



American Solar Energy Society's  
**Estimating the Jobs Impacts of  
Tackling Climate Change**

Roger H. Bezdek, Ph.D.  
Principal Investigator, Management Information Services, Inc.

for the  
American Solar Energy Society

October 2009

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**Front cover photos: Above:** Solar Richmond in Richmond, California, gives San Francisco Bay Area companies incentives to hire graduates of its Green-Collar Job Training in solar PV and solar thermal. Angela Greene, Solar Richmond Project Manager (second from left) and Jen Williams, Solar Richmond Executive Assistant (second from right), pose here with students from the solar training program.

Credit: Solar Richmond

**Below:** Solar Energy International has been providing hands-on workshops and online courses in renewable energy and sustainable building technologies since 1991.

Credit: Solar Energy International

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October 2009

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# Foreword

This work is the fourth partnership between the American Solar Energy Society (ASES) and Management Information Services, Inc. (MISI) to study the size and scope of the energy efficiency and renewable energy (EE&RE) industry in the United States. Earlier work focused on the total number of green jobs and the total revenue generated by the EE&RE industry. Our data for 2007 show more than one trillion dollars in EE&RE sales, more than 9 million jobs, more than \$100 billion in corporate profit, and more than \$150 billion in federal, state, and local government tax revenue.

In early 2009, we projected this 2007 data to 2030 under three scenarios—base case, moderate incentives, and an aggressive scenario involving a national sustained commitment to a green economy. In the aggressive scenario, we forecast that by 2030, industry sales could reach \$4.3 trillion, and the EE&RE industry could be an economic driver responsible for nearly 37 million jobs—about 17 percent of the 2030 American workforce ([www.ases.org/greenjobs](http://www.ases.org/greenjobs)).

In 2007, ASES published our landmark work, *Tackling Climate Change in the U.S.: Potential Carbon Emissions Reductions with Energy Efficiency and Renewable Energy by 2030*, edited by Chuck Kutscher ([www.ases.org/climatechange](http://www.ases.org/climatechange)). This report assessed the potential for reducing U.S. carbon emissions by broadly deploying EE&RE technologies. We estimated the revenues and costs of this broad deployment and found that the effort results in a net savings to the U.S. economy.

Our current report (summarized here), *Estimating the Jobs Impacts of Tackling Climate Change* ([www.ases.org/climatejobs](http://www.ases.org/climatejobs)), asks “What is the **net** employment effect of implementing the aggressive scenario outlined in the *Tackling Climate Change* report?” This question is timely, because the broad, aggressive, sustained deployment of EE&RE addresses both climate change and economic stagnation. The solution for one is the solution for the other.

The repercussions for national security, energy independence, public health, and global competitiveness are profound. By vigorously embracing the new energy economy, U.S. leaders can make our country safer, reduce U.S. dependence on foreign energy, mitigate climate change, support a robust export industry of U.S.-manufactured renewable energy products, and satisfy Americans’ desire for EE&RE in their homes, businesses, and communities.



Brad Collins  
Executive Director  
American Solar Energy Society  
Boulder, Colorado  
October 2009

# Introduction

A study prepared for the American Solar Energy Society (ASES) finds that the United States can reduce carbon emissions and generate more than 4.5 million net jobs by 2030 if U.S. policymakers aggressively commit to programs that support energy efficiency and renewable energy (EE&RE). According to ASES/MISI, this effort will result in a net savings to the U.S. economy.

This work builds on findings in the January 2007 ASES publication, *Tackling Climate Change in the U.S.: Potential Carbon Emissions Reductions with Energy Efficiency and Renewable Energy by 2030*, and the January 2009 ASES publication, *Green Collar Jobs in the U.S. and Colorado—Economic Drivers for the 21<sup>st</sup> Century*. The Tackling Climate Change (TCC) initiative referenced throughout this document is a strategy for addressing climate change using the aggressive EE&RE growth scenario described in the *Green Collar Jobs* report. The new study, *Estimating the Jobs Impacts of Tackling Climate Change*, estimates the net number of jobs likely to result from such an initiative.

These findings are very timely, because they address two of the most pressing challenges U.S. policymakers face—rebuilding an economy battered by recession and mitigating climate change. A key strategy for rebuilding the economy is creating jobs, and a key strategy for mitigating climate change is reducing U.S. carbon emissions. The ASES/MISI study demonstrates that investing in EE&RE helps meet both these objectives.

In this document, we summarize selected findings in this ASES/MISI report. The complete report is available at [www.ases.org/climatejobs](http://www.ases.org/climatejobs) as a free download.

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*EE&RE technologies could displace approximately 1.2 billion metric tons of carbon emissions annually by 2030—the magnitude of reduction that scientists believe is necessary to prevent the most dangerous consequences of climate change.*

# Background

In January 2007, ASES published *Tackling Climate Change in the U.S.: Potential Carbon Emissions Reductions From Energy Efficiency and Renewable Energy by 2030*,<sup>1</sup> which detailed how energy efficiency and renewable energy (EE&RE) technologies can provide the emissions reductions required to address global climate change. It analyzed energy efficiency in buildings, transportation, and industry, and assessed six RE technologies—concentrating solar power, photovoltaics, wind power, biomass power, biofuels, and geothermal power. The findings indicated that EE&RE technologies could displace approximately 1.2 billion metric tons of carbon emissions annually by 2030—the magnitude of reduction that scientists believe is necessary to prevent the most dangerous consequences of climate change.

However, the 2007 *Tackling Climate Change* report did not estimate the jobs impacts of these initiatives, and the jobs issue has become increasingly important and contentious as climate change legislation moves through the U.S. Congress. In *Estimating the Jobs Impacts of Tackling Climate Change*,<sup>2</sup> prepared for the American Solar Energy Society (ASES) by Management Information Services, Inc. (MISI) in September 2009, the authors estimated the jobs impacts of the initiatives detailed in *Tackling Climate Change* through 2030. ASES/MISI

summarizes those findings in this document.

## **EE&RE as Economic Drivers**

Energy efficiency and renewable energy (EE&RE) industries have been driving significant economic growth in the United States for some time. In 2006, these industries generated 8.5 million new jobs, nearly \$970 billion in revenue, more than \$100 billion in industry profits, and more than \$150 billion in increased federal, state, and local government tax revenues. In addition, EE&RE provided important stimulus to the beleaguered U.S. manufacturing industry, displaced imported oil, and helped reduce the U.S. trade deficit.

In 2007, the news was even better. EE&RE generated more than 9 million jobs, \$1,045 billion in revenue, and nearly \$160 billion in federal, state, and local tax revenues. To put this in perspective, EE&RE sales outpaced the combined sales of the three largest U.S. corporations. Total sales for Wal-Mart, ExxonMobil, and General Motors in 2007 were \$905 billion.

If U.S. policymakers aggressively commit to programs that support the sustained orderly development of EE&RE, our national prospects look even brighter. According to research<sup>3</sup> conducted by the American Solar Energy Society (ASES)

<sup>1</sup> [www.ases.org/climatechange](http://www.ases.org/climatechange)

<sup>2</sup> [www.ases.org/climatejobs](http://www.ases.org/climatejobs)

<sup>3</sup> [www.ases.org/greenjobs](http://www.ases.org/greenjobs)

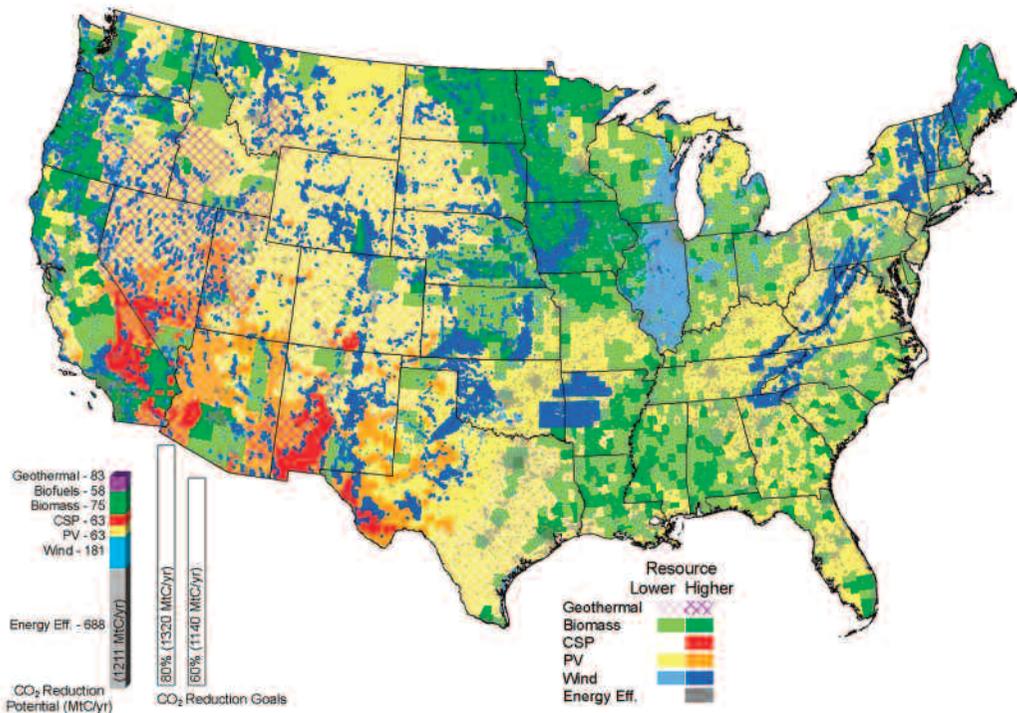
and Management Information Services, Inc. (MISI), the EE&RE industry could—in an aggressive effort—generate up to \$4.3 trillion in revenue in the United States and create more than 37 million jobs by the year 2030. These 37 million jobs would represent nearly one out of every

five jobs in 2030, and many would be jobs that could not easily be outsourced.

Every corner of the country can benefit from EE&RE—the United States is extremely rich in renewable energy resources. The map below illustrates how potential

**Figure 1**

**U.S. map indicating the potential contributions from energy efficiency and renewable energy by 2030. Concentrating solar power (CSP) and wind are based on deployment scenarios. Other renewables indicate resource locations.**



Developed by the American Solar Energy Society and the National Renewable Energy Laboratory for *Tackling Climate Change in the U.S.: Potential Carbon Emissions Reductions from Energy Efficiency and Renewable Energy by 2030*. See [www.ases.org/climatechange](http://www.ases.org/climatechange).

renewable resource contributions in 2030 are distributed throughout the country.

Of course, some jobs will be lost in the transition to a clean energy economy, but the ASES/MISI research summarized here indicates that deploying the climate change mitigation technologies described here will result in 4.5 million **net** jobs by 2030. Nationally and locally, the EE&RE industry can help move us toward a vibrant, robust, environmentally sustainable future. If we fail to invest in EE&RE, the United States runs the risk of losing ground to EE&RE programs and industries located in other nations.

### **EE&RE and Jobs**

As of September 2009, the United States has lost nearly eight million jobs since the beginning of the recession. With so many Americans out of work, policymakers are appropriately focused on the economic and jobs creation impacts of all their decisions, including climate change mitigation policies.

As previous ASES research<sup>1</sup> has demonstrated, EE&RE technologies have the potential to provide most, if not all, of the U.S. carbon emissions reductions that will be needed to limit atmospheric concentrations of carbon dioxide to less than 480 ppm. And although debate has historically focused

on using new renewable energy technologies to offset traditional energy sources, EE&RE is more than a source of electricity, fuel, or energy savings. It is a source of jobs.

Unlike some industries, EE&RE is a realistic target industry for job creation in nearly all states. EE&RE jobs require a wide range of skills, and the vast majority are standard jobs for accountants, engineers, computer analysts, clerks, factory workers, truck drivers, mechanics, etc. Table 1 lists the net jobs in selected occupations generated by the Tackling Climate Change initiative in 2030.

The occupational data in the ASES/MISI study demonstrate that growing jobs in EE&RE will create a variety of jobs that command higher than average pay, many of which take advantage of U.S. manufacturing capabilities that have been languishing in recent years. This can revitalize local economies and create opportunities for skilled workers. States and communities with traditional manufacturing economies can recruit EE&RE companies to take advantage of their infrastructure and skilled workers. Jobs at EE&RE companies also require a wide range of education and skill levels—from Ph.D. to long-term on-the-job training and trade certifications.

<sup>1</sup> [www.ases.org/climatechange](http://www.ases.org/climatechange)

**Table 1**

**Net Jobs by Occupation Generated by the TCC initiative in 2030**  
(Selected Occupations)

<b>Industry</b>	<b>Jobs (thousands)</b>
Agricultural Equipment Operators	12
Architects	5
Bookkeeping and Accounting Clerks	66
Carpenters	73
Cashiers	44
Cement Masons and Concrete Finishers	19
Compliance Officers	8
Computer Software Engineers	20
Computer Systems Analysts	17
Cost Estimators	16
Customer Service Representatives	64
Drywall Installers	11
Electricians	49
Electric Power Line Workers	13
Farm Workers and Laborers	142
Financial Analysts	6
Hazardous Materials Removal Workers	14
Human Resource Specialists	7
Industrial Engineers	14
Industrial Production Managers	11
Operating Engineers	34
Painters	19
Plumbers	35
Power Plant Operators	5
Purchasing Agents	14
Refuse and Recyclable Material Collectors	30
Security Guards	22
Sewer Pipe Cleaners	6
Shipping and Receiving Clerks	30
Structural Iron and Steel Workers	5
Tool and Die Makers	7
Waste Treatment Plant Operators	8
Welders and Solderers	28

Source: American Solar Energy Society and Management Information Services, Inc., 2009.

# Economic and Jobs Impacts

To address the potential costs of tackling climate change, ASES/MISI examined the various technology costs in the ASES *Tackling Climate Change* report. To estimate the equivalent annual cost of deploying these technologies, they considered the deployment curve for each—how many gigawatt-hours of electricity or gallons of cellulosic ethanol or energy saved through efficiency would occur each year between 2005 (the base year of the study) and 2030. They then estimated how much each deployment would cost in the year deployed.

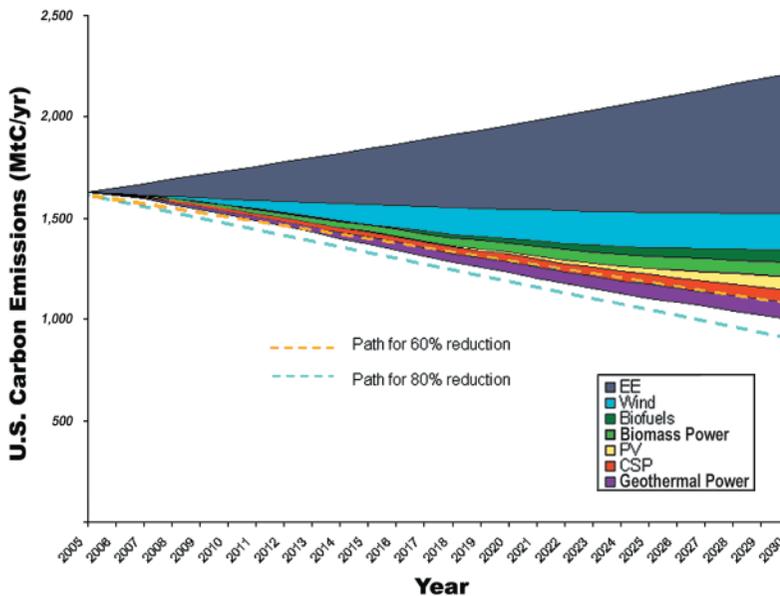
and development and learning curves. Renewable energy plants and energy efficiency deployed in any year will contribute energy for 25 years or more into the future, and analysts used standard life-cycle cost-analysis techniques to develop an equivalent annual cost in 2005 dollars of all that energy per year for each technology. Finally, they subtracted current and projected costs of the conventional energy displaced to derive the net cost. Table 2 and Figures 3 and 4 summarize the net costs and jobs impact of the TCC initiative in 2020 and 2030.

For each technology, they took into account supply curves and research

Table 2 shows that the net costs of the EE&RE components of the

**Figure 2**

**Potential carbon reductions in 2030** from energy efficiency and renewable energy technologies and paths to achieve reductions of 60% and 80% below 2005 emissions value by 2050.



Developed by the American Solar Energy Society for *Tackling Climate Change in the U.S.: Potential Carbon Emissions Reductions from Energy Efficiency and Renewable Energy by 2030* ([www.ases.org/climatechange](http://www.ases.org/climatechange)).

**Table 2**  
**Net Costs and Jobs Resulting From the TCC initiative**

	Net Costs			Net Jobs	
	Annualized	2020	2030	2020	2030
	billion 2005 dollars			thousand FTE	
Energy Efficiency	-\$107.9	-\$84.8	-\$17.4	3,533	3,360
Wind	\$0.0	\$0.3	-\$0.4	149	93
Biofuels	\$9.2	-\$0.5	-\$7.6	261	257
Biomass Power	\$2.6	\$3.3	\$4.5	122	172
Photovoltaics	\$4.7	\$5.3	\$16.0	105	340
Concentrating Solar	\$6.6	\$5.2	\$2.2	156	147
Geothermal Power	\$2.5	\$4.0	\$6.7	93	144
<b>Total</b>	<b>-\$82.3</b>	<b>-\$67.2</b>	<b>\$4.0</b>	<b>4,419</b>	<b>4,513</b>

Source: American Solar Energy Society and Management Information Services, Inc., 2009.

*Note: Table 2 lists the net (i.e., net of conventional) total life-cycle energy costs for energy efficiency and renewable energy deployments that occurred in the stated year. Positive means a net cost compared to conventional and negative means a net savings.*

Tackling Climate Change initiative differ dramatically among technologies and over time. For example, in 2020, energy efficiency has net savings of \$85 billion, and all of the renewable energy technologies except for biofuels have net costs. By 2030, energy efficiency’s savings attributable to the initiative have declined to \$17 billion, and all of the RE technologies except wind and biofuels have net costs.

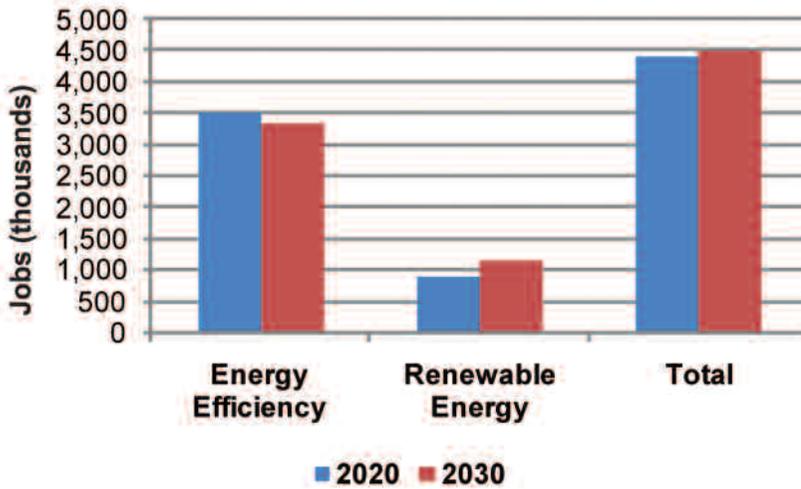
In general, as Table 2 and Figures 3 and 4 show, the energy efficiency component of the Tackling Climate Change initiative generates many more net jobs than the renewable energy component does. As the energy efficiency of products, buildings, and processes in the United States increases, the number of net energy efficiency jobs attributable to the initiative declines, from more than 3.5

million in 2020 to more than 3.3 million in 2030. As many renewable energy technologies and industries mature, the number of net jobs attributable to the initiative decline, while other technologies and industries are still ramping up under the initiative and net jobs increase. In total, renewable energy jobs attributable to the initiative increase, from 900,000 in 2020 to 1.15 million in 2030. In this study, energy efficiency produces many more net jobs than renewable energy every year, although the percentage declines over time from 80 percent in 2020 to 74 percent in 2030.

Net job generation differs significantly among the renewable energy sectors, both by technology and by time period. As the initiative’s impact plays out over the study period, some technologies mature and generate fewer net

**Figure 3**

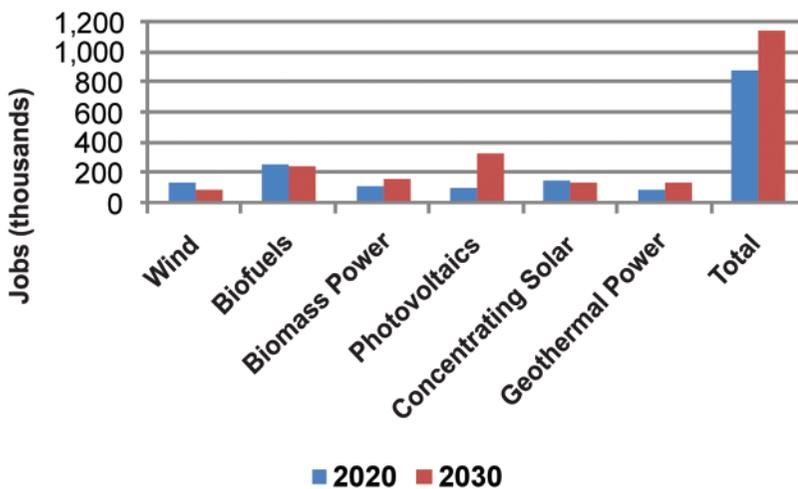
**Energy Efficiency and Renewable Energy Jobs Created by the TCC initiative**



Source: American Solar Energy Society and Management Information Services, Inc., 2009.

**Figure 4**

**Renewable Energy Jobs Created by the TCC initiative**



Source: American Solar Energy Society and Management Information Services, Inc., 2009.

jobs. For example, in 2020, the most jobs attributable to the initiative are generated by biofuels, followed by concentrating solar, wind, biomass power, photovoltaics, and geothermal power. In 2030, photovoltaics generates the most jobs, followed by biofuels, biomass power, concentrating solar, geothermal power, and wind.

The Tackling Climate Change initiative will require deployment costs in most years for most renewable energy technologies. However, this study demonstrates that the net effect would be overwhelmingly positive for the U.S. economy.

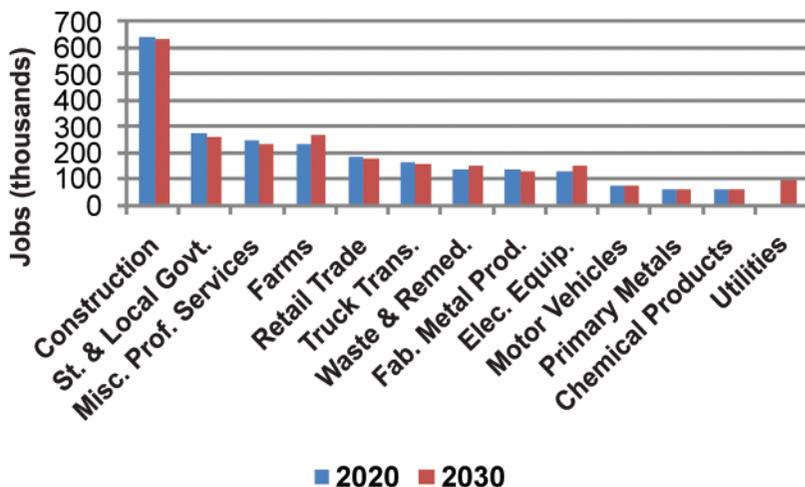
### EE&RE Job Distribution

In addition to purely economic benefits, an examination of the net jobs generated by industry as a re-

sult of the Tackling Climate Change initiative indicates that the impacts are well distributed throughout the U.S. economy. The jobs occur in a broad range of industries, and it is easy to understand the parts they will play in the evolving transformation to a new energy consumption structure and the subsequent economic growth it will foster. The largest net jobs impacts in 2030 are likely to be in construction, state and local government, farms, and miscellaneous professional, scientific, and technical services. Figure 5 summarizes the jobs impacts by industry of the Tackling Climate Change initiative.

The vast majority of the jobs created by the Tackling Climate Change initiative are standard jobs for accountants, engineers, computer analysts, clerks, factory workers, truck drivers, mechanics, etc. and

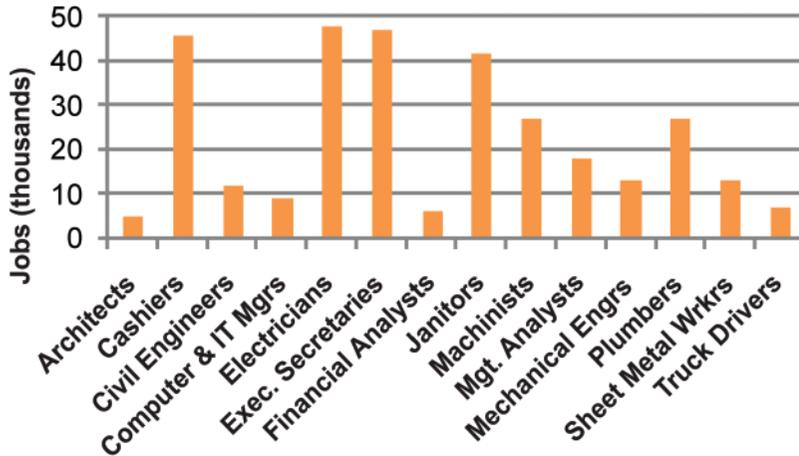
**Figure 5**  
**Net Jobs by Industry Generated by the TCC initiative in 2020 and 2030**



Source: American Solar Energy Society and Management Information Services, Inc., 2009.

**Figure 6**

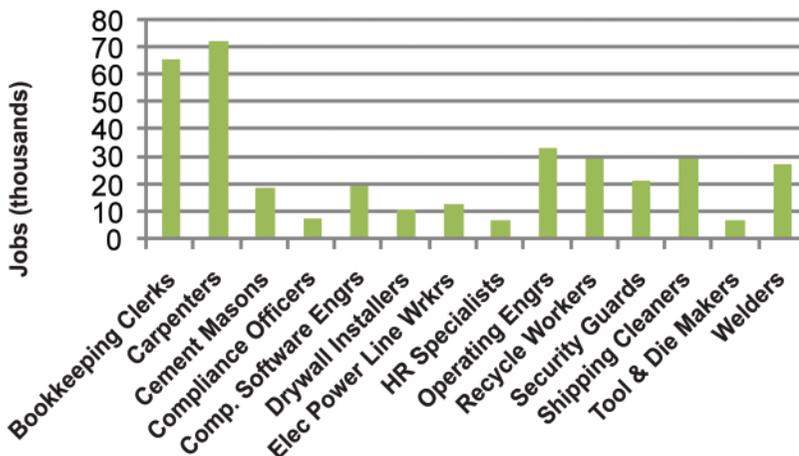
**Net Jobs by Occupation Generated by the TCC initiative in 2020**  
(Selected Occupations)



Source: American Solar Energy Society and Management Information Services, Inc., 2009.

**Figure 7**

**Net Jobs by Occupation Generated by the TCC initiative in 2030**  
(Selected Occupations)



Source: American Solar Energy Society and Management Information Services, Inc., 2009.

most of the persons employed in these jobs may not even realize that they owe their livelihood to climate change mitigation. This is illustrated in Figures 6 and 7, which show the net jobs created by the Tackling Climate Change initiative in 2020 and 2030 within selected occupations.

Thus, occupational data demonstrate that the Tackling Climate Change initiative will create a variety of high-paying jobs, many of which take advantage of manufacturing skills currently going unused. Most areas of the country have the existing infrastructure and skilled workers to accommodate the growth of EE&RE industries.

### ***The Bottom Line***

The issue of the potential costs and jobs impacts of climate change mitigation policies is very timely—and highly contentious. Many policy-makers are concerned about the impacts of these efforts, and some studies contend that these policies could cost the United States trillions of dollars and many millions of jobs over the next several decades. Further, the United States is in the worst economic downturn in seven decades and, as of September 2009, has lost nearly eight million jobs since the beginning of the recession.

The ASES/MISI study clearly demonstrates that climate change mitigation can be a net job creator, estimating that the Tackling Climate Change initiative will create 4.5 million net new jobs by 2030. These jobs will be distributed throughout the economy and the country, and will represent all levels of skill, training, and salaries. And, compared to many other initiatives, the tackling climate change initiative can create more jobs per dollar spent.

The study also demonstrates that the benefits of the Tackling Climate Change initiative go beyond creating jobs. The initiative substantially reduces U.S. carbon emissions at a total, cumulative net savings to the U.S. economy because efficiency saves more money than renewables cost.

Time is of the essence, however. Efforts like these take time to ramp up, and if the United States is to achieve the ambitious climate mitigation job goals outlined here, it must introduce aggressive programs immediately. The bottom line is that addressing climate change can be good for the environment, good for the economy, and good for jobs.

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*The sustained, orderly, and robust development of energy efficiency and renewable energy (EE&RE) will generate at least 4.5 million more jobs than the effort will eliminate.*

# Methodology—A Wind Case Study

The ASES/MISI research summarized here finds that—even accounting for initial deployment costs and displacements—the effect on the U.S. economy of addressing climate change would be overwhelmingly positive. For example, these data show that the sustained, orderly, and robust development of energy efficiency and renewable energy (EE&RE) will generate at least 4.5 million more jobs than the effort will eliminate.

The scenario described in the *ASES Tackling Climate Change* report<sup>1</sup> requires that the United States expand the use of EE&RE technologies more rapidly through 2030 than would be the case under business-as-usual economic growth. In this aggressive scenario, the additional generation contributed by renewable energy technologies would replace existing electric generating output and reduce CO<sub>2</sub> emissions to the levels specified by climate scientists.

However, there is a cost to deploying these technologies and accelerating their growth. The *ASES Tackling Climate Change* report estimated the cost to deploy the technologies, and ASES/MISI used this information as the foundation for its estimates of the economic and employment impacts on the U.S. economy through 2030.

To illustrate how this ASES/MISI study reached its conclusions, consider the wind industry. Al-

though net energy costs for wind increase to more than \$600 million by 2017, they begin to contribute back to the economy as surplus by 2021, and the cost of wind-generated electricity drops to less than the cost of electricity from conventional sources by 2021.

The stimulus provided by accelerating the pace of growth also has a strong impact on the industry, especially in the early years. The ASES/MISI study estimates that the total cost of wind attributable to this acceleration will reach more than \$34 billion in about 2013, and will decrease from then to 2030 as the wind industry matures.

A more profound and lasting effect of accelerating the growth of the wind industry is the impact on the sustainability and long-run capacity of the sector as permanent business relationships form and capital investment increases. In this case, ASES/MISI estimates that by 2020—after 10 years of accelerated wind industry sales—the wind industry infrastructure will have grown to include an additional capacity of almost \$49 billion of output. During this period, the comparable conventional electric industry growth in capacity-level output was estimated to be similar, about \$48 billion.

Because the purchase pattern of inputs to the conventional electric industry is far different from the purchase pattern of expenditures in the wind industry, the profile of wind industry suppliers tends to

<sup>1</sup> [www.ases.org/climatechange](http://www.ases.org/climatechange)

be more employment-intensive than the conventional electricity industry. As a result, a dollar of wind industry output accounts for more jobs than a dollar of conventional electricity industry output.

Taking into account the \$49 billion of wind energy output and the wind industry's purchase pattern, and performing a matrix multiplication using MISI's version of the standard 2007 Input-Output (I-O) model assembled by the U.S. Department of Commerce's Bureau of Economic Analysis (BEA), we estimate that the wind industry will contribute \$96 billion directly and indirectly to U.S. Gross Output in 2020. Taking the comparable figure for conventional electricity output, we estimate that Gross Output would be slightly lower at \$88 billion. Using average employment per dollar of output, available through BEA and the Bureau of Labor Statistics (BLS), we estimate that

additional wind industry employment under the aggressive growth scenario would total around 418,000, compared to 269,000 for conventional electricity.

The final step in the analysis is to project the occupational profile of the net additional jobs. ASES/MISI used a MISI version of the BLS occupation-by-industry matrix and then applied the conventional and wind electricity industry employment data, which resulted in an estimate of net occupational employment that can be attributable to the Tackling Climate Change initiative in 2020.

The estimated net energy cost for wind technology under the Tackling Climate Change initiative was slightly more than \$70 million per year from 2010 through 2030. And, if the United States deploys wind technology aggressively, the result would be 149,000 additional net U.S. jobs by 2020.

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*A dollar of wind industry output accounts for more jobs than a dollar of conventional electricity industry output.*



## AMERICAN SOLAR ENERGY SOCIETY

### **AMERICAN SOLAR ENERGY SOCIETY**

Established in 1954, the nonprofit American Solar Energy Society (ASES) is the nation's leading association of solar professionals and advocates. About half of ASES members are advocates for the transition to the green economy. The other half of the membership has a professional interest in these technologies. Professional members include researchers in a broad range of renewable energy technologies, including solar, wind, biomass, and geothermal. For the past 38 years, ASES has hosted the National Solar Energy Conference, a technical gathering of scientists, researchers, engineers, architects, designers, and educators. ASES is the United States Section of the International Solar Energy Society.

ASES is formally organized into nine technical divisions: Concentrating Solar Power, Clean Energy and Water, Resource Applications, Solar Buildings, Solar Electric, Renewable Fuels and Transportation, Solar Thermal, Small Wind, and Sustainability. Professionals in these divisions participate in the technical paper peer review process for the national conference and provide fact checking for articles in *SOLAR TODAY* magazine. ASES has three standing committees: the Policy Committee, the International Committee, and the Education Committee. In addition, ASES comprises 24 chapters in 41 states and four institutions of higher education.

ASES regularly organizes research and policy initiatives and prepares white papers from these activities. It also publishes *SOLAR TODAY* magazine, and has hosted the annual National Solar Tour every fall for the past 14 years. The Tour is the nation's largest demonstration of green buildings and solar installations in the country.

Headquartered in Boulder, Colorado, ASES represents more than 35,000 professional members, basic members, and chapter affiliates in the United States.

For more information, please visit the ASES website at [www.ases.org](http://www.ases.org).

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Management Information Services, Inc. (MISI) is an economic research and management consulting firm with expertise on a wide range of complex issues, including energy, electricity, and the environment. The MISI staff offers expertise in economics, information technology, engineering, and finance, and includes former senior officials from private industry, federal and state government, and academia. Over the past two decades MISI has conducted extensive proprietary research, and since 1985 has assisted hundreds of clients, including Fortune 500 companies, nonprofit organizations and foundations, academic and research institutions, and state and federal government agencies including the U.S. Department of Energy, the U.S. Department of Defense, NASA, the U.S. Environmental Protection Agency, the General Services Administration, and the U.S. Energy Information Administration.

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