



American Solar Energy Society's  
**Green Collar Jobs in the U.S. and Colorado**  
*Economic Drivers for the 21<sup>st</sup> Century*

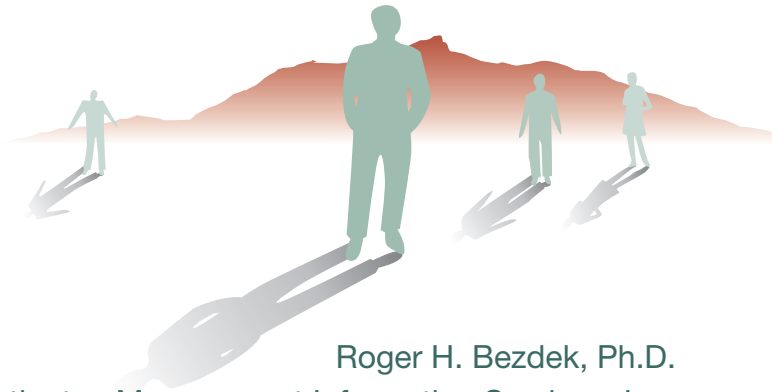
Roger H. Bezdek, Ph.D.  
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for the  
American Solar Energy Society

**Front cover photo:** Patrick Mueller of Bella Energy, based in Louisville, Colorado, installs a 10-kilowatt photovoltaic system at the Colorado State Capitol in Denver.  
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January 2009

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Sincerely,

Kate Drexler and Seth Portner with the Colorado Governor's Energy Office

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For more resources regarding green energy jobs in Colorado, please visit the Colorado Governor's Energy Office (GEO) at [www.colorado.gov/energy](http://www.colorado.gov/energy).

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# Foreword

Since 1954, the American Solar Energy Society (ASES) has led the nation in working toward energy literacy among professionals, decision makers, and the public. Our goal in producing reports such as *Green Collar Jobs in the U.S. and Colorado—Economic Drivers for the 21<sup>st</sup> Century* is to provide competent, accurate, scientifically-based data to help policymakers and other energy professionals make sound energy policy decisions.

There is currently no shortage of interest in and misinformation about the breadth, impact, and potential of the so-called green economy in the United States. The serious decision maker will seek out accurate data on revenues, job creation potentials, and growth forecasts for the burgeoning renewable energy and energy efficiency industries. This information is critical to a clear understanding of the implications of incentives and other stimuli required to make the transition to the sustainable energy economy.

This report presents the second annual review of national data on the size of the renewable energy and energy efficiency (RE&EE) industries, the number of jobs these industries create, and the potential for their growth by 2030. Our previous study of these data included specific data for the state of Ohio and is available on our website, [www.ases.org](http://www.ases.org). This report presents 2007 data, describes the trend from 2006 national data to 2007 national data, and focuses in depth on the RE&EE industries in the state of Colorado.

This work also adds the following contributions to understanding the RE&EE industries:

- A continued refinement of the definitions of the RE&EE industries.
- An update on the estimate of the size and composition of the national RE&EE industries, including technology, sales, tax revenue, jobs, occupations, and skills.
- An updated national forecast of the growth of these industries to 2030 under three separate scenarios.
- An estimate of the size and composition of the RE&EE industries in the state of Colorado and a forecast of their growth by 2030.

Roger Bezdek and his team Management Information Services, Inc., have conducted this study as part of our ongoing effort to describe RE&EE in the United States uniformly and comprehensively and to provide detailed reports on targeted states. Colorado is clearly a leader in providing incentives and leadership that attract RE&EE companies to the state. There is much for other states to replicate in the Colorado “New Energy Economy” effort if we, as a country, want to make RE&EE the economic driver for the 21<sup>st</sup> Century.

We wish to acknowledge and publicly thank Seth Portner and the Colorado Governor’s Energy Office (GEO) for their guidance and support

of this project. The team that GEO recruited to help guide this study provided us with a broad and important perspective on our estimates. They also allowed us to complement the important and continuing work of GEO and other state agencies and departments to advance the New Energy Economy in Colorado.

This work is another timely and important contribution to the ASES mission to accelerate the transition to a low-carbon, green economy. Our economic studies are one of two pillars upon which our policy recommendations are based. The other pillar is our landmark study, *Tackling Climate Change in the U.S.: Potential Carbon Emissions Reductions from Energy Efficiency and Renewable Energy by 2030*, released in January 2007. The graphic below was developed for our climate change study and demonstrates that the RE&EE resources required to develop a low-carbon economy are available everywhere in the United States.

Our policy recommendations for the 111th Congress are also posted on our website, [www.ases.org](http://www.ases.org). These recommendations support the goals detailed in *Tackling Climate Change* as well as the advanced scenario goals enumerated in this study. The solutions for reducing atmospheric carbon concentrations will also create a more robust, sustainable economy. Now is the time to implement those solutions.

Brad Collins  
 ASES Executive Director  
 January 2009  
 Boulder, Colorado

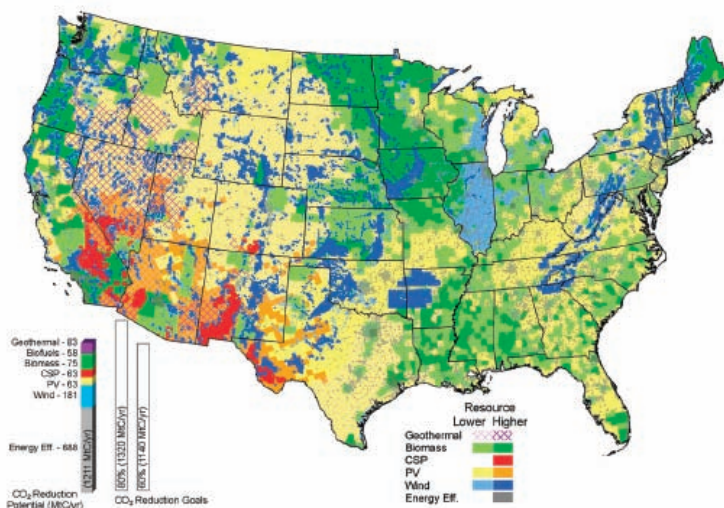


Figure i. This U.S. map indicates the distribution of potential contributions from energy efficiency and renewable energy by 2030. Note that every corner of the country can benefit from energy efficiency and renewable energy. CSP=Concentrating solar power PV=Solar electric (photovoltaics or PV)

# Introduction

In the midst of relentlessly dismal economic news, here's some good news.

Renewable energy and energy efficiency (RE&EE) technologies continue to drive significant economic growth in the United States. In 2006, these industries generated 8.5 million 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. Additionally, RE&EE 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. RE&EE generated more than 9 million jobs, more than \$1 trillion in revenue, and nearly \$160 billion in federal, state, and local tax revenues.

To put this in perspective, RE&EE sales outpaced the combined sales of the three largest U.S. corporations. Total sales for Wal-Mart, Exxon-Mobil, and General Motors in 2007 were \$905 billion.

If U.S. policymakers aggressively commit to programs that support the sustained orderly development of RE&EE, our national prospects look even brighter. According to research conducted by the American Solar Energy Society (ASES) and Management Information Services, Inc. (MISI), the renewable energy and energy efficiency industry could—in a crash 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 four jobs in 2030, and many would be jobs that could not easily be outsourced.

What will it take to get from here to there?

We will need to understand both the current status and structure of the RE&EE sectors and the public policies and regulatory programs most likely to support and encourage orderly growth in these sectors. The ASES/MISI research summarized in this document builds on previous ASES/MISI work that developed a working definition of the RE&EE industry, a baseline of comprehensive RE&EE data describing the size and scope of the RE&EE industry in 2006, and an analysis of three possible growth scenarios. The current research updates that information to include data for 2007 and new forecasts through 2030.

The implications for the United States—and for Colorado and other states—are obvious and serious. Nationally and locally, the RE&EE industries can help move us toward a vibrant, robust, environmentally sustainable future. If we fail to invest in RE&EE, the United States runs the risk of losing ground to RE&EE programs and industries in other nations.

In this document, we summarize selected findings in the ASES/MISI report titled *Defining, Estimating, and Forecasting the Renewable Energy and Energy Efficiency Industries in the U.S. and in Colorado* in an effort to chart a possible course to a sustainable energy future for government and industry decision makers. The complete report, which includes supporting data, is available at [www.ases.org/greenjobs2007](http://www.ases.org/greenjobs2007) as a free download. This summary is also available as a free download at [www.ases.org](http://www.ases.org).

[WWW.ALTERNATIVE-POWER.COM](http://WWW.ALTERNATIVE-POWER.COM)



An employee of Ridgway-based Alternative Power Enterprises installs a photovoltaic system on a home in Mountain Village, Colorado, in 2007.



Wind is one of the fastest growing energy industries in the world, and Colorado is harvesting the wind to produce clean electricity.



# Executive Summary

In 2007, the American Solar Energy Society (ASES) and Management Information Services, Inc. (MISI) undertook the first comprehensive study of the size and scope of the renewable energy (RE) and energy efficiency (EE) industries. Prior to this work, the basic knowledge of the economic impact of these industries was not well documented.

RE&EE technologies and programs have been around for decades and are well understood. However, the literature review ASES/MISI conducted in 2007 revealed deficiencies in the existing analyses of the economic and jobs impacts of RE&EE technologies and initiatives.

For one thing, there were no consistent definitions for either the RE or the EE industry. In addition, there were no aggregated industry data, because analyses and forecasts typically dealt with only a specific sub-element such as wind, photovoltaics (PV), or vehicle fuel efficiency. Another issue was that virtually all the studies we reviewed used different assumptions, scenarios, base years, forecast time horizons, and other parameters, making it difficult or impossible to compare one to another.

The 2007 ASES/MISI work made three major contributions. First, it proposed a rigorous definition of the RE&EE industries. Second, it detailed the current sizes and composition of the RE&EE industries in 2006, including technology, sales, jobs, occupations, and skills. And finally, it forecast RE&EE growth to 2030 under three scenarios. Both the complete report, *Defining, Estimating, and Forecasting the Renewable Energy and Energy Efficiency Industries in the U.S. and in Ohio* and the summary of this work, titled *Renewable Energy and Energy Efficiency: Economic Drivers for the 21<sup>st</sup> Century* are available as free downloads at [www.ases.org/greenjobs2006](http://www.ases.org/greenjobs2006) and [www.ases.org](http://www.ases.org) respectively.

In 2008, ASES/MISI updated their research with 2007 data. *Green Collar Jobs in the U.S. and Colorado* is a summary of *Defining, Estimating, and Forecasting the Renewable Energy and Energy Efficiency Industries in the U.S. and in Colorado*, which details that work. Both are available as free downloads at [www.ases.org/greenjobs2007](http://www.ases.org/greenjobs2007) and [www.ases.org](http://www.ases.org) respectively.

## Executive Summary

- **Developing a Definition**

One of the major contributions of our 2007 work was to develop a rigorous definition of the RE&EE industries. It is an easy call if the RE&EE product or service exists as a distinct, specified entity, but this was rarely the case—especially for the EE industry. In most instances only some of a company’s or organization’s offerings could be classified as part of the RE&EE industries, and quantifying the size of the RE&EE contribution was a challenge.

In the end, there was no simple definitive answer. In effect, ASES/MISI is acting as the definer and “benchmarker” of the industry as it evolves. In the process, we decided that focusing on RE&EE jobs might be a useful approach. For example, under the broad industry definition, an employee working in a private RE company or for an RE&EE advocacy organization would constitute a RE&EE job, as would an employee of the federal or a state RE&EE agency.

Of course, there were ambiguities here too. Most people would agree that the positions in a firm that assembles and installs solar thermal collectors would be considered RE&EE jobs. But what about the jobs involved in producing those solar panels, especially if the factory involved uses coal-based energy, one of the most controversial fossil fuels in terms of emissions?

In addition, we found 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, and other workers. Thus, in our definition, the RE&EE industry encompasses all aspects of renewable energy and energy efficiency, and includes both the direct and indirect jobs created in both these sectors.

Specifically, here are our definitions of jobs within the RE&EE industries for the purposes of this study. We anticipate that these definitions will become the standard for future researchers examining the RE&EE industries.

*In our definition, the RE&EE industry encompasses all aspects of renewable energy and energy efficiency, and includes both the direct and indirect jobs created in both these sectors.*



A job in the RE industry consists of an employee working in one of the major RE technologies—wind, photovoltaics, solar thermal, hydroelectric power, geothermal, biomass (ethanol, biodiesel, and biomass power), and fuel cells and hydrogen. A job in the EE industry consists of an employee working in a sector that is entirely part of the EE industry, such as an energy service company (ESCO) or the recycling, reuse, and remanufacturing sector. It also includes some employees in industries in which only a portion of the output is classified as within the EE sector, such as household appliances, HVAC systems, construction, automobile manufacturing, and others. Finally, in this study, jobs in RE&EE include persons involved in RE&EE activities in federal, state, and local government, universities, nonprofits, trade and professional associations, non-governmental organizations (NGOs), foundations, consultancies, investment companies (analysts, for example), and other related organizations.

[WWW.BESTWAYINSULATION.COM](http://WWW.BESTWAYINSULATION.COM)



Amory Barton and Kyle Willie of Broomfield-based Bestway Insulation take a break while installing insulation at the Colorado Governor's Residence at the Boettcher Mansion in Denver.

## Executive Summary

### • The Size & Scope of RE&EE in 2007

With a working definition of the RE&EE industries, we turned our attention to estimating the size and composition of the RE&EE industries. We found that, in 2007, the U.S. RE&EE industries generated more than \$1 trillion in sales and created more than 9 million jobs—including \$10.3 billion in sales and more than 91,000 jobs in Colorado. U.S. RE&EE revenues represent substantially more than the combined 2007 sales of the three largest U.S. corporations—Wal-Mart, ExxonMobil, and General Motors (\$905 billion).

We also found that RE&EE industries are growing faster than the average U.S. industry and comprise some of the most rapidly growing industries in the world, including wind, photovoltaics (PV), fuel cells, recycling/remanufacturing, and biofuels. Except for hydropower and industry biomass, the RE U.S. energy contribution is still small, although it is growing rapidly.

As Table ES-1 shows, in the United States, RE gross revenues totaled nearly \$43 billion and the number of jobs created by RE exceeded 500,000 in 2007. These jobs were disproportionately for scientific, technical, professional, and skilled workers, and more than 95 percent of the jobs were in private industry. In addition, 70 percent of these jobs were in the biomass sector, primarily ethanol and biomass power, and the second largest number of jobs was in the wind sector, followed by geothermal and photovoltaics.

EE gross revenues nationwide totaled more than \$1 trillion and the number of jobs created by EE totaled nearly 8.6 million. More than 98 percent of these jobs were in private industry, and more than 36 percent were in the recycling, reuse, and remanufacturing sector.

**Table ES-1**

#### **Summary of the U.S. Renewable Energy and Energy Efficiency Industries in 2007**

<b>Industry</b>	<b>Revenues (billions)</b>	<b>Industry Jobs (thousands)</b>	<b>Total Jobs (thousands)</b>
<b>Renewable Energy</b>	\$42.58	218	504
<b>Energy Efficiency</b>	\$1,002.92	3,745	8,586
<b>TOTAL</b>	\$1,045.50	3,963	9,090

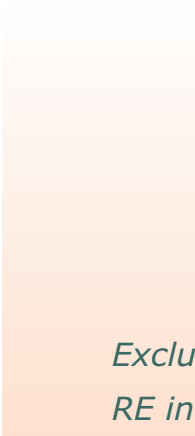
Source: Management Information Services, Inc. and American Solar Energy Society, 2008.

The real growth rate of U.S. gross domestic product (GDP) between 2006 and 2007 was 2.19 percent. Thus, including hydro, the RE industry grew more than twice as fast as the overall U.S. economy. Excluding hydro, the RE industry grew more than three times as fast as the overall U.S. economy.

Further, the biomass power sector is a significant part of the RE industry, but it grew little between 2006 and 2007. Excluding both hydro and biomass power, the U.S. RE industry grew 15.4 percent between 2006 and 2007—more than seven times as fast as the overall U.S. economy.

Some sectors experienced very substantial growth. For example, solar thermal grew more than 35 percent, biodiesel grew 30 percent, ethanol grew nearly 30 percent, and PV grew more than 25 percent.<sup>1</sup>

Total EE industry revenues in the United States increased 7.5 percent, from \$933 billion in 2006 to \$1,003 billion in 2007. Converting the 2006 EE data to constant 2007 dollars indicates that, in real terms, total EE revenues increased 4.4 percent, from \$961 billion in 2006 to \$1,003 billion in 2007. The total number of jobs created by EE increased by more than 800,000. Thus, the U.S. EE industry between 2006 and 2007 grew about twice as rapidly as the overall U.S. economy.



*Excluding both hydro and biomass power, the U.S. RE industry grew 15.4 percent between 2006 and 2007—more than seven times as fast as the overall U.S. economy.*

<sup>1</sup>While the percentage growth figures are important, it should be noted that some of the most rapidly growing RE sectors, such as PV, solar thermal, and biodiesel, are very small, and even relatively modest growth in total revenues will thus produce large percentage increases.

## Executive Summary

### • Forecasting Growth in the RE&EE Industries

The third objective of our 2007 research was to forecast the growth of the RE&EE industries to 2030. To accomplish this, we used the three forecast scenarios we had developed previously—a base case, a moderate scenario, and an advanced scenario.

The base case is essentially a “business as usual” scenario that assumes no change in RE&EE policies and no major RE&EE initiatives over next 21 years. The moderate scenario assumes that various moderate, incremental (above the base case) federal and state RE&EE initiatives are put in place over next two decades. The advanced scenario “pushes the envelope,” and includes what may be realistically feasible both economically and technologically, given favorable market conditions and a sustained public policy commitment.

The scenario forecast results for the United States are summarized in Table ES-2 and Figure ES-1. The results indicate that in the base case, RE revenues increase 130 percent, from \$42.6 billion to \$98 billion, and EE revenues increase 86 percent, from \$1,003 billion to \$1,868 billion. Jobs created by RE in the base case scenario increase 160 percent, from 504,000 to 1.3 million, and jobs created by EE increase 75 percent, from 8.6 million to 15 million.

In the advanced scenario, RE revenues increase 1,200 percent, from \$42.6 billion to \$560 billion, and EE revenues increase 270 percent, from \$1,003 billion to \$3,734 billion. Jobs created by RE in the advanced scenario increase 1,300 percent, from 504,000 to 7.3 million, or 4.3 percent of total U.S. jobs, and jobs created by EE increase 250 percent, from 8.6 million to 30 million, or 17.5 percent of total U.S. jobs.

Thus, under all the scenarios, RE growth is much larger than EE growth, but the economic and job impact of EE remains orders of magnitude larger than that of RE.

**Table ES-2**

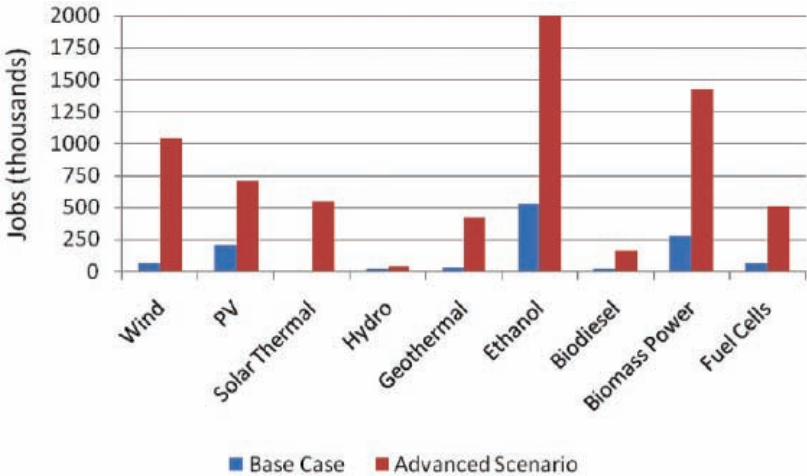
**U.S. Renewable Energy and Energy Efficiency Industries in 2030**

	Revenues (Billions of 2007 Dollars)			Total Jobs Created (Thousands)		
	Base Case	Moderate Scenario	Advanced Scenario	Base Case	Moderate Scenario	Advanced Scenario
<b>RE</b>	\$98	\$212	\$560	1,305	2,846	7,328
<b>EE</b>	1,868	2,036	3,734	14,953	16,658	29,878
<b>Total</b>	\$1,966	\$2,248	\$4,294	16,258	19,504	37,206

Source: Management Information Services, Inc. and American Solar Energy Society, 2008.

**Figure ES-1**

**U.S. Jobs Created By Renewable Energy In 2030  
(Total Jobs Created—Selected Technologies)**



Source: Management Information Services, Inc. and American Solar Energy Society, 2008

# Executive Summary

## • Colorado Case Study

Colorado is well known for its sunny climate and beautiful scenery. It may also soon be known for its concentration of RE&EE companies. But getting from here to there will require a focused and determined effort from state policymakers and businesses.

### *The Colorado RE&EE Industries in 2007*

As Table ES-3 summarizes, we found that in Colorado in 2007, RE generated gross revenues of nearly \$1.1 billion, and created more than 10,000 jobs. As was the case nationwide, the RE jobs were disproportionately for scientific, technical, professional, and skilled workers, and about half of the jobs were in private industry. The largest number of jobs was in the federal government sector, primarily at the National Renewable Energy Laboratory (NREL), followed by the wind and ethanol sectors.

The EE industry in Colorado generated more than \$9 billion in gross revenues in 2007, and created more than 81,000 jobs. The recycling, reuse, and remanufacturing sector generated the largest number of jobs. The miscellaneous durables manufacturing sector came in second, followed by the nondurable manufacturing sector and the construction sector.

The combined RE&EE industries in Colorado accounted for more than \$10 billion in revenues and more than 91,000 jobs. The EE sector in Colorado is more than eight times larger than the RE sector. In 2007 in Colorado, RE&EE accounted for more than four percent of gross state product and for more than three percent of total employment in the state.

**Table ES-3**  
**Summary of the Colorado Renewable Energy and Energy Efficiency Industries, 2007**

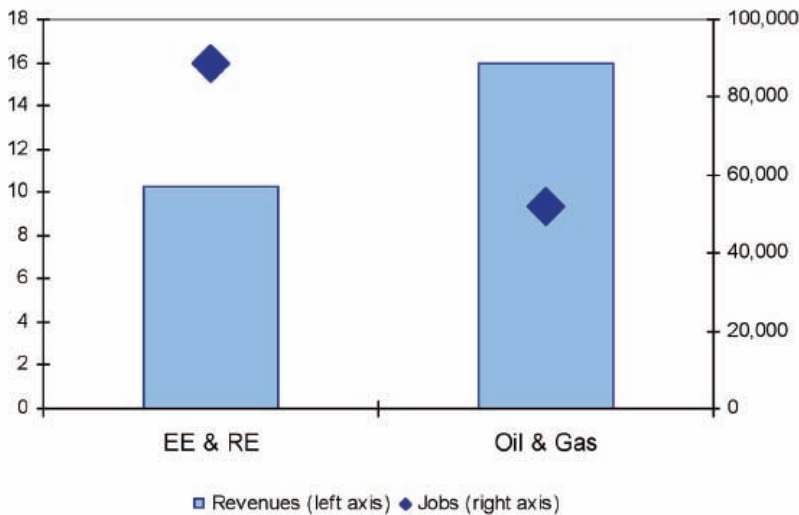
Industry	Revenues (millions)	Industry Jobs	Total Jobs
<b>Renewable Energy</b>	\$1,082	4,415	10,075
<b>Energy Efficiency</b>	\$9,129	35,470	81,210
<b>TOTAL</b>	\$10,211	39,885	91,285

Source: Management Information Services, Inc. and American Solar Energy Society, 2008.

### ***RE&EE in Colorado Compared to the Oil and Gas Sector***

We compared the economic impact of the RE&EE sector to that of the Colorado oil and gas (O&G) sector in Colorado, and Figure ES-2 illustrates the results. In terms of revenues, the O&G sector in Colorado is more than 50 percent larger (\$5.7 billion) than the RE&EE sector. However, the RE&EE sector generates about 70 percent more jobs (39,000) than the O&G sector. Thus, the RE&EE sector in Colorado generates, in total, more than 2.5 times as many jobs per dollar of revenues as does the O&G sector in the state.

**Figure ES-2**  
**Comparative Economic and Jobs Impact of the RE&EE Sector and the O&G Sector in Colorado**



Source: Management Information Services, Inc. and American Solar Energy Society, 2008

### ***Survey of Colorado RE&EE Companies***

We examined a functional, technological, and geographic mix of RE&EE companies in Colorado. The goal was to illustrate and describe the various RE&EE firms in the state, the products and services they provide, the numbers and types of jobs they offer, and other characteristics, and to identify their concerns, priorities, and opportunities.

Our research revealed a wide range of firms located throughout the state. They vary in size from small firms of several employees to large firms employing thousands, although most of them are relatively

small. Workers' skill levels vary from the most basic and rudimentary to very highly skilled technical and professional personnel. The markets for these RE&EE companies range from local to state and regional to national to international.

See pages 50–51 for summaries of several of these case studies. The entire report, which includes the complete survey, is available at [www.ases.org/greenjobs2007](http://www.ases.org/greenjobs2007).

### **Colorado RE&EE Industries in 2030**

Table ES-4 and Figure ES-3 illustrate that RE&EE offer significant development and job creation opportunities in Colorado. In 2030, under the advanced scenario, RE could generate more than \$13 billion in revenues and 113,000 jobs annually, and EE could generate more than \$44 billion in revenues and 500,000 jobs.

We found that employment growth in RE&EE varies among sectors. Some rapidly growing sectors include wind, photovoltaics, architecture and engineering, R&D, energy service companies (ESCO), environmental technologies, biofuels, power technologies, industrial processes, distributed generation, computer controls and systems, and HVAC systems.

RE&EE creates a variety of high-paying jobs, many of which require associate's degrees, on-the-job training, or trade certifications. Most of the jobs created by RE&EE are standard jobs for accountants, engineers, computer analysts, clerks, factory workers, truck drivers, mechanics, and others.

**Table ES-4**  
**Summary of the Colorado Renewable Energy and Energy Efficiency Industries in 2030**

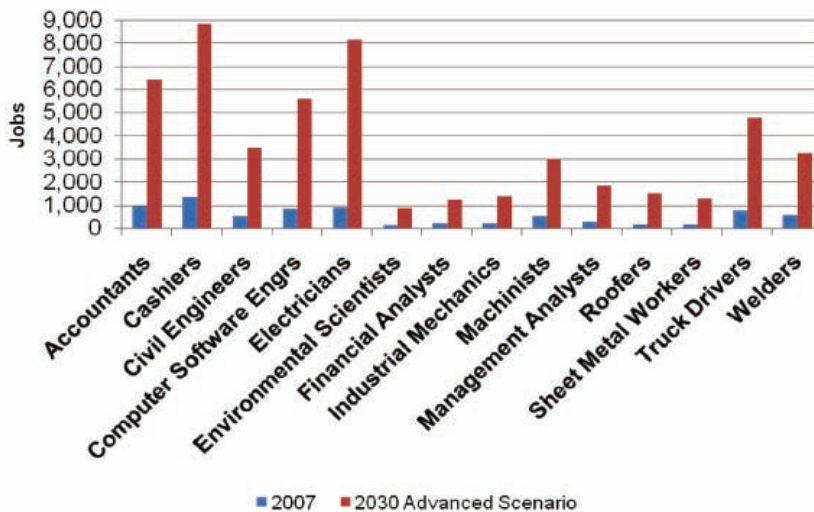
	Revenues (Millions of 2007 Dollars)			Total Jobs Created		
	Base Case	Moderate Scenario	Advanced Scenario	Base Case	Moderate Scenario	Advanced Scenario
<b>RE</b>	\$2,076	\$3,811	\$13,131	17,370	29,400	113,375
<b>EE</b>	17,681	20,479	44,345	174,810	208,620	499,550
<b>Total</b>	\$19,657	\$24,290	\$61,476	192,181	238,020	612,925

Source: Management Information Services, Inc. and American Solar Energy Society, 2008.



**Figure ES-3**

**Colorado Jobs Created by RE&EE in 2030 Compared to 2007  
(Total Jobs Created—Selected Occupations)**



Source: Management Information Services, Inc., 2008.

### ***The Bottom Line for Colorado***

The ASES/MISI work summarized in this report demonstrates how important the RE&EE industries are to the economy and labor market in both the U.S. and Colorado. It also provides industry specifications and benchmarks that can be used in all related studies conducted subsequently. For Colorado, several important policy implications emerge from this research.

First, the RE industry in the state is small and, except for the federal sector, does not currently play a major role in the state economy or job market. Nevertheless, nationwide, Colorado is a disproportionately large player in some RE technologies. Although Colorado gross state product (GSP) accounts for only about 1.7 percent of U.S. GDP, in 2007 Colorado accounted for about six percent of the U.S. wind market, nearly six percent of the U.S. photovoltaics market, about five percent of the U.S. ethanol market, and about five percent of the U.S. biodiesel market.

Second, despite various proposals in recent years that use RE as a job creation program for the disadvantaged, the chronically unemployed, or other target populations, the small number of RE jobs makes this unfeasible in Colorado. However, if we include EE, the situation is different. Combined, RE&EE provided more than 91,000 jobs in Colorado in 2007. We anticipate that both sectors—but especially RE—will grow more rapidly than the state economy as a whole.

Third, Colorado is well positioned to facilitate and take advantage of rapid growth in the RE&EE industries, especially compared to many other states. There are many state government and private industry RE&EE initiatives already underway. These programs combined with local educational initiatives and the presence of NREL should place Colorado firmly in the forefront of the development and growth of the RE&EE sector for the foreseeable future.

Fourth, RE&EE represents an effective job creation mechanism. For example, RE&EE creates, per dollar of expenditure, 2.5 times as many jobs as the oil and gas (O&G) sector in Colorado.

Fifth, the longer the United States and Colorado delay implementing ambitious RE&EE programs and incentives, the more difficult it will be to achieve the goals outlined here for 2030. Thus to achieve the 2030 RE&EE goals, appropriate policies and incentives must be implemented as soon as possible.

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EMS Engineers provided mechanical engineering and commissioning services for the high performance, award-winning Kinard Junior High School in Fort Collins, Colorado.

Finally, a goal of this project is to help create programs that support the emerging RE&EE industry in the state. Our major finding is that Colorado education professionals will have to develop and expand education and training programs in the near future to facilitate the anticipated growth of RE&EE. The challenge is to identify the types of jobs, skills, and education and training requirements that correspond to the employment opportunities RE&EE industries will create in coming decades.

Our complete report (available at [www.ases.org/greenjobs2007](http://www.ases.org/greenjobs2007)), which we summarize in this document, provides information to help the state's labor market and educational planners identify these opportunities. We detail more than 160 RE&EE occupational specialties, including salaries and education and training requirements. This information illustrates that RE&EE creates job opportunities for workers in many different sectors, at all education and skill levels, at a wide range of salaries, and will likely create even more in the future.

With this information in hand, Colorado's education and training programs can be calibrated to address these emerging new energy economy jobs. This would prepare hundreds of thousands of state residents for new jobs and viable long-term career opportunities in rapidly expanding RE&EE fields.

NAMASTE SOLAR ELECTRIC



COURTESY OF JOHNS MANVILLE



Left: Employees of Boulder-based Namaste Solar Electric install a photovoltaic system at the River Clay Condos in Denver; Right: A worker installs Johns Manville blown-in fiberglass insulation to improve the energy efficiency of a new home.

## Executive Summary

### ● The Way Forward

Although Colorado is likely to be a key player in the emerging new energy economy, the same may not be true of many other states or the United States as a whole. It is instructive to consider RE&EE in Germany.

Germany has committed to growing its RE&EE industries. Although it has about one-quarter the GDP and population of the United States, 249,000 German workers do RE jobs (31,000 more than in the United States).

The contrast within specific RE sectors is even more striking. For example, in 2007, there were 84,000 jobs in the in wind sector in Germany, but only 17,000 in the United States (600 in Colorado). In the PV sector, there were 39,000 jobs in Germany, but only 9,000 in the United States (275 in CO).

Germany produces half of the wind rotors in the world and one-third of the solar panels in the world. The country also leads the world in biodiesel production and is second only to the Japanese in fuel cells and hybrid cars. Germany has accomplished all of this in spite of the fact that the United States—and especially Colorado—has better RE resources.

The implications for the United States—and Colorado—are obvious and serious.

If we fail to invest in RE&EE, we run the risk of losing ground to other nations. For the United States to be competitive in a carbon-constrained world, the RE&EE industry will be a critical economic driver.

*If we fail to invest in RE&EE,  
we run the risk of losing ground to other nations.*



Denver-based SolSource Energy Solutions installed the 10-kilowatt photovoltaic system on the Pepsi Center, the first major U.S. sports arena to become carbon neutral.



Ridgway-based Alternative Power Enterprises installed this 1.9-kilowatt photovoltaic system on Telluride High School as part of a collaborative and community demonstration project.



# Background

In 2007, the American Solar Energy Society (ASES) and Management Information Services, Inc. (MISI) undertook the first comprehensive study of the structure, size, and scope of the renewable energy (RE) and energy efficiency (EE) industries. Prior to this work, the basic knowledge of these industries was not well documented.

For example, many studies have explored the potential for specific segments of the RE industry (wind, photovoltaics, biomass, etc.), and many experts have established long-term forecasts of the economic impacts of RE&EE initiatives and spending programs.

But the usefulness of these analyses is limited unless we have an idea of the size and characteristics of existing RE&EE industries. What does it mean to say that “experts predict that the number of jobs will increase threefold by 2015,” when we do not know what the current employment base is? What does it mean to say that “implementation of a certain set of policy incentives will create X thousands of RE&EE jobs by 2020” when we

do not know how many jobs there were in RE&EE in 2007?

Another issue is that all of the important variables differ significantly among forecasts. This makes these studies less valuable in the aggregate than they might be if the parameters were consistent.

The major contributions of our 2007 work were threefold. First, we developed rigorous working definitions of the RE&EE industries. Next, we estimated the size and composition of the RE&EE industries using 2006 data. Third, we forecast their growth to 2030 for the United States and the state of Ohio.

In the study summarized in this document, we updated RE&EE industry data through 2007 and developed updated forecasts through 2030. We also focused on Colorado for a state-level case study on how the RE&EE industries can create jobs and drive economic growth. We anticipate that the findings reported here will become the standard for future economic analyses of the RE&EE industries.



Louisville-based Bella Energy worked with EMC Engineers on this photovoltaic installation for the Antonito School District in the San Luis Valley of Colorado.





# RE&EE Jobs Defined

Despite widespread interest in the size of the RE&EE industries and the number of jobs they generate, prior to our work in 2007 there was no rigorous definition of these industries. We decided that a broader RE&EE definition is more appropriate for several reasons.

First, many renewable energy firms also offer energy efficiency and conservation products and services. Distinguishing between the RE&EE products, services, and sales of these firms would be virtually impossible.

Next, RE&EE are closely related, share many of the same goals, and are often offered as an integrated product. For example, solar buildings have to be extremely energy efficient. Similarly, energy efficient structures often incorporate RE elements and features. In some cases, there is no clear distinction between a "RE" product and an "EE" product. Examples include passive solar design, sustainable buildings, and daylighting, among others.

In addition, RE&EE are large and growing industries that require accepted definitions for current and future economic researchers to follow. Finally, "RE&EE" is a much larger and more robust industry than the RE industry alone.

In our definition, the RE&EE industries include all aspects of the renewable energy and energy efficiency industries, including energy efficient buildings, firms offering energy audits and energy service contracts, and manufacturers, sellers, and installers of a wide array of renewable energy and energy efficiency products and services. We also include hydro (small and large), geothermal, fuel cells, hydrogen, electric and hybrid vehicles, daylighting, and solar, green, and "energy smart" buildings.<sup>1</sup> In addition, our definition includes RE&EE activities in a broad range of organizations.

Because an acceptable industry definition is such an important benchmark, we engaged professional and industry trade leadership in this "defining stage." We solicited input from key researchers and leaders of the American Council for an Energy Efficiency Economy, the Renewable Fuels Association, the Biomass Coordinating Council, the American Wind Energy Association, the Solar Energy Industries Association, the Geothermal Energy Association, the National Hydrogen Association, and other organizations. To facilitate future research, we also related these industry and job categories to the North American Industrial Classification System (NAICS) standard.<sup>2</sup>

<sup>1</sup>Energy smart buildings use intelligent building design as well as renewable energy and energy efficient building components and systems to minimize energy use and environmental impacts and maximize comfort and utility.

<sup>2</sup><http://www.census.gov/eos/www/naics/>.

Here, finally, are our definitions of jobs within the RE&EE industries. We anticipate that these definitions will become the standard for future researchers of the RE&EE industries at the national and state levels.

A job in the RE industry consists of an employee working in one of

the major RE technologies—wind, photovoltaics, solar thermal, hydroelectric power, geothermal, biomass (ethanol, biodiesel, and biomass power), and fuel cells and hydrogen. A job in the EE industry consists of an employee working in a sector that is entirely part of the EE industry, such as an energy service com-

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Jobs in the renewable energy and energy efficiency industries tend to be disproportionately higher paying technical and professional positions.

pany (ESCO) or the recycling, reuse, and remanufacturing sector. It also includes some employees in industries in which only a portion of the output is classified as within the EE sector, such as household appliances, HVAC systems, construction, automobile manufacturing, and others. Finally, in this study, jobs in RE&EE include

persons involved in RE&EE activities in federal, state, and local government, universities, non-profits, trade and professional associations, non-governmental organizations (NGOs), foundations, consultancies, investment companies (analysts, for example), and other related organizations.

COURTESY OF VESTAS WIND SYSTEMS A/S



A worker services a wind turbine in Germany, which has made a national commitment to renewable energy technologies.

ALISON PICHER FOR BELLA ENERGY



Bella Energy solar technicians Bruce Herteledy, Dana Moseman (on top), and Rice Loomis (in tie-dyed t-shirt) install a 44.3-kilowatt ground-mounted photovoltaic system at Boulder County's Maintenance Facility at Walden Ponds. The installation is part of a Boulder County effort to reduce carbon emissions.



# The Size and Scope of RE&EE

In our 2007 work, once we had determined what constituted a RE&EE job, we turned our attention to estimating the size and composition of the RE&EE industry. To do this, we first addressed the RE&EE industries separately, and then combined them. In this document, which summarizes our 2008 work, we updated the data through 2007.

There is relatively little rigorous and comprehensive research addressing the practical relationship between RE&EE and existing jobs or future job creation. Some research is even off the mark, because it emphasizes jobs creation in classically green activities such as RE&EE specialists or workers in recycling plants.

Although these jobs are obviously related to RE&EE, ASES/MISI's data suggest that they constitute only a small portion of the total number of RE&EE jobs. Most RE&EE jobs are standard jobs for accountants, engineers, computer analysts, clerks, factory workers, truck drivers, mechanics, and others. In fact, most of the persons employed in these jobs may not even realize that they owe their livelihood to RE&EE.

## How Big is the RE Industry?

In this study, we define RE energy technologies as hydroelectricity, biomass, geothermal, wind, photovoltaics, solar thermal, fuel cells, and hydrogen.<sup>1</sup>

Except for hydro and industry biomass, the RE U.S. energy contribution is small (see Figure 1), but growing rapidly. In 2007, RE accounted for about seven percent of total U.S. energy consumption.

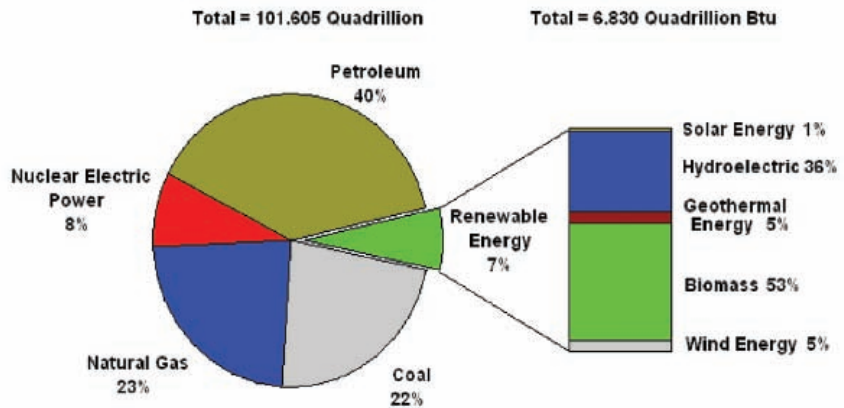
### *RE Revenues and Jobs in 2007*

In 2007, RE gross revenues totaled nearly \$43 billion, and RE created more than 500,000 jobs. More than 95 percent of these jobs were in private industry, and 70 percent were in the biomass sector, primarily ethanol and biomass power.

The second largest number of jobs was in the wind sector, followed by the geothermal and photovoltaics sectors. There were relatively few jobs in the solar thermal or biodiesel sectors. More than half of the RE jobs in government (federal, state, and

<sup>1</sup>Some RE applications contribute to both RE and EE. For example, in this study daylighting is implicitly included in the energy efficient construction sector, and plug-in electric vehicles are a component of the energy efficient vehicles sector.

**Figure 1**  
**Renewable Energy in the United States, 2007**



Source: U.S. Energy Information Administration, 2008.

local) were involved with research and development (R&D) at U.S. Department of Energy (DOE) laboratories. Although relatively small today, the RE industry includes some of the most rapidly growing industries in the world, such as wind, photovoltaics, fuel cells, and biofuels. Table 1 summarizes the status of the U.S. renewable energy industry in 2007.

As Table 1 shows, in 2007 the components of the RE industry differed markedly in terms of both revenues and jobs. For example, biomass power accounted for 41 percent and ethanol accounted for 20 percent of total industry revenues. Hydroelectric power accounted for slightly more than eight percent of total industry revenues. Wind accounted for slightly less than eight percent of total industry revenues, and fuel cells and hydrogen combined ac-

counted for about 4.5 percent of total industry revenues.

In terms of total jobs created, the relative contributions of the RE sectors differ somewhat from the relative contributions based on revenues. This is due to the fact that different RE technologies and industries have very different job creation effects.

There are several salient examples of this. First, hydroelectric power generated 8.2 percent of RE revenues and 3.6 percent of total RE jobs. Next, biomass power generated 41 percent of RE revenues and 31 percent of total RE jobs. Finally, ethanol generated 20 percent of RE revenues and 39 percent of total RE jobs. In all, private industry generated 90 percent of RE revenues, and 96 percent of total RE jobs.

**Table 1****The Renewable Energy Industry in the United States, 2007**

<b>Industry Segment</b>	<b>Revenues/ Budgets (billions)</b>	<b>Industry Jobs</b>	<b>Total Jobs Created</b>
Wind	\$3.30	17,300	39,600
Photovoltaics	1.30	8,700	19,800
Solar Thermal	0.14	1,300	3,100
Hydroelectric Power	3.50	7,500	18,000
Geothermal	2.10	10,100	23,200
Biomass			
Ethanol	8.40	83,800	195,700
Biodiesel	0.40	3,200	7,300
Biomass Power	17.40	67,100	154,500
Fuel Cells	1.10	5,600	12,800
Hydrogen	0.81	4,100	9,400
<b>Total Private Industry</b>	<b>38.45</b>	<b>208,700</b>	<b>483,400</b>
Federal Government	0.65	900*	2,100
DOE Laboratories	1.90	3,800**	8,700
State and Local Government	0.95	2,600	5,800
<b>Total Government</b>	<b>3.50</b>	<b>7,300</b>	<b>16,600</b>
Trade and Professional Associations and NGOs	0.63	1,600	3,500
<b>TOTAL ALL SECTORS</b>	<b>\$42.58</b>	<b>217,600</b>	<b>503,500</b>

\*Includes Federal employees and direct support contractors.

\*\*Includes federal employees, laboratory employees, and direct support contractors.

Source: Management Information Services, Inc. and American Solar Energy Society, 2008.

**U.S. RE Growth, 2006-2007**

Renewable energy consumption in the United States declined about one percent between 2006 and 2007 to 6,830 trillion Btu. The cause of this decline was a

14 percent decrease in hydroelectricity in 2007 due to reduced precipitation in several regions of the country. In contrast, both total and nonrenewable energy consumption increased two percent.

There was wide variation in the consumption of individual renewable energy sources. Biomass-based energy increased seven percent and wind-generated electricity increased 21 percent. Major increases in consumption of biomass for biofuels (ethanol and biodiesel) were largely responsible for the increase in biomass during 2007.

From 2003 through 2007, renewable energy consumption's average annual growth rate was three percent, compared with just one percent for total energy consumption. Biofuels, wind, and photovoltaics were largely responsible for the increase, with five-year average annual growth rates in the range of 25 to 30 percent.

Slightly more than half of the nation's renewable energy consumption occurred in the electric

power sector in 2007, while the industrial sector was the second-leading consumer of renewable energy, accounting for nearly 30 percent. The transportation, residential, and commercial sectors accounted for nine, eight, and two percent, respectively. While the electric power sector currently consumes the most renewable energy (51 percent), its use decreased eight percent between 2006 and 2007. For comparison, in 2003, the electricity sector accounted for 59 percent of total renewable energy consumption.

In contrast, transportation sector renewable energy consumption increased 30 percent during 2007, and residential sector consumption grew 12 percent. Residential sector growth was due to significant increases in biomass, geothermal, and solar/photovoltaic. Commercial and industrial uses of renewable energy

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[WWW.GOBLUESUN.COM](http://WWW.GOBLUESUN.COM)



Left: James Weingardt, owner of Bestway Insulation, stands in front of the 2007 Boulder Energy Makeover house. Bestway installed the insulation for this project, which included many other local businesses and organizations. Right: A Blue Sun Biodiesel FUSION™ B20 biodiesel pump stands ready for business at the Nambe Falls Travel Center north of Santa Fe, New Mexico. Blue Sun has retail pumps in Colorado, Idaho, Nebraska, New Mexico, Washington, and Wyoming.



changed little between 2006 and 2007 and have also changed little as a fraction of total renewable consumption since 2003. That could change for the industrial sector if ethanol and biodiesel use continues to grow rapidly, resulting in increased feedstock consumption. This is especially significant in view of the fact that the largest biomass fuel consumed in the industrial sector—wood and derived fuels—has grown little since 1989 and appears to have peaked in 1997.

Within the electric power sector, wind energy consumption has grown each year since 1998. From 2003 to 2007, wind's share of total renewable energy consumption increased from two percent to five percent. For the first time, wind energy consumption in the electric power sector exceeded geothermal. Hydro electricity accounted for 36 percent of total

renewable consumption in 2007, down from 46 percent in 2003. However, hydro consumption is tied mostly to precipitation, which varies year to year, and few plants are being built or retired.

Electricity generation from renewable sources decreased nine percent in 2007 to 351 billion kilowatt-hours. Excluding hydro electricity, however, renewable electricity generation grew seven percent. This gain was led by a 21 percent increase in electricity from wind and moderate increases in electricity from biomass waste. There has been little change in generation from the largest non-hydro renewable electricity source, wood and derived fuels, since 2003.

With the exception of hydro, changes in renewable electricity capacity generally reflected generation changes in 2007. Total re-

DOE/NREL PIX 15237, IBERDROLA RENEWABLES, INC.



ALISON PICHER FOR BELLA ENERGY



Left: Farmers and ranchers can graze livestock and grow crops adjacent to wind farms, which produce electricity without emissions. Right: From left, Bella Energy solar technicians Bruce Herteledy, Dana Moseman, and Rice Loomis install a photovoltaic system near Walden Ponds as part of Boulder County's effort to reduce carbon emissions.

newable electricity capacity increased five percent to 107 gigawatts (GW), led by a 38 percent (or 4,000 MW) increase in wind capacity. Total nonrenewable electric capacity rose just one percent, to 892,000 MW.

### ***RE Revenues and Jobs, 2006-2007***

RE industry revenues increased 8.7 percent, from \$39.2 billion in 2006 to \$42.6 billion in 2007. Excluding the hydroelectric sector, RE industry revenues increased 11.1 percent, from \$35.2 billion to \$39.1 billion.

However, to eliminate the effects of inflation, we compared growth rates in constant, real dollars. Converting the 2006 RE data to constant 2007 dollars indicates that, in real terms, total RE revenues increased 5.5 percent, from \$40.4 billion in 2006 to \$42.6 billion in 2007. Excluding the hydroelectric sector, RE industry revenues increased 7.8 percent, from \$36.3 billion to \$39.1 billion.

The real growth rate of U.S. gross domestic product (GDP) between 2006 and 2007 was 2.19 percent. Thus, including hydro, the RE industry grew more than twice as fast as the overall U.S. economy. Excluding hydro, the RE industry grew more than three times as fast as the overall U.S. economy.

Further, the biomass power sector is a significant part of the RE industry, but it grew little between 2006 and 2007. Excluding both

hydro and biomass power, the U.S. RE industry grew 15.4 percent between 2006 and 2007—more than seven times as fast as the overall U.S. economy.

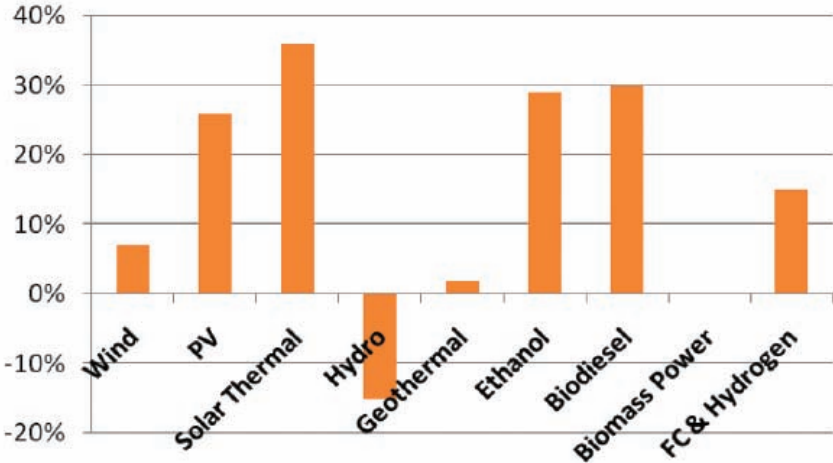
As Figure 2 shows, some sectors experienced very substantial growth. For example, solar thermal grew more than 35 percent, biodiesel and ethanol each grew nearly 30 percent, and photovoltaics grew more than 25 percent.

Although percentage growth figures are important, some of the most rapidly growing RE sectors, such as PV, solar thermal, and biodiesel, are very small. In these cases, even relatively modest growth in total revenues will produce large percentage increases.

The RE sectors that generate the most jobs can be different from those that grow the most rapidly. Figure 3, which shows the total number of jobs generated by the RE sectors in 2007, illustrates this. Despite the differential growth rates of the sectors between 2006 and 2007, ethanol and biomass power dominate job creation, followed far behind by wind, geothermal, photovoltaics, and hydro.

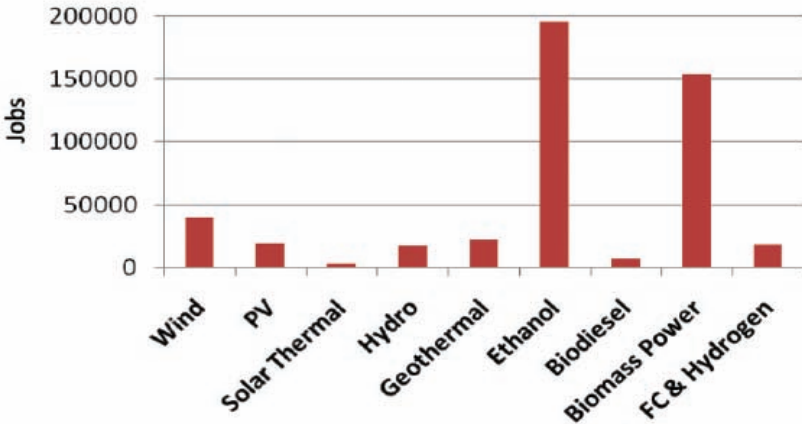
As we've noted elsewhere, most jobs created by RE are standard jobs, and most of the persons employed in these jobs may not even realize that they owe their livelihood to renewable energy. Table 2 (page 30), which lists the jobs created by RE in the United States in 2007 within selected occupations, illustrates this.

**Figure 2**  
**Increase in Real RE Revenues, 2006-2007**  
**(Constant 2007 dollars)**



Source: Management Information Services, Inc. and American Solar Energy Society, 2008.

**Figure 3**  
**Total U.S. RE Jobs in 2007**



Source: Management Information Services, Inc. and American Solar Energy Society, 2008.

**Table 2****RE Jobs in the United States in 2007, by Selected Occupations**

<b>Occupation</b>	<b>Jobs</b>
Agricultural Equipment Operators	4,260
Biochemists and Biophysicists	1,580
Bookkeeping and Accounting Clerks	8,228
Business Operations Specialists	3,390
Carpenters	780
Chemical Technicians	1,880
Civil Engineers	3,080
Computer and IT Managers	1,210
Computer Programmers	2,660
Computer Software Engineers	3,260
Database Administrators	560
Electrical and Electronic Equipment Assemblers	840
Electricians	6,330
Engineering Managers	1,350
Environmental Engineers	630
Environmental Science Technicians	1,690
Employment, Recruitment, and Placement Specialists	600
Forest and Conservation Workers	1,440
HVAC Mechanics and Installers	2,130
Industrial Engineers	1,340
Industrial Production Managers	760
Inspectors, Testers, and Sorters	2,400
Janitors and Cleaners	3,610
Machinists	1,820
Mechanical Engineers	1,950
Payroll and Timekeeping Clerks	1,160
Plumbers, Pipefitters, and Steamfitters	4,670
Purchasing Agents	1,280
Sales Representatives	4,140
Security Guards	1,310
Sheet Metal Workers	1,600
Shipping and Receiving Clerks	2,210
Surveyors	690
Tax Preparers	580
Tool and Die Makers	620
Training and Development Specialists	650
Truck Drivers	9,500

Source: Management Information Services, Inc. and American Solar Energy Society, 2008.

## How Big is the EE Industry?

Specifying and estimating the size of the EE industry is much more difficult than estimating the size of the RE industry. The RE industry is fairly well defined and consists of distinct sectors.

The EE “industry,” on the other hand, is much more nebulous. There are specific elements that are clearly part of the EE industry—the ESCO industry and the recycling industry, for example. However, most EE spending is included in partial segments of large industries, such as vehicles, buildings, lighting, appliances, and others.

### ***EE Revenues and Jobs in 2007***

In 2007, EE gross revenues totaled more than \$1 trillion, and EE provided nearly 8.6 million

jobs. More than 98 percent of these jobs were in private industry, and the recycling, reuse, and remanufacturing sector accounted for more than 36 percent of these jobs. It is interesting to note that the gross EE revenues in 2007 represent substantially more than the combined sales of the three largest U.S. corporations—WalMart, ExxonMobil, and General Motors (\$905 billion).

The nondurable manufacturing sector generated the second largest number of jobs, followed by the miscellaneous durables manufacturing sector, and the computers, printers, copiers, and other office equipment sector. There were relatively few jobs generated by the ESCO sector, the utilities sector, or the government sectors. Table 3 summarizes the status of the U.S. energy efficiency industry in 2007.

*The gross EE revenues in 2007 represent substantially more than the combined sales of the three largest U.S. corporations—WalMart, ExxonMobil, and General Motors (\$905 billion).*

**Table 3****The Energy Efficiency Industry in the United States, 2007**

<b>Industry Segment</b>	<b>Revenues/ Budgets</b> (billions 2007 dollars)	<b>EE Industry Jobs</b> (thousands)	<b>Total Jobs Created</b> (thousands)
ESCO	3.8	23	53
Recycling, reuse, & remanufacturing	290.0	1,372	3,154
Vehicle manufacturing	86.0	193	443
Household appliances and lighting	35.0	134	308
Windows and doors	13.0	54	123
Computers, printers, copiers, etc.	105.0	360	828
TV, video, and audio equipment	48.0	193	447
HVAC systems	13.0	47	108
Industrial and related machinery	21.0	82	187
Miscellaneous durable manufacturing	110.0	397	901
Nondurable manufacturing	218.0	518	1,183
Utilities	2.2	14	32
Construction	48.0	288	660
<b>Total Private Industry</b>	993.0	3,675	8,427
Federal government EE spending	3.8	16	37
State government EE spending	3.2	29	65
Local government EE spending	2.4	22	50
<b>Total Government</b>	9.4	67	152
EE Trade and Professional Associations and NGOs	0.5	3	7
<b>TOTAL ALL SECTORS</b>	\$1,002.9	3,745	8,586

Source: Management Information Services, Inc. and American Solar Energy Society, 2008.

*Clearly the RE&EE industries could be powerful economic drivers.*

**U.S. EE Growth, 2006-2007**

Total EE industry revenues increased 7.5 percent, from \$933 billion in 2006 to \$1,003 billion in 2007. However, in order to eliminate the effects of inflation, we compared growth rates in constant, real dollars. Converting the 2006 EE data to constant 2007 dollars indicates that, in real terms, total EE revenues increased 4.4 percent, from \$961 billion in 2006 to \$1,003 billion in 2007. The total number of jobs created (directly and indirectly) by EE grew more than 800,000 (see Table 3).

**The Bottom Line**

The results of this research are impressive. Clearly the RE&EE industries could be powerful economic drivers.

As Table 4 demonstrates, in 2007, the combined U.S. RE&EE industries generated more than \$1 trillion in revenues (up from \$972 billion in 2006) and more than 9.1 million jobs (up from 8.5 million in 2006). In addition, this growth in revenues and jobs resulted in an increase of nearly \$160 billion in federal, state, and local tax revenues (up from more than \$150 billion in 2006).

RE grew more rapidly than EE and slightly increased its share of the total revenues of the two industries, from 4.0 percent in 2006 to 4.1 percent in 2007. RE also slightly increased its share of the total jobs generated by the two industries, from 5.3 percent in 2006 to 5.5 percent in 2007.

**Table 4**  
**Summary of the U.S. RE&EE Industries in 2007**

<b>Industry</b>	<b>Revenues (billions)</b>	<b>Industry Jobs (thousands)</b>	<b>Total Jobs Created (thousands)</b>
Renewable Energy	\$42.58	218	504
Energy Efficiency	1,002.92	3,745	8,586
<b>TOTAL</b>	<b>\$1,045.50</b>	<b>3,963</b>	<b>9,090</b>

Source: Management Information Services, Inc. and American Solar Energy Society, 2008.



The Friedlander residence in Boulder features high-performance glazing from Boulder-based Alpen, a division of Serious Materials Inc.





SERIOUS MATERIALS INC.



Fort Collins-based Envirofit retrofits dirty two-stroke engines with clean, fuel-efficient direct injection technology in southeast Asia. The result is less air pollution and more fuel savings.



# Forecasting Growth in the RE&EE Industries

The third objective of our research is to forecast the growth of the RE&EE industry to 2030. To accomplish this, we developed three forecast scenarios—a base case, a moderate scenario, and an advanced scenario.

## Base Case

The base case is essentially a “business as usual” scenario, which assumes no change in policy and no new major RE&EE initiatives during next 21 years. The base case also assumes that U.S. and Colorado RE&EE industries continue to develop according to the general trends and rates of growth seen during the past two decades. Results indicate that RE development is minimal under the base case scenario.

The base case is based loosely on the Energy Information Administration (EIA) reference case from the *Annual Energy Outlook 2008*, which assumes that “all current standards, laws, and regulations remain as currently enacted.” Under the EIA refer-

ence case, total U.S. primary energy consumption is projected to increase from 99.5 quadrillion Btu (quads) in 2006 to 118 quads in 2030.

During this period, the share of renewable energy is forecast to increase gradually from about seven percent in 2007 to about nine percent in 2030, while coal is expected to remain constant at about 24 percent of U.S. energy consumption. Biofuels use is expected to increase from 5.6 billion gallons in 2006 to 25.8 billion gallons in 2030, or about 16 percent of total gasoline consumption by volume.

Even with currently available renewable energy technologies, this projection is not consistent with an energy strategy that emphasizes sustainability, climate stabilization, and a healthier environment. The base case clearly indicates that without substantial change in policy, RE&EE is unlikely to significantly increase its share of the U.S. energy market.

*The base case clearly indicates that without substantial change in policy, RE&EE is unlikely to significantly increase its share of the U.S. energy market.*

## Moderate Scenario

The moderate scenario assumes that policymakers implement various moderate, incremental (above the base case) federal and state RE&EE initiatives during the next two decades. It assumes a continuation of the positive policies that are in place, plus market conditions favorable to renewables.

We based this scenario on several "mid-range" estimates. For example, the Western Governors' Association (WGA) conducted a two-year study of clean energy technologies in the region. WGA concluded that, in just the western states, renewable energy could contribute upwards of 68 GW by 2020.

In addition, the Electric Power Research Institute (EPRI) conducted an analysis that emphasized the value in a "balanced

generation portfolio" and included a CO<sub>2</sub> cost beginning in 2015. This analysis estimated that electricity from new renewable resources (excluding hydropower) can reach 13 percent of demand by 2030.

The WGA estimate and EPRI "balanced generation portfolio" estimates present a more aggressive strategy than the base case scenario. However, compared to the assessments of the renewable industry and others, these have to be considered moderate scenario potentials.

## Advanced Scenario

The advanced scenario "pushes the envelope." It indicates what is possible using current or impending technologies in such a scenario. The advanced scenario also assumes that the RE&EE industries are available to take the

RALOS GMBH, EVERGREEN SOLAR, INC.



Germany has committed to installing renewable energy systems like this 12-kilowatt photovoltaic system on a farmer's barn near Buecken.

United States in a new direction. This scenario requires appropriate, aggressive, sustained public policies at the federal and state level during next two decades. The results of the advanced scenario represent a dramatic indication of what would be possible under a long-term program of aggressive renewable energy development.

Factors that might drive such a scenario include fossil fuel shortages and price increases, security concerns, and action to help mitigate global warming, among other things. For renewable energy proponents in the agricultural sector, rural economic development and jobs are already driving aggressive RE&EE growth.

Although we cannot know with confidence what the drivers of an advanced scenario might be, we did determine what might be realistically feasible both economically and technologically in such a “crash” scenario, based in part on existing programs in other countries. For example, Germany projects that renewable energy technologies will meet 50 percent of its energy requirements by 2050. In the United States under an advanced scenario, additional renewable capacity could exceed 600 GW by 2030, potentially

more than the new, additional electric power generating capacity needed by that date according to EIA.

Electric Power Research Institute (EPRI) analyzed an aggressive strategy with both high natural gas prices and high CO<sub>2</sub> costs.<sup>1</sup> This analysis forecast substantial growth of new renewables in the electric supply sector. The results, excluding geothermal and hydropower power, forecast a renewable contribution to electricity of 16 percent by 2030, and as much as 25 percent by 2050.

Similarly, the outlook for renewable fuels is robust. The National Biodiesel Board (NBB) has estimated that biodiesel could displace five percent of petroleum diesel in a near- to mid-term timeframe.<sup>2</sup> The Renewable Fuels Association (RFA) has presented an overall outlook for its sector, noting the dramatic growth in the industry.<sup>3</sup> RFA expects this growth to be sustained, with ethanol reaching 14 to 15 billion gallons in the mid-term future.

But this is not the full potential of the resource. RFA projects that 30 percent of motor fuel—60 billion gallons of annual production—could come from renewable

<sup>1</sup>Electric Power Research Institute, “Role of Renewable Energy in a Sustainable Electric Generation Portfolio,” 2007; Electric Power Research Institute, “Renewables: A Promising Coalition of Many,” *EPRI Journal*, Summer 2007, pp. 8-15.

<sup>2</sup>National Biodiesel Board, *Contribution of the Biodiesel Industry to the Economy of the United States*, September 2006.

<sup>3</sup>Renewable Fuels Association, *Building New Horizons: Ethanol Industry Outlook 2007*, 2007; Renewable Fuels Association, *Tales from the Heartland: Ethanol Industry Outlook 2008*, 2008.

sources by 2030. In addition, the advent of plug-in hybrid vehicles and other electricity-based transportation systems and technologies would allow renewable energy sources to contribute even more to displacing the need for imported oil.

Under the advanced scenario, we forecast that renewable electricity generation will reach 30 percent by 2030. Different technologies will present different challenges and opportunities, and will require different policies to encourage success, especially in the advanced scenario. Here are some specific issues for selected RE technologies.

### ***Wind Power***

To ensure a robust wind industry in the United States, wind developers would benefit from im-

proved access to transmission infrastructure, a long-term production tax credit (PTC) extension, new state and national renewable portfolio standards (RPS) as well as effective implementation of existing standards, continued research support, development of an offshore regime supportive of wind development, continued priority on federal lands, and recognition of bird/bat mitigation success.

### ***Solar Energy***

To flourish in the United States, the solar industry would benefit from the elimination of local covenant restrictions, the development of consistent and effective net metering policies and interconnection standards at state and federal levels, the stabilization of silicon availability and price, new state and national RPS

COURTESY OF VESTAS WIND SYSTEMS A/S



Left: Wind turbines near Portland, Oregon, produce jobs as well as emission-free electricity.

NAMASTE SOLAR ELECTRIC



Right: An employee of Boulder-based Namaste Solar Electric works on a residential photovoltaic installation.

as well as effective implementation of existing standards, research and support to reduce balance of systems cost, infrastructure development, assistance in dealing with competition from foreign markets, inclusion in state and federal renewable laws, the modification of the investment tax credit to remove the cap and extend the credit for multiple (8-10) years, and other incentives.

### **Hydroelectric and Water Power**

Water power is more likely to become common in the United States if policymakers address challenges such as regulatory streamlining and resolving licensing issues for the new technologies such as ocean, tidal, and in-stream power, research and development support for both the

next generation of conventional hydropower equipment and new technologies, a long-term extension of the Section 45 PTC, and the inclusion of ocean, tidal, in-stream, and pipe-in projects, equitable treatment in state RPS efforts, and transmission support.

### **Geothermal Energy**

Geothermal is particularly interesting because it has the potential to provide base load electricity. To grow in the United States, the geothermal industry needs a long-term PTC extension, new state or national RPS and effective implementation of existing standards, restoration of the DOE R&D program, support for an exploratory drilling program and characterization of the U.S. hydrothermal resource base, demonstration of geopressured and oil field co-production, con-

DOE/NREL PIX 06595, U.S. ARMY CORPS OF ENGINEERS



DOE/NREL PIX 10991, GEOTHERMAL RESOURCES COUNCIL



Left: Ice Harbor Dam near Burbank, Washington, on the Snake River produces electricity but no air pollution. Right: Mammoth Pacific Power Plant, a geothermal plant located in the eastern Sierra Nevada mountain range in California, generates 28 megawatts of electricity, but releases no emissions into the atmosphere or onto the land.

sistent work towards an Enhanced Geothermal Systems demonstration, funding and prioritization of public land leasing and permitting, and inclusion in state renewable initiatives.

### ***Biomass Power***

To maximize its contribution to a sustainable energy future in the United States, the biomass industry requires an extension of the biomass PTC, and the inclusion of a thermal credit to promote high efficiency combined heat and power applications, new state and national RPS and effective implementation of existing standards,

access to a sustainable supply of feedstock (including from public lands), inclusion in state renewable efforts without excessive restrictions, continued research support, credits for other attributes (pollutant and criteria pollutant reductions, greenhouse gas [GHG] emissions reductions, and recovered thermal energy) and—in the case of distributed biomass applications—recognition of grid benefits in tariff design and cost allocation, inclusion of landfill gas and appropriate municipal solid waste technologies as creditable renewable energy systems, and reasonable interconnection standards.

*None of the impediments to achieving the advanced scenario are insurmountable if the political will exists to support renewable energy at the federal and state levels.*





## Biofuels

Challenges for biofuels developers include deploying first-of-a-kind biorefinery technology, increasing cellulosic biofuels research, development, deployment, and commercialization funding, expanding and modernizing fueling infrastructure, and increasing the number of flexible-fuel vehicles on the road.

Achieving the goals of the advanced scenario will require progress in improving performance, lowering cost, and overcoming challenges of market acceptance at scale for each RE technology. However, none of the impediments to achieving the advanced scenario are insurmountable if the political will exists to support renewable energy at the federal and state levels.

DOE/NREL PIX 07892, MIKE MCPHEETERS,  
COURTESY OF BLACK AND VEATCH



WWW.GOBLUESUN.COM



Left: The Grayling Generating Station burns biomass (waste wood), providing more than 36 megawatts of electricity to Grayling, Michigan, using a renewable resource. Right: A farmer fills up his tractor with Blue Sun FUSION™ B20 biodiesel.

## The Bottom Line

Achieving success in any scenario is subject to significant uncertainties in key market drivers, including volatility in oil and gas prices, the pace and scale of action on climate change, the extent of technology breakthroughs, and federal and state government RE policies and incentives. However, public policy<sup>1</sup> and future energy prices are likely to be the major determinants of future market share for RE.

Although no one can predict the future with precision, the ASES/MISI approach has been vetted in the peer-reviewed literature and found to be credible.<sup>2</sup> The American Council for an En-

ergy Efficient Economy has also analyzed our approach and found it to be valid.<sup>3</sup> In addition, Al Gore's staff has reviewed our analysis and has used it to help formulate some of Mr. Gore's energy policy recommendations.

Table 5 shows the total revenues generated and jobs created in 2030 under each of the scenarios. The results of the forecast national scenarios, from 2006 to 2030 indicate that, in the base case, RE revenues increase 145 percent, from \$39 billion to \$95 billion, and EE revenues increase 95 percent, from \$933 billion to \$1,818 billion. Also, in the base case, jobs created by RE increase 190 percent, from 446,000 to 1.3 million, and jobs created by EE

**Table 5**  
**U.S. Renewable Energy and Energy Efficiency Industries in 2030**

	Revenues (Billions of 2007 Dollars)			Total Jobs Created (Thousands)		
	Base Case	Moderate Scenario	Advanced Scenario	Base Case	Moderate Scenario	Advanced Scenario
<b>RE</b>	\$98	\$212	\$560	1,305	2,846	7,328
<b>EE</b>	1,868	2,036	3,734	14,953	16,658	29,878
<b>Total</b>	\$1,966	\$2,248	\$4,294	16,258	19,504	37,206

Source: Management Information Services, Inc. and American Solar Energy Society, 2008.

<sup>1</sup>See, for example, American Wind Energy Association, "Wind Energy Production Tax Credit," September 2008; Navigant Consulting, "Economic Impacts of Tax Credit Expiration," February 2008; University of Colorado, Denver, School of Public Affairs, "Presidential Climate Action Plan," December 2007.

<sup>2</sup>See Roger H. Bezdek, Robert Wendling, and Paula DiPerna, "Environmental Protection, the Economy, and Jobs: National and Regional Analyses," *Journal of Environmental Management*, Vol. 86, No. 1 (January 2008), pp. 63-79; Roger H. Bezdek, and Robert Wendling, "Jobs Creation and Environmental Protection," *Nature*, Vol. 434, No. 7033 (March 31, 2005), p. 678; Roger H. Bezdek, and Robert Wendling, "Potential Long-Term Impacts of Changes in U.S. Vehicle Fuel Efficiency Standards," *Energy Policy*, Vol. 33, No. 3 (February 2005), pp. 407-419.

<sup>3</sup>Karen Ekrhardt-Martinez and John A. Laitner, *The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture*, American Council for an Energy-Efficient Economy, Report E083, May 2008.

increase 85 percent, from 8 million to 15 million.

In the advanced scenario, RE revenues increase 1,400 percent, from \$39 billion to \$597 billion, and EE revenues increase 320 percent, from \$933 billion to \$3,933 billion. Also in the advanced scenario, jobs created by RE increase 1,700 percent, from 446,000 to 7.9 million and jobs created by EE increase 300 percent, from 8 million to 32 million. Thus, under all scenarios RE growth is much larger than EE growth, but the economic and job impact of EE remains orders of magnitude larger than RE.

## Time is of the Essence

ASES/MISI developed similar RE&EE 2030 forecast scenarios in 2007,<sup>1</sup> and the alert reader will note that the current forecasts for the RE&EE industries in 2030 are significantly smaller than the 2007 forecasts. For example, real RE revenues in 2030 are about 10 percent (\$55 billion) lower in the 2008 forecast than in the 2007 forecast, and the total number of jobs generated by RE in 2030 is about eight percent (591,000 jobs) lower in the 2008 forecast than in the 2007 forecast. In addition, real EE revenues in 2030 are about eight percent (\$317 billion) lower in the 2008 forecast than in the 2007 forecast, and the total number of jobs generated by EE in

2030 is about seven percent (2.3 million jobs) lower in the 2008 forecast than in the 2007 forecast.

The reason for this decline is straightforward. In 2007, we assumed that the extremely ambitious large-scale federal, state, and local government incentives, policies, and mandates characterizing the advanced scenario would be implemented beginning in 2008. Obviously, this has not occurred, and in this study we assume that these policies and incentives will be implemented in 2009.

The United States has lost a year of valuable time that we could have spent working toward achieving the RE&EE 2030 goals, and the negative impact on the RE&EE industries in 2030 is significant. All of the RE&EE programs and initiatives take years to be implemented and ramped up, and in all of the RE&EE sectors the largest gains are made in the years immediately preceding the target year of 2030, with the single largest gains in 2029 and 2030. It is the large gains in these last years that are lost by starting the advanced program in 2009 instead of 2008, and it will be very difficult to recoup these gains.

The longer the United States delays, the more difficult it will be to achieve the RE&EE goals outlined here for 2030.

<sup>1</sup>Roger H. Bezdek, *Defining, Estimating, and Forecasting the Renewable Energy and Energy Efficiency Industries in the U.S. and in Ohio*, 2007.

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An Alternative Power Enterprises employee works on a residential grid-tied 4-kilowatt photovoltaic system on Hastings Mesa near Placerville, Colorado.



# Colorado Case Study

Colorado is well positioned to facilitate and take advantage of rapid growth in the RE&EE industries, especially compared to many other states. Although RE&EE is still small in the state, there are many state government and private industry RE&EE initiatives already in place. These programs, combined with educational and private sector initiatives and the presence of facilities like the National Renewable Energy Laboratory (NREL), are likely to place Colorado firmly in the forefront of the development and growth of the RE&EE sector for the foreseeable future.

## RE&EE in Colorado in 2007

As Table 6 shows, the RE&EE industries in Colorado in 2007 accounted for more than \$10 billion in revenues and generated more than 91,000 jobs. RE&EE accounted for more than four per-

cent of Colorado gross state product (GSP) and more than three percent of total employment in the state.

The RE&EE companies in Colorado represent a wide diversity of size, function, and technologies. These firms employ a broad range of workers at all educational and skills levels and at widely differing earnings levels. In addition, few employees at these organizations are renewable energy or energy efficiency specialists. Most work as machinists, engineers, laborers, clerks, bookkeepers, accountants, maintenance workers, and cost estimators, among other jobs.

Table 7, which describes the actual jobs created by the RE&EE industries in Colorado in 2007, makes this point forcefully. Most employees are "RE&EE" workers only because the company they work for is a RE&EE firm.

**Table 6**  
**Colorado Renewable Energy and Energy Efficiency Industries, 2007**

Industry	Revenues (millions)	Industry Jobs	Total Jobs
Renewable Energy	\$1,082	4,415	10,075
Energy Efficiency	\$9,129	35,470	81,210
<b>TOTAL</b>	<b>\$10,211</b>	<b>39,885</b>	<b>91,285</b>

Source: Management Information Services, Inc. and American Solar Energy Society, 2008.

**Table 7****RE Jobs in Colorado in 2007, by Selected Occupations**

<b>Occupation</b>	<b>Jobs</b>
Accountants and Auditors	950
Bookkeeping and Accounting Clerks	1,260
Business Operations Specialists	953
Cashiers	1,337
Construction Managers	377
Civil Engineers	519
Computer Software Engineers	844
Computer Support Specialists	376
Computer and IT Managers	177
Customer Service Representatives	1,398
Electricians	912
Electronics Engineers	358
Environmental Engineers	113
Environmental Scientists and Specialists	131
Executive Secretaries and Administrative Assistants	1,288
Financial Analysts	183
Glaziers	152
HVAC Mechanics and Installers	241
Industrial Machinery Mechanics	184
Inspectors, Testers, and Sorters	449
Janitors and Cleaners	1,520
Machinists	498
Management Analysts	275
Marketing Managers	127
Mechanical Engineers	219
Order Clerks	209
Roofers	167
Plumbers, Pipefitters, and Steamfitters	458
Recyclable Materials Collectors	121
Security Guards	802
Sheet Metal Workers	145
Stock Clerks	939
Training and Development Specialists	137
Truck Drivers	769
Waste Treatment Plant Operators	408
Welders and Solderers	538

Source: Management Information Services, Inc. and the American Solar Energy Society,, 2008.

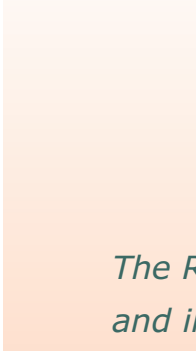
It is important to note that as the U.S. manufacturing sector is losing jobs, many RE&EE technologies are growing rapidly.<sup>1</sup> In Colorado and other states, these types of firms can help revitalize the manufacturing sector and provide the types of diversified, high-wage jobs that all states seek to attract. RE&EE is more than a way to offset other energy sources—it also produces more jobs.

### **RE&EE Firms in Colorado**

In the complete report summarized here (available as a free download at [www.ases.org/greenjobs2007](http://www.ases.org/greenjobs2007)), we examined a functional, technological, and geographic mix of RE&EE companies in Colorado. Although the survey was not meant to be comprehensive or exhaustive, we believe it is a useful way of describing the types of real people and products that characterize the RE&EE industries in Colorado. Behind the

data and forecasts, the RE&EE industries in Colorado comprise hundreds of firms employing thousands of persons.

In general, these firms are located throughout the state, in major urban centers, suburbs, small towns, and rural areas. They range in size from small firms of several employees to large firms employing thousands, although most of them are relatively small. Workers in these organizations range from those with the most basic and rudimentary skills to very highly skilled technical and professional employees. These organizations serve a variety of markets, from local to state and regional to national to international. We provide brief profiles of a few of these companies here. The complete report (available at [www.ases.org/greenjobs2007](http://www.ases.org/greenjobs2007)) includes more details.



*The RE&EE sector in Colorado generates (directly and indirectly) more than 2.5 times as many jobs per dollar of revenues as does the O&G sector in the state.*

<sup>1</sup>For example, wind power is the fastest growing source of electrical power in the world.



Left: Ridgway-based Alternative Power Enterprises installed this 10-kilowatt photovoltaic system in Montrose, Colorado. Right: New Mexico Governor Bill Richardson fuels the Blue Sun Biodiesel dragster at a grand opening event for a new Blue Sun FUSION™ biodiesel retail pump at the Nambé Falls Travel Center north of Santa Fe.

**Alternative Power Enterprises, Inc.**

Alternative Power Enterprises, Inc. (APE) was founded in 1992 and is headquartered in Ridgeway, Colorado. It has six employees, and provides renewable energy systems and services for space heating, water heating, and electrical power to residential and business clients. Ninety-five percent of its clientele is residential and five percent is commercial.

APE specializes in solar energy, solar hot water, solar space heating, solar electric, and solar water pumping systems, and customizes small or large power systems based on clients' needs. The company also distributes solar hot water heaters and performs site services in Colorado and the Four Corners region.

**Blue Sun Biodiesel.** Blue Sun Biodiesel, located in Golden, produces diesel oil from dryland oilseed and is one of America's leading biodiesel/biofuel research, production, and distribution companies. Founded in 2001, it has 17 employees, five of whom are degreed technologists.

Blue Sun Fusion, Blue Sun's flagship product, is available at numerous pumps throughout Colorado, New Mexico, Idaho, and several other states. It is a blend of premium Blue Sun Biodiesel (20 percent) and petroleum diesel fuel (80 percent), combined with Blue Sun's proprietary additive package specifically tailored for regional climates and seasons. Research indicates that Blue Sun Fusion outperforms diesel fuel in terms of emissions reductions.





Left: Envirofit's clean-burning biomass cook stoves not only reduce fuel consumption and toxic emissions, they also offer local entrepreneurs in developing nations a sustainable business model. Right: Wind turbines near Mehuken, Norway, generate clean, renewable electricity.

### **Envirofit International.**

Founded in 2003, Envirofit International is based in Fort Collins and has 30 employees in Colorado, 29 of them degreed technologists. It designs, develops, manufactures, and sells direct injection retrofits for two-stroke gasoline engines to increase energy efficiency and reduce carbon emissions in developing countries.

Envirofit also develops and distributes well-engineered products like cook stoves for low-income markets that traditionally have been overlooked. Established as a U.S. tax-exempt corporation, Envirofit used initial donations and institutional support to fund product development and early stage product commercialization, and uses operating income to develop and expand its businesses.

### **Vestas American Wind Technology.**

Vestas, one of the world's leading suppliers of wind energy technologies, is establishing manufacturing operations in Windsor and Brighton, Colorado. By the fall of 2008, the Windsor plant, which makes turbine blades, had more than 300 production employees, and it will eventually employ more than 600 workers. The two Brighton plants, which will make nacelles and blades, will employ another 1,400 people. Vestas sells its products to commercial and utility customers.

The Vestas Group, headquartered in Denmark, currently employs about 12,000 people worldwide. Vestas has installed more than 35,000 wind turbines in 63 countries, including more than 9,600 in the U.S. In 2007, it had a 23 percent market share internationally.

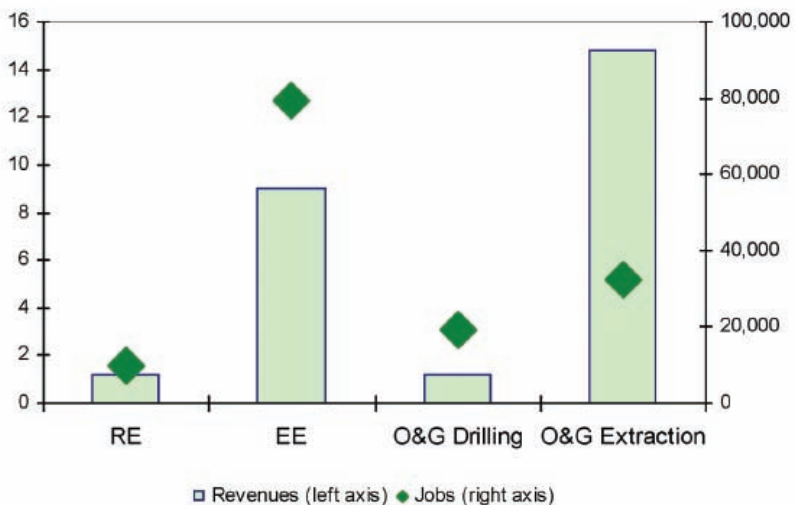
### RE&EE in Colorado Compared to the Oil and Gas Sector

The economic impact of the RE&EE sector can be compared to that of the Colorado oil and gas sector, as estimated by the Colorado Energy Research Institute (CERI) at the Colorado School of Mines.<sup>1</sup> The CERI study estimated the economic and employment impacts on Colorado of the oil and natural gas (O&G) industries in the state, as directed by the Colorado legislature. Comparison of the CERI estimates with those derived here for RE&EE can provide perspective on the relative impacts of these energy sectors on the state economy and labor market.

The O&G sector in Colorado is more than 50 percent larger (\$5.7 billion) than the RE&EE sector. However, the RE&EE sector generates about 70 percent more jobs (39,000) than the O&G sector. Thus, the RE&EE sector in Colorado generates (directly and indirectly) more than 2.5 times as many jobs per dollar of revenues as does the O&G sector in the state.

As Figure 4 shows, the number of jobs generated per dollar of revenues differs dramatically among RE, EE, O&G extraction, and O&G drilling, completion, and recompletion. RE generates about 9,300 jobs per billion dollars of revenues, EE generates about 8,900 jobs per billion dollars of

**Figure 4**  
**Comparative Economic and Jobs Impact in Colorado of RE, EE, O&G Extraction, and O&G Drilling, Completion, and Recompletion**



Source: Management Information Services, Inc. and American Solar Energy Society, 2008.

<sup>1</sup>Colorado Energy Research Institute, Oil and Gas Impact Analysis, June 2007.

revenues, O&G extraction generates about 2,200 jobs per billion dollars of revenues, and O&G drilling, completion, and recompletion generates about 16,000 jobs per billion dollars of revenues. (Recompletion refers to the practice of redrilling an oil or gas well to a new producing zone or depth when the current zone is depleted.)

## RE&EE in Colorado in 2030

Unlike some industries, RE&EE is a realistic target industry for job creation in Colorado. With a wide variety of the required skills as well as ongoing research into RE&EE technologies, communities in Colorado can choose to build clusters around different segments of the RE industries.

However, Colorado must recognize that it is in fierce competition as communities around the United States compete for new

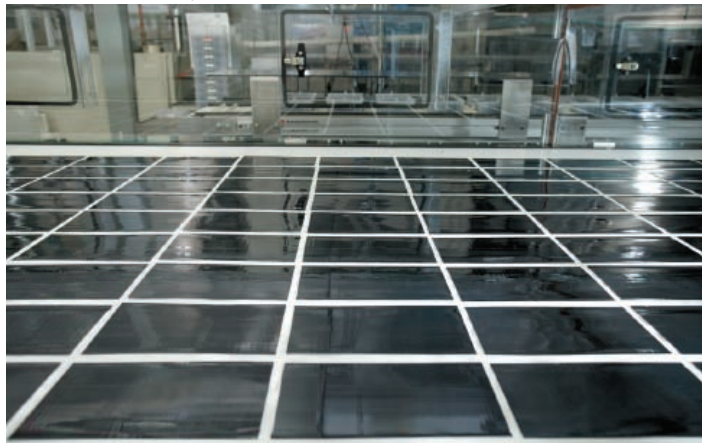
emerging energy industries with traditional university-centered research areas, high-tech metropolitan areas, and regions traditionally associated with manufacturing. The wide variety of entrance points to the RE&EE industries makes this market easier to penetrate if Colorado can market its strengths in high-tech, research, education, and construction and operation.

The sooner Colorado implements state policies and incentives and private sector initiatives favorable to RE&EE, the sooner it can reap the advantages of a clean energy economy. Colorado has some advantage over other states in that it has many public and private programs designed to encourage the development of the RE&EE industries. The complete report summarized in this document (available as a free download at [www.ases.org/greenjobs2007](http://www.ases.org/greenjobs2007)) provides more details about these and other programs.

[WWW.ALTERNATIVE-POWER.COM](http://WWW.ALTERNATIVE-POWER.COM)



[EVERGREEN-SOLAR,INC.](http://EVERGREEN-SOLAR,INC.)



Left: Alternative Power Enterprises employees install a photovoltaic system in Ouray, Colorado, in July 2007. Right: Manufacturing renewable energy technologies like photovoltaics often produces jobs that cannot easily be outsourced.

## ***Support from the State***

### **The Governor's Energy Office.**

The Governor's Energy Office (GEO) offers a number of initiatives to consumers, businesses, and nonprofits around the state to reduce energy use and carbon footprints. For example, GEO is partnering with four utility companies to offer a rebate for small wind turbine installations, is developing energy efficiency and renewable energy programs for new and retrofit construction, and is working with local jurisdictions and homebuilders throughout Colorado to promote green building practices and financing options for the installation of renewable energy technologies.

GEO also works in close partnership with building departments to provide energy code training, information, and other resources to support local adoption and implementation of the 2006 International Energy Conservation Code (2006 IECC). And GEO has streamlined the process for choosing an ESCO by providing a list of 11 pre-approved ESCOs that will provide the highest level of service and dependability.

### **The Colorado Climate Action Plan.**

The Colorado Climate Action Plan envisions training thousands of workers to improve energy efficiency in homes, stores, and factories, and training thousands of others to build wind farms, solar facilities, and geothermal plants across the state. The targets for this program are to reduce GHG emissions to 20 percent below 2005 levels by 2020 and 80 percent below 2005 levels by 2050. The Plan also includes initiatives that affect transportation, utilities, research and innovation, recycling and solid waste, state leadership, and education and workforce development.

DOE/NREL PIX 07158, WARREN GRETZ



The Ponnequin Wind Farm in Colorado offsets carbon emissions with clean wind-generated electricity.

### **Greening of State**

**Government.** The Greening of State Government executive orders charge state departments, agencies, and offices to take a position of leadership in the New Energy Economy. State government will reduce energy consumption, increase the use of renewable energy sources, increase the energy efficiency and decrease the environmental impact of the state vehicle fleet, implement environmental purchasing standards, and reduce waste and increase recycling. Greening Government enables state employees to take a position of leadership regarding energy conservation and efficiency, thereby reducing the environmental impact of state operations.

### **New Energy Communities**

**Initiative.** A part of Colorado's New Energy Economy initiative, the New Energy Communities Initiative works to maximize energy efficiency and conservation, enhance community livability, promote economic development in downtowns, and address climate change by reducing carbon emissions. The Initiative focuses on greening public facilities, greening downtowns, and greening homes.



### **Private Sector Initiatives**

In addition to—and at least partly as a result of—state government policies and incentives, a number of private sector RE&EE initiatives are underway in Colorado. The Danish company **Vestas** is developing major wind turbine manufacturing facilities in Windsor and Brighton that will eventually employ a total of more than 2,000 people.

**AVA Solar Inc.**, which is a spin-off from Colorado State University, is planning to build a manufacturing plant in Colorado that will use new technology to manufacture cheaper solar panels. The new factory will employ 500 people and will be capable of producing enough solar panels every year to generate 200 MW of power. Production is expected to begin by the end of 2008.

**IBM Corp.** has opened a 115,000-square-foot “green data center,” the first of its kind for the company, at its campus in Boulder. IBM invested \$350 million in the center to meet demand for more energy efficient data centers and to help itself and its clients reduce energy costs. IBM received \$732,000 in incentives from the city of Boulder and the Colorado Office of Economic Development and International Trade to help support the Boulder data center.

### **Renewable Energy Systems Americas Inc.**

, a British developer and builder of wind energy farms, is moving its U.S. headquarters from Austin, Texas, to Broomfield. RES-Americas plans to relocate 70 full-time jobs from Texas and add another 70 positions within the next year for a total of 140 employees in Broomfield. The company will receive economic incentives from Broomfield for the move. Founded in 1997, RES-Americas has grown to become one of the country's leading wind farm developers, actively participating in developing more than 12 percent of the installed wind power capacity in the United States.

**Siemens Energy** has announced that it will establish a new U.S. wind turbine research and development center in Boulder. The new facility will eventually employ about 50 people and will focus on atmospheric science research, aerodynamic blade design, structural dynamics, wind turbine dispatch prediction, and reliability. Siemens will test basic wind turbine characteristics and verify new performance enhancing features and turbine reliability under severe weather conditions for a minimum period of three years. The company cited the proximity of institutions such as NREL and the National Wind Technology Center as well as support from the state of Colorado and the city of Boulder as important factors in the decision to locate in Boulder.

**Table 8****Summary of the Colorado Renewable Energy and Energy Efficiency Industries in 2030**

	Revenues (Millions of 2007 Dollars)			Total Jobs Created		
	Base Case	Moderate Scenario	Advanced Scenario	Base Case	Moderate Scenario	Advanced Scenario
<b>RE</b>	\$2,076	\$3,811	\$13,131	17,370	29,400	113,375
<b>EE</b>	7,681	20,479	44,345	174,810	208,620	499,550
<b>Total</b>	\$19,657	\$24,290	\$61,476	192,181	238,020	612,925

Source: Management Information Services, Inc. and American Solar Energy Society, 2008.

All of these initiatives increase the probability that RE&EE firms will locate or develop in Colorado. The advanced scenario in Table 8 illustrates the growth possible in the RE&EE industries in Colorado in 2030 when public and private entities support favorable market conditions and a sustained public policy commitment.

***The Bottom Line for Colorado***

The ASES/MISI work summarized in this report demonstrates how important the RE&EE industries are to the economy and labor market in both the United States and Colorado. For Colorado, several important policy implications emerge from this research.

First, the RE industry in the state is small and, except for the federal sector—primarily the National Renewable Energy Laboratory (NREL), a U.S. Department of Energy (DOE) laboratory—does not currently play a major role in the state economy or job market. For example, in 2007, RE accounted for less than 0.6 percent of Colorado gross state product (GSP) and the total jobs created by RE accounted for only about 0.4 percent of total Colorado employment.

Nevertheless, nationwide, Colorado is a disproportionately large player in some RE technologies. Although Colorado GSP accounts for only about 1.7 percent

of U.S. GDP, in 2007 Colorado accounted for about six percent of the U.S. wind market, nearly six percent of the U.S. photovoltaics market, about five percent of the U.S. ethanol market, and about five percent of the U.S. biodiesel market.

Second, despite various proposals in recent years that use RE as a job creation program for the disadvantaged, the chronically unemployed, or other target populations, this is not currently feasible in Colorado. Total employment in Colorado is more than 2.6 million and unemployed Coloradoans number more than 100,000. The total number of jobs generated by RE (excluding NREL) is only about 4,600, and employment in the RE industry (excluding NREL) is only about 2,000.

However, if we include EE, the situation is different. Combined, RE&EE created more than 91,000 jobs in Colorado in 2007, nearly 40,000 of which were in the RE&EE industries. We anticipate that both sectors—but especially RE—will grow more rapidly than the state economy as a whole. The current total of about 91,000 jobs generated by RE&EE in Colorado may increase to more than 600,000 within 20 years. This rapid growth of jobs from a large base of employment provides both challenges and opportunities for Colorado labor, education, apprenticeship, and job training programs in the coming decades.

Third, Colorado is well positioned to facilitate and take advantage of rapid growth in the RE&EE industries, especially compared to many other states. Many supportive state government and private industry RE&EE initiatives are already in place. These programs combined with educational initiatives like the recently announced School of Global Environmental Sustainability at Colorado State University and the presence of NREL give Colorado an edge.

Fourth, RE&EE represents an effective job creation mechanism. For example, RE&EE creates, per dollar of expenditure, 2.5 times as many jobs as the oil and gas (O&G) sector in Colorado.

Fifth, the longer the United States and Colorado delay implementing ambitious RE&EE programs and incentives, the more difficult it will be to achieve the goals outlined here for 2030. Every year's delay has a highly disproportionate and negative impact on the achievement of the long-term RE&EE 2030 goals. Time lost in the next several years will be very difficult to make up, and—to achieve the 2030 RE&EE goals—appropriate policies and incentives must be implemented as soon as possible.

Finally, a goal of this project is to help create programs that support the emerging RE&EE industry in the state. Our major finding is that Colorado education professionals will have to develop and





SERIOUS MATERIALS INC.

Boulder-based Alpen, a division of Serious Materials Inc., provided the high-performance glazing for the Friedlander residence in Boulder.

expand education and training programs in the near future to facilitate the anticipated growth of RE&EE. However, most of these programs should focus on the EE sector—at least in the short term—simply because there are about eight times as many EE jobs in the state as RE jobs. In the future, RE jobs will increase more in percentage terms, but the overwhelming number of jobs created during the next two decades in the RE&EE sector in Colorado will be related to EE.

Of course, many of the RE&EE jobs, skills, and education and training requirements overlap. For example, the largest numbers

of jobs created in the RE&EE sector are related to energy efficient construction and green buildings, but green buildings contain important elements of both RE&EE.

Another example of RE&EE overlap is the rapidly growing market for “Green IT,” which involves the use of computer resources in an energy and environmentally efficient way. Green criteria include energy efficiency, using low-emission building materials, recycling, using RE technologies, and other green strategies. It is thus clear that the jobs, skills, and education and training requirements needed to support green buildings, green IT, and other sectors and technologies contain important elements of both RE and EE.

[WWW.ALTERNATIVE-POWER.COM](http://WWW.ALTERNATIVE-POWER.COM)



Ridgway-based Alternative Power Enterprises installed this photovoltaic system in Ophir, Colorado, in August of 2007.

## ***Challenges and Opportunities in Colorado***

The challenge is to identify the types of jobs, skills, and education and training requirements that correspond to the employment opportunities RE&EE industries will create in coming decades. Our complete report (available at [www.ases.org/greenjobs2007](http://www.ases.org/greenjobs2007)) provides information to help the state's labor market and educational planners identify these opportunities. We detail more than 160 RE&EE occupational specialties, including salaries and education and training requirements.

The opportunity is that Colorado's education and training programs can be calibrated to address these emerging new energy economy jobs. This would prepare hundreds of thousands of state residents for new jobs and viable long-term career opportunities in rapidly expanding RE&EE fields.

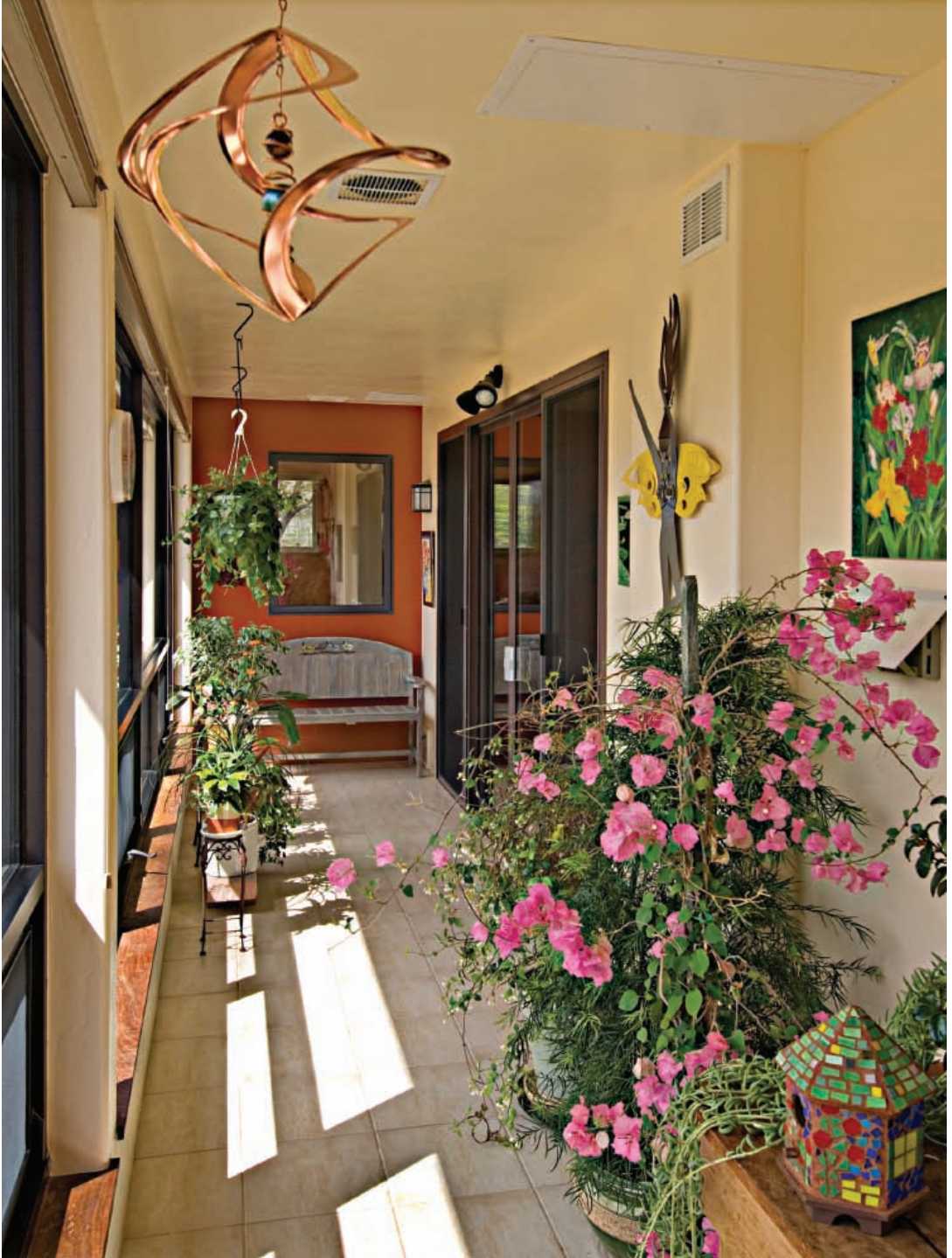
HENRY MUELLER DESIGN, INC., BOULDER, CO



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Left: Daylit interior of a home near Boulder, Colorado. Daylighting reduces the need for electric lighting during daylight hours. Right: An AVA Solar technician monitors the production process at the company's Longmont facility.



The sunspace in the Solar Harvest home built by Boulder builder EcoFutures provides heat for the house and a home for healthy plants. This is the first net-zero energy home in the city of Boulder.



# The Way Forward

Although Colorado is relatively well positioned to participate in the emerging new energy economy, the same may not be true of many other states or the United States as a whole. It is instructive to contrast the United States with Germany, noting that the United States—and especially Colorado—has better RE resources than Germany does.

What Germany has, however, is a commitment to growing its RE&EE industries. The results are impressive.

Germany has about one-quarter the GDP and population of the United States, but it has 249,000 RE jobs (31,000 more than the United States). In Germany, RE employment has grown 16 percent over the past year. In the United States, RE employment has grown 12 percent in the same period.

The contrast within specific RE sectors is even more striking. For example, in 2007, there were 84,000 jobs in the wind sector in Germany, but only 17,000 in the United States (600 in Colorado). In the PV sector, there were 39,000 jobs in Germany, but only 9,000 in the United States (275 in Colorado).

Germany's GDP is about 14 times the GSP of Colorado and its population is about 16 times the population of Colorado. However, Germany has 58 times the number of RE jobs as Colorado, 140 times the number of jobs in the wind sector as Colorado, and 142 times as many jobs in the PV sector as Colorado.

In addition, Germany produces half of the wind rotors in the world and one-third of the solar panels in the world. The Germans also lead the world in

biodiesel production and are second only to the Japanese in fuel cells and hybrid cars. By 2020, the number of German RE jobs will exceed the number of jobs in machinery or vehicle manufacturing.

The implications for the United States—and Colorado—are obvious and potentially ominous unless we initiate ambitious RE&EE policies and incentives soon.

RE&EE can create skilled, well-paying jobs, many of which are not subject to foreign outsourcing. RE&EE can create jobs in two categories that every state is eager to attract and retain—college-educated professional workers, many with advanced degrees, and highly skilled technical workers, with advanced training and technical expertise, many of them in the manufacturing sector.

Clearly, a robust RE&EE industry in Colorado—and in the rest of the United States—would be good economic news for workers as well as local and state governments and economies. Nationally and locally, the RE&EE industry can help move us toward a vibrant, robust, environmentally sustainable future.

If we fail to invest in RE&EE, however, the United States runs the risk of losing ground to RE&EE programs and industries in other nations. If we refuse to address policy and regulatory barriers to the sustained, orderly development of the RE&EE industry, other countries have already and will continue to take the lead and reap the economic and environmental benefits. For the United States to be competitive in a carbon-constrained world, the RE&EE industry will be a critical economic driver.

*For the United States to be competitive in a carbon-constrained world, the RE&EE industry will be a critical economic driver.*



SERIOUS MATERIALS INC.

High-performance glazing from Alpen, a division of Serious Materials, creates a bright interior and a healthy space for plants in the Emmons residence in Boulder.

TONI DEVOLDER, PHOTOGRAPHER. ©2006 ECOFUTURES BUILDING, INC.



The dining room in the Solar Harvest, built by Boulder builder EcoFutures, features bamboo floors, elegant cabinetry, and compact fluorescent lights.





# List of Acronyms

<b>ASES</b>	American Solar Energy Society
<b>DOE</b>	U.S. Department of Energy
<b>EIA</b>	Energy Information Administration
<b>EPRI</b>	Electric Power Research Institute
<b>ESCO</b>	Energy service company
<b>GDP</b>	Gross domestic product
<b>GED</b>	General Educational Development
<b>GHG</b>	Greenhouse gas
<b>GSP</b>	Gross state product
<b>GW</b>	Gigawatt
<b>MISI</b>	Management Information Services, Inc.
<b>NAICS</b>	North American Industrial Classification System
<b>NBB</b>	National Biodiesel Board
<b>NGO</b>	Non-governmental organization
<b>O&amp;G</b>	Oil and gas
<b>PTC</b>	Production tax credit
<b>PV</b>	Photovoltaic
<b>R&amp;D</b>	Research and development
<b>RE&amp;EE</b>	Renewable energy and energy efficiency
<b>RFA</b>	Renewable Fuels Association
<b>RPS</b>	Renewable portfolio standard
<b>WGA</b>	Western Governors' Association





## AMERICAN SOLAR ENERGY SOCIETY

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Founded in 1954, the American Solar Energy Society (ASES) is the nation's oldest and largest professional organization dedicated to the advancement of solar and renewable energy technologies in the United States. Its professional members include researchers in a broad range of renewable energy technologies, including solar, wind, biomass, and geothermal. For the past 37 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 eight topical divisions: Concentrating Solar Power, Clean Energy and Water, Resource Applications, Solar Buildings, Solar Electricity, Renewable Fuels and Transportation, Solar Thermal, 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 13 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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