Renewable Energy and Energy Efficiency:

Economic Drivers for the 21st Century

Roger Bezdek, Principal Investigator,
Management Information Services, Inc.
for the
American Solar Energy Society

Front cover, top: 4 Times Square, a 48-story skyscraper at the corner of Broadway and 42nd Street, was the first major office building to be constructed in New York City in the 1990s. The building's most advanced feature is the photovoltaic skin, a system that uses thin-film PV panels to replace traditional glass cladding material. The developer, the Durst Organization, has implemented a wide variety of healthy building and energy efficiency strategies. Kiss + Cathcart Architects designed the building's PV system in collaboration with FXFowle, the base building architects.
Photo credit: ©Andrew Gordon Photography, Courtesy of FXFOWLE ARCHITECTS.

Front cover, center: The lobby of the innovative 4 Times Square office building in downtown New York City.
Photo credit: ©Andrew Gordon Photography, Courtesy of FXFOWLE ARCHITECTS.

Front cover, bottom: Careful urban planning can affect the energy efficiency—and the economic health—of communities. Portland, Oregon, is a vibrant, inviting, bicycle- and pedestrian-friendly city that also features a convenient and accessible public transportation system.
Photo credit: Portland Oregon Visitors Association (www.pova.com)/David Falconer

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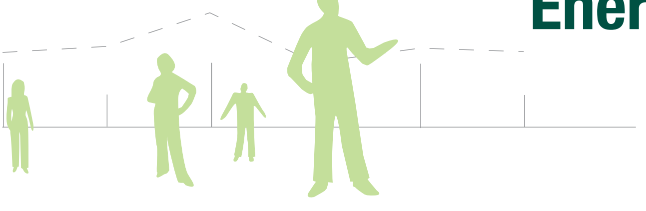

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Foreword

For more than five decades, the American Solar Energy Society (ASES) has led the nation in disseminating information for policymakers and other energy professionals to help them make sound energy policy decisions. As our latest addition to that effort, we are pleased to offer ***Renewable Energy and Energy Efficiency: Economic Drivers for the 21st Century***. This is another important and timely contribution to ASES' ongoing work to accelerate the U.S. transition to a sustainable energy economy.

Despite widespread interest in the size of the renewable energy and energy efficiency (RE&EE) industries and the number of jobs these industries create, until now no one had conducted a comprehensive study of these industries. Our study addresses this issue, and adds the following major contributions to the body of knowledge related to RE&EE:

- A rigorous definition of the RE&EE industries.
- An estimate of the size and composition of the RE&EE industries, including technology, sales, tax revenue, jobs, occupations, and skills.
- A forecast of the growth of these industries to 2030 under three scenarios.

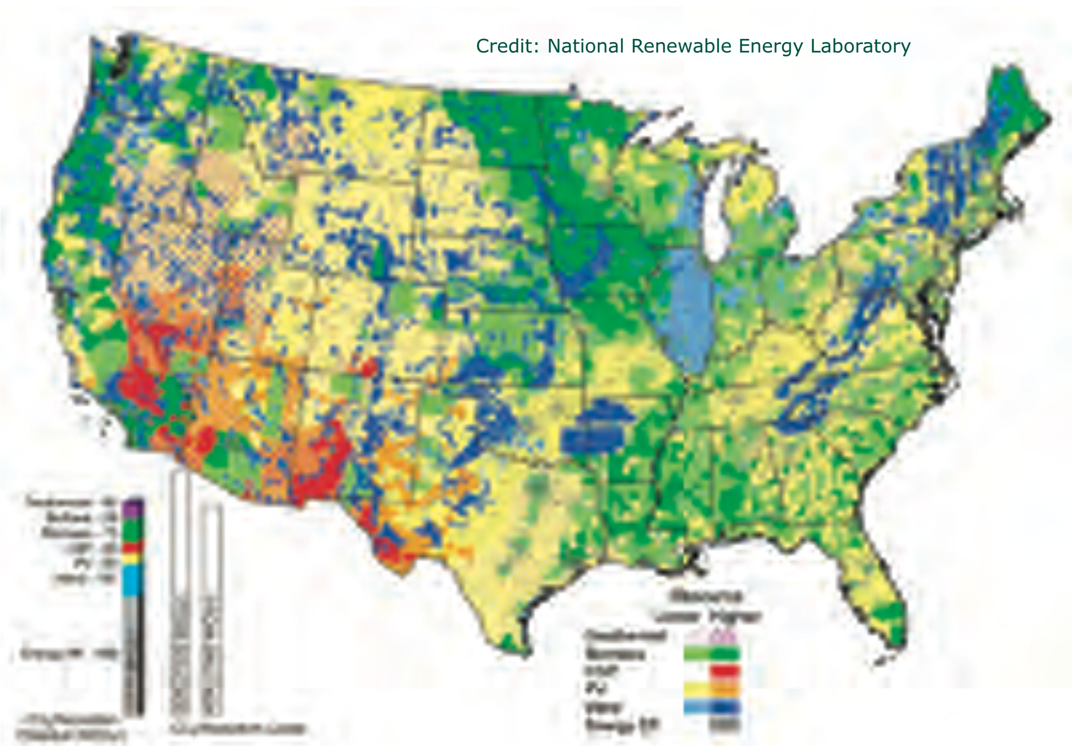
Roger Bezdek, President of Management Information Services, Inc., was the principal investigator on this project. Dr. Bezdek is an expert in economic research, analysis, and forecasting. Under the direction of the American Solar Energy Society, and with a special focus on the state of Ohio, this work was first presented at the 36th annual National Solar Energy Conference, SOLAR 2007, held in Cleveland, Ohio in July 2007. The special focus on Ohio was made possible by financial support from the Ohio Department of Development and data collection by Green Energy Ohio.

The study's two most striking findings are the size of these industries and the broad economic benefits that could accrue if regulators and policymakers support aggressive growth in these sectors. In 2006, more than 8 million Americans worked in these industries and RE&EE generated $933 billion of revenue. By 2030, under an aggressive deployment forecast scenario, there could be more than 40 million Americans employed in these industries—about one in every four working Americans. And in the aggressive scenario, the RE&EE industries could generate $4.53 trillion in annual revenue.

We wish to acknowledge and publicly thank Sara Ward and the Ohio Department of Development and Bill Spratley and Green Energy Ohio. Thanks also to Steve Clemmer of the Union of Concerned Scientists and Skip Laitner of the American Council for an Energy Efficient Economy for reviewing and improving the manuscript.

This report is the second in a three-part ASES effort to provide a framework for helping decision makers move toward a sustainable energy economy. The first was the 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 this study, which is available at www.ases.org/climatechange. The third piece will be a series of policy recommendations to support carbon mitigation and economic development, which ASES will release in May 2008.

Brad Collins
ASES Executive Director
November 2007
Boulder, Colorado



Credit: National Renewable Energy Laboratory

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)

David Beach/Ecocity Cleveland

The wind turbine on the front lawn of the Great Lakes Science Center in Cleveland, Ohio, helps increase public awareness about renewable energy, and provides an estimated 7 percent of the building's annual energy needs.

Introduction

It's all good news.

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

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 2006 were $905 billion.

If U.S. policymakers aggressively commit to programs that support the sustained orderly development of RE&EE, the news gets even better. 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 $4.5 trillion in revenue in the United States and create 40 million new jobs by the year 2030. These 40 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 provides 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.

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 Ohio* 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 as a free download.

DOE/NREL, PIX 12476, Daniel McGuire

Dan McGuire, policy chairman American Corn Growers Association (ACGA) and program director for American Corn Growers Foundation (ACGF), stands in front of wind turbines on Dan Juhl's Woodstock wind farm east of Pipestone, Minnesota. Because farmers can "double crop"—grow crops or graze animals up to the base of turbines located on their land—wind energy has become an important economic development driver in many rural areas.

Executive Summary

Renewable energy and energy efficiency (RE&EE) technologies and programs have been around for decades and are well understood. However, the literature review the American Solar Energy Society (ASES) and Management Information Services, Inc. (MISI) conducted as part of the research collected in the report titled *Defining, Estimating, and Forecasting the Renewable Energy and Energy Efficiency Industries in the U.S. and in Ohio* revealed deficiencies in the existing analyses of the economic and jobs impacts of RE&EE technologies and initiatives.

For one thing, there are no consistent definitions of either the RE or the EE industry. In addition, there are no aggregated industry data, because the analyses and forecasts usually deal only with a specific sub-element of the RE&EE industry (wind, photovoltaic or PV, vehicle fuel efficiency, etc.).

Virtually all of the studies we reviewed use different assumptions, scenarios, base years, forecast time horizons, and other parameters, making it difficult or impossible to compare one to another. And many of the forecasts take the form of "If we spend $X billion on technology Y over the next … years, then Z will be the result." Because all of the important variables differ significantly among the forecasts, in the aggregate they are less useful than they might be.

In our report, we remedied these deficiencies. First, we developed working definitions of the RE&EE industry. Next, we established a baseline of 2006 data describing the size and scope of the RE&EE industry that analysts can use to make forecasts meaningful and easy to compare. And finally, we forecast the growth of the RE&EE industry to 2030 under three different scenarios.

Executive Summary
Developing a Definition

The first objective, and one of the major contributions of our study, is to develop a rigorous definition of the RE&EE industry. We anticipate that the definition outlined here will become the standard for future economic analyses of the RE&EE industry.

Precisely what is the "renewable energy" or the "energy efficiency" industry? From windows and doors to airliners and automobiles to home appliances and industrial motors, manufacturers and marketers are quick to tout products' "renewable" or "energy efficiency" attributes. In addition, a growing number of organizations advertise their programs as contributing to energy efficiency or supporting renewable energy. As we worked toward a meaningful definition of the RE&EE industry, we had to sort through these claims and decide which products and programs deserved to be included in our definition.

It is an easy call if the RE&EE product or service exists as a distinct, specified entity, but this was rarely the case. Typically, only some of a company's or organization's offerings could be classified as part of the RE&EE industry, and quantifying the size of the RE&EE contribution was a challenge.

Evergreen Solar

The fast-growing renewable energy and energy efficiency sector is a source of well-paying jobs, many of which are not subject to foreign outsourcing.

In the end, there is no single definitive answer to these questions. In effect, ASES/MISI is acting as the definer and "benchmarker" of the industry as it evolves. We decided that these issues could perhaps be illustrated by focusing on RE&EE jobs. 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, etc. 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.

Vestas Wind Systems A/S

DOE/NREL, PIX 14830, Ed Hancock

Left: These 3.0 megawatt Vestas wind turbines near Bockingharde, Germany, generate clean, carbon-free electricity. **Right**: Homes at the Alys Beach community in western Florida use between 49% and 73% less energy than conventional homes in this hot humid climate zone.

Executive Summary
The Size and Scope of RE&EE

Once we had a definition of the RE&EE industry, we turned our attention to estimating the current size and composition of the RE&EE industry. To do this, we first addressed the RE and EE industries separately, and then combined them.

In our study, we define renewable energy technologies primarily as hydroelectricity, biomass, geothermal, wind, photovoltaics, and solar thermal.[1] Except for hydro and industry biomass, the RE U.S. energy contribution is small (see Figure ES1), although it is growing rapidly.

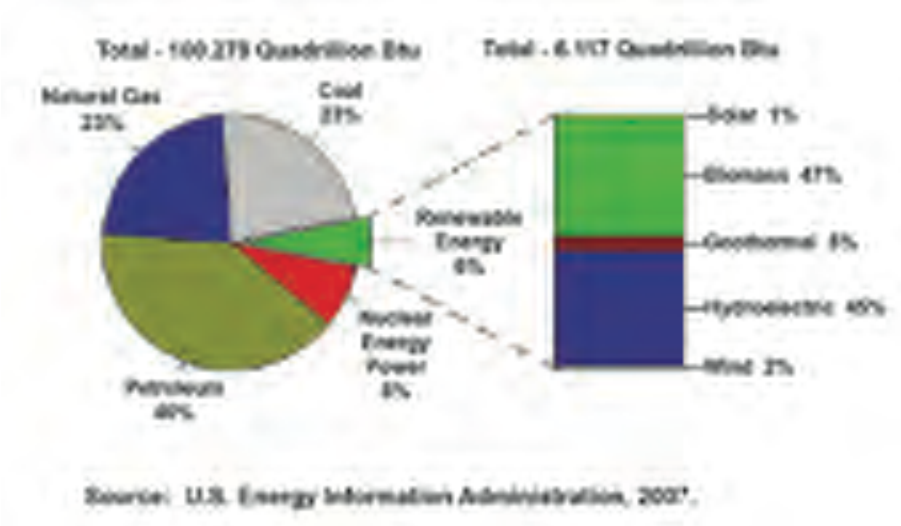


Figure ES1—Renewable Energy in the U.S., 2006

RE gross revenues totaled nearly $40 billion in 2006, and the RE industry was responsible for more than 450,000 direct and indirect jobs. The jobs created were disproportionately for scientific, technical, professional, and skilled workers, and more than 90 percent of the jobs were in private industry.

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, but the EE "industry" is much more nebulous and difficult to define. Most EE spending is included in partial segments of large industries, such as vehicles, buildings, lighting, appliances, etc.

[1] 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.

Renewable energy and energy efficiency reduce the risks associated with fuel price volatility and can facilitate an industrial boom, create millions of jobs, foster new technology, and revitalize the manufacturing sector.

In the private sector, we included insulation sales, energy service company (ESCO) industry sales, and the U.S. recycling and reuse industry sales. For other industries, we only included the portion of their sales that related to EE. For example, we included vehicles that get at least 10 percent better mpg than the CAFE mileage as energy-efficient vehicles. We used the Energy Star ratings for lighting products and household appliances, windows and doors, and components of the industrial sector.

The results of our research are impressive. As Table ES1 demonstrates, in 2006 the combined RE&EE industry generated nearly a trillion dollars in industry sales, 8.5 million new jobs, more than $100 billion in industry profits, and more than $150 billion in increased federal, state, and local government tax revenues. In addition, RE&EE reduce the risks associated with fuel price volatility and can facilitate an industrial boom, create millions of jobs, foster new technology, revitalize the manufacturing sector, enhance economic growth, and help reduce the trade and budget deficits.

Table ES1

Summary of the U.S. Renewable Energy and Energy Efficiency Industries in 2006

Industry	**Revenues** (billions)	**Direct Jobs** (thousands)	**Total** (direct plus indirect) **Jobs Created** (thousands)
Renewable Energy	$39.2	196	452
Energy Efficiency	932.6	3,498	8,046
TOTAL	$971.8	3,694	8,498

Executive Summary
Forecasting Growth in the RE&EE Industry

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.

Martin Bond for Kramer Junction Company

Each of the nine Kramer Junction solar electric generating system (SEGS) power plants—which use parabolic trough collectors to focus the sun's energy on a pipe carrying a heat-transfer fluid—produces enough electricity to power about 30,000 homes. Some of these plants have been operating for more than 20 years.

The base case is essentially a "business as usual" scenario, which assumes no change in policy and no major RE&EE initiatives over next 23 years. The base case clearly indicates that without substantial change in policy, renewable energy is unlikely to significantly increase its share of the U.S. energy market.

The moderate scenario assumes that various moderate, incremental federal and state RE&EE initiatives are put in place during next two decades. This scenario incorporates modest initiatives, and assumes a continuation of the positive policies that are in place, with market conditions favorable to renewables. In this scenario about 15 percent of electricity generation is attributable to RE and similar growth is forecast for deployment of EE technologies.

The advanced scenario "pushes the envelope." It indicates what is possible using current or impending technologies and includes what may be realistically feasible both economically and technologically in such a scenario. In this scenario, nearly thirty percent of our electricity is generated from renewable sources and we estimate similar growth in EE.

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 and future energy prices are likely to be the major determinants of future market share for RE.

Table ES2 shows the total revenues generated and jobs created in 2030 under each of the scenarios. 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.

Table ES2

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

	Revenues (Billions of 2006 Dollars)			**Total Jobs Created** (Direct Plus Indirect – Thousands)		
	Base Case	Moderate Scenario	Advanced Scenario	Base Case	Moderate Scenario	Advanced Scenario
RE	$95	$227	$597	1,305	3,138	7,918
EE	$1,818	$2,152	$3,933	14,953	17,825	32,185
Total	$1,913	$2,379	$4,530	16,258	20,963	40,103

Source: Management Information Services, Inc. and American Solar Energy Society, 2007.

Executive Summary
Ohio Case Study

As part of this project, we focused on the RE&EE industry in Ohio. In 2006 in Ohio, gross revenues for RE totaled nearly $800 million, and the RE industry created more than 6,600 jobs. As was true nationwide, these jobs were disproportionately for scientific, technical, professional, and skilled workers, and more than 90 percent of the jobs were in private industry. In Ohio, the largest number of jobs was in the wind sector, followed by the biomass and the geothermal sectors.

Gross revenues for EE totaled more than $50 billion in Ohio in 2006, and the number of jobs created totaled nearly 500,000. More than 90 percent of the EE jobs were also in private industry, and over 50 percent of the jobs were in the manufacturing sector. The second largest number of jobs was in recycling, followed by durable manufacturing and vehicle manufacturing.

As part of the case study, we took a detailed look at a wind company located in Ohio. This analysis illustrates important points that also emerged in our national analysis. First, firms working in the RE&EE and related areas employ a wide range of workers at all educational and skill levels and at widely differing earnings levels. Second, in RE&EE companies, few of the employees are classified as RE or EE specialists. Most of the workers are in occupations such as laborers, clerks, bookkeepers, accountants, maintenance workers, cost estimators, etc. All of these employees owe their jobs and livelihoods to RE&EE, but, in general, they perform the same types of activities at work as employees in firms that have little or nothing to do with RE or EE.

Fletcher Miller, Green Energy Ohio

Energy efficiency and renewable energy are good business for the city of Cleveland, Ohio, where local government and citizens alike are enthusiastically embracing sustainability.

It is instructive to note that although the RE&EE debate typically focuses on applying new technology to offset traditional energy sources, RE&EE are more than a source of fuel or energy savings. They are significant sources of jobs. Regions like Ohio with traditional manufacturing economies can recruit RE&EE companies to take advantage of their highly skilled manufacturing workers, many of whom are idle or underemployed.

However, Ohio must also 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. In addition, Ohio must compete for RE&EE jobs with traditional high-tech metropolitan areas and metropolitan areas traditionally associated with manufacturing. The wide variety of entrance points to the RE&EE industry makes this market easier to penetrate if Ohio can market its strengths in manufacturing, research, education, construction, and operation, and create an attractive business environment for these specific industries.

Table ES3 illustrates that RE&EE offer significant development opportunities for Ohio. Under the advanced scenario, in 2030 RE could generate annually nearly $18 billion in revenues and 175,000 jobs and EE could generate annually over $200 billion in revenues and over 2 million jobs.

Table ES3

Summary of the Ohio Renewable Energy and Energy Efficiency Industries in 2030

	Revenues (Billions of 2006 Dollars)			**Total Jobs Created** (Direct Plus Indirect – Thousands)		
	Base Case	Moderate Scenario	Advanced Scenario	Base Case	Moderate Scenario	Advanced Scenario
RE	$2.0	$5.7	$17.7	21	56	174
EE	$96.7	$114.7	$202.6	964	1,150	2,096
Total	$98.7	$120.4	$220.3	985	1,206	2,270

Source: Management Information Services, Inc. and American Solar Energy Society, 2007.

This is important because Ohio needs a new source of jobs. Over the last 10 years, Ohio total employment increased 2.7 percent, while total U.S. employment increased 14 percent during same period, more than 5 times as fast.

Although Ohio does have a skilled workforce and needs manufacturing jobs, the state is not in the forefront of some RE industries. The contrast with Germany is especially relevant, particularly because Ohio has much better RE resources than Germany does.

Germany has about one-fourth the gross domestic product and population of the U.S., but has more RE jobs (214,000 vs. 194,000). RE employment in Germany has increased 36 percent in two years. We don't even know how much RE employment has increased in the United States, because—until now—no one has estimated actual RE employment.

The implications for the United States—and for Ohio and other states—are obvious and serious.

Clearly, a robust RE&EE industry in Ohio—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, the United States runs the risk of losing ground to international RE&EE programs and industries. If we refuse to address policy and regulatory barriers to the sustained, orderly development of the RE&EE industry, other countries will 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 renewable energy and energy efficiency industry will be a critical economic driver.

S.A.G. Solarstrom/Gero Deibert, Evergreen Solar, Inc.

Even though Germany has modest solar resources compared to many parts of the United States, Germans have enthusiastically embraced renewable energy technologies. The 20-kilowatt photovoltaic system on this school in Wittnau, Germany, was installed in August 2005.

DOE/NREL, PIX 10750, Warren Gretz

Researcher Keith Emery takes measurements at the National Renewable Energy Laboratory's (NREL's) Outdoor Test Facility (OTF) in Golden, Colorado. NREL uses advanced state-of-the-art laboratories and outdoor test beds to characterize the performance and reliability of PV cells, modules, and small systems.

Background

Establishing a Baseline

Although the renewable energy and energy efficiency (RE&EE) industry is in the media spotlight these days, it is nothing new. RE&EE technologies and programs have existed for decades and are well understood.

However, the literature review we conducted as part of this study revealed deficiencies in the existing analyses of the economic and jobs impacts of RE&EE technologies and initiatives. For one thing, there are no consistent definitions of either the RE or the EE industry. In addition, there are no aggregated industry data, because the analyses and forecasts usually deal only with a specific subelement of the RE&EE industry (wind, photovoltaic or PV, vehicle fuel efficiency, etc.).

Another issue is that virtually all of the studies we reviewed use different assumptions, scenarios, base years, forecast time horizons, and other parameters, making it difficult or impossible to compare one to another. None of the studies make any attempt to develop a comprehensive current or historical base year for RE or EE economic activity or employment, and few disaggregate employment into specific jobs, occupations, or skills.

Finally, all of the forecasts we studied take the form of "If we spend $X billion on technology Y over the next…years, then Z will be the result." Because all of the important variables differ significantly among the forecasts, in the aggregate they are less useful than they might be.

In our report, we remedied these deficiencies. First, we developed working definitions of the RE&EE industry. Next, we established a baseline of 2006 data describing the size and scope of the RE&EE industry that analysts can use to make forecasts meaningful and easy to compare. And finally, we forecast growth of the RE&EE industry to 2030 under three different scenarios.

Incorporating Existing Research

In addition to identifying the gaps in analysis and forecasting, our literature search also confirmed how important the RE&EE industry is to the U.S. economy and labor market. For example, one review of 13 independent reports and studies[2] concluded that the renewable energy sector generates more jobs than the fossil fuel-based energy sector per unit of energy delivered (i.e., per average megawatt). Another report[3] estimated that a $30 billion in-

[2] Daniel M. Kammen, Kamal Kapadia, and Matthias Fripp, *Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?* RAEL Report, University of California, Berkeley. April 2004 (corrected 1/31/06).

[3] *Apollo Jobs Report: For Good Jobs and Energy Independence*, the Institute for America's Future, the Center on Wisconsin Strategy, and the Perryman Group, January, 2004.

The evidence is that renewable energy and energy efficiency can drive economic development, create jobs, AND mitigate climate change.

vestment per year for 10 years in RE&EE would add more than 3.3 million jobs to the economy, stimulate $1.4 trillion in new gross domestic product, stimulate the economy by adding $953 billion in personal income and $323.9 billion in retail sales, and produce $284 billion in net energy cost savings. This report also found that, by creating jobs and stimulating economic growth, this investment would generate sufficient new returns to the U.S. treasury from increased income to pay for itself in about a decade.

We also reviewed analyses of RE&EE's potential for mitigating climate change without causing major economic dislocations. One report[4] analyzed whether a basic climate policy that included a carbon tax or a cap-and-trade system would increase or decrease the demand for workers in general and for union labor in particular.

The researchers found that a responsible approach to addressing carbon emissions not only avoids most harmful effects on workers, but even results in benefits for most of the workforce. Despite some job losses, the net effect within a carbon-constrained energy economy is positive, creating roughly five jobs for each job lost. Because unionization rates are higher on average in more energy-intensive industries, the positive effect on union jobs is not as strong, but it is still true that four union jobs are created for every three lost.

These results have several important implications. First, those who claim that climate change cannot be addressed without huge economic costs and massive unemployment are simply wrong. A responsible climate-change policy package can significantly reduce carbon emissions while simultaneously conferring modest economic benefits on the working population as a whole by improving energy efficiency and increasing the demand for labor.

A second implication of these results is the importance of revenue recycling. Much of the negative impact of carbon/energy taxes is based on the assumption that the revenue will not be recycled through cuts in other taxes. It is critical, therefore, that the pricing policy be accomplished either by permits that are sold or by energy taxes, not through permits that are given away to industries at no cost (i.e., "grandfathered" to existing companies).

[4] James P., and J. Andrew Hoerner. *Making Green Policies Pay Off: Responsible Climate-Change Package Can Benefit Environment, Workforce.* Washington, D.C.: Center for a Sustainable Economy and Economic Policy Institute, April 2000.

A third conclusion is that there are some industries that will be hurt by an effective climate policy, requiring policies that help these industries adapt or provide compensation. Coal mining and oil imports will fall, and some coal miners will lose their jobs. But these researchers suggest that a generous transition assistance package would cost less than one percent of the annual energy tax or permit revenues.

Thus, although some industries and some workers will be seriously affected by any efforts to reduce carbon emissions, the results reported by these researchers show that the predictions of economic disaster grossly overstate the likely size of these effects. In fact, the evidence is that RE&EE can drive economic development, create jobs, AND mitigate climate change.

DOE/NREL, PIX 03282, Jim Miller

First Solar

Left: Many hydropower facilities use large impoundment dams, but simply diverting a portion of a stream or river lessens the environmental impact of using hydropower to generate electricity. **Right**: Renewable energy jobs are often well-paying, skilled positions that cannot easily be outsourced to other countries.

Nicole Cappello, Georgia Tech

Professor Bernard Kippelen, Associate Director of the Center for Organic Photonics and Electronics at the Georgia Institute of Technology, is developing solar cells that can be fabricated on flexible plastic substrates.

Developing a Definition

The first objective, and one of the major contributions of our study, is to develop a rigorous definition of the RE&EE industry. We anticipate that the definition outlined here will become the standard for future economic analyses of the RE&EE industry.

The Dilemma

Although analysts have conducted RE&EE industry studies and forecasts for more than three decades, fundamental gaps in our understanding of these sectors remain. No rigorous definitions currently exist for either of these industries, nor do we have a clear picture of their size, structure, and composition.

Many studies analyze components of the RE industry (e.g., wind, photovoltaics, biomass, and so on), and experts have established long-term forecasts of the economic impacts of major proposed RE&EE initiatives and spending programs. However, these analyses are of limited usefulness until we have a better idea of the size and characteristics of the existing RE&EE industry.

For example, what does it mean to say that "experts predict that the number of jobs in the industries 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 jobs by 2020" when we do not know how many jobs there were in RE in 2006?

The Challenge

Precisely what is the "renewable energy" or the "energy efficiency" industry? Answering that question involved difficult and complex decisions. We offer a sampling of the issues we confronted here.

Manufacturers offer many products—windows and doors, gas and oil furnaces, home appliances, and motors, for example—at wide ranges of energy efficiencies and prices. How do we evaluate and categorize these? What constitutes an "energy-efficient" product?

RE&EE is currently a very powerful public relations and marketing strategy. Many things are advertised as being "energy-efficient" or "renewable," and no one advertises their product as being "energy inefficient." We had to take care to sort through these claims.[5]

For example, we include hybrid vehicles as part of the RE&EE industry, but how are these to be disaggregated from the total operations of the automobile manufacturers? If Toyota, GM, Ford, etc. have specific factories dedi-

[5] For example, several years ago MISI conducted an audit of the mandated RE&EE programs in New Jersey for the New Jersey Board of Public Utilities. We found that some utilities in the state were classifying natural gas fuel cells as "renewable."

cated to only these vehicles, this may be feasible. But what about joint production lines or factories that produce a range of vehicle types? What about the parts suppliers? What about all of the automobile dealerships? Do we allocate a portion of their sales to the RE&EE industry based on the portion of "fuel-efficient" vehicles they sell?

More generally, in our definition we wanted to distinguish among classes of vehicles on the basis of fuel efficiency. Obviously, a Hummer getting 11 mpg is not fuel-efficient, but a small vehicle getting 35 mpg is. Is the latter part of the RE&EE industry? If so, how do we quantify it? To make this issue even more complex, in our forecast scenarios we hypothesized a very substantial increase in U.S. vehicle fuel efficiency standards. In this scenario, we only included vehicles that get at least 10 percent better mpg than the corporate average fuel economy (CAFE) mileage as part of the RE&EE industry.

It is an easy call if the EE product exists as a distinct, specified entity produced solely at a specific plant, rather than as one product out of many being produced at a plant. For example, Venture Lighting International is located in Solon, Ohio, a suburb of Cleveland, and specializes in energy-efficient metal halide lighting systems. Thus, all of Venture Lighting's products can legitimately be classified within the RE&EE industry. However, what about a large GE facility that produces, among other things, energy-efficient light bulbs? And what is the definition of an energy-efficient light bulb, anyway? More efficient than what?

Another important point to keep in mind is that, while this specific study examines the RE&EE industry in Ohio as a state-specific case study, our definition had to be general enough to apply to the whole RE&EE industry throughout the U.S. This is one of the main values of our study and, in addition, we cannot have a different industry definition for each state. Thus, some RE&EE options that may have little application in Ohio, such as large hydro, solar thermal power plants, and geothermal power plants, are nevertheless an integral part of our industry definition.

Another major decision involved how we handled federal, state, and local government, nonprofit, non-governmental organizations (NGOs), foundations, and other organizations. Should the federal RE&EE research and development (R&D) activities be included as part of the RE&EE industry? Is the National Renewable Energy Laboratory part of the industry? What about all of the numerous (and rapidly growing) state and local government RE&EE activities? What about all of the federal, state, and local RE&EE trade, professional, and interest groups? Are ASES, the American Wind Energy Association, the Solar Energy Industries Association, and similar groups part of the RE&EE industry?

We decided to include all these groups in our industry definition for a several reasons. First, not including them would exclude significant and important public, NGO, and nonprofit activities. Second, such an exclusion could lead to contradictory results. For example, if PV panels are installed on a school by a private company paid with public funds, then, under this definition, the installation activities would be included in the industry definition. However, if the PV panels are installed on a school by state or local government employees paid with public funds, then, under this definition, the installation activities would not be included in the industry definition.

There is no single definitive answer to these questions. In effect, ASES/MISI is acting as the definer and "benchmarker" of the industry as it evolves.

We also had to relate these industry and job categories to the North American Industry Classification System (NAICS) standard.[6] The U.S. Department of Energy's (DOE's) Energy Information Administration (EIA) has made a start at this, but cannot devote the resources required due to competing demands within DOE. ASES covers some of the above list already, but we also had to deal with issues at the edges of the definition.

Because an acceptable industry definition is a desirable short-term outcome, we engaged national and Ohio state and industry trade leadership in this "defining stage." We solicited the assistance of the

DOE/NREL, PIX 00060, Pacific Gas & Electric

DOE/NREL, PIX 06981, Pacific Gas & Electric

Top: Geothermal power facilities like the Geysers, a dry steam geothermal field in Calistoga, California, can provide baseload electricity to supplement wind and solar installations. **Bottom**: Improving the energy efficiency of industrial and manufacturing processes, such as the wine bottle production pictured here, reduces energy use and saves companies money.

[6] www.census.gov/EPCD/www/NAICS.HTML

key researchers and CEOs of biofuels, wind, solar, geothermal, hydrogen, and other relevant companies and associations.

But we still did not have an authoritative definition of the RE&EE industry.

Focusing on Jobs

These issues can perhaps be illustrated by focusing on RE&EE jobs. For example, under the broad industry definition, an employee workingin 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.

However, there were ambiguities here too. For example, most people would agree that the positions in a firm that assembles and installs solar thermal collectors on residences and commercial office buildings for solar heating and solar hot water heating 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? Here, we will include these manufacturing jobs as jobs created indirectly by RE&EE expenditures.

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

Toyota Motor Sales, USA, Inc.

First Solar

Left: Gasoline/electric hybrid cars like the Toyota Prius shown here have proved so popular with consumers that buyers often wait months to take delivery of their car. **Right**: As the energy efficiency and renewable energy industry continues to grow, it will place new demands on workforce training programs and industrial and utility regulators.

Although these jobs certainly count as jobs related to RE&EE, our data suggest that these types of jobs constitute only a small portion of the jobs created by RE&EE. The vast majority of the jobs created by RE&EE are standard jobs for accountants, engineers, computer analysts, clerks, factory workers, truck drivers, mechanics, etc. In fact, most of the workers employed in these jobs may not even realize that they owe their livelihood to RE&EE. In formulating our definition, we included these indirect jobs created by RE&EE expenditures.

The Definition

Obviously, the RE industry includes technologies such as wind energy, photovoltaics, solar thermal energy, and biomass. But should all hydropower technologies be included, even large, environmentally threatening systems? What about geothermal energy? Daylighting? Climate-responsive buildings? Hydrogen?

In addition to the obvious RE technologies, we decided to include the following industries and technologies, among others:

- Hydro—small and large
- Geothermal
- Fuel cells
- Hydrogen
- Energy conservation and energy efficiency products
- Electric and hybrid vehicles
- Passive, solar/green, sustainable buildings, and energy-smart design
- Daylighting

In our view, this is appropriate for several reasons. For one thing, many renewable energy firms also offer energy efficiency and conservation products and services. Distinguishing among the RE&EE products, services, and sales of these firms would be virtually impossible.

In addition, RE&EE are closely related, share many of the same goals, and are often offered as integrated products or services. 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 an "RE" product and an "EE" product. Examples include passive solar design, sustainable buildings, daylighting, etc. Finally, "RE&EE" is a much larger and more robust industry than the RE industry alone.

Thus, the RE&EE industry encompasses all aspects of the energy efficiency industry, including insulation manufacturers and installers, energy audits and energy service contract firms, and manufacturers, sellers, and installers of a wide array of energy efficiency products and services. And, as the jobs discussion above demonstrates, the RE&EE industry extends deep into communities, providing many jobs indirectly related to the RE&EE industry.

Solargenix Energy

Nevada Solar One, a 64-megawatt concentrating solar power plant located near Boulder City, just outside of Las Vegas, Nevada, required a workforce averaging 400 people, and peaking at 850 people, who put in 1.5 million work-hours to complete the project.

The Size and Scope of RE&EE

Once we had a definition of the RE&EE industry, we turned our attention to the next objective of our research, which is to estimate the current size and composition of the RE&EE industry. To do this, we first addressed the RE and EE industries separately, and then combined them. What follows is a summary of the process that we used to arrive at the size and scope of the RE&EE industry.

How Big is the RE Industry?

In our study, we define renewable energy technologies primarily as hydroelectricity, biomass, geothermal, wind, photovoltaics, and solar thermal. Except for hydro and industry biomass, the RE U.S. energy contribution is small (see Figure 1), although it is growing rapidly. In fact, the RE industry contains some of the fastest-growing industries in the world, including wind, fuel cells, and biofuels.

As Table 1 indicates, RE gross revenues totaled nearly $40 billion in 2006, and the RE industry was responsible for nearly 450,000 direct and indirect jobs. The jobs created were disproportionately for scientific, technical, professional, and skilled workers, and more than 90 percent of the jobs were in private industry. Nearly 70 percent of the jobs were in the biomass sector—primarily ethanol and biomass power. The second largest number of jobs was in the wind sector, followed by the hydroelectric and the geothermal sectors. Relatively few jobs were in the solar thermal sector or the biodiesel sector. Over half of the RE jobs in government (federal, state, and local) were R&D-oriented jobs at DOE laboratories.

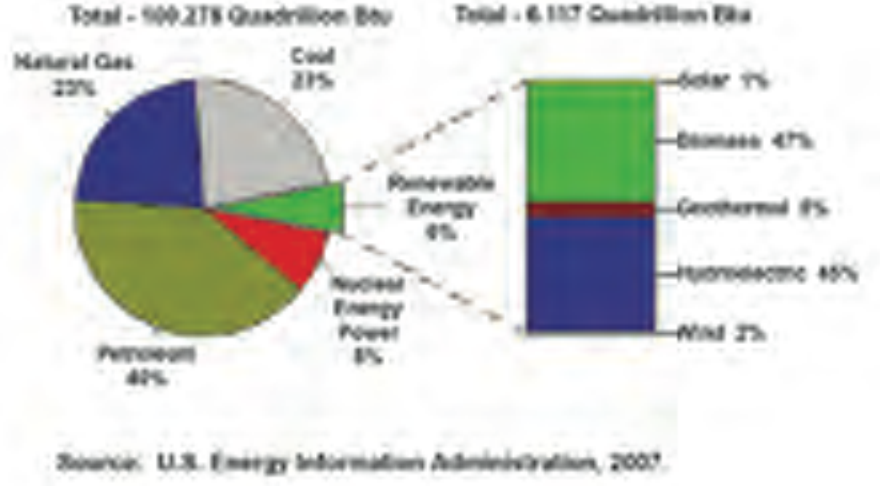


Figure 1—Renewable Energy in the U.S., 2006

Table 1
The Renewable Energy Industry in the U.S., 2006

Industry Segment	Revenues/ Budgets (billions)	Direct Jobs	Total (direct plus indirect) Jobs Created
Wind	$3.0	16,000	36,800
Photovoltaics	1.0	6,800	15,700
Solar Thermal	0.1	800	1,900
Hydroelectric Power	4.0	8,000	19,000
Geothermal	2.0	9,000	21,000
Biomass			
Ethanol	6.3	67,000	154,000
Biodiesel	0.3	2,750	6,300
Biomass Power	17.0	66,000	152,000
Fuel Cells	0.9	4,800	11,100
Hydrogen	0.8	4,000	9,200
Total, Private Industry	**35.4**	**185,150**	**427,000**
Federal Government	0.5	800*	1,850
DOE Laboratories	1.8	3,600**	8,300
State and Local Government	0.9	2,500	5,750
Total Government	**3.2**	**6,900**	**15,870**
Trade and Professional Associations and NGOs	0.6	1,500	3,450
TOTAL, ALL SECTORS	**$39.2**	**193,550**	**446,320**

Source: Management Information Services, Inc. and American Solar Energy Society, 2007.

*Includes Federal employees and direct support contractors.
**Includes Federal employees, laboratory employees, and direct support contractors.

The vast majority of the jobs created by RE are standard jobs for accountants, engineers, computer analysts, clerks, factory workers, truck drivers, mechanics, etc. Table 2 lists the jobs created by renewable energy in the U.S. in 2006 within selected occupations.

Table 2
Renewable Energy Jobs Generated in the U.S. in 2006 by Selected Occupations

Occupation	Jobs
Accountants and Auditors	5,917
Bookkeeping and Accounting Clerks	7,488
Biochemists and Biophysicists	1,395
Cashiers	3,631
Chemists	1,747
Civil Engineers	2,851
Computer Software Engineers	2,023
Computer and IT Managers	1,132
Customer Service Representatives	5,385
Electricians	5,610
Electronics Engineers	1,593
Environmental Engineers	569
Environmental Science Technicians	1,488
Environmental Scientists and Specialists	1,785
Executive Secretaries and Administrative Assistants	5,357
Financial Analysts	589
Forest and Conservation Workers	1,266
Graphic Designers	1,135
Human Resource Specialists	496
HVAC Mechanics and Installers	1,936
Industrial Machinery Mechanics	1,105
Inspectors, Testers, and Sorters	1,997
Janitors and Cleaners	3,247
Machinists	1,349
Management Analysts	2,923
Marketing Managers	674
Mechanical Engineers	1,705
Office Clerks	9,723
Pipelayers	542
Plumbers, Pipefitters, and Steamfitters	4,227
Security Guards	1,394
Sheet Metal Workers	1,473
Stock Clerks	2,345
Training and Development Specialists	595
Truck Drivers	6,601
Welders and Solderers	1,665

Source: Management Information Services, Inc. and American Solar Energy Society, 2007.

Note that there are more jobs for cashiers (3,631) than for biochemists and biophysicists (1,395), more jobs for office clerks (9,723) than for environmental engineers (1,593), more jobs for executive secretaries (5,357) than for forest and conservation workers (1,266), and so on.

How Big is the EE Industry?

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, but the EE "industry" is much more nebulous and difficult to define. There are specific elements that are clearly part of the EE industry, such as federal and state EE programs, utility EE spending, the insulation industry, the recycling industry, etc. However, most EE spending is included in partial segments of large industries, such as vehicles, buildings, lighting, appliances, etc.

Private Sector Sales

In the private sector, we included insulation sales, which in 2006 totaled approximately $5 billion. Roughly 98 percent of those sales were fiberglass and two percent were cellulose. We also included sales in the energy service company (ESCO) industry and the U.S. recycling and reuse industry, which encompasses recycling collection, recycling processing, recycling manufacturing, and reuse and remanufacturing.

For other industries, we only included the portion of their sales that related to EE. For example, as noted above, we classified vehicles that get at least 10 percent better mpg than the CAFE mileage as energy-efficient vehicles. Vehicle industry statistics indicate that about 15 percent of new U.S. vehicles are classified as small or hybrid, so we estimated that the portion of new vehicle sales accounted for by EE vehicles is 15 percent, or about $73 billion.

We used the Energy Star ratings for lighting products and for household appliances to determine what percentage of these industries belong in the EE industry. We found that the market penetration of EE lighting and household appliances varies widely:

• Compact fluorescent lights	< 5%
• Clothes washers	~15%
• Dishwashers	~40%
• Refrigerators	~23%
• Room air conditioners	~28%

Based on the market penetration of Energy Star lighting and appliances, we estimated that the EE portion of the lighting and appliances industry is about 20 percent or about $22 billion.

Similarly, we used Energy Star ratings to determine the portion of the window and door industries that should be allocated to the EE industry. In 2006, U.S. sales in the window and door industry totaled approximately $30 billion. The market share of Energy Star windows was about 53 percent, and the market share of Energy Star doors was about 30 to 40 percent. We estimate that the EE portion of the 2006 window and

DOE/NREL, PIX 09533, Doug Balcomb

DOE/NREL, PIX 09207, Jim Yost

Left: At the Harmony Library in Fort Collins, Colorado, daylighting provides a substantial portion of the lighting the building requires. **Right**: Diffusing skylights in the warehouse at the BigHorn Home Improvement Center in Silverthorne, Colorado, admit daylight while preventing glare and reducing the need for electric lighting.

door industry is about 40 percent or $12 billion.

We also used data on the market penetration of Energy Star products in our analysis of the industrial sector:

- Computers, copiers, and FAX machines: 90%+
- TV: 50%
- VCR: 90%+
- Audio electronic equipment: 40%
- Heating, Ventilating, and Air-Conditioning (HVAC): 30%+

We then took that percentage of the total sales for those industries to arrive at the amount spent on the EE portion. Total sales were:

- Computers, copiers, and FAX machines: $100 billion
- TV, video, and audio sales: $90 billion
- HVAC: $40 billion

The EE portions of these industries in 2006 were:

- Computers, copiers, and FAX machines: $90 billion
- TV, video, and audio sales: $45 billion
- HVAC: $12 billion

Total U.S. 2006 industrial and related machinery industry sales were $190 billion. We estimate that EE had about a ten percent market penetration, and thus the EE portion of this industry totaled $19 billion. We used similar methods to derive the EE components of the other industries and sectors included in Table 3.

We estimate that utility EE spending in 2006 totaled approximately $2 billion, all of which we included in our estimate.

The value of construction put in place in 2006 totaled approximately $1,200 billion. Some portion of this huge industry had to be classified as being part of the EE industry. We obtained assistance and information from the national and state EE rating organizations, such as the U.S. Green Building Council, to determine which portion of the industry should be classified within the EE industry.

For example, we found that 1.6 percent of the total U.S. nonresidential buildings market and 8 percent of the multi-family building market is LEED-certified. On the residential side, the *McGraw-Hill Construction Repor*t estimates that the residential green market totaled about $8 billion in 2006, or about 2 percent of new housing starts.

In some states, such as New York and Washington, green buildings account for 5 to 10 percent of the new construction market. Using these and related data, we estimate that about 3 percent of the new construction industry can be allocated to the EE industry, amounting to about $36 billion.

Government Programs

To arrive at the federal totals, we noted that the 2006 federal EE budget totaled approximately $1 billion, and we included all of this in the EE industry. In addition, in 2006, climate change spending totaled approximately $6 billion. We deducted the approximately $1 billion federal EE budget and the approximately $0.5 billion RE budget to derive a net of approximately $4.5 billion. We assumed that about half of this $4.5 billion, or $2.3 billion, relates to EE and is thus part of the EE industry. We then added the 2006 federal EE budget back into the total, which is how we arrived at the $3.3 billion total for federal EE spending.

DOE/NREL, PIX 09173, Jim Yost

DOE/NREL, PIX 09213 Jim Yost

Left: An transpired solar collector installed on the south wall of the warehouse at the BigHorn Home Improvement Center in Silverthorne, Colorado, provides cost-effective preheated ventilation air to the warehouse. **Right**: Ross Foltz of Foltz Engineering designed the unglazed transpired solar ventilation preheat system at the BigHorn Home Improvement Center.

All state EE budgets combined in 2006 totaled approximately $3 billion, and we included all of these in our estimate. Local government spending is about 75 percent as large as state government spending. Applying this ratio to state EE spending of $3 billion yields an estimate of local government EE spending of about $2.3 billion.

Trade and Professional Associations and NGOs

On the basis of discussions with representatives of EE trade and professional associations and NGOs we estimate that in 2006, EE trade and professional associations and NGOs had budgets totaling approximately $500 million. The number of employees of these organizations totaled about 3,000.

Energy Efficiency Jobs

Our analysis turned up some interesting jobs information. The total number of jobs created (directly and indirectly) by EE in 2006 exceeded 8 million, and more than 90 percent of those jobs were in private industry. More than 50 percent of the jobs were in the manufacturing sector, and the second largest number of jobs was in recycling, followed by the construction industry. Nearly 80 percent of the EE government jobs were in state and local government.

SunPower Corporation

DOE/NREL, PIX 11666, Ed Hancock

Left: Dr. Richard Swanson, President and Chief Technical Officer of SunPower Corporation, demonstrates his enthusiasm over SunPower's high-efficiency solar panels. **Right**: The atrium at Oberlin College's Adam Joseph Lewis Center for Environmental Studies in Oberlin, Ohio, is a brightly daylit space. The building incorporates many features that reduce energy use and lessen its impact on the environment.

Table 3
The Energy Efficiency Industry in the U.S., 2006

Industry Segment	**Revenues/** Budgets (billions$)	**Direct Jobs** (thousands)	**Total** (direct plus indirect) **Jobs Created** (thousands)
Insulation	$5	26	60
ESCO	3	19	44
Recycling	275	1,310	3,013
Vehicle manufacturing	73	165	380
Household appliances and lighting	22	86	198
Windows and doors	12	51	117
Computers, copies, and FAX machines	90	312	718
TV, video, and audio equipment	45	183	421
HVAC systems	12	45	104
Industrial and related machinery	19	76	175
Miscellaneous durable manufacturing	105	389	894
Nondurable manufacturing	220	528	1,214
Utilities	2	14	32
Construction	36	227	522
Total, Private Industry	**919**	**3,431**	**7,892**
Federal government EE spending	3.3	15	35
State government EE spending	3	28	64
Local government EE spending	2.3	21	48
Total Government	**8.6**	**64**	**147**
EE trade and professional associations and NGOs	0.5	3	7
TOTAL, ALL SECTORS	**$932.6**	**3,498**	**8,046**

Source: Management Information Services, Inc. and American Solar Energy Society, 2007.

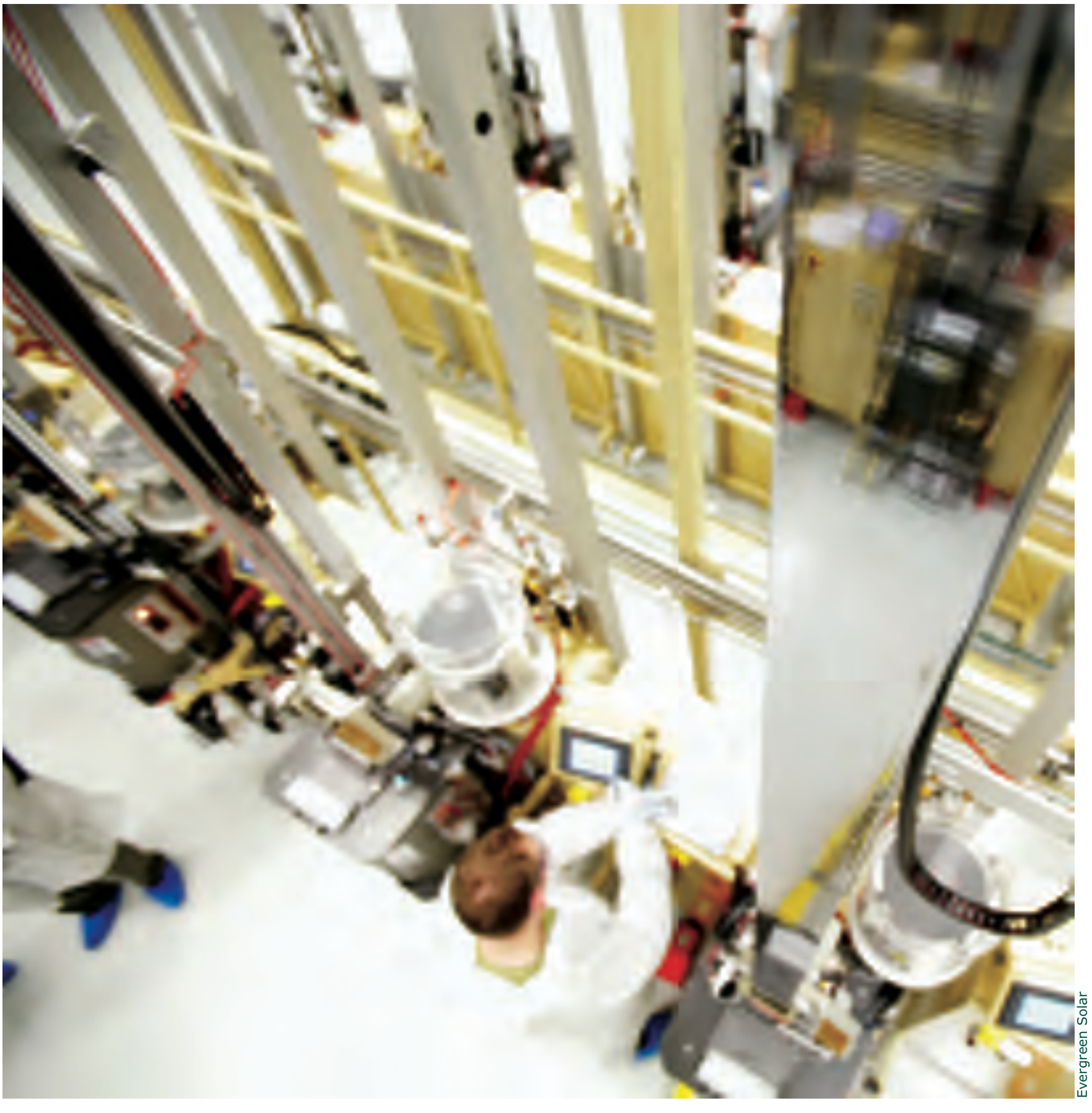
The Bottom Line

The results of our research are impressive. As Table 4 demonstrates, in 2006 the combined RE&EE industry generated nearly a trillion dollars in industry sales, 8.5 million new jobs, more than $100 billion in industry profits, and more than $150 billion in increased federal, state, and local government tax revenues. In addition, RE&EE reduce the risks associated with fuel price volatility and can facilitate an industrial boom, create millions of jobs, foster new technology, revitalize the manufacturing sector, enhance economic growth, and help reduce the trade and budget deficits.

Table 4
Summary of the U.S. Renewable Energy and Energy Efficiency Industries in 2006

Industry	**Revenues** (billions)	**Direct Jobs** (thousands)	**Total** (direct plus indirect) **Jobs Created** (thousands)
Renewable Energy	$39.2	196	452
Energy Efficiency	932.6	3,498	8,046
TOTAL	$971.8	3,694	8,498

Source: Management Information Services, Inc. and American Solar Energy Society, 2007.


Evergreen Solar

According to the research summarized in this report, the renewable energy sector created more than 450,000 jobs in 2006.

Forecasting Growth in the RE&EE Industry

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 major RE&EE initiatives over next 23 years. The base case also assumes that U.S. RE&EE industry continues to develop according to the general trends and rates of growth seen over the past two decades. Results indicate that RE development is minimal under the base case scenario.

The base case is based loosely on the EIA reference case from the *Annual Energy Outlook 2007*, which assumes that "all current standards, laws, and regulations remain as currently enacted." Under the EIA reference case, total U.S. primary energy consumption is projected to increase from 100 quadrillion Btu (quads) in 2005 to 131 quads in 2030. During this period, the share of renewable electricity generation is forecast to remain constant at 9 percent, while coal is expected to increase its share of electric power generation from 50 percent in 2005 to 57 percent in 2030. The number of gallons of ethanol consumed is projected to increase from 4 billion in 2005 to 14.6 billion in 2030, or about 8 percent of total gasoline consumption by volume.

This base-case projection may not be 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, renewable energy is unlikely to significantly increase its share of the U.S. energy market.

Moderate Scenario

The moderate scenario assumes that various moderate, incremental (above the base case) federal and state RE&EE initiatives are put in place during next two decades. This scenario was based on various "mid-range" estimates, incorporating modest initiatives, and assumes a

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

DOE/NREL, PIX 09395, Angus Duncan

GE Energy

Left: The project to build this system in Westsound, Washington, on Orcas Island and three others, similar in scale, are part of a network of green power projects that together generate 1 megawatt of power a year. **Right**: Building-integrated photovoltaic products like these electricity-generating photovoltaic shingles replace conventional roofing shingles on this Premier Power Home in Lincoln, California.

continuation of the positive policies that are in place, with 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 gigawatts (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_2 cost, beginning in 2015. This analysis estimated that electricity from new renewable resources (excluding hydropower) could supply 13 percent of demand by 2030. We estimated that the renewable electricity generation under the moderate scenario would be about 15 percent.

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 relatively moderate scenario potentials.

Advanced Scenario

The advanced scenario "pushes the envelope." It indicates what is possible using current or impending technologies and includes what may be realistically feasible both economically and technologically in such a scenario. The advanced scenario also assumes that the RE&EE industry is available to take the 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, recognition of global warming, etc. 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 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. This is potentially more than the new, additional electric power generating capacity needed by that date according to EIA. EPRI analyzed an aggressive strategy with both high natural gas prices and high costs. This analysis forecast substantial growth of new renewables in the electric supply sector. The results, excluding geothermal and hydropower, 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 has estimated that biodiesel could displace five percent of petroleum diesel in a near- to-mid-term timeframe. The Renewable Fuels Association (RFA) has presented an overall outlook for its sector, noting the dramatic growth in the industry. 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 could come from renewable sources by 2030, which would be 60 billion gallons of annual production. In addition, the advent of plug-in hybrid vehicles and other electricity-based transportation systems and technologies would allow renewable energy sources to further contribute to displacing the need for imported oil.

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 technologies. Under the advanced scenario, renewable electricity generation is forecast to reach 30 percent by 2030.

DOE/NREL, PIX 10636, Tennessee Valley Authority

DOE/NREL, PIX 02149, U.S. Department of Energy, Craig Miller Productions

Left: The Buffalo Mountain Wind Project in Oliver Springs, Tennessee, contributes almost 2 megawatts of wind power capacity to the state's electric grid. **Right**: The Nanatorium roof at the Georgia Institute of Technology in Atlanta, features photovoltaics (right) to produce electricity and a solar-thermal heat system (left) to heat pool water.

Wind Power

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

DOE/NREL, PIX 01077, David Parsons

DOE/NREL, PIX 06359, Warren Gretz

Sunpower Corporation

Left: Researchers at the National Renewable Energy Laboratory worked with Calpine Corporation to improve the efficiency of the Geysers geothermal power plant in California. **Center**: Nearly 70% of the jobs in the renewable energy sector are in biomass, such as this biomass gasifier at the McNeil Generating Station in Burlington, Vermont. **Right**: Dan Shugar, President, SunPower Corporation, Systems (far left), joins San Francisco Mayor Gavin Newsom (right) and others dedicating a photovoltaic system at the city's Southeast Wastewater Treatment Plant.

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, consistent 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 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.

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 is insurmountable if the political will exists to support renewable energy at the federal and state levels.

DOE/NREL, PIX 09218, Jim Yost

DOE/NREL, PIX 10283, Robb Williamson

Left: Daylighting in the retail store at BigHorn Home Improvement Center in Silverthorne, Colorado, substantially reduces the electric lighting load. Compact fluorescent fixtures supplement natural light when needed and at night. **Right**: The Chesapeake Bay Foundation's Philip Merrill Environmental Center, Annapolis, Maryland, uses extensive glazing for daylighting and to maximize views of the Chesapeake Bay.

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 and future energy prices are likely to be the major determinants of future market share for RE.

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.

In the base case, jobs created by RE increase 190 percent, from 446,000 to 1.3 million, and jobs created by EE 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.

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

	Revenues (Billions of 2006 Dollars)			**Total Jobs Created** (Direct Plus Indirect – Thousands)		
	Base Case	Moderate Scenario	Advanced Scenario	Base Case	Moderate Scenario	Advanced Scenario
RE	$95	$227	$597	1,305	3,138	7,918
EE	$1,818	$2,152	$3,933	14,953	17,825	32,185
Total	$1,913	$2,379	$4,530	16,258	20,963	40,103

Source: Management Information Services, Inc. and American Solar Energy Society, 2007.

Matt Sullivan

Victory Farms, home of the Robert Howard family in Blacklick, Ohio, gets much of its power from a grid-connected, net-metered 18-kilowatt wind turbine and solar electric arrays.

Ohio Case Study

As part of this project, we focused on the RE&EE industry in Ohio. There are many thousands of RE&EE companies located throughout the United States and Ohio, and they generate jobs in virtually every community.

The Ohio RE&EE Industry in 2006

In 2006 in Ohio, gross revenues for RE totaled nearly $800 million, and the RE industry created more than 6,600 jobs. These jobs were disproportionately for scientific, technical, professional, and skilled workers, and more than 90 percent of the jobs were in private industry. The largest number of jobs was in the wind sector, followed by the biomass and the geothermal sectors.

Gross revenues for EE totaled more than $50 billion in Ohio in 2006, and the number of jobs created totaled nearly 500,000. More than 90 percent of the EE jobs were also in private industry, and over 50 percent of the jobs were in the manufacturing sector. The second largest number of jobs was in recycling, followed by durable manufacturing and vehicle manufacturing.

Table CS1 offers a snapshot of the RE&EE industry in Ohio in 2006.

RE Company Profile

Given the wide diversity in the size, function, and technologies of RE&EE companies, it is impossible to estimate the job profile of the "average" RE or EE firm. However, it is possible to identify the jobs and earnings profiles of typical types of firms involved in RE&EE-related areas of work. Table CS2 illustrates this by showing the 2006 occupational job distribution and employee earnings of a typical wind turbine-manufacturing company.

Table CS1
The Ohio Renewable Energy and Energy Efficiency Industry, 2006

Industry	**Revenues** (millions)	**Direct Jobs**	**Total** (direct plus indirect) **Jobs Created**
Renewable Energy	$785	2,880	6,615
Energy Efficiency	50,120	205,780	496,535
TOTAL	$50,905	208,660	503,150

Source: Management Information Services, Inc. and American Solar Energy Society, 2007.

Table CS2

Typical Employee Profile of a 250-person Wind Turbine Manufacturing Company, 2006, Selected Occupations

Occupation	Employees	Earnings
Engine and Other Machine Assemblers	31	$36,300
Machinists	27	40,500
Team Assemblers	16	30,100
Computer-Controlled Machine Tool Operators	12	40,600
Mechanical Engineers	10	71,600
First-Line Supervisors/Managers of Production/Operating	10	59,600
Inspectors, Testers, Sorters, Samplers, and Weighers	8	40,400
Lathe and Turning Machine Tool Setters/Operators/Tenders	6	40,000
Drilling and Boring Machine Tool Setters/Operators/Tenders	4	39,800
Welders, Cutters, Solderers, and Brazers	4	39,900
Laborers and Freight, Stock, and Material Movers	4	29,800
Maintenance and Repair Workers	4	44,100
Tool and Die Makers	4	43,600
Grinding/Lapping/Polishing/Buffing Machine Tool Operators	4	34,800
Multiple Machine Tool Setters/Operators/Tenders	4	40,800
Industrial Engineers	3	70,400
Industrial Machinery Mechanics	3	46,000
Engineering Managers	3	108,300
Shipping, Receiving, and Traffic Clerks	3	32,100
General and Operations Managers	3	120,600
Industrial Production Managers	3	93,100
Industrial Truck and Tractor Operators	3	34,200
Purchasing Agents	3	56,200
Cutting/Punching/Press Machine Setters/Operators/Tenders	3	31,400
Production, Planning, and Expediting Clerks	3	45,200
Milling and Planing Machine Setters/Operators/Tenders	3	40,600
Mechanical Drafters	2	39,900
Customer Service Representatives	2	39,100
Bookkeeping, Accounting, and Auditing Clerks	2	35,600
Office Clerks, General	2	29,400
Sales Representatives, Wholesale and Manufacturing	2	55,300
Janitors and Cleaners	2	29,800
Sales Engineers	2	72,500
Accountants and Auditors	2	59,800
Tool Grinders, Filers, and Sharpeners	2	44,000
Executive Secretaries and Administrative Assistants	2	43,200
Mechanical Engineering Technicians	2	50,900
Electricians	2	49,600
Other employees	48	49,700
Employee Total (126 occupations in the industry)	**250**	**$46,400**

Source: Management Information Services, Inc. and American Solar Energy Society, 2007.

This look at a wind company illustrates important points that also emerged in our national analysis. First, firms working in the RE&EE and related areas employ a wide range of workers at all educational and skills levels and at widely differing earnings levels. Second, in RE&EE companies, few of the employees are classified as RE or EE specialists. Most of the workers are in occupations such as laborers, clerks, bookkeepers, accountants, maintenance workers, cost estimators, etc. All of these employees owe their jobs and livelihoods to RE&EE, but, in general, they perform the same types of activities at work as employees in firms that have little or nothing to do with RE or EE.


Vestas Wind Systems A/S

Wind is a cost-effective electricity generation technology that produces no carbon emissions during the generation process.

Thus, the occupational job distribution of a typical wind turbine manufacturing company differs relatively little from that of a company that manufactures other products. The employees are "RE" workers only because the company they work for is manufacturing a renewable energy product. Importantly, with the current national angst concerning the erosion of the U.S. manufacturing sector and the loss of U.S. manufacturing jobs, it is relevant to note that many RE&EE technologies are growing rapidly. In Ohio 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.

It is instructive to note that although the RE&EE debate typically has focused on applying new technology to offset traditional energy sources, RE&EE are more than a source of fuel or energy savings. They are sources of jobs. As shown here, employment growth in the RE&EE industry varies for the different segments of the industry, but new breakthroughs in RE&EE technologies will come from the growing sectors of the industry, including architectural and engineering services, materials processing, and research and development.

In addition, utilities represent a sector that has pioneered a number of alternative energy technologies. Site-based generation technologies, including photovoltaics and wind systems, can eliminate the transmission and distribution losses that occur when electricity from centralized plants is delivered via transmission lines. Site-based, distributed generation also provides more reliable, localized power, and enables power production all across the electrical grid. In addition, utilities could explore superconducting power lines, which could significantly reduce the loss of electricity due to transmission. Increasingly, however, RE&EE advances will come from all areas of the economy, and may not necessarily be captured by traditional industry sources of energy technologies.

Occupational data demonstrate that the RE&EE industry creates a variety of high-paying jobs, many of which take advantage of manufacturing skills currently going unused as manufacturing continues to undergo restructuring across the U.S. generally and in states like Ohio specifically. Regions like Ohio with traditional manufacturing economies can recruit RE&EE companies to take advantage of their highly skilled manufacturing workers, many of whom are idle or underemployed.

As Table CS3 illustrates, wages and salaries in many sectors of the RE&EE industry are higher than U.S. average wages. Although many high-tech industries almost exclusively require highly educated workers with masters or doctoral degrees, the RE&EE industry requires a wide variety of occupations. Nevertheless, many occupations in the RE&EE industry include jobs that require associate's degrees, long-term on-the-job training, or trade certifications, including engineers, chemists, electrical grid repairers, power plant operators and power dispatchers, chemical technicians, mechanical engineering technicians, and RE&EE technicians, all of which pay higher than U.S. average wages.

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

However, Ohio must also recognize that it is in fierce competition as communities around the U.S. compete for new emerging energy industries with traditional university-centered research areas, including Palo Alto (Stanford University), Ann Arbor (University of Michigan), Boulder (University of Colorado), Trenton (Princeton University), and Albany (SUNY-Albany).

In addition, Ohio must compete for RE&EE jobs with traditional high-tech metropolitan areas like San Jose, Colorado Springs, and Washington, D.C., along with metropolitan areas traditionally associated with manufacturing, like Dothan, Alabama. The wide variety of entrance points to the RE&EE industry makes this market easier to penetrate if Ohio can market its strengths in manufacturing, research, education, and construction and operation.

RE&EE Firms in Ohio

We conducted a survey of existing RE&EE companies in Ohio, examining a functional, technological, and geographic mix of companies. Our research revealed a wide range of firms lo-

Table CS3

Renewable Energy and Energy Efficiency Occupations: Wages, Educational Requirements, and Growth Forecasts, Selected Occupations

Occupation	10 year % Growth Forecast	Median Salary	% With Bachelor's Degree	Education
Materials Scientists	8	$74,400	94	Bachelor's
Physicists	7	91,500	92	Doctoral
Microbiologists	17	63,400	96	Doctoral
Biological Technicians	17	36,500	60	Associate
Conservation Scientists	6	53,800	88	Bachelor's
Chemists	7	63,500	94	Bachelor's
Chemical Technicians	4	40,100	27	Associate
Geoscientists	6	73,200	94	Doctoral
Natural Science Managers	14	99,100	90	Bachelor's
Environmental Eng. Technicians	24	42,000	18	Associate
Soil and Plant Scientists	20	58,000	64	Bachelor's
Mechanical Eng. Technicians	12	46,500	18	Associate
Environmental Sci. Technicians	16	38,500	47	Associate
Biomedical Engineers	31	75,400	60	Bachelor's
Chemical Engineers	11	79,200	92	Bachelor's
Mechanical Engineers	10	77,000	88	Bachelor's
Electrical Engineers	12	76,000	83	Bachelor's
Environmental Engineers	14	74,500	82	Bachelor's
Computer Scientists	26	94,000	67	Doctoral
Life & Physical Sci. Technicians	20	45,200	50	Associate
Utility Plant Operatives	4	53,000	10	OJT
HVAC Technicians	12	37,600	14	OJT
Energy Audit Specialists	18	39,500	18	OJT
Forest & Conservation Workers	6	27,000	8	OJT
Refuse & Recycling Workers	5	26,000	2	OJT
Insulation Workers	6	$30,200	2	OJT

Source: Management Information Services, Inc. and U.S. Bureau of Labor Statistics, 2007.
OJT=On-the-Job Training

cated throughout the state, in major urban centers, suburbs, small towns, and rural areas. The size of the companies ranged from small firms of several employees to large firms employing hundreds. The survey also revealed that RE&EE firms in Ohio are engaged a wide variety of activities, including manufacturing, engineering, R&D, installation, monitoring, analysis, etc., and require a wide variety of occupations, skills, education, training, and experience. The list of RE&EE companies includes some of the most sophisticated, innovative, high-tech firms in the state.

Ohio in 2030

Table CS4 illustrates that RE&EE offer significant development opportunities for Ohio. Under the advanced scenario, in 2030, RE could generate annually nearly $18 billion in revenues and 175,000 jobs and EE could generate annually over $200 billion in revenues and over 2 million jobs.

Our research also reveals that employment growth in RE&EE varies among sectors. Growing sectors include architecture and engineering, R&D, ESCOs, environmental technologies, biofuels, power technologies, industrial processes, distributed generation, computer controls and systems, and HVAC systems, among others.

RE&EE create a variety of high-paying jobs, many of which take advantage of the manufacturing skills of Ohio workers. Ohio, with its traditional manufacturing economy, can recruit RE&EE companies to take advantage of its skilled workforces for wind turbine manufacturing, biofuels production, etc.

This is important because Ohio needs a new source of jobs. Over the last 10 years, Ohio total employment increased 2.7 percent—from 5.3 million in 1996 to 5.4 million in 2006—while total U.S. employment increased 14 percent

Table CS4
Summary of the Ohio Renewable Energy and Energy Efficiency Industries in 2030

	Revenues (Billions of 2006 Dollars)			**Total Jobs Created** (Direct Plus Indirect – Thousands)		
	Base Case	Moderate Scenario	Advanced Scenario	Base Case	Moderate Scenario	Advanced Scenario
RE	$2.0	$5.7	$17.7	21	56	174
EE	$96.7	$114.7	$202.6	964	1,150	2,096
Total	$98.7	$120.4	$220.3	985	1,206	2,270

Source: Management Information Services, Inc. and American Solar Energy Society, 2007.

during same period, more than 5 times as fast. In addition, Ohio's share of total U.S. jobs decreased from 4.4 percent to 4.0 percent. During the same period, Ohio manufacturing jobs decreased 23 percent, from 1.03 million in 1996 to 797,000 in 2006, a loss of 233,000 jobs, and Ohio's share of U.S. manufacturing jobs decreased from 6.0 percent to 5.6 percent. In 1996, manufacturing jobs accounted for 19.4 percent of total Ohio jobs, but in 2006 they accounted for only 14 percent.

As the following graphs illustrate, the RE&EE industry could play a significant role in boosting Ohio's economy.

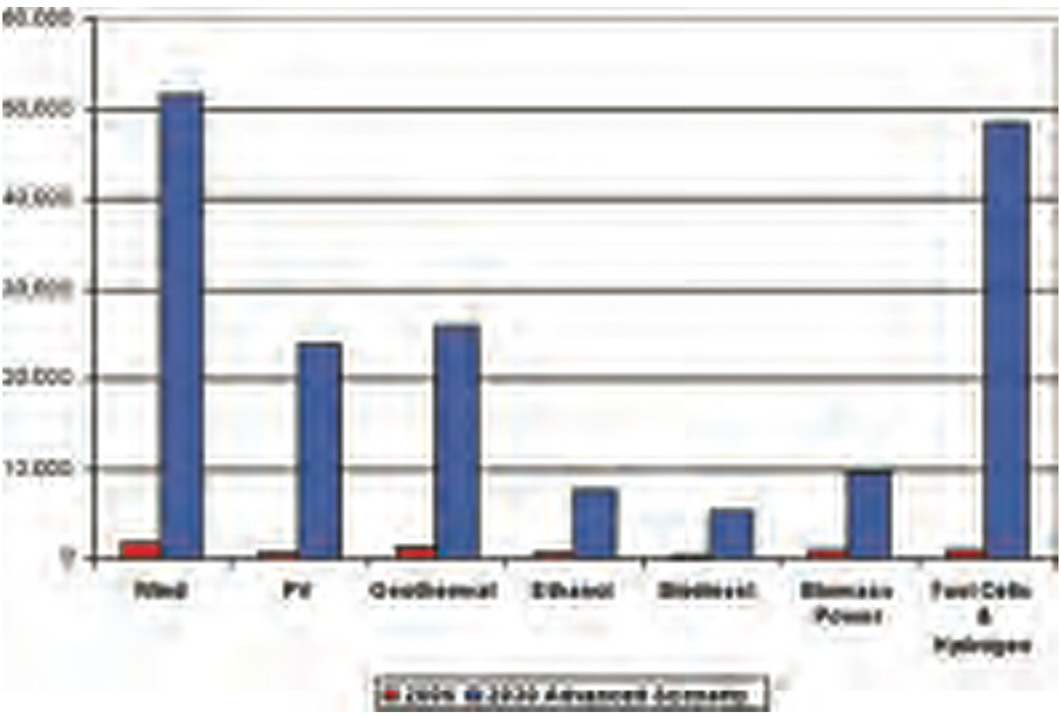


Figure CS1—Ohio Job Growth 2006-2030 in Selected Renewable Energy Technologies

Source: Management Information Services, Inc. and American Solar Energy Society, 2007.

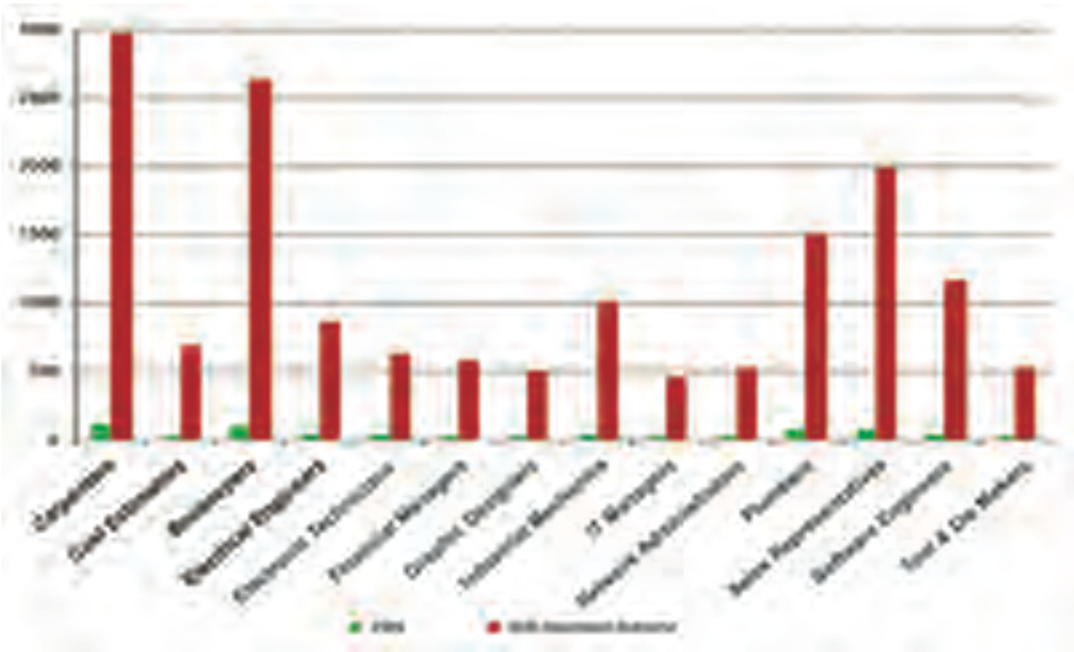


Figure CS2—Ohio Jobs Created By Renewable Energy In 2030 (Total Jobs Created—Selected Occupations)

Source: Management Information Services, Inc. and American Solar Energy Society, 2007.

The Bottom Line for Ohio

Although Ohio does have a skilled workforce and needs manufacturing jobs, the state is not in the forefront of some RE industries. There are 31 PV manufacturing firms in the U.S., but only one in Ohio, 25 solar thermal collector manufacturing firms in U.S., but none in Ohio. In 2006, Ohio accounted for only 0.2 percent of solar thermal collectors (34,700 ft^2) installed in U.S. (total installed was 16 million ft^2), and ranked only 22nd among states in terms of collectors installed.

Ohio also trailed far behind neighboring states—Michigan had 238,000 ft^2 of collectors installed, Pennsylvania had 234,000 ft^2 installed, and Illinois had 463,000 ft^2 of collectors installed. With no solar thermal manufacturing and few installations, Ohio has effectively ceded leadership in this segment of the RE industry.

The contrast with Germany is especially relevant, particularly because Ohio has much better RE resources than Germany does. Germany has about one-fourth the gross domestic product and population of the U.S., but has more RE jobs (214,000 vs. 194,000).

Ohio has only 2,900 RE jobs, just 1.5 percent of the U.S. total. RE employment in Germany has increased 36 percent in two years. We don't even know how much RE employment has increased in the United States, because—until now—no one has estimated actual RE employment. Germany produces one-half of the wind rotors and one-third of the solar PV panels in the world, leads the world in biodiesel production, is second only to Japan in fuel cells and hybrid vehicles, and by 2020, German RE jobs will exceed those in machinery or vehicle manufacturing.

First Solar

A German farmer grazes his sheep next to a solar electric photovoltaic array. Farmers can also "double-crop" with wind turbines, raising crops or grazing animals up to the base of the turbines.

Vestas Wind Systems A/S

Sheep graze around the turbines at this California wind farm.

The Way Forward

The implications for the United States—and for Ohio and other states—are obvious and serious.

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 Ohio—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, the United States runs the risk of losing ground to international RE&EE programs and industries. If we refuse to address policy and regulatory barriers to the sustained, orderly development of the RE&EE industry, other countries will 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.

Renewable energy and energy efficiency can create skilled, well-paying jobs, many of which are not subject to foreign outsourcing.

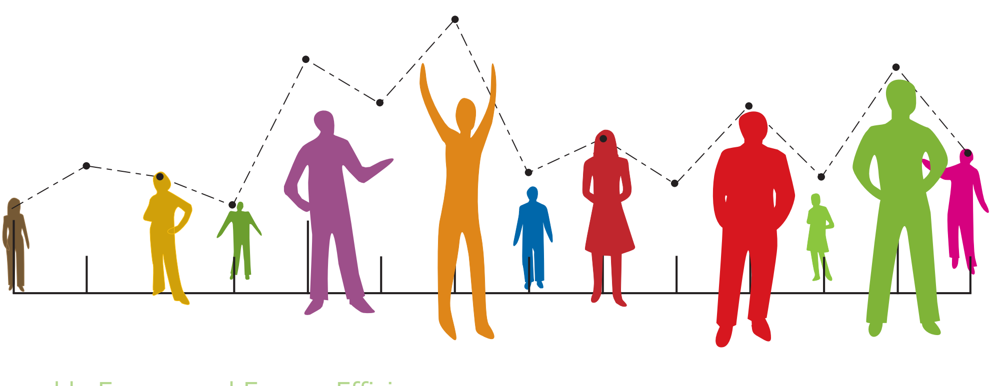
Evergreen Solar

American Honda Motor Co., Inc.

Top: Many of the jobs in the renewable energy sector require high skill levels and advanced training. **Bottom**: The 2008 Honda Civic gasoline/electric hybrid sedan gets an average of 40 miles per gallon in the city and 45 miles per gallon on the highway.

List of Acronyms

ASES	American Solar Energy Society
CAFE	Corporate average fuel economy
DOE	U.S. Department of Energy
EIA	U.S. Department of Energy's Energy Information Administration
EPRI	Electric Power Research Institute
ESCO	Energy service company
MISI	Management Information Services, Inc.
NGO	Non-governmental organization
OJT	On-the-job training
PTC	Production tax credit
RE&EE	Renewable energy and energy efficiency
RFA	Renewable Fuels Association
RPS	Renewable portfolio standard
WGA	Western Governors' Association



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