens. That being said, you may be able to offer additional research that needs to be conducted with the convergence of green energy. Thank you, Nick Gilewski

DILLUTE AND INTERMITTENT WIND AND SOLAR. THE DILUTENESS PROBLEM AND THE INTERMITTENCY PROBLEM!!!!

FOSSIL FUEL USAGE IN GERMANY HAS INCREASED NOT DECREASED SINCE THE PENETRATION OF RENEWABLE ENERGY. GERMAN ELECTRICITY BILL HAS GONE UP DRAMATICALLY, CAUSING ENERGY POVERTY.

CHEAP AND PLENTIFUL

DEMAND CURVE, WHICH CHANGES THRUOUGHT THE DAY. THE DUCK CURVE!

INTENSE RAMPS, GRID FLEXIBILITY AND OVERGENERATION!

ECONOMIC – COAL AND NUCLEAR ARE NOT ECONOMIC DUE TO SOLAR.

SOLAR CURTAILMENT. SOLUTION WOULD BE TO HAVE MORE OF A DEMAND AT NIGHT AND LESS DURING THE DAY OR ENERGY STORAGE.

THE REAL PROBLEMS

1. DUCK CURVE
2. UNRELIABLE LOCAL GRID
3. HIGH ELECTRIC RATES

# References

AEC. (n.d.). *About Us AEC*. Retrieved from Advanced Energy Research and technology Center: https://www.stonybrook.edu/commcms/aertc/about/index.php

Berk, I., Kasman, A., & Kilinc, D. (2018). Policy convergence as a multifaceted concept: the case of renewable energy policies in the European Union. *Energy Ecomonics*, 1-6.

Creswell, D. J., & Creswell, J. W. (2018). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. In D. J. Creswell, & J. W. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (pp. 1-4). California: Sage Publications.

Data.Gov. (n.d.). *About Data.Gov*. Retrieved from Data.Gov: https://www.data.gov/about

DOE. (n.d.). *About Department of Energy*. Retrieved from The Department of Energy: https://www.energy.gov/about-us

EIA, U. E. (2018, November 8). 2017 Carbon Dioxide Emissions at Electric Plants. Washington, District of Columbia, United States.

Energy Sage. (n.d.). *The History of Solar Eneregy*. Retrieved from Energy Sage: https://news.energysage.com/the-history-and-invention-of-solar-panel-technology/

EPA . (n.d.). *Greenhouse Gas Emissions*. Retrieved from United States Environmental Protection Agency: https://www.epa.gov/ghgemissions/overview-greenhouse-gases

EPA. (n.d.). *Greenhouse Gas Emissions*. Retrieved from United States Environmental Protection Agency: https://www.epa.gov/ghgemissions/overview-greenhouse-gases#carbon-dioxide

European Commission. (n.d.). *Policies, Information and Services*. Retrieved from European Commission: https://ec.europa.eu/info/departments/energy\_en

FERC. (2019, January 15). *Federal Energy Regulatory Commission*. Retrieved from About FERC: https://www.ferc.gov/about/about.asp

IBM. (n.d.). *Why IBM SPSS Software*. Retrieved from IBM SPSS Software: https://www.ibm.com/analytics/spss-statistics-software

IEEFA. (2019, March 27). *Insitute for Energy Economics and Financial Analysis*. Retrieved from About IEEFA: http://ieefa.org/about/

Kenton, W. (2018, May 25). *Descriptive Statistics*. Retrieved from Investopedia: https://www.investopedia.com/terms/d/descriptive\_statistics.asp

Lindsey, R. (2018, August 1). *Climate.gov*. Retrieved from Climate Change: Atmospheric Carbon Dioxide: https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide

Maykuth, A. (2017, August 16). *What happens to the grid when solar power goes dark during the eclipse?* Retrieved from The Inquirer Daily News Philly.com: https://www.philly.com/philly/business/energy/what-happens-to-the-grid-when-solar-power-goes-dark-during-the-eclipse-20170818.html

NASA. (2019, January 1). *Carbon Dioxide Facts*. Retrieved from Global Climate Change: https://climate.nasa.gov/vital-signs/carbon-dioxide/

NASA. (n.d.). *About NASA*. Retrieved from National Aeronautics and Space Administration: https://www.nasa.gov/about/index.html

NERC. (n.d.). *About NERC*. Retrieved from North American Reliability Corporation: https://www.nerc.com/AboutNERC/Pages/default.aspx

NOAA. (n.d.). *National Oceanic and Atmospheric Administration*. Retrieved from About NOAA: https://www.noaa.gov/about-our-agency

NREL. (n.d.). *About NREL*. Retrieved from National Renewable Energy Labratory: https://www.nrel.gov/about/

Okioga, I. T., Wu, J., Sireli, Y., & Hendren, H. (2018). Renewable energy policy formulation for electricity generation in the United. *Elsevier*, 365-384.

SPSS. (n.d.). *Inferential Statistics*. Retrieved from SPSS Tutorials: https://www.spss-tutorials.com/inferential-statistics/

Wnynn, G. (2018, February). Wind and Solar Won't Break the Grid: Nine Case Studies. Cleveland, Ohio, United States.