# Technologies and Technology Policies in the U.S.: Public Attitudes and Opinion

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## Introduction to Science, Technology and Public Policy

This report represents the collective efforts of the students in the *Science and Technology Policy* course at the Bush School of Government and Public Service during the spring semester of 2017.

The students were asked to match their own science and technology policy interests with a number of public opinion surveys conducted between 2012 and 2016 under the auspices of the Institute for Science, Technology and Public Policy (ISTPP) at the Bush School. Each student selected a topic focusing on a specific scientific issues, technology, or problem, and then conducted background research on the selected interests or topics. The background research was used to define the scope of the problem, and to frame the research in a way that set the stage for subsequent data analysis. Then the data that seemed most appropriate to the selected topics were made available, and students conducted a variety of different types of analysis. The papers contained in this report reflect the independent and original research and analysis conducted by each student.

Efforts were made to coordinate the analyses conducted by each student. As students selected the topic for their respective papers, they took into consideration the topics selected by the other students. As the background research took form, class discussions provided feedback, insights, and recommendations. As the data analysis progressed, opportunities for students to present preliminary findings yielded additional recommendations. Final report chapters were presented, at least in preliminary form, to the others in the class for discussion and comment. Each student received directed feedback from at least one other student. The final report was reviewed and edited by Gillian Acca and others.

The result is a report that: 1) takes advantage of original data collection projects at ISTPP; 2) provides a forum for students to present and make accessible their respective research; 3) represents the collective work of the students; 4) shows a high level of analytic competence; and 5) demonstrates a reasonably high level of coordination in both style and substance.

# Section 1

# U.S. National and Subnational Energy Technologies and Policies

# CHAPTER 1

## *The Nation's Electric Grid and the Public's Perception of a Terrorist Act Upon It*

**Morgan Anderson**

### INTRODUCTION

The electric grid is the system that provides stability in a world that necessitates electricity to power everyday life. According to the U.S. Department of Energy, the total United States energy production has increased 16% in the past 10 years (2015). The electric grid is the way electrical power is delivered from a producer to a consumer. The increase in production of power shows there is an increase in the amount of power being consumed by things like electronic devices and household appliances. If the electrical grid fails, chaos and social disorder will soon follow. Without electricity, the economy struggles because stocks cannot be traded, cash cannot be withdrawn, and emergency services are not able to save the injured. The electrical grid needs to be protected and maintained because it is critical to the government, businesses, and services that protect the people. Although the grid system is currently stable, concerns exist regarding the aging critical infrastructure and potential cyber vulnerabilities that could impair the power grid. The first part of this chapter will address the background of the electric grid, the process, the vulnerabilities, the implications of a cyber-attack, and then examine the current cybersecurity policy involving the electric grid. The second part of this chapter will analyze the public's perception of a cyber-attack on the electric grid and what they believe the federal government should spend on cybersecurity.

## PART I: ISSUE CONTEXT

### HISTORY

Thomas Edison laid the foundation for the current electric grid in 1882 with the successful construction of the first U.S. power plant called Pearl Street Station in lower Manhattan (Masters 2017). Pearl Street Station provided power to 400 bulbs in less than 1 square mile of the city through a direct current (DC) distribution lines (Lesser 2017). The construction of the power plant involved solving the issue of creating a generator that was powerful enough and building the network of wires and underground tubes (ETHW 2015). Edison invented a "jumbo" dynamo that was four times the size of previous generators and produced 100 kilowatts (ETHW 2015). The network of wires and underground tubes delivered the energy to the customer and required the streets of lower Manhattan to be dug up (ETHW 2015). Overall, the system's construction costs were $300,000 and the power plant became profitable 2 years later (ETHW 2015). The success of Edison's power plant created a desire in many American's to have electricity in their homes. However, the demand for electricity could not be met because the energy could not be sustained over great distances. Direct current only allows power to flow in one direction and the power does not travel long distances well (MIT Engineering 2013). The discovery of alternating current (AC) by George Westinghouse changed the electric grid.

AC power allows energy to travel between a power plant and a consumer when the two are in locations far away. AC allows the current to flow back and forth creating an oscillating repetition, which allows it to travel efficiently (MIT Engineering 2013). In addition, AC has the ability to transform from a high-voltage power that is created initially in power plants to a higher voltage for transport and then back down to distribute reasonable voltages for everyday use (MIT Engineering 2013). High-voltage is important because the greater the voltage, the further the current can be transmitted according to Ohm's Law (Lesser 2017). AC power allowed cities to receive power from a power plant in the countryside that was safe to use in their everyday homes.

After World War II, the demand for electricity grew and utilities operating individually operating utilities were integrated to meet the rising demand (Lesser 2017). The integration of utilities ensured reliable service and reduced costs by building a backup generating capacity in case unexpected problems arose with another power plant (Lesser 2017). During this time, high-voltage transmission lines were constructed to transport electricity over greater distances (Lesser 2017). As the price of electricity dropped, more people were able to afford electricity and it began to change the way people lived.

Today, the electric grid consists of 6,000 power plants and over 2.7 million miles of power lines (McBride 2016). The local grids are connected to form three main interconnections that operate independently from each other (EIA N.d.). The three main interconnections are the Eastern Interconnection, the Western Interconnection, and the Electric Reliability Council of Texas (EIA N.d). The basic system of the electric grid has not changed since Thomas Edison created the first power plant. However, technology has improved over time to provide the majority of Americans across the country with enough energy to power the 21st-century life.

## TECHNICAL PROCESS

The electric grid is designed to get power from where it is produced to where it will be consumed. In order to understand the challenges the system undergoes, it is essential to have knowledge of the how the electric grid actually works. The complexity of the energy distribution process can be categorized into the following stages:  power generation, transmission, and distribution.

### Generation

The power plant creates energy through a spinning electrical generator (Brian and Roos 2017). The spinning electrical generator requires something to spin it, which is commonly a steam turbine (Brian and Roos 2017). Burning fossil fuels or coal is the most common way to power steam turbines (Brian and Roos 2017). Other renewable energies that provide fuel for power plants include hydroelectric dams, solar panels, and wind turbines. In 2014, 11% of the United States' electricity was produced by renewable energy sources (Brian and Roos 2017). Even though renewable energy is a growing energy source, it is a variable because it is dependent upon nature. Coal power plants are used to consistently provide energy because it takes a long time to ramp the power plant up or down for electricity output (Brian and Roos 2017). Natural-gas-fueled plants are highly flexible in the amount of time it takes to adjust their electricity output and are often used to meet peaks in the demand of electricity (Brian and Roos 2017). Finally, renewable energy is used whenever it is available. The energy created from any type of power plant does not produce the high-voltage power necessary to transport efficiently, and therefore needs to step up the voltage. Newly generated power travels to transmission substations that use transformers to convert it to extremely high voltages. This particular transformer is a step-up transformer that converts power to high voltages for transmission over long distances (Brian and Roos 2017).

## Transmission

Transmission is when power travels through wires and across electric poles on its way to the consumer. Transmission lines can be found in the form of underground cables or overhead power lines. The voltages the transmission lines carry are so high because as electricity flows through the wires, some of it dissipates (McNamara 2017). Thus, using a transformer increases the voltage, which allows less electricity to be lost in the transmission process. In order for power to be useful for consumers, the voltage needs to be stepped down through a transformer (Brian and Roos 2017). The step-down transformer takes the voltage of 100,000 volts to around 10,000 volts (Brian and Roos 2017). After the decrease in voltage, a distribution bus “splits the distribution power off in multiple directions” and decreases the voltage even further to meet local energy needs (Brian and Roos 2017).

## Distribution

After the voltage has been decreased sufficiently, the distribution lines carry electricity to the consumer. When the energy is approaching its final destination, the energy goes through a set of transformers (Brian and Roos 2017). The transformers reduce the 7,200 volts carried on the distribution lines to the 240 volts that normal consumers can utilize (Brian and Roos 2017). The energy then enters through the watt-hour meter, which measures a consumer's electrical consumption (Brian and Roos 2017). Smart meters are replacing watt-hour meters and they communicate directly with the power company (Brian and Roos 2017). After the power enters the house, the entire process of the electrical system is complete.

## CURRENT CHALLENGES

The current challenges the electric grid faces are centered on the fact that a complex system needs to be protected and updated to address the needs of the country. The design and the construction of the electric grid were started in the early 1900s and continued to grow with the increase in demand for electricity. Even though current technology has been created to compliment the system built in the 1920s, new critical infrastructure needs to be built in order to encourage growth in technology. The reliance on IT systems "exposes the electric grid to potential and known cybersecurity vulnerabilities including: an increased number of entry points and paths can be exploited; the introduction of new, unknown vulnerabilities resulting from an increased use of new system and network technologies; and wider access to systems and networks due to increased connectivity" (Glenn 2017).

Understanding the reliance between society and IT is important when trying to brainstorm solutions to the main challenges. The three main challenges with the electrical grid are found within power outages, aging infrastructure, and cyber-attacks.

### Power Outages

Power outages can be caused by either an intentional attack by cyberterrorists or unintentionally by weather. The problem with power outages is one city's power outage can cause another city to have power outages due to the interconnections. In 2003, over 8 states lost power due to a transmission line that hit an overgrown tree, which caused a local outage and then power outages cascaded through the system (Barron 2003). Effects included fifty million people without power for several days, thousands of stranded commuters, and flooded hospitals. This is just one example that demonstrates the vulnerability of the interconnectedness of the grid. In addition, the 2003 blackout exemplifies how society is impacted when there is a malfunction of the electric grid.

## Aging Infrastructure

The electric grid consists of over 200,000 transmission lines and 6,000 power plants across the country that need to either be repaired or maintained. The majority of the electrical infrastructure was constructed right after WWII when the demand for electricity was high. Because the average age of a power plant is now over 30 years, power transformers averaging over 40 years of age, and 70% of transmission lines being 25 years or older, the system is quite antiquated (Campbell 2011). The equipment is difficult to replace because it is large, hard to move and custom-built (Lesser 2017). Aging infrastructure that breaks frequently and cannot be repaired means there are more possibilities for unintentional blackouts to happen due to the system not working correctly. Unless a solution is found to repair the old infrastructure or a construction project updating the entire system, the entire infrastructure will continue to degrade and cause disruptions to the system.

## Cyber-Attacks

The world is increasingly dependent on the Internet and communications networks to power their devices and organizations. The more businesses and operating systems utilize the

Internet, the easier it is for cyber criminals and terrorists across the world to gather information, steal money, or disrupt operating systems. Cyber criminals are targeting countries' electric grids because it affects every aspect of society. In 2015, Ukraine experienced a cyber-attack on their power grid through "spear-phishing" incursion (Smith 2016). The cyber criminals stole credentials necessary to gain access to utilities' operations and for nine months, the hackers studied the Ukrainian electric system (Smith 2016). Months later the "hackers remotely took control of three of Ukraine's 30 power distribution utilities" (Smith 2016). The hackers interfered with the electric grid's operations at 50 substations and shut off electricity to about 700,000 people (Smith 2016). Similarly, experts believe hackers had access to several U.S. energy companies' industrial control networks (Smith 2016). Because the power grid is so interconnected, "successfully taking down one or more utilities could destabilize larger areas of the grid" (Smith 2016). Cyber-attacks on the electric grid could result in social chaos, lack of control, and no means to communicate a plan to the nation. Control systems, communication, and Internet access are the three most vulnerable aspects of the electric grid because they are the least protected.

### *Control Systems*

The control system's vulnerabilities are caused by the lack of security surrounding third-party access and remote maintenance portals. The primary function of a control center is to "provide centralized monitoring of power system operations, to retain historical data, and to allow for the manual and automatic control of field equipment" (SANS Institute 2001). Corporate MIS systems have access to other utilities or power pools and to their vendors. These systems can allow malicious actors utilize the security weakness of the corporate MIS system to gain access to the electric grid. The second major vulnerability is remote maintenance and administration ports that can also access control centers, such as the Energy Management System (EMS; SANS Institute 2001). The EMS "controls the flow of power through that utility's section of the power grid" and is vulnerable from both outside and insider threats (SANS Institute 2001). External threats can gain access to the power grid when a utility's EMS is connected to a Local Area Network (SANS Institute 2001). Internal threats can utilize the company's own remote maintenance and administration ports, "which may enable workers to dial-in to troubleshoot problems, do other administrative tasks or even operate EMS applications" (SANS Institute 2001).

*Communication and Internet Access*

Communication systems and Internet access are vulnerable to unauthorized system access and the interception of private network communications. Because the grid is capable of two-way communications, which are potential points of unauthorized system access, they can be monitored or hacked (Campbell 2013). The smart grid is the new initiative championed by the Department of Energy to have the entire electric grid "talk" to one another. However, systems such as supervisory control and data acquisition (SCADA), which was deployed before the smart meters, have the "communication infrastructure comprised of private microwave radio and private fiber networks, and public networks for communication between control system elements" (SANS Institute 2001). If criminals wanted to hack into this particular system the damage of a physical attack and the interception or jamming of communications are the only things hackers could accomplish (SANS Institute 2001). As the equipment and operations become fully integrated with communications and Internet access systems, the company will need to have a strict and thorough policy and technological boundaries to protect the grid.

**FUTURE TECHNOLOGY**

Because the physical electric grid continues to degrade, it will need to be replaced. The new part of the system will be a transition part, both compatible with the current system and innovative in order to help usher in the updated electrical system. Currently, there is an initiative funded by the Department of Energy (DOE) to develop the "smart grid" which is "a fully automated power delivery network that monitors and controls every customer and node, ensuring a two-way flow of electricity and information" (Department of Energy, N.d). The "smart grid" allows "greater real-time responsiveness in connecting power producers and consumers" (McBride 2016). The real-time responsiveness is found in smart meters, which are attached to the transmission lines by houses and businesses and can constantly monitor demand and supply (McBride 2016). "Smart appliances can "talk" to the grid and shift electricity use to off-peak times, which eases the burden on the grid, lowering prices and helping to avoid blackouts" (McBride 2016).

However, strong opposition to the smart grid exists. Opponents claim "the information processing attributes which make the smarter grid attractive are the very same attributes which can increase the vulnerability of the electric power system and its critical infrastructure to a potentially devastating cyber-attack" (Campbell 2011). Further, the group believes:

> "while these new components may add to the ability to control power flows and enhance the efficiency of grid operations, they also potentially increase the susceptibility of the grid to cyber-attack since they are built around microprocessor devices whose basic

> functions are controlled by software programming and subject to manipulation over a network" (Campbell 2011).

Tension exists because one group believes in innovation and the other focuses on security. In each era of history, idealists and realists have debated on whatever issue was pertinent at that time. Disagreements following this type of division occur in the technical aspect of the job, and these ideological differences on this matter are strong with policy and regulations.

## POLICY

The major cybersecurity policies and standards are created and implemented by the private owners of the electric grid. Even though the federal government has a significant role in promoting the electric grid's resilience, it does not have the jurisdiction to implement security measures on the grid (GAO 2017). DOE is the lead agency for the federal grid, which is only a small portion of the United States' electric grid (GAO 2017). Policy and regulation regarding the electrical grid are limited to the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007. The two groups majorly involved in these policies are the North American Electric Reliability Corporation (NERC) and the Federal Energy Regulatory Committee (FERC).

### Energy Policy Act of 2005

The act changed U.S. energy policy by providing tax incentives and loan guarantees for energy production (EPA 2017). For the first time, reliability standards were mandated (Campbell 2011). NERC was given the responsibility to "develop specific reliability and operation standards to ensure the reliability and safe operation of the bulk power system" (Campbell 2011). FERC is responsible for "enforcing NERC's reliability standards" (Campbell 2011). In addition, "FERC oversees the bulk power system that transmits electricity across state lines, which is subject to federal regulation" (Masters 2017). Any standards identified through the NIST-led process are voluntarily useless because FERC was not provided with additional authority to require any utility or manufacturer of a smart grid technology to follow the NIST standard (U.S. Government Accountability 2015). Even though standards were being developed and written to provide guidance to stakeholders who were essential in maintaining and developing the smart grid, no one would be required to implement it because FERC never approved it.

The Energy Independent and Security Act (EISA) of 2007

"EISA established a federal policy to support the modernization of the electricity grid and required actions by a number of federal agencies" (U.S. Government Accountability Office 2015). In addition, "EISA directed NIST to develop a framework for protocols and standards for the Smart Grid to achieve 'interoperability' of devices and systems" (Campbell 2011). The outcome of the NIST framework for the Smart Grid was FERC never approved the NIST.

The policies discussed were not helpful in establishing a cooperative environment with the purpose of outlining how to address the growth or the security of the electrical grid. Standards need to be implemented because protecting the electrical grid is defending the American way of life.

## PART II: RESEARCH ON PUBLIC'S OPINION OF CYBERSECURITY

The public perception of cyber-attacks on the electric grid is essential for understanding if the public is concerned about this issue, and if they support their elected officials allocating time and resources to addressing cyber threats. Public support is essential in whether efforts to protect the electric grid will be successful. Americans must be concerned about a cyber-attack on the electric grid if they adapt their behaviors and expect the government to allocate money to securing the grid. In general, people and the American government do not like change because it involves new practices and requires new legislation, budgets and political capital to respond to the new issue.

The first research question posed is: does political ideology affect a person's level of concern about a cyber-attack on the electric grid? This exploratory research seeks to discover what affects public concern of cyber-attacks on the electric grid. If political ideology is found to significantly impact the level of public concern, then more needs to be done to show all people how cyber-attacks will affect them.

The second research question is: does a person's level of concern about a cyber-attack on the electric grid affect their belief of how much the government should spend on cybersecurity? The research conclusions to this question are important because this determines whether concern lead to support of action.

The article is organized as follows: the background of the American people's perception of cybersecurity and their concern about a cyber-attacks on the electric grid; the research design and the empirical results; and finally a discussion of the implications of the findings for cybersecurity policy.

## LITERATURE REVIEW

Studies have shown the American people views on cyber-attacks and specifically cyber-attacks on the electrical grid as a major national security concern. Ever since September 11, 2001, Americans have lost a sense of security and are concerned about terrorist attacks on their nation (Ghosch 2007). As technology has evolved, the way American's can be attacked by terrorists includes more sophisticated means including cyber. Even though the average American is unclear about key technical cybersecurity concepts, such as what encryption or true two-factor authentication is, they all understand they are vulnerable to exploitation and attack through cyber means (Olmstead and Smith 2017). The majority of the research done regarding cyber is focused on understanding: what knowledge the public has about cybersecurity; what the public views as a threat; and if the government is able to protect themselves from a cyber-attack.

The majority of Americans are concerned about cyber-attacks on the nation. According to Pew Research Center, 70% of Americans think cyber-attacks from other countries are a major security threat (Stokes 2014). In addition, a Gallup poll found "adults rank cyber terrorism (73%) along with international terrorism (79%) and development of nuclear weapons by Iran (75%) as the highest of a dozen particular threats (Jones and Saad 2016). Not only are cyber-attacks viewed as threats, they are thought to be among the most serious threats to the United States. These are two of many studies that show the same conclusion that the majority of Americans are concerned about cyber-attacks.

Not only are Americans concerned about cyber-attacks, they are concerned specifically about cyber-attacks on the electric grid. In 2017, Pew Research Center found in a study that 70% of Americans expect the United States will defiantly or probably experience a significant cyber-attack on its public infrastructure (Olmstead 2017). The public infrastructure includes the power grid (Olmstead 2017). Further, a Naval War College study found 78% of Americans believed there would be a disruption of the power grid (Ghosch 2007). These studies articulate that the public is most concerned about cyber-attacks on the electric grid, and further support the conclusion that Americans are concerned about cyber-attacks in general.

Americans are unsure of the government's ability to respond to a cyber-attack. A study by the Pew Research Center found that 10% of Americans feel their government is prepared to handle a major cyber-attack on public infrastructure (Olmstead 2017). This finding is concerning because the majority of Americans are concerned about a cyber-attack and they believe their government is not prepared to handle the attack. Based off of this finding, it would be reasonable to assume that the public's level of concern regarding a cyber-attack and given their perception that the government is not prepared to respond, that they would want to government to become more prepared to address a threat they believe to be critical. Another reasonable assumption would be the American people would support the government spending more on cybersecurity in order to better protect the nation from cyber-attacks.

The previous studies show a strong level of public concern of cyber-attacks and government's ability to respond to them provide a foundation for further research to be done regarding why the public is concerned with cyber-attacks. The findings previously discussed provide validity in pursuing further studies in the area of public perception of cyber-attacks. Even in the aforementioned studies, people were concerned about cyber-attacks, but they do not theorize or explain what might affect those concerns or how these findings could affect future action. Research needs to be done to understand if people are more concerned because they share a particular ideology and what role the government should have.

## HYPOTHESES

In order to answer the research questions posed; the following two hypotheses need to be tested:

Hypothesis 1: The more politically conservative a person is, the more concerned they are about an attack on the electric grid.

*Rationale:* A strong defense and powerful homeland and national security are central to conservative's beliefs. Individuals who identify as conservatives focus on having a strong military and security agencies in order to exert influence and power through the nation's ability to secure the nation (Friedersdorf 2017). In turn, it is a reasonable assumption that conservatives would be concerned about a cyber-attack on the electric grid because they would pay attention to anything that could affect the security of the United States.

Hypothesis 2: The more concerned a person is about a cyber-attack on the electric grid, the more likely that person is to believe the government should spend more money on cybersecurity.

*Rationale:* A person who is more concerned about an issue is more likely to want to fix it. Not only are they going to be more likely to want to fix it, they are going to be more willing to devote resources like time and money to fix it. Specifically, people who are more concerned about a cyber-attack on the electric grid are going to be more supportive of more money being spent on it.

## METHODOLOGY

The hypotheses are measured using The U.S. National Lone Wolf Terror Perception Public Opinion Survey conducted by the GfK Group on behalf of the Bush School of Government and Public Service at Texas A&M University. The study aimed to identify the factors that underlie US public opinion regarding various terrorism-related issues including information about specific terrorism incidences, government trust and responsibility, knowledge levels, and risk perceptions, and their policy preferences.

A team of researchers and scholars at the ISTPP and elsewhere developed the questionnaire during the spring of 2016. Most of the questions were borrowed from other public domain surveys. Additional questions, particularly those eliciting information about personal demographics, are standard questions used by GfK. Original questions, particularly those eliciting information about specific events and policy issues, were developed for this project and pre-tested among a convenience sample of students at the Bush School.

The target population consisted of the general US population of adults 18 years and older. To sample the population, GfK sampled households from its KnowledgePanel, a probability-based web panel designed to be representative of the United States. The survey consisted of two stages: a pretest to determine incidence and length of the survey, and the main survey with the study-eligible respondents. To qualify for the main survey, a panel member must have been 18 years and older. The survey was pre-tested by GfK from April 29 through May 2, 2016, and the full panel was engaged from May 5 through May 17, 2016. The median time of survey completion was 21 minutes.

The number of respondents sampled and participating in the survey, the survey completion rate for the main interview, and the incidence/eligibility rate are presented below.

| Number Sampled | Number Completed | Completion Rate | Qualified | Incidence Rate |
|---|---|---|---|---|
| 2831 | 1730 | 61% | 1730 | 100% |

The total number of respondents composing the nationally representative sample is 1,525.

Instead of sending the standard email reminder on day three of the field period, the following steps were taken to maximize the response or incidence rate:

- Additional email reminders to non-responders were sent on days 7 and 12 of the field period;
- Participants were eligible to win an in-kind prize through a monthly GfK sweepstakes

The relationship between the level of concern regarding a cyber-attack on the electric grid and political ideology is analyzed in SPSS. In hypothesis 1, the dependent variable, a person's level of concern regarding a cyber-attack on the electric grid, is measured using the following survey question: "How concerned are you that terrorists will attack the United States by a cyber-attack on the nation's power grid in the next 6 months?" There are four categories the respondents could choose 'not concerned', 'somewhat concerned', 'very concerned', and 'extremely concerned'. This question was chosen to measure the dependent variable because the wording of the question and hypothesis were almost identical. Level of concern regarding a cyber-attack on the electric grid is the critical topic that needed to be studied and it is reflected in the survey. Though the question specifies terrorist as the perpetrator and the timeline within the next six months, the overall level of concern of an attack on the power grid includes attacks by any perpetrator and timeline. This question is a sample of the overall concern of a cyber-attack on the power-grid by any actor at any point in the future. The independent variable for hypothesis 1, political ideology, measures how liberal or conservative a respondent is based on seven categories ranging from extremely liberal to extremely conservative. Political ideology is used to measure the level of conservatism because it is a better indicator of someone's values over a long period of time. Political parties change their position to issues in response to events, and therefore people will change their party affiliation based on the party's stance on an issue.

The relationship between the amount of money the government should spend on cybersecurity and the level of concern regarding a cyber-attack on the electric grid is analyzed in SPSS. In hypothesis 2, the dependent variable, the amount of money the government should spend on cybersecurity, is measured using the following survey question: "How much money do you believe the U.S. government should spend to deal with a cyber-attack on the power grid?" The four specified options include "not concerned," "somewhat concerned," "very concerned," and "extremely concerned." The independent variable for hypothesis 2, level of concern regarding a cyber-attack on the electric grid is measured in the same way it was in hypothesis 1.

## RESULTS AND ANALYSIS

The following tables describe one of the two hypotheses and determine whether the hypotheses are supported or rejected.

**Table 1: Political Ideology vs. Level of Concern against Cyber Attack**

| | | Political Ideology | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Extremely Liberal | Liberal | Slightly Liberal | Moderate | Slightly Conservative | Conservative | Extremely Conservative |
| Level of Concern about a Cyber Attack on the Electric Grid in the next 6 months | Not Concerned | 31.1% | 22.1% | 23.8% | 17.9% | 10.8% | 13.7% | 20.0% |
| | Somewhat Concerned | 34.4% | 43.1% | 40.0% | 45.4% | 47.1% | 40.6% | 37.6% |
| | Very Concerned | 18.1% | 24.6% | 25.6% | 23.4% | 32.8% | 30.5% | 29.5% |
| | Extremely Concerned | 16.4% | 10.2% | 10.6% | 13.3% | 9.3% | 15.2% | 12.9% |
| | Total | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n | 61 | 244 | 160 | 619 | 204 | 315 | 85 |

The trend in Table 1 shows that among individuals in the "slightly conservative," "conservative" and "extremely conservative" categories are more concerned than those in other categories about a cyber-attack on the electric grid. The people in the "extremely liberal" (31%), "liberal" (22.1%) and "slightly liberal" (23.8%) categories tend to be "not concerned" as "slightly conservative" (10.8%), "conservative" (13.7%), and "extremely conservative" (20%) individuals about a cyber-attack on the electric grid. Among those who identify themselves as a "slightly conservative", "conservative" and "extremely conservative," they remain "somewhat concerned" or "very concerned" about a cyber-attack on the electric grid. On the other hand, the "extremely liberal," "liberal", and "slightly liberal" are low in the area of "somewhat concerned" or "very concerned" about a cyber-attack. Finally, those who identify themselves as a "slightly conservative" (9.3%), "conservative" (15.2%) and "extremely conservative" (12.9%) are slightly higher than the "extremely liberal" (16.4%), "liberal" (10.2%), and "slightly liberal" (10.6%) in being "extremely concerned" about a cyber-attack on the electric grid.

Political ideology does slightly affect the level of concern about a cyber-attack, but the variable is not casual. There is a slightly positive tendency in the relationship between political ideology and the level of concern of a cyber-attack on the electric grid ($r = 0.085$, $p = 0.002$). Due to the trend and then strength of the trend, hypothesis number one seems to be supported.

There are clear trends in Table 1-2 that shows as the level of concern about a cyber-attack increases, so does the support for the government spending higher levels of money to deal with a cyber-attack. People who are "extremely concerned" about a cyber-attack are lowest in the category of "very low level of spending" (2.8%) and highest in the category of "very high level of spending" (64.9%). In addition, people who are "not concerned" and "somewhat concerned" about a cyber-attack are the least supportive of "pretty high level of spending" and "very high level of spending" as opposed to respondents who believe are "very concerned" and "extremely concerned."

**Table 1-2: Level of Concern of a Cyber-attack vs. the Level of Spending the Government Should Spend to Deal with a Cyber-attack on the Electric Grid**

| | | Level of Concern of a Cyber-attack | | | |
|---|---|---|---|---|---|
| | | Not Concerned | Somewhat Concerned | Very Concerned | Extremely Concerned |
| Level of Spending the Government should spend to deal with the threat of a cyber-attack on the electric grid | Very Low Level of Spending | 17.4% | 2.8% | 1.4% | 2.8% |
| | Somewhat Low Level of Spending | 37.2% | 26.9% | 15.3% | 3.8% |
| | Pretty High Level of Spending | 32.6% | 51.6% | 47.1% | 28.5% |
| | Very High Level of Spending | 12.8% | 18.7% | 36.2% | 64.9% |
| | Total | 100% | 100% | 100% | 100% |
| | n | 298 | 709 | 439 | 211 |

An individual's level of concern about a cyber-attack on the electric grid greatly affects their opinion on the level government should spent to deal with a cyber-attack. The value of Pearson's r, .405, indicates there is a moderately positive correlation between the level of public concern of a cyber-attack and the level of spending the government should spend to deal with a cyber-attack. The p-value, .000, is less than .05, which means the relationship between the variable is statistically significant. Based on these findings, the second hypothesis also seems supported.

The research and results discussed provide some insight into the public's opinion regarding cyber-attacks on the electric grid. Both hypotheses have been accepted, even though the strengths in tendencies were not as strong in some instances. In the following section, the results will be discussed and analyzed to gleam insight as to why the results were so.

Although the first hypothesis was accepted, the strength of the relationship between political ideology and level of concern were not as high as originally expected. The highest percent of every political ideology was in the "somewhat concerned" category. Even though the conservatives were in general more concerned in each category involving concern about an attack, the majority of respondents were at least somewhat concerned. This is a critical finding because this means everyone, regardless of political ideology, believes this is an issue for him or her. In politics, this finding means it is a bi-partisan issue and is not affected by moral ideologies. Conservatives are still more concerned about cyber-attacks, which can be explained, as they are still more interested in security issues than liberals. However, the issue has become a concern for most Americans, which means that the media, private businesses, and/or the government have been doing a good job describing the vulnerability of the electric grid to a point where the majority of Americans believes it is a threat.

The level of concern about a cyber-attack does affect an individual's opinion on what level of spending the government should have to deal with a cyber-attack. The trends and the strength of those relationships were expected because if people are concerned about an issue they are going to want to provide adequate funding in order to address the problem. Even though the American public is not well aware of the technical processes behind cyber and the electric grid, they do understand that it is extremely expensive (Olmstead and Smith 2017). This finding supports the assumption that the individuals who are concerned about a threat want to give the government a very high level of money to address this issue because they do understand how catastrophic an attack on the grid could be.

## LIMITATIONS

Although this study has significant findings, there are some limitations to the study that could have affected the outcome. One limitation is the respondent's understanding of who has authority over the electric grid. The authority of enacting and creating policy to protect the grid is in the hands of the private sector, and the government only can assist when assistance is requested. It is not clear if the respondents knew the answer to this question when responding to what level of spending the government should have to deal with cyber-attacks on the electric grid. In addition, it is unknown whether the respondents knew the likelihood of a severe attack on the electric grid, or if they assumed any attack on the electric grid would be extremely severe. Finally, it is unclear what the respondents who reported supporting more government spending would want the spending to be used for. Respondents might want greater spending to on security to prevent an attack in the future, or to respond to an attack that has already occurred. The unknown level of knowledge each respondent has regarding cyber means there is difficulty in understanding the exact meaning the responses.

## POLICY IMPLICATIONS

The level of people who are concerned about a cyber-attack on the electric grid regardless of political ideology, and who are supportive of high levels of government spending mean that people will expect the government to do more to protect the electric grid. Although the public wants to see the government do more about securing the electric grid, the electric grid is owned by the private sector, which means the majority of the security is taken care of by its owners. However, the public's opinion could be used to support more funding for partnerships between DOE, DHS and the electric companies. In addition, more money could be allocated to cyber response teams that are deployed when called upon by the private sector or for a government cyber official could be attached to each major electric company as a way of direct support to the private sector. The government has the support of the people to focus on cyber preparedness of the electric grid, which means the government should be able to create and implement policy related to this area with ease.

## CONCLUSIONS

The public's level of concern about a cyber-attack on the electric grid, and their support of the government's spending to protect it, is vital in developing a comprehensive policy that involves the utility companies to secure the electric grid for the sake of the entire United States. The electric grid is an integral part of the critical infrastructure and our way of life. Understanding the process of how the electrical grid operates, the challenges it incurs, and opportunities for innovation, is an essential in understanding what the government's role is in protecting the security of the electric grid. Even though people who identify as conservatives are slightly more concerned about a cyber-attack on the electric grid, the majority of respondents from every political ideology are concerned. This study also found the higher the level of concern affects the individuals' belief of the level of spending government should have to deal with a cyber-attack on the electric grid. Policymakers and the owners of the critical infrastructure need to be working together to address current cybersecurity threats and fixing vulnerabilities in order to protect the nation and all American citizens.

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# CHAPTER 2

# *Nuclear Energy:*

# *Contemporary Policies and Public Opinion*

**Kevin Sprague**

## INTRODUCTION

For several decades now, public concern in the field of energy production has begun to grow as humanity has developed more efficient technology and gained a greater understanding of the external impacts energy sources have on the environment. Highly developed nations have the distinct advantage of having multiple energy sources, all with varying degrees of efficiency and cleanliness. However, selecting a primary source of energy involves a myriad of factors outside of efficiency and cleanliness, including politics, fiscal feasibility, and public opinion. These factors hold especially true in the case of nuclear power, which is consistently the target of both public and political scrutiny. This paper seeks to examine determining characteristics in public opinion regarding nuclear energy use and expansion through an examination of the history of the nuclear industry in the United States, the evolution of nuclear regulatory policy as a consequence of its development, and the root causes of fluctuations in public opinion since the technology's inception.

## HISTORY OF NUCLEAR DISASTERS

The development of nuclear technology traces much further back than energy production, with significant research beginning around 1939 revolving around weapons development. While the initial goal of nuclear energy research was weaponization, in 1939 Francis Perrin "demonstrated the idea of introducing neutron-absorbing material to limit the multiplication of neutrons and thus control the nuclear reaction (which is the basis for the operation of a nuclear power station)" (World Nuclear Association, 2014).

Given the initial objectives of nuclear research, it is not surprising that we have observed a noticeable hesitation in the public's willingness to support greater efforts in the field of nuclear energy development. Much of the world's first exposure to nuclear technology was the awesome power displayed in 1945, when the United States deployed two nuclear bombs against the Japanese Empire. While many of the post-World War II efforts in the field of nuclear technology were focused on weapons development, "the United States government encouraged the development of nuclear energy for peaceful civilian purposes" (Department of Energy, 2016), prompting congress to create the Atomic Energy Commission (AEC). During the 1950's, nuclear research was diverted away from weapons development and towards "show[ing] that nuclear energy could produce electricity for commercial use" (Department of Energy, 2016).

The 1960s marked the transition into mainstream nuclear energy production that the United States is currently experiencing. A driving force behind the growing popularity of nuclear energy, experts now regarded nuclear energy "as a safe, clean alternative to current energy practices" (EBSCO, 2017), and encouraged expanding its use as an energy source. Because of the declining demand for energy in the United States that occurred during the 1970s and 1980s, development and production of new nuclear plants slowed significantly, while "concern grew over nuclear issues, such as reactor safety, waste disposal, and other environmental considerations" (Department of Energy, 2016). With citizens becoming wary of nuclear power, the federal government was forced to act.

**Nuclear Disasters**

A primary point of contention regarding nuclear energy is the amount of damage it can cause in the case of a system failure or natural disaster. While the event of a nuclear meltdown is tremendously unlikely (so unlikely in fact, that researchers cannot determine what actually happens during a meltdown, since there exists such a small body of data), the results can often be catastrophic. Since the nuclear energy has been utilized as a fuel source, there have been only two top priority nuclear disasters in the world; Fukushima, Japan in 2011 and Chernobyl, Ukraine in 1986.

The most famous nuclear disaster of them all, the Chernobyl incident occurred in 1986 when a power surge created a rupture in a critical element, "releasing radiation into the atmosphere and cutting off the flow of coolant into the reactor" (Lallanilla, 2013). The catastrophic disaster was partially due to improper maintenance of the facility and workers not following proper safety protocol during maintenance procedures. Although this is regarded as the worst nuclear power disaster in history, "a total of 31 people died from radiation exposure or other direct effects of the disaster" (Lallanilla, 2013), a number that pales in comparison to other power plant disasters. This figure of course does not take into consideration the long term effects of radiation exposure and cannot accurately account for deaths that occurred years after the disaster.

One of the most severe, and most recent, nuclear meltdown occurred at the Fukushima Power Plant in Japan in early 2011. A major tsunami caused by an earthquake off of the coast of Japan flooded the Fukushima Power Plant, knocking vital cooling systems offline and causing reactor fuel rods to begin to meltdown and leak deadly radiation into the surrounding area" (Ripley, 2016). While there were only two direct deaths from the disaster, the Fukushima stands as the second most severe nuclear meltdown in history.

**Economics of Nuclear Energy**

One of the primary concerns regarding the feasibility of increased nuclear energy production is the costs associated with building, maintaining, and operating the facilities. Nuclear power plants are notorious for their large upfront investments in capital when compared to other forms of energy, with projections stating that "a natural gas power plant could be constructed for as little as \$850/kW, recent estimates put construction of a nuclear power plant at \$4000/kW" (Schultz, 2012). While the costs associated with natural gas are certainly lower, nuclear power has the added benefit of producing zero greenhouse gas emissions. Taking a closer look at the numbers, much of the perceived cost associated with nuclear energy comes from varying degrees of uncertainty, with "risk[s] in construction delays, public opposition, and changes in the regulatory environment, all of which could lead to significant cost overruns and adversely affect the profitability of a project." (Shultz, 2012).

While advancements in the construction of nuclear power plants is likely needed to reduce costs, maintaining a plant remains highly cost-efficient. In 2008, "nuclear plant owners in the US spent an average of just 0.49 cents per kilowatt hour for fuel and 1.37 cents per kilowatt hour for non-fuel [operations and management]" (Adams, 2010). Low operating and maintenance costs can possibly lead to a surplus of energy, allowing the United States to become an energy exporter opposed to an importer. Unfortunately, the operating costs of a nuclear power plant remain well above other sources, such as natural gas which varies in the $.07-.14 region for the cost of fuel. (World Nuclear Association, 2014).

Constructing and maintaining nuclear power plants across the nation can spur sustainable job growth, both at the local and federal level. A study conducted by Oxford Economics estimated that "52 new reactors will be operational by 2030 and estimates the creation of 350,000 jobs" (Loris, 2008) for the United States alone. Being that nuclear power plants involve significant amounts of technical training and skills, the demand for nuclear scientists and engineers in the country will rise significantly, increasing the country's competitiveness on the global scientific stage.

**History of U.S. Policy Regarding Nuclear Energy**

The growing concern surrounding the utilization of nuclear energy prompted legislators to enact rules regarding the safe construction and operation of nuclear energy plants, as well as regulations involving the safe disposal of nuclear waste. The development and popularity of nuclear energy spawned an entire series of literature and government policies, beginning with the Nuclear Regulatory Act of 1946, which aimed to cease the proliferation of nuclear technology because "the effect of the use of any atomic energy for civilian purposes upon the social, economic, and political structures of today cannot be determined" (Cantelon, Hewlett, and Williams, p. 77, 1991). The wary nature of this legislation serves as evidence of the myopic mindset present when initial applied atomic research was taking place. However, as technology progressed and scientists began to discover other more practical uses for nuclear fission, the first nuclear era began.

The adaptation of nuclear technology for civilian use primarily began in the mid-1950s, when President Dwight D. Eisenhower signed the Atomic Energy Act of 1954 (Nuclear Regulatory Commission, 2016). While this act was serving simply as an amendment to the 1946 policy, President Eisenhower's initiative opened the doors for the production of nuclear power plants and further research regarding the safety and efficiency of nuclear energy. Several authors cite this act as the beginning of the First Nuclear Era in the United States.

The increasing popularity of nuclear energy prompted legislatures to create a specific agency with the task of regulating the non-defense aspects of nuclear technology. Under the Energy Reorganization Act of 1974, the Nuclear Regulatory Commission (NRC) was created to ensure public health and safety with regards to any nuclear energy applications (Nuclear Regulatory Commission, 2016). The three primary functions of the NRC today include the licensing of the construction and operation of nuclear power plants, the inspection and enforcement of nuclear regulations, and proactively researching solutions to problems before they arise (Nuclear Regulatory Commission, 2016). As noted earlier, the safety and effectiveness of nuclear energy was becoming questionable in the public eye. With the public skeptical of nuclear energy, creating a new agency specifically designed to monitor safety and enforce regulations was likely as much a political action as it was a response to increasing demand.

Growing concern for the storage and disposal of nuclear waste prompted the enactment of the Nuclear Waste Policy Act of 1982. While the act does not specifically identify an area for waste disposal, it does "[establish] procedures to evaluate and select sites for geologic repositories and for the interaction of state and federal governments" (Environmental Protection Agency, 2016). Several government agencies are involved in the selection of a permanent storage facility for nuclear waste, each with their own solution to an ever-growing problem. For several decades, legislatures have proposed Yucca Mountain, Nevada as the premiere nuclear waste storage facility for the United States. Even though Yucca Mountain has been designated and utilized for quite some time, the site has remained a controversial topic. In 2009, President Obama proposed a budget that appeared to stop "the $8 billion project to prepare Yucca Mountain in Nevada as the nation's nuclear waste repository" (Harris, 2009). For the time being, waste is stored on site at nuclear power plants, however without a permanent storage solution, advancements in the field of nuclear energy may be hindered.

Nuclear waste and the costs associated with its disposal have been an area of contention in the implementation of expansionary nuclear policy. Waste from nuclear energy plants is classified into three categories of low, medium, and high categories, with the latter describing the "spent fuel that is still present after it has been used inside of nuclear reactors" (CEF, 2017). Due to the high radioactivity and its extreme risk to human life, the storage of nuclear waste is an expensive endeavor, and without a central disposal facility, waste "caretaking is estimated to cost about $4 million per year" (Kadak, 2012). With polls showing "eighty-six percent of Americans believe the federal government should develop a final repository for used nuclear fuel" (NEI, 2015), the development of a storage facility will likely alter public perceptions regarding nuclear energy usage.

Prior to the Obama Administration, President George W. Bush spearheaded new legislation that aimed to ease regulation and create incentives for green energy technology, specifically nuclear energy. The Energy Policy Act of 2015 provided subsidies and tax incentives for several energy markets, with the largest tax reduction of $4.3 billion applying to nuclear energy. While the act provided incentives and loan guarantees to nuclear energy providers, it is important to note that the act did not revolve around nuclear energy reform, but instead focused on alternative energy sources as an industry.

The realm of nuclear energy regulation has normally been the responsibility of the federal government, however states often enact policy in the field in addition to federal regulation. “In 1976, a voter referendum in California led to a law that prohibited the construction of new nuclear plants in the nation's largest state” (World Nuclear Association, 2016), and with a permanent storage facility still not emplaced, nuclear power plants in California began to systematically shut down.

Recently, the United States House of Representatives passed the Advanced Nuclear Technology Development Act of 2017, which aims to increase safety and provide support for innovation in the developing new reactor technology. This legislation is still pending approval from the Committee on Commerce, Science, and Transportation.

## PUBLIC PERCEPTION OF NUCLEAR ENERGY

A driving force behind government support or opposition of nuclear power rests in the power of the public. While it is unlikely that the average person has even the slightest idea of how nuclear power plants are operated or maintained, politicians must act according to the will of their constituency if they are to remain in power. According to a Gallup poll conducted in 2015, the public support for nuclear energy totals at 44% in favor, after a steady decline from 62% approval in 2010 (Riffkin 2015). As expected, the majority of Americans favor moving toward perceived safer energy production, such as wind or solar power. While Republicans remain the most likely to support the use and expansion of nuclear energy, all forms of political alignment have shown a decrease in support from polling conducted in 2015. However, in a technical subject such as this, the "public opinion on nuclear energy is highly changeable and easily influenced, because most Americans do not feel well informed about the subject" (Bisconti 2016).

Several studies have found that the more knowledgably an individual is regarding nuclear power, the more likely they are to be in support of its use. According to several studies, "making electricity from nuclear power turns out to be far less damaging to human health than making it from coal, oil or even clean-burning natural gas" (Brown, 2011).

Fluctuations in public opinion of nuclear are largely attributable to changes in the technology's public image and the political venue in which it is presented. In its early days, nuclear energy found a comfortable home in government controlled by a small portion of government and largely remained immune to outside interference. Actors in the government with heavy influence over nuclear policy displayed it as a safe source of energy, focusing on its benefits to the economy and technological innovation. However as authors Baumgartner and Jones (p. 1047, 1991) point out, as the "ethical, social, or political implications of such policies assume center stage, a much broader range of participants can suddenly become involved." The increased level of participation and the ever growing number "of active participants in the debate was associated with dramatic changes in the image of nuclear policy" (Baumgartner and Jones 1991: 1053). Public wariness toward nuclear energy sources continued for decades, and the heightened number of political actors along with shifts in the arena for public debate, still shape the way in which nuclear policy is formed today.

## Nuclear Energy and the Political Parties

As with other forms of energy, nuclear energy comes with a strong partisan division. With some early exceptions, advancements in nuclear power have been primarily opposed by environmentalists in the Democratic Party and promoted by prominent members of the Republican Party. While Republicans often do not specifically promote nuclear energy on its own, it does favor an "all-of-the-above energy strategy that involves responsible development of all our energy resources, and results in a domestic, secure energy supply that is stable, reliable, and affordable" (Hopf 2012). The Democratic Party as a whole remains "completely silent on nuclear energy" (Hopf 2012), only expressing concerns about the environment as a general issue, instead of the specific effects of nuclear energy.

## Public Opinion

Several decades after its development, a strong divide remains in opinions toward nuclear energy's safety, efficiency, and feasibility as a primary energy source for the country. Given that nuclear energy use is a highly politicized issue, its future will hinge heavily on the public's perception and the ability of politicians to gather support or opposition for future policy. This paper examines how opinions regarding nuclear energy use, safety, and expansion are effected by subject knowledge through the use the 2012 Energy National Public Survey.

## Hypotheses

The following hypotheses are posed for purposes of determining how public opinion of nuclear energy is affected by perceived subject knowledge:

*Hypothesis 1:*

*$H_0$: Individuals that consider themselves more informed are not any more likely to view nuclear energy as a safe energy source*

*$H_a$: Individuals that consider themselves more informed are more likely to view nuclear energy as a safe energy source*

*Hypothesis 2:*

*$H_0$: Individuals that consider themselves more informed are not any more likely to view local nuclear energy plant construction favorably*

*$H_a$: Individuals that consider themselves more informed are more likely to view local nuclear energy plant construction favorably*

*Hypothesis 3:*

*$H_0$: Individuals that consider themselves more informed are not any more likely to promote the use of increased nuclear power*

*$H_a$: Individuals that consider themselves more informed are more likely to promote the use of increased nuclear power in the United States*

**Methods**

This study will examine the effects of a greater or lesser understanding of nuclear energy on public opinion of its safety, facility construction, and government regulation. The following question regarding subject knowledge was posed to survey respondents and will be utilized as the independent variable for this study:

> *Q4-2: How informed do you consider yourself to be about the [nuclear] energy in the United States? (0-10 scale)*

This question on its own relies on self-identification of subject knowledge and speaks little to the objective reality of a survey respondent's actual knowledge level. To determine if a higher self-identified knowledge of nuclear energy correlates to an actual increased subject knowledge, responses were cross-tabulated with two objective questions regarding energy generation and nuclear energy:

> *Q11: Electricity produced by coal, natural gas, nuclear, and oil relies upon heat to turn water into steam to spin large turbines, which generate the electricity (True or False)*
>
> *Q12: One fingertip sized uranium pellet produces roughly the same amount of energy as 150 gallons of oil (True or False)*

Results for the cross-tabulation between self-identified knowledge and question 11, shown in Table 2-1, point to a strong positive correlation between the two variables, with the percentage of correct answers increasing as respondents indicated higher knowledge levels. The results in Table 2-2 indicates a weak positive correlation with low p-values between professed knowledge and a correct answer to question 12. These results indicate that while higher scores do not necessarily constitute expertise, a higher self-identified knowledge level in this case is strongly correlated with an apparent greater understanding of electricity generation and a slightly greater understanding of nuclear energy production. Given that this is not a complete test of subject knowledge, analysis will focus primarily on relationships between self-perceived knowledge and aspects of nuclear energy, while only suggesting implications that the correlated greater objective understanding of the subject has on a respondent's answers.

In order to analyze the results, survey respondents were distributed into three knowledge cohorts, grouped by responses to question 4-2:

| | |
|---|---|
| Cohort 1 | Indicated a response of 3 or below |
| Cohort 2 | Indicated a response between 4 and 7 |
| Cohort 3 | Indicated a response of 8 or above |

For purposes of this paper, "knowledge" and "perceived knowledge" will be used interchangeably in reference to an individual's self-identified understanding of nuclear energy and not to suggest a direct correlation to the individual's objective understanding of the subject.

**Table 2-1: Cross tabulation between knowledge level (Question 4-2) and Question 11**

**Q11. Electricity produced by coal, natural gas, nuclear, and oil relies upon heat to turn water into steam to spin large turbines, which generate the electricity.**

| P=.000 | TRUE | FALSE |
|---|---|---|
| 0 | 58.0 | 42.0 |
| 1 | 61.4 | 38.6 |
| 2 | 69.5 | 30.5 |
| 3 | 68.3 | 31.7 |
| 4 | 70.3 | 29.7 |
| 5 | 75.9 | 24.1 |
| 6 | 80.9 | 19.1 |
| 7 | 82.1 | 17.9 |
| 8 | 78.4 | 21.6 |
| 9 | 79.6 | 20.4 |
| 10 | 87.0 | 13.0 |

**Table 2-2: Cross tabulation between knowledge level (Question 4-2) and Question 12**

**Q12. One fingertip sized uranium pellet produces roughly the same amount of energy as 150 gallons of oil.**

| P=.006 | TRUE | FALSE |
|---|---|---|
| 0 | 58.0 | 42.0 |
| 1 | 60.7 | 39.3 |
| 2 | 63.0 | 37.0 |
| 3 | 73.2 | 26.8 |
| 4 | 74.5 | 25.5 |
| 5 | 68.8 | 31.2 |
| 6 | 75.6 | 24.4 |
| 7 | 74.1 | 25.9 |
| 8 | 76.8 | 23.2 |
| 9 | 66.0 | 34.0 |
| 10 | 72.5 | 27.5 |

To test the three hypotheses identified above, knowledge cohorts were cross tabulated with three questions:

> *Q28_3: How would you feel if a [nuclear] power generating facility were built about [5/50/100] miles away from where you live? (Strongly oppose/oppose/neither oppose nor support/support/strongly support)*
>
> *Q41: This energy source [nuclear] is safe (True/unsure/false)*
>
> *Q51: Promote the increased use of nuclear power (Strongly oppose/oppose/neither oppose nor support/support/strongly support)*

The results to each cross tabulation were individually analyzed to identify clustering of responses by knowledge cohort. Additionally, Pearson's P-value was utilized to determine the statistical significance of each relationship.

## RESULTS AND ANALYSIS

A cross tabulation of perceived knowledge and the respondent's opinion regarding the construction of a new local nuclear energy facility (Table 2-3) indicate a strong positive correlation between the two variables. Individuals in the lowest knowledge cohort viewed the construction of a new local plant least favorably, with 62% of respondents indicating they would oppose or strongly oppose and only 7.7% in support. As the respondent's perceived knowledge of nuclear energy increases, support for facility construction sharply increases to 19.5% and 46% in the second and third cohorts, respectively. The tabulation calculated a p-value of 0.000, suggesting high statistical significance between the two variables; however a low calculated adjusted R-squared of .0576 indicates low correlation and a weak linear relationship between the two variables.

**Table 2-3: Cross tabulation of Cohort and Question 28-3**

**"How would you feel if the following power generating facilities were built about [5/50/100] miles away from where you live?**

| Response | Cohort | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Strongly Oppose | 36.2 | 28.4 | 26.4 |
| Oppose | 25.8 | 21.1 | 11.7 |
| Neutral | 30.8 | 31 | 15.9 |
| Support | 6.2 | 14.5 | 27.2 |
| Strongly Support | 1.5 | 5 | 18.8 |

When analyzing the relationship between knowledge and opinions regarding the safety of nuclear facilities (Table 2-4), another positive correlation is observed. While views of nuclear energy facilities as being unsafe fall from 45.1% to 35.5% from the first cohort to the third, views of the facilities being safe rises from just 11% to 45.9%. The small observed decrease of 9.6% in unfavorable views with the accompanied increase of 34.9% is due to the decreased level of uncertainty among respondents as knowledge increases. Responses of "unsure" declined from 43.9% in the first cohort, to 35.5% in the second and just 18.6% in cohort three. These results indicate that as knowledge increases, the increase in positive opinions regarding facility safety are primarily due to decreased levels of uncertainty. A Pearson's p-value of 0.000 points to high statistical significance between the two variables, but is again accompanied by a low adjusted R-squared of .0356, indicating low collinearity between the variables.

**Table 2-4: Cross tabulation of cohort and Question 41-3 "[Nuclear Energy] is safe"**

| Response | Cohort | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| True | 11.0 | 24.9 | 45.9 |
| Unsure | 43.9 | 35.5 | 18.6 |
| False | 45.1 | 39.6 | 35.5 |

The results of the cross tabulation between knowledge and opinions regarding the increased use of nuclear energy (Table 2-5) in the United States reveal similar results to the previous two tabulations. A higher knowledge cohort is strongly associated with greater support for the increased use of nuclear energy in the country, with supporting responses increasing from 16.5% to 56.3% between the first and third cohorts. For this particular question, respondents in the first knowledge cohort primarily remained neutral, with 49.4% of respondents showing no propensity toward support or opposition. Again, as the respondents' perceived knowledge increases, the likelihood of neutrality of nuclear energy expansion sharply declines to a mere 17.7%. Results show declines in opposition to be much smaller regarding this tabulation than in other categories, with the percentage of respondents opposing increased use falling from 34.2% to just 26%. Again, the calculations resulted in a Pearson's p-value of 0.000 and a low adjusted R-squared value of .0336, suggesting strong statistical significance but exceedingly low collinearity between the variables.

**Table 2-5: Cross tabulation of cohort and Question 51: Promote the increased use of nuclear power**

| Response | Cohort | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Strongly Support | 3.6 | 9.3 | 27.3 |
| Support | 12.9 | 21.8 | 29 |
| Neutral | 49.4 | 36.3 | 17.7 |
| Oppose | 18.8 | 17.6 | 7.1 |
| Strongly Oppose | 15.4 | 15.1 | 18.9 |

A comparative analysis between the cross-tabulations reveals that in all three cases, favorable views tend to increase as self-indicated knowledge regarding nuclear energy increases. As knowledge increases, particularly in the top echelon encompassing respondents with a knowledge level of 8 or higher, heavy migration from opposition, uncertainty, and neutrality toward support take place in every instance analyzed. In fact, a lower level of uncertainty appears to be the most consistent byproduct of perceived higher subject expertise.

Correlations between higher perceived knowledge and correct answers to objective knowledge based questions imply that a higher understanding of nuclear energy or electricity generation are correlated, albeit weakly. These results make some implications about greater objective knowledge and more favorable opinions toward nuclear energy; however, a more accurate assessment of innate knowledge would have to be administered in order to gain any conclusive results.

High statistical significance was observed in every cross tabulation, however was associated with a low adjusted R-squared value, indicating weak linear relationships. Weak linear correlation between all analyzed variables is possibly due to large disparity in change when observing the differences between the cohorts 1 and 2 and the differences between cohorts 2 and 3. The high statistical significance of every cross tabulation leads to the rejection of all three null hypotheses.

## CONCLUSIONS

From the results, it can be determine that at the very least, an individual's perception of their understanding of nuclear energy has a significant effect on their likelihood to support or oppose it as an energy source. As discussed earlier, public perception of nuclear energy has played a pivotal role in its viability in the United States since its inception. Efforts toward understanding the public's perception of nuclear energy will provide governments with a wealth of information, leading to the development of strategies to assist them in either supporting or opposing its expansion.

## Appendix 2-A:
## Survey questions used in the Analysis

**Q4. How informed do you consider yourself to be about the following electrical energy sources in the United States? Place yourself on a scale from 0 to 10, with 0 indicating not at all informed and 10 indicating very well informed.**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Energy Sources | Not informed at all | | | | | | | | | | Very well informed |

Coal (4-1)
Nuclear (4-2)
Natural Gas (4-3)
Hydroelectric (4-4)
Solar (4-5)
Wind (4-6)

**Q28. How would you feel if the following power generating facilities were built about [5/50/100] miles away from where you live?**

| Energy Source | Strongly Oppose | Oppose | Neither Oppose Nor Support | Support | Strongly Support |
|---|---|---|---|---|---|

Coal (28-1)
Nuclear (28-2)
Natural Gas (28-3)
Hydroelectric (28-4)
Solar (28-5)
Wind (28-6)

**Q41. This energy source is safe**

| Energy Source | True | Unsure | False |
|---|---|---|---|

Coal (41-1)
Nuclear (41-2)
Natural Gas (41-3)
Hydroelectric (41-4)
Solar (41-5)
Wind (41-6)

**Q51. Promote the increased use of nuclear power**

| | | | | |
|---|---|---|---|---|
| Strongly Support | Support | Unsure | Oppose | Strongly Oppose |

# Appendix 2-B: Results from Regressions

| Source | SS | df | MS | | | |
|---|---|---|---|---|---|---|
| | | | | Number of obs | = | 1,448 |
| | | | | F(1, 1446) | = | 89.41 |
| Model | 39.6879645 | 1 | 39.6879645 | Prob > F | = | 0.0000 |
| Residual | 641.858306 | 1,446 | .443885412 | R-squared | = | 0.0582 |
| | | | | Adj R-squared | = | 0.0576 |
| Total | 681.546271 | 1,447 | .471006407 | Root MSE | = | .66625 |

| cohort | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| Q28_3 | .1351792 | .014296 | 9.46 | 0.000 | .107136 | .1632223 |
| _cons | 1.501629 | .038967 | 38.54 | 0.000 | 1.425191 | 1.578067 |

| Source | SS | df | MS | | | |
|---|---|---|---|---|---|---|
| | | | | Number of obs | = | 1,449 |
| | | | | F(1, 1447) | = | 54.45 |
| Model | 24.8368725 | 1 | 24.8368725 | Prob > F | = | 0.0000 |
| Residual | 660.079622 | 1,447 | .456171128 | R-squared | = | 0.0363 |
| | | | | Adj R-squared | = | 0.0356 |
| Total | 684.916494 | 1,448 | .473008629 | Root MSE | = | .6754 |

| cohort | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| Q41_3 | -.1667816 | .0226029 | -7.38 | 0.000 | -.2111195 | -.1224437 |
| _cons | 2.195672 | .0521687 | 42.09 | 0.000 | 2.093337 | 2.298006 |

| Source | SS | df | MS | | | |
|---|---|---|---|---|---|---|
| | | | | Number of obs | = | 1,429 |
| | | | | F(1, 1427) | = | 50.70 |
| Model | 23.0898643 | 1 | 23.0898643 | Prob > F | = | 0.0000 |
| Residual | 649.934628 | 1,427 | .455455241 | R-squared | = | 0.0343 |
| | | | | Adj R-squared | = | 0.0336 |
| Total | 673.024493 | 1,428 | .471305667 | Root MSE | = | .67487 |

| cohort | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| Q51 | -.107153 | .0150493 | -7.12 | 0.000 | -.1366742 | -.0776319 |
| _cons | 2.163807 | .0495304 | 43.69 | 0.000 | 2.066647 | 2.260967 |

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# CHAPTER 3

# *Hydraulic Fracturing:*

# *An Overview of the Technologies, Policies, and Public Opinion on Natural Gas Extraction*

**Candace "Alexa" Davis**

## INTRODUCTION

Hydraulic fracturing, also known as "fracking," refers to a practice used in the oil and gas industry to extract natural gas from shale rock deep beneath the earth's surface. The use of fracking has increased dramatically in the past twenty years. This growth has garnered both praise from oil and gas companies and criticism from environmental and grass roots organizations. Fracking and the increased consumption of natural gas is a significant step towards energy independence and burning cleaner fossil fuels. On the other hand, opponents view the environmental costs of fracking as a call for more stringent regulation, or to ban the practice of fracking altogether. This paper will discuss the history, processes, benefits, environmental costs and federal regulations associated with fracking to better understand this method of natural gas extraction.

## HISTORY

Fracking was first used in the 1940's and later in the 1970's, as a result of research funded by the Department of Energy (Gertner 2012). However, fracking did not become a viable method of natural gas production until the late 1990s, much to the efforts of George P. Mitchell. Often referred to as the "Father of Fracking", Mitchell's background in the oil and gas business spurred his quest for new energy sources when he realized his North Texas oil wells were running dry. For over 15 years, geologists and engineers employed by Mitchell Energy fought to prove that fracking was worth the significant capital investment needed to drill and pump the wells (Gertner 2012). The efforts of Mitchell's team finally paid off: by identifying the right mixture of sand, water and chemicals to inject into the wells, Mitchell's operations produced enough natural gas to make fracking profitable.

Improved extraction techniques such as horizontal drilling have dramatically increased natural gas yields since 2012. According to the Energy Information Agency (EIA), the United States produced 12.3 trillion cubic feet of shale gas from shale and tight oil reserves in 2014. This figure accounted for 48% of the total natural gas produced in the United States in 2014. This amount is only expected to grow: natural gas from shale and tight oil reserves is expected to comprise over 69% of natural gas produced in the U.S. by 2040 (EIA 2016). While this growth is good news for domestic energy production and reducing U.S. dependence on foreign oil, the increase in fracking operations has raised many environmental and health concerns. These issues will be addressed later in this analysis.

## SCIENCE OF FRACKING

In order to understand the environmental concerns associated with fracking, it is necessary to have a basic knowledge of the processes involved with this extraction method. Once a gas deposit has been located, the drilling company must buy the land or the mineral rights of the property from the current owners. The land must then be leveled in order to begin constructing the drilling site (Kosher 2013). After this is completed, the fracking process can begin by drilling the wells. Shale gas is found enclosed within shale rock, which is a fine grained sedimentary rock formed from clay, organic matter and sedimentary deposits. The shale gas held in this rock is contained by small open spaces in the shale formations (Koster 2013). In order to extract the shale gas, deep wells into the shell rock must be drilled. These wells can "travel hundreds to thousands of feet vertically and then anywhere from one to six-thousand feet horizontally" (Kosher 2013). Creating these fissures within the earth allows the natural gas to be extracted via pipelines installed in the well. Horizontal drilling allows for more natural gas to be recovered and significantly increases well productivity (Koster 2013).

The next step in the process is the physical extraction of natural gas from the bedrock. This is accomplished by injecting the wells with millions of gallons of sand, water and chemicals at extremely high pressures. The injected "cocktail" accomplishes several things. First, the highly pressurized mixture widens existing fissures and creates more cracks in the shale rock from which the natural gas is extracted. Second, the sand keeps the fissures open in the bedrock to allow the natural gas to flow up from the well. Third, the chemicals in the well increase the viscosity of the whole mixture and allows for better transportation of the sand and water through the fissures.

This process requires a significant amount of water and chemicals. It takes approximately 7-15 million liters of water to frack a single well. Some of this water and the chemical mixture remain in the earth after a site is fracked. About 50-70% of the mixture is returned at the surface of the well (Koser 2013). “Produced water” is the term used to describe the mixture of water and chemicals that remains after a well is fracked. This produced water is held in tanks at the fracking site or later transported in trucks to an offsite storage location. Some of the produced water is injected back into the wells, going beyond the bedrock where the fracking was actually occurring. Finally, the wells are sealed with concrete in order to “segregate different subsurface zones and rock units…control corrosion, and stabilize the well, the pipe and the rock formation itself” (Conca 2016). The natural gas extracted from the well is now transported via trucks or pipelines to be sold.

## ECONOMIC AND ENVIRONMENTAL BENEFITS

There are many economic benefits that result from the practice of fracking including increased energy independence, job creation and lowering levels of atmospheric carbon dioxide. Revitalizing American energy production lessens the dependence on foreign energy sources. Energy independence has positive economic and security implications. Increased domestic energy production results in job creation and the stimulation of economic activity (Eagan 2016). Additionally, energy independence could allow the U.S. to be “less beholden” to oil producing countries in the Middle East and to adapt a more flexible foreign policy. The EIA has predicted that if oil prices again rise to over $100 a barrel combined with stable natural gas production, the U.S. could expect to be energy independent by 2024 (Eagan 2016).

Increasing domestic production of natural gas has allowed the United States to become an exporter of this fossil fuel. It is predicted that the U.S. will be in the top three natural gas producers by 2020, with exports totaling 8 billion cubic feet (Domm 2016). Other nations, particularly China, have increased their demand for natural gas, which may provide a significant opportunity for the U.S. While China has significant shale reserves, it has not heavily invested in fracking technology to extract the natural gas (Agnihotri 2013). Fracking allows the U.S. to effectively utilize its abundance of natural gas for domestic consumption and facilitates exports to other nations. There is real potential for exportation of natural gas to take off because it is easily transported via pipelines and tankers compared to coal. The U.S. exported 1,783,512 million cubic feet amount of natural gas in 2015 (Domm 2016). Additionally, fracking has positively benefited some areas that have never experienced "significant fossil fuel development" (Rapier 2016). This has led to economic growth in communities where fracking operations have increased significantly.

There are also environmental benefits to fracking and the increased use of natural gas. Natural gas emits 117 British thermal units (BTU) of CO2 when burned. This is significantly less compared to the $CO_2$ content of other fossil fuels, namely coal, which produces 228 BTUs, and petroleum, which produces 157 BTUs (EIA 2016). Increased use of natural gas for electricity generation could have positive implications for $CO_2$ levels in the United States. Because fracking increases the availability of natural gas and the invention of horizontal drilling significantly increases well productivity, natural gas is likely to become cheaper and more easily extracted than coal. It can be expected that natural gas consumption will surpass coal consumption in future years, which has positive environmental impacts for the U.S. (Conca 2016).

**ENVIRONMENTAL COSTS**

Despite these economic benefits, serious environmental concerns surround the practice of fracking. The most serious environmental issues include increased seismic activity, impacts on groundwater supplies, and air pollution. The link between seismic activity and fracking has gained publicity, as areas with significant fracking operations have been experiencing earthquakes at higher rates. It should be noted that fracking does not directly cause earthquakes; rather it is the practice of re-injecting wastewater well below the fracking level that triggers seismic activity. This is because "injected fluids change the subsurface dynamics of pressure and friction, allowing things to move that wouldn't ordinarily move or that wouldn't move so often" (Conca 2016). The majority of these earthquakes are low magnitude. However, when injections occur near pre-existing faults, larger earthquakes are more likely to occur as fracking disturbs the "subsurface pressure regimes that keep the faults closed" (Conca 2016).

These earthquakes have caused safety concerns and illuminated that natural gas extraction has the ability to impact seismic activity in historically stable areas. For example, earthquakes are occurring in previously stable areas such as Kansas and Oklahoma at rates similar to California, which lies on a major fault line. This is a concern for communities in Kansas and Oklahoma because the existing infrastructure has not been built to prepare for earthquakes, and very few homeowners have insurance to protect themselves against earthquakes (Conca 2016).

Groundwater contamination is also a major concern surrounding fracking. There have been several instances of groundwater contamination near fracking sites (Begos 2014). Often residents will notice a strange taste or smell of their tap water, which may indicate a methane leak or chemical contamination of the water supply (Vaidvanathan 2016). Methane contamination is the most common form of pollution from fracking operations. From 2012 to 2013, there were over 897 water contamination complaints across Texas, Oklahoma, West Virginia and Pennsylvania related to fracking (Begos 2014). While these people would claim that fracking is clearly contaminating their ground water, scientists and officials at the Environmental Protection Agency (EPA) have been hesitant to identify a direct relationship. In 2015, the EPA claimed in a contentious draft study that “hydraulic fracturing has not had ‘widespread, systemic impacts on drinking water resources in the United States’” (Vaidvanathan 2016).

In the final 2016 publication, the EPA has tweaked their stance acknowledging the study “found scientific evidence that hydraulic fracturing activities can impact drinking water resources under some circumstances” (U.S. EPA 2016). The report’s results can be interpreted differently depending on an individual’s beliefs about fracking. Those in the oil and gas industry are likely to cite this publication lacks proof of a systematic relationship between fracking and groundwater contamination. While, environmentalists and activists claim if fracking has negatively impacted groundwater in some situations, then there is the potential for widespread groundwater contamination in the future. The ambiguity and inconclusiveness of this report highlights the many questions have yet to be answered concerning the environmental impacts of fracking.

There are also environmental concerns about the sheer amount of water that is used during fracking operations. As previously mentioned, fracking a single well requires 7-15 million liters of water depending on the size of the well (Kosher 2013). This is particularly a cause for concern in areas where groundwater may be scarce or during times of drought. In addition to the amount of water needed for fracking, the fate of produced water after fracking is major issue. The produced water is injected back into the well, stored in pits on site or transported off site in tankers to be reused. However, only 13 percent of the produced water is being recycled after the fracking process is complete (Hardcastle 2016).

This amount must be increased in order to prevent severe waste of ground water resources. Unlike some of the other environmental issues concerning fracking, the outlook on this problem is positive: it can be expected that reuse will improve in coming years due to increasing regulation and higher costs of groundwater. According to a publication from Navigant Research, “revenue from fracking wastewater treatment and recycle systems in the United States is expected to grow at a compound annual growth rate of 30.3 percent to reach $3.8 billion by 2025” (Hardcastle 2016). Research on fracking wastewater technology should be encouraged to ensure these predictions come to fruition.

Air pollution has also been cited as a major environmental issue related to fracking. While natural gas combustion does produce significantly less carbon dioxide than petroleum or coal, it produces a significant amount of another greenhouse gas: methane. Data from the EPA reveals “pound for pound, the comparative impact of $CH_4$ (methane) on climate change is more than 25 times greater than $CO_2$ over a 100-year period” (EPA 2010). This means even though using natural gas instead of coal may lower $CO_2$ emissions, there may be no overall change in greenhouse gasses because natural gas is adding a significant amount of methane to the atmosphere. There are many other fracking pollutants besides methane that threaten then environment and human health. These include “carcinogens, e.g., benzene and silica dust, volatile organic compounds (VOCs) and smog, which contribute to costly, disabling health problems, including premature death, asthma, stroke, heart attack and low birth weight” (Twomey 2016).

**FEDERAL REGULATIONS**

In order to understand why some of these environmental issues caused by fracking are tolerated under federal law, it is necessary to review fracking regulations in the United States.

Interestingly enough, the major statutes responsible for monitoring environmental quality in the United States exempt fracking from many of their regulations. These include the Safe Drinking Water Act, the Resource Conservation and Recovery Act, the Emergency Planning and Community Right-To-Know Act, the Clean Water Act, the Clean Air Act, the Comprehensive Environmental Response, Compensation, and Liability Act, and the National Environmental Policy Act (Brady 2012). Some specific exemptions enjoyed by companies engaged in fracking, and more broadly the oil and gas industry, are detailed below. It is acknowledged that a robust oil and gas industry is important for economic growth and job creation in the U.S. (Price Waterhouse Cooper 2013). Therefore, drilling and mining practices should be granted some immunity from stringent environmental regulations in order to continue reaping the economic benefits from this industry. However, these numerous exemptions are excessive. In their current state, these federal statues cannot effectively mitigate the environmental costs of fracking.

**Safe Drinking Water Act**

The Safe Drinking Water Act (SDWA) established minimum regulations for State Underground Injection Control (UIC) in Part C which states the SDWA must "contain minimum requirements for effective programs to prevent underground injection which endangers drinking water sources" (Brady 2012). Fracking was initially exempt from this definition until 1997 when the U.S. Court of Appeals for the 11th circuit ruled that Part C of the SDWA should include fracking. In 2004, the EPA responded by producing a report that claimed fracking posed little threat to drinking water. Based on this report, Congress passed an amendment to the SDWA in 2005 to exempt fracking from this regulation. This exemption is known as the "Halliburton loophole" due to Vice President Cheney's connections with the energy company Halliburton, which was a major energy company participating in fracking (Brady 2012).

## Clean Water Act

Oil and gas companies also enjoy significant exemptions from the Clean Water Act (CWA). Originally passed in 1972, the CWA is the primary legislation that regulates pollutants discharged into bodies of water and the overall quality of surface water in the U.S. (EPA). In 1987, Congress amended the CWA to require the EPA to include provisions for permitting storm water. These amendments "exempted mining operations and 'oil and gas exploration, production, processing, or treatment operations or transmission facilities'" (Brady 2012). Additional amendments passed in 2005 through the Energy Policy Act included construction to the list of activities exempted in the CWA, expanding the protection enjoyed by oil and gas companies.

## Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

Passed in 1980, CERCLA provides federal funding to pay for the clean-up of abandoned or uncontrolled hazardous waste sites. The fund will also pay for "the clean-up of accidents, spills, and other emergency releases of hazardous substances to the environment" (Brady 2012). In the act, specific chemicals and hazardous wastes are listed that require clean up in the event of a spill. However, the list excludes "crude oil, natural gas, natural gas liquids, liquefied natural gas, and mixtures of natural gas and synthetic gas" (Brady 2012). This results in few incentives for oil and gas companies to prevent accidents or to clean up drilling sites if spills occur.

## TEXAS STATE AND LOCAL REGULATIONS

Another aspect of fracking regulations are state and local rules concerning natural gas extraction. The Texas Railroad Commission (RRC) is the regulatory body charged with monitoring fracking. While oil and gas operations in Texas have historically enjoyed lax regulations, the Texas RRC has recently implemented the “Hydraulic Fracturing Disclosure Rule”. This rule requires fracking operators to publish the chemical ingredients used in the fracking “cocktail” injected into the well (Texas Railroad Commission, 2017). Regulations like this are a step towards more effective regulation that will protect groundwater supplies.

One example of local conflict concerning fracking was seen in the north Texas city of Denton. In 2014, Denton held a city wide referendum proposing a fracking ban which passed with 59% of voters supporting a ban (Malewitz 2015). However, action by the Texas Legislature in House Bill 40 “pre-empts local regulation of all ‘below ground oil and gas activities’ – like bans on hydraulic fracturing or drilling – and says all other related local regulations must be “commercially reasonable’” (Malewitz 2015). The fact that the City of Denton would choose to ban fracking when fracking could continue to provide economic benefits to the area demonstrates the presence of externalities from fracking operations.

## HYPOTHESES

As previously mentioned, this report is interested in the perception of environmental effects of fracking. Question 25c and 25d from the survey measure an individual’s opinion on the seriousness of contamination issues caused by hydraulic fracturing. The fracking variable “numberofdisclosures” represents to the number of fracking sites in each county that fracking companies have disclosed to the EPA. Stata will be used to perform a linear regression between these two variables to determine if a statistically significant relationship exists. The null hypothesis and alternative hypothesis are listed below:

*$H_0$: The number of fracking sites per county of the survey respondent will have no effect on the participants’ ranking of importance about contamination of water sources from fracking*

*$H_1$: As the number of fracking sites per county increase, the survey respondent will place a higher importance on the seriousness of contamination of water sources from fracking.*

The rationale behind this hypothesis is that the closer survey participants may live to a fracking site, the more first-hand experience they may have with environmental degradation due to fracking. For example, if a methane leak from fracking operations contaminates a survey participant’s tap water and causes the water supplies to be shut off, the individual will be directly impacted from an environmental effect associated with fracking.

These concerns are relevant to fracking because the data and literature about environmental effects of fracking are conflicting. Fracking clearly degrades the environment through the drilling, extraction and sealing of fracking wells. The question is how damaging are these practices, and to what extent are these effects dangerous to residential populations near fracking sites. This poses the questions how do residents feel about fracking near their homes and what do individuals perceive the environmental effects of fracking operations to be. This analysis will be used to investigate these questions.

## METHODOLOGY

### *Data Description*

As previously mentioned, environmental concerns associated with fracking have grown as fracking operations have increased across the nation. Data from the Energy-Food-Water Nexus Public Opinion Survey produced by the Institute of Science, Technology and Public Policy at the Bush School of Public Service will be used in order to draw conclusions about public perceptions of environmental effects from fracking.

The GfK Group (formerly Knowledge Networks) conducted the Water-Energy-Food Nexus Public Opinion Survey on behalf of the Bush School's Institute for Science, Technology and Public Policy (ISTPP) at Texas A&M University. Specifically, the study aimed to identify the factors that underlie US public opinion regarding various issues related to the energy-food-water nexus including government trust and responsibility, knowledge levels, and risk perceptions, and their policy preferences. The survey was conducted using samples from KnowledgePanel®.

The questionnaire was developed by a team of researchers and scholars at the ISTPP during the spring and summer of 2015. Most of the questions were borrowed from other public domain surveys. Additional questions, particularly those eliciting information about personal demographics, are standard questions used by GfK. Original questions, particularly those eliciting information specifically about water-energy-food nexus issues, were developed for this project and pre-tested among a convenience sample of students at the Bush School.

The target population consisted of the general US population of adults 18 years and older, with oversamples in Texas and Houston. To sample the population, GfK sampled households from its KnowledgePanel, a probability-based web panel designed to be representative of the United States. The survey consisted of two stages: a pretest to determine incidence and length of the survey, and the main survey with the study-eligible respondents. To qualify for the main survey, a panel member must have been 18 years and older. The survey was pre-tested by GfK from July 17 through July 20, 2015, and the full panel was engaged from August 12 through August 29, 2015. The median time of survey completion was 24 minutes.

The number of respondents sampled and participating in the survey, the survey completion rate for the main interview, and the incidence/eligibility rate are presented below.

| Number Sampled | Number Completed | Completion Rate | Qualified | Incidence Rate |
|---|---|---|---|---|
| 3362 | 1979 | 58.9% | 1979 | 100% |

The total number of respondents who completed the survey, including the oversamples of Texas and Houston residents, is 1,979. The total number of respondents composing the nationally-representative sample is 1,463.

Instead of sending the standard email reminder on day three of the field period, the following steps were taken to maximize the response or incidence rate:

- Additional email reminders to non-responders were sent on day 7, day 12 and day 15 of the field period;
- Participants were eligible to win an in-kind prize through a monthly GfK sweepstakes;

Additional variables were added to the Energy-Food-Water Nexus Public Opinion Survey by Bryce Hannibal of the Institute of Science, Technology and Public Policy. His research included survey participant’s zip-code information and several variables concerning the presence of fracking in these zip-codes as reported to the U.S. Environmental Protection Agency. Additional fracking variables included represent the number of gallons of water used in fracking practices by county and whether or not the Texas Railroad Commission (the primary regulator of oil and gas production and Texas) considers the county a “core fracking county”.

Question 25c and 25d of the Energy-Food-Water Nexus Public Opinion Survey was identified as a question directly related to the idea of perceived environmental effects of fracking. The question taken directly from the survey is included below:

Q25. Some people believe the following items are problems caused by hydraulic fracturing, or fracking. Please indicate your assessment of the seriousness of each item using the scale below.

| Not a Problem at All) | | | | | | | (Extremely Serious Problem) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

a) Competition for water supplies for hydraulic fracturing.

b) Depletion of water sources (streams, groundwater, etc.) used in hydraulic fracturing.

**c) Contamination of water sources from oil and gas drilling using hydraulic fracturing.**

**d) Contamination of water sources from the disposal of fluids used in hydraulic fracturing.**

## Variables

### *Independent and Dependent Variables*

The independent variable for this regression is labeled "numberofdisclosures" represents the number of fracking sites in each county disclosed to the EPA. It will be used to determine if the survey participant lives in a county where fracking operations exist. "Numberofdisclosures" is the independent variable because it is thought to influence the survey participant's concern for environmental issues related to fracking, and therefore can exist "independently" of the dependent variable.

There are two dependent variables used for this analysis: question 25c and question 26d from the Food-Energy-Water Nexus Survey. Question 25c measures the seriousness respondents feel concerning the contamination of water sources from oil and gas drilling using hydraulic fracturing; question 25d measures how serious respondents consider contamination of water sources from the disposal of fluids used in hydraulic fracturing. The respondents measured their concern on a scale of zero to ten; zero being not a serious issue and ten being an extremely serious issue. These questions are the dependent variables because the respondents concern about these contamination issues are influenced by the location of the respondents' home and if fracking is present in their county.

*Controls*

Several control variables were added to the regression that may be related to individuals' perceptions about fracking. However, adding a control variable accounts for this possibility and removes their effects from the equation. Education was included as a control variable. Individuals with a higher education may be more likely to have knowledge about relatively new and "cutting edge" energy technologies. Age was also added as a control. While fracking operations have existed since the 1970s, the fracking boom only began in the 21st century. Environmental concerns about fracking are even more recent. Therefore, it can be argued that younger individuals may be more familiar with fracking operations or have been exposed to media coverage about fracking. The third control variable added to the regression is party identification as an individual's political affiliation may impact their beliefs about the environment. Traditionally, members of the Democratic Party favor regulation protecting the environment. Members of the Republican Party tend to support less regulation and are more supportive of fossil-fuel-based energy policies (Ziegler 2017). These personal views may impact the survey participants' perceptions about environmental impacts of fracking.

## RESULTS AND ANALYSIS

Table 3-1 examines the relationship between the number of fracking sites in the county and the level of seriousness expressed by respondents about water contamination from fracking. Table 3-2 provides the multivariate regression analysis for this relationship. Table 3-3 shows the relationship between the number of fracking sites and the seriousness of water contamination from disposal of fracking fluids. And Table 3-4 provides the multivariate regression analysis for this relationship. The tables below provide results that suggest the number of fracking sites disclosed per county has no impact on the respondents' perceptions of environmental effects from fracking. This conclusion can be drawn because of the high p values in the regression analyses for both questions. Because the p value is greater than .05, we cannot reject the null hypothesis. In the tables, it was expected that participants who felt contamination from fracking was extremely serious, would have more fracking sites located in their county. However, this was not the case. There was no clear trend with either question corresponding to the number of fracking sites. It should be noted that there was a relationship between party idea and how strongly the respondent felt about contamination from fracking. The p value of "party id7" in both Q25c and Q25d is .000, indicating a linear relationship between the variables.

**Table 3-1: The Relationship between the Number of Fracking Sites in the County and the Level of Concern about Contamination from Fracking**

| Question 25C | Number of Fracking Sites Disclosed per County | | | | |
|---|---|---|---|---|---|
| Measure of "Seriousness" | 0 | 1-10 | 11-50 | 51-100 | 100 + |
| 0 | 2% | 4% | 6% | 8% | 2% |
| 1 | 2% | 1% | 0% | 0% | 2% |
| 2 | 2% | 1% | 0% | 0% | 7% |
| 3 | 3% | 3% | 6% | 8% | 2% |
| 4 | 3% | 3% | 13% | 0% | 10% |
| 5 | 11% | 17% | 6% | 8% | 14% |
| 6 | 5% | 8% | 0% | 8% | 2% |
| 7 | 14% | 7% | 6% | 8% | 10% |
| 8 | 14% | 7% | 6% | 8% | 10% |
| 9 | 12% | 11% | 6% | 0% | 5% |
| 10 | 32% | 39% | 50% | 54% | 36% |
| Total % | 100% | 100% | 100% | 100% | 100% |
| n: | 327 | 75 | 16 | 13 | 58 |

**Table 3-2: Regression Analysis Showing the Effect of the Number of Fracking Sites and Perceived Seriousness of Water Contamination**

Question 25C Stata Linear Regression

| Source | SS | df | MS | | | |
|---|---|---|---|---|---|---|
| | | | | Number of obs | = | 467 |
| | | | | F(4, 462) | = | 10.35 |
| Model | 294.277546 | 4 | 73.5693866 | Prob > F | = | 0.0000 |
| Residual | 3284.21068 | 462 | 7.10868112 | R-squared | = | 0.0822 |
| | | | | Adj R-squared | = | 0.0743 |
| Total | 3578.48822 | 466 | 7.67915928 | Root MSE | = | 2.6662 |

| Q25_C | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| numberofdisclosures | -.0003647 | .0006371 | -0.57 | 0.567 | -.0016167 | .0008873 |
| educ | -.0580034 | .1046632 | -0.55 | 0.580 | -.2636783 | .1476714 |
| age | -.0052966 | .0075567 | -0.70 | 0.484 | -.0201464 | .0095533 |
| partyid7 | .3639369 | .0577094 | 6.31 | 0.000 | .2505314 | .4773424 |
| _cons | 6.52412 | .5771932 | 11.30 | 0.000 | 5.389871 | 7.658369 |

**Table 3-3: The Relationship between the Number of Fracking Sites in the County and the Level of Concern about Water Contamination from Disposal of Fracking Fluids**

| Question 25D | Number of Fracking Sites Disclosed per Country | | | | |
|---|---|---|---|---|---|
| Measure of "Seriousness" | 0 | 1-10 | 11-50 | 51-100 | 100 + |
| 0 | 3% | 4% | 6% | 8% | 2% |
| 1 | 2% | 1% | 0% | 0 | 2% |
| 2 | 2% | 1% | 0% | 0% | 7% |
| 3 | 4% | 3% | 6% | 8% | 2% |
| 4 | 3% | 3% | 13% | 0% | 11% |
| 5 | 11% | 16% | 6% | 8% | 15% |
| 6 | 5% | 8% | 0% | 8% | 2% |
| 7 | 10% | 11% | 6% | 8% | 4% |
| 8 | 14% | 6% | 6% | 8% | 11% |
| 9 | 13% | 10% | 6% | 0% | 6% |
| 10 | 34% | 37% | 50% | 54% | 39% |
| Total % | 100% | 100% | 100% | 100% | 100% |
| n: | 312 | 79 | 16 | 14 | 54 |

**Table 3-4: Regression Analysis Showing the Effect of the Number of Fracking Sites and Perceived Seriousness of Water Contamination from Disposal of Fracking Fluids**

Question 25D Stata Linear Regression

| Source | SS | df | MS | | | |
|---|---|---|---|---|---|---|
| | | | | Number of obs | = | 467 |
| | | | | F(4, 462) | = | 9.09 |
| Model | 251.450693 | 4 | 62.8626733 | Prob > F | = | 0.0000 |
| Residual | 3195.05894 | 462 | 6.915712 | R-squared | = | 0.0730 |
| | | | | Adj R-squared | = | 0.0649 |
| Total | 3446.50964 | 466 | 7.39594342 | Root MSE | = | 2.6298 |

| Q25_D | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| numberofdisclosures | -.0002782 | .0006284 | -0.44 | 0.658 | -.0015131 | .0009567 |
| educ | -.0132308 | .1032328 | -0.13 | 0.898 | -.2160948 | .1896332 |
| age | -.0026847 | .0074535 | -0.36 | 0.719 | -.0173316 | .0119622 |
| partyid7 | .3394276 | .0569208 | 5.96 | 0.000 | .2275719 | .4512833 |
| _cons | 6.498083 | .5693052 | 11.41 | 0.000 | 5.379334 | 7.616831 |

Another trend in the data that is worth mentioning is that for both questions the majority of the respondents saw contamination from fracking operations as an issue. For question 25c, 85% of the respondents believed contamination was at least a 5 on the 1-10 grading scale. For question 25d, 87% of the respondents believed contamination was at least a 5 on the 0-10 grading scale. These percentages reveal the majority of respondents feel the contamination related to fracking is at least an issue. The fact that for both questions, a large majority of the respondents viewed contamination from fracking as serious could have significant policy implications, calling for increased efforts to protect ground water from drilling and chemical contamination.

## CONCLUSIONS

### Generalizability of Data

The internal and external validity should be taken into consideration for this analysis. Because of the limitations mentioned above and lack of statistical significance found between the independent and dependent variables, these regression results have internal validity, but not external validity. Several limitations mentioned the subsequent sections of the paper explain why these regression results should not be generalized to other experiments and data sets.

#### *Limitations*

While there are many merits in the data used for this study, several limitations can be identified. First, the current fracking data is limited by several factors. Because many regulatory exemptions exist for fracking, oil and gas companies are not required to report fracking sites or fracking activity to the EPA. Therefore, many unknown fracking sites across Texas may exist and as a result are unaccounted for in this study. While the data used for this analysis is the most accurate data currently available, it is nonetheless incomplete.

In the data analysis, the variable number of fracking sites in a county is used to determine if a survey participant lives in a county where fracking operations occur. As mentioned in the hypothesis section, it is predicted that participants living in counties with significant fracking operations will be more aware of fracking's negative environmental impacts and therefore rate issues of contamination of higher importance to the individual. However, this variable does not account for the fact that the survey participants' place of residence may be very far from the actual fracking site location within the county, isolating them from experiencing any direct environmental impacts. Additionally, if people are strongly opposed to fracking, they might choose to live in an area where there are not fracking sites. On the other hand, it is possible that people have been so negatively affected by fracking; they once lived in an area with fracking operations, and have since moved to escape from any negative environmental effects. It is also a possibility that those who live in areas with significant fracking operations moved there to be employed by the oil and gas industry, and then would have strong reasons to not be opposed to fracking. These are all possible explanations for the absence of a relationship between the two variables.

Another limitation in the data analysis is that no variable discloses the employment of the participants. If a participant is employed by an oil and gas company, they are more likely to disregard the negative environmental effects of fracking as they economically benefit from fracking operations. These effects also have the potential to work in the opposite way: if a participant is employed by an environmental group or a similar field, they may be inherently biased against fracking and oil and gas production. Because these omissions have a potential to seriously impact the analysis' results, it is necessary to acknowledge them.

## SUGGESTIONS FOR FUTURE RESEARCH

Although the relationship between the tested variables was not found to be statistically significant, this research is important and should be focused on in the future. Because 170 of 475 participants replied that contamination of water sources from oil and gas drilling using hydraulic fracturing is extremely important, and that 179 of participants found contamination of water sources from the disposal of fluids used in hydraulic fracturing to be extremely important, alludes to the fact that environmental degradation from fracking operations is a salient issue. Independent studies done by the federal government and the EPA should be continued and expanded upon to truly understand the comprehensive environmental impacts about fracking.

This research also illuminates the lack of available fracking data. For both academic and environmental purposes, this lack of data is a problem. As previously mentioned, fracking operations already enjoys elaborate exemptions from environmental regulation. The least that can be done is accurate and consistent reporting about the location of the operations, and allowing for the information to be public.

As detailed in the first part of this report, the processes by which fracking extracts natural gas raises several environmental concerns including the potential for groundwater contamination, increased seismic activity and the waste of valuable water resources. Loopholes in federal legislation allows for fracking exemptions in several key environmental regulations, preventing the EPA from regulating many aspects of the process. The results from this report have significant implications for public policy regarding fracking operations. Because over 80% of respondents to both question 25C and 25D felt that contamination of groundwater from fracking regulations is an issue (ranked higher than a five on a scale from 1-10), it is clear that the public does not favor contamination of groundwater resources. This concern and perception that negative environmental impacts from fracking are a serious issue could lead to a desire for increased regulation of fracking operations, and elimination of the current exemptions enjoyed by fracking companies.

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# Section 2

# Transitions to Renewable, Sustainable, and Secure Energy Technologies

# Chapter 4

# *Public Opinion on Increasing Solar Energy Use*

**Leah Poffenberger**

## INTRODUCTION

In 2015, renewable energy sources accounted for 10% of energy production in the United States; solar power contributed to 6% of renewable energy production. Fossil fuels remain the major contributors to energy production, with coal, natural gas, and petroleum accounting for 16%, 29%, 36%, respectively (Energy Information Administration 2016). Natural gas has gained popularity as a cheap and relatively clean energy source, surpassing coal for the first time in 2016 (Energy Information Administration 2017). However, natural gas is a high producer of $CO_2$, a driving force of climate change, albeit a lower producer than coal.

In an address to a joint session of Congress, Barack Obama (2009) was explicit about the importance of renewable energy. “To truly transform our economy, protect our security, and save our planet from the ravages of climate change, we need to ultimately make clean, renewable energy the profitable type of energy,” said Obama. However, a shift away from the fossil fuel-driven economy of the United States is unlikely without long-term policies to encourage renewable energy production.

Germany, the 4th largest economy by GDP ($3.73 trillion in 2014), imports over half of its energy resources (Mormann et al 2016), however, since 2010, Germany has been the leading nation in renewable energy development. A movement known as the Energiewende (or “energy transition”), has begun with the goal of producing a secure, reliable low-carbon energy supply (Federal Ministry for the Environment 2010). By 2050, Germany hopes to achieve a decrease in greenhouse gas emissions by at least 80% relative to 1990 and to supply 60% of the country’s energy needs with renewable energy sources. Thirty percent of gross German power production came from renewable energy in 2016 with solar contributing 6% of total energy production (Clean Energy Wire, 2017.) A comparison of US and German energy source mixes can be found in Appendix A.

Germany’s success in increasing renewable energy use is a result policies enacted to incentivize renewable energy deployment and deregulate energy (Mormann et al. 2016). Development of renewable energy sources was encouraged generous 20-year feed-in tariffs (FITs), which incentivized rapid production of new renewable energy sources: The faster the energy source is deployed, the quicker the energy producer can begin benefiting from FITs. (Strum 2017) Energy deregulation, which began in the 1990s when Germany separated transmission and distribution assets allowed for an increase in small to mid-size renewable energy resources, mainly owned by local actors. (Mormann et al. 2016) Investment in renewable energy provided the opportunity for a sort of citizen participation as a variety of energy market newcomers were able to unseat the large energy companies in Germany and drive energy costs down (Strum 2017).

Although Germany's national policies are encouraging in the movement towards renewable energy production, the United States faces challenges in transitioning to renewable energy while meeting the needs of individual states. The variability of natural resources and state budgets create difficulties in creating national policies for renewable energy expansion as some states may be less capable of transitioning than others. Solar energy produces a small fraction of the United States energy supply, with a majority, 57% in 2015, coming from California (California Solar Statistics 2017).

California has become a front-runner in developing an energy base with a lowered reliance on fossil fuels. The California Global Warming Solutions Act of 2006, or AB 32, which ultimately seeks to lower carbon emissions to 1990 levels by 2020, launched a bipartisan commitment to environmental concerns (Mormann et al 2016 and Wara 2014). In addition to diversifying California's renewable energy portfolio, AB 32 created standards for tailpipe emission, low carbon fuel gasoline, and energy efficiency in buildings.

Although solar energy contributes a relatively small percentage of power production, it plays an important role in California's energy diversification. California is home to the largest solar power installation in the world and derives 6% of its total energy production from solar power.[10] In addition to large-scale solar installations, California has enjoyed success with the Million Solar Roofs program, which was launched in 2007 with the goal of installing one million solar panels on home or business rooftops by 2018 (EGS 2015).

Germany and California both represent unique cases of extreme dedication to reducing carbon emissions and may provide insight into expanding energy production from renewable resources. Solar power is likely an energy resource that could be more widely utilized by other states to supplement energy production from fossil fuels.

This chapter will discuss policies to increase the production of energy from solar sources in the United States. The first part of this chapter explores the mechanics of solar energy production, its effects on energy sector employment, and its environmental impacts as well as the policies of leading solar energy producers. The second half of this chapter will include an analysis of factors influencing public support for increased solar energy production and several policy options that encourage renewable energy production.

## PART I: BACKGROUND OF SOLAR ENERGY PRODUCTION AND CURRENT SUCCESSFUL PROMOTION POLICIES

### Mechanics of Solar Energy Production

Solar energy is produced via two methods: photovoltaic (PV) and thermal. PV turns sunlight directly into electricity, while solar thermal works much like other energy types that rely on creating and harnessing heat. Please see Appendix B for figures depicting these processes. PV's direct conversion to electricity makes it difficult to store with current technology, meaning it can only supply energy while the sun is shining (SEIA 2014). Solar thermal can be stored, allowing a more continuous energy supply, but it tends to produce less energy in low-irradiation environments than PV, meaning it has low energy output on cloudy or winter days (Quaschning 2004).

Solar energy can be collected in remote solar farms and distributed via the power grid, or by distributed energy resource (DER) systems located on or nearby the energy's destination. DER systems are typically PV solar panels, which creates a unique situation for DER users. If a solar panel creates more energy than necessary to power the building it is attached to, energy companies provide "net metering," where they will discount a customer's energy bill based on their solar panel's production (Schneider and Sargent 2014). DER has been popular in California as part of the Million Solar Roofs program, as well as in other areas. (EGS 2015). The potential for lower energy costs over the long-term due to net-metering and feed-in tariffs attract consumers to install DER systems, despite high up-front costs.

Energy from DERs that isn't needed can easily be rerouted back into the power grid, but, when combined with other energy sources, too much surplus energy can overload the power grid. California has dealt with energy surpluses on particularly sunny and windy days, which has a negative effect on solar and wind use: In the event of an energy surplus, solar farms are often turned off. (Sommer 2016) Energy production from solar farms is much easier to moderate than coal or natural gas powered plants that require heat to produce energy and thus, can't easily be turned on and powered up again when an energy surplus dissipates.

California has considered a plan to share surplus renewable energy with surrounding states, such as Utah, that aren't producing solar energy. This plan highlights two issues involved with the use of solar energy: the need for better energy storage technology and the inefficiency of single states enacting isolated energy policies. Energy policies, possibly on a national level, promoting cooperation across states to facilitate improved infrastructure for energy sharing may be crucial to renewable energy adoption in the United States.

Developing energy storage for electricity produced by PV is crucial to expanding solar energy, as storage would allow for the collection of energy for use when there is no sun. A hydrogen energy storage system has been used in Nigeria which is capable of providing small power loads over a fairly long period of time but conversion efficiency is fairly low—34% (Douglas 2016).

Another issue to address as renewable energy gains popularity is the need to update the power grid to handle an increase of energy sources and two-way power flow from DER systems. In its energy transition, Germany has experienced a need for power grid that is built specifically to handle the variance in energy influx from renewable energy and the increased number of energy producers. (Mormann et al 2016). Germany has recently begun planning for grid improvements with proposals to incentivize investment in the distribution grid. (CEW 2015)

**Impacts on Energy Sector Employment**

A major concern in the transition to renewable energy is the loss of jobs in traditional fuel sources. The replacement of coal with natural gas as a top energy producer has contributed to a downturn in coal production and the loss of jobs. Policymakers with constituents in areas dependent on oil, natural gas, or coal are often economic repercussions, making them hesitant to consider renewable energy sources.

Between 2008 and 2012, the coal industry lost 49,000 jobs while natural gas, solar and wind industries combined added 175,000 jobs (Haerer and Pratson 2015). One million dollars of solar energy output results in 5.4 jobs, while oil/natural gas and coal produce 0.8 and 1.9 jobs, respectively (Robertson 2010). These data indicate a positive impact on job formation by renewable energy jobs.

However, the concern of policymakers for constituents working in coal may not be unfounded: increases in natural gas, wind, and solar energy job availability did not occur in areas that were affected by losses of coal jobs (Haerer and Pratson 2015). Policy could be enacted to bring renewable energy jobs to areas negatively affected by coal downturn or to incentivize fossil fuel workers to relocate to areas with available green jobs.

## Environmental Impacts

Although solar energy production is a cleaner process in terms of $CO_2$ emissions than fossil fuels, it may not come without an environmental impact. Production of solar cells includes mining and smelting of heavy metals, which produce a very small level of emissions. However, it is estimated that replacing fossil fuels with solar energy would still result in an 89-98% decrease in greenhouse gas emissions (Fthenakis et al 2008).

Another environmental concern that has arisen with the expansion of solar and wind energies is avian mortality. Little empirical data exists on avian mortality at solar facilities, but a preliminary report (Walston et al 2016) indicates that between 37,800 and 138,600 birds have died as a result of solar-related causes. The two main causes of avian death are collision-related mortality and solar flux-related mortality, resulting from the burning effects of concentrated sunlight.

Solar farms have brought up concerns of land degradation and habitat loss due to the large area needed to produce energy: PV farms require 3.5-10 acres per megawatt (Union of Concerned Scientists 2013). Recent research has begun to examine the impact of solar farms on the local climate to establish what, if any, ground temperature changes take place. Preliminary research shows a small increase in ground and air temperature around desert PV farms (Yang et al, 2017).

## Promoting Solar Energy Use in the United States

The increase in solar energy usage in the United States has reduced the price per Watt of generating power by 60% since 2008 (SEIA 2017). This reduction in cost was partially due to a growth in installed capacity produced by a loan program from the Department of Energy. Solar energy has also grown in popularity due to tax credits for solar installation. Since a solar investment tax credit was implemented in 2006, annual solar installation has seen a 1,600% increase (SEIA 2017).

The ten states with the highest per-capita solar electricity capacity (Arizona, California, Colorado, Delaware, Hawaii, Massachusetts, Nevada, New Jersey, New Mexico and North Carolina), have all enacted similar policies to promote solar energy among homeowners (Schneider and Sargent 2014). A majority of these states have enacted net metering policies, interconnection policies, renewable electricity standards, and creative financing options. Other states may be able to implement similar policies to raise their percentage of power production from solar sources. A map appears in Appendix C which shows the distribution of solar power plants in the United States.

In order to undergo an energy transition in the same vein as Germany, the United States will need to commit to a long-term effort to transition away from fossil fuels. An embrace of renewable energy may also provide an increase in job opportunities in energy, making up for lost jobs in the coal industry.

## PART II: ASSESSING SUPPORT FOR INCREASED SOLAR ENERGY PRODUCTION

A crucial factor in increasing popularity of renewable energy sources is understanding the influences of public opinion on energy source choices. Both Germany and California have experienced a certain amount of freedom to experiment with renewable resources due to positive public responses to efforts to slow climate change (Mormann et al 2016). Other areas with high economic reliance on fossil fuel production may experience greater difficulty in transitioning to a reduced reliance on fossil fuels.

The primary research question guiding this analysis is: Do people in general support an increase in solar energy production and, if so, what policies do they support? In order to determine what factors may increase support for solar energy expansion, four different characteristics—region of residence, level of education, monthly cost of electricity bill, and political ideology—were selected. Monthly cost of electricity was used in an attempt to determine if people with higher bills might see solar energy as a cost-reduction option.

The four selected characteristics were also used to analyze favorability of specific policy options among those who support an increase in solar energy production. The two policy options focus on incentivizing energy companies to produce energy from more renewable sources by: increasing federal funding for renewable energy technology research, or providing tax cuts to companies developing renewable energies.

**Hypotheses on Factors Influencing Support for Increased Solar Energy Production**

The following hypotheses have been developed to determine what influences people to favor an increase in solar energy. Region of residence, level of education, cost of electricity per month, and political ideology were identified as possible factors for affecting support of solar as an energy source over the next 25 years.

*Hypothesis 1:* People who live in the South are less likely to support an increase in solar as an energy source over the next 25 years.

*Hypothesis 2:* People who are more educated are more likely to support an increase in solar as an energy source over the next 25 years.

*Hypothesis 3:* People who have high monthly electricity bills are more likely to support an increase in solar as an energy source over the next 25 years.

*Hypothesis 4:* People who identify as liberal are more likely to support an increase in solar as an energy source over the next 25 years.

**Hypotheses on Policy Options for Increased Solar Energy Production**

The following hypotheses are proposed in order to determine favorable policy options aimed at increasing development of renewable energy. The two policy options are: increasing federal funding for research on renewable energy technologies and providing tax cuts to energy companies to develop renewable energy technologies.

*Hypothesis 5a:* People who live in the Northeast are more likely to support increasing federal funding for research on renewable energy technologies.

*Hypothesis 5b:* People who are more educated are more likely to support increased federal funding for research on renewable energy technologies.

*Hypothesis 5c:* People who identify as more liberal are more likely to support increased federal funding for research on renewable energy technologies.

*Hypothesis 6a:* People who live in the West are more likely to support providing tax cuts to energy companies to develop renewable energy technologies.

*Hypothesis 6b:* People who are highly educated are more likely support providing tax cuts to energy companies to develop renewable energy technologies.

*Hypothesis 6c:* People who identify as more conservative are more likely to support providing tax cuts to energy companies to develop renewable energy technologies.

**Collection of Survey Data**

All data used in this research was provided by the U.S. National Energy Public Opinion Survey.

The GfK Group (formerly Knowledge Networks) conducted the Energy Public Opinion Survey on behalf of the Bush School's Institute for Science, Technology and Public Policy (ISTPP) at Texas A&M University. Specifically, the study aimed to identify the factors that underlie US public opinion regarding various energy-related issues including government trust and responsibility, knowledge levels, and risk perceptions, and their policy preferences. The survey was conducted using a sample from KnowledgePanel®.

The questionnaire was developed by a team of researchers and scholars at the ISTPP during the spring of 2012. Most of the questions were borrowed from other public domain surveys. Additional questions, particularly those eliciting information about personal demographics, are standard questions used by GfK. Original questions, particularly those eliciting information specifically about energy policy issues, were developed for this project and pre-tested among a convenience sample of students at the Bush School.

The target population consisted of the general US population of adults 18 years and older. To sample the population, GfK sampled households from its KnowledgePanel, a probability-based web panel designed to be representative of the United States. The survey consisted of two stages: a pretest to determine incidence and length of the survey, and the main survey with the study-eligible respondents. To qualify for the main survey, a panel member must have been 18 years and older. The survey was pre-tested by GfK from May 8 through May 9, 2012, and the full panel was engaged from May 11 through May 26, 2012. The median time of survey completion was 28.6 minutes.

The number of respondents sampled and participating in the survey, the survey completion rate for the main interview, and the incidence/eligibility rate are presented below.

| Number Sampled | Number Completed | Completion Rate | Qualified | Incidence Rate |
|---|---|---|---|---|
| 2454 | 1525 | 62% | 1525 | 100% |

The total number of respondents composing the nationally-representative sample is 1,525.

Instead of sending the standard email reminder on day three of the field period, the following steps were taken to maximize the response or incidence rate:

- Email reminders to non-responders were sent on day three of the field period;
- Additional email reminders to non-responders were sent on day 10 of the Main field period.

**Methodology of Data Analysis**

This analysis used responses to three opinion questions and four demographic questions from the U.S National Energy Public Opinion Survey. Bivariate cross-tabulations using demographic questions as independent variables and responses to opinion questions as dependent variables are presented. For all cross-tabulations, the number of valid cases was at least 95% of the survey's total sample size N=1525. Tables 4-1 through 4-4 show the cross-tabulations for the four demographic variables (region, education, monthly electricity cost, and political ideology) with the dependent variable being responses to "Do you favor an increase or decrease in the use of solar energy?" (Energy Survey, Question 3).

Tables 4-5a through 4-5b use region, education, and political ideologies as independent variables for the dependent variable: "Indicate whether you strongly support, support, oppose, or strongly oppose increasing federal funding for research on renewable energy technologies" (Energy Survey, Question 48).

Tables 4-6a through 4-6b show cross-tabulations between the same three independent variables and the dependent variable "Indicate whether you strongly support, support, oppose, or strongly oppose giv[ing] tax cuts to energy companies to develop renewable energy technologies" (Energy Survey, Question 49).

All table cells indicate percent of the column total respondents who indicated the response denoted by the row. A Pearson Chi-square test was conducted on each table to indicate if a relationship exists between the two variables. Chi-square values are included for each table along with a p-value to denote statistical significance. A significance level of $p < 0.05$ was set for this analysis. A Pearson's R measuring the strength of relationship between variables are included for

all tables excluding tables 4-1, 4-5a, and 4-6a, which show data for region, a non-ordinal variable.

**Factors Influencing Support for Increased Solar Energy Production**

The following four tables show the cross-tabulations between demographic data and a question selected from the Energy Survey that measured support for increased solar energy production. The hypothesis that is being tested by each table will be listed as well as an interpretation of the statistical analysis for each cross-tabulation.

***Table 4-1: The effect of region based on state of residence on support for increased solar energy***

*Hypothesis 1:* People who live in the South are less likely to support an increase in solar as an energy source over the next 25 years.

| *Do you favor an increase or decrease in the use of the following energy sources over the next 25 years? (Solar)* | Northeast | Midwest | South | West |
|---|---|---|---|---|
| Increase | 84.5% | 81.7% | 73.7% | 82.1% |
| Stay the same | 10.2% | 14.2% | 20.6% | 13.5% |
| Decrease | 5.3% | 4.1% | 5.7 | 4.5% |
| Total | 100% | 100% | 100% | 100% |
| n= | 283 | 345 | 544 | 33 |

Pearson Chi-square: 20.37 P-value: 0.0002

*Finding:* There is a relationship between region of state and support for an increase in energy over the next 25 years according to the Pearson chi-square value. The p-value shows this relationship is significant. A smaller percentage of people from the South favor an increase in the use of solar over the next 25 years than people from other regions.

***Table 4-2: The effect of education by category on support for increased solar energy***

*Hypothesis 2:* People who are more educated are more likely to support an increase in solar as an energy source over the next 25 years.

| *Do you favor an increase or decrease in the use of the following energy sources over the next 25 years? (Solar)* | Less than high school | High school | Some college | Bachelor's degree or higher |
|---|---|---|---|---|
| Increase | 64.7% | 76.5% | 81.0% | 84.6% |
| Stay the same | 26.3% | 17.7% | 15.6% | 11.0% |
| Decrease | 9.0% | 5.8% | 3.5% | 4.4% |
| Total | 100% | 100% | 100% | 100% |
| n= | 133 | 451 | 405 | 518 |

Pearson Chi-square: 31.229 P-value: 0.000 Pearson's R: -0.120

*Finding:* There is an increase support for increased use of solar as an energy source over the next 25 years with higher education. The p-value denotes an extremely significant relationship between education and solar energy support. The Pearson's R value denotes an association. People with more education are more supportive of use of solar as an energy source.

***Table 4-3: The effect of amount paid for electricity per month on support for increased solar energy***

*Hypothesis 3:* People who have high monthly electricity bills are more likely to support an increase in solar as an energy source over the next 25 years.

| *Do you favor an increase or decrease in the use of the following energy sources over the next 25 years?* | Under $50 | $51-100 | $101-150 | $151-200 | $201-250 | $251-300 | $301-350 | $351-400 | Over $401 |
|---|---|---|---|---|---|---|---|---|---|
| Increase | 78.1% | 80.7% | 82.8% | 73.5% | 84.1% | 81.3% | 85.2% | 75.0% | 44.4% |
| Stay the same | 15.1% | 15.3% | 13.3% | 20.5% | 10.2% | 8.3% | 11.1% | 12.5% | 44.4% |
| Decrease | 6.8% | 4.0% | 3.8% | 6.0% | 5.7% | 10.4% | 3.7% | 12.5% | 11.1% |
| Total | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| n= | 192 | 503 | 390 | 200 | 88 | 48 | 27 | 8 | 9 |

Pearson Chi-square: 24.618 P-value: 0.07 Pearson's R: 0.023

*Finding:* There is no clear relationship between amount paid per month for electricity and support for increased use of solar energy. The p-value is above 0.05, meaning there is no statistically significant relationship with support for favoring an increase in solar energy over the next 25 years.

***Table 4-4: The effect of political ideology on support for increased solar energy***

*Hypothesis 4:* People who identify as liberal are more likely to support an increase in solar as an energy source over the next 25 years.

| *Do you favor an increase or decrease in the use of the following energy sources over the next 25 years? (Solar)* | Strongly liberal | Liberal | Slightly liberal | Middle of the road | Slightly conservative | Conservative | Strongly Conservative |
|---|---|---|---|---|---|---|---|
| Increase | 92.5% | 91.4% | 89.0% | 80.6% | 82.2% | 72.1% | 49.5% |
| Stay the same | 3.8% | 7.4% | 8.6% | 16.9% | 13.2% | 18.4% | 33.7% |
| Decrease | 3.8% | 1.1% | 2.5% | 2.5% | 4.6% | 9.5% | 16.8% |
| Total | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| n= | 53 | 175 | 163 | 510 | 174 | 305 | 101 |

Pearson Chi-Square: 115.114 P-value: 0.000 Pearson's R: 0.236

*Finding:* The high Chi-square value and extremely low p-value show there is a strong, statistically-significant relationship between political ideology and support for solar energy use over the next 25 years. The Pearson's R shows a strong association. People who identify as more liberal are more in favor of increased solar energy use.

## Policy Options for Increased Solar Energy Production

The following tables show cross-tabulations between three demographic variables (region, education, and political ideology) and two different questions selected from the Energy Survey as policy options. Tables 4-5a through 4-5c show relationships between demographic variables and a policy option for increasing funding for renewable energy technology research. Tables 4-6a through 4-6c will show relationships between the same three demographic variables and a policy option to increase tax cuts for companies to develop renewable energy resources. The hypothesis tested by each table will be listed as well as an interpretation of the findings from each statistical analysis.

***Table 4-5a: The effect of region by state of residence on support for increased federal funding for research of renewable energy technologies***

*Hypothesis 5a:* People who live in the Northeast are more likely to support increasing federal funding for research on renewable energy technologies.

| Indicate whether you strongly support, support, oppose, or strongly oppose increasing federal funding for research on renewable energy technologies | | Northeast | Midwest | South | West |
|---|---|---|---|---|---|
| | Strongly Support | 28.0% | 25.9% | 24.9% | 31.4% |
| | Support | 37.5% | 30.4% | 32.8% | 29.0% |
| | Unsure | 23.6% | 27.1% | 26.9% | 23.7% |
| | Oppose | 6.2% | 9.8% | 9.5% | 9.0% |
| | Strongly Oppose | 4.7% | 6.8% | 5.9% | 6.9% |
| | Total | 100% | 100% | 100% | 100% |
| | n= | 275 | 336 | 539 | 334 |

Pearson Chi-square: 13.245 P-value: 0.351

*Finding:* The high p-value indicates no statistically significant relationship between region and support for increased federal funding. Region does not appear to affect level of support for increasing federal funding for research on renewable energy technology.

***Table 4-5b: The effect of education by category on support for increased federal funding for research of renewable energy technologies***

*Hypothesis 5b:* People who are more educated are more likely to support increased federal funding for research on renewable energy technologies.

| | | Less than high school | High school | Some college | Bachelor's degree or higher |
|---|---|---|---|---|---|
| Indicate whether you strongly support, support, oppose, or strongly oppose increasing federal funding for research on renewable energy technologies. | Strongly Support | 26.6% | 18.3% | 28.1% | 34.4% |
| | Support | 30.5% | 31.9% | 34.8% | 31.0% |
| | Unsure | 36.7% | 32.4% | 26.1% | 16.5% |
| | Oppose | 2.3% | 10.0% | 7.0% | 10.8% |
| | Strongly Oppose | 3.9% | 7.4% | 4.0% | 7.3% |
| | Total | 100% | 100% | 100% | 100% |
| | n= | 128 | 448 | 399 | 509 |

Pearson Chi-square: 71.458 P-value: 0.000 Pearson's R: -0.073

*Findings:* The chi-square statistic indicates there is a relationship between education and support for increased federal funding for research on renewable energy technologies. This relationship is statistically significant, and is associated according to the Pearson's R value. Higher education is associated with more support for increased federal funding for renewable energy research.

***Table 4-5c: The effect of political ideology on support for increased federal funding for research of renewable energy technologies***

*Hypothesis 5c:* People who identify as more liberal are more likely to support increased federal funding for research on renewable energy technologies.

| Indicate whether you strongly support, support, oppose, or strongly oppose increasing federal funding for research on renewable energy | | Strongly liberal | Liberal | Slightly liberal | Middle of the road | Slightly Conservative | Conservative | Strongly Conservative |
|---|---|---|---|---|---|---|---|---|
| | Strongly Support | 67.9% | 46.6% | 36.6% | 25.1% | 23.3% | 14.7% | 13.9% |
| | Support | 17.0% | 35.6% | 37.3% | 37.2% | 33.7% | 27.3% | 15.8% |
| | Unsure | 13.2% | 16.1% | 23.0% | 30.8% | 25.6% | 26.0% | 18.8% |
| | Oppose | 0.0% | 1.7% | 3.1% | 4.7% | 10.5% | 20.3% | 19.8% |
| | Strongly Oppose | 1.9% | 0.0% | 0.0% | 2.2% | 7.0% | 11.7% | 31.7% |
| | Total | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n= | 53 | 174 | 161 | 506 | 172 | 300 | 101 |

Pearson Chi-square: 368.557 P-value: 0.000 Pearson's R: 0.409

*Findings:* There is an extremely significant relationship, as well as a strong association between political ideology and support for increased federal funding for research on renewable energy technologies. People who identify as strongly liberal are much more likely to strongly support increased federal funding for research on renewable energy technologies.

***Table 4-6a: The effect of region by state of residence on support for tax cuts for companies to develop renewable energy resources***

*Hypothesis 6a:* People who live in the West are more likely to support providing tax cuts to energy companies to develop renewable energy technologies.

Indicate whether you strongly support, support, oppose, or strongly oppose giv[ing] tax cuts to energy companies to develop renewable energy technologies.

| | Northeast | Midwest | South | West |
|---|---|---|---|---|
| Strongly Support | 24.5% | 20.0% | 22.8% | 28.4% |
| Support | 37.4% | 38.8% | 37.8% | 29.9% |
| Unsure | 26.3% | 28.1% | 25.8% | 27.5% |
| Oppose | 7.2% | 7.5% | 9.6% | 8.4% |
| Strongly Oppose | 4.7% | 5.7% | 3.9% | 5.7% |
| Total | 100% | 100% | 100% | 100% |
| n= | 278 | 335 | 534 | 334 |

Pearson's Chi-square: 14.115 P-value: 0.293

*Findings:* The high p-value indicates no statistically significant relationship between region and support for giving tax cuts to energy companies to develop renewable energy technology. Region does not appear to affect level of support for increasing tax cuts for energy companies.

***Table 4-6b: The effects of education by category on support for tax cuts for companies to develop renewable energy resources***

*Hypothesis 6b:* People who are highly educated are more likely support providing tax cuts to energy companies to develop renewable energy technologies.

| Indicate whether you strongly support, support, oppose, or strongly oppose giv[ing] tax cuts to energy companies to develop renewable energy technologies. | | Less than high school | High school | Some college | Bachelor's degree or higher |
|---|---|---|---|---|---|
| | Strongly Support | 25.2% | 17.9% | 23.1% | 29.2% |
| | Support | 26.8% | 35.9% | 38.6% | 36.9% |
| | Unsure | 40.2% | 31.9% | 25.1% | 20.3% |
| | Oppose | 5.5% | 8.0% | 10.0% | 8.1% |
| | Strongly Oppose | 2.4% | 6.3% | 3.3% | 5.5% |
| | Total | 100% | 100% | 100% | 100% |
| | n= | 128 | 448 | 399 | 507 |

Pearson's Chi-square: 46.743 P-value: 0.000 Pearson's R: -0.073

*Findings:* The chi-square statistic indicates there is a relationship between education and support for giving tax cuts to energy companies to develop renewable energy technologies. This relationship is statistically significant, and is associated according to the Pearson's R value. Higher education is associated with more support for increased tax cuts for energy companies.

***Table 4-6c: The effects of political ideology on support for tax cuts for companies to develop renewable energy resources***

*Hypothesis 6c:* People who identify as more conservative are more likely to support providing tax cuts to energy companies to develop renewable energy technologies.

Indicate whether you strongly support, support, oppose, or strongly oppose giv[ing] tax cuts to energy companies to develop renewable energy technologies.

| | Strongly liberal | Liberal | Slightly liberal | Middle of the road | Slightly Conservative | Conservative | Strongly Conservative |
|---|---|---|---|---|---|---|---|
| Strongly Support | 52.9% | 36.6% | 27.5% | 21.8% | 25.0% | 16.3% | 13.9% |
| Support | 35.3% | 41.4% | 40.0% | 33.9% | 30.8% | 40.0% | 35.6% |
| Unsure | 3.9% | 15.4% | 26.4% | 34.9% | 26.7% | 22.3% | 17.8% |
| Oppose | 5.9% | 5.7% | 3.1% | 6.5% | 11.0% | 13.7% | 12.9% |
| Strongly Oppose | 2.0% | 1.1% | 0.0% | 3.0% | 6.4% | 7.7% | 19.8% |
| Total | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| n= | 51 | 175 | 160 | 505 | 172 | 300 | 101 |

Pearson Chi-square: 176.450 P-value: 0.000 Pearson's R: 0.246

*Findings:* There is a significant relationship, as well as a strong association between political ideology and support for giving tax cuts to energy companies to develop renewable energy technologies. People who identify as more liberal are much more likely to strongly support giving tax cuts to companies to develop renewable energy technologies.

**Analysis of Influential Factors and Policy Options for Increased Solar Energy Production**

Data from Tables 4-1 through 4-4 show that most people favor an increase in solar energy over the next 25 years. For all four independent variables, a large majority of people from all groups, with the exception of those identifying as strongly conservative and people paying over $401 a month for electricity, responded that they supported increased solar energy. While solar energy is widely favored, region of residence, level of education and political ideology influenced opinion on solar energy use. People who live in the Northeast, have a bachelor's degree or higher, and identify as strongly liberal are the most likely to support an increase in solar energy use.

The independent variable in Table 4-3, monthly cost of electricity, had been selected in an attempt to determine if people would see solar energy expansion as a potential cost reduction measure. No significant relationship was identified, likely because people were unsure whether increased solar energy would lower or raise their existing energy bills. Those paying the highest rates of over $401 were least likely to support an increase in solar energy use, with only 44% responding they would support an increase in solar energy.

Analyses of Tables 4-5a through 4-5c show that education and political ideology were highly associated with favoring increasing federal funding for renewable energy research. Tables 4-6a through 4-6c also showed education and political ideology with favoring tax cuts for companies to develop renewable energy technology.

Education had the same association for both policy options, but the association between political ideology and favoring increasing federal funding was much stronger (0.409) than association between political ideology and favoring tax cuts (0.246). This suggests that providing tax cuts to companies to expand renewable energy is a more favorable policy option as support is less polarized by ideology.

A limitation for this analysis was the lack of survey questions on specific solar energy policies, especially questions on small-scale solar. Cost of electricity per month was used as an independent variable in an attempt to measure whether people associated an increase in solar with lower energy costs, which could result from net metering from DER systems.

## CONCLUSIONS

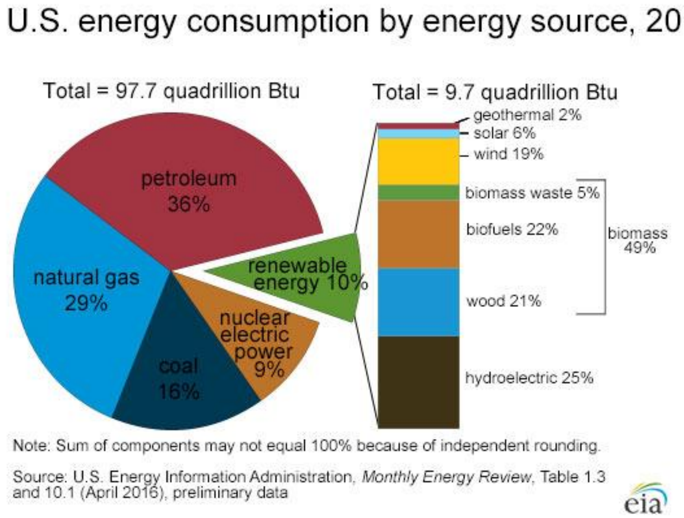
Despite the small contribution of solar to the current US energy mix, an increase in solar energy production seems to be widely favored. The widespread desire for more solar energy productions may indicate that Germany and California may not be alone in their freedom to experiment with solar energy expansion initiatives. Public opinion favoring an increase in solar and a concern for the climate allowed Germany and California to implement strategies to increase solar energy production despite brief increases in energy cost (Mormann et al 2016). Because an increase in solar energy production is favorable to a majority people surveyed in the national sample of the Energy survey, it may be possible to infer that the United States as a whole has relative freedom in experimenting with solar energy initiatives at national, state, and local levels.

Although the Energy survey did not ask questions directly relating to policies to increase solar energy production, people's opinions on increasing federal funding to increase renewable energy research and providing tax cuts to companies to promote development of renewable energy resources show tax cuts are likely a more favored option to increase solar energy use. The smaller association between political ideology and supporting tax cuts when compared to political ideology and supporting increased federal funding indicates that tax cuts are a more bipartisan policy option.

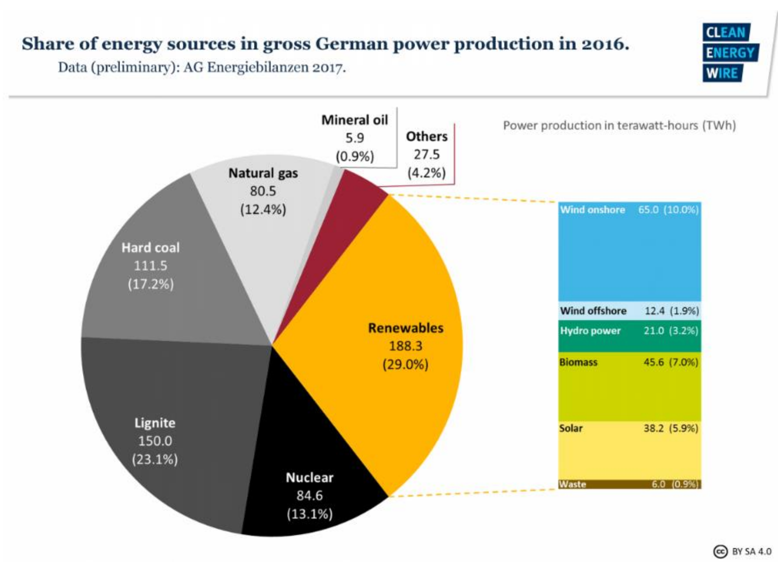
Beyond tax cuts, incentives for individuals to introduce small scale solar may be another favorable policy option. However, based on questions from the Energy survey, there was no way to measure support for small scale versus large scale solar, or favorability of small-scale policy incentives. States such as California and North Carolina have experienced success in solar energy source expansion through such incentives, which may indicate a need for more focus on small-scale solar than large-scale solar incentives. A survey of New Hampshire conducted by The

Alliance for Solar Choice (2016) found that 70% of survey participants were in favor of net metering credits. More research should be conducted on favorability of small-scale solar and policy options providing incentives to individuals in a wider population.

**Appendix 4-A: Share of Energy Sources in the US and Germany**



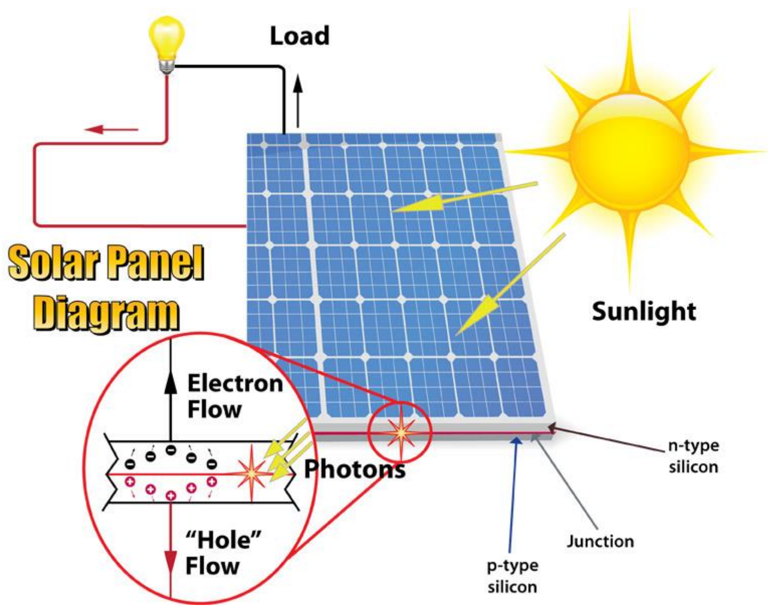

(Energy Information Administration 2016)




(Clean Energy Wire 2017)

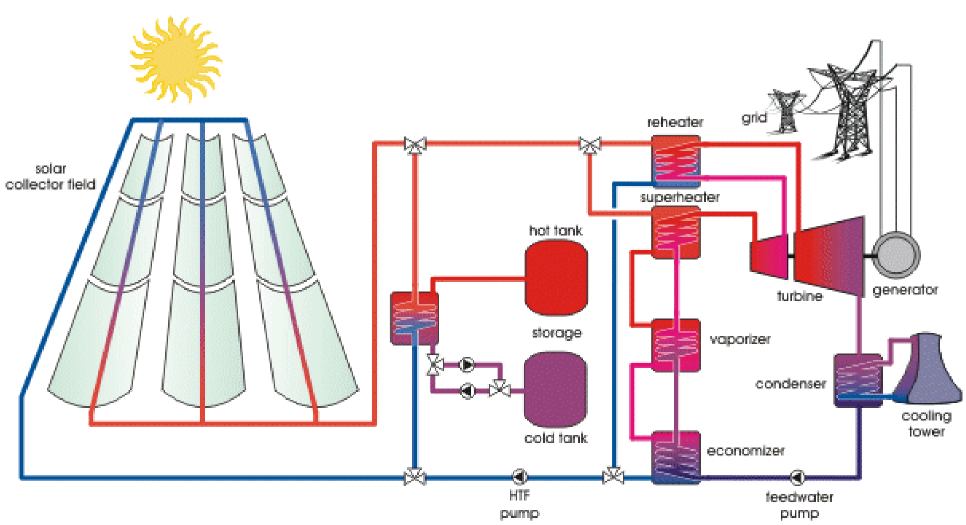
**Appendix 4-B:**

*The process of photovlatic solar energy production:*




(Diagram 2017)

*The process of thermal solar energy production:*




(Quaschning 2004)

**Appendix 4-C:**

*Distribution of solar power plants in the United States:*

(Energy Information Administration 2017)

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# CHAPTER 5

# *Energy Security and Climate Policy: Bridging Policy Solutions*

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## INTRODUCTION

Energy security has been a topic for debate in many spheres of policy, including national security, economics, the environment, domestic politics, and international affairs. In an increasingly interconnected global energy market, energy consumers consume more and more energy every year, and rates are expected to continue to grow (U.S. EIA). Energy is the facilitator and enabler for expansive international trade and commerce. With this interconnectedness and reliance on others for imports of key resources and energy products,, the global energy market is volatile, subject to the contingencies related to politics, violence, and rapid increases in global energy demand.

More recently, climate change has become a prominent issue that has and will continue to shape and define policy. Now, policymakers are faced with the task of developing cost-effective, sustainable approaches to energy that ensures both security and reduces greenhouse gas emissions. The International Energy Agency (IEA) has highlighted this challenge, and devised a framework to navigate the energy security-climate change policy nexus.

Public opinion on these issues can shape public policies on these areas. The Council of Foreign Relations conducted a survey of Americans and found that 82 % expressed concern that energy shortages and prices will destabilize the world economy. 79% expressed concern that competition for energy will lead to greater conflict and war between nations, and 82% said the way the world produces and uses energy is causing environmental problems including climate change (Public Opinion 2012).

## LITERATURE REVIEW

### Defining Energy Security

The IEA defines energy security as “the uninterrupted availability of energy sources at an affordable price” (IEA 1). Policies can improve energy security in two different time dimensions: through short-term or long-term energy security (IEA 1). Short-term energy security policy can be seen as reactive measures taken in response to changes in quantity demanded and supplied in energy markets. Long-term energy security policy is a more proactive, progressive approach to stimulating future growth. Long-term security promotes shifts in supply and demand of energy products, and creates more sustainable, climate friendly products.

Short-term energy security focuses on the response to, recovery from, and resilience through sudden changes within the market. The International Energy Agency focuses in many multilateral efforts to achieve short-term energy security. One of the Agency’s core activities and functions is to ensure collective emergency response after a serious oil supply disruption. In addition to certain short-term resiliency measures, countries must also ensure long-term energy stability and security.

Long-term energy security policies center around timely investment in 1) diversification of energy resources, products, and technologies, 2) improvements in integration of supply chains, and 3) addressing sustainable environmental needs. Tactics and methods to implement such policies, however, face very high initial costs and long lead times, which can lead to barriers to entry and a lack of competition and diversity of firms. In their report “World Energy Resources 2016”, the World Energy Council stated that to truly spur and stimulate long-term energy security growth, certain liberal economic and fiscal policies must be reconsidered to incentivize private sector investment in these industries (World Energy Res.).

**History of Energy Security and Climate Change**

Historically, energy security was used as a tool to advance political-military policy. During World War I, Winston Churchill shifted the British Navy’s power source from coal to oil--thus improving his fleet’s speed and reducing dependence on Welsh coal supplies (Yergin). However, after World Wars I and II, for over 3 decades, the United States grew in GDP, and in demand for transportation, oil, electricity, in sum, energy.

Research and innovation during World War II brought nuclear power into the energy market, when more than 200 power plants were planned throughout the US. Demand for cars and transportation grew. This growth was prioritized over energy efficiency and sustainability during this period, as cars grew in size and weight (UCSUSA). In 1970, the average mpg was 13.5, and gas was relatively cheap--less than $0.25 per gallon (UCSUSA). Life was good for the American consumer. However, the 1970s "oil shocks" demonstrated to both the United States and other Western nations that they needed to reconsider their foreign dependence on oil.

The Organization of the Petroleum Exporting Countries (OPEC), is a nongovernmental organization whose objective is to " co-ordinate and unify petroleum policies among Member Countries, in order to secure fair and stable prices for petroleum producers; an efficient, economic and regular supply of petroleum to consuming nations; and a fair return on capital to those investing in the industry" (Brief History). It was founded in Baghdad by 5 nations (Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela). By 1969, membership grew to 10.

In October 1973, a coalition of Arab nations, led by Syria and Egypt, attacked the Sinai Peninsula and the Golan Heights (areas which were occupied by Israel in a previous conflict from 1967 onward (President's). After hearing the Soviet Union was sending arms to Syria and Egypt, the United States sent a strategic airlift to deliver arms and supplies to Israel.

To retaliate, later in October 1973, the Organization of Arab Petroleum Exporting Countries (OAPEC), which included all members of OPEC as well as Egypt and Syria, enacted an embargo against nations who supported the Israelis during the Yom Kippur War. This led to a drastic increase in the price of oil. In the short run, consumers cannot rapidly adjust their demand for a change in the price of oil (World Nuclear). The immediate economic ramifications were intense. Panic ensued, and rationings and restrictions in oil purchases in the United States were limited. After the embargo stopped, prices continued to rise, which led to a global recession, unemployment, inflation, and decline in investment.

In response to the embargo, the United States and other affected developed nations within the Organization for Economic Co-operation and Development (OECD) formed the International Energy Agency in November 1974. Its mission is "to ensure reliable, affordable and clean energy for its 29 member countries and beyond." its four main focus areas are "energy security, economic development, environmental awareness and engagement worldwide" (IEA 2). Its original members counted at 17, including the United States, and featured several Northern and Western European Countries, as well as Japan, Turkey, and Canada. The organization would be hosted at the OECD in Paris.

Creation of the IEA was not the only measure taken by these nations to reduce energy dependency. Several countries worked to diversify their power sources. France developed an extensive nuclear power plan to provide electricity. Japan aimed to develop a more balanced mix of energy sources, including coal, gas, and nuclear energy. Germany addressed their vulnerability through developing nuclear electricity and devising investment incentives for the renewable energy industry (World Nuclear).

U.S. climate and environmental policy first became prominent through multiple policies and agencies created under the Nixon administration, including the National Environmental Policy Act of 1969, the creation of the Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration in 1970, and the Clean Air Act of 1970. The agency signaled climate threats such as carbon emissions, influenced fuel economy standards, and set precedent for the international community. In 1979, the World Climate Conference was the first time that climate change was addressed at the international level (Gupta 2010). In 1988, the UN Environment Programme created the Intergovernmental Panel on Climate Change, which organized and coordinated scientific research on climate change.

That same year, President Ronald Reagan signed the Montreal Protocol to address ozone layer deterioration. This act ensured US participation in the international climate change conversation. In 1997, the United Nations adopted the Kyoto Protocol, based on the UN

Framework Convention on Climate Change, which committed parties to reduce greenhouse gas emissions. However, the United States is the only signatory that has yet to ratify the protocol.

**A Framework to Analyze Energy Security**

In his 2006 "Ensuring Energy Security," Yergin describes a previous energy security framework, and proposes adjustments to this framework. The old framework Yergin describes contains several key components: diversification, resilience, market supply-chain stability, and high quality information to inform decision-making. Yergin applied one additional component to this framework, which he noted as critical: international cooperation.

Diversification, Yergin states, is the multiplication of one's energy source substitutes to reduce vulnerability to market shocks. After the Oil Embargo of 1973, as demonstrated earlier, many nations diversified their energy portfolio. Resilience is a "security margin" in the supply system that buffers against shocks and enables a smoother, more integrated recovery. One measure of energy resilience which the United States has taken is the Strategic Petroleum Reserve, developed in 1975 in response to the Arab Oil Embargo (World Nuclear). The stockpile was used twice, once on the eve of the Persian Gulf War in 1991, and after Hurricane Katrina and Rita, when refinery capacity was severely hampered in the Gulf Coast.

Market supply chain sustainability has grown to be a larger and larger challenge as world markets become more integrated, and demand for energy grows. The U.S. Energy Information Administration (USEIA) projects that energy use worldwide will have increases in demand over the next three decades (U.S. EIA). Interestingly, Non-OECD Asian countries, including India and China specifically, will account for more than half of the world's total increase in energy consumption. This increase in demand, as well as regional political and security challenges pose an ever increasing challenge to market supply chain sustainability. The oil and gas industry is most vulnerable to these regional and political instability, as regional conflicts can affect access to pipelines and other modes of energy transit (World Nuclear).

High quality information to support decision-making underpins healthy markets (Yergin). Organizations such as the IEA have developed information collection and analytic capabilities; they disseminate their knowledge about world markets and energy prospects to producers and policymakers across the globe (Yergin). The International Energy Forum educates consumers to ensure an informed energy literate population. Yergin states that policymakers and the private sector must collaborate with consumers to promote high-quality timely information during contingencies such as shocks.

Lastly, Yergin highlights bilateral and multilateral international cooperation as necessary in a new energy security framework. He emphasizes that in an increasingly interdependent global energy market, the preceding aspects of an energy security framework are necessary but not sufficient. To fully cooperate in a connected global market the United States must integrate energy security into this global model. International cooperation can also be applied to climate change initiatives. Public opinion polls from the Pew Research Center found that approximately half of Americans surveyed agreed with this policy action to affect climate change, through international agreement to limit carbon emissions (Funk and Kennedy 2016).

## THEORY

### Linking Energy Security Policy and Climate Change

The IEA has linked climate change mitigation and energy security policies in several ways. Concentrations of greenhouse gases in the atmosphere are rising. Over most of the last millennium, concentrations of carbon dioxide were approximately 280 parts per million (ppm).

Beginning in the mid-19th century, this has increased to 378 ppm in 2004 (IEA 2016). As a result, the greenhouse effect, or the trapping of the sun's warmth in the planet's lower atmosphere, is intensifying and is heating the earth and changing the global climate patterns.

The burning of fossil fuels, coal, gas, and oil, is responsible for over 60% of total emissions (IEA 2016). However, the IEA has provided many policy approaches to reduce energy-related greenhouse gas emissions:

1) Improving energy efficiency: through increasing efficiency of power plants, cars, and buildings, etc.

2) Switching to less carbon-intensive fossil fuels, such as reducing coal, with a carbon emission factor of approximately 26 tC/TJ

3) Switching to emission-free energy resources, such as nuclear and renewable energy sources, (solar, wind, geothermal).

4) Capturing and storing carbon dioxide emissions to prevent entrance into the atmosphere. (IEA 2016).

Energy Policy policy measures have focused on four areas or categories, based on what the IEA identifies as 4 broad categories:

1) Energy system disruptions due to extreme weather or accidents

2) Short-term balancing of supply and demand in electricity markets

3) Regulatory Failures that inhibit effective markets, such as failure to supervise natural monopolies in the electricity or natural gas industries

4) Concentration of fossil fuel resources in certain regions of the world. Many resources are concentrated in politically sensitive regions, and transport of fuels to market can be limited by geopolitical constraints (IEA 2016).

There are several areas where energy security policy objectives and climate change policy objectives can overlap. Climate change policies such as switching to emission free sources (e.g. nuclear, solar, wind) can apply to Yergin's diversification stipulation and to the concentration of resources issue that the IEA identified. However, energy efficiency of energy-consuming products can also benefit the energy security model, by reducing amounts of energy resources needed.

**Political Ideology and Policy Solutions**

Despite the clear linkages between solutions for energy security and climate change, policymakers face influences from political ideologies. There is an unwavering effort to discredit scientific findings related to man-made global climate change. Collumb (2014) notes that the ideological differences in supporting or disfavoring climate change policy is rooted in laissez-faire opposition to regulation. Collumb provides a more complex argument to define why conservatives and libertarians disfavor climate change policies, stating that there are additional factors at play, rather than just short-term economic interests of the oil and gas sectors. The scientific explanation for global climate change not only threatens these short-term incentives of profit in the energy markets, Collumb explains it threatens the pro-market position that capitalism and the invisible hand sort out market failures.

Operating off of these assumptions, this paper seeks to identify whether or not there exist policies to reframe the climate change policy agenda to attract bipartisan support. First, it will test and see if political ideology is a determinant of concern for energy insecurity. Next, it will test if political ideology is a determinant of concern for climate change. Last, it will test various climate and energy policy solutions to determine if political ideology affects whether a person is for or against these solutions.

## HYPOTHESES

**Hypothesis 1:** The more conservative an individual is, the more likely they are to not view climate change as a concern.

**Hypothesis 2:** Political ideology has no effect on concern for energy security.

**Hypothesis 3:** The more conservative an individual is, the more likely they are to oppose climate change policies.

**Hypothesis 4:** Political ideology has no effect on support for energy security policies.

## METHODOLOGY

This paper examines the relationship between political ideology (as the independent variable) and a number of dependent variables measuring different aspects of attitudes about energy security. These measures of the dependent variables include: 1) the level of concern about climate change; 2) the level of concern about energy security; 3) the level of support for climate change policies; and 4) the level of support for energy security policies. This paper utilizes the ISTPP Energy Survey and Climate Change Survey. Political ideology, the independent variable, was self-reported on a scale from: Extremely Liberal, Liberal, Slightly Liberal, Moderate, Slightly Conservative, Conservative, and Extremely Conservative. Responses were cross-tabulated with the independent variable, political ideology and then their Pearson R and P values at the 95% level are measured.

The following questions were asked to measure different aspects related to energy security:

1) **Concern about Climate Change**

Q1. On a scale from 0 to 10, with 0 indicating not at all concerned and 10 indicating extremely concerned, how concerned are you about each of the following issues? (from the Energy Survey) Global Warming; Environment

2) **Concern about Energy Security**

Q1. On a scale from 0 to 10, with 0 indicating not at all concerned and 10 indicating extremely concerned, how concerned are you about each of the following issues? (from the Climate Change Survey) Energy Supply

Q29. How important do you feel energy is as a vital national security issue for the United States? (from the Energy Survey)

1. Very important 2. Somewhat important 3. Unsure 4. Not so important 5. Not important at all

3) **Support for Climate Change Policies**

A number of policy options have been proposed to deal with issues associated with America's energy supply. For each policy option, please indicate whether you: strongly support, support, oppose, or strongly oppose that policy. (from the Energy Survey)

Q45. Require better fuel efficiency for cars and trucks.

Q48. Increase federal funding for research on renewable energy technologies.

Q49. Provide tax cuts to energy companies to develop renewable energy technologies.

4) **Support for Energy Security Policies**

Q32. Looking to the future, how important do you think it is for the United States to reduce its dependence on foreign oil? (from the Energy Survey)

1. Very important 2. Somewhat important 3. Unsure 4. Not so important 5. Not important at all

## RESULTS AND ANALYSIS

Tables 5-1 and 5-2 demonstrate that the more conservative an individual is, the more likely they are to not view climate change as a concern. Thus, we can accept Hypothesis 1 at the 99.9% confidence level. This ties to Collumb's observation that politically conservatives tend to denounce climate change. Tables 5-3 and 5-4 show no relationship between political ideology and energy security concerns, and Table 5-8 demonstrated support to reduce foreign oil dependence across all ideologies. This finding demonstrates a common link; each political ideology supports increased policy for energy security.

However, Collumb's theory can be scrutinized by the findings in Tables 5-5, 5-6, and 5-7. These tables demonstrate that more politically liberal people are more likely they to support climate change policies, regardless of policy type. More politically conservative people are more likely to oppose any climate change policy, even if traditionally conservative policy mechanisms are suggested, such as the tax breaks to renewables industries, as in Table 5-7.

## Table 5-1: Political Ideology and concern for global warming

| Concern for Global Warming | Political Ideology | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Extremely Liberal | Liberal | Slightly Liberal | Moderate | Slightly Conservative | Conservative | Extremely Conservative |
| | Not at all Concerned | 3% | 4% | 1% | 5% | 8% | 17% | 52% |
| | 1 | 3% | 1% | 2% | 2% | 5% | 8% | 6% |
| | 2 | 3% | 3% | 2% | 1% | 8% | 9% | 4% |
| | 3 | 3% | 4% | 6% | 5% | 9% | 11% | 8% |
| | 4 | 7% | 1% | 3% | 4% | 8% | 8% | 2% |
| | 5 | 3% | 9% | 10% | 15% | 13% | 16% | 0% |
| | 6 | 10% | 8% | 12% | 11% | 12% | 10% | 2% |
| | 7 | 17% | 16% | 17% | 12% | 11% | 6% | 6% |
| | 8 | 17% | 15% | 16% | 14% | 10% | 6% | 0% |
| | 9 | 3% | 16% | 15% | 10% | 7% | 4% | 2% |
| | Extremely Concerned | 24% | 22% | 15% | 20% | 8% | 6% | 17% |
| | n | 29 | 183 | 142 | 442 | 154 | 278 | 48 |
| | N | | | | | | | 1276 |
| | Pearson's R | -.3317 | | | | | | |
| | P Value | 0.000 | | | | | | |

## Table 5-2: Political Ideology and Concern for the Environment

| Concern for Environment | Political Ideology | | | | | | |
|---|---|---|---|---|---|---|---|
| | Extremely Liberal | Liberal | Slightly Liberal | Moderate | Slightly Conservative | Conservative | Extremely Conservative |
| Not at all Concerned | 7% | 5% | 1% | 3% | 3% | 4% | 23% |
| 1 | 0% | 0% | 1% | 1% | 2% | 3% | 8% |
| 2 | 7% | 3% | 1% | 2% | 6% | 6% | 4% |
| 3 | 0% | 2% | 0% | 2% | 5% | 8% | 2% |
| 4 | 7% | 2% | 4% | 3% | 9% | 10% | 13% |
| 5 | 7% | 8% | 9% | 13% | 10% | 16% | 19% |
| 6 | 10% | 6% | 13% | 10% | 14% | 13% | 6% |
| 7 | 14% | 12% | 19% | 14% | 19% | 12% | 6% |
| 8 | 14% | 19% | 15% | 19% | 18% | 12% | 0% |
| 9 | 7% | 19% | 15% | 10% | 6% | 7% | 4% |
| Extremely Concerned | 24% | 23% | 18% | 21% | 7% | 8% | 10% |
| n | 29 | 183 | 142 | 442 | 154 | 278 | 48 |
| N | | | | | | | 1276 |
| Pearson's R | -0.3090 | | | | | | |
| P Value | 0.000 | | | | | | |

## Table 5-3: Political Ideology and Concern for Energy Supply

| Energy Supply | Political Ideology | | | | | | |
|---|---|---|---|---|---|---|---|
| | Extremely Liberal | Liberal | Slightly Liberal | Moderate | Slightly Conservative | Conservative | Extremely Conservative |
| Not at all Concerned | 4% | 4% | 3% | 2% | 3% | 4% | 9% |
| 1 | 7% | 2% | 1% | 1% | 2% | 3% | 4% |
| 2 | 4% | 4% | 2% | 1% | 5% | 4% | 4% |
| 3 | 4% | 6% | 3% | 4% | 5% | 4% | 10% |
| 4 | 4% | 4% | 6% | 6% | 8% | 7% | 9% |
| 5 | 14% | 10% | 16% | 17% | 12% | 20% | 15% |
| 6 | 7% | 10% | 14% | 13% | 18% | 17% | 7% |
| 7 | 7% | 14% | 20% | 12% | 19% | 13% | 4% |
| 8 | 25% | 17% | 12% | 17% | 16% | 11% | 7% |
| 9 | 7% | 11% | 10% | 10% | 5% | 7% | 9% |
| Extremely Concerned | 18% | 17% | 13% | 18% | 8% | 9% | 24% |
| n | 28 | 183 | 140 | 440 | 153 | 276 | 46 |
| N | | | | | | | 1266 |
| Pearson's R | -.1198 | | | | | | |
| P value | 0.000 | | | | | | |

## Table 5-4: Political Ideology and Energy as vital to National Security

| | | Political Ideology | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Extremely Liberal | Liberal | Slightly Liberal | Moderate | Slightly Conservative | Conservative | Extremely Conservative |
| Energy Vital to National Security | 1. Very important | 57% | 59% | 55% | 47% | 59% | 64% | 67% |
| | 2. Somewhat important | 35% | 29% | 28% | 31% | 29% | 22% | 16% |
| | 3. Unsure | 4% | 11% | 15% | 19% | 11% | 11% | 9% |
| | 4. Not so important | 2% | 1% | 2% | 2% | 1% | 1% | 3% |
| | 5. Not important at a | 2% | 1% | 0% | 1% | 1% | 1% | 5% |
| | n | 54 | 178 | 164 | 509 | 174 | 305 | 103 |
| | N | | | | | | | 1,487 |
| | Pearson's R | -0.0210 | | | | | | |
| | P Value | 0.418 | | | | | | |

## Table 5-5: Political Ideology and Support for Requiring Higher Automobile and Truck Fuel Efficiency Standards

| | | Political Ideology | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Extremely Liberal | Liberal | Slightly Liberal | Moderate | Slightly Conservative | Conservative | Extremely Conservative |
| Require Fuel Efficiency | 1. Strongly Support | 77% | 61% | 53% | 40% | 41% | 35% | 25% |
| | 2. Support | 9% | 31% | 27% | 39% | 37% | 36% | 39% |
| | 3. Unsure | 6% | 6% | 17% | 17% | 16% | 14% | 10% |
| | 4. Oppose | 4% | 1% | 2% | 2% | 4% | 13% | 10% |
| | 5. Strongly Oppose | 4% | 0% | 1% | 1% | 2% | 2% | 17% |
| | n | 54 | 178 | 164 | 509 | 174 | 305 | 103 |
| | N | | | | | | | 1,487 |
| | Pearson's R | 0.2589 | | | | | | |
| | P Value | 0.000 | | | | | | |

### Table 5-6: Political Ideology and Support for Federal Funding of Renewables Research

| Increase Federal Funding on Renewables Research | Political Ideology | | | | | | |
|---|---|---|---|---|---|---|---|
| | Extremely Liberal | Liberal | Slightly Liberal | Moderate | Slightly Conservative | Conservative | Extremely Conservative |
| 1. Strongly Support | 68% | 47% | 37% | 25% | 23% | 15% | 14% |
| 2. Support | 17% | 36% | 37% | 37% | 34% | 27% | 16% |
| 3. Unsure | 13% | 16% | 23% | 31% | 26% | 26% | 19% |
| 4. Oppose | 0% | 2% | 3% | 5% | 10% | 20% | 20% |
| 5. Strongly Oppose | 2% | 0% | 0% | 2% | 7% | 12% | 32% |
| n | 54 | 178 | 164 | 509 | 174 | 305 | 103 |
| N | | | | | | | 1,487 |
| Pearson's R | 0.4087 | | | | | | |
| P Value | 0.000 | | | | | | |

### Table 5-7: Political Ideology and support for tax cuts to private companies that engage in renewables research

| Tax Cuts for Renewables | Political Ideology | | | | | | |
|---|---|---|---|---|---|---|---|
| | Extremely Liberal | Liberal | Slightly Liberal | Moderate | Slightly Conservative | Conservative | Extremely Conservative |
| 1. Strongly Support | 53% | 37% | 28% | 22% | 25% | 16% | 14% |
| 2.Support | 35% | 41% | 40% | 34% | 31% | 40% | 36% |
| 3. Unsure | 4% | 15% | 29% | 35% | 27% | 22% | 18% |
| 4. Oppose | 6% | 6% | 3% | 7% | 11% | 14% | 13% |
| 5. Strongly Oppose | 2% | 1% | 0% | 3% | 6% | 8% | 20% |
| n | 54 | 178 | 164 | 509 | 174 | 305 | 103 |
| N | | | | | | | 1,487 |
| Pearson's R | 0.2456 | | | | | | |
| P Value | 0.000 | | | | | | |

**Table 5-8: Political Ideology and perceived importance of reducing foreign oil dependence**

| | | Political Ideology | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Extremely Liberal | Liberal | Slightly Liberal | Moderate | Slightly Conservative | Conservative | Extremely Conservative |
| Reduce Foreign Oil Dependence | 1. Very important | 74% | 65% | 63% | 58% | 65% | 75% | 73% |
| | 2. Somewhat important | 19% | 29% | 25% | 26% | 26% | 19% | 13% |
| | 3. Unsure | 2% | 4% | 9% | 14% | 9% | 4% | 9% |
| | 4. Not so important | 4% | 1% | 2% | 2% | 0% | 2% | 3% |
| | 5. Not important at a | 2% | 1% | 1% | 1% | 0% | 0% | 3% |
| | n | 54 | 178 | 164 | 509 | 174 | 305 | 103 |
| | N | | | | | | | 1,487 |
| | Pearson's R | 0.2687 | | | | | | |
| | P Value | 0.074 | | | | | | |

## SUGGESTIONS FOR FURTHER RESEARCH

Further research is necessary to determine how to frame climate change solutions into energy security solutions. First, researchers must determine the root causal factor behind climate change skeptics. Further research must be conducted to test Collumb's theory of conservative climate skeptics.

## CONCLUSION

These findings have large implications for policymakers and policy-framers. To begin an integrated approach to climate change and energy security policy, policymakers and agenda setters can reframe climate change policies to fit into the energy security agenda. By promoting aspects such as product diversification, reduction of foreign oil dependency, and stabilizing energy supply, policymakers can implement both climate change and energy security solutions.

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# Section 3

# Influences on Technological Responses to Domestic Terror Threats and Environmental Problems

# Chapter 6

# *Public Opinion on Surveillance Technology and Policy*

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## HISTORY AND BACKGROUND

Society has always grappled with the implementation of new, controversial technologies into public life. Currently, the uses of cloning, GMOs, and nuclear power are debated in both how they should be used and even if they should be used at all. However, one of the most debated technological uses for the United States is the use of surveillance technology, specifically used to track terrorist activity. No government wants its nation to face an attack or security threat, but using surveillance comes at the cost of our privacy and our fourth amendment rights. The greater our desire to track illegal and threatening activity, the more we have to allow government to monitor our private activities. Furthermore, we do not have a clear definition of who is a terrorist, and the state could abuse this definition to spy on any potential threats to its power. So how do we go about balancing our security without sacrificing our privacy with government overreach? This question is important to both the American public and government officials. The focus for policymakers should be on surveillance technologies that the federal government can use for attack prevention, but have some cost to private security.

In order to understand how to best use surveillance technology for the United States government, you must first define the threat. Attacks on the United States can come in many forms; biological threats, chemical threats, nuclear threats, cyber security threats, attacks on key infrastructure, or attacks with firearms and explosives. These attacks can come from either lone actors, organized terror groups, or state actors. These attacks also occur on different scales. Setting off a dirty bomb in a major city would cause much more damage than a mass shooting. Different technological uses could help prevent different sorts of attacks. While mass collection of emails and phone calls could help search the general population for lone wolf actors, they will not prevent attacks that occur from foreign states. State actors need to be investing in the proper technology to deal with the different levels of threats.

Any modern day attack that would truly threaten United States security would involve the attackers using technology of some sort. It is of the utmost importance that policymakers understand the communication, surveillance, and weapons technology involved, both to understand how it can prevent and commit damage to the United States. The forms of surveillance and communications technology available for a government to be able to use in order to gather information is ever expanding. Telephones, both landline and cellular, can be wiretapped by the federal government in order to listen to calls or texts made between devices. Wiretapping rules were established thanks to the judicial rulings in cases such as Berger v. New York (1967) or Katz v. United States (1967) (Carr). These cases regulated how officers could establish wiretaps, but still allowed for electronic recording to be permissible. These wiretap rules were used up until 2001, when the NSA was given unprecedented access to wiretapping through the Patriot Act. This allowed the NSA to collect any form of phone communication in the country in an effort to prevent lone wolf attacks up until 2015 (Weisman). A government collecting metadata on its population could lead to the location of attackers through analysis of words used in communication. It also allows for the storage of communications for someone who gets placed on a terror watch list, allowing for officials to view past communications. This has great benefits to a government wishing to prevent attacks, but monitoring technology such as this falls into a legal and moral grey area.

Computer technology is one of the most important technologies when it comes to national security. Computers are used as the interfaces for power grids, nuclear reactors, traffic lights, air traffic controls, and personal information. Cyber terrorism can be defined as the creation of general fear and suffering through the abuse of computer networks (Testimony of Dorothy Denning). Individuals or groups can attempt to commit cyber terrorism through identity theft, stealing from corporations, or interfering with government activity. Examples of potential computer attacks include installing malicious software on another computer to transmit information such as key strokes, obtaining information on a hard drive remotely, accessing a webcam, obtaining sent emails, or transmitting false data for election results. Monitoring computer and internet traffic has the potential to provide information on many of these sorts of attacks, and two U.S. laws laid the foundation for computer tracking. First, the U.S. government was granted the ability to monitor electronic communication devices starting in 1986 with the Computer Fraud and Abuse Act. Second, the 1994 Communications Assistance for Law Enforcement Act (CALEA) requires that all internet traffic and devices using internet have the technology included so the federal government can monitor activity (Electronic Frontier Foundation). The uses of surveillance expanded even more under the Patriot act. This act rewrote all current surveillance laws, giving the federal government the authority to wiretap, monitor internet communications, and allowing for the sharing of "any tangible thing," as part of any terrorism or foreign intelligence investigation (U.S. PATRIOT ACT). The federal government has recognized how vital computer security to prevent bioterrorism, blackouts, nuclear terrorism, and hacking the government and corporations, but the methods the government uses for surveillance are often in conflict with privacy rights.

Imaging and video recording is another way that government could use for surveillance. Video surveillance gives a live recording of what happens at a given location where the camera is installed. CCTV is a common occurrence in European nations for governments to be able to monitor public areas, but not in the United States. This type of technology is more often employed by private companies for security purposes, usually breaking and entering or theft (Gras, Marianne). However, imaging and video technology when paired with either drone or satellite technology gives the user much more options for surveillance. Drones would give government or law officials the ability to deploy cameras in any given area in a moment's notice. This could be used to view protests, large events, or major cities where attacks may take place. Drone surveillance is not preventative but is reactive. Information about an attack must be given to properly place the drone to look for suspicious individuals. Satellite imaging is useful for an entirely different purpose. Satellites allow us to remotely obtain aerial photographs of usually inaccessible locations. This applies when attempting to assess the defense infrastructure of an opposing state, or for a terrorist to assess a building off of Google Maps (Hearn). When the imaging becomes more precise, the uses will increase.

The technology is also available for a state to use biometric or RFID (Radio Frequency Identification) tracking. Biometric tracking is a technology that measures and analyzes human physical and/or behavioral characteristics for authentication, identification, or screening purposes, which includes eye scanners, fingerprints, DNA, facial patterns, or voice recognition (Woodward). The ability to lock accounts or travel behind biometric data gives the state full control over who accesses said locked activities. A state could obtain biometric data for individuals on a watch list and prevent them from anything with a biometric lock. RFID tracking is tracking a radio chip from a satellite based on a coordinate based location of the chip (RFID Journal). As long as an RFID chip is present, an individual can track a chips movement anywhere on the globe. Cell phones have RFID technology present. Both sets of technology allow of a state to monitor the movement or behavior of individuals or groups. A state would have the vested interest in obtaining the rights to track suspected citizens, and could prevent attacks as they were about to occur.

Finally, there is data mining and social network analysis. Data mining is a computer science subfield that uses data about an individual (i.e. credit card purchases or locations tagged on social media) and running that data through algorithms to discover patterns or knowledge about a person that could be unknown otherwise (Han, Jiawei). Social media analysis is a way of mapping individuals and organizations that a person interacts with online (Ethier). Using these two forms of surveillance together can result in being able know what a person is doing, who they are communicating with, where and when they work, and more. In theory, it can be the perfect way to track the daily habits of one individual who is online. This makes data mining and social media analysis a tool to locate lone wolf terrorists who are getting violent ideas online. Government could use potentially use these profiling methods for people who are suspicious in order to preemptively stop attacks.

The history of communications technology legislation in the United States did not start with much of the technology we have in the 21st century. Legislation goes back to the establishment of the FCC in 1934, designed to regulate communications technology, and the NSA in 1952, designed to gather information about potential threats to the U.S. The first established U.S. law regarding how electronic surveillance could be used came from Title III of the Omnibus Crime Control and Safe Streets Act of 1968 (Carr). This law was passed following the Berger v. New York and Katz v. United States rulings, legalized the use of wiretapping and electronic surveillance, so long as constitutional and statutory limitations are followed. Ten years later, the United States passed the Foreign Intelligence Surveillance Act, which established the legal method for obtaining access to monitor potential foreign threats (The Foreign Intelligence Surveillance Act of 1978). This was the first piece of legislation that allowed the U.S. to gather electronic information regarding foreign states. The Foreign Intelligence Surveillance Act also established the FISA courts for issuing warrants regarding electronic information. The U.S. then passed the Electronic Communications Privacy Act (ECPA) in 1986, adding other forms of communication, such as where wireless and internet communications,  to a list of communication forms that could be monitored by the NSA, FBI, and other government organizations.  The last important pre-9/11 communications law passed was CALEA in 1994. This law required telecommunications companies to ensure that all communication devices have built-in surveillance capabilities.

Communications and surveillance legislation came to newfound importance to the American public and legislators after the terrorist attacks on September 11, 2001. The Patriot Act was passed on Oct. 26, 2001, and made changes to all the previously created communications and surveillance legislation. The act expanded all authority for surveillance within the United

States, allowed for secret courts to issue warrants for government surveillance without the public knowing, and created a security environment where anyone and anything was investigable if security was potentially threatened. The passage of the Patriot Act was the single biggest step the government has taken to push against privacy rights. The Department of Homeland Security was created two years later to coordinate federal terrorism investigations. The Patriot Act and the DHS has led to a modern era of data collection where the government has more power currently to collect communications than at any time previously. These new surveillance techniques have created controversies about American intelligence operations, such as the leaked NSA bulk collection of data in 2013. This bulk data collection was ruled illegal in court, and legislation has since been updated to stop bulk collection, but this is not the first incident of government overreach in data collection. Incidents of government overreach in privacy of citizens include the findings in the "Church Committee" investigations in 1975 (Senate Select Committee to Study Governmental Operations with Respect to Intelligence Activities), leaked warrantless wiretapping from 2002-2005 (Risen, James and Lichtblau, Eric), and a reported 1.3 million counts of demands by law enforcement for electronic information by 2012.

So where does current U.S. law stand on using different technologies for surveillance? Before this is answered, two issues must be addressed. First, we can only discuss the information that is available to the public about surveillance. Much of the surveillance that goes on in the United States is done by security or military agencies (NSA, CIA, FBI, ect.) and secrecy is important to the operations of said agencies. Second, "the Court is likely to address new technologies deliberately, and incrementally, using the old-fashioned common law, case-by-case approach to decision making—rather than attempt to devise broad rules that would decide a large category of cases not presently before the Court (Paul Larkin)." Security regulations that need to exist for new technologies that infringe upon the 4th amendment may not be written until long after a violation occurs. This leads to more regulations existing for technology that has been around longer, such as phone surveillance, but emerging technology has little to no regulation regarding how surveillance can be done.

The main obstruction to surveillance use by the U.S. government is the 4th amendment. The amendment provides, "the right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no Warrants shall issue, but upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized. (Cornell University Law, Legal Information Institute) "Telephone communication is currently the most protected technological form of communication. Under most circumstances, to legally wiretap a phone or obtain text messages, a traditional warrant must be obtained. This excludes the unconstitutional mass data collection by the NSA. However, with internet privacy, online documents can be obtained without a warrant. The ECPA, "allows the government to obtain access to digital communications -- including email, Facebook messages, information sitting in your public cloud provider's databases, and a variety of other files -- with only a subpoena and not a warrant once those items are 180 days old. "(Brandon Butler) The ECPA puts less privacy on online documents as opposed to paper ones. The legislation is even less clear with emerging technology, such as drones, satellites, RFID, GPS, or biometrics. Some states have laws dealing with privacy from individual emerging technologies, such as drones(Freedom from Drone Surveillance Act, Illinois General Assembly, The 2016 Florida Statutes, Chapter 934, Searches and Seizures using a Drone), but nothing is established at a federal level. The laws written for technology uses, by both the government and the public, often end up being written only after the technology is well understood. This delay in effective technological legislation makes it so emerging technologies do not have written laws until they are outdated by the next invention.

With all of this information, the ultimate question for policymakers becomes how to balance using technology for security and terrorism prevention, while not infringing on the privacy rights. Terrorism and threats to the State are extremely hot topics in politics, and current U.S. legislation allows for government to use technology for extensive counterterrorism purposes. These counterterrorism measures often directly prevent citizens from executing their right to privacy, such as the actions taken by the NSA following 2001. There is no clear answer to how policymakers should approach saving lives from attacks while keeping privacy sustained. The only clear recommendation to be made is that policymakers need to understand the technology, and understand it quickly. Writing legislation for a piece of technology years after the technology is outdated serves no purpose to Americans privacy or security. Experts on technology need to educate policymakers to the best of their ability in order for the true consequences to be understood.

## PUBLIC OPINION ANALYSIS

The opinions of Americans on surveillance is going to greatly shape the future of how such technology is used. The threat that is the mind of many Americans today is that of terrorism originating from the Middle East.  Surveillance of groups such as ISIS can prevent attacks from occurring as well as save lives, and it is generally accepted that our military infrastructure should use such technology against external threats. But how do Americans feel about using surveillance within their own communities when a threat is detected? Different types of threats could illicit different responses from Americans, and these differences will determine how we implement surveillance.

The U.S. National Lone Wolf Terror Perception Public Opinion Survey collected data on the public opinion of Americans about national security and lone wolf terrorism attacks. Within the survey, an embedded experiment was created. This question proposes that there is a chance of a terrorist attack within the respondents community, that the attacker is either a white supremacist or a Muslim extremist, and that the attacker either belongs to an organization or is acting alone. The focus of this paper is on the difference in willingness to use surveillance methods based on the identity of the suspect, either a white supremacist or a Muslim extremist.

Hypothesis:

$H_0$: If the respondent is told that there will be an attack, then the desire to use surveillance technology will differ based on the identity of the attacker

$H_1$: If the respondent is told that there will be an attack, then the desire to use surveillance technology will not differ based on the identity of the attacker.

The justification for this hypothesis is that Americans will fear for their safety equally regardless of who the attacker is. Identity should not play a role in the desire to feel safe and secure from potential threats. If a difference in desire to use surveillance technology is found, then the null hypothesis can't be rejected.

## METHODOLOGY

Within the U.S. National Lone Wolf Terror Perception Public Opinion Survey, the question of focus is question 29. This question acted as an experiment within the survey to attempt to measure differences in desired government response to a potential terrorist attack from respondents. Question 29 parts G and H specifically ask how respondents would feel about using technology and surveillance to stop said threat. Question 29 G asks how the respondent would feel about "searching all mail, email, and recording all telephone calls for the next 2 to 3 weeks," and question 29 H asks how respondents feel about, "Instituting an Internet blackout in your area for the next 2 to 3 weeks to prevent electronic communications." Half of the respondents were told the attacker was a white supremacist, and the other half were told the attacker was a Muslim extremist. The identity of the attacker was selected from this experiment as the independent variable, and the desire to use surveillance techniques, measured by questions 29 G and H, were selected as the dependent variable.

In order to test for intermediate variables between the two groups of respondents, other questions on the survey were used. The survey questions of focus for the hypotheses are question 1 part G, which asks respondents about their concern level for national security on a four response scale, question 32, which asks about the respondents political party affiliation on a seven point response scale, and question 33, which asks about how often the respondent attends religious services on a six point response scale. Other questions were tested on a need by need basis if specific results emerged from previous comparisons in order to validate or invalidate other relationships in the data.

For all variables tested, some basic descriptive statistics were gathered in order to describe relationships between variables. Chi-squared distributions and Pearson's P values were calculated to test for statistical significance between variables. The Pearson's P value is most important for the variable analysis. A value of .05 or less indicates that there is a strong relationship between the two variables, and a value larger than .05 indicates a weaker relationship. R-squared was also calculated to see if the data had any relationship to a fitted regression line. In order to validate the

## RESULTS AND ANALYSIS

When tabulating the identity of a potential attacker alongside searching all mail, email, and recording all telephone calls for the next 2 to 3 weeks, a clear relationship is displayed (Table 6-1). Individuals are more likely to be in support or strongly support electronic communications searches when the attacker is a Muslim extremist, and more likely to be neutral or against electronic communications searches when the attacker is a white supremacist. Respondents were 3.34% more likely to support and 3.5% more likely to strongly support surveillance of Muslim extremists. Respondents were also 4.6% more likely to strongly oppose surveillance and 1.42% more likely to oppose surveillance if the attacker is a White supremacist. The relationship is clear in that the desire to use surveillance steadily increases if the attacker is a Muslim extremist. The Pearson's P-value for the tabulation came out to 0.029, displaying a statistically significant relationship between the two variables. The R-squared value of 0.0051 tells that this variable does not display a relationship to a fitted regression line. This tabulation provides strong evidence for rejecting the research hypothesis.

The relationship between attacker identity and support for an internet blackout for 2 to 3 weeks was present but much weaker (Table 6-2). Individuals are still more likely to support or strongly support the use of an internet blackout for a Muslim extremist, and more likely to be opposed or strongly opposed if the attacker is a white supremacist. The Pearson's P-value for the tabulation came out to 0.356, displaying a weak overall relationship. The R-squared value was also very low, demonstrating no relationship to a fitted regression line. However, it should be noted that the responses for this question were much less supportive of the measure overall. Less than 20% of respondents would be in support of an internet blackout, and greater than 55% opposed regardless of who the attacker is. Also, support for an internet blackout has a very strong relationship with access to high speed internet (Table 6-27), making high speed internet an intermediate variable within this relationship. It is due to this intermediate variable that the relationship is not as clear when asking respondents if they support an internet blackout as opposed to electronic surveillance.

In order to validate this relationship, intermediate variables were tested for. Political affiliation (Tables 6-3 through 6-8), religiosity (Tables 6-9 through 6-14), concern for national security (Tables 6-15 through 6-20), and education (Tables 6-21 through 6-26) were tested to see if relationships still emerged when other variables were accounted for. With all the intermediate variables that were tested, the relationship was still displayed with only very small outliers. Regardless of an individual's political affiliation, religiosity, concern for national security, or education, respondents were always more likely to be in support of using either electronic surveillance or an internet blackout if the respondent was identified as a Muslim extremist. The only exception to this was if the respondent indicated that he or she obtained a bachelor’s degree or greater (Tables 6-23 and 6-26). If the respondent fell into this category, the difference in response rate disappeared, and a relationship was no longer displayed. Educated respondents were willing to use or not use each surveillance method equally depending on the identity of the attacker. Further research should be done to see if education is a determining variable in how terrorist identities are perceived, as the Lone Wolf Terrorism survey does not provide the details needed for more investigation.

After fully investigating intermediate variables with both question 29G and question 29H, it is safe to say that the null hypothesis cannot be rejected. There is a relationship between the identity of an attacker and the desire to use surveillance technology in order to prevent an attack. Both dependent variables displayed this relationship to varying degrees, and by using intermediate variables it was demonstrated that the desire to use surveillance technology does not depend on religiosity, concern for national security, political affiliation, or education unless the respondent holds a bachelor's degree or greater. Further research should be done in order to determine if this relationship is present across other identity groups, such as Christian extremists, Black extremists, or criminal organizations such as the Cartel.

## DATA LIMITATIONS

When obtaining the statistical data necessary, some limitations were encountered with the data. First, a number of respondents refused to answer the questions used in the research. These respondents had to be dropped from the data in order to properly view a relationship within said data. Second, once the research had been started and the relationship between identity and desire to use surveillance technology investigated, the trend that respondents were more accepting of using surveillance technology on Muslim attackers became apparent early on. This very noticeable trend was distracting while trying to complete the research, and was always present when trying to write about the topic. Due to how strong the relationship was with identity and question 29G, it became challenging to continue to complete unbiased research into the topic. At times I found myself investigating this relationship specifically instead of the hypothesis. A third limitation came from the difference in P values when testing for intermediate variables. With some variable analysis, P values would differ greatly based on which half of responses were being analyzed. For example, The P value for Table 6-3 was 0.035 while the P value for Table 6-4 was 0.969, and both samples were half of the responses for the same questions. Finally, the description of identities could have caused problems with how respondents answered the questions. A white supremacist and Muslim extremist are not completely comparable identities, as one identifies a group based on race while the other identifies a group based on religion. It is possible this comparison is like comparing apples and oranges. Respondents could view an attack by a Muslim extremist as another 9/11 or San Bernardino, while viewing an attack by a white supremacist as something minor in comparison. Attacks done by Muslim extremists often get labeled quickly as Islamic terrorism, while attacks by white supremacists will get labeled as a gun problem, a mental health problem, or just written off as a onetime incident. Respondents could view attacks from a Muslim extremist as more severe, and the survey did not attempt to measure differences in perceived severity of an attack depending on the identity.

## CONCLUSIONS

The data demonstrates that there is a link between the identity of an attacker and the desire from a respondent to use surveillance technology to prevent an attack. Individuals are more concerned about terrorism when the attacker is Muslim extremist as opposed to a white supremacist. Muslim Americans have been concerned about their perception to the rest of the country since 9/11, and it does not seem that bias against Muslims is going away. This difference in perception and concern could create a policy environment where American surveillance is used more frequently against Muslim individuals. Americans should be careful when approaching how and why they want to use surveillance technology, as once the government is given the power to survey the population, there will be no incentive for the government to retract said powers. Further research should be done in order to evaluate the desire to use surveillance technology based on the perceived severity of an attack instead of identity of an attacker, as well as looking into different identity types that could be considered threatening. The future of American surveillance very much depends on how Americans want to use these new technologies. If Americans desire to avoid the slippery slope that leads to mass surveillance in an Orwellian style society, we need to evaluate today how and why these technologies are used.

Appendix 6-A

Questions used for Survey Analysis (in order of appearance on survey)

**Concern for National Security:** How concerned are you about each of the following issues? g) Terrorism and national security

**Q29** Suppose the Department of Homeland Security announced that there was likely to be a terrorist attack in the United States committed by an unknown [IF _Q29A=1 INSERT: white supremacist; IF DOV_Q29A=2 INSERT: Muslim extremist] acting [IF DOV_Q29B=1 INSERT: on their own; IF DOV_29B=2 INSERT: in coordination with an organization] in the next 2 to 3 weeks and it was determined that there was a [IF DOV_Q29C=1 INSERT: one in a hundred; IF DOV_Q29C=2 INSERT: one in a thousand] chance that this attack would occur in your area. How much would you support or oppose that the following actions be taken for the next 2 to 3 weeks to prevent potential terrorist attacks?

g) Searching all mail, email, and recording all telephone calls for the next 2 to 3 weeks
h) Instituting an Internet blackout in your area for the next 2 to 3 weeks to prevent electronic communications

**Religiosity:** How often do you attend religious services?

1. More than once a week
2. Once a week
3. Once or twice a month
4. A few times a year
5. Once a year or less
6. Never

**Party Identification:** Do you think of yourself as closer to...

Strong Republican............................... 1
Not Strong Republican ....................... 2
Leans Republican................................ 3
Undecided/Independent/Other........... 4
Leans Democrat................................... 5
Not Strong Democrat .......................... 6
Strong Democrat ................................ 7

**Education - Categorical** 1. Less than High School 2. High School 3. Some College 4. Bachelor's degree oh higher

**Access to High Speed Internet** 1.No 2.Yes

Appendix 6-B

Table 6-1: Attacker identity by support for electronic surveillance

| | White supremacist | Muslim Extremist | |
|---|---|---|---|
| Strongly Oppose (0) | 32.60% | 27.96% | |
| 1 | 19.90% | 18.48% | |
| 2 | 23.81% | 22.99% | |
| 3 | 11.36% | 14.69% | |
| Strongly Suppot (4) | 12.33% | 15.88% | |
| Total | n=819 | n=844 | |
| chi2=10.7559 | R2=0.0051 | P=0.029 | |

Table 6-2: Attacker identity by support for internet blackout

| | White supremacist | Muslim Extremist | |
|---|---|---|---|
| Strongly Oppose (0) | 41.10% | 36.94% | |
| 1 | 20.85% | 20.31% | |
| 2 | 22.07% | 24.58% | |
| 3 | 8.78% | 10.45% | |
| Strongly Suppot (4) | 7.20% | 7.72% | |
| Total | n=820 | n=842 | |
| Chi2=4.3854 | R2= 0.0017 | P=0.356 | |

Table 6-3: Political affiliation by support for electronic surveillance, White supremacist respondents

| | Strong Repulican | Not strong Republican | Leans Republican | Undecided | Leans Democrat | Not strong Deomcrat | Strong Democrat | Total |
|---|---|---|---|---|---|---|---|---|
| Strongly Opposed (0) | 42 | 21 | 50 | 13 | 49 | 33 | 59 | 266 |
| 1 | 22 | 12 | 28 | 5 | 40 | 32 | 24 | 163 |
| 2 | 26 | 26 | 31 | 9 | 45 | 31 | 27 | 195 |
| 3 | 11 | 9 | 17 | 1 | 27 | 16 | 12 | 93 |
| Strongly Support (4) | 17 | 9 | 21 | 1 | 9 | 20 | 24 | 100 |
| Total | 118 | 77 | 147 | 29 | 170 | 132 | 146 | 817 |
| | $Chi^2$=38.0192 | $R^2$=0 | P=0.035 | | | | | |

Table 6-4: Political affiliation by support for electronic surveillance, Muslim Extremist respondents

| | Strong Repulican | Not strong Republican | Leans Republican | Undecided | Leans Democrat | Not strong Deomcrat | Strong Democrat | Total |
|---|---|---|---|---|---|---|---|---|
| Strongly Opposed (0) | 37 | 30 | 43 | 7 | 44 | 31 | 44 | 236 |
| 1 | 21 | 20 | 31 | 4 | 32 | 21 | 27 | 156 |
| 2 | 26 | 24 | 34 | 6 | 34 | 32 | 38 | 194 |
| 3 | 23 | 17 | 19 | 4 | 19 | 26 | 16 | 123 |
| Strongly Support (4) | 24 | 20 | 25 | 3 | 18 | 23 | 21 | 134 |
| Total | 131 | 111 | 152 | 24 | 147 | 133 | 146 | 843 |
| | $Chi^2$=12.8418 | $R^2$=0.0007 | P=0.969 | | | | | |

Table 6-5: Difference between responses by identity type in percentages

| | Strong Repulican | Not strong Republican | Leans Republican | Undecided | Leans Democrat | Not strong Deomcrat | Strong Democrat |
|---|---|---|---|---|---|---|---|
| Strongly Oppose (0) | -7.35% | -0.25% | -5.72% | -15.66% | 1.11% | -1.69% | -10.27% |
| 1 | -2.61% | 2.43% | 1.35% | -0.57% | -1.76% | -8.45% | 2.05% |
| 2 | -2.19% | -12.14% | 1.28% | -6.03% | -3.34% | 0.58% | 7.53% |
| 3 | 8.24% | 3.63% | 0.94% | 13.22% | -2.96% | 7.43% | 2.74% |
| Strongly Suppot (4) | 3.91% | 6.33% | 2.16% | 9.05% | 6.95% | 2.14% | -2.05% |

| Key | |
|---|---|
| Black fill with white text | Difference in favor of response for Muslim extremist |
| Grey fill with black text | Difference not in favor of response for Muslim extremist |

Table 6-6: Political affiliation by support for internet blackout, White supremacist respondents

| | Strong Repulican | Not strong Republican | Leans Republican | Undecided | Leans Democrat | Not strong Deomcrat | Strong Democrat | Total |
|---|---|---|---|---|---|---|---|---|
| Strongly Opposed (0) | 57 | 30 | 64 | 12 | 72 | 46 | 56 | 336 |
| 1 | 24 | 16 | 32 | 6 | 36 | 30 | 27 | 170 |
| 2 | 17 | 16 | 30 | 11 | 40 | 33 | 34 | 181 |
| 3 | 11 | 10 | 11 | 0 | 16 | 11 | 13 | 72 |
| Strongly Support (4) | 9 | 5 | 10 | 1 | 7 | 11 | 16 | 59 |
| Total | 118 | 77 | 147 | 30 | 171 | 131 | 146 | 818 |
| | $Chi^2$=21.8355 | $R^2$=0.0038 | P=0.589 | | | | | |

Table 6-7: Political affiliation by support for internet blackout, Muslim Extremist respondents

| | Strong Repulican | Not strong Republican | Leans Republican | Undecided | Leans Democrat | Not strong Deomcrat | Strong Democrat | Total |
|---|---|---|---|---|---|---|---|---|
| Strongly Opposed (0) | 49 | 40 | 54 | 8 | 60 | 39 | 61 | 311 |
| 1 | 34 | 18 | 41 | 4 | 26 | 21 | 27 | 171 |
| 2 | 25 | 33 | 30 | 7 | 35 | 37 | 40 | 207 |
| 3 | 12 | 11 | 16 | 3 | 15 | 23 | 8 | 88 |
| Strongly Support (4) | 11 | 9 | 10 | 2 | 10 | 13 | 10 | 65 |
| Total | 131 | 111 | 151 | 24 | 146 | 133 | 146 | 842 |
| | $Chi^2$=29.0579 | $R^2$=0.0002 | P=0.218 | | | | | |

Table 6-8: Difference between responses by identity type in percentages

| | Strong Repulican | Not strong Republican | Leans Republican | Undecide | Leans Democra | Not strong Deomcra | Strong Democra |
|---|---|---|---|---|---|---|---|
| Strongly Oppose (0) | -10.90% | -2.93% | -7.78% | -6.67% | -1.01% | -5.79% | 3.42% |
| 1 | 5.62% | -4.56% | 5.38% | -3.33% | -3.24% | -7.11% | 0.00% |
| 2 | 4.68% | 8.95% | -0.54% | -7.50% | 0.58% | 2.63% | 4.11% |
| 3 | -0.16% | -3.08% | 3.11% | 12.50% | 0.92% | 8.90% | -3.42% |
| Strongly Suppot (4) | 0.77% | 1.61% | -0.18% | 5.00% | 2.76% | 1.38% | -4.11% |

| Key | |
|---|---|
| Black fill with white text | Difference in favor of response for Muslim extremist |
| Grey fill with black text | Difference not in favor of response for Muslim extremist |

Table 6-9: Religiosity by support for electronic surveillance, White supremacist respondents

| | More than once a week | Once a week | Once or twice | A few times | Once a year | Never | **Total** |
|---|---|---|---|---|---|---|---|
| Strongly Opposed (0) | 25 | 48 | 16 | 40 | 49 | 89 | 267 |
| 1 | 9 | 39 | 19 | 22 | 34 | 40 | 163 |
| 2 | 19 | 37 | 16 | 47 | 31 | 45 | 195 |
| 3 | 6 | 15 | 10 | 15 | 20 | 27 | 93 |
| Strongly Support (4) | 10 | 20 | 11 | 13 | 16 | 31 | 101 |
| Total | 69 | 159 | 72 | 137 | 150 | 232 | 819 |
| | $Chi^2$=26.5476 | $R^2$=0.0007 | P=0.148 | | | | |

Table 6-10: Religiosity by support for electronic surveillance, Muslim Extremist respondents

| | More than once a week | Once a week | Once or twice | A few times | Once a year | Never | Total |
|---|---|---|---|---|---|---|---|
| Strongly Opposed (0) | 21 | 42 | 19 | 30 | 33 | 91 | 236 |
| 1 | 11 | 33 | 12 | 18 | 35 | 47 | 156 |
| 2 | 25 | 48 | 17 | 23 | 28 | 53 | 194 |
| 3 | 13 | 26 | 10 | 18 | 23 | 34 | 124 |
| Strongly Support (4) | 8 | 35 | 14 | 25 | 17 | 35 | 134 |
| Total | 78 | 184 | 72 | 114 | 136 | 260 | 844 |
| | $Chi^2$=26.7151 | $R^2$=0.0066 | P=0.143 | | | | |

Table 6-11: Difference between responses by identity type in percentages

| | More than once a week | Once a week | Once or twice | A few times | Once a year | Never |
|---|---|---|---|---|---|---|
| Strongly Oppose (0) | -9.31% | -7.36% | 4.17% | -2.88% | -8.40% | -3.36% |
| 1 | 1.06% | -6.59% | -9.72% | -0.27% | 3.07% | 0.84% |
| 2 | 4.52% | 2.82% | 1.39% | -14.13% | -0.08% | 0.99% |
| 3 | 7.97% | 4.70% | 0.00% | 4.84% | 3.58% | 1.44% |
| Strongly Suppot (4) | -4.24% | 6.44% | 4.17% | 12.44% | 1.83% | 0.10% |

| Key | |
|---|---|
| Black fill with white text | Difference in favor of response for Muslim extremist |
| Grey fill with black text | Difference not in favor of response for Muslim extremist |

Table 6-12: Religiosity by support for internet blackout, White supremacist respondents

| | More than once a week | Once a week | Once or twice | A few times | Once a year | Never | Total |
|---|---|---|---|---|---|---|---|
| Strongly Opposed (0) | 29 | 64 | 21 | 60 | 57 | 106 | 337 |
| 1 | 11 | 33 | 21 | 26 | 39 | 42 | 172 |
| 2 | 17 | 34 | 17 | 31 | 33 | 49 | 181 |
| 3 | 5 | 18 | 6 | 14 | 14 | 15 | 72 |
| Strongly Support (4) | 7 | 11 | 6 | 6 | 9 | 20 | 59 |
| Total | 69 | 160 | 71 | 137 | 152 | 232 | 821 |
| | $Chi^2$=17.0794 | $R^2$=0.0014 | P=0.648 | | | | |

Table 6-13: Religiosity by support for internet blackout, Muslim Extremist respondents

| | More than once a week | Once a week | Once or twice | A few times | Once a year | Never | Total |
|---|---|---|---|---|---|---|---|
| Strongly Opposed (0) | 33 | 58 | 29 | 33 | 40 | 118 | 311 |
| 1 | 14 | 44 | 14 | 20 | 28 | 51 | 171 |
| 2 | 17 | 43 | 13 | 39 | 42 | 53 | 207 |
| 3 | 9 | 21 | 11 | 12 | 18 | 17 | 88 |
| Strongly Support (4) | 4 | 18 | 4 | 10 | 10 | 19 | 65 |
| Total | 77 | 184 | 71 | 114 | 138 | 258 | 842 |
| | $Chi^2$=32.2984 | $R^2$=0.0026 | P=0.040 | | | | |

Table 6-14: Difference between responses by identity type in percentages

| | More than once a week | Once a week | Once or twice | A few times | Once a year | Never |
|---|---|---|---|---|---|---|
| Strongly Oppose (0) | 0.83% | -8.48% | 11.27% | -14.85% | -8.51% | 0.05% |
| 1 | 2.24% | 3.29% | -9.86% | -1.43% | -5.37% | 1.66% |
| 2 | -2.56% | 2.12% | -5.63% | 11.58% | 8.72% | -0.58% |
| 3 | 4.44% | 0.16% | 7.04% | 0.31% | 3.83% | 0.12% |
| Strongly Suppot (4) | -4.95% | 2.91% | -2.82% | 4.39% | 1.33% | -1.26% |

| Key | |
|---|---|
| Black fill with white text | Difference in favor of response for Muslim extremist |
| Grey fill with black text | Difference not in favor of response for Muslim extremist |

Table 6-15: Concern for national security by support for electronic surveillance, White supremacist respondents

| | **Not Concerned** | **Somewhat** | **Very** | **Extremely** | **Total** |
|---|---|---|---|---|---|
| Strongly Opposed (0) | 21 | 84 | 84 | 77 | 266 |
| 1 | 9 | 48 | 58 | 48 | 163 |
| 2 | 9 | 57 | 76 | 53 | 195 |
| 3 | 2 | 20 | 36 | 35 | 93 |
| Strongly Support (4) | 1 | 16 | 27 | 56 | 100 |
| Total | 42 | 225 | 281 | 269 | 817 |
| | $Chi^2$=41.6792 | $R^2$=0.0334 | P=0.000 | | |

Table 6-16: Concern for national security by support for electronic surveillance, Muslim Extrmist respondents

| | Not concerned | Somewhat | Very | Extremely | Total |
|---|---|---|---|---|---|
| Strongly Opposed (0) | 29 | 70 | 87 | 50 | 236 |
| 1 | 9 | 52 | 61 | 34 | 156 |
| 2 | 12 | 65 | 60 | 57 | 194 |
| 3 | 4 | 30 | 44 | 45 | 123 |
| Strongly Support (4) | 6 | 25 | 34 | 69 | 134 |
| Total | 60 | 242 | 286 | 255 | 843 |
| | $Chi^2$=58.8271 | $R^2$=0.0443 | P=0.000 | | |

Table 6-17: Difference between responses by identity type in percentages

| | Not concerned | Somewhat | Very | Extremely |
|---|---|---|---|---|
| Strongly Oppose (0) | -1.67% | -8.41% | 0.53% | -9.02% |
| 1 | -6.43% | 0.15% | 0.69% | -4.51% |
| 2 | -1.43% | 1.53% | -6.07% | 2.65% |
| 3 | 1.90% | 3.51% | 2.57% | 4.64% |
| Strongly Suppot (4) | 7.62% | 3.22% | 2.28% | 6.24% |

| Key | |
|---|---|
| Black fill with white text | Difference in favor of response for Muslim extremist |
| Grey fill with black text | Difference not in favor of response for Muslim extremist |

Table 6-18: Concern for national security by support for internet blackout, White supremacist respondents

| | Not concerned | Somewhat | Very | Extremely | Total |
|---|---|---|---|---|---|
| Strongly Opposed (0) | 21 | 106 | 105 | 104 | 336 |
| 1 | 6 | 41 | 65 | 58 | 170 |
| 2 | 10 | 49 | 75 | 47 | 181 |
| 3 | 3 | 18 | 28 | 23 | 72 |
| Strongly Support (4) | 2 | 10 | 10 | 37 | 59 |
| Total | 42 | 224 | 283 | 269 | 818 |
| | $Chi^2$=36.4480 | $R^2$=0.0109 | P=0.000 | | 0 |

Table 6-19: Concern for national security by support for internet blackout, Muslim Extremist respondents

| | Not concerned | Somewhat | Very | Extremely | Total |
|---|---|---|---|---|---|
| Strongly Opposed (0) | 36 | 98 | 106 | 71 | 311 |
| 1 | 4 | 53 | 66 | 48 | 171 |
| 2 | 16 | 61 | 68 | 62 | 207 |
| 3 | 1 | 16 | 31 | 40 | 88 |
| Strongly Support (4) | 3 | 13 | 14 | 35 | 65 |
| Total | 60 | 241 | 285 | 256 | 842 |
| | $Chi^2$=54.243 | $R^2$=0.0377 | P=0.000 | | |

Table 6-20: Difference between responses by identity type in percentages

| | **Not concerned** | **Somewhat** | **Very** | **Extremely** |
|---|---|---|---|---|
| Strongly Oppose (0) | 10.00% | -6.66% | 0.09% | -10.93% |
| 1 | -7.62% | 3.69% | 0.19% | -2.81% |
| 2 | 2.86% | 3.44% | -2.64% | 6.75% |
| 3 | -5.48% | -1.40% | 0.98% | 7.07% |
| Strongly Suppot (4) | 0.24% | 0.93% | 1.38% | -0.08% |

| Key | |
|---|---|
| Black fill with white text | Difference in favor of response for Muslim extremist |
| Grey fill with black text | Difference not in favor of response for Muslim extremist |

Table 6-21: Education level by support for electronic surveillance, White supremacist respondents

| | Less than high school | High School | Some College | Bachlor's degree or more | Total |
|---|---|---|---|---|---|
| Strongly Opposed (0) | 21 | 70 | 76 | 100 | 267 |
| 1 | 17 | 51 | 49 | 46 | 163 |
| 2 | 24 | 75 | 50 | 46 | 195 |
| 3 | 14 | 28 | 25 | 26 | 93 |
| Strongly Support (4) | 14 | 41 | 20 | 26 | 101 |
| Total | 90 | 265 | 220 | 244 | 819 |
| | $Chi^2$=23.9927 | $R^2$=0.0183 | P=0.20 | | |

Table 6-22: Education level by support for electronic surveillance, Muslim Extremist respondents

| | Less than high school | High School | Some College | Bachlor's degree or more | Total |
|---|---|---|---|---|---|
| Strongly Opposed (0) | 19 | 55 | 57 | 105 | 236 |
| 1 | 19 | 37 | 48 | 52 | 156 |
| 2 | 23 | 66 | 52 | 53 | 194 |
| 3 | 13 | 43 | 38 | 30 | 124 |
| Strongly Support (4) | 17 | 53 | 36 | 28 | 134 |
| Total | 91 | 254 | 231 | 268 | 844 |
| | $Chi^2$=36.8105 | $R^2$=0.0291 | P=0 | | |

Table 6-23: Difference between responses by identity type in percentages

| | Less than high school | High School | Some College | Bachlor's degree or more |
|---|---|---|---|---|
| Strongly Oppose (0) | -2.45% | -4.76% | -9.87% | -1.80% |
| 1 | 1.99% | -4.68% | -1.49% | 0.55% |
| 2 | -1.39% | -2.32% | -0.22% | 0.92% |
| 3 | -1.27% | 6.36% | 5.09% | 0.54% |
| Strongly Suppot (4) | 3.13% | 5.39% | 6.49% | -0.21% |

| Key | |
|---|---|
| Black fill with white text | Difference in favor of response for Muslim extremist |
| Grey fill with black text | Difference not in favor of response for Muslim extremist |

Table 6-24: Education level by support for internet blackout, White supremacist respondents

| | Less than high school | High School | Some College | Bachlor's degree or more | Total |
|---|---|---|---|---|---|
| Strongly Opposed (0) | 28 | 87 | 94 | 128 | 337 |
| 1 | 15 | 49 | 51 | 56 | 171 |
| 2 | 32 | 75 | 42 | 32 | 181 |
| 3 | 6 | 28 | 19 | 19 | 72 |
| Strongly Support (4) | 9 | 26 | 14 | 10 | 59 |
| Total | 90 | 265 | 220 | 245 | 820 |
| | $Chi^2$=47.3570 | $R^2$=0.0358 | P=0 | | |

Table 6-25: Education level by support for internet blackout, Muslim Extremist respondents

| | Less than high school | High School | Some College | Bachlor's degree or more | Total |
|---|---|---|---|---|---|
| Strongly Opposed (0) | 20 | 73 | 81 | 137 | 311 |
| 1 | 19 | 47 | 40 | 65 | 171 |
| 2 | 27 | 72 | 66 | 42 | 207 |
| 3 | 10 | 34 | 29 | 15 | 88 |
| Strongly Support (4) | 14 | 28 | 15 | 8 | 65 |
| Total | 90 | 254 | 231 | 267 | 842 |
| | $Chi^2$=69.1827 | $R^2$=0.0661 | P=0 | | |

Table 6-26: Difference between responses by identity type in percentages

| | Less than high school | High School | Some College | Bachlor's degree or more |
|---|---|---|---|---|
| Strongly Oppose (0) | -8.89% | -4.09% | -7.66% | -0.93% |
| 1 | 4.44% | 0.01% | -5.87% | 1.49% |
| 2 | -5.56% | 0.04% | 9.48% | 2.67% |
| 3 | 4.44% | 2.82% | 3.92% | -2.14% |
| Strongly Suppot (4) | 5.56% | 1.21% | 0.13% | -1.09% |

| Key | |
|---|---|
| Black fill with white text | Difference in favor of response for Muslim extremist |
| Grey fill with black text | Difference not in favor of response for Muslim extremist |

Table 6-27: Support for an Internet blackout by Access to high speed internet

| | No | Yes | |
|---|---|---|---|
| Strongly Oppose (0) | 28.75% | 41.50% | |
| 1 | 15.29% | 21.87% | |
| 2 | 32.11% | 21.20% | |
| 3 | 12.84% | 8.84% | |
| Strongly Suppot (4) | 11.01% | 6.59% | |
| Total | n=327 | n=1335 | |
| Chi2=41.13 | R2= 0.0198 | P=0 | |

# Appendix 6-C:

## The U.S. National Lone Wolf Terror Perception Public Opinion Survey

The GfK Group (formerly Knowledge Networks) conducted the U.S. National Lone Wolf Terror Perception Public Opinion Survey on behalf of the Bush School's Institute for Science, Technology and Public Policy (ISTPP) at Texas A&M University. Specifically, the study aimed to identify the factors that underlie US public opinion regarding various terrorism-related issues including information about specific terrorism incidences, government trust and responsibility, knowledge levels, and risk perceptions, and their policy preferences. The survey was conducted using a sample from KnowledgePanel®.

The questionnaire was developed by a team of researchers and scholars at the ISTPP and elsewhere during the spring of 2016. Most of the questions were borrowed from other public domain surveys. Additional questions, particularly those eliciting information about personal demographics, are standard questions used by GfK. Original questions, particularly those eliciting information about specific events and policy issues, were developed for this project and pre-tested among a convenience sample of students at the Bush School.

The target population consisted of the general US population of adults 18 years and older. To sample the population, GfK sampled households from its KnowledgePanel, a probability-based web panel designed to be representative of the United States. The survey consisted of two stages: a pretest to determine incidence and length of the survey, and the main survey with the study-eligible respondents. To qualify for the main survey, a panel member must have been 18 years and older. The survey was pre-tested by GfK from April 29 through May 2, 2016, and the full panel was engaged from May 5 through May 17, 2016. The median time of survey completion was 21 minutes.

The number of respondents sampled and participating in the survey, the survey completion rate for the main interview, and the incidence/eligibility rate are presented below.

| Number Sampled | Number Completed | Completion Rate | Qualified | Incidence Rate |
|---|---|---|---|---|
| 2831 | 1730 | 61% | 1730 | 100% |

The total number of respondents composing the nationally-representative sample is 1,525. Instead of sending the standard email reminder on day three of the field period, the following steps were taken to maximize the response or incidence rate:

- Additional email reminders to non-responders were sent on days 7 and 12 of the field period;
- Participants were eligible to win an in-kind prize through a monthly GfK sweepstakes

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# CHAPTER 7

# *Upstream, Downstream: Agricultural Pollution in the Gulf of Mexico and Regional Support for Nutrient Reduction Strategies*

**Elizabeth McCrory**

## INTRODUCTION

A 6,474-square mile span of the Gulf of Mexico contains no life. The natural habitat of thousands of species has ceased to exist because of a hypoxic "dead zone" that has stifled the area's plant and marine life (NOAA 2015). This habitat loss is attributed to the growth of toxic algae consuming all oxygen in the water (NOAA 2015), which thrives off the delivery of chemical nutrients from the 1.2 million square miles of the Mississippi River drainage basin (U.S. Army Corps of Engineers 2017).

Conesville, Iowa is situated in the center of the basin, and approximately 1,500 miles upstream from this hypoxic area the size of Connecticut. The sleepy farm town with a population of 400 sits just north of two Mississippi River tributaries responsible for contributing the largest chemical loads derived from farming and agricultural production to the hypoxic area, now the second largest in the world. The effects of agricultural pollution throughout the Mississippi River Drainage Basin significantly contribute to larger issues downstream. The Nature Conservancy

(2010) cites pollution derived from the watersheds of the Upper Midwest as "the highest contributors of sediment and nutrients to the Upper Mississippi River Basin," resulting in severe oxygen deficiencies in the Gulf of Mexico and have posed a subsequent threat to the area's commercial fishing industry.

Multiple factors contribute to the increasingly concerning problem of deteriorated water quality resulting from nutrient runoff in the 12 states bordering the 2300-mile long Mississippi River. However, mechanisms to address and resolve this issue rely on broad interstate collaboration and federal assistance to an extent largely nonexistent. This chapter will discuss potential nutrient management strategies and the public support for the government-led implementation of such strategies. The first part of this chapter will address the specific causes of hypoxia along the Gulf Coast, discuss the effect of agricultural pollution on the region's waterways, natural habitat, and drinking water supplies, and then examine the policy conversation surrounding surface water quality and in the Mississippi River Watershed with a specific focus on the Upper Midwest. The latter half of the chapter will analyze hypotheses on the public support for potential policy alternatives aimed at preventing nutrient runoff in the agricultural industry and the role of government in managing agricultural activities among the population of Midwestern states.

## PART I: ISSUE CONTEXT AND POTENTIAL RECOMMENDATIONS

### Causes of Hypoxia

The formation of the Gulf's sizable dead zone area is the result of a natural phenomenon known as coastal hypoxia. Coastal hypoxia occurs in water bodies when the amount of oxygen dissolved in water is depleted to an extent where aquatic organisms can no longer be supported

(NOAA 2015). In the Gulf of Mexico, hypoxia has resulted from the discharge of nutrients from the Mississippi River increasing the growth of algae that settle at the floor of the Gulf and consuming the dissolved oxygen (NOAA 2015). Depletion of the Gulf's dissolved oxygen has resulted in an expansive oxygen dead zone and the loss of habitat for regional aquatic animals and plant life (NOAA 2015). A NOAA (2015) representation of the distribution of hypoxic areas along the Gulf Coast is provided in Appendix A.

The occurrence of hypoxia in the Gulf of Mexico derives from several causes driven by primarily human activity. Foremost, the nutrient discharge responsible for oxygen deficiencies flows from the Mississippi River and originates at upstream point sources farming or industrial activities (Mississippi River/Gulf of Mexico Task Force 2017). While the presence of discharged nitrogen oxides from the production of fossil fuels share some of the blame (Mississippi River/Gulf of Mexico Task Force 2017), agricultural production activities are the primary source of nutrient runoff. In the Upper Midwest, where farming and animal production accounts for nearly 40 percent of land use (Natural Resources Conservation Service 2017), nutrients like phosphorus and nitrogen are used to fertilize the land for crop and animal production (Mississippi River/Gulf of Mexico Task Force 2017. These nutrients settle in the soil and are washed downstream during periods of snowmelt, heavy rain, and flooding, eventually reaching the Gulf of Mexico and contributing to dissolved oxygen deficiencies (Mississippi River/Gulf of Mexico Task Force 2017). Although agricultural activity is responsible for the largest nutrient loads delivered to the Gulf, at least a quarter of all nitrogen and phosphorus runoff is from more urban sources (Porter et al. 2015) Wastewater containing nitrate and silica, as well as phosphorus runoff from industrial sites and municipal areas during storms also contribute to hypoxia (Conrad et al 2016). The map presented in Appendix B describes the sources of runoff to the Mississippi River Drainage Basin by industry (USGS 2014).

Human activity in the form of development in natural areas has also assisted in the formation of hypoxic areas on the Gulf Coast. Natural nutrient runoff barriers like freshwater wetland areas and riparian zones throughout Mississippi River Drainage Basin have been commercially developed, preventing the filtration of nutrients found in agricultural discharge and wastewater (Mississippi River/Gulf of Mexico Task Force 2017). In the upstream farming areas of the Upper Midwest, soil erosion resulting from decades of mass scale farming has been compounded by minimal flood control efforts. These interrelated circumstances have contributed the wider issue of nutrient runoff and eventual hypoxia. Frequent tilling and animal pasturing in the Upper Midwest has also augmented soil erosion (Mississippi River/Gulf of Mexico Task Force 2017). During periods of flooding, increasingly permeable soil sediment containing nutrient-laden fertilizers can drain into surface water, affecting water quality and altering ecosystems downstream (Conrad et al. 2016). The map presented in Appendix C provides a geographical juxtaposition of nutrient runoff contributions to the Mississippi River Drainage Basin (USGS 2014).

## Larger Problems Resulting from Agricultural Activity

Attention paid to reducing nutrient runoff is largely focused on the hypoxic areas along the Gulf Coast. However, excess nitrogen and phosphorus loads derived from farming practices can also contribute to broader environmental issues such as habitat degredation. As noted in a 2007 USDA report, agriculture in the United States is responsible for "the most extensive effect on wildlife habitat of any human-induced factor," largely because of the ongoing development of prairies, forests and wetlands into crop and pasture land use (Brady 2007). Biodiversity and connectivity within the nation's heartland have deteriorated resulting from mass-scale farming, giving way to the decline of keystone species of plant and animals (Brady 2007)

Concessions in the quality of surface water has also resulted from land development for agricultural activity in the Upper Midwest. Constant cultivation of soil for farming and pasturing has contributed to concerns of soil erosion and subsequent excessive sediment delivery to surface water, to the detriment of fish and other aquatic organisms (Brady 2007). Fertilizing agents including nitrogen and phosphorus are also carried in these soils, causing impairments in regional surface waterways (Brady 2007). The Environmental Protection Agency (2017) estimates that of the 264,924 assessed rivers and streams of the upper Midwest (regions 5 and 7), approximately 73 percent are considered impaired with the largest harm to recreational areas and aquatic wildlife as well as surface water used for the public drinking water supply.

Further downstream, development of the once-native wetlands of the region has increased the severity of consequences resulting from agricultural activity. Wetlands are a biologically diverse composition of plants and animals that serve as storage for suspended sediments and floodwaters, preventing harmful runoff from reaching larger bodies of water (Hypoxia Task Force Report 2015). Historical wetland loss has begun to reverse with efforts by state and federal governments to restore thousands of acres of wetlands designed to remove nutrient runoff and collect sediment (Environmental Protection Agency 2017). Regardless these efforts in wetland restoration programming, efforts to mitigate the primary problem of agricultural pollution are largely contradicted by federal statute. While the Clean Water Act of 1970 includes provisions protecting wetlands and other waters from "discharged dredged and fill material," such as sand, soil, and gravel, farming material is exempted from regulation and runoff derived from animal production is loosely regulated (Environmental Protection Agency 2017).

Perhaps the most consequential result of agricultural pollution are the costs associated with the effect of upstream runoff on downstream waterways. Hypoxic areas impact revenues from fisheries, recreation, and tourism, as well as on public health (Hypoxia Task Force Report 2015). A 2015 EPA report estimates an annual loss between $189 and 589 million in commercial fishing expenditures and between $182 and 567 million in boating expenditures in the hypoxic areas of the Gulf Coast (Hypoxia Task Force Report 2015). Further, the report attributes a $813 million in public expenditures due to contamination of public drinking water supplies (Hypoxia Task Force Report 2015). Estimates for preventing and controlling hypoxia through the development and maintenance of conservation plans range even higher, with a 2014 approximation calling for an annual $2.7 billion investment from public and private entities to "effectively reduce the size of the hypoxic zone," (Hypoxia Task Force Report 2015).

## Nutrient Reduction Strategy Recommendations

Confronting hypoxia and the broader issue of water quality resulting from farm pollution can be facilitated through a nutrient reduction strategy. Nutrient reduction strategies seek to reduce the nutrient loads carried by the surface waters of the Mississippi River Drainage Basin and discharge downstream in the Gulf of Mexico (Mississippi River/Gulf of Mexico Task Force 2017). Such strategies contain a factual basis and inventory of affected ecosystems and include recommendations for policy action for both state officials and other affected stakeholders, such as crop and animal farmers and their representative interest groups.

State governments and federal agencies have been integral in the formation and implementation of nutrient reduction strategies. The Hypoxia Task Force (HTF), an entity organized by the Environmental Protection Agency (EPA), is the lead federal agency in nutrient reduction. The HTF was formed in 1997 and works alongside the Army Corps of Engineers, the

National Oceanic and Atmospheric Administration, and the Departments of Interior and Agriculture to collect data, coordinate reduction strategies and provide programming assistance to states alongside other federal agencies (Porter et al 2015). The HTF also fosters relationships between states to implement the 2008 Gulf Hypoxia Action Plan and the development of individual state strategies under a 2011 recommended framework (Hypoxia Task Force Report 2015). Nutrient reduction strategies have been compiled in the 12 states bordering the Mississippi River as well as Indiana and Ohio, each with each state strategy recognizing a "designated priority watershed," with a documented need for substantial nutrient reduction (Mississippi River/Gulf of Mexico Task Force 2017).

Soil conservation strategies are also supported through financial incentives and are available at the federal level. The U.S. Department of Agriculture's Farm Service Agency oversees the Conservation Reserve Enhancement Program (CREP), a federal conservation easement program allowing farmers to take their land out of production and convert to grass or wetlands to prevent erosion and runoff from occurring (Gulf Hypoxia Action Plan 2008). While enrollment in CREP is voluntary, landowners are paid an annual rental rate over 10 to 15 years to convert their land, an option that allows farmers to maintain income while preserving the quality of their land (Conservation Reserve Enhancement Program 2017). In 2014, 17 million acres of land in the Mississippi River Drainage Basin had been enrolled in CREP, resulting in a reduction of over 500 million pounds of nitrogen and phosphorus loads (Hypoxia Task Force Report 2015).

The basis of both federal and state nutrient reduction strategies is the promotion of measures that are both voluntary and cost-effective. As identified in the EPA's 2008 Hypoxia Action Plan, "voluntary, incentive-based, practical, and cost-effective" actions are the overarching principle guiding the goal of reducing nutrient discharge to the Gulf Coast. This principle of voluntary initiatives is echoed in nearly every state nutrient reduction strategy (Hypoxia Task Force Report 2015). Typically promoted by collaborations between interest groups and state agencies, initiatives are based around set reduction goals and encourage the implementation practices at the individual-farm level (Hypoxia Task Force Report 2015).

Several approaches have been considered in both state nutrient reduction strategies to curb nutrient loads, with agricultural conservation practices being the primary recommendation. HTF directs states to implement nutrient reduction strategies reflecting a combination of regulatory approaches, financial incentives and voluntary initiatives to curb agricultural pollution and prevent runoff from reaching surface waters. The states have adapted these directions in differing policy manifestations. In Ohio, state law requires anyone applying nutrients to an area of land to be certified through an educational program about the impact of nutrients on water quality (Hypoxia Task Force Report 2015). In other states, such as Indiana and Illinois, major dischargers of nutrients must receive permits to discharge nutrient loads and are limited to a total maximum daily load (TMDL) of a certain level. Such restrictions on discharges have proven effective in Minnesota, where a regulation on phosphorus discharges reduced the loads nearly 70 percent over 15 years (Hypoxia Task Force Report 2015).

The state of Iowa has led the charge in financial incentives designed to lower nutrient loads at the local level, working with the Iowa Farm Bureau and other interest groups to garner interest. The state's Department of Agriculture has implemented cost-sharing mechanisms designed to curb runoff from the state's nonpoint sources through the planting of cover crops to prevent extensive runoff during the rainy seasons (Hypoxia Task Force Report 2015). The state has introduced financial incentives such as density bonuses as well as assistance in the creation of conservation easements designed to encourage the reconstruction of lost wetland areas and increase the total area able to intercept drainage from pasture or cropland (Iowa Department of Agriculture 2016).

State involvement in voluntary efforts to reduce nutrient loads ranges. Ohio and Arkansas emphasize public education on manure management, tillage practices with minimal disturbance to soil, and the creation of buffer zones (Ohio Environmental Protection Agency 2013; Arkansas Natural Resources Commission 2014). Both state nutrient reduction strategies note the role the local soil and water conservation districts in outreach efforts to facilitate these initiatives but do little to incorporate them into wider use. Moreover, both state strategies condone the use of nutrient reduction practices posing potential threats to economic development, further hindering widespread incorporation (Ohio Environmental Protection Agency 2013; Arkansas Natural Resources Commission 2014). Funding for these programs also ranges. States such as Iowa, Illinois, and Minnesota have increased funding to the voluntary programs included in their respective nutrient reduction strategies but many states rely heavily on federal grant money to implement their proposed programs (Hypoxia Task Force Report 2015). A table compiled by the USGS (2014) detailing the share of nutrient runoff by state is available in Appendix D.

## Summary of Background Information

The agricultural states of the American heartland contribute $985 billion to the nation's gross domestic product every year. Farming and crop production is the region's primary economic driver, using 40 percent of the area's land (Natural Resources Conservation Service 2016) and supporting 2.6 million Americans (Economic Research Service 2016). However, the nine states supporting the nation's beef, pork, and grain industry are also largely responsible for a hypoxic "dead zone" spanning more than 6400 square miles along the coast of the Gulf of

Mexico (NOAA 2015). A severe reduction in the Gulf's dissolved oxygen was instigated by the discharge fertilizing chemicals flowing down from the farm and pasturelands of the Upper Midwest (Hypoxia Task Force 2015). The area is expected to maintain its size, as discharges of phosphorus and nitrogen continue to flow downriver from upstream point and nonpoint sources (NOAA 2016).

Reclamation of natural habitats in the Gulf through reduced nutrient runoff from upstream requires the implementation of targeted policies at all levels of government. These policies must include defined nutrient reduction goals, incentivized nutrient reduction strategies, and effective regulations to hold polluting farms accountable for their effect on the broader ecosystem. Serious consideration of these strategies is imperative to the nation's water quality and the health of economies supported by surface water resources but is reliant on the support of the public. The following section will test hypotheses on public support for nutrient reduction policy options and government implementation of preferred policies using public opinion data on the attitudes reflected in the agricultural region of the Midwest. This analysis seeks to understand attitudes toward support for the government management of agricultural pollution and for selected policy alternatives aimed at reducing nutrient runoff.

## PART II: PUBLIC SUPPORT FOR NUTRIENT REDUCTION AND MANAGEMENT

Vital to the consideration and implementation of the recommendations discussed prior is the public support for nutrient reduction policy alternatives and public or private management of agricultural resources. The six hypotheses detailed below represent the next two stages in the policy process: The identification of policy alternatives and the implementation of alternatives by government or private organizations.

These hypotheses have been developed to measure public attitudes toward three agricultural management policy alternatives and the role of selected government organizations in implementing alternatives. The selected policy alternatives have been historically suggested as options to mitigate nutrient runoff and were previously mentioned in this paper. Given the regulatory force of federal, state, and local governments in implementing nutrient reduction strategies and allocating funding detailed in the previous section, the focus of this data analysis will be placed on attitudes toward the government's role in implementing and managing policy alternatives.

Each hypothesis discussed in this section seeks to understand the public attitudes toward a set of nutrient reduction policy alternatives and the selected agent of policy implementation, depending on their regional demographics. A specific rationale deriving each overarching hypothesis is also included before separate sub-hypotheses indicating the level of support for each policy alternative or government organization.

This analysis considers the attitudes of survey respondents hailing from the Midwestern states of Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas are considered in specificity by each sub-hypothesis. The focus on these states derives from the large agricultural operations housed within the region as well as the substantial contributions of agricultural and nutrient runoff originating from this area of the broader Mississippi River Drainage Basin.  For these reasons, the responses of Midwestern survey respondents regarding agricultural policy and agents of implementation are expected to be stronger or lesser depending on the question posed.

**Hypotheses on Public Support for Policy Alternatives, Government Implementation**

<u>Hypotheses on Attitudes and Support for the Agricultural Management Policy Alternatives</u>

*Hypothesis 1:* Midwestern populations will have strong preferences regarding agricultural management policy options.

*Rationale:* With the Midwest being home to large agricultural practices, persons living in this area will have strong views and attitudes toward agricultural management practices designed to preserve water quality.

- *Sub-Hypothesis #1a:* Midwestern populations will have less support for requiring farmers use soil conservation measures than Other Regions.
- *Sub-Hypothesis #1b:* Midwestern populations will have more support tax incentives for implementing efficient irrigation systems for agriculture than Other Regions.
- *Sub-Hypothesis #1c:* Midwestern populations will have the most support for tax incentives for farmers to reduce the use of fertilizers and pesticides compared to Other Regions.

<u>Hypotheses on Attitudes and Support Toward Government Role in Implementing Alternatives</u>

*Hypothesis 2*: Midwestern populations will have strong attitudes toward the government's role in managing agricultural resources.

*Rationale*: The decentralized nature of the greater Midwestern region reflects a general disdain for federal control over local activities such as farming and animal production, driving a potentially stronger preference for state or local implementation of policy alternatives.

- *Sub-Hypothesis #2a:* Midwestern populations will be more averse to federal involvement in the management of agricultural resources than Other Regions.
- *Sub-Hypothesis #2b*: Midwestern populations will be more supportive of state

involvement in the management of agricultural resources than Other Regions.

- *Sub-Hypothesis #2c:* Midwestern populations will be the most supportive of local involvement in the management of agricultural resources when compared Other Regions.

## Data Collection and Methodology

Each hypothesis in this analysis is tested using data provided by the Water, Food, Energy Nexus Survey conducted by the Institute for Science, Technology, and Public Policy at the Bush School of Government and Public Service at Texas A&M University. Please see Appendix E for a full description of the Water-Food-Energy Nexus Survey.

This analysis utilized six responses from two survey questions and regional demographic information from the survey's national sample size of 1,358 respondents. Using the statistical program STATA, respondents were categorized into a binary independent variable of "Midwestern Region," and "Other Region" to measure the attitudes of the survey's Midwestern respondents to respondents from all other regions of the nation. As previously noted, "Midwestern Region," contains responses from survey participants hailing from Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas. The "Other Region" variable consists of respondents hailing from the Northeast, South, and West. STATA was also used to replace all "refused" responses to missing values, in an effort report data that reflected the survey question's scale of answers.

The following section presents a statistical analysis reflecting the six responses as dependent variables to the regional demographic information's independent variable. The Tables 7-1A through 7-2C indicate the question asked of the respondent and the percent of total respondents indicating a viewpoint. Included in each table is the Pearson's chi-square value, indicating a relationship between two variables, a P-value, to determine statistical significance, and Pearson's R, or a correlation coefficient, measuring the strength of a positive or negative relationship between two variables. A P-value less than .05 is deemed statistically significant for the purposes of this analysis. These figures were also computed using STATA.

## Support for Policy Alternatives

Selected data from the Water, Energy, Food Nexus Survey measure public support for policy alternatives regarding agricultural management. The survey proposes three different policy alternatives to the survey's sample size:  Tax incentives for the effective irrigation systems, tax incentives for reducing the use of fertilizers and pesticides, and requiring farmers to utilize soil conservation measures. These policy alternatives have been either proposed or implemented on a voluntary basis in state nutrient reduction strategies within the Mississippi River Drainage Basin.

Tables 7-1A through 7-1C provide data comparing the support for each policy measure among Midwestern respondents and respondents from all other regions. The tables each describe a sub-hypothesis and seek to support overarching hypothesis #1 that Midwestern populations will have the strongest preferences regarding agricultural management policy options. If the reported P-value is less than .05, the sub-hypothesis is considered "rejected."

**TABLE 7-1A: Midwestern Attitudes Toward Soil Conservation Requirements**
***Sub-Hypothesis #1a:*** *Midwestern populations will have less support for requiring farmers use soil conservation measures than other regional populations than Other Regions.*

| Policy options have been proposed to manage water resources. Indicate your level of opposition or support for the following option: Require farmers use soil conservation measures. | | Midwest Region | Other Regions |
|---|---|---|---|
| | **Strong Oppose** | 1.85% | 2.45% |
| | **Oppose** | 4.01% | 5.51% |
| | **Neutral** | 39.20% | 36.02% |
| | **Support** | 40.43% | 41.63% |
| | **Strong Support** | 14.51% | 14.39% |
| | **Total** | 100% | 100% |
| | N= 1,358 | | |

**Pearson chi$^2$(4) = 2.19 P = 0.70 Pearson's R: .008**

***Finding*:** The value of Pearson's R indicates there is a no correlation between geographical demographics and attitudes toward soil conservation measures. The P-value, being significantly greater than .05, indicates the relationship between Midwestern population and support for required soil conservation measures is insignificant. Given these factors, the hypothesis is rejected.

**TABLE 7-1B: Midwestern Attitudes Toward Efficient Irrigation Tax Credits**
***Sub-Hypothesis #1b:*** *Midwestern populations will have more support tax incentives for implementing efficient irrigation systems for agriculture than Other Regions.*

| Policy options have been proposed to manage water resources. Indicate your level of opposition or support for the following option: Tax incentives for implementing efficient irrigation systems for agriculture. | | Midwest Region | Other Regions |
|---|---|---|---|
| | **Strong Oppose** | 2.15% | 2.76% |
| | **Oppose** | 4.60% | 4.29% |
| | **Neutral** | 29.14% | 30.67% |
| | **Support** | 52.76% | 46.32% |
| | **Strong Support** | 11.35% | 15.95% |
| | **Total** | 100% | 100% |
| | N= 1,358 | | |

**Pearson chi$^2$(4) = 6.20 P = 0.18 Pearson's R: -.009**

***Finding***: The value of Pearson's R indicates there is a no correlation between geographical demographics and attitudes toward tax incentives for efficient irrigation systems. The P-value, being greater than .05, further indicates the relationship between Midwestern population and support for tax incentives for implementing efficient irrigation systems is insignificant. Given these factors, the hypothesis is rejected.

**TABLE 7-1C: Midwestern Attitudes Toward Reduced Fertilizer/Pesticide Tax Credits**
***Sub-Hypothesis #1c****: Midwestern populations will have the most support for tax incentives for farmers to reduce the use of fertilizers and pesticides when compared to Other Regions.*

| Policy options have been proposed to manage water resources. Indicate your level of opposition or support for the following option: Tax incentives for farmers to reduce the use of fertilizers and pesticides. | | **Midwest Region** | **Other Regions** |
|---|---|---|---|
| | **Strong Oppose** | 2.15% | 2.85% |
| | **Oppose** | 7.67% | 5.30% |
| | **Neutral** | 31.90% | 34.15% |
| | **Support** | 43.56% | 40.88% |
| | **Strong Support** | 14.72% | 16.82% |
| | **Total** N= 1,358 | 100% | 100% |

**Pearson chi$^2$(4) = 4.23 P = 0.38 Pearson's R: -0.12**

***Finding***: The value of Pearson's R indicates there is a minimal negative correlation between geographical demographics and attitudes toward tax incentives for farmers to reduce their use of fertilizers and pesticides. The P-value, being greater than .05, further indicates the relationship between Midwestern population and support for tax incentives for the reduction of fertilizers and pesticides is insignificant. Given these factors, the hypothesis is rejected.

## Support for Agents of Policy Implementation

The Water, Energy, Food Nexus Survey also provides data measuring public support for government organizations implementing selected nutrient runoff abatement policy alternatives. The survey proposes three levels of government to respondents: federal, state and local. The level of support for non-governmental organizations, such as nonprofits, private industry, and farmers is also asked by the survey but is not tested in this analysis because of the focus on government policies to address nutrient runoff.

Tables 7-2A through 7-2C provide data comparing the support for the survey's included government entities among Midwestern respondents and respondents from all other regions. The tables each describe a sub-hypothesis and seek to support overarching hypothesis #2 that Midwestern populations will have strong attitudes toward the government's role in managing agricultural resources. If the reported P-value is less than .05, the sub-hypothesis is considered "rejected."

**TABLE 7-2A: Midwestern Attitudes Toward Federal Involvement in Agricultural Management**

***Sub-Hypothesis #2a****: Midwestern populations will be more averse to federal involvement (e.g. U.S. Department of Agriculture) in the management of agricultural resources than Other Regions.*

| | | Midwest Region | Other Regions |
|---|---|---|---|
| Indicate what you think the appropriate role, or level of involvement, should be for the following types of organizations in managing agriculture programs: Federal Government | **No Role** | 7.55% | 9.29% |
| | **Minor Role** | 36.59% | 31.07% |
| | **Major Role** | 36.25% | 36.86% |
| | **Lead Role** | 19.64% | 22.78% |
| | **Total** N= 1,358 | 100% | 100% |

**Pearson $chi^2(3) = 4.29$ P = 0.23 Pearson's R: -.0246**

***Finding****:* The value of Pearson's R indicates there is a no correlation between geographical demographics and attitudes toward the involvement of the federal government in managing agricultural resources. The P-value, being greater than .05, further indicates the relationship between the Midwestern population and support for federal management of agricultural resources is insignificant. Given these factors, the hypothesis is rejected.

**TABLE 7-2B: Midwestern Attitudes Toward State Involvement in Agricultural Management**

***Sub-Hypothesis #2b:*** *Midwestern populations will be more supportive of state involvement in the management of agricultural resources than Other Regions.*

| | | Midwest Region | Other Regions |
|---|---|---|---|
| Indicate what you think the appropriate role, or level of involvement, should be for the following types of organizations in managing agriculture programs: State Government | **No Role** | 6.97% | 5.92% |
| | **Minor Role** | 41.82% | 41.83% |
| | **Major Role** | 46.67% | 43.53% |
| | **Lead Role** | 4.55% | 8.73 % |
| | **Total** | 100% | 100% |
| | N= 1,358 | | |

**Pearson chi$^2$(3) = 6.63 P = 0.08 Pearson's R: -.037**

***Finding:*** The value of Pearson's R indicates there is no correlation between geographical demographics and attitudes toward the involvement of state governments in managing agricultural resources. The P-value, being greater than .05, further indicates the relationship between the Midwestern population and support for state management of agricultural resources is insignificant. Given these factors, the hypothesis is rejected.

**TABLE 7-2C: Midwestern Attitudes Local Involvement in Agricultural Management**

***Sub-Hypothesis #2c****: Midwestern populations will be the most supportive of local involvement in the management of agricultural resources when compared to other regions.*

| | | Midwest Region | Other Regions |
|---|---|---|---|
| Indicate what you think the appropriate role, or level of involvement, should be for the following types of organizations in managing agriculture programs: Local Government | **No Role** | 10.30% | 9.11% |
| | **Minor Role** | 45.76% | 42.14% |
| | **Major Role** | 36.97% | 41.24% |
| | **Lead Role** | 6.97% | 7.51% |
| | **Total** | 100% | 100% |
| | N= 1,358 | | |

**Pearson chi$^2$(3) = 2.35 P = 0.50 Pearson's R: -.037**

***Finding****:* The value of Pearson's R indicates there is no correlation between geographical demographics and attitudes toward the involvement of local governments in managing agricultural resources. The P-value, being significantly greater than .05, further indicates the relationship between the Midwestern population and support for local management of agricultural resources is insignificant. Given these factors, the hypothesis is rejected.

### Analysis of Support for Policy Alternatives and Government Implementation

The above tables provide limited context and insight toward the attitudes of Midwestern populations regarding agricultural management policy options and the preferred organizational implementation of these policies. Foremost, no significant relationship is apparent between regional demographics and support of the selected nutrient reduction practices, resulting in a rejection of the hypothesis that Midwestern populations will have strong attitudes toward agricultural management policy alternatives.

Furthermore, any significant relationships between regional demographics and support for government's role in managing agricultural resources have been nullified by this analysis. Of the three levels of government queried in the survey, not one provided a significant relationship with regional demographics. The hypothesis that Midwestern populations will have the strongest preferences regarding government involvement in agricultural management is also rejected, as well as each sub-hypothesis regarding the intensity of support for different levels of government. While no significant relationship was found between the selected variables, this analysis reflects a finding nonetheless: Attitudes regarding agricultural policy and management in the Midwest are no different than the attitudes of people living in other areas of the U.S. The pronounced lack of concern within the Midwest may imply that issues of habitat degradation and deterioration of water quality are not explicitly connected to agricultural activity.

Any machination of existing programming or alternatives identified by the survey will require significant coordination across all levels of government to facilitate a substantial reduction in nutrient delivery to the Gulf of Mexico. However, existing efforts to coordinate nutrient reduction strategies involve state and federal actors, as well as interest groups, but are largely voluntary with no significant incentive or compliance requirement. States are largely inconsistent or lackadaisical in their efforts to enforce strategies and meet reduction goals while federal agencies do not enforce accountability standards making states responsible for setting nutrient reduction goals. Whether limited public support for policy alternatives is a product of inconsistent policy implementation or inconsistent policy implementation is driven limited public support, lack of public support for additional voluntary nutrient reduction strategies may prove to be a significant barrier in the effectiveness of future programming efforts.

The challenge of successfully implementing a government-managed nutrient reduction plan with significant public support is exemplified in Iowa, an agriculturally dominant state contributing significant nutrient runoff to surface waterways. The state's 2013 Nutrient Reduction Strategy has increased the use of nutrient reduction practices on Iowa farms (Iowa Farm and Rural Life Poll 2016), yet much of the state's strategy and financial incentives are voluntary. Approximately 40 percent of Iowa farmers partake in nutrient reducing farming practices (Iowa Farm and Rural Life Poll 2016). Regardless of increased participation in recent years, 34 percent of Iowa farmers expressed unwillingness to work with government agencies on soil conservation and nutrient reduction efforts, further progress in managing nutrient runoff in the state is at risk (Iowa Farm and Rural Life Poll 2016).

This example and the pattern of support reflected in the Water, Energy, Food Nexus Survey present significant challenges in managing nutrient runoff and reducing hypoxic zones in the Gulf of Mexico. Regardless of existing collaborations among government agencies, nonprofit organizations, and individual farmers and their contribution of significant financial and human resources to combat nutrient runoff, widespread public concern for water quality and agricultural pollution have hindered the effectiveness of the existing voluntary strategies.

Further research is needed to determine if mechanisms to garner public support and awareness of the effects of nutrient runoff may prove more influential in advancing nutrient reduction strategies than the introduction of legislation and regulation at the state level. While this analysis did not measure the support among Midwesterners in nonprofits and interest groups, perhaps an evaluation of support for these organizations in the management of agriculture would be beneficial in future policy implementation by government entities. Moreover, analyzing just the Midwestern-based population on the traits of political ideology, income level, and occupation may also prove useful in measuring support for selected policy alternatives.

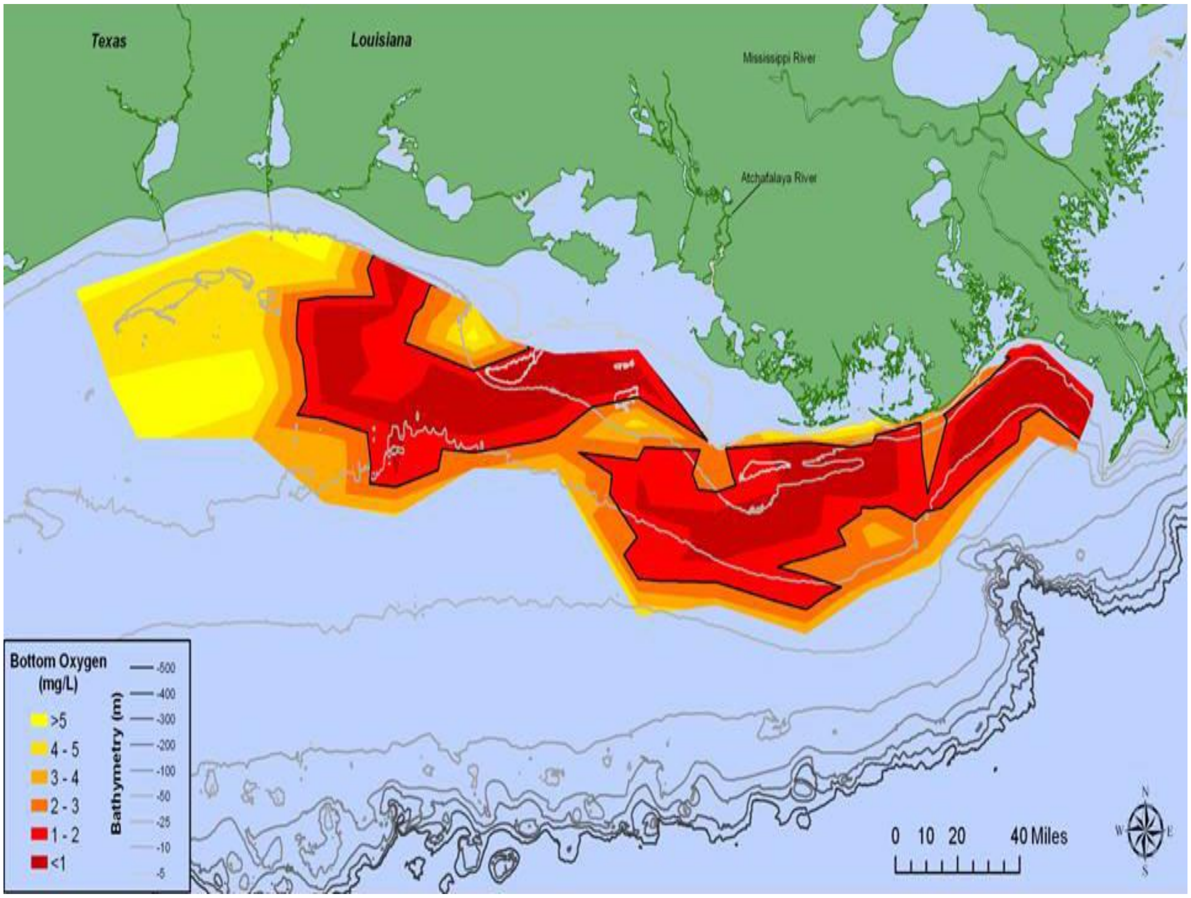
## CONCLUSIONS

Water quality and environmental concerns arising from an ongoing failure to effectively manage nutrient runoff up and down the Mississippi River Drainage Basin have reached a pivotal point in the policy process. Voluntary actions to mitigate micro-level runoff in the agricultural regions of the Midwest have not been conducive to significantly reducing nutrient loads negatively affecting natural habitats, public health, and regional industry downstream. Without pointed political action and adequate public attention paid to confront the ever-growing problem of agricultural runoff and impairment of waterways, the irreversible environmental damage is imminent, with costly expenditures attached.

Local, state and federal governments have begun to introduce policy alternatives aimed at reducing the nutrient runoff discharged into the Gulf of Mexico, yet, a substantial change in behavior has yet to be completely incentivized. Existing state nutrient reduction strategies support practices reducing runoff but do not include mechanisms requiring accountability from farmers or addressing the broader public effects of agricultural pollution.

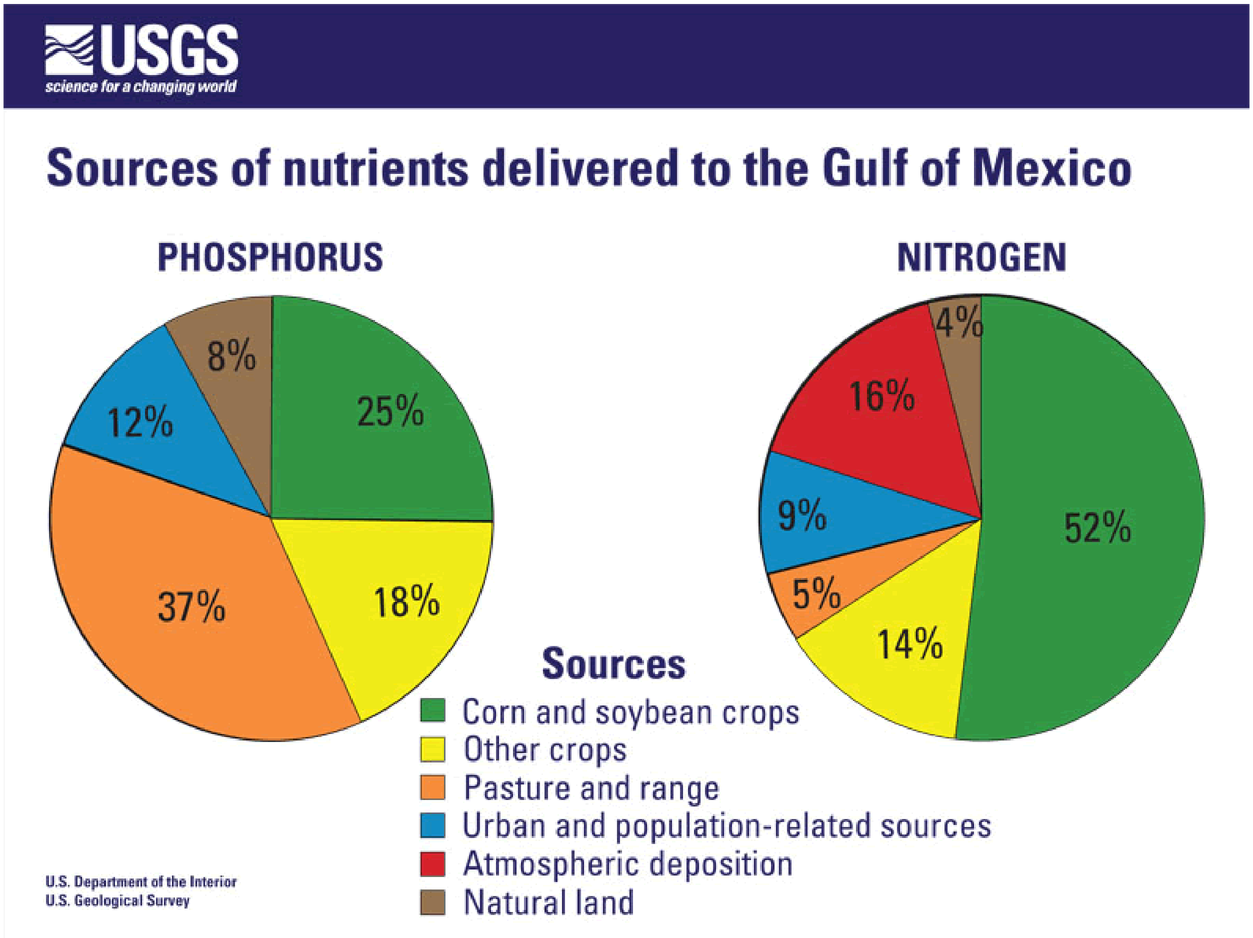
The data analysis conducted for this chapter sought to indicate the level of support for both financially incentivized and/or mandatory agricultural management policies is apparent among broad populations, with significant support in the agricultural region of the Midwest. However, the results of this analysis fail to reach any conclusions, as no significant relationship between the attitudes of Midwest-dwelling populations support for government involvement in agricultural management, nor the broad support of laws and regulations requiring nutrient reduction was reached. Any future consideration of policies mandating nutrient reduction and polluter accountability will likely require public support and trust in all levels of government and government policies. Policymakers at all levels must involve affected stakeholders throughout the agricultural industry and the Mississippi River Drainage Basin to address agricultural management, its effects on biodiversity, and effective solutions to mitigating both environmental and economic damage.

## APPENDIX 7-A: Hypoxic Regions in the Northern Gulf of Mexico[1]




[1] U.S. Department of Commerce: National Oceanic and Atmospheric Association. 2015. "2015 Gulf of Mexico Dead Zone 'Above Average.'" http://www.noaanews.noaa.gov/stories2015/080415-gulf-of-mexico-dead-zone-above-average.html (February 4, 2017).

**APPENDIX 7-B: Source of Nutrient Runoff by Industry[2]**

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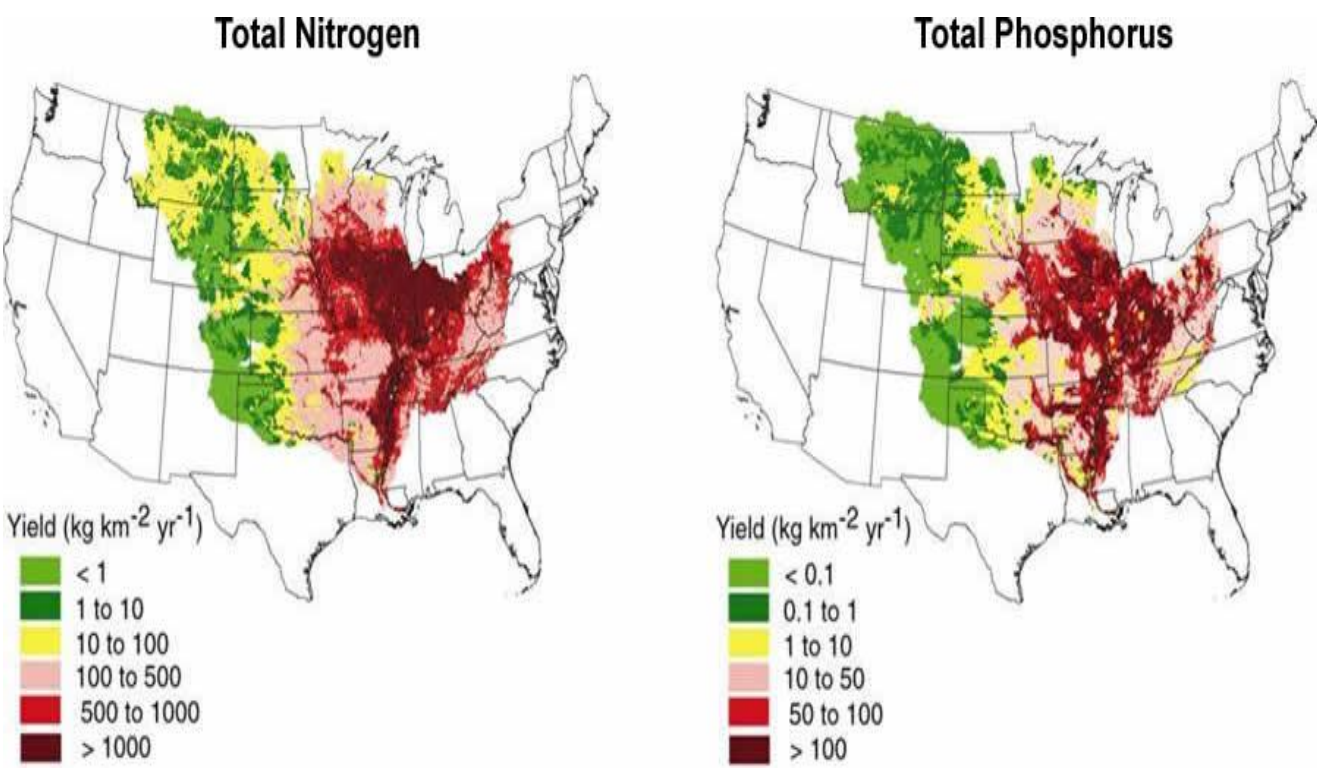
[2] U.S. Department of Interior: United States Geological Survey. 2014. "National Water Quality Assessment Program: Differences in Phosphorus and Nitrogen Delivery to the Gulf of Mexico from the Mississippi River Basin." https://water.usgs.gov/nawqa/sparrow/gulf_findings/index.html (April 4, 2017).

## APPENDIX 7-C: Geographical Description of Nitrogen and Phosphorus Runoff[3]




[3] U.S. Department of Interior: United States Geological Survey. 2014. "National Water Quality Assessment Program: Differences in Phosphorus and Nitrogen Delivery to the Gulf of Mexico from the Mississippi River Basin." https://water.usgs.gov/nawqa/sparrow/gulf_findings/index.html (April 4, 2017).

## APPENDIX 7-D: Share of Nutrient Runoff Contributions by State[4]

**Share of the nutrient flux (mass per time) delivered to the Gulf of Mexico from States in the Mississippi and Atchafalaya River Basins.**

(Note: The States are listed in descending order of their percentage contribution to the total nutrient flux delivered to the Gulf of Mexico.)

| Total Nitrogen | | | | Total Phosphorus | | | |
|---|---|---|---|---|---|---|---|
| State | Percent of Total Flux | Cumulative Percent of Total Flux | Delivered Yield ($kg\ km^{-2}\ yr^{-1}$) | State | Percent of Total Flux | Cumulative Percent of Total Flux | Delivered Yield ($kg\ km^{-2}\ yr^{-1}$) |
| Illinois | 16.8 | 16.8 | 1734.9 | Illinois | 12.9 | 12.9 | 117.4 |
| Iowa | 11.3 | 28.1 | 1167.2 | Missouri | 12.1 | 25.0 | 89.4 |
| Indiana | 10.1 | 38.2 | 1806.6 | Iowa | 9.8 | 34.8 | 89.2 |
| Missouri | 9.6 | 47.8 | 800.5 | Arkansas | 9.6 | 44.4 | 94.6 |
| Arkansas | 6.9 | 54.7 | 750.1 | Kentucky | 9.0 | 53.4 | 113.4 |
| Kentucky | 6.1 | 60.8 | 879.5 | Indiana | 8.4 | 61.8 | 132.3 |
| Tennessee | 5.5 | 66.3 | 757.7 | Tennessee | 5.3 | 67.1 | 61.9 |
| Ohio | 5.4 | 71.7 | 1082.3 | Mississippi | 4.4 | 71.5 | 101.6 |
| Mississippi | 3.4 | 75.1 | 863.5 | Ohio | 4.1 | 75.6 | 72.1 |
| Nebraska | 3.2 | 78.3 | 244.6 | Oklahoma | 3.3 | 78.9 | 24.1 |
| Kansas | 3.1 | 81.4 | 221.7 | Nebraska | 3.3 | 82.2 | 21.9 |
| Minnesota | 2.9 | 84.3 | 340.7 | Kansas | 2.6 | 84.8 | 16.2 |
| Wisconsin | 2.7 | 87.0 | 406.8 | Louisiana | 2.4 | 87.2 | 67.4 |
| Oklahoma | 2.5 | 89.5 | 206.1 | Wisconsin | 2.4 | 89.6 | 31.7 |
| Pennsylvania | 1.9 | 91.4 | 705.0 | West Virginia | 2.1 | 91.7 | 52.8 |
| West Virginia | 1.8 | 93.2 | 505.9 | Minnesota | 2.0 | 93.7 | 20.1 |
| Louisiana | 1.7 | 94.9 | 513.0 | Pennsylvania | 1.9 | 95.6 | 61.9 |
| Alabama | 1.1 | 96.0 | 925.6 | South Dakota | 1.6 | 97.2 | 11.0 |
| South Dakota | 0.9 | 96.9 | 72.0 | Alabama | 0.9 | 98.1 | 72.7 |
| North Carolina | 0.6 | 97.5 | 534.2 | Texas | 0.7 | 98.8 | 8.3 |
| Texas | 0.6 | 98.1 | 80.9 | Virginia | 0.4 | 99.2 | 32.0 |
| Virginia | 0.5 | 98.6 | 377.7 | New York | 0.2 | 99.4 | 50.0 |
| Montana | 0.4 | 99.0 | 20.3 | North Carolina | 0.2 | 99.6 | 13.2 |
| North Dakota | 0.2 | 99.2 | 34.6 | Colorado | 0.2 | 99.8 | 2.1 |
| New York | 0.2 | 99.4 | 634.7 | North Dakota | 0.1 | 99.9 | 1.2 |
| Georgia | 0.2 | 99.6 | 590.8 | Montana | 0.1 | 100.0 | 0.3 |
| Wyoming | 0.1 | 99.7 | 11.7 | Georgia | 0.1 | 100.0 | 30.5 |
| Colorado | 0.1 | 99.8 | 6.9 | Maryland | <0.1 | 100.0 | 37.5 |
| Maryland | <0.1 | 99.9 | 640.9 | Michigan | <0.1 | 100.0 | 1.2 |
| Michigan | <0.1 | 100.0 | 61.0 | Wyoming | <0.1 | 100.0 | 0.2 |
| New Mexico | <0.1 | 100.0 | 0.1 | New Mexico | <0.1 | 100.0 | <0.1 |

[4] U.S. Department of Interior: United States Geological Survey. 2014. "National Water Quality Assessment Program: Differences in Phosphorus and Nitrogen Delivery to the Gulf of Mexico from the Mississippi River Basin." https://water.usgs.gov/nawqa/sparrow/gulf_findings/index.html (April 4, 2017).

## APPENDIX 7-E: Water, Energy, Food Nexus Survey Description

The GfK Group (formerly Knowledge Networks) conducted the Water-Energy-Food Nexus Public Opinion Survey on behalf of the Bush School's Institute for Science, Technology and Public Policy (ISTPP) at Texas A&M University. Specifically, the study aimed to identify the factors that underlie US public opinion regarding various issues related to the energy-food-water nexus including government trust and responsibility, knowledge levels, and risk perceptions, and their policy preferences. The survey was conducted using samples from KnowledgePanel®.

The questionnaire was developed by a team of researchers and scholars at the ISTPP during the spring and summer of 2015. Most of the questions were borrowed from other public domain surveys. Additional questions, particularly those eliciting information about personal demographics, are standard questions used by GfK. Original questions, particularly those eliciting information specifically about water-energy-food nexus issues, were developed for this project and pre-tested among a convenience sample of students at the Bush School.

The target population consisted of the general US population of adults 18 years and older, with oversamples in Texas and Houston. To sample the population, GfK sampled households from its KnowledgePanel, a probability-based web panel designed to be representative of the United States. The survey consisted of two stages: a pretest to determine incidence and length of the survey, and the main survey with the study-eligible respondents. To qualify for the main survey, a panel member must have been 18 years and older. The survey was pre-tested by GfK from July 17 through July 20, 2015, and the full panel was engaged from August 12 through August 29, 2015. The median time of survey completion was 24 minutes.

The number of respondents sampled and participating in the survey, the survey completion rate for the main interview, and the incidence/eligibility rate are presented below.

| Number Sampled | Number Completed | Completion Rate | Qualified | Incidence Rate |
|---|---|---|---|---|
| 3362 | 1979 | 58.9% | 1979 | 100% |

The total number of respondents who completed the survey, including the oversamples of Texas and Houston residents, is 1,979. The total number of respondents composing the nationally-representative sample is 1,463.

Instead of sending the standard email reminder on day three of the field period, the following steps were taken to maximize the response or incidence rate:

- Additional email reminders to non-responders were sent on day 7, day 12 and day 15 of the field period;
- Participants were eligible to win an in-kind prize through a monthly GfK sweepstakes.

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## Conclusion to the Report

This report presented seven chapters, each of which focused on a specific issue of technology and technology policy in the U.S. In each chapter, the selected topic was introduced through a lens of a problem or issue involving science and technology, and this introduction was used as an entrée into some aspect of national public opinion. In some chapters, the main focus was on purely attitudinal assessments of the issue or problem, revealing how concerned people are with a given technological or policy problem. Often, analysis of public willingness to support different public policy options to address a specific problem are also presented. Each chapter relied on major nationally representative public opinion surveys conducted under the auspices of the Institute for Science, Technology and Public Policy at Texas A&M's Bush School of Government and Public Service.

Chapter 1 examined aspects of the potential for cyber-attacks in the U.S. with special emphasis of attacks on the nation's electric power grid. It found that even though people who identify as conservatives are slightly more concerned about a cyber-attack on the electric grid, the majority of respondents from every political ideology are concerned. This study also found higher level of concern affects the individuals' belief of the level of spending government should have to deal with a cyber-attack on the electric grid. Policymakers and the owners of the critical infrastructure need to be working together to address current cybersecurity threats and fixing vulnerabilities in order to protect the nation and all American citizens.

Chapter 2, analyzing public opinion on the use of nuclear power generation in the U.S., looked at public perceptions of safety, and willingness to support construction and increased reliance on nuclear electric production. It made a valiant attempt to show that people with the lowest levels of factual knowledge about nuclear energy were the people least supportive of the technology. The chapter infers from the results that if the general public could be better informed and educated, support for increased use of nuclear power generation will follow.

Chapter 3 also examined technologies associated with energy production, in this case the use of hydraulic fracturing (fracking) technologies for extracting oil and natural gas. The chapter investigated the extent to which living in close proximity to a fracking site influenced peoples' views about problems associated with fracking, especially contaminated water supplies, competition for water supplies, and water depletion. Using information about whether people live in counties with fracking sites derived from alternative sources, the chapter found very little relationship. People living in counties with large numbers of fracking sites were not appreciably more likely to consider the consequences of fracking to be serious problems. The implication is that people have largely come to discount the dangers of living near fracking.

Continuing the energy theme, Chapter 4 examined public attitudes toward increasing use of solar electricity generation. The analysis found that people who live in the Northeast part of the U.S., people who are better educated, and people who are politically liberal are considerably more likely to favor increased use of solar energy. These same patterns reflect support for increased federal funding for solar research, and for federal tax cuts for companies to develop renewable energy technologies. The amount paid for electricity bore no relationship to support for, or opposition to, increased solar energy.

Chapter 5 examined the extent to which public opinion reflected a willingness to support climate protection policies and national energy security policies. The analysis showed that political ideology in particular is related to attitudes toward climate protection, concern for the environment, and energy security. In short, politically conservative people are much less likely to support climate protection policies, are much less likely to express concern for the environment, are much less likely to support fuel efficiency standards for motor vehicles, are much less likely to support federal policies promoting renewable energy, but are much more likely to be concerned about national security and energy security than their politically liberal counterparts.

Chapter 6 turned its attention to public opinion concerning increased use of technologies used for the purpose of public surveillance as a counter-terrorism policy. The chapter examined whether concern for national security, per se, might be said to influence people to be more supportive of increased electronic surveillance. What the paper showed is that it is difficult to disentangle attitudes associated with surveillance from attitudes associated with the perceived perpetrators of terrorist acts. Specifically, when people perceive that “Muslim extremists” pose the greatest threat to homeland security, they are much more likely to support a variety of specific uses of technology for surveillance.

Chapter 7 examined the problem of hypoxic or “dead zone” water ways primarily caused by use of agricultural chemicals, especially fertilizers. The issue for this chapter is whether people who live in some regions of the U.S. are more likely than others to be supportive of public policies to reduce agricultural sources of water pollution responsible for creating these zones. The analysis found very little evidence that regional of residence matters. People living in the Midwestern part of the U.S. were not appreciably less supportive of such policies even though they were expected to be less supportive by virtue of being a heavy agricultural producing region.