THE CLEAN ENERGY MANUFACTURING JOB MARKET AND ITS ROLE IN THE UNITED STATES ECONOMY

by

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Abstract

This paper provides an overview of green jobs in the United States, with a focus on synthesizing various estimates of the current and future number of green jobs, and relating these to estimates of the future number of clean energy manufacturing jobs. In doing so, it answers the following two research questions: "can lost manufacturing jobs become clean energy jobs?" and "can existing manufacturing jobs be saved from disappearing by transforming into clean energy jobs?" By combining current federal policies and expected growth numbers for the wind and solar energy industries, this paper presents a conservative estimate of approximately 235,000 clean energy manufacturing jobs generated in the United States by the year 2020. The most promising option for America's manufacturing workforce is a transition towards work in clean energy industries by redefining existing jobs, a move that requires initiative from both the public and private sector.

Keywords: Clean energy; manufacturing, renewable energy; employment

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List of Acronyms

ACESA	American Clean Energy and Security Act
ARRA	American Recovery and Reinvestment Act
ASES	American Solar Energy Society
AWEA	American Wind Energy Association
BLS	Bureau of Labor Statistics
Btu	British Thermal Unit
CCS	Carbon Capture and Storage
CSP	Concentrated Solar Power
DOE	Department of Energy
DOL	Department of Labor
EE	Energy Efficiency
EIA	Energy Information Administration
GreenMAP	Green Manufacturing Action Plan
GWh	Gigawatt Hour
ISS	Infinia Solar System
kW	Kilowatt
kWh	Kilowatt Hour
MISI	Management Information Systems, Inc.
MW	Megawatt

O&M	Operations and Management
PERI	Political Economy Research Institute
PV	Photovoltaics
R&D	Research and Development
RE	Renewable Energy
RE&EE	Renewable Energy and Energy Efficiency
REPP	Renewable Energy Policy Project
RES	Renewable Electricity Standard
RPS	Renewable Portfolio Standard
SEIA	Solar Energy Industries Association
UNEP	United Nations Environment Programme
VC	Venture Capital

1. Introduction

The United States' labour force has historically been renowned for the strength of its manufacturing sector, which over the years has produced record productivity rates (U.S. Bureau of Labor Statistics: Major sector productivity and costs index, 2009). However, since manufacturing employment peaked in June of 1979 at 19.5 million workers, job losses within this sector have been on the rise. Thirty years after this peak, the manufacturing labour market is the smallest it has been in nearly 70 years, with under 12 million registered workers. The economic recession that hit in late 2007 has not helped this trend, resulting in a high unemployment rate that currently sits at 9.5 percent and is accompanied by 6.5 million total job losses across the country (Goodman, 2009). The U.S. Department of Labor suggests that the largest declines have occurred in manufacturing, professional and business services, and construction (U.S. Bureau of Labor Statistics: Employment situation summary, 2009).

As unemployment rates in the United States rise, concerns over the future of its natural environment are also taking centre stage. Climate change is a pressing issue for consumers, businesses and policy makers worldwide. The U.S. is facing a particularly large amount of pressure to transition away from its pattern of heavy fossil fuel consumption, towards cleaner sources of energy that still meet the needs of its energy-loving citizens. Facing the worst economic crisis since the Great Depression and environmental degradation that threatens the future of our planet, the United States is currently seeking solutions that address its labour issues, environmental concerns and economic needs concurrently. One solution that has taken centre

stage with the Obama administration is investment in clean energy technologies and the green-collar job market.

The American government hopes that the development of a clean energy economy will increase employment rates and stimulate local economies. In recent years, it has committed a significant amount of public money towards the development of clean energy technologies and green job training, and is working towards introducing stricter renewable electricity standards (RES). When rationalizing the investment in clean energy, the government points to the job creation potential as one of its primary objectives. Under the clean energy economy, workers in dying industry sectors such as manufacturing can be retrained in industries that have a smaller environmental impact, thus transitioning from blue-collar jobs to green-collar jobs. Investing in a clean energy economy not only provides direct job growth, but also stimulates the U.S. labour force indirectly by offering businesses new and innovative energy supplies in a changing world economy.

A number of technical reports and research papers examining the job-creation potential of clean technologies, increased RES targets and investment in different areas of a clean energy economy have been produced, primarily within the past five years. While very few of these publications agree on the exact number of jobs that will be created from such a shift in public policy and investment, most support the notion that clean energy jobs will secure long-term employment for United States workers. An important consideration that has not been researched extensively is how this shift will affect manufacturing workers in particular.

The current paper combines the most recent data on employment figures, domestic energy consumption rates, clean energy jobs, renewable energy production capacity and clean energy investments by both the public and private sectors to answer the following two research

questions: “can lost manufacturing jobs become clean energy jobs, and can existing manufacturing jobs be saved from disappearing by transforming into clean energy jobs?” Based on the answers to these questions, the current paper also provides recommendations on how businesses in the private sector might take advantage of the growing clean energy labour market.

2. United States Economy

2.1. Labour Statistics by Industry

The United States Bureau of Labor Statistics (BLS) segments its industries based on whether they are goods-producing or service-producing. The country's Goods-Producing Industries include the supersectors of Natural Resources and Mining, Construction and Manufacturing, while its Service-Producing Industries include such supersectors as Financial Activities, Real Estate, and Healthcare. In June 2009, Goods-Producing Industries employed nearly 19 million workers, while Service-Producing Industries employed over 112 million workers (U.S. Bureau of Labor Statistics: Employment by major industry sector, 2009).

Productivity is a defining characteristic of the American manufacturing workforce. Workers within this sector have improved productivity, which is the amount of goods produced within a given period of time, almost every year since the Bureau of Labor Statistics began tracking this variable in 1987. Despite high productivity rates, wages remain below the national average. In May 2008, the most recent period for labour statistics, employees working in manufacturing earned a mean annual income of $32,320, while the entire American labour force had a mean annual salary of $42,270 (U.S. Bureau of Labor Statistics: Employment by major industry sector, 2009).

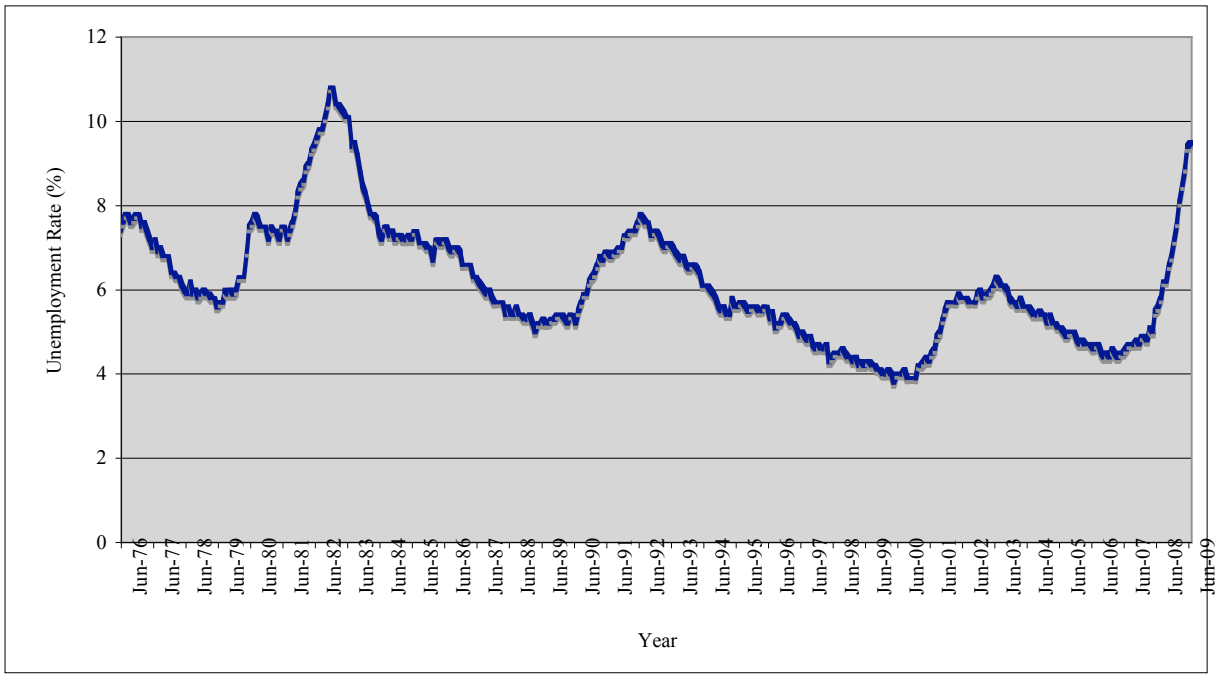
2.2. Labour Force

2.2.1. Unemployment Rates

In June 2009, approximately 9.5 percent of the United States labour force was unemployed (U.S. Bureau of Labor Statistics: Employment situation summary, 2009). This figure marks the highest unemployment rate seen in the U.S. since 1983 (see Figure 1:

Unemployment Rates in the United States, 1976-2009). More than 7.2 million Americans have lost their jobs since the start of the recession in December 2007, bumping the unemployment rate up by 4.6 percentage points within the same period (U.S. Bureau of Labor Statistics: Employment situation summary, 2009).

Figure 1: Unemployment Rates in the United States, 1976-2009



Source: Bureau of Labor Statistics

Many of the country's major industries account for the majority of job losses, with particularly steep declines in the manufacturing sector (U.S. Bureau of Labor Statistics: Employment situation summary, 2009). Since the onset of the recession, a total of 1.9 million manufacturing jobs have been lost, placing the manufacturing labour force at an estimated 11.9 million workers, its lowest since 1941 (U.S. Bureau of Labor Statistics: Employment by major industry sector, 2009). The rise in unemployment has been linked to the concurrent rise in labour productivity, a trend that emerged during the Industrial Revolution of the late 18th century, when businesses focused on minimizing labour costs and exploiting natural resources. Research from

2005 states that since 1990, five out of every six U.S. manufacturing job losses had been due to productivity growth (Ward, 2006). Unfortunately, improvements in worker productivity have resulted in fewer people in the workforce and an increase in the amount of roles outsourced to overseas labour markets. The country's manufacturing sector, for example, tripled its labour productivity between 1950 and 2000, but also accounts for one of the highest job loss rates nationwide (United Nations Environment Programme, 2008). In order to reverse rising unemployment numbers, the United States needs to discover a way to use the high productivity of its labour force to its advantage. Many believe that the best way to do this is by investing in new industries that are labour-intensive, such as clean energy technologies.

2.2.2. Manufacturing Workforce

Manufacturing employment in the United States has been on the decline for years. Between 1996 and 2006, jobs declined at an average rate of 1.9 percent annually, with an overall decline of 18 percent. During this same period, the entire American workforce grew by an average annual rate of 1.1 percent, with an overall 12 percent increase (U.S. Bureau of Labor Statistics: Employment by major industry sector, 2009). A total of 4.6 million manufacturing jobs have been lost in the United States since 1999, with many of them being sent overseas (Apollo Alliance, 2009; Pew Charitable Trusts, 2009). To make matters worse, in December 2007, the United States entered an economic recession that left the country's manufacturing sector particularly hard hit. Approximately one million manufacturing jobs have been lost since the onset of the recession, including 200,000 in January 2009 alone (Apollo Alliance, 2009). The majority of damage to the country's manufacturing sector has occurred within "dirty" industries (in terms of carbon emissions) such as auto manufacturing. The state of Michigan, for example,

has reached a 12.6 percent unemployment rate since the onset of the recession, primarily due to the faltering of its Detroit-based auto manufacturers (Pew Charitable Trusts, 2009).

Both the private and public sectors agree that America needs to invest in long-term solutions in order to effectively emerge from the immediate fiscal crisis and avoid similar pitfalls in the future. One such solution is investment in clean energy technologies that will ensure long-term job creation in some of the country's most vulnerable sectors, such as manufacturing (Pew Charitable Trusts, 2009).

2.3. Consumption of Fossil Fuels

The United States' energy consumption is a key independent variable to consider when gauging whether former or existing manufacturing jobs can survive in a clean energy economy. Unless the country's energy-consuming sectors begin to adopt clean sources of energy, new jobs will not be created in these industries. It is no secret that the United States has an affinity for fossil fuel consumption. The country's utilization of oil, natural gas and coal has been on the rise for years, and in 2006, it was ranked as the top consumer of both petroleum and natural gas worldwide, and ranked second for its coal consumption (EarthTrends, 2009; EIA: United States energy profile, 2009).

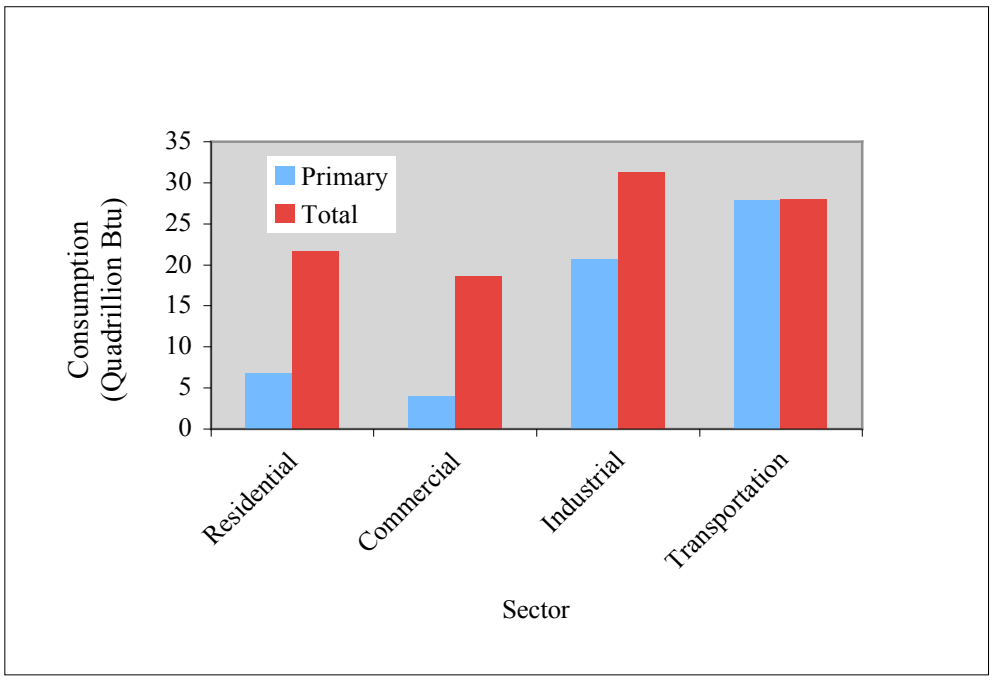
In discussions about the United States' energy usage, its oil utilization is perhaps the most widely criticized. The country's domestic production of oil peaked in 1970, at which point net imports of foreign oil accounted for 21 percent of its total consumption (Global Insight, 2008). Nowadays, the country ranks as the top importer of crude oil (International Energy Agency, 2006), and the Energy Information Administration (EIA) estimates that so far in 2009, an average of 56.9 percent of the country's total crude oil consumption is supplied by its net imports (EIA: Petroleum trade, 2009). Global Insight, the world's largest economics organization

providing economic and financial data, predicts that this figure will rise to 65 percent by 2030, unless the United States government decides to take steps to increase its energy independence.

The country's growing consumption rates, combined with its increased reliance on foreign sources of oil, have several implications for its future. First, high usage rates of environmentally degrading fossil fuels raises the question of whether the country will deplete its environment beyond repair. Second, dependence on foreign oil raises the issue of national security, since many of America's largest suppliers are countries renowned for political unrest and widespread violence. And third, the trade deficit resulting from the country's excessive importing of oil threatens its future economic stability.

The most recent data from the EIA reveals that the largest consumer of energy within the United States is its industrial sector, which consists of all facilities and equipment used for producing, processing, or assembling goods. This includes manufacturing companies, as well as companies from natural resource industries and construction (see Figure 2: Energy Consumption by Sector, 2008). Despite this sector's large consumption of fossil fuels, its energy utilization is actually considered promising for the future of renewable energy. As Figure 3 shows, the industrial sector's renewable energy supply, as a percentage of its total energy consumption, has been on the rise since 2003. This upward trend is expected to continue as clean energy technologies are continually developed and become more affordable. If its renewable energy consumption pattern continues, America's industrial sector could support many new jobs within clean energy companies, including manufacturing jobs. Many consider this a solution to the United States' heavy dependence on foreign oil, and a ticket to keep money within the domestic economy, thereby stimulating employment and other sectors of the economy.

Figure 2: Energy Consumption by Sector, 2008

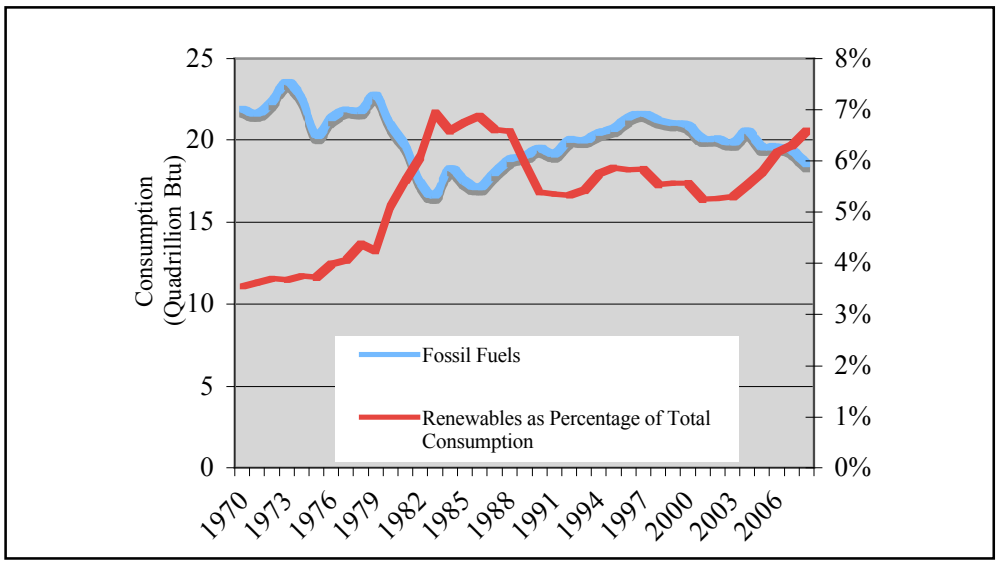


[a]The EIA distinguishes between primary, secondary and tertiary forms of energy. When coal is converted to synthetic gas to produce electricity, for example, coal is primary energy, synthetic gas is secondary energy, and electricity is tertiary energy

[b]British thermal units (Btu) describe the quantity of heat required to raise the temperature of 1 pound of liquid water by 1 degree Fahrenheit at the temperature at which water has its greatest density (approximately 39 degrees Fahrenheit).

Source: EIA: Energy consumption by sector (2008)

Figure 3: Industrial Sector Energy Consumption, 1970-2008



Source: EIA: Energy consumption by sector (2008)

3. Clean Energy Economy

In order to understand how manufacturing workers might fit into the United States' clean energy plan, it is useful to examine the various definitions that have been offered to describe this emerging economy. As outlined below, the clean energy economy is a broad concept that spans a number of industries, and can often result in confusion or disagreement over which subsegments should be included. In order to minimize confusion, several authors have further subdivided it into categories, each of which holds a different job-creation potential. Of these categories, the clean energy generation sector, also known as the renewable energy sector, holds significant promise for rebuilding or redefining American manufacturing jobs. Wind energy and solar energy in particular are growing at above-average rates. This growth, combined with the need for substantial infrastructure requirements at the outset of production, makes wind and solar energy two of the best options for the manufacturing workforce.

3.1. Definition

In order to ensure a sustainable future, founded upon a strong domestic workforce and energy independence, the United States is slowly transitioning towards a clean energy economy. This remains a relatively new concept, with no agreed upon universal definition. Instead, several organizations with an interest in this area offer a description of what they believe constitutes a clean energy economy. The Pew Charitable Trusts, for example, states that "a clean energy economy generates jobs, businesses and investments while expanding clean energy production, increasing energy efficiency, reducing greenhouse gas emissions, waste and pollution, and conserving water and other natural sources." In any case, experts agree that the clean energy

economy must have a positive net energy yield, reduce greenhouse gas emissions compared with other sources of energy, and be produced and distributed in a sustainable and safe manner (Pew Charitable Trusts, 2009).

The Pew Charitable Trusts breaks the clean energy economy into five categories: (1) Clean Energy; (2) Energy Efficiency; (3) Environmentally Friendly Production; (4) Conservation and Pollution Mitigation; and (5) Training and Support (see Table 1: Overview of the Five Clean Energy Economy Categories; for a more thorough overview of subsegments, refer to Appendix A). This paper focuses on the potential for manufacturing job creation within the Clean Energy category (which will also be referred to as "renewable energy"), which includes energy generation, transmission and storage (Pew Charitable Trusts, 2009). Six out of 10 jobs in the renewable energy category result from the generation of energy from clean sources, such as wind and solar (Pew Charitable Trusts, 2009). From this number, it is clear that a clean energy economy holds great potential for employment within the wind and solar energy industries. In fact, the next section reveals that increasing employment through the generation of new jobs or the transformation of existing jobs, is a primary objective of the American government's clean energy agenda. But just how many of these jobs are suitable for manufacturing workers requires further investigation.

Table 1: Overview of the Five Clean Energy Economy Categories

Category	Description
Clean Energy[a]	Jobs, businesses and investments that produce, transmit and store clean, renewable power from solar, wind, low-impact hydro, hydrogen fuel cells, marine and tidal, geothermal and small-scale biopower energy sources.
Energy Efficiency	Jobs and businesses that help Americans reduce the amount of energy we use, whether to run a manufacturing plant or heat and cool an office building or home.
Environmentally Friendly Production	Jobs, businesses and investments that seek to mitigate the harmful environmental impacts of existing products and develop and supply alternatives that require less energy and emit fewer greenhouse gases. Environmentally friendly production comprises six areas: transportation, manufacturing, construction, agriculture, energy production and materials.
Conservation and Pollution Mitigation	Jobs, businesses and investments that enable the United States to manage water and other finite natural resources more effectively and to mitigate emissions of greenhouse gases and other pollutants that result from the continued use of fossil fuels. Also included are efforts to recycle materials used in production processes, which can save energy.
Training and Support	Jobs, businesses and investments that provide specialized services to the other four categories of the clean energy economy.

[a]Will also be referred to as "renewable energy"
Source: Pew Charitable Trusts, 2009

3.2. Goals

An economy founded upon clean energy technologies promises to bring more than environmental benefits to the United States. Experts agree that such a framework addresses environmental, economic and employment issues equally. In the case of the United States, its clean energy agenda has been inspired by a dedication to reduce greenhouse gas emissions, decrease the country's dependence on foreign oil, improve its trade deficit, and perhaps the most widely talked about goal, create American jobs (Global Insight, 2008). Table 2 shows one research team's estimation that although an economy built on renewable energy sources will destroy jobs in the traditional fossil fuel sectors, its overall impact on employment will be positive; creating over one million construction, manufacturing, installation, operations and management (O&M) and processing jobs by the year 2020.

Table 2: Employment Impacts of a 15 percent Renewable Portfolio Standard (RPS) by 2020

	Net Gain/Loss in Jobs by 2020
Overall for all sectors of the economy	+ 1,314,000
Coal mining	– 23,900
Oil and gas mining	– 61,400
Oil refining	– 6,300
Electric Utilities	– 35,100
Natural Gas Utilities	– 26,200

Source: Kammen, Kapadia & Fripp, 2004

3.3. Clean Energy Generation Sectors

As noted earlier, wind energy and solar energy are two of the fastest growing sectors of the American renewable energy industry. In addition to the growth in each segment's energy generating capacity,[1] they have also recorded above-average growth in their respective number of jobs. In order to better understand how this growth in employment might translate to increases in manufacturing jobs, the following section provides an overview of wind and solar energy, and specifically discusses how their components are manufactured.

3.3.1. Wind

Wind energy is a form of converted solar energy. As the sun radiates down, different geographical landscapes absorb its rays at different rates, causing hot air to rise and cooler air to replace it. The kinetic energy created from the movement of this air results in wind energy (AWEA: Wind energy basics, 2009). In order to convert this power into a usable form of energy, a wind turbine must be manufactured. Wind turbines are rotating pieces of machinery, made predominately from steel and typically composed of 20 separate components (Sterzinger & Svcek, 2004). Wind turbines vary in size and corresponding energy generating capacity. In 2008,

[1] Energy generating *capacity* refers to the maximum output, commonly expressed in kilowatts (kW) or megawatts (MW = 1000 kW), that generating equipment can supply to system load, adjusted for ambient conditions. Energy *generation* -- the process of producing electric energy by transforming other forms of energy -- is the amount of electric energy produced, expressed in kilowatthours (kWh) (or megawatthours, MWh). 1 kWh = 3412 Btu. Source: EIA

some 25,369 MW of wind electricity generating capacity produced roughly 52 million MWh of electricity in the United States; during this same period, the average American household consumed roughly 1.5 billion MWh of electricity (AWEA: Wind power outlook 2009; EIA: Annual consumption by sector, 2008). The majority of wind turbines manufactured today have power ratings ranging from 250 watts to 5 MW (AWEA: Wind energy basics, 2009).[2] Not surprisingly, the amount of energy generated by these machines largely depends on the speed of the wind within the area where the turbine is located. Generally, installing a single wind turbine is not considered to be economically viable. Therefore, in order to maximize the efficiency of wind electric turbines, they are installed in groups of large machines, named "wind power plants" or "wind farms" (AWEA: Wind energy basics, 2009).

Wind power is quickly emerging as one of the United States' leading new power generation sources. In 2008, the country increased its installed wind energy capacity by 8,545 MW, corresponding to a 42 percent share of the nation's total new generating capacity (AWEA: Annual wind industry report, 2009). Between 2004 and 2008, wind power grew by an average annual growth rate of 32 percent, propelling the United States ahead of Germany to claim the position as world-leader in wind energy production and in cumulative wind energy power generating capacity. Additionally, the U.S. also was the world's largest market for new wind turbine installations in 2008 (AWEA: Wind power outlook 2009).

3.3.2. Solar

Solar energy can be converted into a usable form of energy through one of three ways: solar photovoltaics (PV); concentrated solar power (CSP); and solar thermal (see Table 3: Overview of Solar Technologies). The majority of solar energy consumption in the United States

[2] The American Wind Energy Association (AWEA) estimates that one MW of wind capacity can serve between 250 and 300 American homes.

comes from solar PV sources, in which semiconducting materials are used to convert sunlight into electricity, and from solar thermal sources, in which energy from the sun is converted into heat for such applications as water heating systems (EIA: Renewable and alternative fuels, 2009).

Table 3: Overview of Solar Technologies

Solar Technology	Description
Solar PV	PV devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material. Electrons in certain types of crystals are freed by solar energy and can be induced to travel through an electrical circuit, powering any type of electronic device.
Concentrated Solar Power	CSP plants are utility-scale generators that produce electricity by using mirrors or lenses to efficiently concentrate the sun's energy. CSP technologies include parabolic trough systems, power towers, compact linear Fresnel, and dish systems, which concentrate the thermal energy of the sun to heat water to drive a conventional steam turbine.
Solar Thermal	Solar power is harnessed to provide thermal (heat) energy, for example to heat water (in homes or pools) or rooms (solar space heating and cooling).

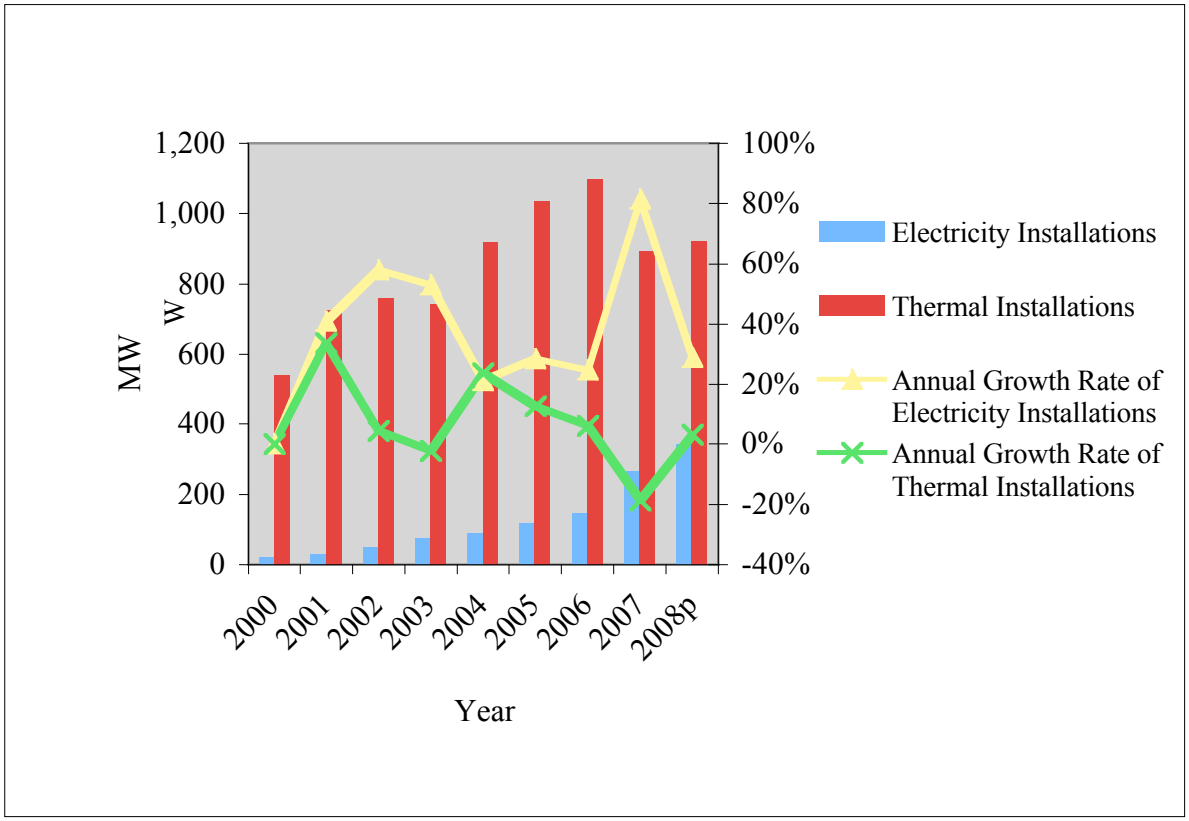
Source: Solar Energy Industries Association: Solar technology & products, 2009

The United States' solar energy industry has managed to grow even amidst the country's financial crisis, with a 29 percent increase in new solar electric installations and a three percent increase in new solar thermal installations in 2008 (see Figure 4: Solar Energy Capacity Additions and Annual Growth Rates). In 2008, the total solar energy generating capacity in the United States was estimated at 9,183 MW.[3] Many analysts believe that the United States is poised to become a world leader in solar energy production, largely due to its favorable climate and existing innovative solar power technologies. The Southwestern United States is already one of the largest destinations for CSP exploitation in the world, with abundant sunshine year-round (Gereffi, Dubay, & Lowe, 2008). This is good news for a clean energy workforce, since the

[3] The Solar Energy Industries Association estimates that one MW of solar electric capacity provides enough electricity to power between 150 and 250 American homes.

expansion of this industry will undoubtedly lead to jobs throughout the value chain, as new plants are constructed, solar energy components are manufactured, and skilled workers are required for the maintenance and operation of new plants.

Figure 4: Solar Energy Capacity Additions and Annual Growth Rates



Source: SEIA: U.S. solar industry year in review 2008.

3.4. Summary

This section outlined how the clean energy economy is a broad concept with no universally agreed upon definition, resulting in occasional confusion or dispute over which technologies and industrial sectors actually qualify as being "clean". Despite this ambiguity, the American government has made it clear that a primary objective of its clean energy agenda is to provide a boost to employment. Not surprisingly, just how much of a boost is expected for the U.S. workforce depends on the forecaster's definition of a "clean energy job". The ensuing

section will clarify the terminology and various classifications used for this emerging section of the labour market.

4. Clean Energy Jobs in the United States

A considerable amount of attention is being drawn to the intersection between employment and environment. Reports outlining the potential for so-called “green jobs”, “clean energy jobs” and “green-collar jobs” in the United States are pouring in everywhere from international agencies to governments, and new organizations are being created specifically to address the profound crisis in the country’s employment and environment sectors. The Blue Green Alliance, for instance, was created as a national, strategic partnership between labour unions and environmental organizations dedicated to expanding the number and quality of jobs in the green economy (Blue Green Alliance, 2009). Unfortunately, the inconsistency in the terminology used to describe the employment opportunities of a “green” or “clean energy” economy often leads to confusion and substantial variation in future job projection numbers. Table 4 outlines the terminology that will be used to discuss employment opportunities in the context of this report, unless otherwise specified.

Table 4: Employment Terminology to be used in the Current Paper

Expression	Description
Green Job	Employment in (1) renewable energy, (2) energy efficiency, (3) conservation and pollution mitigation, (4) environmentally friendly protection, and (5) training and support of the first four categories
Clean Energy Job	
Green-Collar Job	Traditional blue-collar jobs in (1)manufacturing, (2) construction, and (3) maintenance that exist within one of the five clean energy sectors listed above
Renewable Energy Job	Employment within the renewable energy sectors, including wind energy solar energy
Clean Energy Manufacturing Job	Employment in the manufacturing of components used for the generation of renewable energy

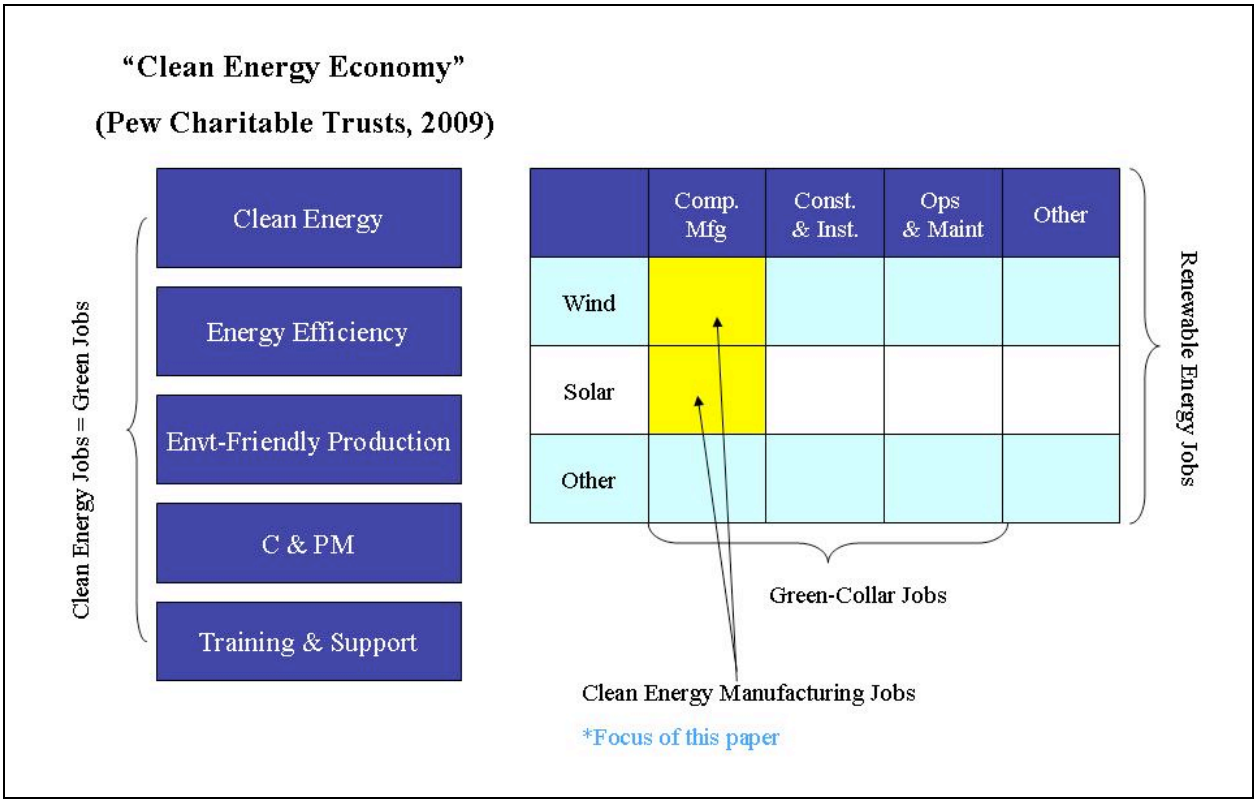
Note: "Green jobs" and "clean energy jobs" will be used synonymously

Many suggest that the pursuit of green jobs will be a key economic driver in the 21st century (United Nations Environment Programme, 2008). Environmental awareness is being increasingly built into companies' business models, as these organizations aim to honour their social responsibilities and improve the environments in which they operate. As the economy becomes greener, large-scale investments are made in new technologies, thus providing a major stimulus to labour markets.

This section provides an overview of green jobs in the United States, with a focus on synthesizing various estimates of the current and future number of green jobs, and relating these to estimates of the future number of clean energy manufacturing jobs (see Figure 5: Illustration of Clean Energy Jobs Studies and Estimation of Clean Energy Manufacturing Jobs). It begins by examining how the term was coined, and how green jobs are created. It then provides a snapshot of current clean energy job numbers in the United States, based on estimates from several different organizations, each of which offers a separate definition of what constitutes a clean energy job. In order to answer this paper's two research questions, this section also broadly examines the transferable manufacturing skills that can be applied in the clean energy economy

to revitalize this workforce. This section then looks at how these skills can be transferred to the wind and solar energy industries in particular, due to the above-average growth rate of these industries and their need for component manufacturing. After establishing *how* the growing renewable energy sector can recreate disappeared manufacturing jobs and redefine existing manufacturing jobs, data will be synthesized to gauge *how many* of these jobs will be created between now and 2020. Finally, this section concludes by outlining research into the negative aspects of clean energy jobs and evaluates the strength of the arguments presented by these researchers.

Figure 5: Illustration of Clean Energy Jobs Studies and Estimation of Clean Energy Manufacturing Jobs



4.1. Definition

Much like the clean energy economy, the concept of green jobs remains in its infancy, and thus lacks a universally accepted definition. The United Nations Environment Programme

(UNEP) defines green jobs as positions in agriculture, manufacturing, construction, installation, and maintenance, as well as scientific and technical, administrative, and service-related activities, that contribute substantially to preserving or restoring environmental quality (United Nations Environment Programme, 2008). The Political and Economic Research Institute (PERI) offers a much simpler definition, stating that a green job is one that is contributing to fighting global warming and building a green economy (Pollin & Wicks-Lim, 2008). The American Solar Energy Society (ASES), on the other hand, considers it more useful to examine green jobs across a broader spectrum. According to this organization, green jobs can be found anywhere from professions that have improved their level of environmental resource degradation or extraction, to professions that have a clear positive impact on the environment (American Solar Energy Society & Management Information Systems, Inc., 2008). Not surprisingly, the level of projected new green jobs varies depending on which definition is being used for analysis.

4.2. Green Job Creation

Movement towards a clean energy economy affects employment in one of four ways: new jobs are created; existing jobs are substituted; existing jobs are eliminated without direct replacement; and existing jobs are transformed and redefined (see Table 5: Employment Impact of a Clean Energy Economy). Although this paper discusses the potential for "new" clean energy jobs, it should be noted that the majority of these are in fact existing jobs that are either substituted or transformed and redefined. That is, these jobs do not require an entirely new and unique set of skills that would require significant investments in employee training programs. Instead, most clean energy jobs build on the existing skill sets of American workers, resulting in an easy transition from "dirty" energy workers to clean energy workers.

Table 5: Employment Impact of a Clean Energy Economy

Employment Impact	**Example**
New jobs are created	Workers are hired to manufacture new pollution control equipment that meet new environmental standards
Existing jobs are substituted	Coal mining jobs are replaced with solar energy jobs
Existing jobs are eliminated	New environmental regulations ban the use of certain packaging materials, eliminating jobs in the production of these materials
Existing jobs are transformed and redefined	A construction worker who has always worked on projects for "dirty" industries is employed to build a solar energy plant

Source: United Nations Environment Programme, 2008

Several reports have examined the effects of substituting existing jobs in the fossil fuel industry with new jobs in renewable energy industries. In all cases, findings indicate that the renewable energy sector generates more jobs per unit of energy delivered (expressed in job-years per Gigawatt hour) than the fossil fuel-based sector (see Table 6: Average Employment for Different Energy Technologies Normalized to the Amount of Energy Produced). In addition to generating more jobs per unit of energy, the renewable energy industry also creates more jobs per dollar invested than the fossil fuel industry (Kammen, Kapadia & Fripp, 2004). Investments made in solar and wind energy yield similar employment results, with 5.65 person-years[4] and 5.70 person-years of employment per million dollar invested respectively (Kammen, Kapadia & Fripp, 2004). Fossil fuels, on the other hand, generate only 3.96 person-years of employment for every million dollars of investment.

[4] A person-year refers to one whole year, or fraction thereof, worked by an employee, including contracted manpower.

Table 6: Average Employment for Different Energy Technologies Normalized to the Amount of Energy Produced

Technology	Total Job-Years per GWh
Solar PV	0.91
Solar Thermal	0.27
Geothermal	0.25
Biomass	0.22
Carbon Capture & Storage	0.18
Wind	0.17
Nuclear	0.15
Coal	0.11
Natural Gas	0.11
Energy Efficiency	0.38

Source: Kammen & Engel, 2009

Looking beyond the jobs directly resulting from a clean energy economy is the promise of indirect jobs 'radiating out' from this sector (United Nations Environment Programme, 2008). The United Nations Environment Programme argues that creating green jobs in the clean energy sector has the potential to impact broader sections of the American economy, which account for a larger proportion of the country's total workforce. By supplying clean energy solutions for businesses, this sector is essentially greening the operations of "dirty" industries, thereby transitioning them into the clean energy economy and redefining their jobs as environmentally friendly. Since the primary focus of this paper is how the wind energy and solar energy industries can impact manufacturing employment, a form of direct employment, the creation of indirect jobs will not be discussed at length in this paper. However, it should be noted that these represent an additional employment benefit of the clean energy economy.

4.3. Current Clean Energy Job Figures

Since there is no universally accepted definition of green jobs or clean energy jobs, employment figures within these sectors of the American labour force vary depending on their source (see Table 7: Summary of Green Jobs Figures from Reviewed Studies, Based on Definition for Green Jobs). A 2009 report released by the Pew Charitable Trusts, for instance,

conducted a conservative analysis of current and future jobs within the clean energy economy. Researchers only examined those workers directly working towards developing clean, renewable sources of energy, increasing energy efficiency, reducing greenhouse gas emissions and conserving natural resources. Based on this framework, the report states that in 2007, a total of 68,203 businesses across all 50 states and the District of Columbia accounted for 770,385 jobs in the clean energy economy (Pew Charitable Trusts, 2009). By contrast, a 2008 study released by the American Solar Energy Society and Management Information Systems, Inc. (MISI) used a more broadly defined clean energy workforce, and found that in 2006, the U.S. clean energy industry employed over 9 million workers both directly and indirectly (American Solar Energy Society & Management Information Systems, Inc., 2008). The conservative estimate put forth by the Pew Charitable Trusts corresponds to only half a percent of the country's total workforce, while that presented by ASES and MISI corresponds to 6.8 percent of the American labour force.

Despite these discrepancies, most researchers agree that the growth of clean energy jobs is currently outpacing growth in the rest of the U.S. labour force, and employment is expected to continue to grow for the foreseeable future. The Pew Charitable Trusts outlines that between 1998 and 2007, clean energy jobs grew by 9.1 percent, while total jobs grew by only 3.7 percent (Pew Charitable Trusts, 2009). This organization anticipates sustained employment growth within the industry through sufficient public and private support. Similarly, ASES and MISI project an approximate 300 percent increase in the number of clean energy jobs by 2030, through aggressive policy implementation and investment (American Solar Energy Society & Management Information Systems, Inc., 2008).

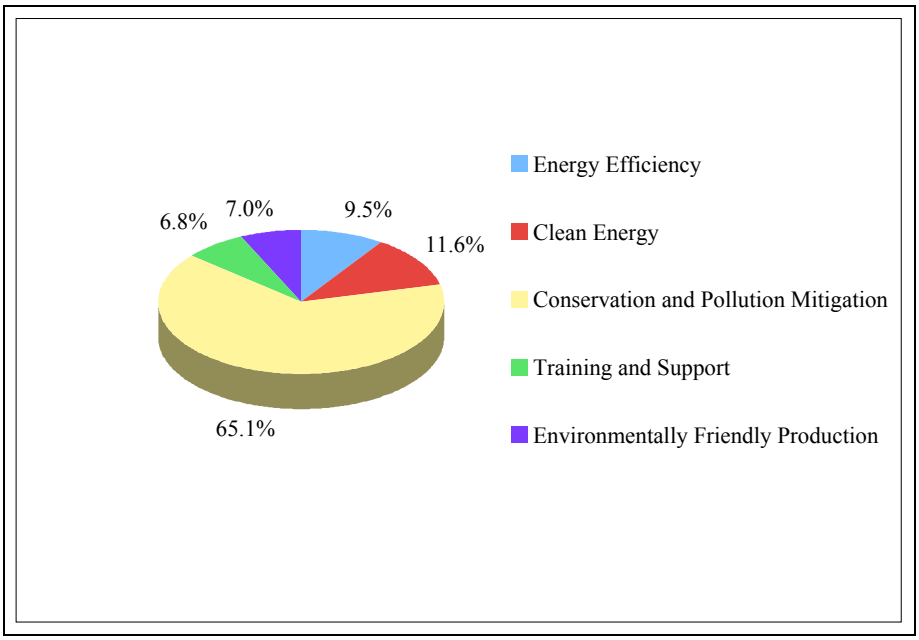
Table 7: Summary of Green Jobs Figures from Reviewed Studies, Based on Definition for Green Jobs

Authors	**Year**	**Green Job Definition**	**Number of Green Jobs (Year)**	**Projected Growth of Green Jobs (Year)**
Kammen, Kapadia & Fripp	2004	Workers directly employed by the renewables sector, holding jobs in construction, manufacturing, installation, O&M and fuel processing	--	Up to 240,850 (2020)
Bezdek	2007	Jobs within the RE&EE industry, created both directly and indirectly, from hydroelectricity, biomass, geothermal, wind, PV, and solar thermal technologies and energy efficiency	(2006) Direct: 3,694,000 Indirect: 4,804,000 Total: 8,498,000	(2030) Base: 16,258,000 Moderate: 20,963,000 Advanced: 40,103,000
The ASES and MISI	2008	Jobs which, as a result of environmental pressures and concerns, have produced the development of numerous products, processes, and services, which specifically target the reduction of environmental impact. Environment-related jobs include those created both directly and indirectly by environmental protection expenditures	9,090,000 (2007)	(2030) Base: 16,258,000 Moderate: 19,504,000 Advanced: 37,206,000
Global Insight	2008	Workers employed in any activity that generates electricity using renewable or nuclear fuels, agriculture jobs supplying corn or soy for transportation fuel, manufacturing jobs producing goods used in renewable power generation, equipment dealers and wholesalers specializing in renewable energy or energy-efficiency products, construction and installation of energy and pollution management systems, government administration of environmental programs, and supporting jobs in the engineering, legal, research and consulting fields	751,051 (2006)	4,214,700 (2038)
UNEP	2008	Positions in agriculture, manufacturing, construction, installation, and maintenance, as well as scientific and technical, administrative, and service-related activities, that contribute substantially to preserving or restoring environmental quality	639,870 (2006)	--
Pew Charitable Trusts	2009	Workers employed in a clean energy economy generates jobs, businesses and investments while expanding clean energy production, increasing energy efficiency, reducing greenhouse gas emissions, waste and pollution, and conserving water and other natural resources	770,385 (2007)	--

Research shows that the majority of jobs in the clean energy economy exist within the area of Conservation and Pollution Mitigation (see Figure 6: Jobs in the Clean Energy Economy by Category, 2007). However, this is considered to be a relatively capital intensive section of the industry, which leads experts to believe that future clean energy job creation will occur in more

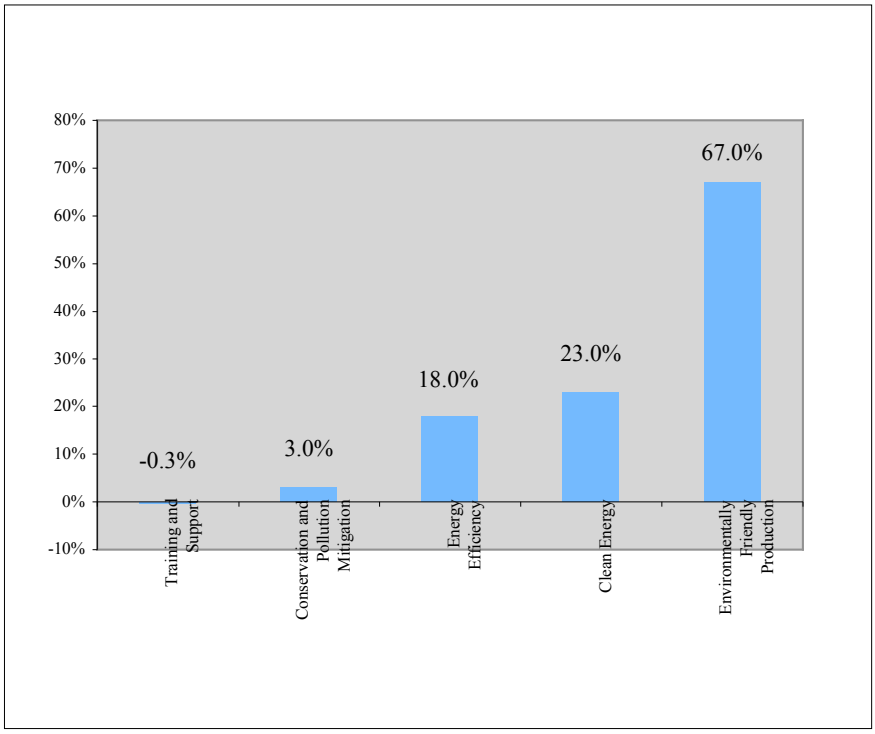
labour-intensive categories that are already recording high growth rates, such as Clean Energy (see Figure 7: Growth of Clean Energy Jobs by Category, 1998-2007).

Figure 6: Jobs in the Clean Energy Economy by Category, 2007



Source: Pew Charitable Trusts, 2009

Figure 7: Growth of Clean Energy Jobs by Category, 1998-2007



Source: Pew Charitable Trusts, 2009

Research shows that the majority of existing renewable energy jobs are in fact indirect. A 2007 study by Bezdek, for instance, found that 56 percent of jobs within the renewable energy and energy efficiency (RE&EE) industry came from indirect sources (Bezdek, 2007). Similarly, a 2008 report released by UNEP also revealed that in 2006, 56 percent of both the wind energy and solar energy industries' workers held indirect jobs (see Table 8: Distribution of Direct and Indirect Jobs in the Clean Energy Economy, 2006). While this means that clean energy manufacturing workers, whose jobs are directly created through investment in renewable sources of energy, currently represent a small portion of the renewable energy workforce, this distribution is expected to change. Up to 80 percent of jobs created from new investments in renewable energy sources are expected to be manufacturing jobs (Apollo Alliance, 2009; Kammen, Kapadia & Fripp, 2004; Sterzinge & Svcek, 2004).

Table 8: Distribution of Direct and Indirect Jobs in the Clean Energy Economy, 2006

Industry Segment	Direct Jobs	Direct and Indirect Jobs
Wind Power	16,000	36,800
Solar PV	6,800	15,700
Solar Thermal	800	1,900
Other Renewables	161,550	372,600
Total, Government	6,900	15,870
Trade and Professional Associations, NGOs	1,500	3,450
TOTAL	193,550	446,320

Source: United Nations Environment Programme, 2008

Evidently, there is no consensus on the absolute number of jobs that currently exist within the clean energy economy. Relative growth figures, however, are much more consistent between publications. Since a primary objective of developing the United States' clean energy economy is to ensure a sustainable, long-term future, it is more useful to examine the potential for growth in clean energy employment.

4.4. Future Clean Energy Job Figures

Much like current clean energy jobs figures in the United States, projections for the growth of green jobs vary according to the definition being used (see Table 7: Summary of Green Jobs Figures from Reviewed Studies, Based on Definition for Green Jobs**Error! Reference source not found.**). The Pew Charitable Trusts, for instance, states that in 2007, jobs in the clean energy economy accounted for 0.49 percent of all jobs within the United States. Although green jobs may appear to represent a relatively small segment of the American workforce, this organization claims that their growth is outpacing overall growth amongst American workers. Between the years 1998 and 2007, employment in the clean energy economy grew by an average of 1 percent per year, while total employment in the United States grew by an average of 0.4 percent per year (Pew Charitable Trusts, 2009). Although specific numbers might vary between studies, the general trend from estimating future growth of green jobs is that employment within this sector is expected to increase, particularly when coupled with aggressive investment in clean energy technologies. Not surprisingly, larger investments yield higher employment figures.

To illustrate this trend, the American Solar Energy Society released a report that aimed to estimate growth in the renewable energy and energy efficiency industries to 2030, based on differing investment scenarios (see Table 9: Employment Impacts of Investing in the RE&EE Industry, 2030). In order to do so, the authors of the study developed three forecasting scenarios: a base case, a moderate scenario, and an advanced scenario. Employment projections for the base case scenario were based on those policies in existence at the time of writing. Under these "business as usual" regulations, the authors believe that renewable energy is unlikely to significantly increase its share of the United States energy market, and jobs within this sector

will suffer as a result, with only 1.3 million new jobs being created in 23 years. The moderate case scenario assumes that moderate incremental policy changes will be introduced by federal and state officials throughout a 20-year period, resulting in 3.1 million new jobs within the clean energy sector. Finally, projections under the advanced scenario were based on the implementation of forward-thinking and aggressive long-term federal and state policies that might propel the United States into a world-leading position within clean energy industries. Under such a scenario, the authors of the report believe that new direct and indirect clean energy jobs could total nearly 8 million by the time 2030 rolls around.

Table 9: Employment Impacts of Investing in the RE&EE Industry, 2030

	Total Jobs Created (Thousands)		
	Base Case	Moderate Case	Advanced Case
RE	1,305	3,138	7,918
EE	14,953	17,825	32,185
Total	16,258	20.963	40,103

Source: Bedzek, 2007

Looking beyond numbers, several researchers have also examined the quality of future clean energy jobs. One of the most promising aspects of this economy is its ability to stimulate job growth across a range of educational and professional backgrounds. Although there is a strong need for high-level managers within the proposed clean energy economy, policymakers are focusing a great deal of attention on its ability to stimulate blue-collar workers. Many analysts see great potential for the generation of green-collar jobs in the manufacturing, construction and maintenance of clean energy products. These are considered to be particularly promising for the future of America's workers because construction and maintenance green-

collar jobs are not easily outsourced, and therefore hold great potential to stimulate domestic economies and workforces (United Nations Environment Programme, 2008). Clean energy manufacturing jobs, however, are much more vulnerable to being outsourced to international markets, since components may easily be shipped to their final destination. Despite this risk, green-collar jobs in manufacturing are thought to be the most likely to repair the damaged U.S. labour force. To better understand how the United States can avoid the outsourcing of clean energy manufacturing jobs, the following section looks at how domestic clean energy manufacturing jobs can be created, and paints a picture of the nature of these jobs in the wind and solar energy industries in particular.

4.5. Clean Energy Manufacturing Jobs

Clean energy represents one of the most promising opportunities for American manufacturing. Large numbers of jobs have been lost by workers who possess transferable skills. If used properly, these skills could help accelerate America's journey towards becoming a leader of clean energy technologies. Experts argue that current or former blue-collar employees in dying industries, such as auto manufacturing, are better off using their manufacturing expertise in emerging industries, such as clean energy. The domestic market for clean energy components, such as solar panels and wind turbines, is projected to grow to $325.1 billion within the next decade (Makower, Pernick & Wilder, 2009). Experts believe that the demand for solar and wind power will continue to expand over the next 20 years, and an anticipated 70 to 80 percent of the new jobs created in those industries will be in the manufacturing sector (Apollo Alliance, 2009; Kammen, Kapadia & Fripp, 2004). In order to capitalize on this opportunity, policies and

programs are required to help transition blue-collar manufacturing workers towards work in the renewable energy job market.

4.5.1. Creating Clean Energy Manufacturing Jobs

Recognizing the inherent opportunity in investing in domestic clean energy manufacturing, a national coalition of labour, business, community, and environmental leaders formed the Apollo Alliance. This think-tank recently released its Green Manufacturing Action Plan ("GreenMAP"), which paves the road for a transition towards a clean energy economy that stimulates green-collar manufacturing jobs. In its report, the Apollo Alliance estimates that $50 billion of federal and private investment in industrial retooling and retraining programs would create 250,000 direct manufacturing jobs in the United States, support an additional 725,000 indirect jobs, and generate as much as $120 billion in revenue (Apollo Alliance, 2009). This organization stipulates that the states most likely to benefit from manufacturing jobs resulting from investments in clean energy technologies are the twenty states that have experienced the greatest manufacturing job losses (Apollo Alliance, 2009).

The Apollo Alliance hopes that laying out a clear roadmap will direct manufacturing workers away from traditionally "dirty" industries and towards industries that use clean energy technologies. Several American companies have demonstrated the viability of such a transition, such as Infinia Corporation in the Pacific Northwest.

4.5.2. Infinia Corp.: Transition towards Green-Collar Jobs

Workers at Infinia Corp., an energy technology company based out of Washington State, have demonstrated the viability of transitioning blue-collar auto manufacturers into green-collar solar energy manufacturers. In early 2009, the company introduced its signature Infinia Solar

System (ISS) after recognizing that the growing number of out-of-work auto manufacturers were rich in transferable work skills that could be successfully used in the manufacturing of clean energy components. The ISS is an innovative dish that looks like a satellite television receiver, but that converts the sun's heat into electricity. The dish is powered by Infinia's Stirling engine, a mechanical device made largely from steel, that converts externally-applied temperature differential into electricity (Infinia Corporation: Infinia Solar System product specification, 2009). This concentrated solar dish system was the first of its kind to be specifically designed for mass manufacturing by American auto manufacturers (Gereffi, Dubay, & Lowe, 2008). This is a perfect example of how the clean energy economy can transform and redesign existing jobs in dirty industries. The ISS is manufactured by workers in existing auto production lines, which in 2008 were underutilized by approximately 21 percent (Gereffi, Dubay, & Lowe, 2008). By diversifying and expanding the product mix for these workers, Infinia is helping to protect their jobs against such variables as a decrease in the consumer demand for cars. The company estimates that its Infinia Solar System has the potential to create as many as 500,000 manufacturing jobs. This is just one example of how the solar and wind energy industries can help reinvent manufacturing jobs. The following section provides a more detailed overview of the kind and number of manufacturing jobs within these renewable energy industries.

4.6. Clean Energy Generation *Manufacturing* Jobs

While several researchers have offered estimates of how many jobs can be created through the development of these technologies, few have examined how employment opportunities within the renewable energy industries will benefit the United States' manufacturing workforce specifically, and none have examined how the present combination of private and public investment might lead to wind and solar energy manufacturing jobs. This

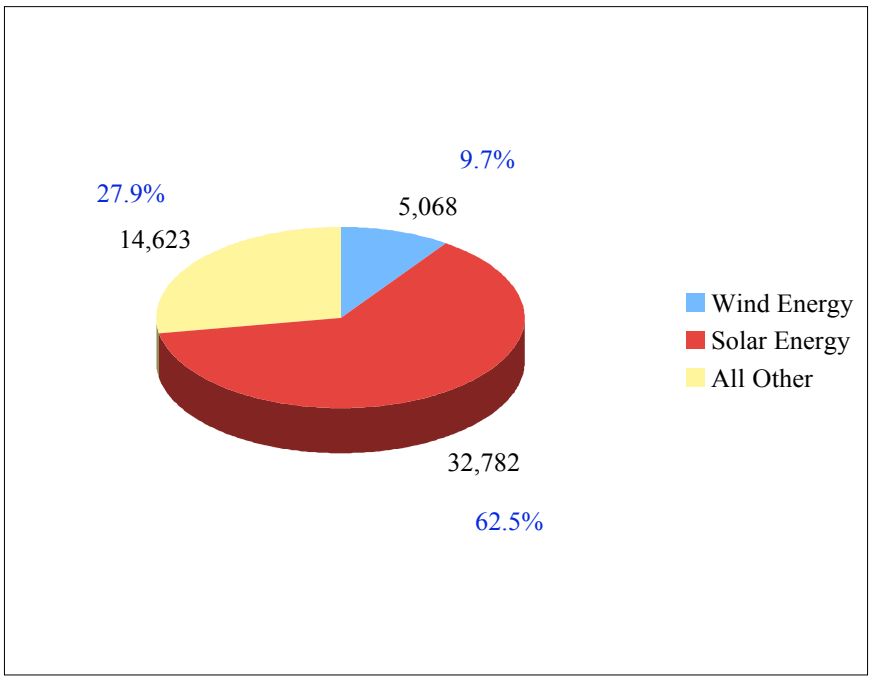
section addresses this paper's two research questions by synthesizing current and future estimates of manufacturing jobs in the wind and solar energy industries. In order to understand how current investments in wind and solar energy technologies in the U.S. might relate to these findings, the following section will provide an overview of public and private investments, and relate these to potential manufacturing employment figures.

4.6.1. Wind Energy Manufacturing Jobs

The United States recently passed Germany to claim the title of world-leader in wind generation capacity (Makower, Pernick & Wilder, 2009). In spite of its growing wind energy segment, the U.S. is not yet considered a leader of wind energy manufacturing. Currently, 80 percent of this activity takes place within the European Union and the majority of turbines and blades used within the U.S. are imported from Europe (United Nations Environment Programme, 2008). However, experts agree that the United States is well positioned to build its wind power manufacturing base, due to its strong scientific and industrial base (United Nations Environment Programme, 2008). Evidently, the country's labour force is not the biggest obstacle preventing it from surging in this sector, but rather its federal support of domestic wind energy development.

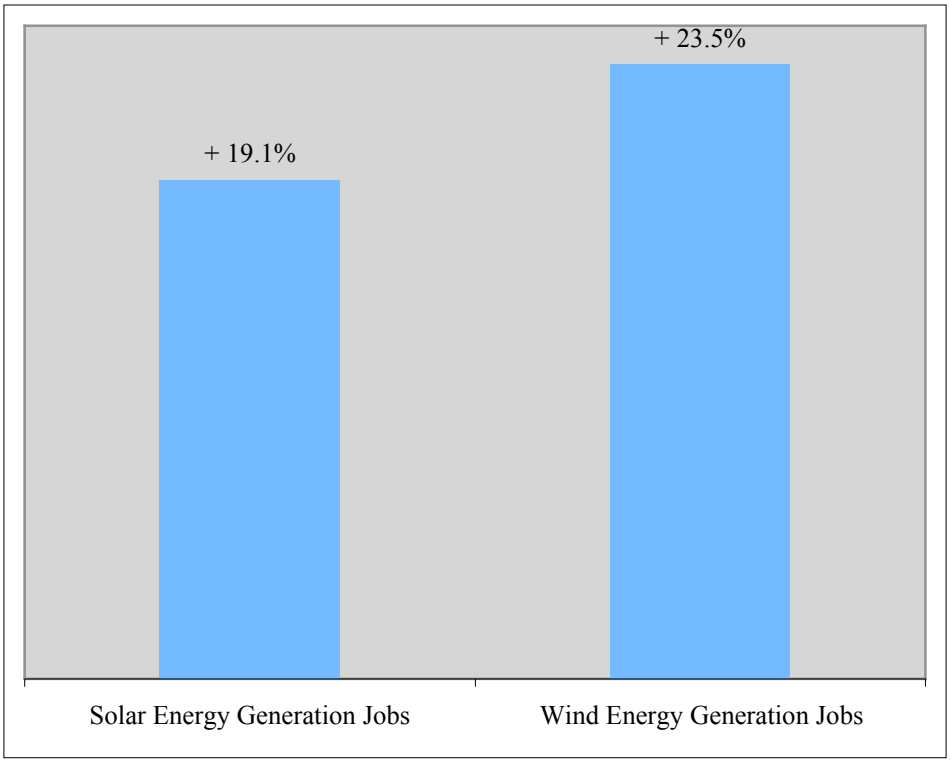
The Pew Charitable Trusts estimates that nearly 10 percent of workers within the renewable energy sector of the clean energy economy are employed by the wind power industry, which according to its own "clean energy" definition, corresponds to just over 5,000 workers (see Figure 8: Renewable Energy Jobs, 2007). Although this number may seem somewhat small, employment data also reveals exceptional growth within this job market, with a 23.5 percent increase between 1998 and 2007. The next largest growth rate was seen in the solar power industry, whose jobs grew by 19.1 percent within the same period (see Figure 9: Change in Renewable Energy Jobs, 1998-2007).

Figure 8: Renewable Energy Jobs, 2007



Source: Pew Charitable Trusts, 2009

Figure 9: Change in Renewable Energy Jobs, 1998-2007



Source: Pew Charitable Trusts, 2009

Skilled manufacturers are particularly critical to the future of the wind energy industry, as manufacturing jobs account for 70 percent of all new jobs resulting from wind energy development. Every 1000 MW of energy supplied by wind requires a corresponding $1 billion investment in its manufacturing components and an additional 3,000 jobs in manufacturing (Sterzinger & Svrcek, 2004). A report released in 2004 reviewed job creation studies within the renewable energy sector and outlined potential job creation for five separate scenarios, each with a different mix of energy sources. Of these forecasts, scenario 3 had the largest proportion of energy supplied by wind, and also had the highest corresponding manufacturing job potential (see Table 10: Comparison of Estimated Job Creation through Different Energy Supply Mixes by 2020). These findings suggest that America's dying manufacturing sector stands to benefit the most from the development of wind energy technologies.

Table 10: Comparison of Estimated Job Creation through Different Energy Supply Mixes by 2020

Scenarios	**Average employment associated with each scenario (jobs)**		
	Construction, Manufacturing, Installation	**O&M and Fuel Processing**	**Total Employment**
Scenario 1: 20% Renewable Portfolio Standard (RPS) by 2020 (85% biomass, 14% wind energy, 1% solar PV)	52,533	188,317	240,850
Scenario 2: 20% Renewable Portfolio Standard (RPS) by 2020 (60% biomass, 37% wind energy, 3% solar PV)	85,008	91,436	176,444
Scenario 3: 20% Renewable Portfolio Standard (RPS) by 2020 (40% biomass, 55% wind energy, 5% solar PV)	111,879	76,139	188,018
Scenario 4: Fossil Fuels as Usual to 2020 (50% coal and 50% natural gas)	22,711	63,657	86,369
Scenario 5: 20% Gas Intensive by 2020 (100% natural gas)	22,023	61,964	83,987

Source: Kammen, Kapadia & Fripp, 2004

In 2004, the Renewable Energy Policy Project (REPP) released a report examining employment in the manufacturing of wind energy components. These authors conducted a state-by-state analysis of current players in the wind energy market, potential players within this

sector, as well as potential employment gains from a 50,000 – 77,000 MW increase in wind energy generation. These numbers were developed from a report produced by the EIA, which estimated that in order to reach RES targets of 10 percent and 20 percent by 2020, the United States would need to up its wind energy capacity to 50,000 MW and 77,000 MW, respectively. Findings from this research indicate that all fifty states stand to gain from increased investment within the wind energy sector, with many of the states hardest hit by manufacturing unemployment standing to gain the most (see Table 11: Top 20 States Benefiting from Wind Investment, with Job Loss Demographics). In fact, the 20 states that stand to benefit the most from wind energy manufacturing jobs, account for 76 percent of total manufacturing job losses between the years of 2001 and 2004. On a national scale, these authors estimate that a $77 billion investment in 77,000 MW of supplemental wind power would result in the creation of 231,000 manufacturing jobs (Sterzinger & Svrcek, 2004).

Table 11: Top 20 States Benefiting from Wind Investment, with Job Loss Demographics

State	Potential New Clean Energy Jobs	Average Investment ($Billions)	Manufacturing Jobs Lost, Jan 2001-May 2004	Rank in U.S.
California	12,717	4.24	318,000	1
Ohio	11,688	3.90	165,500	3
Texas	8,943	2.98	169,600	2
Michigan	8,549	2.85	129,300	8
Illinois	8,530	2.84	131,500	6
Indiana	8,317	2.77	63,500	13
Pennsylvania	7,622	2.54	155,200	5
Wisconsin	6,956	2.32	68,300	10
New York	6,549	2.18	130,500	7
South Carolina	4,964	1.65	56,800	17
North Carolina	4,661	1.55	156,600	4
Tennessee	4,233	1.41	59,700	15
Alabama	3,571	1.19	45,300	19
Georgia	3,532	1.18	65,700	11
Virginia	3,386	1.13	57,500	16
Florida	3,371	1.12	56,800	18
Missouri	3,234	1.08	36,700	23
Massachusetts	3,210	1.07	84,900	9
Minnesota	3,064	1.02	38,800	21
New Jersey	2,920	0.97	65,400	12
20 State Total	120,017	40	2,055,600	
% U.S. Total	80%	80%	76%	

Source: Sterzinger & Svrcek, 2004

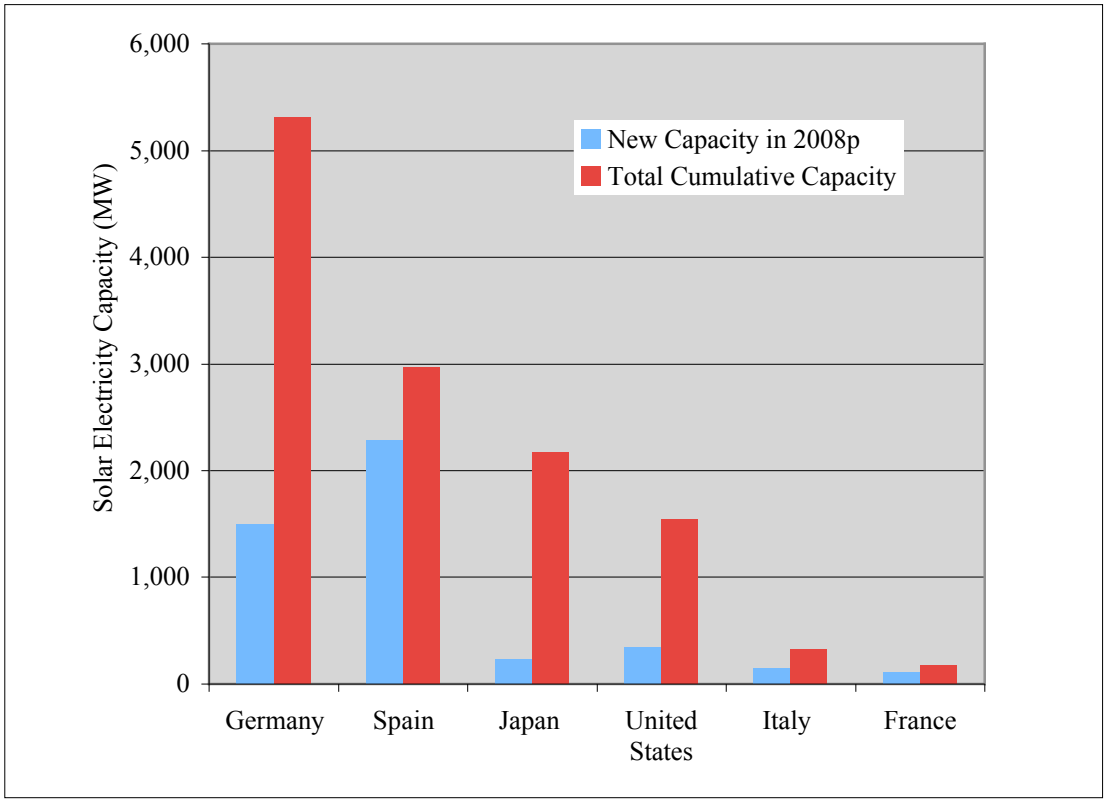
Recognizing the inherent opportunity in this growing industry, the United States Department of Energy (DOE) launched its Wind Powering America program in July 2008, which aims to increase wind energy's contribution to the country's electrical supply to 20 percent by 2030 (U.S. Department of Energy, 2008). Within the next two decades, consumer demand is expected to grow at an annual rate of 1.3 percent. At this rate, significant development is required if supply is to meet demand, thereby resulting in great potential for increased employment within this sector. Estimates presented in the DOE's "20% Wind Energy by 2030" report indicate a wind energy job generation potential of 260,000 jobs per year (U.S. Department of Energy, 2008). This equates to more than 6 million new manufacturing jobs between the years

2007 and 2030, most of which are expected to be located in the areas hardest hit with unemployment (Kammen & Engel, 2009).

4.6.2. Solar Energy Manufacturing Jobs

The solar power sector currently employs the majority of workers within the renewable energy industry, accounting for 62.5 percent of all jobs in 2007 (see Figure 8: Renewable Energy Jobs, 2007). Roughly 80 percent of jobs created from new investments in the solar energy industry are expected to be in manufacturing, while the remaining jobs will primarily be in construction and installation (Sterzinger & Svcek, 2005). In its Clean Energy Trends 2009 report, Clean Edge predicts that markets for the manufacturing and installation of solar energy modules and components will likely grow from $29.6 billion in 2008 to $80.6 billion by 2018 which, according to the Apollo Alliance, would result in a corresponding 255,000 increase in the number of solar energy manufacturing jobs (Apollo Alliance, 2009; Makower, Pernick & Wilder, 2009). The United States currently sits behind Germany, Japan and Spain for the title of the world's largest market for PV electricity capacity (see Figure 10: Solar Electricity Capacity of Leading Countries Worldwide, 2008). In 2005, it was also considered a leader of solar energy component manufacturing, retaining an 8.5 percent share of global production (European Photovoltaic Industry Association & Greenpeace, 2006).

Figure 10: Solar Electricity Capacity of Leading Countries Worldwide, 2008

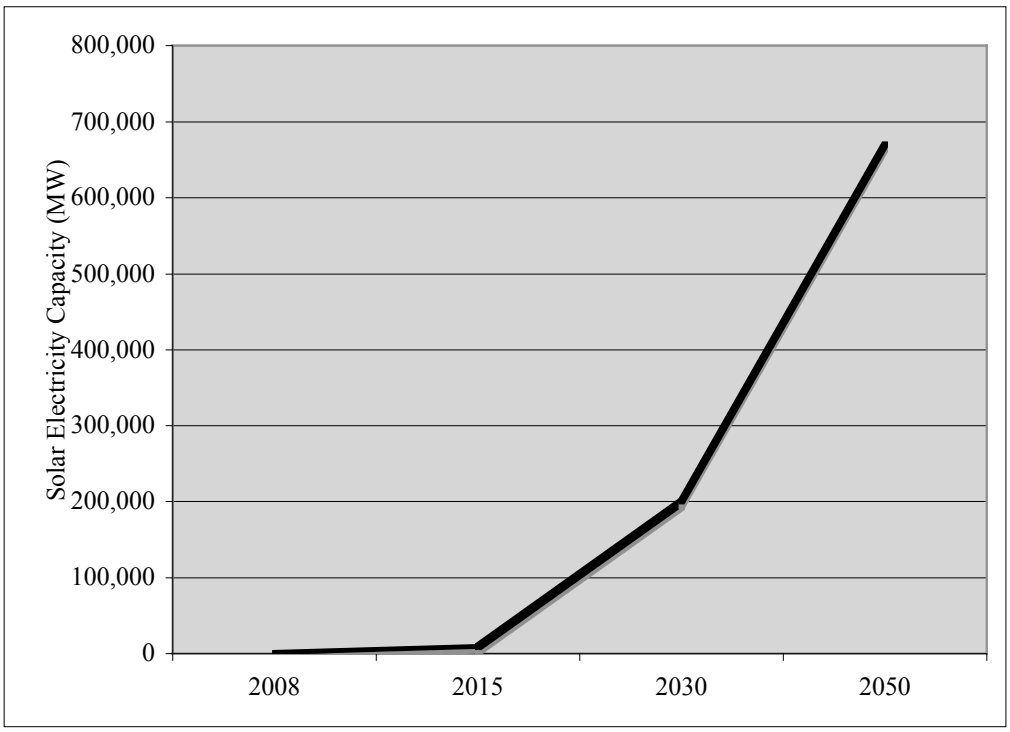


Source: SEIA: U.S. solar industry year in review 2008

The solar energy industry has received much more widespread support from federal, state and local governments than the wind energy industry. The federal government, for example, has been collaborating with private research firms for years, in an effort to expand the solar power industry through increased research and development. In April 2008, the DOE announced a five-year commitment worth $60 million to further the development of low-cost CSP technology (Gereffi, Dubay, & Lowe, 2008). Many of these investments have helped stimulate both economic and employment growth within this industry, with the largest improvements occurring within the solar PV sector. In 2007, U.S. manufacturing of solar PV components increased dramatically, with domestic manufacturers reporting a 74 percent increase in production over 2006 levels. Manufacturing continued to grow in 2008, with a reported 60 percent further increase in production levels (SEIA: U.S. solar energy year in review 2008).

In 2005, the U.S. Solar Energy Industries Association (SEIA) and Renewable Energy Policy Project laid out a "PV Roadmap", which aims to increase the country's solar electricity capacity through the year 2050 (see Figure 11: PV Roadmap for Increased Solar Electricity Capacity, 2008-2050). For their report, researchers conducted a thorough analysis of domestic companies that have the potential to enter the solar PV manufacturing market and mapped out the location of new jobs under the proposed plan. Projections were based on anticipated growth figures of 30 percent per year over the next 20 years within the solar PV industry. The SEIA and REPP predict that such a commitment would require an additional $34 billion investment by 2015 – of which $27 billion would be directed towards the manufacturing sector – and would result in the creation of 42,000 new manufacturing jobs by the same year. By 2050, this roadmap would result in a 280,000 increase in total solar PV manufacturing employment (see Table 12: Anticipated Employment Effects of a PV Roadmap, 2015-2050). By contrast, failure to expand the American solar industry through increased investment and higher renewable energy targets would result in the creation of only 8,000 new jobs within this same period. Similar to the wind industry, the REPP's report shows that the solar industry holds the potential to revitalize the country's dying manufacturing workforce, since the 20 states that would receive the bulk of investment funds account for 75 percent of recent manufacturing job losses (Sterzinger & Svcek, 2005).

Figure 11: PV Roadmap for Increased Solar Electricity Capacity, 2008-2050



Source: Sterzinger & Svcek, 2005

Table 12: Anticipated Employment Effects of a PV Roadmap, 2015-2050

Year	Total Employment (Thousands)		Manufacturing Employment (Thousands)	
	Baseline	Roadmap	Baseline	Roadmap
2015	28,000	62,000	22,400	49,600
2030	59,000	260,000	47,200	208,000
2050	95,000	350,000	76,000	280,000

Source: Sterzinger & Svcek, 2005

4.6.3. Summary

Publications examining future clean energy manufacturing jobs within the wind and solar energy industries present a range of potential job creation estimates. The discrepancy results from differences in the federal RES or RPS targets used for analysis, the timeline for reaching

such standards, as well as the relative mix of electricity supplied by either wind or solar energy. By the year 2030, wind energy manufacturing employment is expected to see an increase of as many as 6 million jobs, while solar PV manufacturing alone is expected to create up to 280,000 jobs by the year 2050. Although these projections sound encouraging for the future of America's manufacturing workforce, not everyone agrees with a clean energy agenda's ability to positively impact employment.

4.7. Criticism of Clean Energy Jobs

The promise of a clean energy workforce is not universally acknowledged. While many policymakers, researchers and labour organizations support investment in the clean energy economy in order to promote job growth, others remain skeptical of its ability to stimulate employment. Critics primarily argue against clean energy jobs for two reasons. Firstly, they state that creating new jobs or transforming existing jobs is a costly process, without enough benefits to make this employment shift worthwhile. Secondly, they argue that the total jobs destroyed through investment in clean energy jobs outnumber the total jobs created, resulting in a shrinking workforce and higher unemployment rates.

4.7.1. High Cost

Critics argue that the transition towards a workforce of clean energy workers will involve time-consuming and expensive employee training programs, thereby resulting in costs that outweigh total benefits to society. One downside is that funding such programs will likely increase federal debt, which ultimately costs taxpayers. Furthermore, some believe that government spending on green jobs training results in indirect financial costs to both individuals and businesses. Critics point out that spending on renewable electricity tends to raise the price of

power, since wind- and solar-power plants cost more to build and run than coal-fired ones. Extensive government borrowing also makes it harder for businesses to raise money ("The grass is always greener", 2009).

A study by the American Solar Energy Society reveals that transitioning towards green jobs is in fact a relatively low-key process involving minor changes to existing roles, and does therefore not require extensive training, financed through government spending. The study states that "the vast majority of the jobs created by RE&EE are standard jobs for accountants, engineers, computer analysts, clerks, factory workers, truck drivers, mechanics, etc. In fact, most of the workers employed in these jobs may not even realize that they owe their livelihood to RE&EE." (American Solar Energy Society & Management Information Systems, Inc., 2008). This smooth transition is expected to hold true for the manufacturing workforce as well. As stated earlier, the majority of clean energy manufacturing jobs will result from the transformation and redefinition of existing jobs, thereby requiring minimal investment of time and money for worker training programs.

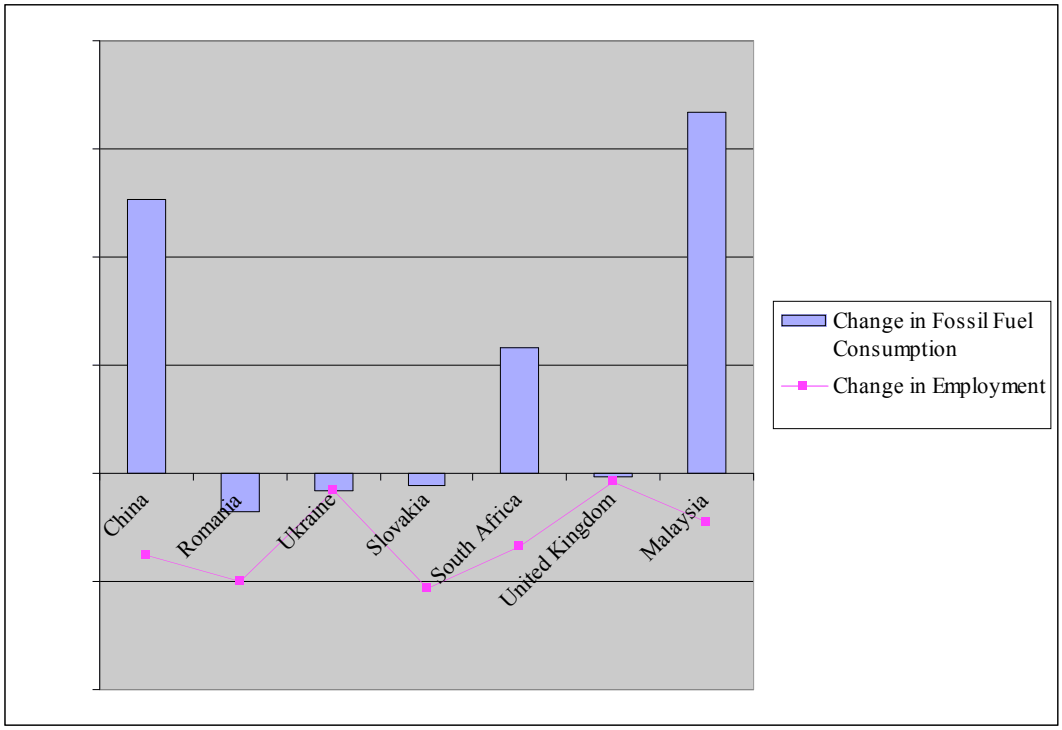
In examining the financial cost of transitioning workers into the clean energy economy labour market, many critics suggest that federal money in particular is better spent on a carbon capture and storage (CCS) federal program. CCS describes the removal of carbon dioxide directly from industrial or utility plants and subsequently storing it in secure reservoirs (Herzog & Golomb, 2004). However, this argument only considers the promotion of clean energy jobs as a means to mitigate the negative effects of climate change. While a clean energy workforce improves the physical environment, it also offers the larger benefit of reducing unemployment rates and directing the United States labour market towards long-term sustainability. Federal investment in CCS is considered less favourable from a job creation perspective, since research shows that this type of program has a lower job multiplier compared to the average job multiplier for renewable

energy technologies (see Table 6: Average Employment for Different Energy Technologies Normalized to the Amount of Energy Produced).

4.7.1. Job Destruction

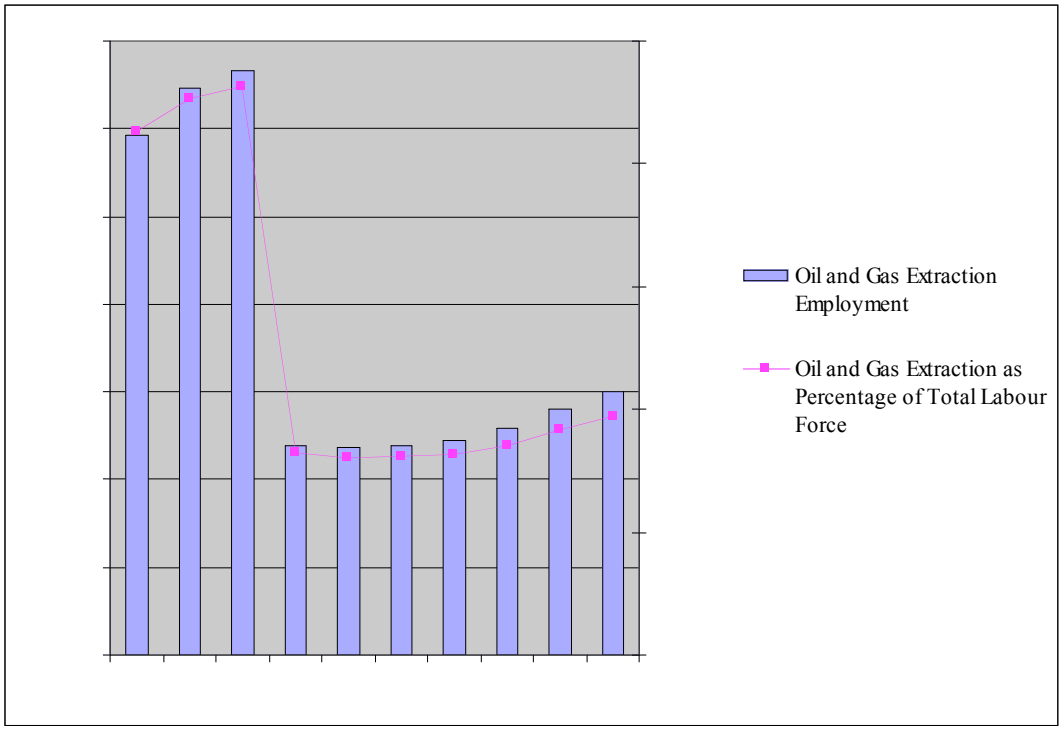
Building a clean energy workforce threatens to eliminate existing jobs without direct replacement. This is particularly true for workers within the traditional fossil fuel industries, since an increase in the United States' supply of clean energy will inevitably result in a corresponding decrease in its supply of coal, natural gas and oil, which will negatively impact employment. However, as a rule of thumb, extractive industries do not employ many workers. In an effort to keep labour costs low, there has been increasing mechanization within global extracting industries over the past several years, which has a corresponding negative effect on employment figures. Global employment within mining extraction industries has decreased even with considerable upward shifts in fossil fuel consumption, as Figure 12 illustrates through examples of countries with substantial mining sectors. Although the United States has recently experienced a slight increase in oil and gas extraction employment, this sector continues to represent a minor portion of the country's total employed labour force (see Figure 13: United States Oil and Gas Extraction Employment, 1999-2008). Furthermore, employment within mining and natural resource extraction is expected to decrease by two percent annually through the year 2016, while total employment within the country is expected to grow by one percent annually during the same period (U.S. Bureau of Labor Statistics,: Industries at a glance: Natural resources and mining, 2009). A similar trend exists within the United States' oil-refining workforce, as over 40 percent of these jobs disappeared between 1980 and 1999 (Kammen, Kapadia & Fripp, 2004).

Figure 12: Mining Employment in Selected Countries Compared with Average Fossil Fuel Consumption, 1996-2006



Note: Includes coal and metals mining and oil and gas extraction jobs.
Source: United Nations Environment Programme, 2008

Figure 13: United States Oil and Gas Extraction Employment, 1999-2008



Source: Bureau of Labor Statistics: Employment by major industry sector, 2009

To further support the notion that investment in clean energy jobs can do more harm than good in an employment context, a group of Spanish researchers released a study in 2009 that examined the effects on employment of government spending on renewable energy technologies. This research was sparked by President Obama's unveiling of the American Recovery and Reinvestment Act (ARRA), which allocated a significant amount of federal funds to developing its renewable energy sources, in an attempt to model commitments made by other "leading" countries in this sector, such as Spain. The authors point out that in the interest of job creation, the United States government should avoid similar policies to those of its Spanish counterparts, as this country's federal contributions to the renewables sector has actually destroyed 2.2 jobs for every one that it has created in the clean energy economy (Alvarez, 2009). This conclusion is based on the authors' analysis of how the Spanish government's contributions to green job subsidies could have otherwise been spent in the economy, and the estimated employment impacts of such alternative spending. Through two separate analyses, which compared federal contributions to green job creation to the average stock of capital per worker and the annual productivity of workers, these researchers deduced that such spending in fact has negative employment effects. Although useful to compare federal policies amongst industrialized countries, the argument presented in this report is weak for several reasons. First, it fails to account for the indirect job creation potential that results from increased public investment in the renewable energy sector. Second, it only considers how *direct* government spending might affect the American workforce, rather than analyze how a wider scope of government aid – in the form of tax incentives, for instance – might affect employment. And third, it does not take into consideration the United States' existing manufacturing workforce and infrastructure, which is poised for higher productivity rates and lower upfront capital costs.

As shown in the previous section, the allocation of public funds is often at the centre of debates over the promise of clean energy jobs. The following section examines why investments by the federal government are so integral to such a shift in employment, and provides an overview of how private sector investments might also impact this movement.

5. Clean Energy Investment in the United States

In the 1970s, the vast majority of capital inflows to clean energy technology companies were in the form of government research and development (R&D) projects (Pernick & Wilder, 2008). Nowadays, public investment is no longer exclusively directed at stimulating product innovation through R&D funding. Instead, the United States government is diversifying its spending and federal policies to target other segments of the clean energy economy, such as employment. This section shows how the federal government is trying to foster the growth of the clean energy manufacturing job market in two ways: through direct public spending; and through the implementation of federal policies that provide incentive for investment by the private sector.

New investments are good indicators of current or future growth within an industry, and are almost always accompanied by increases in employment. It is therefore important to consider how the flow of capital within renewable energy industries will impact future job creation. Government policies are equally important to consider in estimating how the American manufacturing workforce will benefit from a clean energy agenda. For example, the previous section showed how influential RES and RPS targets are for stimulating employment in wind and solar energies. Before evaluating whether disappeared manufacturing jobs can be recreated or existing manufacturing jobs can be redefined by the wind and solar energy industries, current federal policies will be discussed.

5.1. Public Sector

The United States government has long been criticized for its unwillingness to acknowledge the realities of climate change and to diversify its energy sources. However, in the wake of environmental and economic crises, the United States government appears to be

changing its position with respect to clean energy as a means towards a sustainable future. Federal policymakers have taken considerable steps to reduce the country's reliance on foreign oil, to minimize its carbon footprint and to revamp the American workforce. Since 2007, the government has committed itself to transition from an energy-intensive, dirty economy, to a labour-intensive, clean economy through investments in green jobs training, the development of renewable energy technologies, and the implementation of renewable electricity standards. Three legislative pieces in particular, the Green Jobs Act of 2007, the American Recovery and Reinvestment Act of 2009 and the American Clean Energy and Security Act (ACESA) of 2009, are integral to the future of a United States built on clean energy and a strong workforce.

5.1.1. Green Jobs Act (2007)

The Green Jobs Act was introduced as a part of the 2007 Energy Bill, and was designed to increase the number of American workers who are qualified to work in the clean energy economy. This Act, currently in its trial stages, allocates federal money towards the gathering of labour market statistics and the development of curriculum and job training in and for the renewable energy and energy efficiency industries (Green for All, 2009; see Appendix B for a more detailed overview). However, critics are quick to outline that the $125 million fund is insufficient to adequately address workforce issues within clean energy industries. Many organizations, such as Green For All and the Apollo Alliance, recommend at least doubling this investment and creating a federal program to direct funds administered under the Act toward the development of skill standards, training, and clear pathways for advancement for all current and expected workers in the renewable energy equipment and component manufacturing industries (Apollo Alliance, 2009).

5.1.2. American Recovery and Reinvestment Act (February 2009)

On February 17th, 2009, President Barack Obama signed into law the ARRA, a $787 billion stimulus package which aimed to, amongst other goals, enhance the United States' energy independence and stimulate its struggling labour force (Pollin, Heintz & Garrett-Peltier, 2009). Mr. Obama was very clear in his belief that the ARRA holds the potential to solve his country's economic crisis by creating or protecting 3.5 million jobs over the next two years (Recovery.gov, 2009). The Act was intentionally designed to stimulate employment opportunities for domestic workers by investing in industries based on America's resources, ingenuity and workers, and by making it difficult for beneficiaries to outsource these new jobs (Recovery.gov, 2009). The ARRA provides a boost to American steelworkers, for example, by requiring the use of domestic steel, iron and manufactured goods in public works.

Total environmental spending in the ARRA amounts to roughly $100 billion, which will be allocated to nine sectors through five different types of funding: direct public spending, grants, tax incentives, loan guarantees, and bonds. The largest investments are to be made in the development of renewable energy technologies, with $25.3 billion committed to this sector. Since only $27.6 billion of the total $100 billion of federal money will be allocated as direct public spending, the government hopes that the remaining $72.4 billion will be enough incentive to stimulate private-sector investments and investments by local and state governments (Pollin, Heintz & Garrett-Peltier, 2009). Based on this incentive program, a report by PERI and the Center for American Progress estimates that private-sector and state/local government investments could total up to $180 billion over a five-year period (Table 13: Environmental Spending Through the ARRA ($Million).

Table 13: Environmental Spending Through the ARRA ($Million)

Type of Funding	Direct Public Spending	Grants	Tax Incentives	Loan Guarantees	Bonds	Total
Federal Spending						
Renewable Energy	$2.5	$2.3	$16.0	$4.0	$0.6	$25.4
Energy Efficiency	7.2	14.4	2.0	0.0	0.8	$24.4
Transportation	0.6	20.1	2.1	0.0	0.3	$23.1
Grid	6.6	4.4	0.0	2.0	0.0	$13.0
Nuclear Decontamination	6.0	0.0	0.0	0.0	0.0	$6.0
Fossil		3.4	0.0	0.0	0.0	$3.4
Science	1.6	0.0	0.0	0.0	0.0	$1.6
Other	2.3	0.7	0.0	0.0	0.0	$3.0
Government Admin	0.8		0.0	0.0	0.0	$0.8
Total	$27.6	$45.3	$20.1	$6.0	$1.7	$100.7

Source: Pollin, Heintz & Garrett-Peltier, 2009

Ninety percent of federal contributions through the ARRA are scheduled for issuance between 2009 and 2014 (Pollin, Heintz & Garret-Peltier, 2009). However, analysts believe that the boost in private-sector investment will be delayed, given the length of time required to apply for and receive federal money. Significant increases in private investments are not expected until 2010, which means that job creation could be delayed even beyond this point.

5.1.3. American Clean Energy and Security Act (June 2009)

On June 26th, 2009, the American House of Representatives passed a historic climate change bill, moving the American Clean Energy and Security Act to the Senate. The bill stipulates a variety of standards, regulations, and restrictions governing energy efficiency and carbon emissions. It was designed to strengthen the American workforce and revitalize the American economy through establishing energy security, reducing greenhouse gas emissions, and creating millions of green jobs (Green for All, 2009). The bill includes an $860 million allocation to the Green Jobs Act – a significant boost over the $125 million that was originally granted to this program. This increase reflects a federal response to public opinion and highlights

the influential role that the American public will have in the development of future clean energy policies. Particular focus is being paid to salvaging the country's manufacturing sector. The bill promises significant investments in updating manufacturing plants and providing blue-collar workers with new skills for clean energy manufacturing technologies (Broder, 2009; "House passes landmark climate change bill", 2009).

The ACESA is meant to act as a roadmap for the American government's new clean energy policies. At the foundation of the ACESA are two provisions that are believed to hold significant job-creation potential. The first is a cap-and-trade program that aims to reduce carbon emissions by explicitly limiting conventional fossil fuel production and consumption (Pollin, Heintz & Garret-Peltier, 2009). The second is a renewable energy electricity standard that would require electric utilities to meet 20 percent of their electricity demand through renewable energy sources and energy efficiency by 2020 ("House passes landmark climate change bill", 2009).

5.1.3.1. Cap-and-Trade Program

The ACESA's carbon cap-and-trade system provides a schedule for reducing greenhouse gas emissions through the year 2050. This program would impose costs on businesses that fail to meet carbon emissions requirements by the specified deadlines, and would reward businesses that successfully integrate clean energy solutions into their everyday operations. The program has two implications for employment. First, it might destroy jobs within companies that fail to meet these emissions standards, and thus face higher costs. However, the American government hopes that this system will instead stimulate job growth by encouraging companies to subscribe to renewable energy electricity, thus expanding these industries and creating employment opportunities.

5.1.3.2. Renewable Energy Electricity Standard

Research by the Political Economy Research Institute suggests that in order to meet an RES of 20 percent by 2020, the United States would have to see a $30 billion annual increase in investment in clean energy (Pollin, Heintz & Garret-Peltier, 2009). Based on employment estimates by the Apollo Alliance, presented above, this could result in up to 150,000 full-time clean energy manufacturing jobs per year, resulting in the creation of 1.65 million clean energy manufacturing jobs by the year 2020. A report out of Berkeley was recently released in response to the new federal RES targets. These authors present similar numbers, estimating that this federal policy will produce more than a million additional jobs than if all of the United States' energy was supplied by fossil fuels (Kammen & Engel, 2009).

5.2. Private Sector

Private capital, whether in the form of corporate investments, venture capital (VC), debt equity or the public stock markets, is considered critical to the growth of an emerging sector (Pernick & Wilder, 2008). The majority of studies relating private sector investments to the creation of green jobs specifically examine the role of VC money.

5.2.1. Venture Capital

When calculating job growth potential within industries, it is useful to examine the flow of venture capital money. Generally speaking, inflows of venture capital investments are reflective of innovation and growth within an industry, which implies job creation through association. A 2004 report published by the Natural Resources Defense Council and Environmental Entrepreneurs suggests that for every $100 million devoted to venture capital investments within clean-tech, 2,700 jobs are created (Burtis, 2004).

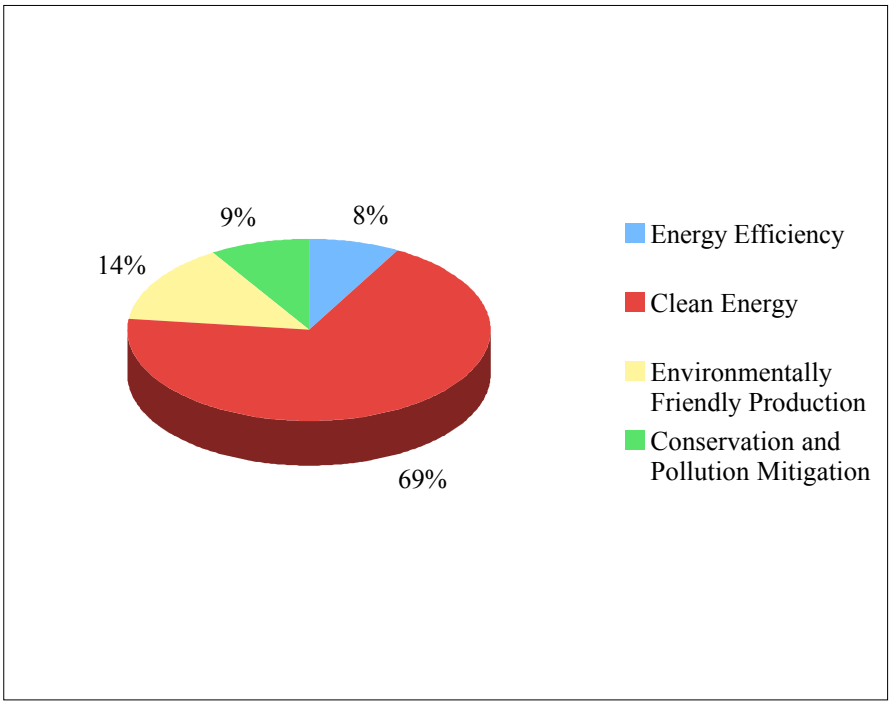
Since 2006, venture capital investments in businesses that are integral to the clean energy economy have jumped by an annual average of $1.6 billion (Pew Charitable Trusts, 2009). In 2008, clean venture capital investments accounted for 15 percent of all global venture capital investments, up from just one percent in 2000 (Pernick & Wilder, 2008; Pew Charitable Trusts, 2009). Clean tech is now considered one of the largest VC investment sectors, and in 2006, was projected to grow by 56 percent before 2009 (Pernick & Wilder, 2008). Although private investment numbers were down in the clean-tech sector during the recessionary period of 2009, it is expected that this sector fared better than the venture capital market as a whole, which saw a 61 percent decrease in investments during the first quarter of 2009 (Pew Charitable Trusts, 2009).

On a national level, U.S.-based VC investments were up 22 percent in 2008, and American clean energy businesses received $5.9 billion in total investments; a 48 percent increase over 2007 investment totals (Makower, Pernick & Wilder, 2009; Pew Charitable Trusts, 2009). Perhaps more encouraging is the fact that venture capital investments in the domestic clean energy economy outnumbered international investments (Pew Charitable Trusts, 2009), suggesting that the United States' clean energy economy is outpacing that of other countries' and domestic jobs are likely to result.

Of the five categories within the clean energy economy, Clean Energy attracts the most venture capital money, accounting for 69 percent of all clean venture capital investments between 2006 and 2008 (see Figure 14: Areas of VC Investment Within the Clean Energy Economy, 2006-2008). The generation of energy from renewable sources, such as wind and solar, accounts for over half of clean venture capital investments, totaling 54 percent of all private financing during this same time period. Combining manufacturing employment figures

presented in the previous section, with VC data outlined above, approximately 60,000 to 69,000 clean energy manufacturing jobs should have been created in the wind and solar energy industries in 2008.

Figure 14: Areas of VC Investment Within the Clean Energy Economy, 2006-2008



Source: Pew Charitable Trusts, 2009

This section demonstrates how the creation of clean energy manufacturing jobs largely depends on investments from the private sector. Without private contributions, the wind and solar energy industries are unlikely to experience sustainable growth that will secure long-term employment for the country's manufacturing workers.

Now that investment numbers, renewable energy industry profiles, employment figures and policy details have been laid out, the ensuing section will combine this information to address this paper's two research questions and draw conclusions for how American manufacturing workers might transition into the wind and solar energy industries.

6. Implications for Manufacturing Workforce and Conclusions

As described in the previous five sections, the creation of manufacturing jobs within the wind energy and solar energy industries depends on a number of factors: federal policies; direct government spending; incentive programs that stimulate local and state governments as well as the private sector; and investment in renewable energy industries from private sources. The studies reviewed in these sections present an array of estimated future employment numbers for green jobs in general, and more specifically for clean energy manufacturing jobs. In order to better understand how these findings might combine with current government policies to stimulate employment in the United States' shrinking manufacturing sector, this section creates an estimate of how many jobs will be created in the manufacturing of components in the wind energy and solar PV energy industries. Calculations are based on two key assumptions: (1) a 20 percent RES by the year 2020, as stipulated in the ARRA; and (2) an increase in energy generation capacity proportional to the projected increase in an industry's revenues.

The estimates presented in Figure 15 are considered conservative, since the model used does not consider a number of factors that might influence job creation, including:

- **Direct spending through the ARRA**. The current draft of the ARRA stipulates a $25.3 billion commitment to renewable energy. However, wind and solar energy are not the only renewable sources of energy that will benefit from this allocation of federal funds. Since there is no way of knowing exactly how these funds will be allocated by sector, it is not included in the current model.

- **The private sector's response to investment incentives provided by the ARRA**. Because these incentives reward investment in emerging technologies and new programs, it is impossible to estimate how the private sector will respond. Moreover, it is anticipated that the issuance of federal ARRA funds will be delayed until at least 2015 (Pollin, Heintz & Garrett-Peltier, 2009).

- **Manufacturing of components for solar thermal and CSP technologies.** No researchers have examined how manufacturing workers in particular will benefit from increased investment in these areas. Instead, the presented estimate is based on increased activity in the manufacturing of solar PV components.

- **The United States' evolving share of world wind energy and solar energy markets.** While many proponents of the United States' clean energy agenda believe that it will enable the country to increase its share of global wind and solar markets, estimating this increase is beyond the scope of this paper. It is therefore assumed that the U.S. will maintain a constant share of global solar and wind energy markets.

Figure 15: Estimated Impact of a 20% RES by 2020 on Manufacturing Jobs in the Wind and Solar Energy Industries

	Wind Energy	Solar PV Energy
Expected Increase in Revenues[1]	204.7%	206.8%
Corresponding Increase in Energy Generation Capacity[2]	51,922 MW	18,986 MW
New Manufacturing Jobs/ Independent Variable	3,000/ 1,000 MW[3]	10% increase/ Year[4]
Estimated New Manufacturing Jobs	155,766	79,881

[1]From Makower, J., Pernick, R. & Wilder, C. (March 2009) *Clean energy trends 2009*. Clean Edge Report, San Francisco, CA.

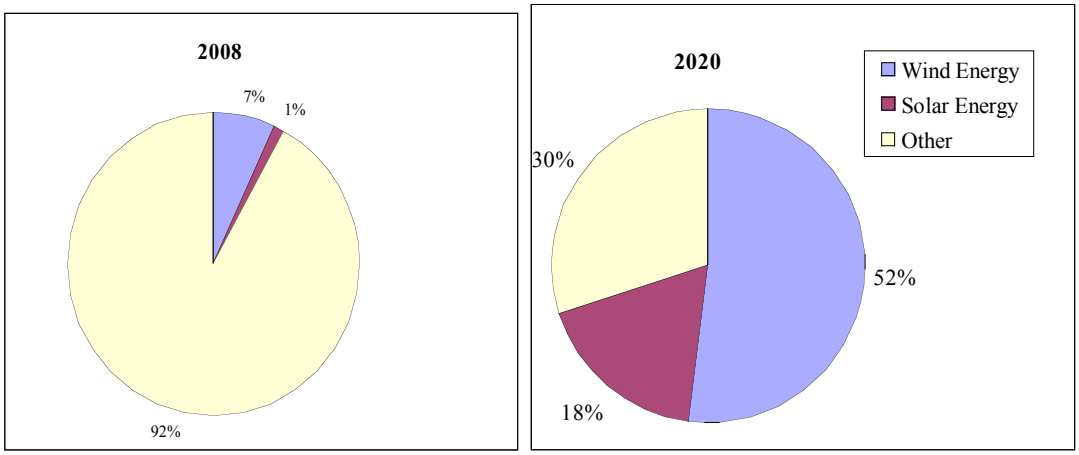
[2]Calculated from: (2008 energy generation capacity)*(Increase in revenues)

[3]From Sterzinger, G. & Svcek, M. (September 2004) *Wind turbine development: Location of manufacturing activity,* Renewable Energy Policy Project Technical Report.

[4]Based on 30% annual growth in the manufacturing of PV components. From Sterzinger, G. & Svcek, M. (January 2005) *Solar PV development: Location of economic activity*. Renewable Energy Policy Project Technical Report.

A report by PERI and the Center for American Progress anticipates that the United States' renewable energy sector will need to increase its energy generation capacity by 104,000 MW in order to meet the ARRA's 20 percent RES target by the year 2020 (Pollin, Heintz & Garrett-Peltier, 2009). Based on this number, the expected increase in energy generation capacity for the wind and solar PV energy industries, as outlined in Figure 15, would correspond to an electricity mix made up of 52 percent wind energy and 18 percent solar PV energy (see Figure 16: Electricity Mix of the United States' Renewable Energy Supply, 2008 and 2020). These ratios are substantially higher than those from 2008, which is consistent with growth estimates for these industries presented earlier in this paper.

Figure 16: Electricity Mix of the United States' Renewable Energy Supply, 2008 and 2020



The model used in this section suggests that a conservative estimate for the creation of clean energy manufacturing jobs is approximately 235,000 by the year 2020. This does not seem like much, considering the United States' saw over 200,000 manufacturing jobs disappear in January 2009 alone (Apollo Alliance, 2009). While the development of wind and solar energy technologies might not create as many *new* manufacturing jobs for former manufacturing workers in the United States, there appears to be tremendous potential for transforming and redefining *existing* manufacturing jobs. With a new federal commitment to merging the economy and the environment, many of the country's dirty manufacturing industries are likely to experience decreases in production. However, this shift in production does not necessarily have to be accompanied by a corresponding decrease in employment. As demonstrated by solar manufacturers at Infinia Corp., there is great potential to capitalize on the underutilization of both personnel and capital assets within these industries, and transition manufacturing employees towards work in the clean energy economy.

The successful transition of blue-collar manufacturing workers towards work in green-collar positions is somewhat influenced by federal training programs and manufacturing labour unions, which sometimes have the ability to create green-collar employment opportunities for

their members. However, businesses competing in the solar and wind energy industries also need to recognize the value of a manufacturing workforce known for exceptional productivity rates, and an American economy that is increasingly moving away from dirty industries, and towards cleaner ones.

7. Recommendations for Key Stakeholders

A long-term commitment to a clean energy economy that stimulates the domestic manufacturing labour market requires action on behalf of several groups within the United States. Government, businesses, educational institutions, workers and consumers are integral to the country's transition towards a sustainable future and the reinvention of its manufacturing labour force.

7.1. Government

Perhaps the most essential player in developing the clean energy manufacturing labour market is the United States government. Policies set at the federal level have the ability to stimulate private sector investment, regulate emissions levels, promote forward-thinking policies at the state and local levels and create domestic employment opportunities. Although this is an important stakeholder to consider, discussing the amendment of existing federal policies and the implementation of new federal policies is beyond the scope of this paper. Instead, the following discussion will focus on the role of private sector businesses in supporting the clean energy economy and developing the clean energy manufacturing labour market, either directly or indirectly.

7.2. Businesses

As demonstrated in the previous section, the bulk of existing federal policies are designed to provide incentives for clean energy investments by the private sector. These policies have built a unique economic climate, in which businesses have an opportunity to gain competitive advantage through investing in the environment and the country's labour force. Listed below are

recommendations for private organizations to capitalize on government offerings and contribute towards developing a long-term sustainable future for the American economy.

7.2.1. Take Advantage of Public Clean Energy Investments

Businesses can benefit from federal, state and local clean energy initiatives from financial and personnel perspectives.

Qualifying for financing remains challenging in the current economic climate. Many businesses may no longer rely on the strength of their historical financial performance to raise funds or their high credit ratings to qualify for debt financing. Instead, companies should adjust their business models to match current market trends receiving federal support, such as clean energy technologies. Additionally, meeting eligibility criteria for federal financing makes an organization more likely to stay aligned with the most current governmental standards, and reduces its risk of facing significant future costs as these regulations tighten and become more costly to businesses. The proposed cap-and-trade program also presents an opportunity for highly efficient companies to make a profit off of their low emissions levels.

Businesses can provide a boost to the American workforce and improve upon their own personnel by taking advantage of federal programs, designed specifically to ease the transition towards employment in the clean energy economy. One such way is by performing workforce recruitment within green jobs training programs. The federal government has agreed to spend $500 million on projects that prepare workers for careers in the energy efficiency and renewable energy sectors (U.S. Department of Labor, 2009). By recruiting these members of the labour force, companies benefit from the addition of newly trained and often inspired employees, who possess valuable skills sets that are designed to compete within the intersection between the environment and the economy. The Green Industries and Occupations program might also be

advantageous to the private sector. Through this series of grants, the Department of Labor (DOL) aims to help redirect the career pathways of target populations, such as auto manufacturing workers who have been affected by significant automotive-related restructurings (U.S. Department of Labor, 2009).

7.2.2. Partner with Educational Institutions

Recognizing the inherent opportunity in the clean energy economy, and the need to build a platform of well-educated and well-qualified worker to ensure its long-term success, several educational institutions have begun to introduce clean energy college and university programs. The University of Texas at Austin, for instance, has a Clean Energy Technologies group within its Mechanical Engineering Department. Part of this group's mission statement is to "prepare students for careers in clean energy technologies that will ensure continued economic growth in the century ahead." (The University of Texas at Austin, 2009). By partnering with institutions that are investing in clean energy programs, through co-op initiatives for instance, businesses are more likely to build an engaged workforce, with tremendous skill and knowledge of these emerging technologies.

7.2.3. Innovate Based on Workforce Needs

In order to remain competitive in an increasingly global economy, United States businesses will need to capitalize on domestic strengths, such as the productivity of its workforce, to gain competitive advantage in international markets. By incorporating a highly skilled and highly productive manufacturing workforce into the planning process for new products, companies are more likely to reach economies of scale at a relatively early stage of production. Infinia Corp. is a perfect example of how businesses can innovate to meet the skills

of its available labour force. Throughout the development of its ISS, the company consulted members of the underutilized auto-manufacturing workforce to ensure that its product design matched their production skills, and to maximize their feeling of connectedness to the end product.

8. Summary

Successfully transitioning the United States' shrinking manufacturing workforce towards employment in the clean energy economy requires action from federal officials and private businesses. While the wind and solar energy industries hold potential to transform and redefine traditional blue-collar manufacturing jobs into green-collar jobs, these industries do not represent a long-term solution to the numerous job losses that have taken place within the American manufacturing workforce. In order to redefine existing manufacturing jobs, further support is needed from both the public and private sectors. Continued federal investment in researching and developing clean energy technologies and training clean energy workers is expected to continue to drive the growth of the wind and solar energy industries, promote private sector investment and stimulate domestic employment.

Appendices

Appendix A

United States Clean Energy Economy Subsegments

	Subsegment
	Clean Energy
Energy Generation	Energy consulting
	Energy management
	Biomass
	Geothermal
	Hydro
	Marine and tidal
	Hydrogen
	Multiple
	Other
	Research and testing
	Solar
	Co-generation
	Accessory equipment and controls
	Other generation equipment
	Wind
Energy Transmission	Cable and equipment
	Services
	Transmission
Energy Storage	Advanced batteries
	Battery components and accessories
	Fuel cells
	Hybrid systems
	Uninterruptible power supply
	Energy Efficiency
Energy Efficiency	Machinery
	Energy conservation consultant
	Energy conservation software
	Energy conservation products
	Glass
	Lighting

	Meters and measuring devices
	Energy research
	Solar appliances and devices
	Environmentally Friendly Production
Transportation	Alternative fuels
	Logistics
	Motor vehicles and equipment
Manufacturing/ Industrial	Advanced packaging
	Industrial surface cleaning
	Process management
	Monitoring and control
Construction	Building materials
	Design and construction
	Site management
	Real estate and development
Agriculture	Aquaculture
	Land management
	Supplies and materials
	Agribusiness consultant
Energy Production	Biofuel
	Coal gasification and pyrolysis
Materials	Bio
	Chemical
	Nano
	Other
	Conservation and Pollution Mitigation
Air and Environment	Emissions monitoring and control
	Environmental consulting
	Environmental remediation
	Cleanup/safety
Recycling and Waste	Consulting
	Recycling
	Waste treatment
Waste and Wastewater	Consulting
	Pumps
	Research and testing
	Water conservation
	Water and wastewater treatment
	Training and Support
Business Services	Legal services
	Marketing/public relations
	Green firm business portal
	Staffing services
Finance/ Investment	Project financing
	Project insurance

	Venture capital/private equity
	Emissions trading and offsets
Research and Advocacy	Alternative fuels
	Geothermal
	Public education, job training
	Solar
	Wind
	Energy generation
	Energy storage
	Green building
	Transportation

Appendix B

Green Jobs Act of 2007

Note: these are specifications from the original Act, which included $125 million of proposed federal spending. Detailed allocation of federal funds towards green jobs training programs under the new ACESA is not yet available.

The GJA authorizes spending for 5 related green job programs, listed below.

1. **National Research Program** (10 percent of total appropriation; $12.5 million if fully funded)

The Department of Labor (DOL), acting through the Bureau of Labor Statistics, will collect and analyze the labor market data necessary to track workforce trends and identify the types of skills and green jobs we need to train people for. The DOL will use this information to provide technical assistance and capacity building to the training partnerships described below.

2. **National Energy Training Partnership Grants** (30 percent; $37.5 million if fully funded)

DOL will award competitive grants to non-profit partnerships to carry out training that leads to economic self-sufficiency and to develop an energy efficiency and renewable energy industries workforce. The partnerships must include the equal participation of industry and labor, and may include related stakeholders like local workforce investments boards, educational institutions, and community-based organizations.

3. **State Labor Market Research, Information, and Labor Exchange Research Program** (10 percent; $12.5 million if fully funded)

DOL will award competitive grants to states to administer labor market and labor exchange information programs, in coordination with the one-stop delivery system. Activities will also include the identification of job openings; the administration of skill and aptitude testing; and counseling, case management, and job referrals. These programs will be administered by the state agency that administers the employment service and unemployment insurance programs and services can only be delivered by state agency staff.

4. **State Energy Training Partnership Program** (30 percent; $37.5 million if fully funded)

DOL will award competitive grants to states to enable them to administer, via the state agency that administers their employment service and unemployment insurance programs, renewable energy and energy efficiency workforce development programs. It will award grants to partnerships that essentially mirror the national partnerships in their make-up. Priority will be

given to states that demonstrate that their activities meet state and national policies associated with energy efficiency, renewable energy and reduction of emissions.

5. **Pathways Out Of Poverty Demonstration Program** (20 percent; $25 million if fully funded)

DOL will award competitive grants to training partnerships that serve individuals under 200% of the federal poverty line or a locally defined self-sufficiency standard. The partnerships must include community-based organizations, educational institutions, industry, and labor; demonstrate experience implementing training programs and recruit and support participants to the successful completion of training; and coordinate activities with the WIA system. In awarding grants, priority will be given to partnerships that target
low-income adults and youth and plan to implement various strategies that enable access to, and successful completion of, training, including ensuring that supportive services are delivered by organizations with direct access to and experience with targeted populations.

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