Renewable Energy

Is the Move Towards Clean Energy Beneficial to Employment?

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12/19/2014

Expanding the use of renewable energy will be required in the future due to the exhausting supply of fossil fuel reserves. This study uses a meta-analysis to look at the conclusion of11 independent reports and studies that analyze the employment impacts of the renewable energy industry in the United States. These various studies employ a range of methods, but all provide outcomes of similar nature – the net job change for a certain amount of investment. Normalizing those numbers to display how many jobs are created for $1 million invested, this study shows that the renewable energy industry will lead to a net job increase by relying higher on renewable energy in the future.

1. Introduction

In recent years, the renewable energy industry has been targeted as a high priority for investment, as it pertains to both environmental and economic impacts. Creating a more reliable energy foundation has notable environmental benefits but the debate is whether renewable energy can also act as a positive driving factor for economic expansion through job creation. This paper examines how reorganizing the United States energy grid to renewable energy sources would impact the labor market. As Wei, Patadia, & Kammen (2009) state "job creation is an especially pressing issue as the world recovers from the most severe recession in decades" (919).

To illustrate how the labor market would be impacted by a greater investment in renewable energy sources, this paper undertakes a meta-analysis by examining previous studies centered around the topic of renewable energy. A meta-analysis contrasts and combines results from most if not all the different studies in hopes of identifying patterns among study results as well as sources of disagreement and other interesting conclusions that may surface in multiple studies (Greenland & O'Rouke, 2008). This paper assesses eleven studies that examined the effects of renewable energy source reliance on the job market.

The rest of the paper proceeds as follows. In Section 2, the major events in the background on renewable energy are described. Section 3 goes in depth on each of the methodologies and conclusions from the eleven studies analyzed. In Section 4, the patterns discovered from the meta-analysis are laid out. The next section, Section 5, sets out to look at popular media about both the fossil fuel industry and the renewable energy industry. Finally, Section 6 concludes.

2. Background

The emergence of renewable energy can be traced to 1927, when the Jacobs Wind Electricity Company developed the first commercial wind turbine. They created this turbine for the remote farmers who were not on the electric grid and could not afford a gasoline generator as both the generator and gasoline were extremely expensive (Righter, 1996). However, American public policy aimed at clean energy did not begin until the 1970s with President Nixon and the oil crisis. In 1970, following various environmental disasters and immense pressure from citizens for better ecological and wildlife well-being, President Nixon reorganized the United States energy policies to include a new Environmental Protection Agency (EPA). Nixon's aim was to alleviate the concern citizens felt towards the environment after the 1969 Santa Barbara oil spill (Energy Division, 2005). The EPA's purpose was to protect human health and the environment through research, monitoring, and enforcement of legislatures. Later in the decade, following oil shortages caused by embargos from various Middle Eastern nations, the United States realized the volatility in dependence on foreign oil and the need to reorganize its energy policies once again. The United States could no longer worry only about making domestic companies environmentally friendly, but also look into new energy sources that would not cause such volatility - namely renewable resources. The EPA was tasked with the research into finding such resources and how they could be harnessed (EPA, 1974).

Since its inception, the EPA has passed multiple acts to promote energy conservation and to increase the use of renewable energy sources (US Legal, 2014). The 1975 Energy Conservation Act was directed at reducing the amount of fossil fuels used by the United States as well as create higher energy efficiency. A second act, the Energy Policy Act of 1992, was directed at reducing fossil fuel usage and increase the use of renewable energy. The creation of

these energy conservation acts has proven controversial as the oil industry alone provides 9.8 million jobs and generates over $1.2 trillion, or 8% of the United States GDP (American Petroleum Institute, 2013).

Since Barack Obama has taken presidency, he has promoted the idea of renewable energy through various bills and acts that he has signed into law. Although each bill is not solely dedicated to renewable energy, Obama acknowledged that renewable energy needed to be invested in, and these bills were opportunities for action. The first bill was passed in February 2009, following the Great Recession. This bill, the American Recovery and Reinvestment Act gave $27.2 billion to energy efficiency and renewable energy research and investment (U.S Government Printing Office, 2009). President Obama also has been working to fulfill his "Presidential Memorandum," which set the goal that by 2020, the United States would obtain 20% of its electricity from renewable energy sources, and there would be a higher restriction on carbon dioxide on existing power plants (Wood, 2014; Burger, 2014). These acts signal to the world that the United States is attempting to move forward in its clean energy industry.

That signal, however, has been mixed as several legislation acts have been defeated. In 2009, the American Clean Energy and Security Act was defeated in Senate, although it had passed the House of Representatives. This act would have put a cap on greenhouse gas emissions for the nation as well as require electric utilities to meet 20% of their electric demand through the use of renewable energy sources (Waxman & Markey, 2009). Even as recently as May of 2014, the Senate was blocking forward movement in clean energy (Atkin, 2014). There was a tax cut bill that would have given a $13 million subsidy to the wind industry market to compete with fossil fuels, however, certain Senators who have investments in the fossil fuels industry would not allow this bill to pass with that subsidy included. With the defeat of this renewable energy

subsidy, on the gap in subsidies between the two energy sources remains substantial, with fossil fuels receiving more subsidies by roughly $3 million (Open Secrets, 2014). The uneven distribution of subsidies may be a result from the amount of political contributions each industry has made – with fossil fuels donating over $20 million, and renewable energy only $500,000 in the same period (National Institute on Money in State Politics, 2013). This provides a suggestion of the length at which those invested in fossil fuels will go to ensure their industries survival.

3. Studies Examined

Since there has been a growing importance of renewable energy sector, the interest on its effect on the labor market has also been increasing. My study takes the definition of "green jobs" from the United Nations Environment Program (2008) which states that "green jobs typically refer to those jobs that play a direct role in reducing environmental impact of enterprises and economic sectors, ultimately to the levels that are sustainable" and expands it to include all jobs associated with the renewable energy industry, whether they be direct (construction, maintenance, et al), indirect (supplier of building supplies), or induced (non-industry jobs created by the economic impact of the change). In short, as employed in this paper, a green job is any job created by an expansion in the renewable energy market. This paper also discusses net jobs only, meaning that the concluding results take into account the jobs lost in the fossil fuel industry due to an expansion in the renewable energy industry.

The research studies reviewed are from a variety of academic journals, Universities, and non-government organizations. Although all the studies reviewed here look at the implications for the impact on the United States labor market, they use a variety of methods, and as expected, there are wide ranges for the potential impact on the labor market. *Table 1* gives an overview of the various studies and the methodology that were used.

Table 1

Reference	Year	Author(s)	Study – Type of Model
1	2001	World Wide Fund for Nature	Clean Energy: Jobs for America's Future (I-O model)
2	2001	Singh & Fehrs	THE WORK THAT GOES INTO RENEWABLE ENERGY (analytical model)
3	2004	Kammen, Kapadia, & Fripp	Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate? (analytical model)
4	2006	Sterzinger	Jobs and Renewable Energy Project (analytical model)
5	2007	Scott, Roop, Schultz, Anderson & Cort	The impact of DOE building technology energy efficiency programs on U.S. employment, income, and investment (I-O model)
6	2008	Laitner & McKinney	Positive Returns: State Energy Efficiency Analyses Can Inform U.S. Energy Policy Assessments (I-O model)
7	2009	Wei, Patadia, & Kammen	Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US? (analytical model)
8	2009	Pollin, Heintz & Garrett-Peltier	The Economic Benefits of Investing in Clean Energy How the economic stimulus program and new legislation can boost U.S. economic growth and employment (I-O model)
9	2009	Bezdek	Estimating the Jobs Impacts of Tackling Climate Change (analytical model)
10	2010	Garrett-Peltier	The Employment Impact Of Economy-Wide Investments in Renewable Energy and Energy Efficiency (I-O model)
11	2012	Rivers	Renewable energy and unemployment: A general equilibrium analysis (analytical model)

There are two main types of methodologies conducted in these studies - Input-Output models (I-O models) and analytical models, both of which have their respective advantages and disadvantages. Input-Output models are able to provide the most complete picture of the economy as a whole as it depicts inter-industry relationships within the economy by showing how an output from one industrial sector may become an input to another industrial sector. (Miller & Blair, 2009) In the input-output matrix, a column generally represents inputs to an

industrial sector, while rows represent the outputs from a given sector. This format allows the reader to see if the sectors are dependent on one another. However, they require several strong assumptions in order to reach their high level of aggregation (Kammen, 2004), and there is no transparent derivation of how the inputs (renewable energy) create the outputs (employment changes). The analytical models are generally simpler and easier to understand, however, they usually do not depict the indirect effects of a study, and in the case of renewable energy, do not describe the job losses in the fossil fuel industry (Kammen, 2004). Alone, these studies create only one idealized scenario as focused on by the individual author(s), but together, these studies manage to create a general pattern in the labor market, despite the studies containing different methodologies and data points.

The studies that analyzed the impact on the labor market using the I-O model were the World Wide Fund for Nature (2001), the Scott et al. (2007), the Laitner & McKinney, the Pollin et al. (2009), and the Garrett-Peltier (2009) studies. The World Wide Fund for Nature concluded their Climate Protection Scenario would create a net annual 1.3 million employment increase by 2020 along with a decrease in fossil fuel consumption and a decline in carbon emissions. The Scott et al. study depicted an increase in employment by 446,000 and real income would increase by $7.8 billion as the reliance on renewable energy was increased.. Pollin et al. stated that continual investments to clean energy would cause an expansion in employment that would continue to grow over time, resulting in over a 1.7 million net increase in employment opportunities, reducing the unemployment rate by one full percentage point. The study conducted by Garrett-Peltier was different from the other I-O studies in that she did not look at the total increase in jobs, but at how many jobs would be created for every million dollars invested in renewable energy. In her results, Garrett-Peltier concludes that one million dollars in renewable energy and energy efficiency creates 7.29 net jobs. Although all these studies used the same type of methodology, the results vary in terms of amount of jobs created by a higher

reliance in renewable energy.

The rest of the studies were conducted using an analytical model. Since an analytical model can be employed in multiple ways, I will go into greater detail about each study.

For the study conducted by Singh and Fehrs, the bulk of their analysis was via surveys, retrieved over the phone and written communication. Looking at each specific renewable energy source (solar, wind, water), Singh and Fehrs determine how many person-years (of work) are required per each megawatt of energy. Taking the results, Singh and Fehrs compared the person-years of each renewable energy source and compared it to coal person-years. What they find is that renewable energy sources provide more than 40% more employment that coal.

The approach taken by Kammen, Kapadia & Fripp was a more general approach than that of Singh and Fehrs. They looked at employment levels for each type of energy source (fossil and renewable), and divided it into two types of employment - construction/installation and manufacturing, and operations and maintenance. The authors then separated the different employment opportunities based on how much reliance the United States had on renewable energy, whether the United States be 0% reliant or 20% reliant (with the renewable energies being broken down differently). They found that the highest amount of total employment created until 2020 occurred with 20% reliant in renewable energy, with the specific types being broken down as such: 40% biomass, 55% wind, and 5% solar PV). They found that 20% renewable energy reliant produced 163,669 jobs whereas fossil fuels only produced 86,369 jobs. However, this study only conducts five scenarios, so there are other results that are likely to produce higher total employment, and they only looked at 0% reliant and 20% reliant on renewable energy, so there are many more possibilities in that extent as well.

Sterzinger used the survey basis of the Renewable Energy Policy Project (REPP) jobs calculator to represent his hypothesis on how expansion in renewable energy industries had to the potential to create jobs. Collecting reports from various states, Sterzinger was able to

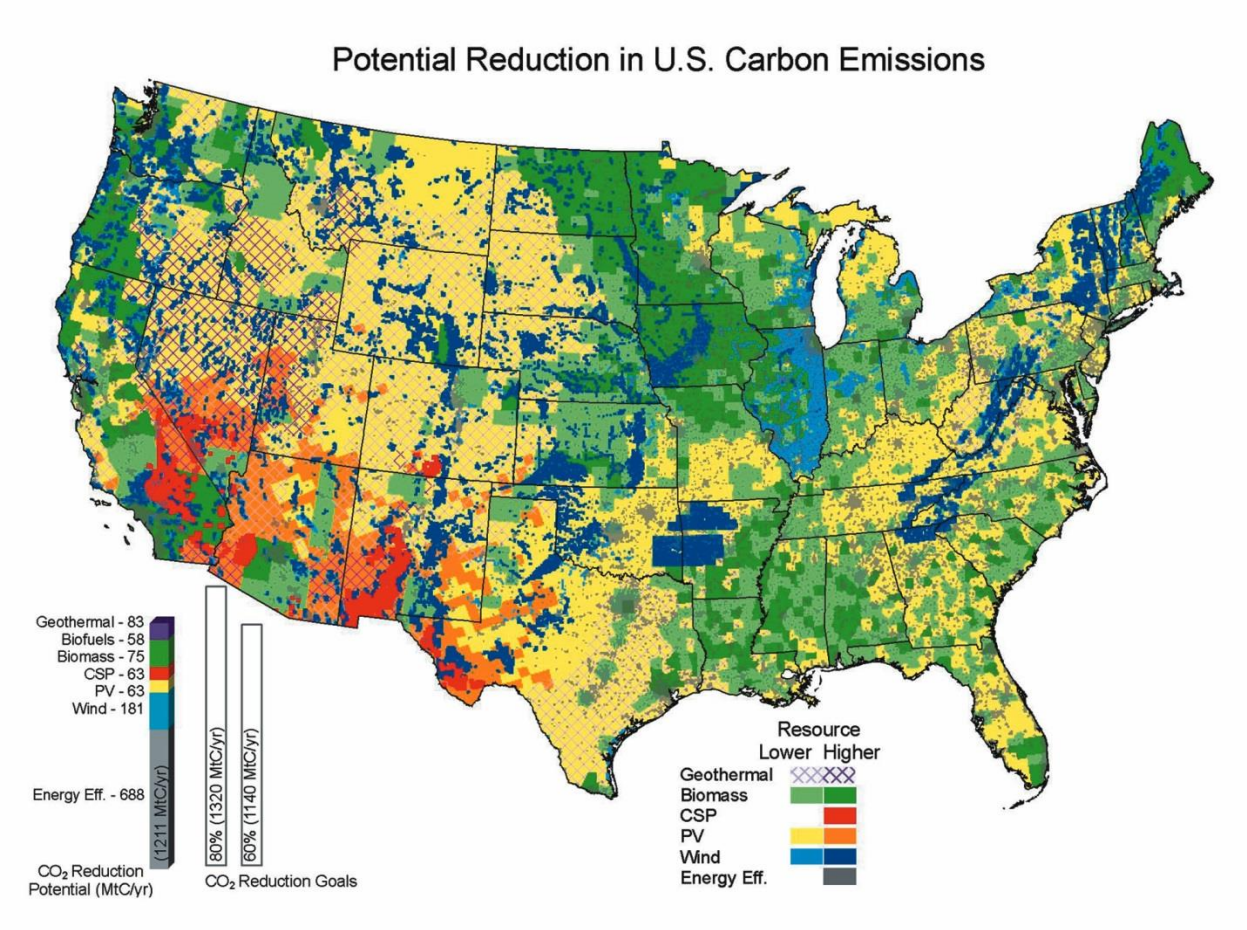
determine the geographic dispersion of employment from heightened renewable energy reliance. Looking at state reports gathered by REPP, Sterzinger shows that every 1,000 megawatts of energy could create 4,000 jobs in Pennsylvania. The limitation on his analysis is that there is not a detailed report for each state, so it is hard to grasp what the overall effect of increased renewable energy has on the labor market.

Wei, Patadia, and Kammen's (2009) paper shows that all non-fossil fuel technologies produce more jobs per unit of energy than fossil fuel technologies. For optimal employment creation, their paper suggests that policy makers should create long term, consistent policies as that is also best suited for economic growth. Like ASES, Wei, Patadia, and Kammen conclude that over four million jobs will be created by relying more on renewable energy in the future.

The American Solar Energy Society study (Bezdek, 2009) observes that renewable energy jobs require a wide variety of skills including engineers, mechanics, factory workers, truck drivers, accountants, et al. A common feature of these types of jobs is that they are jobs that are hard to outsource to another country. Using data collected in 2006, ASES discussed the net costs associated with each type of renewable energy. Using 2005 dollars they looked at the potential costs in 2020 and 2030. They also depicted the net jobs associated with each energy type. Using this data, ASES created a detailed table describing all the direct and indirect jobs that would be created with renewable energy industry expansion. The ASES study concludes that the renewable energy industry has the potential to create 4.5 million net jobs by 2030. *Figure 1* below represents the most efficient way to optimize on renewable energy, based on the study by ASES. Based on the map and the data within the study, ASES concludes that renewable energy will require high initial costs to build the renewable energy plants and reroute the United States energy grid, however, once renewable energy has been implemented, the costs of renewable energy will substantially decrease over time. As stated by ASES, these various impacts lead to a positive effect on the United States economy, suggesting that the United States needs to switch

over to a higher reliance on renewable energy.

Figure 1

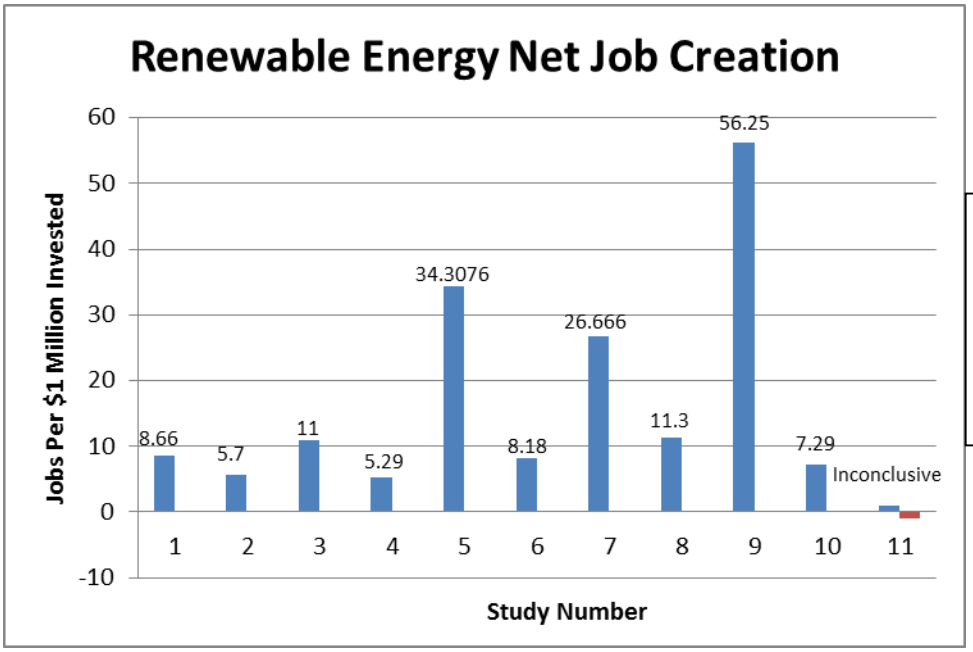


The final study that used an analytical model was that of Rivers. He utilized a mathematical model, manipulating equations to show how renewable energy affected the labor market. Differentiating various production functions for fossil fuels and renewable energy, as well as consumer utility, Rivers uses these equations to linearize a general equilibrium model. By using this model, Rivers is able to describe the behavior of each of the different industries in respect to unemployment. What Rivers concludes separates him from the rest of the studies - he finds that subsidies used to promote renewable energy, as well as taxes that discourage the use of fossil fuels actually lead to an increase in unemployment, although the change is relatively small.

4. Data Analysis

The eleven studies mentioned perform various methodologies which resulted in a wide range of results, depicted below in *Graph 1*. This graph depicts the net jobs created by higher reliance in renewable energy, meaning that the loss of fossil fuel jobs have been taken into account in the data.

Graph 1



Range

5.29-56.25*

*Rivers Data is inconclusive and is not featured in the range

*Study Number refers to Reference Numbers in Table 1
*Rivers did not supply definite job loss/creation numbers leading to an inconclusive data point

Graph 1 shows that majority (10/11) of the studies conclusively result in a net job increase by switching over to the renewable energy industry. The range of their results varies from 5.29-56.25 jobs per $1 million invested, which could be an outcome due to the different data studied by the different studies, however, the main conclusion to be made is the positive number associated with the results. The study performed by Rivers did not detail specifics about job losses or creations, but he stated either result was possible. Due to his inconclusive results, his study number (11) is depicted with both positive and negative outcomes with the note

"inconclusive" above. To showcase the conclusions of each study, *Table 1* has been expanded below for a final picture of the studies and their results.

Table 1 Expanded

Reference	Year	Author(s)	Study – Type of Model	Net Job Change
1	2001	World Wide Fund for Nature	Clean Energy: Jobs for America's Future (I-O model)	+8.66 jobs per $1 million invested in renewable energy
2	2001	Singh & Fehrs	THE WORK THAT GOES INTO RENEWABLE ENERGY (analytical model)	+5.7 jobs per $1 million invested in renewable energy
3	2004	Kammen, Kapadia, & Fripp	Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate? (analytical model)	+11 jobs per $1 million invested in renewable energy
4	2006	Sterzinger	Jobs and Renewable Energy Project (analytical model)	+5.29 jobs per $1 million invested in renewable energy
5	2007	Scott, Roop, Schultz, Anderson & Cort	The impact of DOE building technology energy efficiency programs on U.S. employment, income, and investment (I-O model)	+34.3076 jobs per $1 million invested in renewable energy
6	2008	Laitner & McKinney	Positive Returns: State Energy Efficiency Analyses Can Inform U.S. Energy Policy Assessments (I-O model)	+8.18 jobs per $1 million invested in renewable energy
7	2009	Wei, Patadia, & Kammen	Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US? (analytical model)	+26.666 jobs per $1 million invested in renewable energy
8	2009	Pollin, Heintz & Garrett-Peltier	The Economic Benefits of Investing in Clean Energy How the economic stimulus program and new legislation can boost U.S. economic growth and employment (I-O model)	+11.3 jobs per $1 million invested in renewable energy
9	2009	Bezdek	Estimating the Jobs Impacts of Tackling Climate Change (analytical model)	+56.25 jobs per $1 million invested in renewable energy
10	2010	Garrett-Peltier	The Employment Impact Of Economy-Wide Investments in Renewable Energy and Energy Efficiency (I-O model)	+7.29 jobs per $1 million invested in renewable energy
11	2012	Rivers	Renewable energy and unemployment: A general equilibrium analysis (analytical model)	Inconclusive results due to lack of detail

As the data results from the different studies all seem to be congruent that renewable energy creates net jobs, it is interesting that the studies all had such different answers. As noted before, the range of outcomes could be due to the different data observed for each study, or it could be due to the type of methodology used. Below, in *Table 2*, are the averages of the net job creation by each methodology, as well as a general average for all the studies. Observe that due to the inconclusive data by Rivers that his study is not used to determine the averages.

Table 2

	I-O Models	**Analytical Models**	**Both**
Average	13.95	20.98	17.46

The general average net job creation based on the studies is 17.46jobs per $1 million dollars invested into renewable energy. While the analytical models' average is above the general average, and the I-O models' average is below the general average, they both are relatively close to the 17.46 net jobs created per $1 million invested. Comparing the highest points between each model, the analytical models' highest point is 56.25 and the I-O models' high point is 34.3076. Although these is a 20 job per $1 million invested difference between the two points, these are the two highest net job creation points in *Graph 1* suggesting that neither model completely overstates or understates the net job creation.

For American public policy, it is important to note that both Lovins (1976) and Wei et al (2010) agreed that renewable energy would provide local distributed jobs as installation can occur everywhere in the United States, whereas fossil fuels were more centrally located to where the resource is deposited. This results in larger domestic employment growth all over the United States, leading to the net increase in job opportunities.

The growth in the green jobs market also targets any concerns with jobs being displaced overseas. According to the American Solar Energy Society (ASES, 2008), job growth

in the renewable energy industry is biased towards technical, scientific, professional, and skilled workers. In other words, both skilled and unskilled labor is required by the renewable energy industry. For example, wind energy requires workers for the construction and installation of wind turbines, but also maintenance workers as well. It also requires intense planning on the locations of these wind farms, so various other employment is necessary to scope out possible sites, obtain permits, and supervise each step of the installation process. Concluding that the wind energy industry requires a variety of workers, most of whom cannot be outsourced. Wind and hydro energy industries also employ a wide variety of workers, just with different skill sets to create each type of renewable energy created.

To summarize my results, we find that the renewable energy industry generates more jobs than the fossil fuel industry per million dollars invested.

5. Popular Media and Renewable Energy

Based on the net increase in jobs opportunities by switching to renewable energy, it is surprising that the media does not depict this fact. The media instead, has focused mainly on the fossil fuels industry following the discovery of the Parshall Oil Field beneath North Dakota. This domestic source of oil has decreased the need for oil imports, while also providing new job creation during a time of recession. "Oil and gas extraction alone created 150,000 jobs last year – about 9% of all new jobs created in 2011" (Lowrey, 2012). The domestic production of oil also created a milestone for the United States in that for the first time in almost 20 years, the United States will "produce more oil domestically than we import" (Bradley Jr, 2013). These two articles from the *New York Times* and *Forbes* are just two of many articles directed at the promotion of the fossil fuel industry.

While the fossil fuel industry is capturing the attention of the media through the means of well-known, large magazines, the renewable energy industry is just starting to gain footing in the media. One article discovered stated that the Pear Energy Corporation compared job creation

between the fossil fuel industry and renewable energy, finding that fossil fuels created just 5 jobs per $1 million invested whereas renewable energy created 17 jobs per $1 million invested (Shahan, 2013). Their conclusion towards renewable energy net job creation is congruent with the data shown in my meta-analysis, being just 0.46 jobs per $1 million invested different from mine. This discovery of consistency between my study and the Pear Industry's study furthers the evidence that my results are strong.

6. Conclusion

The work analyzed in this thesis provides the reader with a foundation for understanding different reports and studies aimed at renewable energy, while also providing a normalized methodology for direct comparison of the employment impacts from switching over to renewable energy sources.

We find that all renewable energy jobs create more jobs per dollar than fossil fuels, although the extent of jobs created per million dollars invested varies between studies. As solar, wind, and hydro energy plants can be more widely dispersed throughout the United States, and not only centralized to the areas where the mineral is deposited, the renewable energy industry allows for a wider range in employment growth areas. This study also concludes that there is a net increase in jobs, concluding that the switch over to renewable energy sources will create more jobs in that industry than is lost from the fossil fuel industry.

Potential limitations from the study arise from the studies themselves. While some of the studies are not explicitly biased towards one industry or the other, some studies, like the one from the American Solar Energy Society, is clearly biased towards the renewable energy industry and their results were the study with the largest net job increase according to *Graph 1*. This bias is concerning as the data may have been influenced to show only the positives in renewable energy, and down play the job losses from fossil fuels. If there is bias in this study, there is the potential for bias in other studies. A second limitation to this study was the lack of

studies provided that stated that renewable energy was dangerous to the labor market. While the lack of studies may mean that all studies agree that the renewable energy industry generates more net jobs for the market, then why has the government not made the switch?

Since this switch to renewable energy has not yet occurred, this could be a possible expansion to this study, looking at what needs to happen in order for the switch to be made – how much money will it cost, how long will it take, etc. Another possible expansion on this topic would be to look at how much energy is created per job or person-years, allowing for the reader to be informed not only about the costs, but the amount of output created, allowing for a more concrete picture of the benefits from renewable energy. There are other expansions that can be taken on this subject, but these are just a few ideas of where the research could go.

With the fossil fuel reserves being depleted, the switch over to renewable energy will have to occur in the future, and this study shows that the switch is beneficial for the economy as it leads to an increase in employment opportunities.

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