DEFINING, ESTIMATING, AND FORECASTING THE RENEWABLE ENERGY AND ENERGY EFFICIENCY INDUSTRIES IN THE U.S AND IN COLORADO

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And

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EXECUTIVE SUMMARY

Although analysts have conducted renewable energy (RE) and energy efficiency (EE) industry studies and forecasts for more than the past three decades, no rigorous definitions currently exist for either of these industries or for their current size, structure, and composition. In 2007, ASES and MISI undertook the first comprehensive study of the size the breadth of the RE and EE industries, and we thus created the standard definition that provides comparability between data. Prior to our earlier work, the basic knowledge of these industries was not well documented.

This report estimates and forecasts the RE&EE industries for the U.S. and Colorado, and the major contributions of the research summarized here include:

- Development of a rigorous definition of the RE and the EE industries
- Estimation of their current sizes and composition, including technology, sales, jobs, occupations, and skills
- Forecasting their growth to 2030 under three scenarios

It is anticipated that these data will provide a foundation for subsequent analyses conducted of the RE&EE industries.

The U.S. RE&EE Industries in 2007

We found that, in 2007, the U.S RE&EE industries generated $1,045 billion in sales and created over 9 million jobs – including $10.3 billion in sales and over 91,000 jobs in Colorado. The U.S. RE&EE revenues represent substantially more than the combined 2007 sales of the three largest U.S. corporations -- Wal-Mart, ExxonMobil, and GM ($905 billion). RE&EE are growing faster than the U.S. average and contain some of the most rapidly growing industries in the world, such as wind, photovoltaics, fuel cells, recycling/remanufacturing, and biofuels. With appropriate federal and state government policies, RE&EE could by 2030 generate over 37 million jobs per year in the U.S. – including over 600,000 jobs in Colorado.

Tables EX-1 and EX-2 show the estimated 2007 sizes of the RE&EE industries in the U.S. and in Colorado. In the U.S. for RE:

- RE gross revenues totaled nearly $43 billion and the number of jobs created by RE exceeded 500,000
- Jobs created were disproportionately for scientific, technical, professional and skilled workers, and more than 95 percent of the jobs were in private industry
- Over 70 percent of the jobs were in the biomass sector – primarily ethanol and biomass power, and the second largest number of jobs was in the wind sector of the industry, followed by the geothermal and photovoltaics sectors

Table EX-1
Summary of the U.S. Renewable Energy and Energy Efficiency Industries in 2007

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

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

Table EX-2
Summary of the Colorado Renewable Energy and Energy Efficiency Industries, 2007

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

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

In the U.S. for EE:

- EE gross revenues totaled over $1 trillion and the number of jobs created by EE totaled nearly 8.6 million
- More than 98 percent of the jobs were in private industry
- Over 36 percent of the jobs were generated by the recycling, reuse, & remanufacturing sector, and the second largest number of jobs was generated by the nondurable manufacturing sector, followed by the miscellaneous durables manufacturing sector, and the computers, printers, copiers, etc. sector

Growth of the U.S. RE&EE Industries, 2006 - 2007

Total RE industry revenues increased 8.7 percent, from $39.2 billion in 2006 to $42.6 billion in 2007. Hydroelectric production decreased in 2007, and excluding the hydroelectric sector, RE industry revenues increased 11.1 percent, from $35.2 billion to $39.1 billion.

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

The real growth rate of U.S. GDP between 2006 and 2007 was 2.19%. Thus, including hydro, the RE industry grew more than twice as rapidly as the overall U.S. economy; excluding hydro, the RE industry grew more than three times as fast as the overall U.S. economy. Further, the biomass power sector is a significant part of the RE industry, but it grew little between 2006 and 2007. Excluding both hydro and biomass power, the U.S. RE industry grew 15.4 percent between 2006 and 2007 – more than seven times as fast as the overall U.S. economy. Some sectors experienced very substantial growth: Solar thermal grew more than 35 percent, Biodiesel grew 30 percent, Ethanol grew nearly 30 percent, Photovoltaics grew more than 25 percent.[1]

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

The Colorado RE&EE Industries in 2007

In Colorado, for RE:

- Gross revenues totaled nearly $1.1 billion
- The total number of jobs created totaled more than 10,000
- Jobs created were disproportionately for scientific, technical, professional and skilled workers and about half of the jobs were in private industry
- The largest number of jobs was in the Federal government sector (primarily NREL), followed by the wind and ethanol sectors

In Colorado, for EE:

- Gross revenues totaled over $9 billion
- The total number of jobs created totaled more than 81,000
- The largest number of jobs was generated by the recycling, reuse, & remanufacturing sector, and the second largest number of jobs was generated by the miscellaneous durables manufacturing

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

In Colorado, for RE&EE:

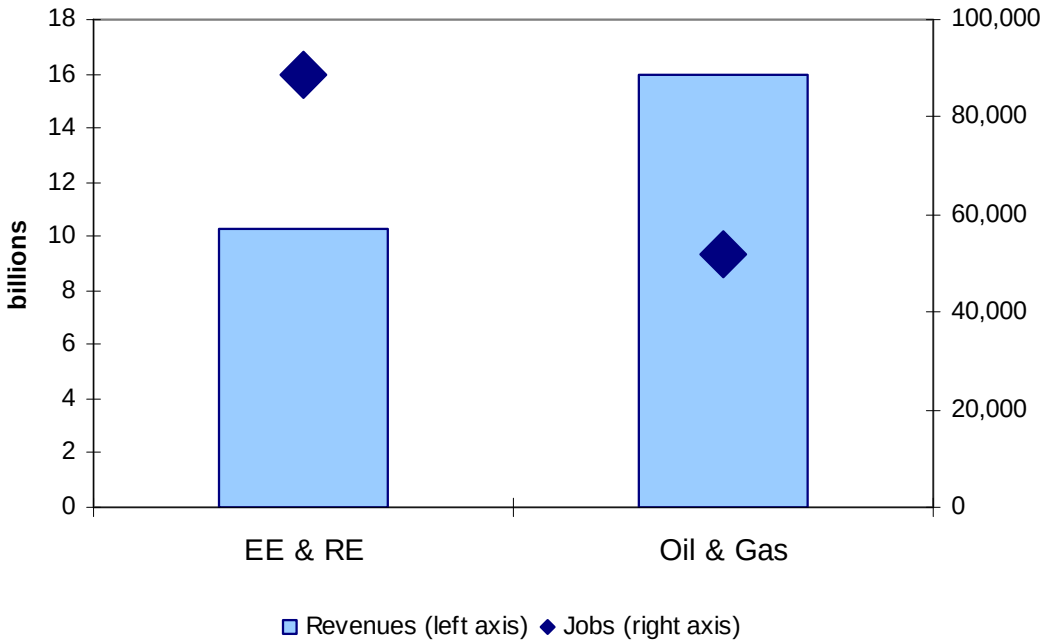
- RE&EE accounted for more than $10 billion in revenues
- RE&EE generated over 91,000 jobs
- The EE sector in Colorado is more than eight times larger than the RE sector

Thus, in Colorado RE&EE accounted for more than four percent of gross state product and for more than three percent of total employment in the state

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

We compared the economic impact of the RE&EE sector to that of the Colorado oil and gas (O&G) sector in the state. The comparative impacts of the sectors are illustrated in Figure EX-1, which shows that, in terms of revenues, the O&G sector in Colorado is more that 50 percent larger ($5.7 billion) than the EE&RE sector. However, the RE&EE sector generates about 70 percent more jobs (39,000) than the O&G sector. Thus, the RE&EE sector in Colorado generates, in total, more than 2.5 times as many jobs per dollar of revenues as does the O&G sector in the state.

Figure EX-1
Comparative Economic and Jobs Impact in Colorado of the RE&EE Sector and the O&G Sector



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

Survey of Colorado RE&EE Companies

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

- Are located throughout the state, in major urban centers, suburbs, small towns, and rural areas.
- Range in size from small firms of several employees to large firms employing thousands -- although most of them are relatively small.
- Employ workers at all levels of skills, from the most basic and rudimentary to the very high skilled technical and professional
- Include those whose market is local, those whose market is state and regional, those who market is national, and those whose market is international.
- Are engaged a wide variety of activities, including design, manufacturing, engineering, renovation, R&D, installation, servicing, testing, monitoring, analysis, etc.
- Require a wide variety of occupations, skills, education, training, and experience
- Include some of the most sophisticated, innovative, high-tech firms in the state
- Are faced with many of the same concerns, problems, and opportunities as other firms in the state.

RE&EE Industry Forecasts

Three scenarios to 2030 were forecast for the U.S. and Colorado: The Base Case, the Advanced Scenario, and the Moderate Scenario. The Base Case:

- Is essentially a “business as usual” case scenario
- Assumes no change in RE&EE policies
- Assumes no major RE&EE initiatives over next 21 years.
- Assumes that the U.S. and Colorado RE&EE industries continue to develop according to the general trends and rates of growth experienced over past two decades

The Moderate Scenario:

- Assumes that various moderate, incremental (above the base case) Federal and state RE&EE initiatives are put in place over next two decades
- Assumes policies such as R&D, tax incentives, RPS mandates, externalities pricing, etc.

- Assumes a continuation of the positive policies that are in place, plus market conditions favorable to RE&EE
- Is based on various "mid-range" estimates, incorporating modest initiatives

The Advanced Scenario:

- "Pushes the envelope" on the RE&EE industry with current or impending technologies
- Requires favorable market conditions and a sustained commitment of public policy to ensure that RE&EE achieves higher levels of contribution to the U.S. energy market
- Assumes RE&EE industries are available to take the U.S. in a new direction, but that appropriate, aggressive public policies at Federal and state levels are required and must be sustained over next two decades
- Represents a dramatic indication of what would be possible under an aggressive renewable energy scenario
- Includes what may be, realistically, feasible both economically and technologically in such a "crash" scenario

The U.S. RE&EE Industries in 2030

The scenario forecast results for the U.S. are summarized in Table EX-3 and Figures EX-2 and EX-3, and indicate that:

Table EX-3
U.S. Renewable Energy and Energy Efficiency Industries in 2030

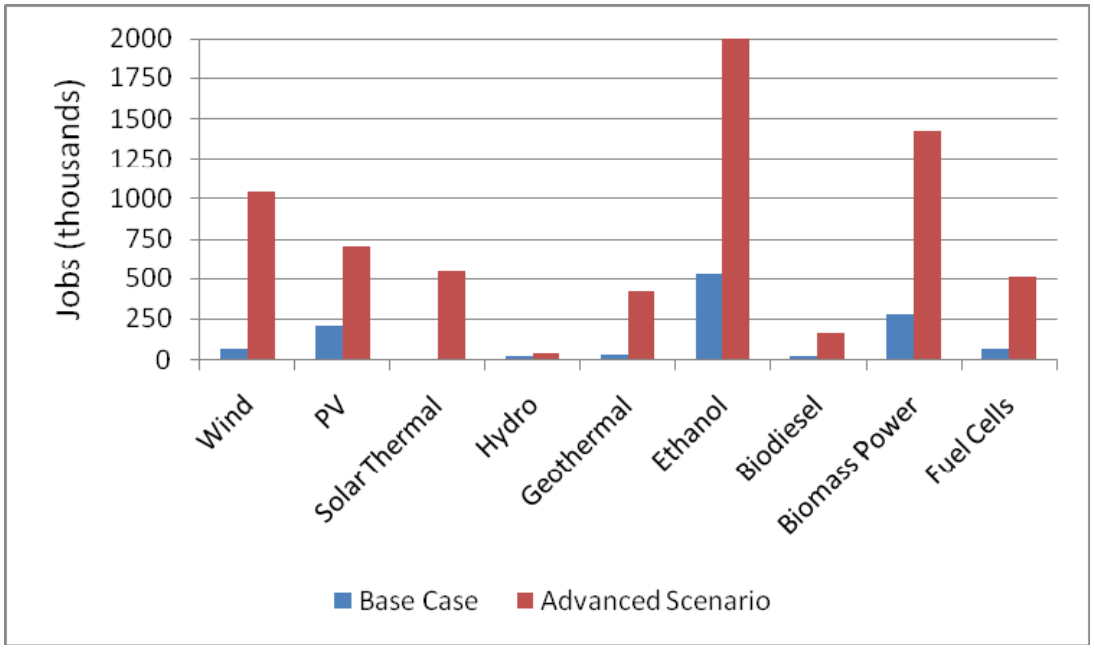
	Revenues (Billions of 2007 Dollars)			Total Jobs Created (Thousands)		
	Base Case	**Moderate Scenario**	**Aggressive Scenario**	**Base Case**	**Moderate Scenario**	**Aggressive Scenario**
RE	$98	$212	$560	1,305	2,846	7,328
EE	1,868	2,036	3,734	14,953	16,658	29,878
Total	$1,966	$2,248	$4,294	16,258	19,504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

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

- In the base case: RE revenues increase 130 percent, from $42.6 billion to $98 billion; EE revenues increase 86 percent, from $1,003 billion to $1,868 billion
- In the base case: Jobs created by RE increase 160 percent, from 504,000 to 1.3 million; jobs created by EE increase 75 percent, from 8.6 million to 15 million

- In the advanced scenario, RE revenues increase 1,200 percent, from $42.6 billion to $560 billion; EE revenues increase 270 percent, from $1,003 billion to $3,734 billion
- In the advanced scenario: Jobs created by RE increase 1,300 percent, from 504,000 to 7.3 million (4.3 percent of total U.S. jobs); jobs created by EE increase 250 percent, from 8.6 million to 30 million (17.5 percent of total U.S. jobs)
- Thus, under all scenarios RE growth is much larger than EE growth; nevertheless, the economic and job impact of EE remains orders of magnitude larger than that of RE

Figure EX-2
U.S. Jobs Created By Renewable Energy In 2030
(Total Jobs Created -- Selected Technologies)



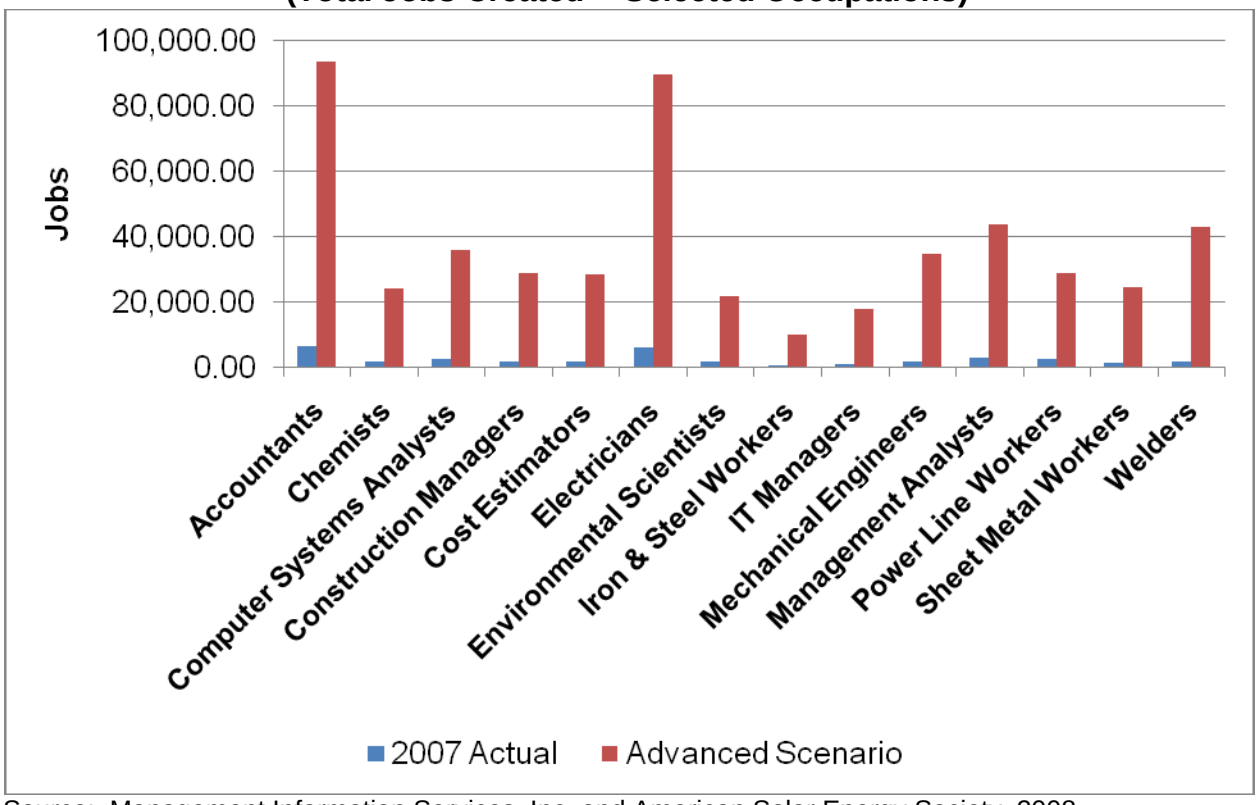
Source: Management Information Services, Inc. and American Solar Energy Society, 2007.

The Colorado RE&EE Industries in 2030

Analogous results for Colorado are summarized in Table EX-4 and Figures EX-3 through EX-6. This table and the figures illustrate that renewable energy and energy efficiency offer significant development opportunities for Colorado:

- Under the advanced scenario, in 2030: RE could generate annually more than $13 billion in revenues and 113,000 jobs, and EE could generate annually over $44 billion in revenues and 500,000 jobs.
- Employment growth in RE&EE varies among sectors: Growing sectors include wind, photovoltaics, architecture and engineering, R&D, energy service companies (ESCO), environmental technologies, bio-fuels, power technologies, industrial processes, distributed generation, computer controls and systems, HVAC systems, and others.
- RE&EE creates a variety of high-paying jobs, many of which require associate's degrees, on-the-job training, or trade certifications and which pay high wages.
- 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. and many of the persons employed in these jobs may not even realize that they owe their livelihood to renewable energy.

Figure EX-3
U.S. Jobs Created By Renewable Energy in 2030 Compared to 2007
(Total Jobs Created -- Selected Occupations)



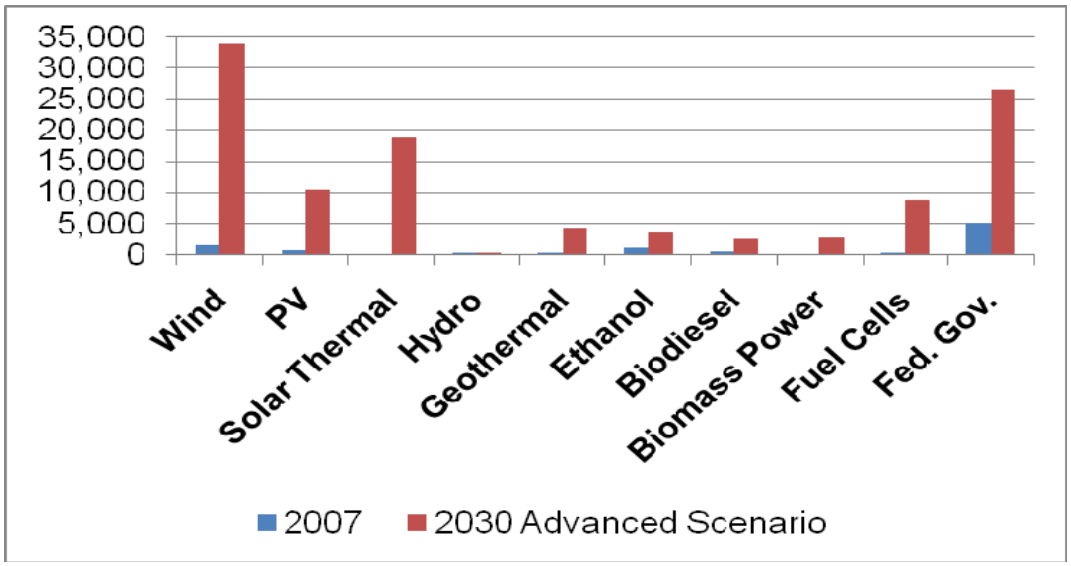
Source: Management Information Services, Inc. and American Solar Energy Society, 2008.

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

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

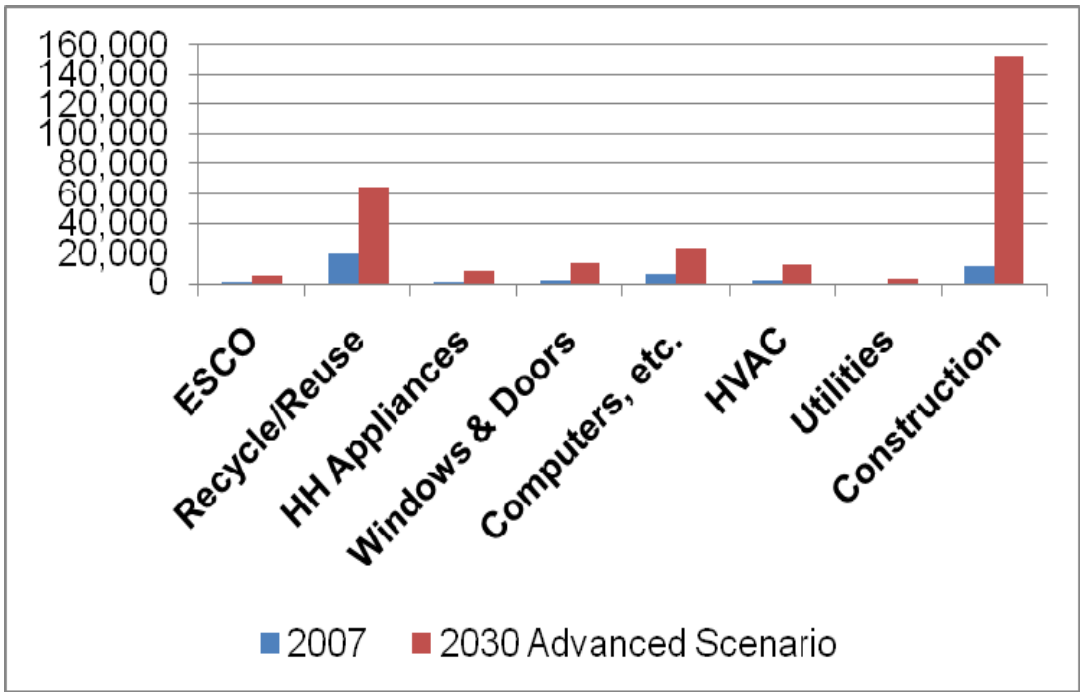
Source: Management Information Services, Inc., 2008.

Figure EX-4
Total Jobs Created by RE in Colorado:
2007 Actual and in 2030 Under the Advanced Scenario



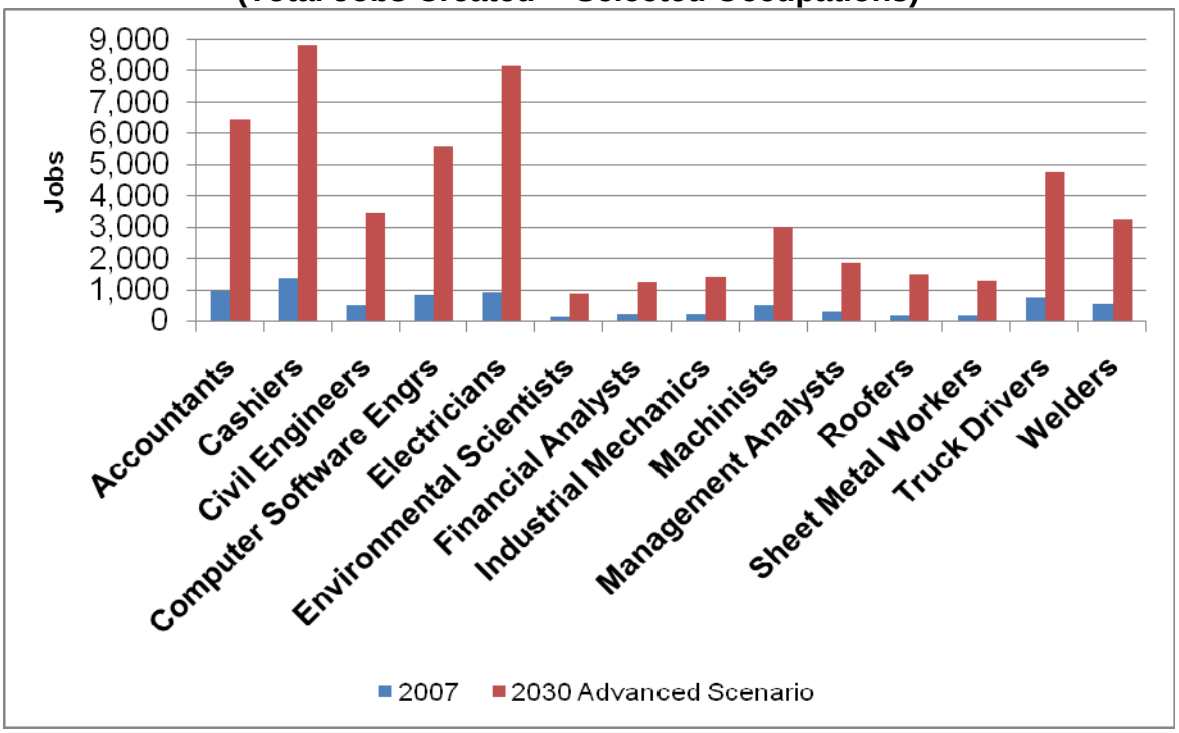
Source : Management Information Services, Inc. and American Solar Energy Society, 2008.

Figure EX-5
Total Jobs Created by EE in Colorado:
2007 Actual and in 2030 Under the Advanced Scenario



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

Figure EX-6
Colorado Jobs Created By RE&EE in 2030 Compared to 2007
(Total Jobs Created -- Selected Occupations)



Source: Management Information Services, Inc., 2008.

Implications

The research reported here is path-breaking in several respects:

- This is the first time that the RE&EE industries have been rigorously specified and actual, comparable sales and employment data derived for two years – 2006 and 2007.
- Second, the RE&EE industries have been disaggregated in detail by technology, sector, sub-industry, and jobs – total jobs and jobs by occupation and skill.
- Finally, these data have been forecast to 2030 on the basis of different scenarios relating to alternative government policies and incentives.

This work represents a major contribution in demonstrating how important RE&EE are to the U.S. and the Colorado economies and labor markets and provides the industry specifications and benchmarks which can be used in all related studies conducted subsequently. The research disaggregates the RE&RE industries into their main components, such as wind, photovoltaics, biofuels, fuel cells, recycling/ remanufacturing, construction, electronics, vehicles, etc. Revenues, jobs, and occupational and skill requirements are estimated for each component and forecast to 2030.

Several important policy implications for Colorado emerge from this research.

First, the RE industry in the state is small and, except for the federal sector – primarily NREL -- does not currently play a major role in the state economy or job market. For example, in 2007, RE accounted for less than 0.6 percent of Colorado gross state product and the total jobs created by RE accounted for only about 0.4 percent of total Colorado employment. Nevertheless, nationwide, Colorado is a disproportionately large player in some RE technologies. For example, although Colorado gross state product (GSP) accounts for only about 1.7 percent of U.S. GDP, in 2007 Colorado had about six percent of the U.S. wind market, nearly six percent of the U.S. photovoltaics market, about five percent of the U.S. ethanol market, and about five percent of the U.S. biodiesel market

Second, despite various proposals that have been made in recent years to use RE as a job creation program for the disadvantaged, the chronically unemployed, or for other target populations, this is simply not feasible at present in Colorado. Total employment in Colorado is over 2.6 million and unemployment totals over 100,000. The total number of jobs generated by RE (excluding NREL) is only about 4,600, and employment in the RE industry (excluding NREL) is only about 2,000.

However, when EE is considered in conjunction with RE, the situation changes. Combined, RE&EE created over 91,000 jobs in Colorado in 2007, nearly 40,000 of which were employment in the industries. Both sectors – but especially RE – are

forecast to grow more rapidly than the state economy as a whole: The current total of about 91,000 jobs generated by RE&EE in Colorado may increase to over 600,000 within 20 years. This rapid growth of jobs from a large base of employment provides both challenges and opportunities for Colorado labor, education, apprenticeship, and job training programs over the coming decades.

Third, Colorado is well positioned to facilitate and to take advantage of rapid growth in the RE&EE industries – especially compared to many other states. There are numerous state government and private industry RE&EE initiatives that are already underway. These types of industry and job creation initiatives combined with educational initiatives, such as the recently announced School of Global Environmental Sustainability at Colorado State University, and the presence of NREL should place Colorado firmly in the forefront of the development and growth of the RE&EE sector for the foreseeable future.

Fourth RE&EE represents an effective job creation mechanism. For example, RE&EE creates, per dollar of expenditure, 3.5 times as many jobs as the oil and gas sector in Colorado. RE&EE creates more than 8,600 jobs per billion dollar of expenditure, whereas the O&G sector creates about 2,500 jobs per billion dollar of expenditure.

Fifth, the longer the U.S. and Colorado delay implementing ambitious RE&EE programs and incentives, the more difficult it will be to achieve the goals outlined here for 2030. Every year's delay at the front end, e.g., 2008, 2009, 2010, has a highly disproportionate and negative impact on the achievement of the long term RE&EE 2030 goals. Time is of the essence, and time lost in the next several years will be very difficult to make up. Thus to achieve the 2030 RE&EE goals, appropriate policies and incentives must be implemented as soon as possible – at both the U.S. and the Colorado state levels.

Finally, a goal of this project is to assist Colorado education professionals to create programs that will facilitate the emerging RE&EE industry in the state. The major finding that emerges is that education and training programs will have to be developed and expanded in the near future to facilitate the anticipated growth of RE&EE. However, most of these programs should, in the immediate future at least, focus on the EE sector simply because there are about eight times as many EE jobs in the state as RE jobs. RE jobs will increase in the future more in percentage terms, but the overwhelming number of jobs created over the next two decades in the RE&EE sector in Colorado will be related to EE.

Of course, many of the RE&EE jobs, skills, and education and training requirements overlap. For example, the largest number of jobs that will be created in the RE&EE sector are related to energy efficient construction and green buildings, but green buildings contain important elements of both RE&EE. Another example of RE&EE overlap is the rapidly growing market for "Green IT" – which involves the use of computer resources in an energy and environmentally efficient way. Green criteria include energy efficiency, using low-emission building materials, recycling, using RE

technologies, and other green strategies. It is thus clear that the jobs, skills, and education and training requirements required for green buildings, green IT, and other sectors and technologies contain important elements of both RE and EE.

Challenges and Opportunities

The challenge is to identify the types of jobs, skills, and education and training requirements corresponding to the employment opportunities that will be created by RE&EE in the coming decades. We here provide information that can assist the state's labor market and educational planners in identifying these opportunities. We have identified over 160 detailed RE&EE occupational specialties and corresponding salaries and education and training requirements. These illustrate that EE&RE currently, and will increasingly in the future, create numerous job opportunities for workers in many different sectors, at all education and skill levels, at a wide range of salaries.

For example, RE&EE will create numerous job opportunities for workers with only an HSD/GED, such as (with corresponding salaries) solar energy system installer ($31,400), wind field technician ($25,900), and recycling center operator ($26,800). RE &EE will create numerous job opportunities for workers with apprenticeship/TS qualifications, such as solar systems designer ($47,100), HVAC engineer ($77,300), and electrical system installer ($44,300). RE&EE will also create numerous job opportunities for workers with Associate's degrees, such as solar installation engineering technician ($47,100), wind turbine technician ($35,100), and energy field auditor ($24,000). Finally, RE&EE will create numerous job opportunities for workers with a Bachelor's and advanced degrees, such as solar energy engineer ($71,300), director of wind development ($138,000), weatherization operations manager ($80,000), and energy trading specialist ($63,500).

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

In sum, renewable energy and energy efficiency offer significant development opportunities for Colorado:

- Under the advanced scenario, in 2030: RE could generate annually over $13 billion in revenues and over 113,000 jobs, and EE could generate annually nearly $44 billion in revenues and 500,000 jobs
- Employment growth in RE&EE varies among sectors: Growing sectors include wind, architecture and engineering, R&D, ESCO, solar thermal, photovoltaics, environmental technologies, bio-fuels, power technologies, fuel cells, industrial processes, distributed generation, computer controls and systems, HVAC systems, and others

- RE&EE create a variety of high-paying jobs, many of which take advantage of Colorado's educational system and workforce skills
- Colorado, with its rapidly expanding RE&EE programs and infrastructure, can recruit RE&EE companies to take advantage of its skilled workforces for wind turbine manufacturing, biofuels production, green IT, fuel cell development, green buildings, etc.
- Wages in many RE&EE sectors are higher than the U.S. average, and RE&EE requires a wide mix of occupations
- RE&EE occupations include many jobs that require associate's degrees, on-the-job training, or trade certifications and which pay high wages
- Unlike some industries, RE&EE is a realistic target for job creation in Colorado: State and local communities can build clusters around industry sectors
- Many entrance points make the RE&EE market easier to penetrate if Colorado can utilize its strengths in workforce, technology, manufacturing, R&D, education, etc.
- The presence of NREL gives Colorado a unique advantage in developing the RE&EE sector, especially the sophisticated R&D-oriented technologies and industries.

RE&EE can create new jobs in Colorado, and these industries generate skilled, well-paying jobs, many of which are not subject to foreign outsourcing. RE&EE can create jobs in two categories that Colorado is eager to attract and retain:

- College-educated professional workers, many with advanced degrees
- Highly skilled, technical workers, with advanced training and technical expertise, many of them in the manufacturing sector

RE&EE thus generate jobs that are disproportionately for highly skilled, well-paid, technical and professional workers, who provide the foundation for entrepreneurship and economic growth. These are the high-skilled, high-wage, technical and professional jobs that all states and regions seek to attract.

I. INTRODUCTION

Although analysts have conducted renewable energy (RE) and energy efficiency (EE) industry studies and forecasts for more than the past three decades, no rigorous definitions currently exist for either of these industries or for their current size, structure and composition. In 2007, ASES and MISI undertook the first comprehensive study of the size the breadth if the RE and EE industries, and we created the standard definition that provides comparability between data. Prior to our earlier work, the basic knowledge of these industries was not well documented. For example, many studies have been conducted on the potential for specific 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, such analyses are of limited usefulness until we have a better idea of the size and characteristics of the existing RE&EE industries. 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&EE jobs by 2020" when we do not know how many jobs there were in RE&EE in 2007?

At present, there is not even a rigorous, generally agreed-upon definition of what constitutes the RE&EE "industry." Obviously, the industry includes technologies such as wind energy, photovoltaics (PV), solar thermal energy, and biomass. But should all hydropower technologies be included, even large, environmentally threatening systems? What about geothermal energy? Day-lighting? Climate-responsive buildings? Hydrogen?

One of the major contributions of this study is to develop a rigorous definition of the RE and the EE industries, estimate their current size and composition, and forecast their growth to 2030 for the U.S. and Colorado. It is anticipated that the findings reported here will become the standard for future economic analyses of the RE&EE industries at the national level and in Colorado. The report is organized as follows:

- Chapter II discusses issues involved in defining and specifying the renewable energy and the energy efficiency industries.
- Chapter III specifies the U.S. renewable energy industry, develops industry estimates for 2007, and compares these to the 2006 industry estimates.
- Chapter IV specifies the U.S. energy efficiency industry, develops industry estimates for 2007, and compares these to the 2006 industry estimates.
- Chapter V summarizes the U.S. renewable energy and energy efficiency industries in 2007.
- Chapter VI develops the renewable energy and energy efficiency industries forecast scenarios for 2030.
- Chapter VII presents the scenario forecast results for 2030.

- Chapter VIII describes the renewable energy and energy efficiency industries in Colorado in 2007.
- Chapter IX compares the RE&EE sector in Colorado with the oil and gas sector in the state.
- Chapter X presents the Colorado RE&EE forecasts to 2030.
- Chapter XI discusses the implications for skills, training, and educational requirements in Colorado.
- Chapter XII summarizes the policy implications derived.

II. ISSUES INVOLVED IN DEFINING AND SPECIFYING THE RENEWABLE ENERGY AND THE ENERGY EFFICIENCY INDUSTRIES

II.A. Difficulties Encountered in Defining the Renewable Energy and Energy Efficiency Industries

As noted earlier, despite the widespread interest in the size of the RE&EE industries and the number of jobs involved, a rigorous definition of these industries had never been attempted prior to our work in 2007. Precisely what is the "renewable energy" or the "energy efficiency" industry? They obviously include a disparate collection of technologies such as solar, wind, PV, biomass/bio-fuels, etc. However, here we specify them to also include the following industries/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[1]
- Daylighting

The concept used here is appropriate for several reasons:

- Many renewable energy firms also offer energy efficiency and conservation products and services. Distinguishing between the RE and EE products, services, and sales of these firms would be virtually impossible.
- RE and EE are closely related, share many of the same goals, and are often offered as an integrated product. For example, solar buildings have to be extremely energy efficient. Similarly, energy efficient structures often incorporate RE elements and features.
- In some cases, there is no clear distinction between a "RE" product and an "EE" product. Examples include passive solar design, sustainable buildings, daylighting, etc.
- RE and EE are large and growing industries that require accepted definitions for current and future economic researchers to follow.
- Finally, "RE and EE" is a much larger and more robust industry than the RE industry.

[1]Energy smart design facilitates the efficient use of energy resources through intelligent building design and the utilization of renewable energy and energy efficient building components and systems.

Thus, the RE and EE industries include all aspects of the energy efficiency industry, including energy efficient buildings, firms offering energy audits and energy service contracts, and manufacturers, sellers, and installers of a wide array of energy efficiency products and services. However, some difficult and complex decisions were necessary in developing rigorous definitions. For example:

- Windows and doors, gas and oil furnaces, home appliances, motors, etc. are offered at wide ranges of energy efficiencies – and prices. How do we evaluate and allocate these? What constitutes an "energy efficient" product? More "energy efficient" than what? Ones that are more energy efficient than similar products currently being offered? Or only ones that meet a current or future energy standard?
- There are fine gradations of the energy efficiencies of many products: Where is the dividing line between a product that is "energy efficient" and one that is not?
- The new generation of many products is more energy efficient than the previous generation. Where is the cutoff?
- Energy efficiency is currently a very powerful PR and marketing strategy. Many things are advertised as being "energy efficient," and no one advertises their product as being "energy inefficient." Care had to be taken to sort through these claims.[1]
- Many electric and gas utilities offer renewable and energy efficiency products and services. Should these be identified, quantified, and included as part of the industry? If so, with some utilities it will be very difficult to accurately segregate these services and products in some markets
- Low-flow faucets, showerheads, and toilets conserve significant amounts of water. In doing so, they indirectly reduce energy requirements by reducing the amount of energy required to pump, transport, and process water. Should water conservation products be thus included in the definition of the RE and EE industry? Some portion thereof?
- Hybrid vehicles are a part of the RE and 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 dedicated 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 and EE industry based on the portion of "fuel efficient" vehicles they sell? Similar questions pertain to vehicle repair and body shops. Do we allocate a portion of their sales to

[1]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."

the RE and EE industry based on the portion of "fuel efficient" vehicles they service and repair? What about flex-fuel vehicles?

- 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 and EE industry? If so, how do we quantify it?
- To make the issue more complex, in our forecast scenarios we hypothesized a very substantial increase in U.S. vehicle fuel efficiency standards. In this scenario, we included vehicles at or above certain fuel efficiency levels as part of the RE and EE industry.
- Wood burning stoves have increased rapidly in popularity and are obviously a biomass heating option. However, outlets that sell wood stoves also sell a wide variety of other products, such as gas stoves, gas logs, decorative fireplace accessories, etc. that cannot be classified as RE & EE. In addition, giant retail outlets such as Wal-Mart and Lowe's also sell wood stoves.
- Many products can serve energy efficiency purposes, but can also serve a variety of other purposes, and it is not always clear at the point of sale what the intended purpose is. For example, caulking products can be used for weather stripping, sealing windows and doors, plugging air leaks, and other energy efficiency purposes. However, they can also be used for a variety of other purposes. Similar comments apply to various filters, valves, and many other products.
- It is relatively straightforward if the EE product exists as a distinct, specified entity being solely produced at a specific plant, rather than as one product out of many being produced at a plant. For example, Venture Lighting, International specializes in energy efficient metal halide lighting systems and thus, all of Venture Lighting's products can legitimately be classified within the 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? More efficient than what?
- Are all recycling, reuse, and remanufacturing activities part of the RE and EE industry?

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

Another major decision involved how we handled federal, state, and local government, nonprofit, NGO, foundations, etc. Should the federal RE and EE R&D activities be included as part of the RE and EE industry? Is NREL part of the industry? What about all of the numerous (and rapidly growing) state and local government RE and EE activities? What about all of the federal, state, and local government RE and EE trade, professional, and interest groups? Are ASES, AWEA, SEIA, etc. part of the RE and EE industry?

There may be some rationale for restricting the industry definition to primarily private entities. However, this may not be desirable. First, it would exclude significant and important public, NGO, and nonprofit activities. Second, it 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.

Thus, we had to decide on whether we wanted to measure the scale of activities or expenditures or, rather, only those activities being conducted by private companies.

These are difficult, complex, and critical questions, for which there is no single definitive answer. One of the major contributions of this project was the development of a rigorous definition of the RE & EE industry, which will become the standard in terms of any type of economic and job analysis of the industry conducted by researchers in the future. In effect, ASES/MISI is here 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 Industrial Classification System (NAICS) standard.[1] EIA has made a start at this, but cannot devote the resources required due to competing interests within DOE. ASES covers some of the above list already, but we also had to deal with issues at the edges of the definition. Since an early outcome is an acceptable industry definition, we engaged professional and industry trade leadership in this "defining stage." We solicited the assistance of the key researchers and CEOs of the American Council for an Energy Efficiency Economy, the Renewable Fuels Association, the Biomass Coordinating Council, the American Wind Energy Association, the Solar Energy Industries Association, the Geothermal Energy Association, the National Hydrogen Association, and other relevant associations.

We utilized the following definitions of jobs within the RE and EE industries:

- A job in the RE industry consists of an employee working in one of the major RE technologies included in this study – wind, photovoltaics, solar thermal, hydroelectric power, geothermal

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

biomass (ethanol, biodiesel, and biomass power), and fuel cells and hydrogen. In addition, in this study, jobs in RE include persons involved in RE activities in the federal, state, and local governments, universities, trade and professional associations, NGOs, consultants, investment company analysts, etc.

- A job in the EE industry consists of an employee working in a sector that is entirely part of the EE industry, such as an ESCO or the recycling, reuse, and remanufacturing sector. It also includes some employees in industries in which only a portion of the output is classified as within the EE sector, such as household appliances, HVAC systems, construction, etc. Finally, in this study, jobs in EE include persons involved in EE activities in the federal, state, and local governments, universities, trade and professional associations, NGOs, consultants, investment company analysts, etc.

II.B. What Constitutes a "Green" Job?

These issues can perhaps be better understood by focusing on RE and EE jobs. For example, under the broad industry definition an employee working in a private RE company or for an RE and EE advocacy organization would constitute a RE and EE job, as would an employee of the federal or a state RE and EE agency. However, there are ambiguities. 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 used coal-based energy, one of the most controversial fossil fuels in terms of emissions, especially greenhouse gases? Here, these manufacturing jobs will likely be included as jobs created indirectly by RE and EE expenditures.

Over the past two decades, MISI has conducted extensive analyses of the economic and jobs impacts of the environmental protection industry in the U.S. at the national and state levels. Many of the issues faced in the current project are analogous to those encountered in defining and estimating the impacts of environmental protection. A review of these can thus be helpful; for example:

- Most analysts would consider jobs in a recycling plant to be environmental jobs. But what if the recycling plant itself produces air pollution?
- What about a firm in Colorado that produces emissions control equipment for power plants in Utah? It seems clear that the jobs in the Colorado company should be considered green or environmental jobs, even though the user of the equipment in Utah may cause pollution in Colorado.

- What about environmental engineers and environmental controls specialists working in a coal-fired power plant? What about the workers who produce environmental control equipment for the plant?

There are many manufacturing establishments throughout the United States that produce products for the automotive industry. Should those that produce components for fuel-efficient vehicles be considered part of the environmental industry, but not those that produce components for gas guzzlers? If so, is there any way to accurately distinguish between these? Should all factories producing catalytic converters be considered environmental jobs, even when some of these converters are used on low miles-per-gallon vehicles?

These relevant questions have, in fact, been generated by shifts in environmental policy itself. The early stages of the environmental movement in the 1970s and 1980s focused primarily on "end-of-the pipe" solutions. That is, the remedies and controls focused on cleaning or minimizing air, water, or solid waste pollutants after they had been produced. However, more recently during the 1980s and 1990s, environmental protection has gradually evolved to include entire processes, so, rather than cleaning up at the end of the pipe, the entire manufacturing and servicing processes are being designed to minimize the production of pollutants. Therefore, it is possible that very efficient processes designed to produce relatively little waste output could actually result in a decrease in the number of environmental jobs if these are defined strictly as “end of the pipe” jobs. A widespread program of energy efficiency, energy conservation, and demand-side management could ultimately result in less need for electric power to begin with and could result in the shutting down of a coal-fired electric power plant. While some may view such a shutdown as an environmental plus, many environmental jobs in that power plant involving pollution abatement and control would be in this case lost. Is this jobs loss desirable?

There is also the issue of how to take account of indirect job creation and how broadly or narrowly to define an indirect environmental job. For example, what of ancillary jobs created across the street from a factory producing solar collectors shortly after it opens, such as a doughnut shop, fast food restaurant, dry cleaner, etc. whose customers are primarily the workers at the renewable energy factory. Are these latter jobs also considered to be “indirect” green jobs or environmental jobs? We include such indirect jobs in the definition, although we also conclude they are not “as green” as the direct jobs created.

While solid waste abatement and control is a major area of environmental concern, does this imply that all persons engaged in trash collection business are performing environmental jobs?

What part of the tourism industry constitutes “ecotourism,” and are all jobs associated with ecotourism green jobs? Are then all the environmental externalities and

costs produced by tourists, such as transportation, water use, or waste, to be forgiven if these tourists are engaged in ecotourism?

Are all land management programs and all forms of alternative energy green industries, with all jobs counting as environmental jobs?

Definitions and Concepts MISI Used in Specifying the Environmental Industry

Jobs can be considered to be “green” relative to the way the job was performed previously, i.e., in a production process, a change in technology that reduces waste emissions or energy consumption makes the jobs in that process “greener” than before. Still, can these jobs continue to be counted as environmental jobs when newer technology makes available ways of furthering green production, e.g., further reducing energy consumption?

Two approaches can be used to address the relativity cited. The first approach targets environmental jobs, which could be new jobs or the greening of existing jobs, and defines a green job as one that emphasizes activities that contribute to environmentally sustainable development. A second approach focuses on the economy as a whole, defining a green economy as an economy that is environmentally sustainable, and environmental jobs as those jobs required to make an economy environmentally sustainable. Similarly, the term “environmental sector” is used to collectively describe companies involved in businesses designed to limit negative environmental impacts. However, this definition of green jobs as employment opportunities arising from expenditures on activities that support environmentally sustainable development, or which reduce negative impacts on the environment, also presents ambiguities.

Therefore, based on extensive research and literature review, MISI considers that environmental jobs are perhaps best understood when viewed in a continuum across a spectrum, with jobs that generate obvious environmental resource degradation or extraction at one end; a range of greener jobs involving clean production measures and technologies to reduce environmental impacts in the center, and the other end of the spectrum where jobs have a positive environmental impact (see Figure III-1).

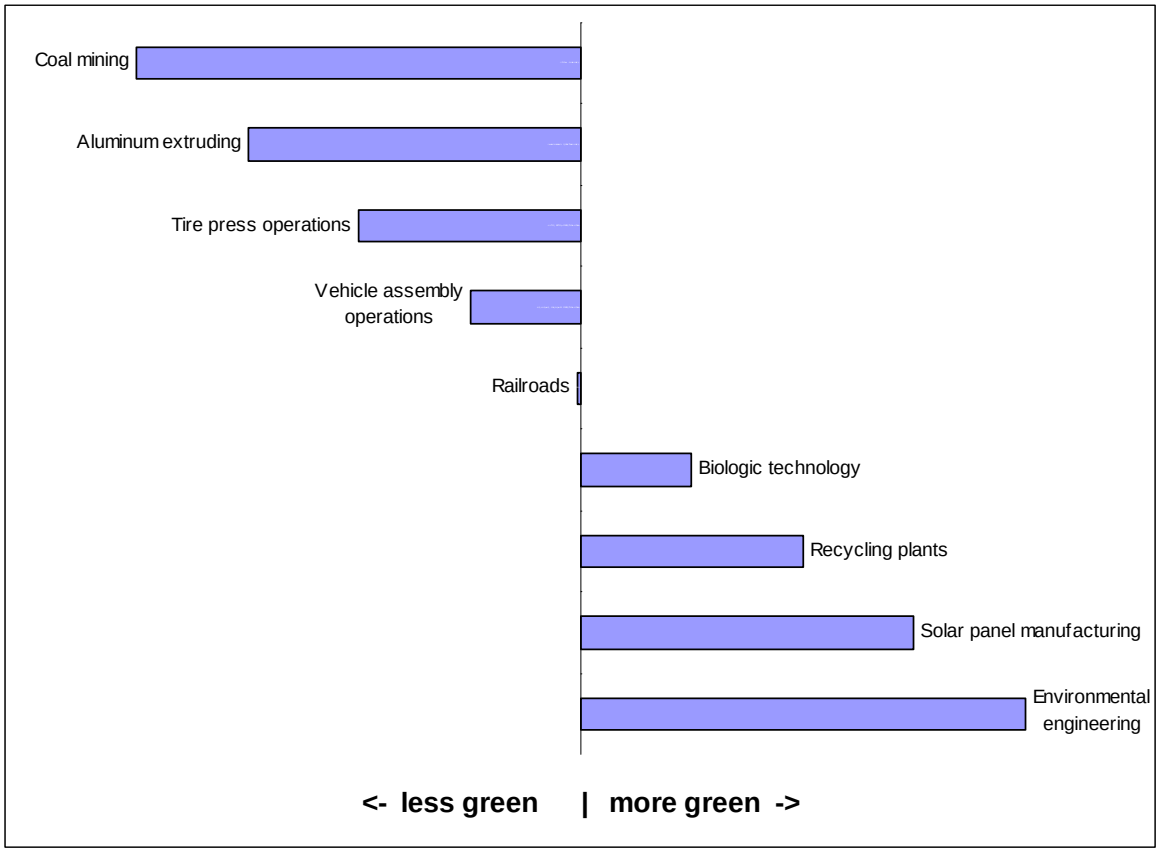
Using the spectrum concept, MISI defines environmental industries and green jobs as those which, as a result of environmental pressures and concerns, have produced the development of numerous products, processes, and services, which specifically target the reduction of environmental impact. Environment-related jobs include those created both directly and indirectly by environmental protection expenditures.

Types of Jobs Created in the RE&EE Industry

There exists relatively little rigorous and comprehensive research addressing the practical relationship between RE&EE and existing jobs or future job creation. Even some research in this area sponsored by various organizations is off the mark, in that it has tended to emphasize jobs creation in classically green activities, such as RE&EE specialists or workers in recycling plants.

However, while these jobs certainly count as jobs related to RE&EE, MISI's data suggests that theses 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 persons employed in these jobs may not even realize that they owe their livelihood to RE&EE.

Figure II-1
The Environmental Job Spectrum by Industry



III. THE U.S. RENEWABLE ENERGY INDUSTRY

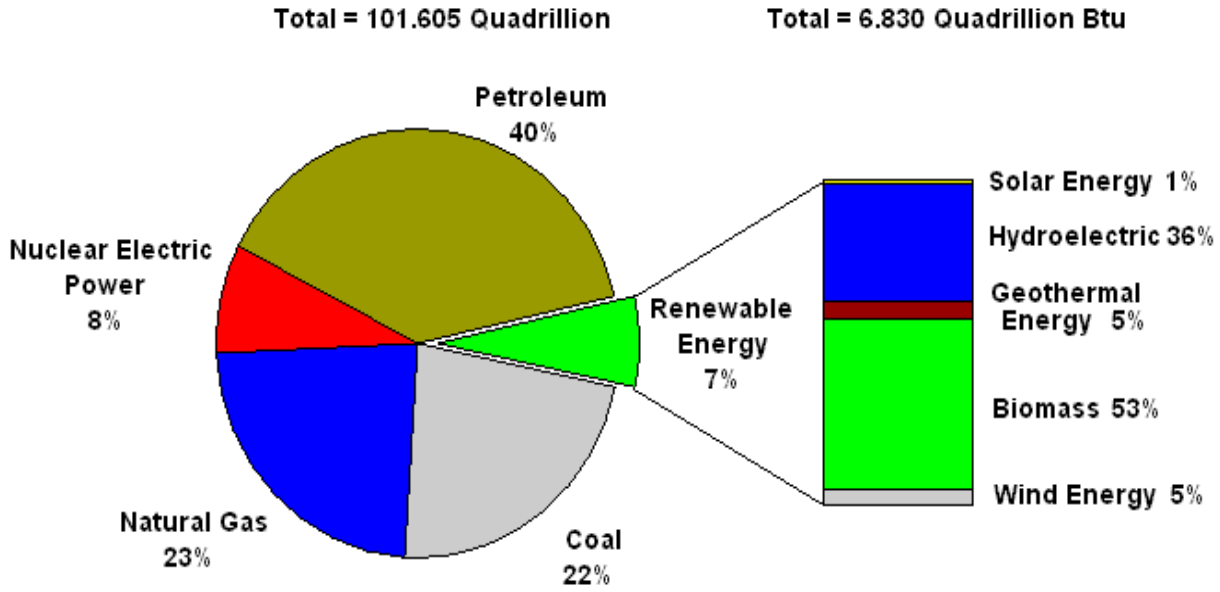
In this study, renewable energy technologies are defined to consist primarily of[1]:

- Hydroelectricity
- Biomass
- Geothermal
- Wind
- Photovoltaics
- Solar thermal
- Fuel Cells and hydrogen

Except for hydro and industry biomass, the RE U.S. energy contribution is small, but is growing rapidly. Some RE technologies, such as ethanol, bio-diesel, and biomass-to-liquids, produce liquid fuels that directly displace imported oil.

As shown in Figure III-1, RE produced about seven percent of total U.S. energy in 2007.

Figure III-1
Renewable Energy in the U.S., 2007



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

III.A. Growth in the U.S. Renewable Energy Industry, 2006 - 2007

[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 consumption in the U.S. declined about one percent between 2006 and 2007 to 6,830 trillion Btu. However, this decrease resulted from a 14 percent decrease in hydroelectricity in 2007 due to reduced precipitation in several regions of the country. In contrast, both total and nonrenewable energy consumption increased two percent.

There was wide variation in the consumption of individual renewable energy sources. As noted, hydroelectricity production declined 14 percent, whereas biomass-based energy increased seven percent and wind-generated electricity increased 21 percent. Major increases in consumption of biomass for biofuels (ethanol and biodiesel) were largely responsible for the increase in biomass during 2007.

From 2003 through 2007, renewable energy consumption's average annual growth rate was three percent, compared with just one percent for total energy consumption. Biofuels, wind, and photovoltaics were largely responsible for the increase, with 5-year average annual growth rates in the range of 25 - 30 percent.

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

In contrast, transportation sector renewable energy consumption increased 30 percent during 2007, and residential sector consumption grew 12 percent. Residential sector growth was due to significant increases in all three energy sources: Biomass, geothermal, and solar/photovoltaic. Commercial and industrial uses of renewable energy changed little between 2006 and 2007 and have also changed little as a fraction of total renewable consumption since 2003. That could change for the industrial sector if ethanol and biodiesel use continues to grow rapidly resulting in increased feedstock consumption. This is especially significant in view of the fact that the largest biomass fuel consumed in the industrial sector, wood and derived fuels, has grown little since 1989 and appears to have peaked in 1997.

Within the electric power sector, wind energy consumption has grown each year since 1998. From 2003 to 2007, wind's share of total renewable energy consumption increased from two percent to five percent. For the first time, wind energy consumption in the electric power sector exceeded geothermal. Hydro electricity accounted for 36 percent of total renewable consumption in 2007, down from 46 percent in 2003. However, hydro consumption is tied mostly to precipitation, which varies year to year, and few plants are being built or retired.

Electricity generation from renewable sources decreased nine percent in 2007 to 351 billion kWh, largely due to reduced precipitation. Excluding hydro electricity,

however, renewable electricity generation grew seven percent. This gain was led by a 21 percent increase in electricity from wind and moderate increases in electricity from biomass waste. There has been little change in generation from the largest non-hydro renewable electricity source, wood and derived fuels, since 2003.

With the exception of hydro, changes in renewable electricity capacity generally reflected generation changes in 2007. Total renewable electricity capacity increased five 107 MW, led by a 38 percent (or 4,000 MW) increase in wind capacity. Total nonrenewable electric capacity rose just one percent, to 892,000 MW.

III.B. Revenues and Jobs

III.B.1. The Renewable Energy Industry in 2006

Table III-1 summarizes the status of the U.S. renewable energy industry in 2006. As shown in this table, in 2006:

- RE gross revenues totaled nearly $40 billion
- The total number of jobs created by RE totaled 450,000
- 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 of the industry, 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
- RE contains some of the most rapidly growing industries in the world, such as wind, photovoltaics, fuel cells, and biofuels

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

Industry Segment	Revenues/ Budgets (billions)[a]	Industry Jobs	Total 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[b]	1,850
DOE Laboratories	1.8	3,600[c]	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

[a]2006 dollars
[b]Includes Federal employees and direct support contractors.
[c]Includes Federal employees, laboratory employees, and direct support contractors.

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

III.B.2. The Renewable Energy Industry in 2007

Table III-2 summarizes the status of the U.S. renewable energy industry in 2007. As shown in this table, in 2007:

- RE gross revenues totaled nearly $43 billion
- The total number of jobs created by RE exceeded 500,000
- More than 95 percent of the jobs were in private industry
- Over 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 of the industry, followed by the geothermal and photovoltaics sectors
- There were relatively few jobs 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
- RE contains some of the most rapidly growing industries in the world, such as wind, photovoltaics, fuel cells, and biofuels

Table III-2 indicates that in 2007 the components of the RE industry differed markedly in terms of their importance in terms of both revenues and jobs. For example:

- Biomass power accounted for 41 percent of total industry revenues
- Ethanol accounted for 20 percent of total industry revenues
- Hydroelectric power accounted for just over eight percent of total industry revenues
- Wind accounted for just under eight percent of total industry revenues
- Fuel cells and hydrogen combined accounted for about 4.5 percent of total industry revenues
- Private industry accounted for just over 90 percent of total RE revenues.

In terms of total jobs created, the relative contributions of the RE sectors differ somewhat from the relative contributions based on revenues. This is due to the fact that different RE technologies and industries have considerably different job creation effects. There are three salient examples of this:

- Hydroelectric power generated 8.2 percent of RE revenues, and 3.6 percent of total RE jobs
- Biomass power generated 41 percent of RE revenues, and 31 percent of total RE jobs
- Ethanol generated 20 percent of RE revenues, and 39 percent of total RE jobs

In all, private industry generated 90 percent of RE revenues, and 96 percent of total RE jobs.

Table III-2
The Renewable Energy Industry in the U.S., 2007

Industry Segment	Revenues/ Budgets (billions)	Industry Jobs	Total Jobs Created
Wind	$3.3	17,300	39,600
Photovoltaics	1.3	8,700	19,800
Solar Thermal	0.14	1,300	3,100
Hydroelectric Power	3.5	7,500	18,000
Geothermal	2.1	10,100	23,200
Biomass			
Ethanol	8.4	83,800	195,700
Biodiesel	0.4	3,200	7,300
Biomass Power	17.4	67,100	154,500
Fuel Cells	1.1	5,600	12,800
Hydrogen	0.81	4,100	9,400
Total, Private Industry	38.45	208,700	483,400
Federal Government	0.65	900*	2,100
DOE Laboratories	1.9	3,800**	8,700
State and Local Government	0.95	2,600	5,800
Total Government	3.5	7,300	16,600
Trade and Professional Associations and NGOs	0.63	1,600	3,500
TOTAL, ALL SECTORS	$42.58	217,600	503,500

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

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

III.B.3. Revenues and Jobs in the U.S. Renewable Energy Industry, 2006 - 2007

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

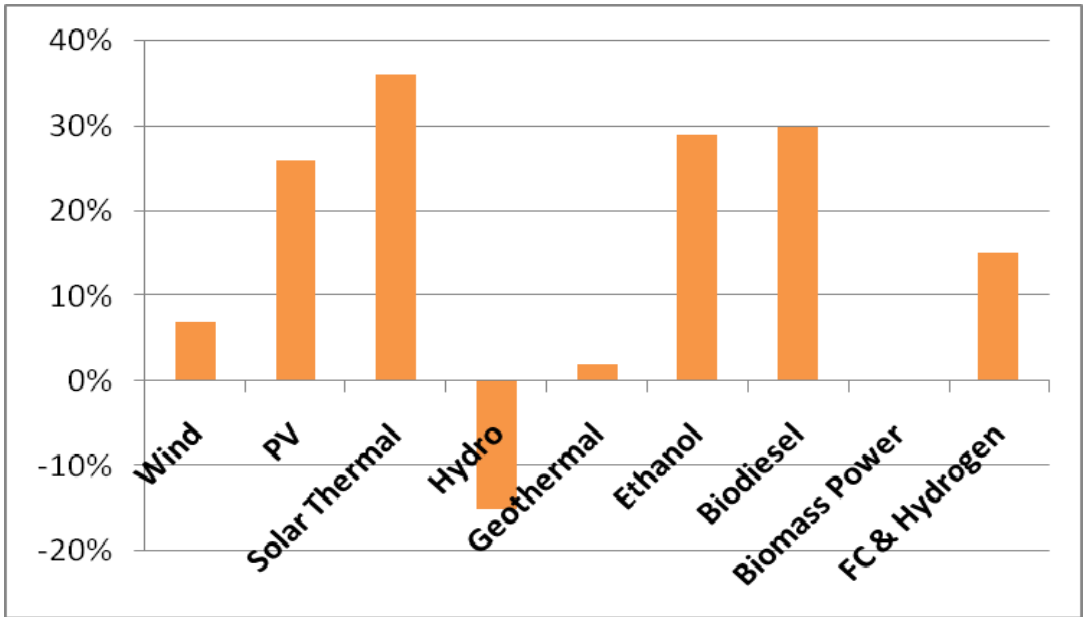
However, in order to eliminate the effects of inflation, growth rates must be compared in constant, real dollars. Converting the 2006 RE data to constant 2007 dollars indicates that, in real terms, total RE revenues increased 5.5 percent, from $40.4

billion in 2006 to $42.6 billion in 2007. As noted, hydroelectric production decreased in 2007. Excluding the hydroelectric sector, RE industry revenues increased 7.8 percent, from $36.3 billion to $39.1 billion.

The real growth rate of U.S. GDP between 2006 and 2007 was 2.19%. Thus, including hydro, the RE industry grew more than twice as rapidly as the overall U.S. economy; excluding hydro, the RE industry grew more than three times as fast as the overall U.S. economy. Further, the biomass power sector is a significant part of the RE industry, but it grew little between 2006 and 2007. Excluding both hydro and biomass power, the U.S. RE industry grew 15.4 percent between 2006 and 2007 – more than seven times as fast as the overall U.S. economy. As shown in Figure III-2, some sectors experienced very substantial growth:

- Solar thermal grew more than 35 percent
- Biodiesel grew 30 percent
- Ethanol grew nearly 30 percent
- Photovoltaics grew more than 25 percent

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



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

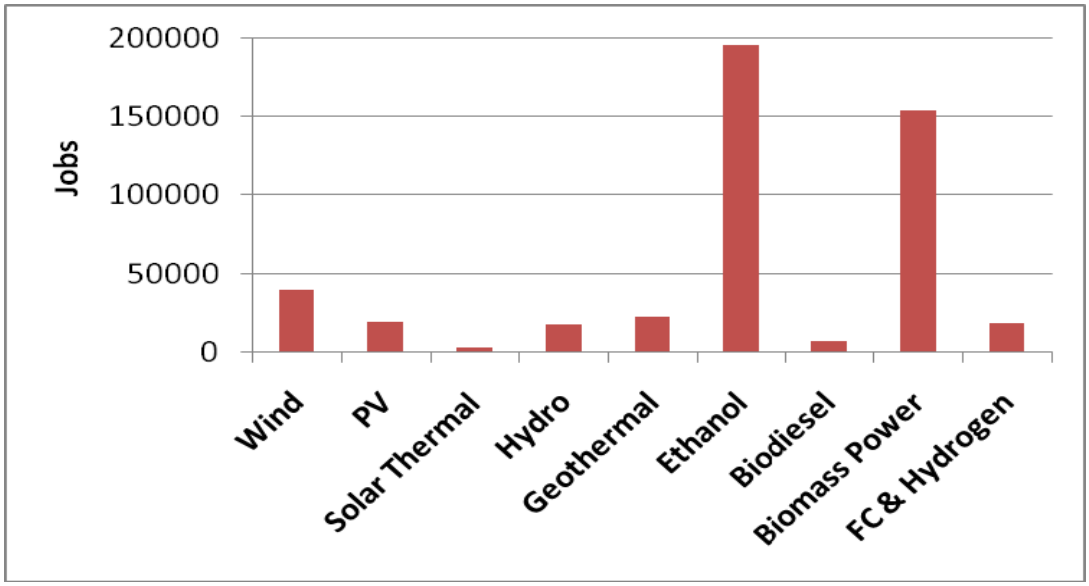
As shown in Figure III-2, the percent revenue increases in the different RE sectors varied widely:

- Some sectors, such as wind, PV, ethanol, and biodiesel grew very rapidly.
- Some sectors, such as geothermal and biomass power grew relatively little.[1]
- The hydro sector contracted.

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

The dominant RE sectors sometimes differ from those that grow the most rapidly. This is illustrated in Figure III-3, which shows the total number of jobs generated by the RE sectors in 2007. Despite the differential growth rates of the sectors between 2006 and 2007, job creation is dominated by ethanol and biomass power, followed far behind by wind, geothermal, photovoltaics, and hydro.

Figure III-3
Total U.S. Jobs Generated by Renewable Energy Sectors in 2007



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

As noted in Chapter II, the vast majority of the jobs created by RE are standard jobs for accountants, engineers, computer analysts, clerks, factory workers, truck drivers, mechanics, etc., and most of the persons employed in these jobs may not even realize that they owe their livelihood to renewable energy. This is illustrated in Table III-

[1]Although biomass power is the largest RE sector in terms of revenues, its real revenue growth between 2006 and 2007 was negligible.

3, which lists the jobs created by renewable energy in the U.S. in 2006 within selected occupations. This table shows that in 2006 RE generated in the U.S.:

- More jobs for shipping and receiving clerks (2,210) than for biochemists and biophysicists (1,580)
- More jobs for carpenters (780) than for environmental engineers (630)
- More jobs for truck drivers (9,500) than for forest and conservation workers (1,440)
- More jobs for janitors (3,610) than for environmental science technicians (1,690)
- More jobs for bookkeeping clerks (8,228) than for civil engineers (3,080)
- More jobs for plumbers (4,670) than for mechanical engineers (1,950)
- More jobs for electricians (6,330) than for computer software engineers (3,260)
- More jobs for inspectors, testers, and sorters (2,400) than for HVAC mechanics and installers (2,130)
- More jobs for security guards (1,310) than for surveyors (690)

Thus, many U.S workers are dependent on renewable energy for their employment, although they often would have no way of recognizing that connection unless it is brought to their attention.

Table III-3
Renewable Energy Jobs Generated in the U.S. in 2007, by Selected Occupations

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

Source: Management Information Services, Inc., 2008.

IV. THE U.S. ENERGY EFFICIENCY INDUSTRY

As discussed, specifying and estimating the size of the EE industry is much more difficult than estimating the size of the RE industry. The RE industry is fairly well defined and consists of distinct sectors such as wind, PV, biomass, hydro, geothermal, etc. The EE "industry," on the other hand, is much more nebulous and difficult to define, specify, and estimate. There are specific elements that are clearly part of the EE industry, such as federal and state EE programs, utility EE spending, the ESCO industry, the recycling industry, etc. However, most EE spending is included in partial segments of large industries, such as vehicles, buildings, lighting, appliances, etc.

IV.A. The Energy Efficiency Industry in 2006

Table IV-I summarizes the status of the U.S. energy efficiency industry in 2006. As shown in this table, in 2006 in the U.S. energy efficiency industry:

- Gross revenues totaled $933 billion
- These sales represent substantially more the combined sales of the three largest U.S. corporations – ExxonMobil, Wal-Mart, and GM ($849 billion)
- The total number of jobs created by EE exceeded 8 million
- More than 90 percent of the jobs were in private industry
- Over 50 percent of the jobs were in the manufacturing sector
- The second largest number of jobs was in recycling, reuse, & remanufacturing followed by the construction industry
- Nearly 80 percent of the EE government jobs was in state and local government

Table IV-1
The Energy Efficiency Industry in the U.S., 2006

Industry Segment	Revenues/ Budgets (billions 2006 dollars)	Industry Jobs (thousands)	Total Jobs Created (thousands)
ESCO	3	19	44
Recycling, reuse, & remanufacturing	275	1,310	3,013
Vehicle manufacturing	73	165	380
Household appliances and lighting	22	86	198
Windows and doors	12	51	117
Computers, copiers, FAX machines, etc.	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	41	253	582
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.

IV.B. The Energy Efficiency Industry in 2007

Table IV-2 summarizes the status of the U.S. energy efficiency industry in 2007.

As shown in Table 4, in 2007:

- EE gross revenues totaled over $1 trillion

- These sales represent substantially more the combined sales of the three largest U.S. corporations – Wal-Mart, ExxonMobil, and GM ($905 billion)
- The number of jobs created by EE totaled nearly 8.6 million
- More than 98 percent of the jobs were in private industry
- Over 36 percent of the jobs were generated by the recycling, reuse, & remanufacturing sector
- The second largest number of jobs was generated by the nondurable manufacturing sector, followed by the miscellaneous durables manufacturing sector, and the computers, printers, copiers, etc. sector
- There were relatively few jobs generated by the ESCO sector, the utilities sector, or the government sectors

IV.C. Growth of the Energy Efficiency Industry, 2006 - 2007

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

Table IV-2
The Energy Efficiency Industry in the U.S., 2007

Industry Segment	**Revenues/ Budgets** (billions 2007 dollars)	**Industry Jobs** (thousands)	**Total Jobs Created** (thousands)
ESCO	3.8	23	53
Recycling, reuse, & remanufacturing	290	1,372	3,154
Vehicle manufacturing	86	193	443
Household appliances and lighting	35	134	308
Windows and doors	13	54	123
Computers, printers, copiers, etc.	105	360	828
TV, video, and audio equipment	48	193	447
HVAC systems	13	47	108
Industrial and related machinery	21	82	187
Miscellaneous durable manufacturing	110	397	901
Nondurable manufacturing	218	518	1,183
Utilities	2.2	14	32
Construction	48	288	660
Total, Private Industry	993	3,675	8,427
Federal government EE spending	3.8	16	37
State government EE spending	3.2	29	65
Local government EE spending	2.4	22	50
Total Government	9.4	67	152
EE Trade and Professional Associations and NGOs	0.52	3	7
TOTAL, ALL SECTORS	$1,002.92	3,745	8,586

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

V. THE U.S. RENEWABLE ENERGY AND ENERGY EFFICIENCY INDUSTIES

Tables V-1 and V-2 summarize the U.S. RE&EE industries in 2006 and 2007. These tables show that:

- Total revenues in the two industries increased from $972 billion in 2006 to $1,046 billion in 2007.
- Direct employment in the industries increased from 3.69 million in 2006 to 3.96 million in 2007.
- Total jobs created increased from 8.5 million in 2006 to 9.1 million in 2007.
- RE grew more rapidly than EE and slightly increased its share of total revenues of the two industries, from 4.0 percent in 2006 to 4.1 percent in 2007.
- RE also slightly increased its share of the total jobs generated by the two industries, from 5.3 percent in 2006 to 5.5 percent in 2007.

Table V-1
Summary of the U.S. Renewable Energy and Energy Efficiency Industries in 2006

Industry	**Revenues** (billions)	**Industry Jobs** (thousands)	**Total 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.

Table V-2
Summary of the U.S. Renewable Energy and Energy Efficiency Industries in 2007

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

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

VI. INDUSTRY FORECAST SCENARIOS

In this study, three forecast scenarios were developed:

- The base case
- A moderate scenario
- An advanced scenario

VI.A. The Base Case

The Base Case:

- Is essentially a "business as usual" case scenario
- Assumes no change in RE&EE policies
- Assumes no major RE&EE initiatives over next 21 years.
- Assumes that the U.S. and Colorado RE&EE industries continue to develop according to the general trends and rates of growth experienced over past two decades

Under the base case, RE&EE development continues to be a small portion of the U.S. economy and employment. We use the base case as a comparison against the two alternative scenarios. The base case indicates that without substantial change in policy, RE&EE is not expected to significantly increase its share of the U.S. energy market.

The base case is essentially a "business as usual" case scenario that assumes no major RE&EE initiatives over the next 21 years. It assumes that the U.S. and Colorado RE&EE industries continue to develop according to the general trends and rates of growth experienced over the past two decades. The base case assumes no change in policy, and the resulting incremental RE&EE development is minimal.

The base case is based loosely on the EIA reference case from the *Annual Energy Outlook 2008*, which assumes that "all current standards, laws, and regulations remain as currently enacted." Under the EIA reference case, total U.S. primary energy consumption is projected to increase from 99.5 quadrillion Btu (quads) in 2006 to 118 quads in 2030.

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

Even with currently available renewable energy technologies, this projection 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, RE&EE is not expected to significantly increase its share of the U.S. energy market.

VI.B. Moderate Scenario

The Moderate Scenario:

- Assumes that various moderate, incremental (above the base case) Federal and state RE&EE initiatives are put in place over next two decades
- Assumes policies such as R&D, tax incentives, RPS mandates, externalities pricing, etc.
- Assumes a continuation of the positive policies that are in place, plus market conditions favorable to renewables
- Is based on various "mid-range" estimates, incorporating modest initiatives
- Assumes changes or extensions of policy and the assumption of conditions that are favorable to renewables

The Moderate Scenario assumes that various moderate, incremental (above the base case) Federal and state RE&EE initiatives are put in place over the next two decades. These would include R&D, tax incentives, RPS mandates, externalities pricing, etc. It assumes a continuation of the positive policies that are in place, plus market conditions favorable to renewables. There have been several "mid-range" estimates, incorporating modest changes or extensions of policy and the assumption of conditions that are favorable to renewables, that this scenario is based on.

For example, the Western Governors' Association (WGA) conducted a two-year study of clean energy technologies in the region. WGA concluded that, in just the Western States, renewable energy could contribute upwards of 68 GW by 2020. In addition, 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) can reach 13 percent of demand by 2030.

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

The Moderate Scenario assumes implementation of various relevant Colorado state policies and initiatives, including:

- The Colorado Climate Action Plan, which involves "bridge strategies" to reduce GHG emissions while pursuing technologies to generate cleaner energy and provides leadership to ensure that long-term solutions, such as renewable energy, are implemented
- Greening of State Government Executive Orders, which charge state departments, agencies, and offices to take a position of leadership in the new energy economy
- The New Energy Economy: Bringing It Home campaign -- a statewide energy efficiency and conservation campaign
- The New Energy Communities Initiative, which seeks to maximize energy efficiency and conservation, enhance community livability, promote economic development in downtowns, and address climate change by reducing carbon emissions
- A variety of other Colorado State Initiatives, such as rebates for RE&EE expenditures, income-based programs, including free energy efficiency upgrades, energy efficiency programs for new and retrofit construction, and matching grants for selected RE technologies
- Governor's Energy Office RE&EE programs, such as partnering with utilities to facilitate small wind turbine installations, encouragement of ENERGY STAR and high performance building programs, partnering to provide energy code training and information, assisting schools to reduce their energy costs, and streamlining the process for selecting ESCOs

VI.C. Advanced Scenario

The Advanced Scenario:

- "Pushes the envelope" on the RE&EE industry with current or impending technologies
- Requires favorable market conditions and a sustained commitment of public policy to ensure that RE&EE achieves higher levels of contribution to the U.S. energy market
- Assumes RE&EE industries are available to take the U.S. in a new direction, but that appropriate, aggressive public policies at Federal and state levels are required and must be sustained over next two decades
- Represents a dramatic indication of what would be possible under an aggressive renewable energy scenario
- Includes what may be, realistically, feasible both economically and technologically in such a "crash" scenario

The Advanced Scenario "pushes the envelope" on the RE&EE industry possible from current or impending technologies. The driving factor may be 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 the driving factors. While the causes may be indeterminate, we determined what may be, realistically, feasible both economically and technologically in such a "crash" scenario. For example, Germany projects obtaining 50 percent of its energy requirements from renewable energy by 2050, and Sweden has a goal of converting most of its transportation fuels to renewable sources by 2020.

The Advanced Scenario requires favorable market conditions and a sustained commitment of public policy to ensure that RE&EE achieves higher levels of contribution to U.S. energy supplies. RE&EE industries are available to take the U.S. in a new direction under the Advanced Scenario, but appropriate, aggressive public policies at the Federal, state, and local levels are required and must be sustained over the next two decades.

The Advanced Scenario represents a dramatic indication of what would be possible under an aggressive RE&EE scenario, and is based on a series of recent reports estimating the maximum feasible RE&EE that may be economically and technologically possible over the next two decades. 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.

For example, the Electric Power Research Institute (EPRI) analyzed an aggressive strategy with both high natural gas prices and high CO_2 costs.[1] This analysis forecast substantial growth of new renewables in the electric supply sector. The results, excluding geothermal and hydropower power, forecast a renewable contribution to electricity of 16 percent by 2030, and as much as 25 percent by 2050.

Similarly, the outlook for renewable fuels is robust, and biodiesel is growing rapidly. The National Biodiesel Board (NBB) has estimated that biodiesel could displace five percent of petroleum diesel in a near-to-mid-term timeframe.[2] The Renewable Fuels Association (RFA) has presented an overall outlook for its sector, noting the dramatic growth in the industry.[3] This growth is expected 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

[1]Electric Power Research Institute, "Role of Renewable Energy in a Sustainable Electric Generation Portfolio," 2007; Electric Power Research Institute, "Renewables: A Promising Coalition of Many," *EPRI Journal*, Summer 2007, pp. 8-15.
[2]National Biodiesel Board, *Contribution of the Biodiesel Industry to the Economy of the United States*, September 2006.
[3]Renewable Fuels Association, *Building New Horizons: Ethanol Industry Outlook 2007*, 2007; Renewable Fuels Association, *Tales from the Heartland: Ethanol Industry Outlook 2008*, 2008.

transportation systems and technologies would allow renewable power to contribute to displacing the need for imported oil.

Achieving the goals of the Advanced Scenario will require that progress is made to advance each RE&EE technology's performance, lower its cost, and overcome challenges of market acceptance at scale. Identifying and overcoming the various obstacles for each technology and end use sector will have to be a priority for federal and state policies. However, none of the impediments to achieving the Advanced Scenario are insurmountable if there is the political will to support renewable energy at the Federal and state levels. Technology-specific challenges, opportunities, and required policies include:

- *Wind power.* Challenges include improved access to transmission; long-term production tax credit (PTC) extension; new state and national renewables portfolio standards (RPS), and effective implementation of existing RPS; continued research support; development of an off-shore regime in a supportive manner; continued priority on federal lands; and recognition of bird/bat mitigation success.
- *Solar energy.* Challenges include local covenant restrictions; consistent and effective net metering polices and interconnection standards at the state and federal levels; silicon availability and price; new state and national RPS and effective implementation of existing RPS; research and support for reduced balance of systems cost; infrastructure development; competition with foreign markets; inclusion in state and federal renewable laws; modification of the investment tax credit to remove the cap and extend multiple (8-10) years; and other incentives.
- *Water power.* Challenges include regulatory streamlining and resolving licensing issues for the new technologies (ocean, tidal, and instream power); research and development support for both the next generation of conventional hydropower equipment and the new technologies; long term extension of the Section 45 PTC and inclusion of ocean, tidal, instream, and pipe-in projects, equitable treatment in state RPS efforts; and transmission support.
- *Geothermal energy.* Challenges include long-term PTC extension; new state or national RPS and effective implementation of existing RPS; restoration of the DOE R&D program; support for exploratory drilling program and characterization of the U.S. hydrothermal resource base; demonstration of geopressured and oil field co-production; consistent work towards Enhanced Geothermal Systems demonstration; funding and prioritization of public land leasing and permitting; and inclusion in state renewable initiatives.
- *Biomass power.* Challenges include 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 RPS; access to 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 (MSW) technologies as creditable renewable energy systems; and reasonable interconnection standards.

- *Biofuels.* Challenges 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.

VI.D. Further Considerations

Within the context of marketplace uncertainties, the major determinant of future market share for RE&EE is public policy.[1] The three scenarios indicate what a business-as-usual (base case) scenario might look like if no policy changes are implemented and the potential for more aggressive renewable energy strategies. However, it must be recognized that achieving any scenario is subject to significant uncertainties in key market drivers. Important factors include:

- Volatility in oil and gas prices
- Pace and scale of action on climate change
- Extent of technology breakthroughs
- Federal, state, and local government RE&EE policies and incentives

Nevertheless, the approach taken in the study has several advantages:

- The approach has been used by MISI and ASES in previous studies, has been vetted in the peer-reviewed literature, and thus has inherent credibility.[2]

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

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

- The ASES/MISI approach has been analyzed by the American Council for an Energy Efficient Economy and found to be valid and credible.[1]
- The ASES/MISI analysis has been reviewed by Al Gore's staff and has been used to help formulate some of Mr. Gore's energy policy recommendations.[2]
- The base case provides a baseline forecast of the RE&EE industry and employment in the U.S. and Colorado over the next quarter century.
- The differences between the estimates and forecasts for the three scenarios indicate the marginal differences from various levels of RE&EE development.
- The Moderate and Advanced Scenarios demonstrate the relative employment and jobs benefits to the U.S. and Colorado of different levels of RE&EE initiatives and policies.

Development of these scenarios provides insight into major policy areas like resource depletion, climate change, balance of payments, national security, and Colorado RE&EE employment. The economic implications under different scenarios – and the impact of coming down the different experience curves at different annual rates – are especially useful.

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

[2]Roger H. Bezdek, "The U.S. Renewable Energy and Energy Efficiency Industries: What Role Can They Play in the Climate Crisis? Will They be Part of a New American Industrial Revolution?" Presented at the Al Gore Climate Summit, Nashville, Tennessee, May 2008.

VII. U.S. RENEWABLE ENERGY AND ENERGY EFFICIENCYFORECASTS TO 2030

The following tables summarize some of the major results for the U.S. of the scenario forecasts:

- Table VII-1 summarizes the U.S. RE&EE industries in 2030
- Table VII-2 shows the U.S. renewable energy industry in 2030 under the three forecast scenarios
- Table VII-3 shows the U.S. jobs created by renewable energy in 2030 under the three forecast scenarios in 2030
- Table VII-4 shows the U.S. energy efficiency industry in 2030 under the three forecast scenarios
- Table VII-5 shows the U.S. jobs created by energy efficiency in 2030 under the three forecast scenarios

Table VII-1
U.S. Renewable Energy and Energy Efficiency Industries in 2030

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

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

VII.A. The U.S. Renewable Energy Industry in 2030

Table VII-2 illustrates that the growth of the U.S. RE industry will be significantly affected by government policies and incentives. The size of the industry in 2030 under the Advanced Scenario is nearly six times as large as under the Base Case. More important, some RE sectors under the Advanced Scenario grow much more than others; for example:

- Wind is 16 times larger under the Advanced Scenario than under the Base Case
- Geothermal is 14 times larger under the Advanced Scenario than under the Base Case
- Fuel cells is nine times larger under the Advanced Scenario than under the Base Case
- Biodiesel is six times larger under the Advanced Scenario than under the Base Case

- Biomass power is five times larger under the Advanced Scenario than under the Base Case
- Photovoltaics and ethanol are more than three times larger under the Advanced Scenario than under the Base Case

Table VII-2
The U.S. Renewable Energy Industry in 2030
(Billions of 2007 Dollars)

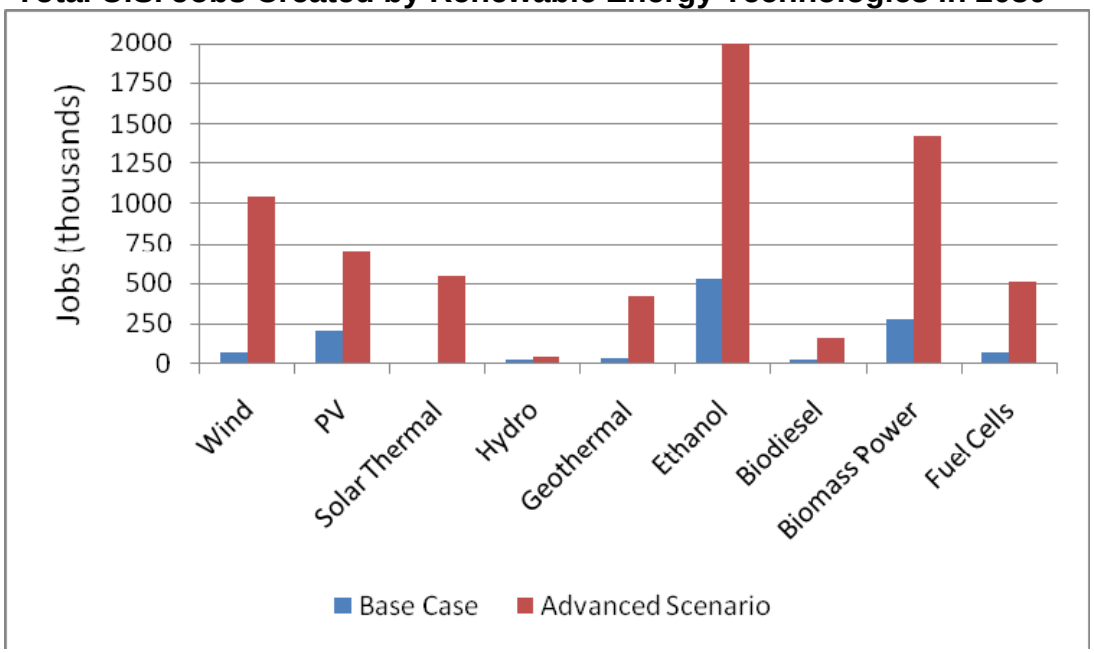
Industry Segment	Base Case	Moderate Scenario	Advanced Scenario
Wind	$5.6	$22	$89
Photovoltaics	13.5	27	45
Solar Thermal	0.2	0.9	29
Hydroelectric Power	4.8	5.1	6.8
Geothermal	2.9	8.2	40
Biomass			
Ethanol	22.6	45	82
Biodiesel	1.3	2.7	7.6
Biomass Power	32.3	68	160
Fuel Cells	5.2	14.1	45
Hydrogen	4.1	12.2	36
Total, Private Industry	92.4	205.2	540.4
Federal Government	0.8	1	2.8
DOE Laboratories	2.3	2.6	7.8
State and Local Government	1.5	2.2	5.7
Total Government	4.6	5.8	16.3
Trade & Professional Associations & NGOs	0.8	1.5	3.6
TOTAL, ALL SECTORS	$97.8	$212.5	$560.3

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

Figure VII-1 and Table VII-3 show that there is a wide variation in 2030 jobs creation between the base case and the Advanced Scenario. For example:

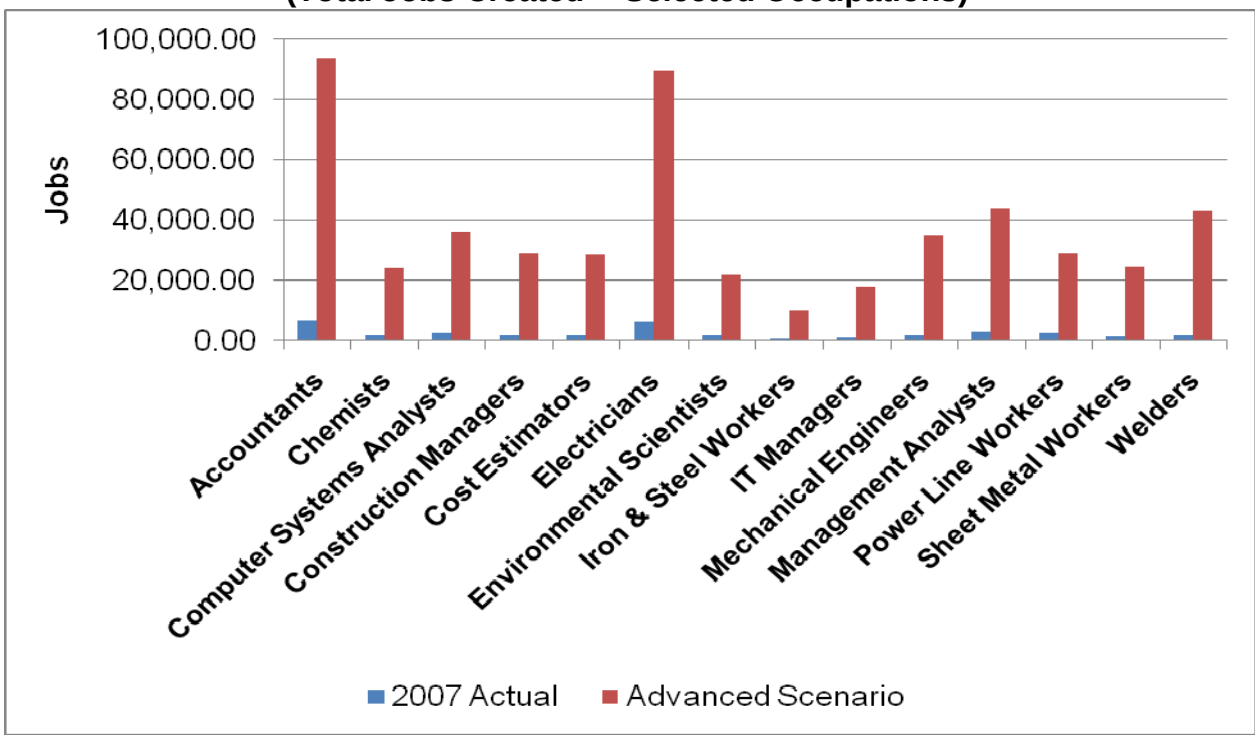
- The largest differentials in terms of the numbers of jobs created are in the ethanol, biomass power, and wind sectors.
- The largest differentials in terms of the percent increases in jobs created are in the solar thermal, geothermal, and wind sectors.

Figure VII-1
Total U.S. Jobs Created by Renewable Energy Technologies in 2030



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

Figure VII-2
U.S. Jobs Created By Renewable Energy In 2030 Compared to 2007
(Total Jobs Created -- Selected Occupations)



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

Table VII-3
U.S. Jobs Created by Renewable Energy in 2030
Total Jobs Created

Industry Segment	Base Case	Moderate Scenario	Advanced Scenario
Wind	66,200	257,000	1,040,000
Photovoltaics	206,000	415,000	700,000
Solar Thermal	3,800	17,000	540,000
Hydroelectric Power	22,400	24,200	32,300
Geothermal	29,000	85,000	415,000
Biomass			
Ethanol	530,000	1,050,000	2,000,000
Biodiesel	25,100	56,900	160,000
Biomass Power	282,000	603,000	1,420,000
Fuel Cells	68,600	158,000	505,000
Hydrogen	47,200	143,000	420,000
Total, Private Industry	1,280,300	2,809,000	7,232,300
Federal Government	3,000	3,100	8,550
DOE Laboratories	11,000	12,300	36,100
State and Local Government	7,000	11,800	29,400
Total Government	21,000	27,200	74,050
Trade & Professional Associations & NGOs	4,700	9,400	21,300
TOTAL, ALL SECTORS	1,305,400	2,845,700	7,327,650

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

VII.B. The U.S. Energy Efficiency Industry in 2030

Table VII.4 illustrates that the growth of the U.S. EE industry will be significantly affected by government policies and incentives. The size of the industry in 2030 under the Advanced Scenario is twice as large as under the Base Case. Some EE sectors under the Advanced Scenario grow much more than others; for example:

Table VII-4
The U.S. Energy Efficiency Industry in 2030
(Billions of 2007 Dollars)

Industry Segment	Base Case	Moderate Scenario	Advanced Scenario
ESCO	7.2	8	14
Recycling, reuse, & remanufacturing	546	580	618
Vehicle manufacturing	154	189	570
Household appliances and lighting	51	62	124
Windows and doors	27	33	71
Computers, copies, FAX machines, etc.	180	171	190
TV, Video, and Audio equipment	98	104	200
HVAC systems	29	34	76
Industrial and related machinery	43	52	114
Miscellaneous durable manufacturing	205	233	522
Nondurable manufacturing	410	451	784
Utilities	5.2	6	14
Construction	93.3	130	373
Total, Private Industry	1,848.7	2,053	3,670
Federal government EE spending	7.2	8	24
State government EE spending	6.2	7	19
Local government EE spending	5.1	6	17
Total Government	18.5	21	60
EE Trade and Professional Associations and NGOs	1	2	4
TOTAL, ALL SECTORS	$1,868.2	$2,076	$3,734

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

- The EE construction sector is more than four times larger under the Advanced Scenario than under the Base Case
- The EE vehicle sector is nearly four times larger under the Advanced Scenario than under the Base Case
- The EE utility sector is nearly three times larger under the Advanced Scenario than under the Base Case
- The EE windows and doors sector is more than 2.5 times larger under the Advanced Scenario than under the Base Case

Table VII-5
U.S. Jobs Created by Energy Efficiency in 2030
Thousands of Total Jobs Created

Industry Segment	Base Case	Moderate Scenario	Advanced Scenario
ESCO	98	121	196
Recycling, reuse, & remanufacturing	5,220	5,178	5,732
Vehicle manufacturing	740	912	2,770
Household appliances and lighting	435	528	1,064
Windows and doors	250	298	645
Computers, copies, FAX machines, etc.	1,360	1,321	1,446
TV, Video, and Audio equipment	870	922	1,775
HVAC systems	240	276	633
Industrial and related machinery	360	623	931
Miscellaneous durable manufacturing	1,640	1,840	4,230
Nondurable manufacturing	2,120	2,429	4,070
Utilities	75	98	204
Construction	1,240	2,964	5,186
Total, Private Industry	14,648	16,270	28,882
Federal government EE spending	70	83	222
State government EE spending	120	148	380
Local government EE spending	100	130	335
Total Government	290	361	937
EE Trade and Professional Associations and NGOs	15	27	59
TOTAL, ALL SECTORS	14,953	16,658	29,878

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

VII.C . Comparison of the 2007 and 2008 Forecasts

Similar RE&EE 2030 forecast scenarios were developed by ASES/MISI in 2007, and it is instructive to compare these with the current forecasts. Focusing on the aggressive scenario, in the current forecast the RE&EE industries in 2030 are significantly smaller than was forecast in 2007:

- Real RE revenues in 2030 are about 10 percent ($55 billion) lower in the 2008 forecast than in the 2007 forecast.
- The total number of jobs generated by RE in 2030 is about eight percent (591,000 jobs) lower in the 2008 forecast than in the 2007 forecast.
- Real EE revenues in 2030 are about eight percent ($317 billion) lower in the 2008 forecast than in the 2007 forecast.
- The total number of jobs generated by RE in 2030 is about seven percent (2.3 million jobs) lower in the 2008 forecast than in the 2007 forecast.

The reason for this decline is straightforward. In 2007 under the aggressive scenario, it was assumed that the extremely ambitious large-scale Federal, state, and local government incentives, policies, and mandates characterizing this scenario would be implemented beginning in 2008. Obviously, this has not occurred, and in this study we assume that these policies and incentives will be implemented in 2009. Nevertheless, the U.S. has lost a year in terms of achieving the RE&EE 2030 goals, and the negative impact on the RE&EE industries is 2030 is significant. All of the RE&EE programs and initiatives take years to be implemented and then ramped up, and in all of the RE&EE sectors the largest gains are made in the years immediately preceding the target year of 2030, and the single largest gains are made in years 2029 and 2030. It is the large gains in these last years that are lost by starting the aggressive program in 2009 instead of 2008, and it will be very difficult to recoup these gains.

This has important policy implications. The longer the U.S. delays in implementing ambitious RE&EE programs and incentives, the more difficult it will be to achieve the goals outlined here for 2030. Every year's delay at the front end, e.g., 2008, 2009, 2010, has a highly disproportionate and negative impact on the achievement of the long term RE&EE 2030 goals. Time is of the essence, and time lost in the next several years will be very difficult to make up. Thus, to achieve the 2030 RE&EE goals, appropriate policies and incentives must be implemented as soon as possible.

VIII. RENEWABLE ENERGY AND ENERGY EFFICIENCY IN COLORADO

VIII.A. Revenues and Employment

As an integral part of this project we assessed:

- The RE&EE industry in Colorado
- RE&EE companies in Colorado
- A profile of jobs in the wind industry
- RE&EE occupations and skills, including salaries, growth, and educational requirements
- RE&EE forecasts for Colorado
- RE&EE opportunities for Colorado
- Problems, challenges, and opportunities for Colorado

We found that the RE benefits to Colorado include:

- New investments
- Total industry sales
- Industry profits
- Total employment created
- Specific jobs created by occupation and skill
- Stimulation of the manufacturing sector
- Tax revenues for the state and local governments
- Technology development and spin-offs
- Revitalization of depressed regions
- Volumes and timeframes of conventional energy displacement

The following tables summarize the current RE industry in Colorado:

- Table VIII-1 shows the renewable energy industry in Colorado, 2007
- Table VIII-2 shows the energy efficiency industry in Colorado, 2007
- Table VIII-3 summarizes the RE&EE industries in Colorado, 2007
- Table VIII-4 shows the 2007 occupational job distribution and employee earnings of a typical wind turbine manufacturing company

Table VIII-1 shows that for RE:

- Gross revenues totaled nearly $1.1 billion
- Employment in the industry totaled over 4,400 jobs
- The total number of jobs created totaled more than 10,000

- Jobs created were disproportionately for scientific, technical, professional and skilled workers and about half of the jobs were in private industry
- The largest number of jobs was in the Federal government sector (primarily NREL), followed by the wind and ethanol sectors

Figure VIII-1 illustrates that, in terms of jobs:

- The RE industry in Colorado is currently dominated by the Federal government sector, which accounts for half of all RE jobs in the state, and this largely reflects the presence of NREL.
- With a budget of nearly $400 million and direct employment of more than 2,300 (including DOE employees, NREL staff, and contractors), NREL clearly dominates the RE sector in Colorado.
- NREL's importance to RE in the state is even greater than the budget and employment data indicate, since the presence of NREL acts as a stimulus to RE technologies and companies
- The next largest sector is wind, which in 2007 included construction activity for the large Vestas manufacturing facility – production at the facility did not begin until early 2008.
- The other RE sectors, account for relatively small portions of the Colorado RE industry.
- Solar thermal, photovoltaics, and biomass power are relatively small portions of the Colorado RE industry.

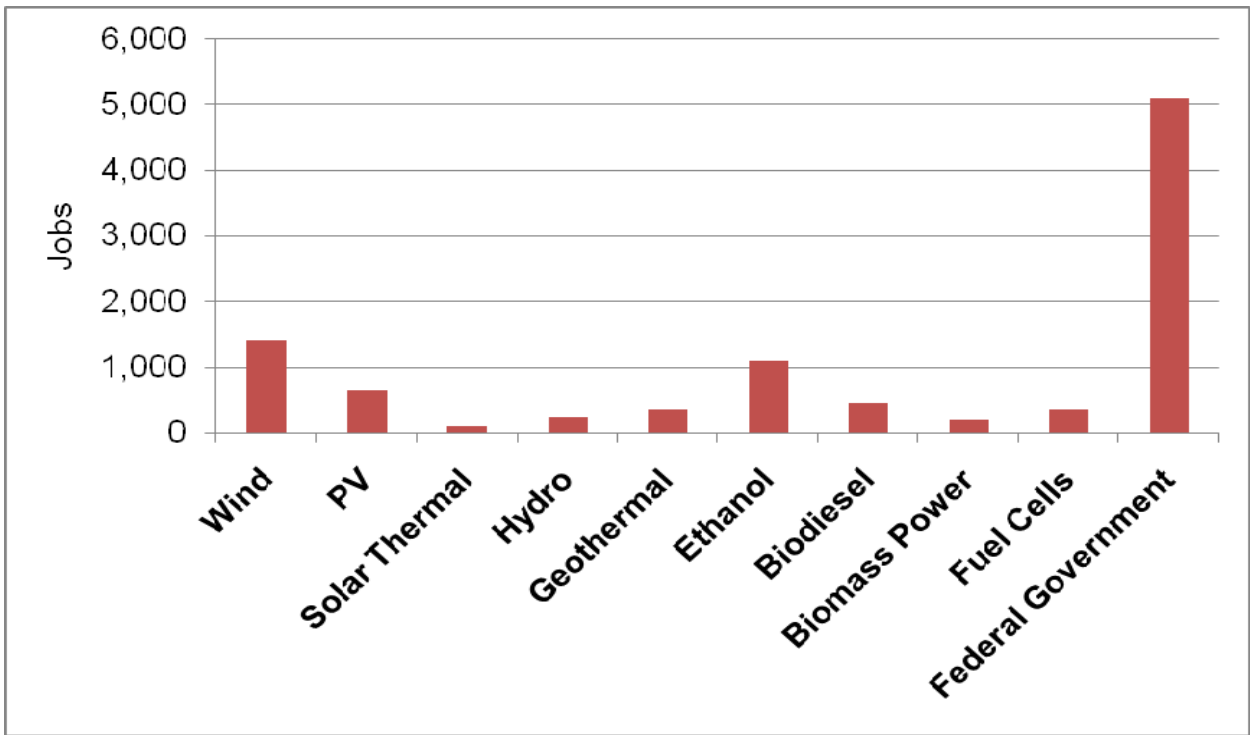
Table VIII-1
The Renewable Energy Industry in Colorado, 2007

Industry Segment	Industry Revenues/ Budgets (millions)	Industry Jobs	Total Jobs
Wind	$200	600	1,400
Photovoltaics	55	275	650
Solar Thermal	5	40	100
Hydroelectric Power	50	100	225
Geothermal	30	150	350
Biomass			
Ethanol	250	500	1,100
Biodiesel	20	200	450
Biomass Power	25	80	200
Fuel Cells and Hydrogen	40	150	350
Total, Private Industry	675	2,095	4,825
Federal Government*	400	2,250	5,100
State and Local Government	2	20	50
Total Government	402	2,270	5,150
Other Sectors**	5	50	100
TOTAL, ALL SECTORS	$1,082	4,415	10,075

*Includes Federal employees, Federal laboratory employees, and support contractors.
**Includes universities, trade and professional associations, NGOs, consultants, investment company analysts, etc.

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

Figure VIII-1
Total Renewable Energy Jobs in Colorado, 2007



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

Table VIII-2 shows that for EE in Colorado:

- Gross revenues totaled more than $9 billion
- The total number of jobs created totaled more than 81,000
- More than 99 percent of the jobs were in private industry
- The largest number of jobs was in recycling, reuse, and remanufacturing
- The second largest numbers of jobs were in the durable and nondurable manufacturing sectors
- Relatively small numbers of jobs were generated in the utility, vehicle, and ESCO sectors
- Government is not a major factor in the EE sector. However, the data in Table VIII-2 somewhat understate the importance of the Federal sector, since, while many NREL programs involve EE, all NREL activities are defined here as being in the RE sector.

Table VIII-2
The 2007 Colorado Energy Efficiency Industry

Industry Segment	Industry Revenues/ Budgets (millions)	Industry Jobs	Total Jobs
ESCO	110	500	1,175
Recycling, reuse, & remanufacturing	1,900	8,800	19,800
Vehicles	170	350	830
Household appliances and lighting	180	650	1,550
Windows and doors	200	800	1,850
Computers, copiers, FAX machines, etc.	600	2,800	6,400
TV, Video, and Audio equipment	700	2,900	6,700
HVAC systems	240	900	2,100
Industrial and related machinery	160	600	1,450
Miscellaneous durable manufacturing	1,900	6,400	14,600
Nondurable manufacturing	2,200	5,900	13,200
Utilities	26	80	200
Construction	730	4,700	11,150
Total, Private Industry	9,116	35,380	81,005
Federal government*	2	15	35
State and local government	9	50	115
Total Government	11	65	150
Other sectors**	2	25	55
TOTAL, ALL SECTORS	$9,129	35,470	81,210

*Substantial Federal EE spending is included in Federal RE spending, from the NREL budget.
**Includes universities, trade and professional associations, NGOs, consultants, investment company analysts, etc.
Source: Management Information Services, Inc. and American Solar Energy Society, 2008.

Table VIII-3 summarizes the RE&EE industries in Colorado in 2007 and shows that:

- RE&EE accounted for more than $10 billion in revenues
- RE&EE generated over 91,000 jobs
- The EE sector in Colorado is more than eight times larger than the RE sector
- RE&EE accounted for more than four percent of gross state product and for more than three percent of total employment in the state

Table VIII-3
The Colorado Renewable Energy and Energy Efficiency Industries, 2007

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

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

VIII.B. Renewable Energy and Energy Efficiency Jobs in Colorado

There are thousands of RE&EE companies located throughout the United States and Colorado, and they generate jobs for over 9 million workers. Given the wide diversity in the size, function, and technologies of these companies, it is impossible to estimate the job profile of the "average" RE&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 7 illustrates this by showing the 2007 occupational job distribution and employee earnings of a typical wind turbine manufacturing company. This table illustrates several important points.

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 renewable energy or energy efficiency specialists. Most of the workers are in occupations such as machinists, engineers, 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&EE.

This is illustrated forcefully in Table VIII-4. The occupational job distribution of a typical wind turbine manufacturing company differs relatively little from that of a company that manufactures other products. Thus, the production of wind turbines and wind turbine components requires large numbers of engine assemblers, machinists, machine tool operators, mechanical and industrial engineers, welders, tool and die makers, mechanics, managers, purchasing agents, etc. These 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 technologies are growing rapidly.[1] In Colorado and other states, these types of firms can help revitalize the manufacturing sector and provide the types of diversified, high-wage jobs that all states seek to attract.

This is also clear from the wide range of functions and tasks that are required by wind energy systems, including:

- Resource Extraction
- Transportation
- Manufacturing
- Integration/Assembly
- Transportation/Shipping
- Wholesales Sales
- Shipping/Transportation
- Retail Sales
- Shipping
- Installation
- Certification
- Activation
- Maintenance and Operation

More generally, while traditional debate on alternative energy has focused on applying new technology to offset traditional energy sources, RE&EE is more than a source of fuel or energy savings. It is source of jobs. As shown here, employment growth in the RE&EE industry varies for the different segments of the industries, 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 are an area for pioneering a number of alternative energy technologies, including superconducting power lines which reduce the 20 percent loss of electricity due to transmission, solar thermal, photovoltaic, and wind systems, and distributed power technologies which will reduce the losses from transmission and supply more reliable localized power and enable power production all across the electrical grid. 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.

[1]For example, wind power is the most rapidly growing source of electrical power in the world.

Table VIII-4
Typical Employee Profile of a 250-person
Wind Turbine Manufacturing Company, 2007
(Selected Occupations)

Occupation	Employees	Earnings
Engine and Other Machine Assemblers	31	$36,900
Machinists	27	41,300
Team Assemblers	16	30,700
Computer-Controlled Machine Tool Operators	12	41,500
Mechanical Engineers	10	73,300
First-Line Supervisors/Managers of Production/Operating	10	60,800
Inspectors, Testers, Sorters, Samplers, and Weighers	8	41,100
Lathe and Turning Machine Tool Setters/Operators/Tenders	6	40,800
Drilling and Boring Machine Tool Setters/Operators/Tenders	4	40,500
Welders, Cutters, Solderers, and Brazers	4	40,600
Laborers and Freight, Stock, and Material Movers	4	30,300
Maintenance and Repair Workers	4	44,900
Tool and Die Makers	4	44,800
Grinding/Lapping/Polishing/Buffing Machine Tool Operators	4	35,500
Multiple Machine Tool Setters/Operators/Tenders	4	41,400
Industrial Engineers	3	71,900
Industrial Machinery Mechanics	3	46,900
Engineering Managers	3	110,600
Shipping, Receiving, and Traffic Clerks	3	32,700
General and Operations Managers	3	123,600
Industrial Production Managers	3	95,000
Industrial Truck and Tractor Operators	3	34,900
Purchasing Agents	3	57,100
Cutting/Punching/Press Machine Setters/Operators/Tenders	3	32,000
Production, Planning, and Expediting Clerks	3	46,100
Milling and Planing Machine Setters/Operators/Tenders	3	41,200
Mechanical Drafters	2	40,600
Customer Service Representatives	2	39,700
Bookkeeping, Accounting, and Auditing Clerks	2	36,300
Office Clerks, General	2	29,800
Sales Representatives, Wholesale and Manufacturing	2	56,300
Janitors and Cleaners	2	30,200
Sales Engineers	2	73,900
Accountants and Auditors	2	61,000
Tool Grinders, Filers, and Sharpeners	2	44,800
Executive Secretaries and Administrative Assistants	2	44,000
Mechanical Engineering Technicians	2	51,900
Electricians	2	50,700
Other employees	48	50,600
Employee Total (126 occupations in the industry)	250	$47,300

Source: Management Information Services, Inc., 2008.

As discussed, 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. and most of the persons employed in these jobs may not even realize that they owe their livelihood to renewable energy. This is illustrated in Table VIII-5, which lists the jobs created by RE&EE in Colorado in 2007 within selected occupations. This table shows that in 2007 RE&EE generated in Colorado:

- More jobs for cashiers (1,337) than for recyclable materials collectors (121)
- More jobs for order clerks (209) than for environmental engineers (358)
- More jobs for executive secretaries (1,288) than for waste treatment plant operators (408)
- More jobs for janitors (1,520) than for environmental scientists and specialists (131)
- More jobs for customer service representatives (1,398) than for roofers (167)
- More jobs for accountants and auditors (950) than for civil engineers (519)
- More jobs for truck drivers (769) than for plumbers (458)
- More jobs for stock clerks (939) than for HVAC mechanics and installers (241)
- More jobs for security guards (802) than for welders (538)
- More jobs for computer business operations specialists (953) than for sheet metal workers (145)

Thus, many Colorado workers are dependent on RE&EE for their employment, although they often would have no way of recognizing that connection unless it is brought to their attention.

Table VIII-5
RE&EE Jobs Generated in Colorado in 2007, by Selected Occupations

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

Source: Management Information Services, Inc., 2008.

VIII.C. Renewable Energy Firms in Colorado

We conducted a survey of selected RE&EE companies in Colorado. The survey was conducted by telephone and the data were self-reported by each company. The data gathering techniques utilized in this study are standard practice for the industry. They include survey data gathered by personal telephone contact with each identified business where information on products, services, number of employees, and estimated revenue are sought.[1]

We examined a functional, technological, and geographic mix of RE&EE companies in Colorado. The goal was to illustrate and describe the various RE&EE firms in the state, the products and services they provide, the numbers and types of jobs they offer, and other characteristics and to identify their concerns, priorities, and opportunities. The survey was not meant to be comprehensive. Rather, we sought to describe the types of real people and products that characterize the RE&EE industries in Colorado – attributes that can often be obscured in statistical data and analyses. We felt it important to emphasize that, behind the data and forecasts, there are hundreds of firms employing thousands of persons that comprise the renewable energy and energy industries in Colorado.

As illustrated in Tables VI-4 and VI-5, our research revealed a wide range of firms, and they:

- Are located throughout the state, in major urban centers, suburbs, small towns, and rural areas.
- Range in size from small firms of several employees to large firms employing thousands -- although most of them are relatively small.
- Employ workers at all levels of skills, from the most basic and rudimentary to the very high skilled technical and professional
- Include those whose market is local, those whose market is state and regional, those who market is national, and those whose market is international.
- Are engaged a wide variety of activities, including design, manufacturing, engineering, renovation, R&D, installation, servicing, testing, monitoring, analysis, etc.
- Require a wide variety of occupations, skills, education, training, and experience
- Include some of the most sophisticated, innovative, high-tech firms in the state

[1]We can only report on the data provided and appreciate that in a small number of cases the data may not be accurate. However, we believe that in aggregate they accurately represent the industry and, because we use the same techniques as other industry survey firms, our data are comparable with other data gathering efforts. The data were obtained from direct conversations with representatives of the companies themselves. There is no way to independently verify data from private companies, and we used the same methods to obtain our information as do firms such as Bloomberg, Dun and Bradstreet, Hoovers, etc.

- Are faced with many of the same concerns, problems, and opportunities as other firms in the state.

Table VI-4 provides a list of selected RE&EE firms in Colorado, their classification as an RE or EE firm, and their locations. Table VI-5 lists 39 of the firms, showing their names, locations in the state, their major RE products and services, and the number of employees in the state. Eighteen of these firms are profiled in detail in Section VIII.D.

Table VIII-6
Renewable Energy and Energy Efficiency Firms in Colorado
(Examples of Selected Firms)

Company	Sector	Location		Company	Sector	Location
A1 Organic	EE	Eaton, Rattler Ridge, Plattsville, Denver, Golden		Industrial Solar Technology Corp.	RE	Golden
Adobe Solar	RE	Denver		Honeywell Building Solutions	EE	Englewood
Alternative Power Enterprises	RE	Ridgeway		ITN Energy Systems	RE&EE	Littleton
Ambient Energy	RE&EE	Denver		Johns Manville	EE	Denver, Littleton
Ameresco	EE	Englewood		LifeSpan Technology Recycling	EE	Denver
Architectural Energy Corporation	EE	Boulder		Lighthouse Solar	RE	Boulder, Glenwood Springs
Architerra Enterprises, Inc.	EE	Silverthorne		Long Building Technologies	EE	Englewood, Grand Junction, Colorado Springs, Ft. Collins
Astralux Power Systems	RE	Boulder		McKinstry	EE	Conifer
AVA Solar	RE	Fort Collins		Metro Skyline Insulation	EE	Englewood
Bella Energy	RE	Louisville		Nameste Solar	RE	Boulder
Bestway Insulation	EE	Broomfield		PCD Engineering Services, Inc.	EE	Longmont
BioEnergy of Colorado	RE	Denver		PowerPod Corporation	RE	Montrose
Blue Sun Biodiesel	RE	Golden		Powers Thermal Insulation	EE	Colorado Springs
Cassatt	EE	Colorado Springs		Precise Renewable Energy	RE	Thornton
Chevron Energy Solutions	EE	Englewood		PrimeStar Solar	RE	Golden
Colorado Energy Savers	EE	Longmont		REC Solar, Inc.	RE	Denver

Colorado Solarworks	RE	Boulder		Siemens Building Technologies	EE	Littleton, Aurora, Colorado Springs
Community Power Corp.	RE	Littleton		Simply Efficient	RE&EE	Lakewood
Dynamic Organic Light	EE	Longmont		Solar Mountain Energy		Divide
E and I Enterprises	EE	Denver		Solar Solutions	RE	Silver Cliff
Eagle Shield Colorado	EE	Colorado Springs		SolSource, Inc.	RE&EE	Denver
Earth & Sky Architecture	EE	Denver		Spirae, Inc.	RE&EE	Fort Collins
Eckert Engineering	EE	Colorado Springs		Standard Renewable Energy	RE&EE	Boulder
Ecofutures Building	EE	Boulder		Starfire Energy	RE&EE	Aurora
EMC Engineers	EE	Lakewood		Sustainable Automation Inc	EE	Boulder
EnergyLogic Inc	EE	Denver, Colorado Springs		TerraVerde Architecture	EE	Boulder
Ennovate Corp.	EE	Aurora		Thames Solar	RE	Denver
Enviro Response	EE	Boulder		Thermal Craft Insulation	EE	Longmont, Boulder
Envirofit International	RE&EE	Fort Collins		Vairex	RE&EE	Boulder
Green Living Renovation	RE&EE	Breckenridge		Versa Power Systems	RE	Littleton
Golden Solar	RE	Golden		Vestas American Wind Technology		
GRX	EE	Denver		Vibrant Solar	RE	Louisville
Idalex Technologies, Inc.	RE&EE	Arvada		Woodward Governor Co.	RE	Ft. Collins
Independent Power Systems	RE	Boulder				

Source: Management Information Services, 2008

Table VIII-7
Summary of Selected, Representative Colorado
Renewable Energy and Energy Efficiency Companies

Company	Location	Products/Services	Jobs (in CO)
A1 Organic	Eaton, Rattler Ridge, Plattsville, Denver, Golden	Recycles organic waste to produce compost mixtures	22
Adobe Solar	Denver	Designs and installs PV systems	2
Alternative Power Enterprises, Inc.*	Ridgeway	Designs, sells, installs, and maintains, solar thermal and electric systems	6
Architectural Energy Corp.	Boulder	Energy efficiency services and related software products	82
Architerra Enterprises, Inc.	Silverthorne	Sales, service, and construction of EE homes and other structures	10
Astralux Power Systems*	Boulder	Design, sales, and R&D, of PV systems	25
AVA Solar, Inc.*	Fort Collins	Design and manufacture of thin film Cad-Tel PV modules	80
Bella Energy*	Louisville	Design and install PV, thermal and wind systems	34
Bestway Insulation*	Broomfield	Insulation products for new and existing buildings	21
Blue Sun Biodiesel*	Golden	Produces diesel oil from dryland oilseed	17
Cassatt*	Colorado Springs	Design, produces, and sells energy efficiency software for buildings	20
Community Power Corp.*	Littleton	Commercializes and markets modular biopower systems	30
DirectNet*	Broomfield	Provides EE products and solutions for data centers	30
Earth & Sky Architecture	Denver	Designs sustainable residential and commercial structures	1

Eckert EE Engineering	Colorado Springs	EE solutions for existing structures	1
Ecofutures Building, Inc.	Boulder	Design and construction of energy efficient structures	10
EMC Engineers, Inc.*	Lakewood	Energy audits and energy efficiency services	
Envirofit International*	Fort Collins	Manufacture and sales of a direct injection retrofit for 2-stroke engines	30
Golden Solar	Golden	Design, install PV systems	7
Independent Power Systems	Boulder	Designs and installs PV systems	20
Johns Manville*	Denver, Littleton	Building and roofing insulation materials; coatings for wind turbine blades	1,000
Lighthouse Solar	Boulder, Glenwood Springs	PV and solar thermal systems design, sales, installation, and service.	31
Long Building Technologies*	Englewood, Grand Junction, Colorado Springs, Ft. Collins	Provides turnkey building energy efficiency systems	110
Lorax Energy Conservation, LLC	Loveland	Distributor of energy efficiency equipment; consultants to builders	3
Nameste Solar*	Boulder, Denver	Design, sells, installs, and maintains PV electric systems	50
Novan Solar, Inc.	Golden	Designs, sells, and installs PV systems	17
PowerPod Corp.	Montrose	Design, assemble and install turnkey modular PV and solar thermal systems	18
PrimeStar Solar, Inc.	Golden	Manufacture and sales of commercial and utility scale solar systems	40
REC Solar, Inc.	Denver	Design, sell and install PV power systems	13
Simply Efficient, LLC	Lakewood	Consulting to building owners for RE&EE systems on retrofit and new construction	8

Solar Solutions, Ltd	Silver Cliff	Designs and installs PV and wind systems	2
SolSource, Inc.*	Denver	Solar energy systems and green building products	15
Standard Renewable Energy	Boulder	PV, solar hot water, wind systems, insulation, and energy audits	45
Starfire Energy	Aurora	PV, solar thermal systems, and attic fans	2
TerraVerde Architecture*	Boulder	Design and construction of green homes and commercial structures	11
Thames Solar Electric	Denver	Designs and installs PV systems	4
Vestas American Wind Technology*	Windsor, Brighton	Designs and manufactures utility level wind turbines	600
Versa Power Systems, Inc.	Littleton	Design, develop, and commercializes solid oxide fuel cells	4
Vibrant Solar	Louisville	Designs and installs PV systems	30

*Companies profiled here.

Source: Management Information Services, Inc., 2008.

VIII.D. Profiles of Colorado Renewable Energy and Energy Efficiency Companies

VIII.D.1. Alternative Power Enterprises, Inc.

Alternative Power Enterprises was founded in 1992 and is headquartered in Ridgeway. It has six employees, and 95 percent of its clientele is residential and five percent is commercial. The company provides renewable energy systems and services for space heating, water heating, and electrical power to residential and business clients. APE provides hot water, space heating, electric and solar water pumping systems and distributes SolarOne's Harvester Portable Solar Power Systems and SEIDO Evacuated Tube Collectors. APE is COSEIA (Colorado Solar Energy Industries Association) certified for active thermal and photovoltaic system installations. Its goal is to make each building energy efficient, energy generating, and balanced with the energy needs of its owners and occupants.

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

The services APE offers include:

- System design and load evaluation: Consulting services to help evaluate loads or power needs, determine site specific characteristics, and design systems.
- Sales of solar power (photovoltaic) systems, solar hot water systems, solar space heating systems, and energy efficient lighting and appliances.
- Installation: On-site certified installation of systems, components, and appliances within the Western Colorado and 4-Corners region.
- Service calls: Certified on-site service, including regular maintenance and trouble shooting of installed alternative power systems.

VIII.D.2. Architectural Energy Corporation

Architectural Energy Corporation is located in Boulder and has branch offices in Chicago, San Francisco, and Franklin, Tennessee. It was founded in 1982, has 115 employees, and has annual sales of $10 million. Its Boulder office has 82 employees, and its staff is about 90 percent engineering and 10 percent administrative and sales. Its clientele is primarily commercial, industrial, government, and public buildings.

AEC provides customized energy efficiency services, consulting, and sales of related software, and offers a wide range of hardware and software products to facilitate renewable energy and energy efficient buildings, including:

- ENFORMA Building Diagnostics (EBD): Utilizes data from building automation systems to identify energy inefficiencies & their financial impacts
- MicroDataNet Systems (MDNS): Wireless data acquisition product line providing users with time sensitive information over the Internet
- D-GenPro: Software to assess feasibility of distributed generation
- SPOT™: Quantifies electric lighting & daylighting characteristics to establish optimal photosensor placement
- WattWiser™ Monitoring System: Allows monitoring of plug loads located throughout a building
- Comfort Advisor™ Service: Allows facility managers to document conditions in buildings' "problem" areas via the Internet
- EnvStd: ASHRAE envelope compliance software
- VisualPlant™: Central plant energy analysis tool

- Hilight: Lighting code compliance program
- Global Energy Master (GEM): Evaluates cost effectiveness of energy efficiency and renewable energy options in buildings.

AEC is a nationally and internationally recognized industry leader with extensive experience in evaluating and commissioning residential, commercial, institutional, and industrial buildings' energy systems. It has a diverse client base, including A&E firms; local, state, and federal government agencies; large and small corporations; utilities; energy service companies; trade and research organizations; federal laboratories; consulting firms; and home energy rating organizations; including Boston Edison, General Motors, Honeywell, IBM, Johns Manville, Johnson Controls, Pacific Gas & Electric, Rockwell International, Southern California Edison, TVA, U.S. Department of Defense, U.S. Department of Energy, Wal-Mart, Xcel Energy, and others

Xcel Energy (the major Colorado utility) selected AEC to lead its Colorado Energy Design Assistance program, which provides free energy design and analysis services and financial incentives to Xcel customers. In recent years, AEC has received a number of awards, including AIA Colorado Firm of the Year, the RESENT Industry Innovation Award, several USEPA awards for technical excellence, Colorado Professional Engineers Company of the Year, and others

VIII.D.3. Atralux Power Systems

Astralux Power Systems (a division of Astralux Environmental Solutions) is a Boulder-based company specializing in energy efficiency and solar energy system design. It was founded in 1991 and is a leader in silicon semiconductor research -- the basis of solar energy technology. It has 25 employees, and all of them are degreed technologists. Its key activities include retail sales, wholesale supplier, systems R&D, systems design, and installation. Approximately 50 percent of its clientele is residential and 50 percent is industrial and commercial

APS serves businesses and residences and has several major government R&D contracts with the U.S. Air Force, Department of Energy, National Science Foundation, and other organizations. It provides professionally designed, aesthetically pleasing, and dependable solar energy to Colorado clients. Its installation team has over 20 years experience and the firm has installed a large number of systems in Colorado.

The Astralux Total Energy Efficiency Solution™ consists of:

- Initial Consultation
- Site Assessment
- Energy Assessment Analysis
- Energy Efficiency Solution Report
- Professional Installation
- "Worry-Free" Guarantee

Astralux uses new and innovative computer models to create detailed and accurate design plans for each system. Each of its solar projects involves an integrated design process and it integrates the computer-aided design, energy analysis, cost-estimating procedures, and all processes in which information is shared. The firm uses recent advances in solar panel technology to allow flexible and aesthetic architectural innovation, and offers several complementary services that assist clients in creating energy efficient buildings.

VIII.D.4. AVA Solar

AVA Solar develops, designs, manufactures, and sells cadmium-telluride thin film PV modules and is based in Fort Collins and Longmont. It was founded in 2007 and has 80 employees – about 45 degreed technologists and 35 technicians. The company has not sold any product, but is aggressively pursuing the commercial and utilities markets.

AVA Solar has developed a thin-film photovoltaic module manufacturing technology that is the culmination of more than 15 years of scientific and engineering effort. During all aspects of this development, large-scale manufacturing was emphasized, and high-volume, highly automated manufacturing processes were benchmarked in developing AVA Solar's production lines. The result is a fully automated, dry, in-line, continuous, single-pass system with high throughputs and yields.

AVA's technology was developed and incubated at Colorado State University with the support of the National Renewable Energy Laboratory in Golden. AVA's proprietary technology will enable the production of low-cost PV modules and will significantly reduce the cost of generating solar electricity. Production capacity will be scaled rapidly to meet the fast growing demand for solar energy.
AVA Solar recently won the DOE Inventions and Innovations' Category III award, awarded only once in the 25-year history of the program. Having achieved technical success in the lab, the company was organized in January 2007, raised an initial round of funding by February, and began construction of its initial pre-production system, which went into pilot production in 2008. In June 2007, AVA Solar closed on its second round of funding and plans to complete its first manufacturing facility in early 2009. And to commence large-scale production. Ongoing lifetime testing has validated a 30+ year product life, and initial PV device efficiencies range from 11 percent to 13 percent.

VIII.D.5. Bella Energy

Bella Energy, located in Louisville, designs and installs PV electric, solar thermal, and wind energy systems and offers clean energy solutions, including solar electricity, energy efficiency, solar heating, and wind power. It was founded in 1982, has 34

employees, and 90 percent of its clientele is residential and 10 percent is commercial and government. Bella Energy is the new name of one of the oldest and most experienced solar companies in Colorado, and its president, Jim Welch, has been a leader in the renewable energy industry for almost 30 years.

Bella Energy is employee owned and offers clean energy solutions, including solar electricity, energy efficiency, solar heating, and wind power. It brings over 100 years of combined experience in solar design to Colorado, and Bella Energy principals have led the renewable energy industry since the 1970s. Their solar electric and hot water systems projects across the globe are off grid, grid tied, commercial, and residential.

In 1982, Jim Welch started the company as Remote Power Inc, one of Colorado's and the nation's first companies to sell and install solar electric systems. Remote Power is credited with Colorado's first solar electric commercial system (ESC Building – 1985) and first utility power system (Platte River Power Authority – 1988).

During the 1990s, Remote Power, continued its solar leadership managing the Nature Conservancy's renewable energy program in the US and Latin America. This included the largest off grid solar project in the country on Santa Cruz Island in 1998.

In the 1990s, Jim Welch managed the Nature Conservancy's renewable energy program, and Ken Olson helped found Solar Energy International, America's leading solar training organization. Welch and Olsen were co-authors of the first photovoltaic manual for the US Department of Energy in 1986, which is still currently in use. Bella Energy has five BAs and three MAs in engineering whose accreditations include AEE energy management and sustainable development professional qualifications. It also employees four CoSEIA photovoltaic installation and six NAPCEP Certified Energy Practitioners certifications, the highest level of U.S. solar certification.

Bella's goal is to provide the highest quality solar energy solutions to empower communities with opportunities to contribute to a sustainable future and clean energy economy.

VIII.D.6. Bestway Insulation

Bestway Insulation is based in Broomfield and was founded in 1976. It has 20 employees, including five degreed technologists and 15 certified installers. It specializes in insulation product sales and installation in new and existing homes and buildings, and 95 percent of its clientele is residential and five percent is commercial.

Bestway is a drywall/insulating contractor specializing in re-insulating existing homes by using blow-in insulation. Its insulation services include:

- Insulating walls built of wood, cedar shingles, vinyl siding, metal siding, metal panels, stucco, pre-pressed composite, drywall and plaster,
- Insulating mobile home walls
- Colored mortar and weeping mortar matched to the building
- Insulating or re-insulating batted walls, garage ceilings, knee walls and cathedral ceilings
- Utilization of cellulose in most applications and fiberglass insulation on others
- Air sealing to help limit air leakage from attics and crawlspaces
- Sound Mitigation

Bestway services:

- Existing residences -- attics & cathedral ceilings, brick wall insulation, wood walls & cantilevers, steel, aluminum, & vinyl sided walls, air sealing, garage ceilings & walls
- New Construction
- Apartments & Hotels
- Multifamily

VIII.D.7. Blue Sun Biodiesel

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

Founded in 2001, Blue Sun is working to incorporate biodiesel into the existing petroleum fuels infrastructure by focusing on an integrated approach to addressing market needs. This approach includes:

- Reducing the cost of feedstocks through the development and production of low-cost dryland oilseed crops and next-generation feedstocks like algae and jatropha,
- Establishing integrated oilseed crush facilities for supply chain efficiency
- Building biodiesel production facilities that yield high quality fuel
- Researching and developing industry-leading biodiesel-specific fuel additives
- Efficiently distributing to end-users with control and oversight throughout the downstream value chain.

In leveraging its positions throughout this integrated structure, Blue Sun manages biodiesel fuel quality at every step between feedstock development and fuel combustion.

The Blue Sun team includes some of the nation's leading biodiesel fuel quality experts, participation from top agronomists at CSU, KSU, and the University of Nebraska, growers in the High Plains region, and an experienced management team. Blue Sun seeks to improve communities and the environment and strengthened national security by reducing U.S. dependence on imported fuel. In striving for these goals, Blue Sun is facilitating the use of biodiesel to improve local, regional, and national air quality, while supporting U.S. agriculture and strengthening the rural economy.

Blue Sun Fusion, Blue Sun's flagship product, is available at numerous pumps throughout Colorado, New Mexico, and Idaho. Blue Sun Fusion is a blend of premium Blue Sun Biodiesel (20%) with petroleum diesel fuel (80%), along with Blue Sun's proprietary additive package specifically tailored for regional climates and seasons. Recent research data indicates that Blue Sun Fusion outperforms diesel fuel significantly in terms of emissions reductions, including the reduction of nitrogen oxides (NO_x), a criteria EPA pollutant that contributes to the formation of ozone.

Blue Sun's agriculture research and development plan is focused on developing low-cost oilseed crops that are well-adapted to the hot, arid growing conditions of the High Plains. Blue Sun estimates that these new types of oilseed crops -- including winter and spring varieties of camelina and canola -- can reduce production costs of biodiesel over the mid- to long-term. This is crucial, since the cost of feedstock represents approximately 75% of the total cost of biodiesel fuels. Blue Sun’s dryland agriculture strategy represents an opportunity to increase the use of domestically-grown biodiesel in North America:

- Blue Sun harvested more than one million lbs of canola and camelina from crop production in Colorado, Nebraska, and Wyoming over the past four years.
- Blue Sun maintains a conventional oilseed breeding facility in Torrington, Wyoming that currently has more than 1,600 experimental lines which include winter and spring canola and winter and spring camelina.
- Advanced materials are evaluated in regional and national performance trials, and currently available cultivars include Wichita (winter canola) and Cheyenne (spring camelina).
- Blue Sun has been awarded several U.S. Department of Energy and U.S. Department of Agriculture grants to breed and commercialize (without genetic modification) new proprietary oilseed varieties for biodiesel production. Blue Sun's crops are bred for improved yield potential and yield reliability.

VIII.D.8. Cassatt

Cassatt is located in Colorado Springs, and was founded in 2003 by Bill Coleman, founder and first CEO of BEA Systems -- the fastest software company to achieve $1 billion in annual revenues. It designs, produces, and sells software to monitor energy use to increase energy efficiency in buildings. It has 20 employees in Colorado, and its clientele is 30 percent government and 70 percent commercial and industrial

Cassatt software makes data centers more efficient, agile, and green. Cassatt Active Response rapidly repurposes servers based on demand, improves availability, and uses Active Power Management to reduce energy consumption and costs. Its major products include:

- Active Power Management: This product line allows administrators to set policies to turn servers off and on, apply policies to pool all server resources, and invoke policies to prioritize the delivery of applications.
- Active Response: This software product line has four editions to meet the different needs of organizations to help make their data centers more efficient. Cassatt Active Response is based on the patented Active Power Management technology that pools physical and virtual server resources for the most efficient utilization, and uses policy-driven controls to systematically power servers off when not needed, and on when they are. The four editions of the Cassatt Active Response product line deliver increased energy savings, better utilization of server assets, and increased application availability, while making it easier for customers to adopt incrementally. The product line includes:
- Cassatt Active Response, Standard Edition -- for power management
- Cassatt Active Response, Premium Edition -- for power management and increased application availability of priority applications
- Cassatt Active Response, Data Center Edition -- for power management, high application availability, and server workload management
- Cassatt Active Response, Enterprise Edition -- for efficient control and optimization of all data center resources across an entire enterprise, and it draws on the capabilities of Standard, Premium, and Data Center editions

The Cassatt Active Response product line includes feature packs to support important additional functionality:

- PG&E Feature Pack -- provides a real-time connection to the Demand Response program from Pacific Gas & Electric. The PG&E Feature Pack “listens” for pricing schedules and critical alerts from PG&E and works in conjunction with Cassatt Active Response to take actions on these notifications from PG&E
- WebLogic Feature Pack -- manages service-level agreements automatically and optimizes J2EE applications, middleware and hardware

Cassatt’s solutions include:

- Active Power Management technology, which powers servers off when they are not needed or idle
- Internal Cloud Computing, which creates an "internal cloud" to make optimal use of the hardware, software, and networks supporting desired applications
- Server Consolidation, which produces cost savings in the data center by reducing the number of servers required
- Virtualization Control, which improves energy efficiency and availability for an entire, heterogeneous data center -- including both virtual and physical servers
- J2EE/SOA Optimization, which creates a virtual pool of resources -- hardware, operating systems, and middleware -- that decouples J2EE applications from their servers. The consolidated pool of resources is shared and free for use by all J2EE applications.
- IT Operations Efficiency, which automates a continuous supply-demand balance by creating intelligent "capacity pooling" across diverse hardware platforms by automatically measuring, analyzing, and responding to resource demands.
- Capacity Demand, which creates a continuous supply-demand balance with "capacity pooling" across multiple hardware platforms.
- Universal High Availability, which allocates and re-provisions new physical and/or virtual machines from bare metal within minutes, regardless of machine locations on the VLAN.

The organizing principle of Cassatt Active Response is service level automation. The service delivery model incorporates all of the capabilities and basic requirements of utility computing. Cassatt implements service level automation through Virtualization Control, Goal-Driven Automation, Utility Metering, and Vendor Neutrality.

VIII.D.9. Community Power Corporation

Community Power Corporation (CPC), located in Littleton, was founded in 1995, and has 30 employees: 15 degreed technologists and 15 technicians. It develops, commercializes, and markets modular biopower systems by converting wood chips and

waste products into gas to be used as fuel for internal combustion engines used to power electric generators. CPC has extensive hands-on knowledge and experience in the design, deployment, and operation of renewable energy distributed generation projects. The firm develops, commercializes, and markets modular biopower systems to meet the needs of distributed energy consumers in both developing and developed countries. Its clientele includes government agencies, such as the U.S. Forest Service, universities, and other institutional clients.

CPC developed BioMax®, a line of small biopower power systems for the global distributed generation market. BioMax® is a small modular distributed energy biomass power system based on downdraft gasifier technology that uses high bulk density fuels such as woodchips and nut shells to produce both heat and power. System options include stationary (enclosure or containerized) as well as a mobile trailer version. Systems from 5 kW to 100 kW are currently under development. CPC's other ongoing commercialization activities include:

- Renewable Fuel Gas Generator: A Gas Production Module that converts biomass to a clean gas for power and heat, bio-fuels research, and hydrogen generation. Depending on a number of variables, the fuel cost for the product gas measured in $/Million Btu is at least 50% less than that of non-renewable natural gas and propane. The Renewable Fuel Gas Generator is also a building block for integration with emerging distributed generation technologies such as Micro-turbines, Fuel Cells, and Thermo-electric Generators.
- Fluid Bed Gasifier: Built to complement the downdraft gasifier, the fluid bed system will process low bulk density biomass fuels such as sawdust and grasses.
- Micro-modular Biopower System: A scaled-down version of the BioMax®, this system is designed for off-grid residences, small villages, or on-grid residences in areas with high electricity and natural gas prices.
- Biomass-fueled Burner: CPC has integrated its Renewable Fuel Gas Generator with a commercial natural gas/propane burner to power thermal applications such as crop drying, space heating/cooling, ice making, and water processes (purification and desalination)
- Community Productive Use Platform (C-PUP): A flexible system that converts local biomass to mechanical, electrical, and thermal power for rural enterprise applications.
- Fiber Processing Facility: The first application of the C-PUP to rural productive use, the facility converts waste coconut husks to geo-textiles for the soil erosion control market.
- Biopower Battery Charger: A unique product that uses an advanced CPC gasifier to operate a free-piston Stirling engine generator from Stirling Technology Company

- Utilimeter: A proprietary electrical energy dispenser and pre-payment system for commercial rural electrification projects

CPC has demonstrated the following capabilities associated with off-grid renewable energy services:

- Project feasibility analysis
- Renewable resource assessment
- Energy demand analysis and load profiling
- GPS mapping and GIS database analysis
- Customer willingness and ability-to-pay assessments
- Power system design, procurement, installation, operation, and maintenance
- Design and establishment of Renewable Energy Service Companies (RESCO)
- Pricing design and implementation
- Development and implementation of RESCO energy service contracts
- Employee and customer training
- Product development
- Financial and economic modeling and revenue collection
- Business Plan preparation and Strategic Partner identification and recruitment
- Customer survey design and implementation, analysis of results and implementation of improvements

In addition, CPC and its associates provide consulting services to a wide variety of organizations that require sustainable solutions to the generation and delivery of electricity services. These organizations include development finance institutions, private sector developers, community or industry-based cooperatives, ecotourism developers, and agencies of national and local governments responsible for health, education, economic and social development, and infrastructure services

VIII.D.10. DirectNet, Inc.

DirectNet is located in Broomfield and has one subsidiary, KVM Switches Online, LLC, also in Broomfield. It was founded in 1995 and has 30 employees. It provides products and solutions for data centers and IT managers that improve energy efficiency, reduce power consumption, and lower energy costs, including:

- Airflow analysis, power monitoring and measurement, cooling best practices, and energy efficient technologies

- Energy efficiency expertise and solutions for data center infrastructure in four functional areas: Power, cooling, management, and enclosures
- Environmental monitoring systems that permit proactive monitoring and response to temperature, humidity, dew point, and airflow
- Cooling solutions for server racks, computer rooms, server rooms, and data centers, including rack cooling modules & Rittal cooling packages
- Server rack strategies and accessories
- Lights Out Data Center Technologies, including remote access digital KVM over IP products (IP KVM switches)
- Cyclades PM intelligent power distribution units that enable remote power management and control of servers and network gear
- Enterprise level device management solutions that allow IT administrators to manage servers, storage devices, and networking equipment at any location, 24x7

DirectNet's annual sales total $18 million and it has more than 500 clients, including many Fortune 500 companies, such as 3M, Alcoa, AT&T, BP, Best Buy, Disney, eBay, ExxonMobil, Fujitsu, GE, Gillette, Hitachi, Honda, Honeywell, IBM, John Deere, Lucent, Microsoft, Mitsubishi, Motorola, Nokia, Pepsico, Pfizer, Toshiba, UPS, Verizon, Wells Fargo, Xerox, & others. For two decades, DirectNet has been providing solutions for facilities and IT Managers seeking energy efficient best practices and technologies solutions for data centers, server rooms, and computer rooms. It is a leading U.S. provider of data center, server, and IT infrastructure management solutions, including KVM over IP, intelligent power, environmental monitoring, cooling, and rackmount solutions.

DirectNet provides pre-sales engineering and design services, installation, training, and pre-and post-sale support, has a proven track record of service with thousands of customers, and has won numerous quality, achievement, and sales awards. It is vendor-independent and provides objective, unbiased guidance on selecting data center products and energy efficiency expertise and solutions for data center infrastructure.

VIII.D.11. EMC Engineers

EMC Engineers, Inc. was founded in 1976 and is headquartered in Lakewood. It conducts energy audits and provides services to help reduce energy waste. The firm has 54 employees, 80 percent of whom are university graduates, and all of its clientele is commercial.

EMC is dedicated to creating sustainable facilities by optimizing performance through energy modeling and analyses, building automation, advanced mechanical and electrical design, construction management, and building commissioning to achieve

lower energy costs, improved comfort, and increased productivity. EMC's services include:

- Energy Services: optimizes energy use for improved efficiency, reduced operational costs, and increased comfort.
  - -- Building energy simulation is the key to designing cost-effective envelopes and HVAC systems.
  - -- Energy management includes audits, feasibility studies, master plans, baseline development, design reviews, and a variety of other energy engineering services to help manage energy budgets.
  - -- Demand Side Management is a strategy for helping large utility customers reduce energy consumption, and it provides utility operators with an effective means of managing demand and limiting the need for new generating capacity.
- Commissioning: The commissioning process for new buildings and major renovations of existing buildings provides facility owners with assurance the facility is functioning to meet their project requirements. EMC has experienced experts in commissioning and LEED certification and has commissioned numerous LEED-NC2.2 projects.
- Facility Design: Integrated systems design controls costs and is crucial to facility renovation and modernization in high performance facilities.
- Sustainable Design: Handling green building systems and renovations.
- GeoExchange systems are endorsed as a renewable technology by EPA, the Department of Energy, and state agencies such as the California Energy Commission.
- LEED Certification
- Design/Build: EMC is skilled at engineer-led, design/build projects, including efforts funded through Energy Savings Performance Contracting. EMC design-build energy retrofit services are available for:
  - -- HVAC system upgrades
  - -- Energy conservation projects
  - -- Solving and correcting building system problems
  - -- Lighting, motor, and electrical system upgrades
  - -- Recommissioning buildings to proper operating conditions
  - -- Building automation systems
- Consulting: EMC has provided comprehensive facility engineering services since 1976.
- Training: EMC offers an extensive training program to:
  - -- Improve system performance
  - -- Shorten the duration of O&M activities
  - -- Improve overall productivity

- Water Resource Management: Planning and implementing water use efficiency

VIII.D.12. Envirofit International

Envirofit International is based in Fort Collins, was founded in 2003, and has 30 employees in Colorado – 29 of them degreed technologists. It designs, develops, manufactures, and sells direct injection retrofit for two-stroke gasoline engines to increase energy efficiency and reduce carbon emissions in developing countries. The firm is a spinoff from the Engines and Energy Conversion Laboratory (EECL) at Colorado State University, where researchers developed a conversion kit for two-stroke engines for snow mobiles. Envirofit is currently producing engines for three-wheel taxis in the Philippines and India.

The company developed from research work at EECL, a world leader in designing energy efficient, low emissions engines. In 2001 the Director of the EECL was involved in the design of a direct injection retrofit kit for two-stroke snow mobiles, and that research evolved to consider the feasibility of a direct injection retrofit for a third-world application. Professors from EECL and the CSU College of Business jointly supervised a graduate student team investigating the feasibility of taking the demonstration kit developed at EECL and commercializing it into a sustainable business. That exercise led the formation of Envirofit in October 2003. Subsequent, substantial funding from the Bohemian Foundation allowed Envirofit to undertake extensive product development and field testing, commercializing its initial retrofit kit in October 2006.

Envirofit International was established to develop well-engineered technology solutions to improve the human condition on a global scale, with a primary emphasis on applications in the developing world. The company develops and disseminates energy efficient, pollution-reducing technologies that enhance the environment and public health, foster economic growth, and alleviate poverty in developing countries.

Envirofit's goal is to develop and distribute well-engineered energy products for low-income markets that traditionally have been overlooked, and it develops and disseminates products and services that address energy and environmental problems in the developing world. Established as a U.S. tax-exempt corporation, Envirofit utilized initial donations and institutional support to fund product development and early stage product commercialization, and uses operating income to develop and expand its businesses.

Envirofit focuses on two major products:

- 2-Stroke Retrofits: Envirofit has developed a direct In-cylinder (DI) fuel injection retrofit kit for two-stroke engines that is cleaner and more fuel efficient than the replacement four-stroke engines.

- Clean Indoor Cookstoves: The company has partnered with the UK charity Shell Foundation to reduce the number of global deaths caused by Indoor Air Pollution (IAP) -- the smoke generated by traditional fires and stoves used in developing world homes. Envirofit is tasked with handling the scale-up and spin off of the Shell Foundation's Breathing Space program, which was founded in 2002 to achieve significant global reductions in IAP. This partnership is part of the Foundation's mission to see 10 million clean-burning stoves sold in five countries over the next five years. The Foundation is providing Envirofit with investment and organizational support to form an independent global entity. In turn, Envirofit International, working with EECL, will design, develop, market, and distribute clean cookstoves that are engineered to emit significantly less toxic emissions and use less fuel.

Envirofit has received numerous international awards, including:

- Envirofit was named a 2005 Environmental TechAward Laureate by Silicon Valley's Tech Museum of Innovation.

- In 2006, Stanford Social Innovation Review selected Envirofit as one of the “Top 10 Most Innovative Technologies for Creating Social Change.”
- It was designated one of the "Plenty Twenty -- Twenty Companies that will Change the World" in 2007.
- It received the "Transport and Mobility" World Clean Energy Award for innovative practices and leadership in implementing broad-based energy solutions.

VIII.D.13. Johns Manville

Johns Manville is headquartered in Denver and has an office in Littleton, and is a Berkshire Hathaway company that provides building and roof insulation and research and development in insulation materials and coatings for wind turbine blades. It is a leading manufacturer and marketer of premium-quality building insulation, commercial roofing, roof insulation, and specialty products for commercial, industrial, and residential applications. JM’s product offerings include formaldehyde-free™ fiber glass building insulation, commercial roofing membranes and roof insulations, filtration media, and mats and reinforcements. It furnishes products to commercial OEMs, distributors, and dealers worldwide.

In business since 1858, the company has annual sales in excess of $2 billion and holds leadership positions in all of the key markets that it serves. Internationally, JM has about 7,800 employees, 650 of whom are located in Colorado, and operates 41 manufacturing facilities in North America, Europe and China. Of the 650 Colorado

employees, 250 are degreed technologists. All of the employees in Colorado have an association with the energy efficiency products produced by JM in an administrative, marketing/sales, or other support assignment; JM does no manufacturing in Colorado.

Johns Manville manufacturing facilities are strategically positioned in North America, Europe, and Asia, and the company has three main business groups: Engineered Products, Insulation Systems, and Roofing Systems. Products from these businesses are marketed throughout the world.

JM is a member of the Green Building Council and dedicated to developing products for sustainable building. It has a 150-year history as a leading producer of quality building materials, and is:

- A trusted advisor for building product solutions
- A leader in building sciences, LEED® credit-contributing products, and "green" building
- Dedicated to sustainable manufacturing and building practices

- The only manufacturer to offer a complete line of Formaldehyde-free fiber glass building insulation products
- Responsive to the needs for energy savings and compliance with all building and environmental codes
- An innovator in the development of functionally superior and environmentally smart new products
- Committed to world-class customer service

VIII.D.14. Long Building Technologies

LONG Building Technologies has offices in Englewood, Grand Junction, Colorado Springs, and Fort Collins and provides turnkey building systems to reduce energy waste and increase energy efficiency. It has 100 employees in Colorado, more than half of whom are university graduates, and all of its clientele is commercial and industrial.

LONG Building Technologies was founded in 1965 as a manufacturer representative of HVAC equipment. The name of the company evolved from Long-Deming to Long & Associates and finally LONG Building Technologies. Over the years the company has diversified and grown from a small manufacturer representative, with its main office in Englewood, to a regional company with additional offices in Colorado, Wyoming, Utah, and Nevada.

Long has expertise in all major building systems technologies and serves commercial, institutional, and industrial facilities of all types and sizes. LONG works with the major Mountain West mechanical contractors and engineers in the application of HVAC and other building technology solutions. The firm provides turn-key, and often

self-funding, building systems solutions that unlock a facility's full operating potential in a changing energy environment.

LONG is organized into four operating groups:

- LONG Mechanical Solutions delivers proactive post-installation operations and maintenance and emergency services 24x7 for all building automation, HVAC system, and refrigeration concerns.
- LONG Security Solutions provides security application engineering and design, commissioning of CCTV, access control, intercommunication, nurse call, and audio/video verified burglar alarms.
- LONG Building Intelligence provides design, installation, and integration of building automation systems, energy management systems, controllable and dimmable lighting systems, fire life safety systems, CCTV and card access employing cutting edge technology, and TCP/IP connectivity.
- LONG Building Environments has expertise in the design, application, and selection of mechanical, HVAC, architectural, and power systems equipment, and represents over 40 major equipment manufacturers on an exclusive basis.

VIII.D.15. Nameste Solar

Namaste Solar is a Boulder-based, employee-owned solar electric company founded in 2004. It originally had three employees and it currently has 50, and 80 percent of its staff has a university degree. About 35 percent of its clientele is commercial and industrial, and 65 percent is residential. It specializes in system design, sales, installation, and maintenance of PV systems.

The company installs solar electric systems in homes and businesses throughout Colorado. Namaste is the leading installer of photoelectric panels in the state, and has a 25 percent market share. The firm has expertise in both grid-tie and stand-alone systems, and has installed over 500 solar PV systems in Colorado since 2006 -- more than any other company. The firm seeks to develop long-term relationships with clients and to cultivate ongoing customer satisfaction by providing design, sales, installation and after-sales services.

Namaste “lives with the technology it sells.” Its main office building in North Boulder is 100% solar-powered and is LEED Gold certified, all of its office furniture is either second-hand or made from recycled materials, and the company uses hybrids and biodiesel installation vans. Namaste won the Eco-Cycle 2006 Outstanding Recycling Program Award in the small business category for diverting as much material as possible from landfills into recycling, and the company donates one% of its revenues

each year to non-profit community organizations in the form of solar PV systems. It was also the recipient of the 2007 Sparks Award from the Boulder Chamber of Commerce

Namaste custom-designs and installs each system for optimal performance, durability, and aesthetics, and its systems are competitively priced. It provides a 10-year warranty on all installations, and its equipment manufacturers provide warranties of 20-25 years for solar panels and 10 years for inverters and racking systems. The firm offers lifetime telephone assistance with all of its systems.

Namaste has established working partnerships with a variety of companies and organizations, including Ben'Jamin Electric, the Boulder Chamber of Commerce, the Boulder Shelter for the Homeless, the Center for Resource Conservation, the CoSEIA Solar Defense/Offense Fund, Daj Design, Inc., Del Pueblo Elementary School -- Legacy Schools Project, Eco-Cycle, Harvard Communities, KGNU Community Radio Station, McStain Neighborhoods, Partnership for Sustainability, Solar Energy International, and Western Resource Advocates.

VIII.D.16. SolSource, Inc.

SolSource, Inc. was founded in 2003 and is headquartered in Denver. The company is composed of mechanical engineers, systems designers, installers, and sales managers with backgrounds in business, HVAC controls, and construction. It has 15 employees, including seven degreed technologists, five installers, and two project managers. It provides systems design and engineering, sales, construction, installation, and management services for PV and solar thermal systems. Approximately half its clientele is residential and half is commercial.

As an engineering, procurement, and contracting firm, SolSource provides complete systems design, installation, and project management services. Each division specializes in supporting commercial property owners, custom builders, and homeowners to enhance the sustainability of their living and working environments. The firm has three divisions: Solar Energy Solutions, Green Building Products, and Construction Services:

- Solar Energy Solutions includes an extensive line of solar electric (photovoltaic), solar heating, and solar thermal systems.
- Green Building Products provides EcoShake roofing shingles and Ultra Touch “natural cotton fiber” insulation.
- Construction Services provides design, engineering, installation, and system commissioning services for solar energy, small scale wind, and green building systems.

The firm’s clients span the state and include architects, builders, private firms, school districts, municipalities, military facilities, and homeowners. From PV systems to Solarwall, to energy audits, to ultra energy efficient structural insulation and recycled

cellulose fiber roof shingles, SolSource proves environmentally friendly and cost-effective solutions. Its goal is to be a comprehensive source for sustainable products and technical integration that mainstreams energy efficient, healthy, and green powered buildings. SolSource offers a full complement of solar electric, solar thermal, and solar heating systems and provides an integrated approach to reducing energy consumption.

While the firm's primary focus is supporting residential, commercial, and institutional clients, it also provides services on a contract basis, and its construction equipment is available for rent by other contractors. Since 2003, SolSource has installed over 750 kW's of PV on over 150 homes, businesses, and schools throughout Colorado.

VIII.D.17. Terra Verde Architects, LLC

Terra Verde Architects is an architecture and interior design firm located in Boulder and was founded in 1996. It has 11 employees, all of them college graduates, and its clientele is 85 percent residential and 15 percent commercial. It specializes in sustainable design and construction of homes and commercial structures using green building practices.

The firm specializes in custom homes and resort projects of all sizes, styles, and price ranges across the country. Terra Verde is dedicated to the principles of sustainability and is recognized internationally for its work in sustainable design and green building practices. It offers a full range of professional services that include:

- Residential Architecture – custom homes and remodels
- Interior Design
- Design/Build
- Community Planning
- Commercial Architecture

Terra Verde's design portfolio encompasses everything from Western Ranch style, log and timber frame, to neo-traditional and contemporary architecture. The firm's principals and staff are active members of the American Institute of Architects (AIA), the United States Green Building Council (USGBC) and the National Association of Home Builders (NAHB).

VIII.D.18. Vestas American Wind Technology

Vestas is the one of the world's leading suppliers of wind energy technologies and is establishing manufacturing operations in Windsor and Brighton. During 2007, about 600 construction jobs were created in developing the Vestas facility, and by the end of the year the company had established 135 production jobs in Colorado. By the fall of 2008, Vestas had over 300 production employees in the state and the facility was

producing blades for 600 wind turbines annually. The Windsor plant will eventually employ over 600 workers at its 400,000-square-foot plant, and Vestas has announced further expansion plans in the state: Two other plants will be completed In 2010 in Brighton, one to manufacture blades and the other to manufacture nacelles for the generators. These new plants will eventually employ an additional 1,400 workers. Vestas clientele is commercial and utilities.

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

The company's core business is the development, manufacture, sale, and maintenance of wind technology that uses wind energy to generate electricity. Vestas wind turbines generate 60 million MWh annually, and over the past 25 years the company has increased the generator effect from its wind turbines a hundredfold. It offers various products to support functionality in regard to the electricity grid and can meet most of the requirements set by authorities and transmission companies worldwide. Vestas products are developed so that their functionality and performance are configured to meet specific grid connection requirements.

Vestas has an extensive portfolio of turbines which are each suited to specific conditions and requirements, including:

- kW - V52-850 kW
- MW – V82-1.65 MW
- 2.0 MW – V80-2.0 MW and V90-1.8/2.0 MW
- 3.0 MW – V90-3.0 MW

Vestas services offered include:

- Planning wind power projects
- Dimensioning wind power projects
- Selecting wind turbine types
- Installing wind farms
- Commissioning and monitoring wind farms
- Servicing and maintenance throughout the lifetime of the wind turbines
- Wind measurements
- Site evaluation
- Grid requirements and connection
- SCADA

VestasOnline® Business is the company's SCADA system for wind power plants. It is a flexible system that includes an extensive range of monitoring and control functions allowing wind power plants to be controlled in the same way as a conventional

power plant. A central server controls the continuous collection, storage, and intelligent processing of data from the entire wind power plant. VestasOnline® Business is based on an advanced SCADA platform that allows the exchange of data with external units such as weather stations and other monitoring systems. A power plant controller provides active and reactive power regulation, power ramping, and voltage control.

Vestas' patented technologies include:

- CFD – mapping wind currents
- OptiTip® – optimum blade positioning
- OptiSpeed® – increased power in changing wind conditions
- Active Stall® - maximum energy, minimum load

Vestas has the world's largest research and development unit in the wind industry, and it is focused on improving the reliability and performance of wind turbines. Researchers continuously monitor a large number of turbines in operation, both in order to determine how the designs can be optimized and to use the data and knowledge to make turbine operation even more reliable and cost-effective. Before introducing a new type of wind turbine, Vestas tests the energy production, power quality, and noise level -- factors crucial to the quality and competitive edge of a turbine. After completing a comprehensive testing procedure, the firm has an independent analyst verify the results.

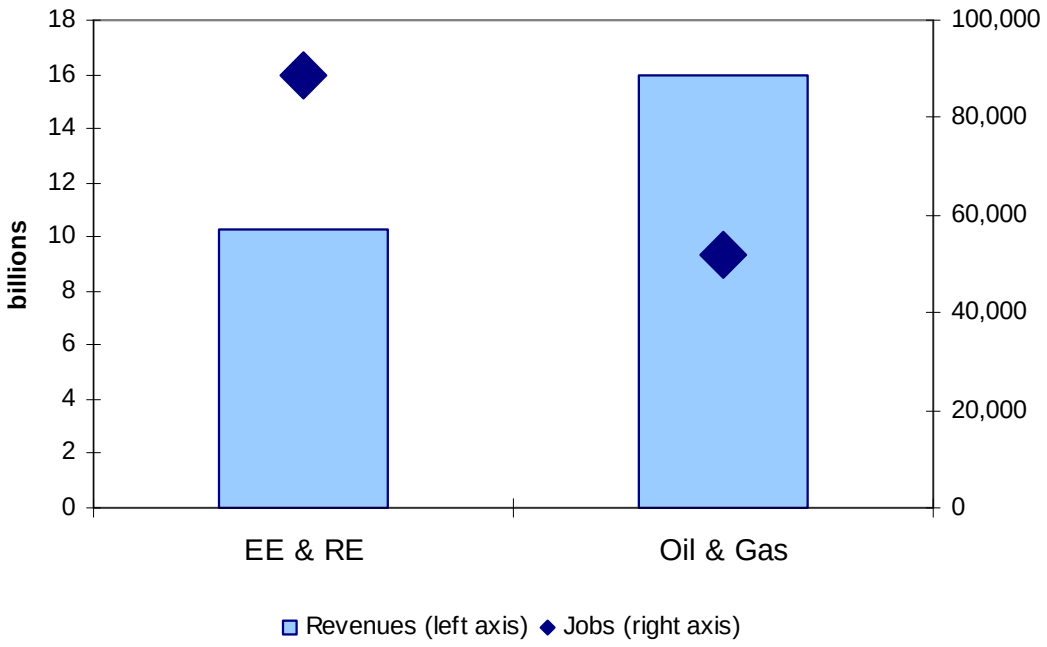
IX. COMPARISON OF THE RE&EE SECTOR IN COLORADO TO THE OIL AND GAS SECTOR

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

These comparative impacts of the sectors are illustrated in Figures IX-1 and IX-2:

- Figure IX-1 shows the economic and jobs impact on Colorado of the aggregate EE&RE sector and the aggregate O&G sector
- Figure IX-2 illustrates the same information for RE, EE, O&G extraction, and O&G drilling, completion and recompletion

Figure IX-1
Comparative Economic and Jobs Impact in Colorado of the RE&EE Sector and the O&G Sector



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

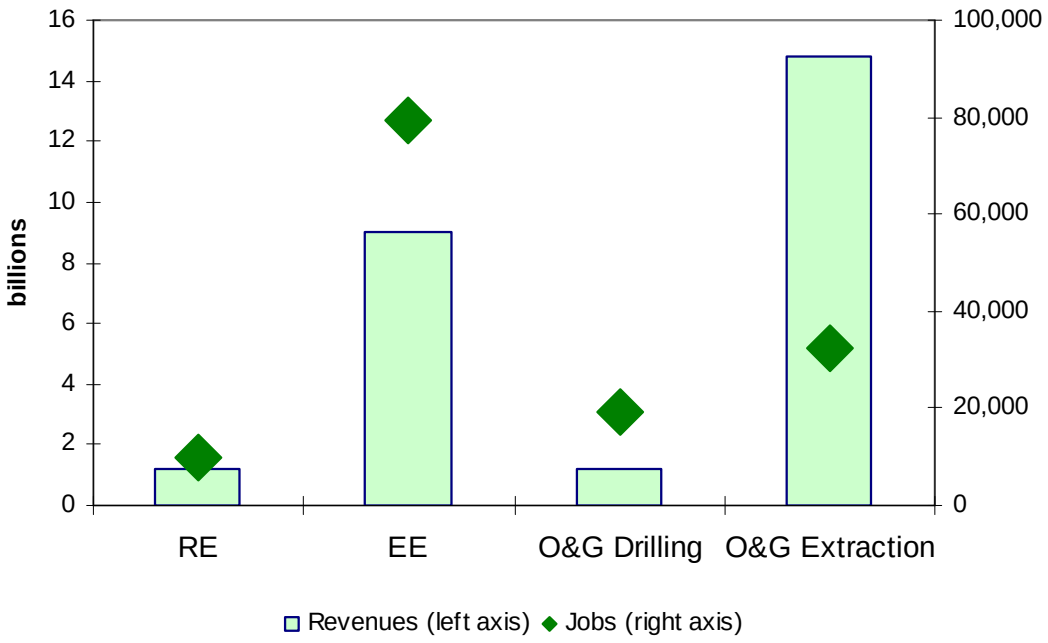
[1]Colorado Energy Research Institute, *Oil and Gas Impact Analysis*, June 2007.

Figure IX-1 shows that, in terms of revenues, the O&G sector in Colorado is more that 50 percent larger ($5.7 billion) than the EE&RE sector. However, the RE&EE sector generates about 70 percent more jobs (39,000) than the O&G sector. Thus, the RE&EE sector in Colorado generates (directly and indirectly) more than 2.5 times as many jobs per dollar of revenues as does the O&G sector in the state.

Figure IX-2 disaggregates these data into the two component parts of each sector and illustrates that jobs generation per dollar of revenues differs dramatically among the four industries:

- RE generates about 9,300 jobs per billion dollars of revenues
- EE generates about 8,900 jobs per billion dollars of revenues
- O&G drilling, completion, and recompletion generates about 16,000 jobs per billion dollars of revenues
- O&G extraction generates about 2,200 jobs per billion dollars of revenues

Figure IX-2
Comparative Economic and Jobs Impact in Colorado of
RE, EE, O&G Extraction, and O&G Drilling, Completion and Recompletion

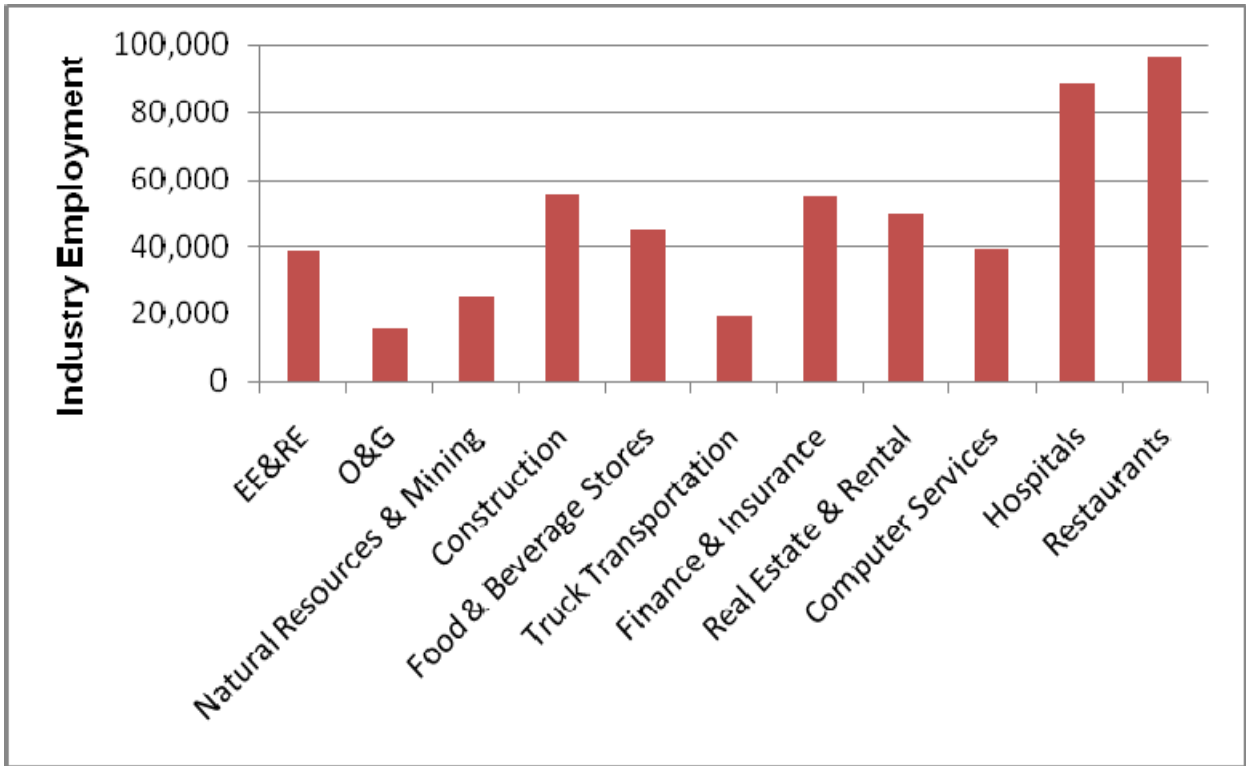


Source: Management Information Services, Inc. and American Solar Energy Society, 2008.

Figure IX-3 shows employment in selected Colorado industries and illustrates how employment in the EE&RE and the O&G sectors compares to employment in various industries:

- Employment in the O&G sector is relatively small compared to most other major industries in the state
- Employment in the RE&EE sector is larger than that in the O&G sector and is also larger than employment in natural resources and mining or in truck transportation
- RE&EE employment is about equal to employment in the computer services industry and in food and beverage stores
- RE&EE employment is somewhat smaller than employment in construction, finance and insurance, or real estate and rental.
- RE&EE employment is less than half that in hospitals or in restaurants

Figure IX-3
Employment in Selected Colorado Industries



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

X. THE COLORADO RENEWABLE ENERGY AND ENERGY EFFICIENCY INDUSTRIES IN 2030

X.A. Drivers for the Colorado Renewable Energy and Energy Efficiency

X.A.1. State Government Initiatives

As discussed, the Colorado base case forecast scenario to 2030 assumes no legislation, programs, initiatives, or incentives that were not in place in 2007 – this is standard practice. The two alternative forecast scenarios – especially the advanced scenario – assume the implementation of various state policies and incentives and private sector initiatives favorable to RE&EE. Some of the major of these are summarized below.

The Colorado Climate Action Plan

The Plan envisions training thousands of workers to improve energy efficiency in homes, stores and factories, and training thousands of others to build wind farms, solar facilities and geothermal plants across the state. Under the plan, Colorado state government will:

- Enact "bridge strategies" that immediately reduce greenhouse gas emissions while pursuing technologies to generate cleaner energy.
- Provide leadership to ensure that long-term solutions, such as renewable energy, are fully developed and broadly implemented.

The Greenhouse Gas Emissions reduction targets are:

- By 2020, reduce greenhouse gas emissions by 20 percent below 2005 levels.
- By 2050, reduce greenhouse gas emissions by 80 percent below 2005 levels.

Transportation sector initiatives include:

- Reducing emissions from passenger vehicles by adopting greenhouse gas emissions standards.
- Expediting broadband access statewide to expand teleworking and teleconferencing options for business, education and government.
- Increasing clean transportation options for state employees through the Greening of State Government program.
- Recognizing community excellence in land use and transportation in the Governor's Annual Awards of Excellence in Sustainability.

Utility sector initiatives to provide greener electricity include:

- Establish a goal for major electric utilities to reduce greenhouse gas emissions by 20 percent by 2020 and work with smaller electric utilities to set comparable goals to reduce greenhouse gas emissions.
- Give utilities flexibility to meet the 2020 goal while encouraging broad implementation of energy efficiency measures that are cost effective, create jobs, and save consumers money.
- Expand renewable energy resources.

Research and Innovation initiatives for Renewable Energy include:

- Partner with research institutions and industry to expand research and development.
- Promote the research and development of new energy resource technologies through the Colorado Renewable Energy Collaboratory.

Recycling/Solid Waste initiatives include:

- Establish a state government waste diversion goal of 75 percent by 2020.
- Expand Greening of State Government to implement a three-bin strategy throughout state government.

Leadership initiatives include:

- The Governor's Energy Office "Best Practices" website.
- Reduce state government energy consumption by 20 percent by 2012.
- Reduce petroleum use in state vehicle fleet by 25 percent by 2012.
- Use performance contract financing to audit and make energy efficiency improvements to state buildings and K-12 schools.
- Increase E-85 fueling stations statewide.

Education and workforce initiatives include:

- Partner with K-12 educators to develop and teach sustainability curricula.
- Partner with higher education to educate the work force needed for the New Energy Economy.
- Utilize the Governor's Jobs Cabinet to create a well-trained workforce for the New Energy Economy.

Greening of State Government

The Greening of State Government Executive Orders charge state departments, agencies, and offices to take a position of leadership in the new energy economy. State government will reduce energy consumption, increase the use of renewable energy sources, increase the energy efficiency and decrease the environmental impact of the state vehicle fleet, implement environmental purchasing standards, and reduce waste and increase recycling. Greening Government enables State employees to take a position of leadership in the New Energy Economy through energy conservation and efficiency, thereby reducing the environmental impact of state operations. Specific mandates include:

- 20% reduction in energy use
- 20% reduction in paper use
- 10% reduction in water consumption
- 25% volumetric reduction in state vehicle petroleum consumption
- Each state department and campus will create a sustainability management system to track and report their greening government performance.

The New Energy Economy: Bringing It Home

This is a statewide energy efficiency and conservation campaign which features television and radio advertisements to educate homeowners, individuals, and consumers about low-cost and simple steps to save energy. The campaign will provide basic advice and tips on how to save money at home and at work, such as:

- "Turn it Down!" Install and use a programmable thermostat or adjust the temperature down when away from home.
- "Unplug it!" Unplug electronics, such as cell phone chargers, when not in use, or install a power strip for controlling devices such as computers, TVs, and entertainment systems.
- "Turn it Off" Turn off the lights when leaving a room and install energy efficient compact fluorescent lights (CFLs).

The goal of this campaign is to help homeowners and consumers across the state to take control of their energy use by starting with these simple steps.

New Energy Communities Initiative

This is part of Colorado's New Energy Economy initiative, and the goal is to maximize energy efficiency and conservation, enhance community livability, promote economic development in downtowns, and address climate change by reducing carbon emissions. The Imitative will focus on three areas:

- Greening Public Facilities - Assist partnerships among counties, municipalities, school districts and other local governments to upgrade, retrofit or develop energy efficient public facilities such as county courthouses, city halls, public works facilities, libraries, judicial facilities and community centers.
- Greening Downtowns - Provide technical and financial resources for energy efficient upgrades/retrofits, streetscape improvements and downtown revitalization.
- Greening Homes - Provide the necessary technical resources to aid local governments in educating homeowners on programs to incorporate energy efficient upgrades/retrofits and adopting model building codes to ensure that new housing units meet higher energy efficiency standards.

Other Colorado State Initiatives

Colorado offers:

- Rebates to qualifying members of participating jurisdictions for the installation of insulation, air sealing measures, solar electric systems, solar domestic hot water systems and small wind turbines.
- A variety of income-based programs, including free energy efficiency upgrades and information about energy efficiency and financial incentives for homes
- Energy efficiency programs for new and retrofit construction
- Matching grants to select program partners with the goal of developing local solar electric and solar domestic hot water system rebate programs. Program partners take part in either the Solar Electric or Solar Domestic Hot Water program and, in some cases, both.
- The Solar Electric Program offers rebates of up to $6,000 per system to qualified homeowners through their local partner.
- The Solar Domestic Hot Water Program offers rebates of up to $3,000 per system to qualified homeowners through their local partner.

The Governor's Energy Office (GEO):

- Is partnering with four utility companies to offer a rebate for Small Wind Turbine installations.
- Is developing energy efficiency and renewable energy programs for new and retrofit construction. GEO is working with local jurisdictions and homebuilders throughout Colorado to encourage implementation of ENERGY STAR New Homes programs, Built Green Colorado High Performance Homes, Design Assistance

services, and financing options for the installation of renewable energy technologies.

- Works in close partnership with building departments to provide energy code training, information, and other resources to support local adoption and implementation of the 2006 International Energy Conservation Code (2006 IECG). GEO currently offers energy code workshops, featuring full day training on both commercial and residential energy codes, specifically the 2006 IECC.
- Is assisting schools reduce their energy costs and allocate the savings toward improved facilities and academics. GEO has developed two programs: The Performance Contracting program to serve existing facilities, and the High Performance Design program for new facilities.
- Has streamlined the process for choosing an ESCO by providing a list of 11 pre-approved ESCOs that will provide the highest level of service and dependability.

X.A.2. Private Sector Initiatives

In addition to, and at least partly as a result of state government policies and incentives, a number of private sector RE&EE initiatives are under way in Colorado; for example:

- The Danish company Vestas is developing a major wind turbine manufacturing facility in Windsor. It will be a 200,000 $ft.^2$ facility on 75 acres, and represents a $60 million investment that will eventually employ more than 600 workers. Construction was initiated in 2007 and production began in early 2008. The company stated "Establishing a blade production in Colorado is an important step forward in our strategy to grow our business in the North American market. We are confident that we have chosen the right location for our blade factory in the USA."
- AVA Solar Inc., a spin-off from Colorado State University, is planning to build a manufacturing plant in Colorado that will use new technology to manufacture cheaper solar panels. The new factory will employ 500 people and will be capable of producing enough solar panels a year to generate 200 megawatts of power. Production is expected to begin by the end of 2008.
- Lakewood-based Abengoa Solar has announced that it will build what it calls the largest solar power plant in the world. Abengoa Solar is a subsidiary of Abengoa S.A., a $4 billion multinational company based in Spain. The plant will be located 70 miles southwest of Phoenix, near Gila Bend, Arizona and is scheduled to go into operation by 2011.

- In 2005, the Colorado School of Mines established the Colorado Fuel Cell Center (CFCC) to advance fuel-cell research, development, and commercialization and to promote business opportunities in Colorado. The CFCC was created with funding from the Governor's Energy Office and co-funding from four partnering organizations. In July 2006, the CFCC was granted status as a Colorado School of Mines research center. The CFCC is managed by a faculty panel consisting of CSM faculty members using the facilities to perform research.
- ConocoPhillips plans to open an international learning center and alternative energy/advanced research center at the end of 2011 on a 432 acre campus in Louisville. The facility will eventually employ 7,000 workers. According to the company, "The leadership thinking of our global alternative energy efforts will be based right here in Louisville, Colorado. This is going to be absolutely critical to ConocoPhillips."
- Colorado State University has announced plans for a unique school to train green collar workers. The school, at CSU's Fort Collins campus, will be called the School of Global Environmental Sustainability and will serve students from various disciplines.
- IBM Corp. has opened a 115,000-square-foot “green data center” -- the first of its kind for the company -- at its campus in Boulder. IBM invested $350 million in the center to meet demand for more energy efficient data centers and to assist itself and its clients reduce energy costs. The data center is part of IBM’s Project Big Green, a program where IBM will invest $1 billion per year to help customers increase the energy efficiency in their data centers. IBM received $732,000 in incentives from the city of Boulder and the Colorado Office of Economic Development and International Trade to help support the Boulder data center.
- California-based REC Solar Inc. has established a commercial division in Westminster. REC Solar, based in San Luis Obispo, California installs residential and commercial solar-electric systems and will target businesses, school districts, and government facilities within Xcel Energy's solar rebate territory. The facility will employ 15 workers, a combination of installation crews, salespeople and engineers, and expects to double its Colorado workforce. The company stated "REC Solar is excited about expanding our presence in Colorado and working with businesses that see the triple bottom line benefits of solar. For the past three years the solar industry in the United States has grown an average of 40 percent, and REC Solar expects to see a 200 percent increase in business in Colorado. With its terrific incentives and progressive populace, Colorado is poised to be a solar leader -- creating green-collar jobs that boost the economy and benefit the environment."

- Renewable Energy Systems Americas Inc., a British developer and builder of wind energy farms, is moving its U.S. headquarters from Austin, Texas to Broomfield. RES-Americas plans to relocate 70 full-time jobs from Texas and add another 70 positions within the next year for a total of 140 employees in Broomfield. The company will receive economic incentives from Broomfield for the move. Founded in 1997, RES-Americas has grown to become one of the country's leading wind farm developers, actively participating in developing more than 12 percent of the installed wind power capacity in the United States. In addition, RES-Americas currently ranks second in number of total megawatts constructed in North America. The company stated "Colorado offers geographic proximity to RES-Americas operations, a business and political atmosphere that is supportive of renewable efforts and a welcoming environment for a high standard of living for RES-Americas employees. Colorado has demonstrated immense leadership in the development of renewable resources and alternative energy. We are proud to now join that effort."
- Siemens Energy has announced that it will establish a new U.S. wind turbine research and development center in Boulder. The new facility will eventually employ about 50 people and will focus on atmospheric science research, aerodynamic blade design, structural dynamics, wind turbine dispatch prediction and reliability. Siemens will test basic wind turbine characteristics and verify new performance enhancing features and turbine reliability under severe weather conditions for a minimum period of three years. The company stated "We are very pleased to establish our first wind turbine R&D competence center in Boulder. The proximity of important institutions such as NREL and the NWTC, as well as the support received from the state of Colorado and the city of Boulder, make Boulder the perfect location for a R&D center in the U.S."

X.B. Industry Forecasts for 2030

Tables X-1, X-2, X-3, X-4, and X-5 summarize the RE&EE industries in Colorado in 2030 under the three scenarios:

- Table X-1 shows the revenues of the RE industry in Colorado in 2030 under the three scenarios
- Table X-2 shows the jobs created by the RE industry in Colorado in 2030 under the three scenarios
- Table X-3 shows the revenues of the EE industry in Colorado in 2030 under the three scenarios
- Table X-4 shows the jobs created by the EE industry in Colorado in 2030 under the three scenarios

- Table X-5 summarizes the EE&RE industries in Colorado in 2030 under the three scenarios

Table X-1
The Colorado Renewable Energy Industry in 2030
(Millions of 2007 Dollars)

Industry Segment	Base Case	Moderate Scenario	Advanced Scenario
Wind	$325	$1,100	$5,200
Photovoltaics	200	350	900
Solar Thermal	7	30	950
Hydroelectric Power	75	80	100
Geothermal	45	100	400
Biomass			
Ethanol	500	800	1,300
Biodiesel	25	40	150
Biomass Power	40	75	400
Fuel Cells and Hydrogen	150	325	1,200
Total, Private Industry	1,367	2,900	10,600
Federal Government*	700	900	2,500
State and Local Government	3	4	11
Total Government	703	904	2,511
Other Sectors**	6	7	20
TOTAL, ALL SECTORS	$2,076	$3,811	$13,131

*Includes Federal employees, Federal laboratory employees, and support contractors.
**Includes universities, trade and professional associations, NGOs, consultants, investment company analysts, etc.

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

Table X-1 shows that for the RE industry in Colorado, in 2030:

- Under the Base Case, RE revenues (2007 dollars) total $2.1 billion
- Under the Moderate Scenario, they total $3.8 billion
- Under the Advanced Scenario they total $13.1 billion

Table X-2
Colorado Jobs Created by Renewable Energy Industry in 2030
Total Jobs Created

Industry Segment	Base Case	Moderate Scenario	Advanced Scenario
Wind	2,250	7,300	34,100
Photovoltaics	2,300	3,800	10,500
Solar Thermal	150	650	18,900
Hydroelectric Power	325	350	450
Geothermal	500	1,100	4,300
Biomass			
Ethanol	1,500	1,900	3,800
Biodiesel	500	800	2,600
Biomass Power	300	550	2,800
Fuel Cells and Hydrogen	1,250	2,600	8,700
Total, Private Industry	9,075	19,050	86,150
Federal Government*	8,100	10,100	26,600
State and Local Government	75	100	275
Total Government	8,175	10,200	26,875
Other Sectors**	120	150	350
TOTAL, ALL SECTORS	17,370	29,400	113,375

*Includes Federal employees, Federal laboratory employees, and support contractors.
**Includes universities, trade and professional associations, NGOs, consultants, investment company analysts, etc.

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

Table X-2 shows that for the RE industry in Colorado, in 2030:

- Under the Base Case, RE generates over 17,000 jobs
- Under the Moderate Scenario, RE generates over 29,000 jobs
- Under the Advanced Scenario RE generates over 113,000 jobs

Thus, in 2030 under the Advanced Scenario, RE revenues and jobs in Colorado would be about seven-fold greater than under the Base Case.

Table X-3
The Colorado Energy Efficiency Industry in 2030
(Millions of 2007 Dollars)

Industry Segment	Base Case	Moderate Scenario	Advanced Scenario
ESCO	$200	$250	$600
Recycling, reuse, & remanufacturing	3,100	3,400	7,000
Vehicle manufacturing	300	370	950
Household appliances and lighting	275	325	900
Windows and doors	450	520	1,400
Computers, copiers, FAX machines, etc.	1,050	1,170	2,900
TV, Video, and Audio equipment	1,450	1,600	3,800
HVAC systems	500	650	1,550
Industrial and related machinery	375	450	975
Miscellaneous durable manufacturing	4,000	4,500	8,400
Nondurable manufacturing	4,100	4,600	8,800
Utilities	80	120	380
Construction	1,500	2,150	9,700
Total, Private Industry	17,630	20,405	48,055
Federal government EE spending	8	10	25
State and local government EE spending	40	60	250
Total Government	48	70	275
Other Sectors	3	4	15
TOTAL, ALL SECTORS	$17,681	$20,479	$48,345

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

Table X-3 shows that for the EE industry in Colorado, in 2030:

- Under the Base Case, EE revenues (2007 dollars) total $17.7 billion
- Under the Moderate Scenario, they total $20.5 billion
- Under the Advanced Scenario they total $48.3 billion

Table X-4
Colorado Jobs Created by Energy Efficiency in 2030
Total Jobs Created

Industry Segment	Base Case	Moderate Scenario	Advanced Scenario
ESCO	2,100	2,700	5,600
Recycling, reuse, & remanufacturing	29,800	33,400	64,650
Vehicle manufacturing	1,450	1,750	4,500
Household appliances and lighting	2,200	2,650	7,750
Windows and doors	3,950	4,750	13,400
Computers, copiers, FAX machines, etc.	11,300	12,700	23,800
TV, Video, and Audio equipment	13,600	15,200	35,100
HVAC systems	4,100	5,600	12,800
Industrial and related machinery	3,200	3,935	8,300
Miscellaneous durable manufacturing	52,100	59,400	108,000
Nondurable manufacturing	25,900	28,900	55,800
Utilities	600	950	3,300
Construction	23,800	35,700	153,100
Total, Private Industry	174,100	207,635	496,100
Federal government EE spending	140	175	400
State and local government EE spending	500	730	2,850
Total Government	640	905	3,250
EE Trade and Professional Associations and NGOs*	70	80	200
TOTAL, ALL SECTORS	174,810	208,620	499,550

*Includes universities, trade and professional associations, NGOs, consultants, investment company analysts, etc.

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

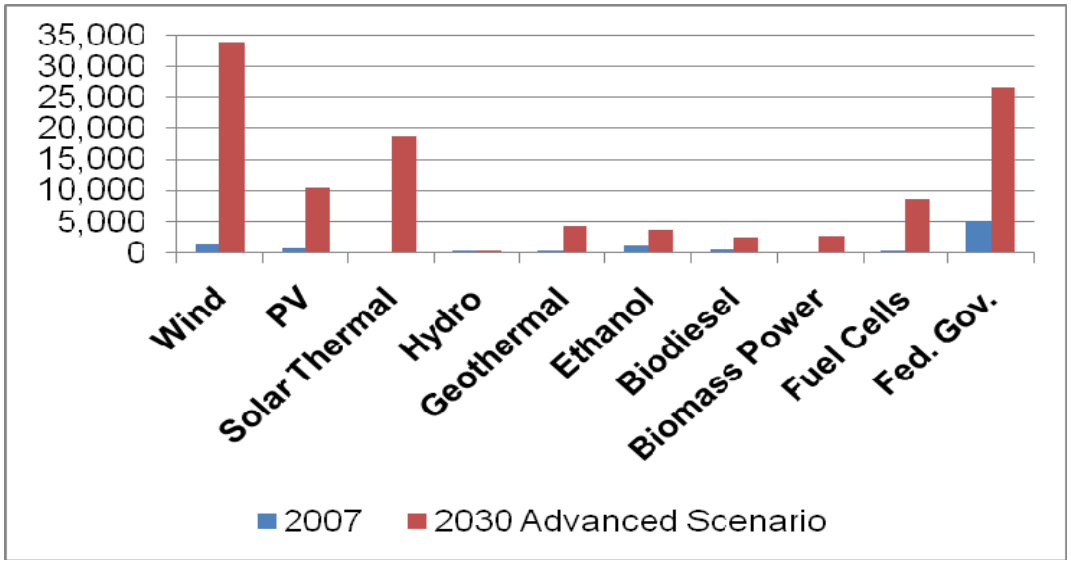
Table X-4 shows that for the EE industry in Colorado, in 2030:

- Under the Base Case, EE generates nearly 175,000 jobs
- Under the Moderate Scenario, EE generates nearly 209,000 jobs
- Under the Advanced Scenario EE generates nearly 500,000 jobs

Thus, in 2030 under the Advanced Scenario, EE revenues and jobs in Colorado would be about three-fold greater than under the Base Case.

Another way to view the future RE potential in Colorado is to compare the 2030 Advanced Scenario with the existing RE industry in the state, as illustrated in Figure X-1. This figure shows the potential increases in RE-related jobs in the state that result from ambitious RE initiatives. It is seen that especially large job increases are possible in the areas of wind, photovoltaics, solar thermal, and fuel cells.

Figure X-1
Total Jobs Created by RE in Colorado:
2007 Actual and in 2030 Under the Advanced Scenario



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

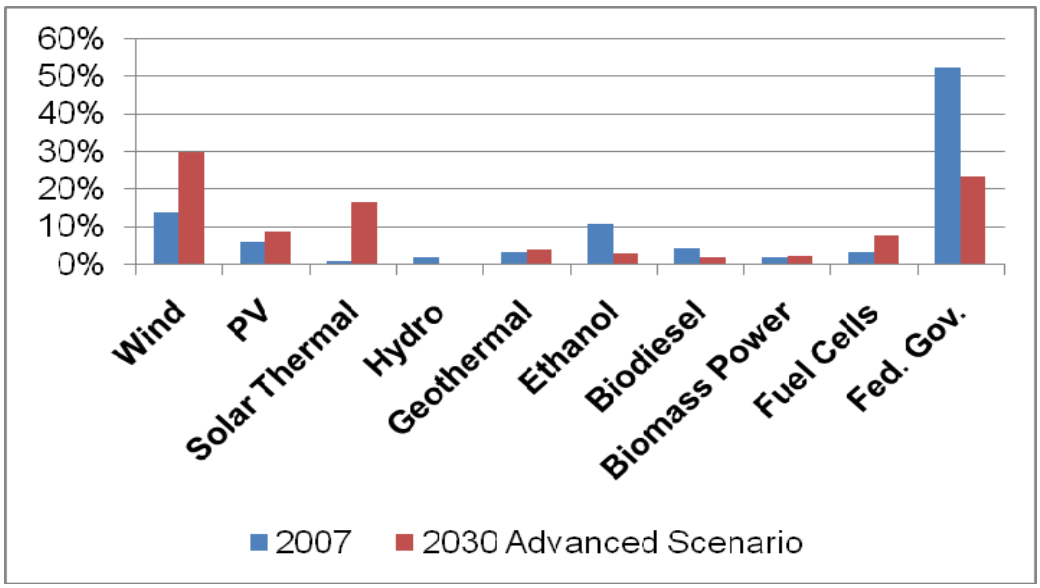
As shown in Figure X-2, the relative distribution of total RE jobs between 2007 and the 2030 Advanced Scenario changes significantly. The percentage of total RE jobs generated in some RE sectors declines markedly; for example:

- The percentage of jobs generated in the federal sector declines from 52 percent to 23 percent.
- The percentage of jobs generated in the hydroelectricity sector declines from two percent to less than 0.5 percent.
- The percentage of jobs generated in the ethanol sector declines from 11 percent to three percent.
- The percentage of jobs generated in the biodiesel sector declines from five percent to two percent.

On the other hand, the percentage of total RE jobs generated in some RE sectors increases markedly; for example:

- The percentage of jobs generated in the solar thermal sector increases from one percent to 17 percent.
- The percentage of total jobs generated in the wind sector increases from 14 percent to 30 percent.
- The percentage of total jobs generated in the fuel cells sector increases from three percent to eight percent.
- The percentage of total jobs generated in the PV sector increases from six percent to nine percent.

Figure X-2
Percent Distribution of Jobs Generated by RE in Colorado:
2007 Actual and 2030 Advanced Scenario

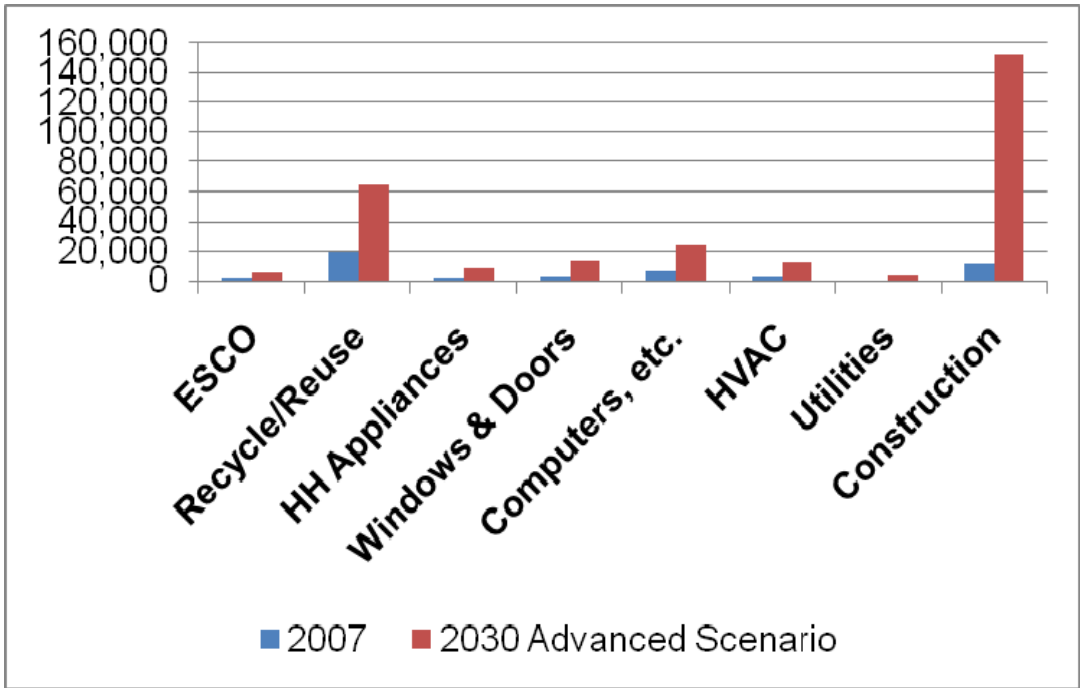


Source : Management Information Services, Inc. and American Solar Energy Society, 2008.

We can assess the future EE potential in Colorado by comparing the 2030 Advanced Scenario with the existing EE industry in the state, as illustrated in Figure X-3. This figure shows the potential increases in EE-related jobs in the state that result from ambitious EE initiatives. It is seen that:

- Especially large percentage increases in jobs generated occur in the windows and doors, HVAC, utilities, and construction sector.
- The salient feature of this table is the dominance in 2030 of the green construction industry.
- In 2007, green construction accounted for less than 14 percent of all EE-generated jobs in Colorado
- In 2030, green construction may account for nearly 30 percent of all EE-generated jobs in Colorado

Figure X-3
Total Jobs Created by EE in Colorado:
2007 Actual and in 2030 Under the Advanced Scenario



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

Table X-5 summarizes the Colorado RE&EE industries in 2030 under the three scenarios. It shows that under the advanced scenario:

- The RE industry is more than six times larger than under the base case, and generates nearly 100,000 more jobs
- The EE industry is about three times larger than under the base case, and generates 410,000 more jobs

Comparing Table X-5 with Table VIII-3 indicates that, while EE will continue to be, by far, the largest portion of the Colorado RE&EE industry, since RE is growing more rapidly it will become a large portion of the combined sector. For example:

- In 2007 in Colorado, the RE industry was a little over ten percent of the combined RE&EE sector
- In 2030 in Colorado under the advanced scenario, the RE industry will comprise nearly 20 percent of the combined RE&EE sector

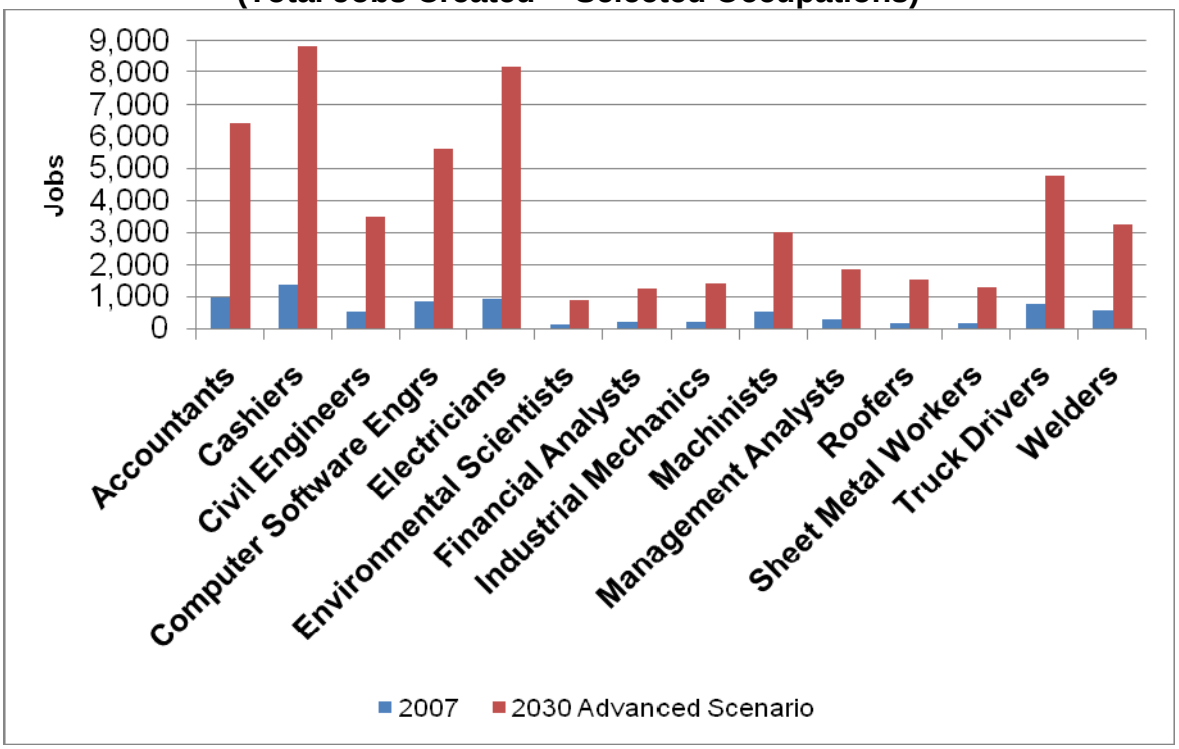
Table X-5
Summary of the Colorado Renewable Energy and Energy Efficiency Industries in 2030

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

Source: Management Information Services, Inc., 2008.

As discussed in Chapter VIII and illustrated in Figure X-4, 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. and most of the persons employed in these jobs may not even realize that they owe their livelihood to renewable energy. This was true in 2007 (as illustrated in Table VIII-5) and will also be true in 2030, as shown in Table X-6, which lists the jobs created by RE&EE in Colorado in 2030 within selected occupations under the advanced scenario. The major difference is that the number of RE&EE jobs created in Colorado in 2030 under the advanced scenario is nearly seven times the number of RE&EE jobs in the state in 2007.

Figure X-4
Colorado Jobs Created By RE&EE in 2030 Compared to 2007
(Total Jobs Created -- Selected Occupations)



Source: Management Information Services, Inc., 2008.

Table X-6 shows that in 2030 under the advanced scenario RE&EE will generate in Colorado:

- More jobs for cashiers (8,847) than for recyclable materials collectors (743)
- More jobs for order clerks (1,382) than for environmental engineers (750)
- More jobs for executive secretaries (8,567) than for waste treatment plant operators (2,461)
- More jobs for janitors (8,165) than for environmental scientists and specialists (882)
- More jobs for customer service representatives (9,305) than for roofers (1,481)
- More jobs for accountants and auditors (6,448) than for civil engineers (3,491)
- More jobs for truck drivers (4,796) than for electric power line workers (791)
- More jobs for stock clerks (6,245) than for HVAC mechanics and installers (1,789)
- More jobs for security guards (4,691) than for welders (3,250)
- More jobs for computer business operations specialists (6,467) than for sheet metal workers (1,279)

Thus, many Colorado workers will be dependent on RE&EE for their employment, although they often would have no way of recognizing that connection unless it is brought to their attention.

Table X-6
RE&EE Jobs Generated in Colorado in 2030
Under the Advanced Scenario, by Selected Occupations

Occupation	Jobs
Accountants and Auditors	6,448
Bookkeeping and Accounting Clerks	8,383
Business Operations Specialists	6,467
Cashiers	8,847
Construction Managers	2,350
Civil Engineers	3,491
Computer Software Engineers	5,612
Computer Support Specialists	2,498
Customer Service Representatives	9,305
Electrical Power Line Workers	791
Electricians	8,176
Electronics Engineers	2,403
Environmental Engineers	750
Environmental Scientists and Specialists	882
Executive Secretaries and Administrative Assistants	8,567
Financial Analysts	1,228
Glaziers	1,350
HVAC Mechanics and Installers	1,789
Industrial Engineers	1,572
Industrial Machinery Mechanics	1,363
Inspectors, Testers, and Sorters	2,714
Janitors and Cleaners	8,165
Machinists	3,009
Management Analysts	1,859
Marketing Managers	871
Mechanical Engineers	1,467
Order Clerks	1,382
Roofers	1,481
Plumbers, Pipefitters, and Steamfitters	4,100
Recyclable Materials Collectors	743
Security Guards	4,691
Sheet Metal Workers	1,279
Stock Clerks	6,245
Truck Drivers	4,796
Waste Treatment Plant Operators	2,461
Welders and Solderers	3,250

Source: Management Information Services, Inc., 2008.

XI. IMPLICATIONS FOR SKILLS, TRAINING, AND EDUCATIONAL REQUIREMENTS

XI.A. Renewable Energy, Energy Efficiency, and Related Occupations

Occupational data demonstrate that the RE&EE industries create a variety of high-paying jobs, many of which take advantage of manufacturing skills currently going unused as manufacturing continues to undergo restructuring in the U.S. and in Colorado. Regions with traditional manufacturing economies can recruit RE&EE companies to take advantage of their highly skilled workforces, since, as illustrated in Table VIII-4, wind turbine manufacturing requires plant operators, machinists, mechanics, engineers, welders, etc.

As shown in Table XI-1, wages and salaries in many sectors of the RE&EE and related industries are higher than U.S. average wages. Although many high-tech industries almost exclusively require highly educated workers with masters or doctoral degrees, as noted, the RE&EE industry requires a wide variety of occupations. Nevertheless, many occupations in the RE&EE industry include jobs which 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 Colorado – and other states. With a wide variety of the required skills as well as ongoing research into RE&EE technologies, communities in Colorado can choose to build clusters around different segments of the RE industries. However, Colorado must recognize that it is in fierce competition as communities around the U.S. compete for new emerging energy industries with traditional university-centered research areas, including Palo Alto (Stanford University), Ann Arbor (University of Michigan), Trenton (Princeton University), the Research Triangle in North Carolina, and other university-industry complexes. In addition, Colorado must compete for RE&EE jobs with traditional high-tech metropolitan areas like San Jose, Boston, 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 industries makes this market easier to penetrate if Colorado can market its strengths in high-tech, research, education, and construction and operation.

Table XI-1
Renewable Energy, Energy Efficiency, and Related Occupations:
Wages, Educational Requirements, and Growth Forecasts
(Selected Occupations)

Occupation	10 year % Growth Forecast	Median Salary	% With Bachelor's Degree	Education
Materials Scientists	8	$75,800	94	Bachelor's
Physicists	7	93,300	92	Doctoral
Microbiologists	17	64,600	96	Doctoral
Biological Technicians	17	37,200	60	Associate
Conservation Scientists	6	54,800	88	Bachelor's
Chemists	7	64,800	94	Bachelor's
Chemical Technicians	4	40,900	27	Associate
Geoscientists	6	74,700	94	Doctoral
Natural Science Managers	14	101,000	90	Bachelor's
Environmental Eng. Technicians	24	42,800	18	Associate
Soil and Plant Scientists	20	59,100	64	Bachelor's
Mechanical Eng. Technicians	12	47,400	18	Associate
Environmental Sci. Technicians	16	39,100	47	Associate
Biomedical Engineers	31	76,900	60	Bachelor's
Chemical Engineers	11	80,800	92	Bachelor's
Mechanical Engineers	10	78,600	88	Bachelor's
Electrical Engineers	12	77,700	83	Bachelor's
Environmental Engineers	14	76,000	82	Bachelor's
Computer Scientists	26	95,900	67	Doctoral
Life & Physical Sci. Technicians	20	46,100	50	Associate
Utility Plant Operatives	4	54,100	10	OJT
HVAC Technicians	12	38,300	14	OJT
Energy Audit Specialists	18	40,300	18	OJT
Forest & Conservation Workers	6	27,500	8	OJT
Refuse & Recycling Workers	5	26,400	2	OJT
Insulation Workers	6	$30,800	2	OJT

Source: Management Information Services, Inc. and U.S. Bureau of Labor Statistics, 2008.

XI.B. Emerging Renewable Energy and Energy Efficiency Jobs, Occupations, and Skills

Continued and increased growth in the RE&EE sector of the U.S. economy will lead to vast new employment opportunities as businesses expand to meet the new, clean, and sustainable energy requirements. Jobs will be created across a new spectrum of work activities, skill levels, and responsibilities. Many of these jobs do not currently exist and do not have occupational titles defined in federal and state government occupational classifications and standards. In addition, many of these new jobs require a different set of skills than current jobs, and training requirements must be assessed so that this rapidly growing sector of the U.S. economy and labor market has an adequate pool of trained and qualified job applicants. At some point in the future many of these occupations will grow in the number of employees classified in the occupation and the federal government will add them to the employment classification system. Until that time, economic and employment analysis and forecasting is usually conducted using the current set of U.S. Labor Department occupational titles.[1]

Tables XI-2 through X-12 identify by occupational title some of the new, green RE&EE jobs that will be created in the expanding RE&EE energy economy.[2] The listings of jobs spans a broad range of what can be classified as "green," (see the discussion in Chapter II), starting with the mainstream renewable energy technologies of solar thermal and photovoltaics, including traditional energy efficiency technologies related to buildings and transportation, and also including a range of jobs related to climate change, carbon capture and storage (CCS), and carbon markets. Many new occupations originating from consulting, research, government, and non-profit institutions are listed separately and have not been specifically classified in a particular RE or EE sector or green technology area.

New occupational titles are listed in the first column of each of the tables. The average Colorado salary, listed in the second column, represents the average of the starting salary and highest salary for that occupation. Wages may be 15-20 percent lower at the beginning of employment and may rise to a level 15-20 percent higher as the person becomes an experienced employee.[3] In addition, wages and salaries are usually much higher in urban areas than in rural areas.

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[1]These are listed in the *2000 Standard Occupational Classification Code*, U.S. Department of Labor, Bureau of Labor Statistics.

[2]We derived these data primarily from the Environmental Defense Fund's September 2008 report, *Green Jobs Guidebook: Employment Opportunities in the New Clean Economy,* a report that specifically addressed the California economy. We revised and adjusted these estimates to account for gaps in the information, to relate specifically to the industries, technologies, and sectors of interest here, and to reflect average Colorado salaries. A variety of other necessary changes were made to make this information useful and relevant here.

[3]As noted, these salary and wage estimates have been adjusted to reflect average Colorado state salary and wage levels.

The third and final column lists the minimum recommended educational attainment to gain entry into that occupation, and a recommended degree is listed for the advanced educational requirements. Obviously, employers will not hold fast to these recommendations, but this information can be useful to educational planners in providing an idea of the knowledge and skills that the employer is seeking in a candidate. Note that the education requirements listed include N/A (no requirement), HSD/GED (high school degree or General Education Development), and Apprenticeship/TS (trade school) to a Master's degree. With the more advanced (Bachelor's degree and up) college requirements, some standard abbreviations were used to further define the recommended degree: CE, ME, EE – for chemical, mechanical, and electrical engineer degrees, etc. Also note that many jobs can be filled by a candidate with one of several related Science or Engineering degrees and they are listed generically as such.

XI.C. Emerging Colorado Renewable Energy Occupations, Salaries, and Skills and Education Requirements

Tables XI-2 through XI-6 show some of the emerging job opportunities and corresponding salaries and education/training requirements in RE in Colorado. These tables illustrate that:

- Salaries vary widely, from $20,000 - $25,000 for solar and biomass technicians, to nearly $140,000 for a director of wind development.
- Educational requirements span the gamut from apprenticeship/ trade school and HSD/GED to advanced college degrees.
- However, there are a wide variety of jobs and education training requirements, and many of the jobs do not require college degrees.
- Similar jobs in different RE industries can have different salaries and education/training requirements. For example, a solar lab technician in Colorado may require an Associate Degree and earn a salary of nearly $41,000, whereas a wind field technician in the state may require only a HSD/GED earn a salary of less than $26,000.
- Similarly, a hydroelectric engineer in Colorado with a Bachelors Degree may earn more than $87,000, whereas a solar energy engineer in Colorado with a Bachelors Degree may earn only a little more than $71,000.
- There exist numerous career paths that allow employees with apprenticeship/TS and HSD/GED to earn relatively high salaries, such as solar operations engineer, solar thermoelectric plant manager, solar residential or commercial electrician foreman, wind field service technician, hydroelectric plant installation technician, and geothermal plant efficiency operator.

Table XI-2
Emerging Colorado Jobs, Salaries, and Educational Requirements in the Solar and PV Industry

Occupational Title	Average Salary	Minimum Education
Solar fabrication technician	$23,092	HSD/GED
Solar lab technician	$40,664	Associate's
Solar hot water heater manufacturing technician	$45,264	Associate's
PV fabrication and testing technician	$45,264	Associate's
Solar energy system installer helper	$23,092	HSD/GED
Solar energy system installer	$31,372	HSD/GED
Solar and PV installation, Roofer	$35,144	HSD/GED
Solar residential installation electrician	$44,344	HSD/GED
Solar commercial installation electrician	$44,344	HSD/GED
Instrumentation/Controls/Electrical systems technician	$35,144	HSD/GED
Solar commercial installation engineering technician	$47,104	Associate's
Solar residential installation electrician foreman	$58,236	HSD/GED
Solar commercial installation electrician foreman	$58,236	Apprenticeship/TS
Solar commercial installation engineer	$74,796	Bachelor's (EE)
Solar energy systems designer	$47,104	Apprenticeship/TS
Solar thermoelectric plant manager	$74,520	Apprenticeship/TS
Solar operations engineer	$87,400	HSD/GED
PV solar cell designer	$77,280	Master's (Science)
Solar energy engineer	$71,300	Bachelor's (Engineer)
PV power systems engineer	$75,440	Master's (EE)
Residential/Commercial solar sales consultant	$59,800	Bachelor's (Business)

Source: Environmental Defense Fund and Management Information Services, Inc., 2008.

Table XI-3
Emerging Colorado Jobs, Salaries, and Educational Requirements in the Wind Industry

Occupational Title	Average Salary	Minimum Education
Wind turbine machinist	$30,452	Apprenticeship/TS
Wind turbine sheet metal worker	$33,212	Apprenticeship/TS
Wind turbine engineering intern	$6,440	HSD/GED
Wind farm electrical system designer	$59,800	Bachelor's (Engineer)
Wind turbine electrical engineer	$87,400	Bachelor's (EE)
Wind turbine mechanical engineer	$87,400	Bachelor's (ME)
Wind field technician	$25,852	HSD/GED
Junior renewable energy technician	$29,532	N/A
Wind generating installer	$31,372	HSD/GED
Electro-mechanical wind turbine technician	$35,144	Associate's
Wind field operations manager for commercial applications	$48,024	Bachelor's (Engineer)
Wind field service technician	$44,344	Apprenticeship/TS
Wind power plant project engineer	$69,000	Bachelor's (Engineer)
Director of wind development	$138,000	Bachelor's (Business)

Source: Environmental Defense Fund and Management Information Services, Inc., 2008.

Table XI-4
Emerging Colorado Jobs, Salaries, and Educational Requirements in the Hydroelectric Industry

Occupational Title	Average Salary	Minimum Education
Hydro-electric component machinist	$30,452	Apprenticeship/TS
Hydro-electric construction sheet metal worker	$33,212	Apprenticeship/TS
Hydro-electric operations maintenance worker	$44,344	HSD/GED
Hydro-electric plant efficiency operator	$45,264	HSD/GED
Hydro-electric plant installation technician	$64,676	Apprenticeship/TS
Hydro-electric plant electrical operations supervisor	$78,200	Associate's
Hydro-electric power generation engineer	$105,800	Bachelor's (ME)
Hydro-electric engineering intern	$6,440	HSD/GED
Hydrologist-Hydrogeologist	$62,882	Bachelor's (Science)
Hydro-electric mechanical engineer	$87,400	Bachelor's (ME)
Hydro-electric electrical engineer	$87,400	Bachelor's (EE)
Hydro-electric structural engineer	$73,600	Bachelor's (CE)
Marine/fisheries biologist	$52,624	Bachelor's (Science)

Source: Environmental Defense Fund and Management Information Services, Inc., 2008.

Table XI-5

Emerging Colorado Jobs, Salaries, and Educational Requirements in the Geothermal Industry

Occupational Title	Average Salary	Minimum Education
Geothermal heat pump machinist	$30,452	Apprenticeship/TS
Geothermal sheet metal worker	$33,212	Apprenticeship/TS
Geothermal engineering intern	$6,440	HSD/GED
Geothermal electrical engineer	$87,400	Bachelor's (EE)
Geothermal power generation engineer	$105,800	Bachelor's (ME)
Geothermal plant installation technician	$46,184	HSD/GED
Geothermal plant efficiency operator	$51,704	HSD/GED
Geothermal operations engineer	$69,000	Bachelor's (Engineer)
Hydrogeologist	$62,882	Bachelor's (Science)
Geothermal mechanical engineer	$87,400	Bachelor's (ME)
Geothermal electrical engineer	$87,400	Bachelor's (EE)
Geothermal power plant structural engineer	$67,160	Bachelor's (CE)

Source: Environmental Defense Fund and Management Information Services, Inc., 2008.

Table XI-6
Emerging Colorado Jobs, Salaries, and Educational Requirements in the Biogas, Biomass, and Hydrogen Industries

Occupational Title	Average Salary	Minimum Education
Landfill gas collection system operator	$40,664	Apprenticeship/TS
Landfill gas system technician	$23,092	HSD/GED
LGE plant installation, operations, engineering & management	$69,000	Bachelor's (Engineer)
Animal waste biomethane gas collection system technician	$40,664	Apprenticeship/TS
Biomass collection, separation and sorting	$21,252	HSD/GED
Biomass plant operations, engineering and maintenance	$69,000	Bachelor's (Engineer)
Hydrogen power plant installation, operations, engineering. & mgt.	$69,000	Bachelor's (CE)
Hydrogen plant operator and operations manager	$94,208	Bachelor's (Engineer)

Source: Environmental Defense Fund and Management Information Services, Inc., 2008.

XI.D. Emerging Colorado Energy Efficiency Occupations, Salaries, and Skills and Education Requirements

Tables XI-7 through XI-9 show some of the emerging job opportunities and corresponding salaries and education/training requirements in EE in Colorado. These tables illustrate that:

- Salaries vary widely, from less than $25,000 for energy field auditors, agricultural workers, and recycling collections drivers to about $115,000 for environmental construction engineers.
- Educational requirements span the gamut from apprenticeship/ trade school and HSD/GED to advanced college degrees.
- However, there are a wide variety of jobs and education training requirements, and many of the jobs do not require college degrees.
- This is especially true in the green buildings sector, where most of the jobs do not require college degrees.
- On the other hand, most of the jobs in the transportation and energy storage industries tend to require college degrees.
- Salaries tend to be higher in the transportation and energy storage industries than in the green buildings or the waste management industries.
- There exist numerous career paths that allow employees with apprenticeship/TS and HSD/GED to earn relatively high salaries, such as field energy consultant, building maintenance engineer, roofing and skylight installer, and hydrogen pipeline construction worker.

Table XI-7
Emerging Colorado Jobs, Salaries, and Educational Requirements in the Green Buildings Industry

Occupational Title	Average Salary	Minimum Education
Field energy consultant	$60,076	HSD/GED
Energy conservation representative	$48,024	HSD/GED
Energy manager & analyst	$82,800	Bachelor's (various)
Energy efficiency finance manager	$82,800	Bachelor's (Business)
Environmental compliance specialist	$46,184	Bachelor's (Science)
Engineering intern	$6,440	HSD/GED
Water systems designer and engineer	$36,984	Apprenticeship/TS
Site supervising technical director	$45,264	Bachelor's (Engineer)
Refrigeration engineer	$73,876	Bachelor's (Engineer)
Lighting & HVAC engineer	$77,280	Bachelor's (Engineer)
Civil engineer	$72,220	Bachelor's (CE)
HVAC engineer	$77,556	Apprenticeship/TS
Electrical engineer	$71,760	Bachelor's (EE)
Residential green building and retrofit architect	$90,620	Bachelor's (Architect)
Commercial green building and retrofit architect	$90,620	Bachelor's (Architect)
Indoor & outdoor landscape architect	$68,080	Bachelor's (Science)
Industrial green systems & retrofit designer	$90,620	Bachelor's (Architect)
Senior HVAC engineer	$89,700	Bachelor's (ME)
Environmental construction engineer	$115,000	Bachelor's (CE)
Energy engineer	$71,300	Bachelor's (Engineer)
Structural design engineer	$74,980	Master's (CE)
Home improvement retrofit trainee	$29,532	N/A
Residential air sealing technician	$31,372	HSD/GED
Insulation installer	$20,332	HSD/GED
HVAC maintenance & repair trainee	$32,292	HSD/GED
Water purification systems service technician	$39,744	HSD/GED
Building maintenance engineer	$64,676	HSD/GED
Machinist	$30,452	Apprenticeship/TS
Welder	$29,532	Apprenticeship/TS
Carpenter	$35,144	Apprenticeship/TS
Electrical system installer	$44,344	Apprenticeship/TS
Field technician	$57,224	Apprenticeship/TS
Green plumber and pipefitter	$60,076	Apprenticeship/TS
HVAC service technician	$48,944	Apprenticeship/TS
Roofing and skylight installer	$52,624	Apprenticeship/TS
Weatherization operations manager	$80,040	Bachelor's (various)
Residential energy field auditor	$24,012	Associate's
Commercial energy field auditor	$24,012	Associate's
Industrial energy field auditor	$24,012	Bachelor's (Science)
Auditing services sales consultant	$59,800	Bachelor's (Business)
Renewable energy consultant	$80,500	Master's (Science)

Source: Environmental Defense Fund and Management Information Services, Inc., 2008.

Table XI-8
Emerging Colorado Jobs, Salaries, and Educational Requirements in the Transportation and Energy Storage Industries

Occupational Title	Average Salary	Minimum Education
Automotive plant assembly	$48,024	HSD/GED
Diesel retrofit installer	$41,584	HSD/GED
Diesel retrofit manufacturer plant labor	$41,584	Apprenticeship/TS
Electric vehicle electrician	$44,344	HSD/GED
Hybrid powertrain development engineer	$69,000	Bachelor's (Engineer)
Powertrain control systems & software engineer	$69,000	Bachelor's (Engineer)
Air pollution specialist	$63,480	Bachelor's (Science)
Senior automotive power electronics engineer	$69,000	Bachelor's (Engineer)
Diesel retrofit designer	$75,440	Master's (Engineer)
Bus system operator	$25,852	N/A
Train system operator	$40,664	HSD/GED
Electric shipyard operator	$40,664	HSD/GED
Biofuel plant field & operations engineer	$69,000	Bachelor's (Engineer)
Biofuel plant field technician	$46,184	HSD/GED
Biodiesel/biofuel technology & product develpmnt. manager	$59,800	Bachelor's (Science)
Alternative fuels policy analyst & business sales	$55,200	Bachelor's (Business)
Agricultural/farm worker	$21,252	N/A
Civil Engineer - agriculture/irrigation/water supply	$92,000	Bachelor's (CE)
Fueling station designer & project engineer	$73,600	Bachelor's (Engineer)
Fuel transporter - trucker	$36,984	HSD/GED
Alternative fueling station operations	$29,532	HSD/GED
Hydrogen pipeline construction	$46,184	HSD/GED
Program manager, environmental construction	$72,220	Bachelor's (Engineer)
Urban planner	$55,384	Bachelor's (Urban Planning)
Environmental engineering manager	$66,838	Bachelor's (Science)
Environmental planner	$61,916	Bachelor's (Science)
Civil engineer	$72,220	Bachelor's (CE)
Energy infrastructure engineer	$77,280	Bachelor's (ME)
Environmental engineer	$48,024	Bachelor's (Engineer)
Battery design engineer	$69,000	Bachelor's (CE)
Battery testing technician	$33,212	Associate's
Battery manufacturing technician	$24,932	HSD/GED

Source: Environmental Defense Fund and Management Information Services, Inc., 2008.

Table XI-9
Emerging Colorado Jobs, Salaries, and Educational Requirements in the Waste Management Industry

Occupational Title	Average Salary	Minimum Education
Recycling collections driver	$19,412	N/A
Recycling center operator	$26,772	N/A
Hazardous materials removal worker	$41,584	HSD/GED
Hazardous waste management specialist	$55,384	Bachelor's (Science)
Solid waste (energy) engineer	$73,600	Bachelor's (Engineer)
Nuclear waste management engineer	$89,700	Bachelor's (NE)
Operations maintenance worker for water services	$36,064	HSD/GED
Associate engineer - wastewater treatment	$70,840	Bachelor's (ME)
Wastewater engineer in industrial facilities	$80,500	Bachelor's (Engineer)
Wastewater plant civil engineer	$71,760	Bachelor's (CE)

Source: Environmental Defense Fund and Management Information Services, Inc., 2008.

XI.E. Emerging Colorado Green Occupations, Salaries, and Skills and Education Requirements in Consulting, Research, Non-Profits, Government, and Carbon Management

Tables XI-10 through XI-12 show some of the emerging green job opportunities and corresponding salaries and education/training requirements in the consulting, research, nonprofit, government, and carbon management sectors in Colorado. These tables illustrate that:

- The average salaries are considerably higher than in the RE or EE sectors, with most jobs paying in excess of $40,000.
- Educational requirements are relatively stringent, and most of the jobs require at least a Bachelor's degree.
- With a few exceptions, such as environmental technician, forestry worker, and power system operator, there is a lack of employment opportunities and career pathways for persons with apprenticeship/ TS and HSD/GED qualifications.

Table XI-10
Emerging Colorado Green Jobs, Salaries, and Educational Requirements in the Consulting, Research, and Non-Profit Industries

Occupational Title	Average Salary	Minimum Education
Environmental technician	$42,780	Associate's
Air quality control engineer	$92,000	Bachelor's (CE)
Greenhouse gas emissions permitting consultant	$63,940	Bachelor's (Science)
Air pollution specialist	$63,480	Bachelor's (Science)
Air resource engineer	$72,220	Bachelor's (Engineer)
Emissions accounting & reporting consultant	$64,400	Bachelor's (various)
Greenhouse gas emissions report verifier	$55,200	Bachelor's (Science)
Water/wastewater quality consultant	$75,440	Bachelor's (Science)
Water resource consultant	$75,440	Bachelor's (Science)
Senior environmental consultant	$78,660	Bachelor's (Science)
Waste reduction, energy efficiency & expert consultant	$64,400	Bachelor's (Science)
Renewable energy consultant	$75,440	Master's (various)
Conservation policy analyst & advocate	$41,400	Bachelor's (Science)
Climate change & energy policy specialist & advocate	$41,400	Master's (Various)
Water resources policy specialist & advocate	$41,400	Bachelor's (Science)

Source: Environmental Defense Fund and Management Information Services, Inc., 2008.

Table XI-11
Emerging Colorado Green Jobs, Salaries, and Educational Requirements in Government

Occupational Title	Average Salary	Minimum Education
Energy commission specialist	$70,380	Bachelor's (various)
Smart grid engineer	$91,080	Master's (EE)
Power system operator	$50,784	HSD/GED
Marine/fisheries biologist	$52,624	Bachelor's (Science)
Water resource engineer	$63,940	Bachelor's (Science)
Environmental research manager	$73,876	Master's (Science)
GIS specialist	$47,380	Bachelor's (Geography)
Engineering geologist	$62,836	Bachelor's (Engineer)
Urban planner	$55,384	Bachelor's (Urban Planning)
Urban renewal planner	$74,704	Master's (Urban Planning)
Conservation of resources commissioner	$90,344	Master's (various)
Power systems operator and instructor	$50,784	HSD/GED
Air quality specialist & enforcement officer	$61,916	Bachelor's (Science)
Air emissions permitting engineer	$64,676	Bachelor's (Science)
Chemist	$63,940	Bachelor's (Chemistry)
Economist	$74,060	Bachelor's (Economics)

Source: Environmental Defense Fund and Management Information Services, Inc., 2008.

Table XI-12
Emerging Jobs, Salaries, and Educational Requirements in the Carbon Management Industry

Occupational Title	Average Salary	Minimum Education
Carbon capture power plant installation, operations, eng. & mgt.	$69,000	Bachelor's (Engineer)
Carbon sequestration plant installation, operations, eng. & mgt.	$69,000	Bachelor's (Engineer)
Geologist & hydrogeologist	$66,010	Bachelor's (Science)
GIS specialist	$47,380	Bachelor's (Geography)
Environmental health & safety engineering manager	$76,360	Bachelor's (Science)
Environmental health & safety lead	$81,420	Master's (Science)
Plant technical specialist - safety instrument testing & repair	$64,400	Bachelor's (various)
Safety investigator - cause analyst	$88,320	Bachelor's (various)
Plant supervising technical operator	$52,624	Bachelor's (Engineer)
Plant safety engineer	$90,620	Bachelor's (various)
Soil conservation technician	$36,984	Bachelor's (Science)
Soil conservationist	$51,704	Bachelor's (Science)
Forestry conservation worker	$34,132	HSD/GED
Conservation forestry consultant	$74,796	Associate's
Forestry supervisor	$41,584	Bachelor's (Forestry)
Restoration planner	$72,220	Master's (Science)
Power marketing specialist	$63,480	Bachelor's (various)
Energy trading specialist	$63,480	Bachelor's (various)
Carbon emission specialist	$63,480	Bachelor's (various)
Market & rate analyst	$72,680	Bachelor's (Business)
Economist	$74,060	Bachelor's (Economics)
Emissions reduction credit marketer & market analyst	$72,680	Bachelor's (Business)
Emissions reduction credit portfolio manager	$46,460	Bachelor's (Business)
Emissions reduction project developer specialist	$63,480	Bachelor's (various)
Emissions reduction project manager	$78,200	Bachelor's (various)
Environmental sampling technician	$35,144	HSD/GED
Climatologist	$69,000	Bachelor's (Science)
Environmental scientist	$69,000	Bachelor's (Science)
Environmental engineer/scientist intern	$6,440	HSD/GED

Source: Environmental Defense Fund and Management Information Services, Inc., 2008.

XII. POLICY IMPLICATIONS FOR COLORADO

XII.A. Findings

Several important policy implications for Colorado emerge from this research.

First, the RE industry in the state is small and, except for the federal sector – primarily NREL -- does not currently play a major role in the state economy or job market. For example, in 2007:

- RE accounted for less than 0.6 percent of Colorado gross state product
- Excluding NREL, RE accounted for less than 0.4 percent of Colorado GSP.
- The total jobs created by RE accounted for only about 0.4 percent of total Colorado employment
- Excluding NREL, direct employment in the RE industry represents only about 0.2 percent of total state employment

Nevertheless, nationwide, Colorado is (even excluding NREL) a disproportionately large player in some RE technologies. For example, although Colorado gross state product (GSP) accounts for only about 1.7 percent of U.S. GDP, in 2007 Colorado had:

- About six percent of the U.S. wind market
- Nearly six percent of the U.S. photovoltaics market
- About five percent of the U.S. ethanol market
- About five percent of the U.S. biodiesel market

On the other hand, Colorado has a disproportionately small share of some other RE markets, such as hydroelectric power, geothermal, and biomass power.

Third, despite various proposals that have been made in recent years to use RE as a job creation program for the disadvantaged, the chronically unemployed, or for other target populations, this is simply not feasible at present in Colorado.

Total employment in Colorado is over 2.6 million and unemployment totals over 100,000. The total number of jobs generated by RE (excluding NREL) is only about 4,600, and direct RE employment (excluding NREL) is only about 2,000. Excluding jobs that are not realistic targets for retraining the unemployed or those lacking adequate skills or training – such as jobs in R&D, hydropower, biomass power, DOE laboratories, financial institutions, etc. – leaves direct RE employment in the state at about 1,500 jobs. Even if RE jobs grew 10 percent annually, this would create only about 150 new jobs each year. And, if most of these were somehow allocated to the unemployed – which is not a realistic assumption, the impact on state unemployment would still be negligible.

Fourth, when EE is considered in conjunction with RE, the situation changes. Combined, RE&EE created over 91,000 jobs in Colorado in 2007, nearly 40,000 of which were employment in the industries. Both sectors – but especially RE – are forecast to grow more rapidly than the state economy as a whole: The current total of about 91,000 jobs generated by RE&EE in Colorado may increase to over 600,000 within 20 years. This rapid growth of jobs from a large base of employment provides both challenges and opportunities for the Colorado education, apprenticeship, and job training programs over the coming decades.

Fifth, Colorado is well positioned to facilitate and to take advantage of rapid growth in the RE&EE industries – especially compared to many other states. Section VII.A described the numerous state government and private industry RE&EE initiatives that are already underway. These types of industry and job creation initiatives combined with educational initiatives, such as the recently announced School of Global Environmental Sustainability at Colorado State University, and the presence of NREL should place Colorado firmly in the forefront of the development and growth of the RE&EE sector for the foreseeable future.

Sixth, RE&EE represents an effective job creation mechanism. For example, RE&EE creates, per dollar of expenditure, 3.5 times as many jobs as the oil and gas sector in Colorado. RE&EE creates more than 8,600 jobs per billion dollar of expenditure, whereas the O&G sector creates about 2,500 jobs per billion dollar of expenditure.

Seventh, the longer the U.S. and Colorado delay implementing ambitious RE&EE programs and incentives, the more difficult it will be to achieve the goals outlined here for 2030. Every year's delay at the front end, e.g., 2008, 2009, 2010, has a highly disproportionate and negative impact on the achievement of the long term RE&EE 2030 goals. Time is of the essence, and time lost in the next several years will be very difficult to make up. Thus to achieve the 2030 RE&EE goals, appropriate policies and incentives must be implemented as soon as possible – at both the U.S. and the Colorado state levels.

Finally, a goal of this project is to derive policy recommendations that will enable Colorado education professionals to create programs to better facilitate the emerging RE&EE industry in the state. The major finding that emerges is that education and training programs will have to be developed and expanded in the near future to facilitate the anticipated growth of RE&EE. However, most of these programs should, in the immediate future at least, focus on the EE sector simply because there are about eight times as many EE jobs in the state as RE jobs. RE jobs will increase in the future more in percentage terms, but the overwhelming number of jobs created over the next two decades in the RE&EE sector in Colorado will be related to EE.

Of course, many of the RE&EE jobs, skills, and education and training requirements overlap. For example, the largest number of jobs that will be created in the RE&EE sector are related to energy efficient construction and green buildings. Green

buildings are designed to meet certain objectives such as protecting occupant health, improving employee productivity, using energy, water, and other resources more efficiently, and reducing the overall impact on the environment. Green buildings contain important elements of both RE&EE, and subcategories of green buildings include:

- Energy efficient buildings – buildings designed and operated to maximize energy conservation and minimize energy consumption
- Renewable energy buildings: Buildings making maximum use of renewable energy technologies such as photovoltaics, solar thermal, passive solar, etc.
- Zero energy buildings: Buildings that consume no net energy
- Negative energy buildings: Buildings that produce excess energy that is sold to the grid

Another example of RE&EE overlap is the rapidly growing market for "Green IT" – which involves the use of computer resources in an energy and environmentally efficient way. A green IT product or service is one that delivers comparable or superior performance, utility, or other benefits to an alternative one while utilizing fewer resources, containing fewer toxic materials, and having a longer lifecycle. Green criteria include energy efficiency, using low-emission building materials, recycling, using RE technologies, and other green strategies. Notably:

- Firms in all sectors of the U.S. economy are becoming increasingly concerned about rapidly rising IT energy costs.
- IT energy consumption and energy efficiency have recently become a priority focus for many companies.
- The potential energy cost savings are generally acknowledged to be enormous, and estimates are that IT energy costs can be reduced by between 40 and 60 percent with currently available technology and methods.
- Companies and organizations will soon have no choice but to "green" their IT standards, since the federal and many state governments are developing prescriptive standards.
- A large number of both small and large companies (including firms in Colorado) have entered the market with "Green IT" products and services that combine elements of both RE&EE.

It is thus clear that the jobs, skills, and education and training requirements required for green buildings, green IT, and other sectors and technologies contain important elements of both RE and EE.

XII.B. Challenges and Opportunities

The challenge is to identify the types of jobs, skills, and education and training requirements corresponding to the employment opportunities that will be created by RE&EE in the coming decades. We here provide information that can assist the state's educational planners in identifying these opportunities. We have identified over 160 detailed RE&EE occupational specialties and corresponding salaries and education and training requirements. These illustrate that RE&EE currently, and will increasingly in the future, create numerous job opportunities for workers in many different sectors, at all education and skill levels, at a wide range of salaries. For example, RE&EE will create numerous job opportunities for workers with only an HSD/GED, such as (with corresponding salaries):

- Solar energy system installer ($31,400)
- Solar installation electrician ($44,350)
- Wind field technician ($25,900)
- Wind generating installer ($31,400)
- Hydroelectric plant efficiency operator ($45,300)
- Geothermal plant installation technician ($46,200
- Landfill gas system technician ($23,100)
- Energy conservation representative ($48,100)
- Residential air sealing technician ($31,400)
- Diesel retrofit installer ($41,600)
- Battery manufacturing technician ($24,900)
- Recycling center operator ($26,800)
- Power system operator ($50,800)
- Forestry conservation worker ($34,100)

RE&EE will create numerous job opportunities for workers with apprenticeship/ TS qualifications, such as (with corresponding salaries):

- Solar systems designer ($47,100)
- Wind turbine machinist ($30,500)
- Hydroelectric component machinist ($30,500)
- Geothermal sheet metal worker ($33,200)
- Landfill gas collection system operator ($40,700)
- HVAC engineer ($77,300)
- Electrical system installer ($44,300)
- Carpenter ($35,100)
- Diesel retrofit manufacturer worker ($41,600)

RE&EE will also create numerous job opportunities for workers with Associate's degrees, such as (with corresponding salaries):

- Solar lab technician ($40,700)
- Solar installation engineering technician ($47,100)
- Wind turbine technician ($35,100)
- Hydroelectric plant operations supervisor ($78,200)
- Energy field auditor ($24,000)
- Battery testing technician ($33,200)

Finally, RE&EE will create numerous job opportunities for workers with Bachelor and advanced degrees, such as (with corresponding salaries):

- Solar energy engineer ($71,300)
- Director of wind development ($138,000)
- Marine/fisheries biologist ($52,600)
- Hydrogeologist ($62,900)
- Geothermal power generation engineer ($105,800)
- Hydrogen plant manager ($94,200)
- Weatherization operations manager ($80,000)
- Biofuel plant engineer ($69,000)
- Engineering infrastructure engineer ($77,300)
- Hazardous waste management specialist ($55,400)
- Renewable energy consultant ($75,400)
- Urban renewal planner ($74,700)
- Energy trading specialist ($63,500)

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

In sum, renewable energy and energy efficiency offer significant development opportunities for Colorado:

- Under the advanced scenario, in 2030: RE could generate annually over $13 billion in revenues and over 113,000 jobs and EE could generate annually nearly $44 billion in revenues and 500,000 jobs
- Employment growth in RE&EE varies among sectors: Growing sectors include wind, architecture and engineering, R&D, ESCO, solar thermal, photovoltaics, environmental technologies, bio-fuels, power technologies, fuel cells, industrial processes, distributed generation, computer controls and systems, HVAC systems, and others
- RE&EE create a variety of high-paying jobs, many of which take advantage of Colorado's educational system and workforce skills

- Colorado, with its rapidly expanding RE&EE programs and infrastructure, can recruit RE&EE companies to take advantage of its skilled workforces for wind turbine manufacturing, biofuels production, green IT, fuel cell development, green buildings, etc.
- Wages in many RE&EE sectors are higher than the U.S. average, and RE&EE requires a wide mix of occupations and skills
- RE&EE occupations include many jobs that require associate's degrees, on-the-job training, or trade certifications and which pay high wages
- Unlike some industries, RE&EE is a realistic target for job creation in Colorado: State and local communities can build clusters around industry sectors
- Many entrance points make the RE&EE market easier to penetrate if Colorado can utilize its strengths in workforce, technology, manufacturing, R&D, education, etc.
- The presence of NREL gives Colorado a unique advantage in developing the RE&EE sector, especially the sophisticated R&D-oriented technologies and industries.

XII.C. A Note of Caution

A note of caution is due here with respect to the RE industry. While Colorado is relatively well positioned to participate in the emerging new energy economy, the same may not be true of many other states or the U.S. as a whole.

Contrast the U.S. with Germany – noting that the U.S. and Colorado have better RE resources than Germany:

- Germany has about ¼ the GDP and population of the U.S.
- Nevertheless:
  -- RE jobs in Germany: 249,000
  -- RE jobs in U.S.: 218,000 (31,000 less than in Germany)
  -- RE jobs in Colorado: 4,300 (two percent of the U.S. total)
  -- German RE employment has increased 16 percent over the past year
  -- U.S. RE employment has increased 12 percent over the past year
  -- We do not know how much RE employment has increased in Colorado over the past year
- The contrast within specific RE sectors is even larger; for example, in 2007:
  -- There were 17,000 jobs in the wind sector in the U.S. (600 in CO), whereas there were 84,000 jobs in the in wind sector in Germany
  -- There were 9,000 jobs in the PV sector in the U.S. (275 in CO), whereas there were 39,000 jobs in the in PV in Germany

- Germany has about 14 times the GDP of Colorado and about 16 times the population of Colorado. Nevertheless:
  -- Germany has 58 times the number of RE jobs as Colorado
  -- Germany has 140 times the number of jobs in the wind sector as CO
  -- Germany has 142 times as many jobs in the PV sector as CO
- Germany produces 1/2 of the wind rotors in the world
- Germany produces 1/3 of the solar panels in the world
- Germany leads in biodiesel; is 2nd to Japan in fuel cells and hybrids
- By 2020, German RE jobs will exceed those in machinery or in vehicle mfg.

The implications for U.S. – and Colorado – are obvious and are potentially ominous unless ambitious RE&EE policies and incentives are initiated soon.

APPENDIX: DERIVATION OF THE 2007 COLORADO RE AND EE INDUSTRIES' ESTIMATES

A.I. Derivation of the Renewable Energy Industry Estimates

In this study, renewable energy technologies are defined to consist primarily of[1]:

- Hydroelectricity
- Biomass
- Geothermal
- Wind
- Photovoltaics
- Solar thermal
- Fuel cells and hydrogen

The Colorado industry data are summarized in Table 1.

Wind

We estimate that in 2007, revenues in the wind industry in Colorado totaled about $200 million and that there were about 600 full time equivalent (FTE) jobs[2] in the wind industry in the state.

In 2007, Colorado had only about 0.2 percent of the U.S. total net wind generation. However, most of the activity in the Colorado wind industry in 2007 was the result of the development of the Vestas wind production facility. During 2007, about 600 temporary and part time construction jobs were created in developing the Vestas facility, and by the end of the year the company had established 135 permanent production jobs in Colorado. By the all of 2008, Vestas had over 300 production employees in the state and the facility was producing blades for 600 wind turbines annually. The Windsor plant will eventually employ over 600 workers at its 400,000-square-foot plant, and Vestas has announced further expansion plans in the state: Two other plants will be completed In 2010 in Brighton, one to manufacture blades and the other to manufacture nacelles for the generators. These new plants will eventually employ an additional 1,400 workers.

[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.

[2]An FTE job is defined as 2,080 hours worked in a year's time, and adjusts for part time and seasonal employment and for labor turnover. Thus, two workers each working six months of the year would be counted as one FTE job.

Table 1
The Renewable Energy Industry in Colorado, 2007

Industry Segment	Industry Revenues/ Budgets[1] (millions)	Industry Jobs[2]	Total Jobs[3]
Wind[4]	$200	600	1,400
Photovoltaics[5]	55	275	650
Solar Thermal[6]	5	40	100
Hydroelectric Power[7]	50	100	225
Geothermal[8]	30	150	350
Biomass			
Ethanol[9]	250	500	1,100

[1]Revenues for private industry; budgets for non-industry organizations.
[2]Full time equivalent (FTE) jobs in Colorado in the renewable energy industry. An FTE job is defined as 2,080 hours worked in a year's time, and adjusts for part time and seasonal employment and for labor turnover. Thus, two workers each working six months of the year would be counted as one FTE job.
[3]Total number of jobs in Colorado generated by renewable energy. Derived using the U.S. Department of Commerce, Bureau of Economic Analysis, Regional Input-Output Multipliers for Colorado.
[4]We estimate that in 2007, revenues in the wind industry in Colorado totaled about $200 million and that there were about 600 FTE jobs in the wind industry in the state. In 2007, Colorado had only about 0.2 percent of the U.S. total net wind generation. However, most of the activity in the Colorado wind industry in 2007 was the result of the development of the Vestas wind production facility. During 2007, about 600 temporary and part time construction jobs were created in developing the Vestas facility, and by the end of the year the company had established 135 permanent production jobs in Colorado.
[5]We estimate that in 2007, revenues in the PV industry in Colorado totaled about $55 million and that there were about 275 FTE jobs in the PV industry in the state. These estimates were derived from ASES and from industry sources in the state. PV activity in Colorado accounts for nearly six percent of the total U.S. PV industry.
[6]The solar thermal in Colorado consists almost exclusively of small distributed systems, although the development in Colorado of production facilities for large central station solar thermal plants in other states is being discussed. We estimate that in 2007, revenues in the solar thermal industry in Colorado totaled about $5 million and that there were about 40 FTE jobs in the solar thermal industry in the state. These estimates were derived from ASES, COSEIA, SEIA, SEPA, and from industry sources in the state.
[7]Colorado has 48 hydroelectric generating stations with a total nameplate capacity of 1,106 MW, which in 2007 generated about 1,800,000 MWh. All of these stations are small: The largest is 324 MW, but most are 10 MW or less. Hydroelectricity accounts for about three percent of total Colorado state electricity generation, but for less than one percent of total U.S. hydroelectric power. We estimate that in 2007, hydro revenues in the state totaled about $50 million and that there were about 100 FTE jobs in hydroelectric power in the state.
[8]Colorado ranks fourth among western states in the number of potential sites for geothermal power generation. However, while Colorado has geothermal direct use and aquaculture projects, the state currently has no geothermal electrical generation projects. The 2007 geothermal industry in Colorado consisted of low temperature (<194^{o} F) resources applications in space and district heating and in agricultural applications and of geothermal heat pumps that rely on the even lower, nearly consistent shallow ground temperature. Using industry sources, we estimate that in 2007, revenues in the geothermal industry in Colorado totaled about $30 million and that there were about 150 FTE jobs in the geothermal industry in the state.
[9]In 2007, Colorado had four ethanol biorefineries in operation with a capacity of about 125 million gallons per year and several more in various planning stages. We estimate that in 2007, revenues generated in

Biodiesel[1]	20	200	450
Biomass Power[2]	25	80	200
Fuel Cells and Hydrogen[3]	40	150	350
Total, Private Industry	675	2,095	4,825
Federal Government[4]	400	2,250	5,100
State and Local Government[5]	2	20	50
Total Government	402	2,270	5,150
Other Sectors[6]	5	50	100
TOTAL, ALL SECTORS	$1,082	4,415	10,075

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

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the ethanol industry in Colorado totaled about $250 million and that there were about 500 FTE jobs in the ethanol industry in the state. This accounted for a little over one percent of the U.S. ethanol industry.

[1]In 2007, Colorado had five of the nation's 90 biodiesel companies and about two dozen biodiesel stations that were selling an average of 5,000 – 40,000 gallons of biodiesel product per month. We estimate that in 2007, revenues in the biodiesel industry in Colorado totaled about $20 million and that there were about 200 FTE jobs in the biodiesel industry in the state. This accounts for about five percent of the U.S. biodiesel industry.

[2]In 2007, Colorado biomass power accounted for about 0.1 percent of the U.S. biomass power industry – about 31,000 kWh. We estimate that in 2007, revenues in the biomass power industry in Colorado totaled about $25 million and that there were about 80 FTE jobs in the industry in the state.

[3]We estimate that in 2007, fuel cell and hydrogen revenues in Colorado totaled about $40 million and that there were about 150 FTE jobs in the industry in the state. This accounts for about two percent of the U.S. industry. These estimates were derived from national and state industry sources and from telephone interviews conducted with senior staff from the Colorado Fuel Center and NREL. Most of the jobs in Colorado consist of employees involved in fuel cell projects at CoorsTek, Proponics (formerly Mesoscopic), Versa Power Systems, Fuel Cell Propulsion Inst., Protera, Inc. (formerly Mobile Energy Solutions), Barber-Nichols, Inc., Vairex Corp., the Colorado School of Mines and NREL.

[4]Includes Federal employees, Federal laboratory employees, and support contractors. Federal renewable energy activities in Colorado are dominated by the National Renewable Energy Laboratory (NREL), located in Golden. In 2007, NREL had about 2,230 total FTE staff, including 130 U.S. Department of Energy employees, about 1,250 NREL employees, and about 850 resident contractor employees. NREL's 2007 budget totaled about $382 million, including $360 million from the DOE Office of Energy Efficiency and Renewable Energy, $11 million from the DOE Office of Science, and $11 million from non-DOE sources. These data were obtained from the DOE and NREL budget and program offices.

[5]Estimated FTE state and local government employees engaged in renewable energy-related activities.

[6]Includes universities, trade and professional associations, NGOs, consultants, investment company analysts, etc.

Photovoltaics

We estimate that in 2007, revenues in the PV industry in Colorado totaled about $55 million and that there were about 275 FTE jobs in the PV industry in the state. These estimates were derived from ASES and from industry sources in the state. PV activity in Colorado accounts for nearly six percent of the total U.S. PV industry.

Solar Thermal

The solar thermal in Colorado consists almost exclusively of small distributed systems, although the development in Colorado of production facilities for large central station solar thermal plants in other states is being discussed. We estimate that in 2007, revenues in the solar thermal industry in Colorado totaled about $5 million and that there were about 40 FTE jobs in the solar thermal industry in the state. These estimates were derived from ASES, COSEIA, SEIA, SEPA, and from industry sources in the state.

Hydroelectric

Colorado has 48 hydroelectric generating stations with a total nameplate capacity of 1,106 MW, which in 2007 generated about 1,800,000 MWh. All of these stations are small: The largest is 324 MW, but most are 10 MW or less. Hydroelectricity accounts for about three percent of total Colorado state electricity generation, but for less than one percent of total U.S. hydroelectric power. We estimate that in 2007, hydro revenues in the state totaled about $50 million and that there were about 100 FTE jobs in hydroelectric power in the state.

Geothermal

Colorado ranks fourth among western states in the number of potential sites for geothermal power generation. However, while Colorado has geothermal direct use and aquaculture projects, the state currently has no geothermal electrical generation projects. The 2007 geothermal industry in Colorado consisted of low temperature (<194^{o} F) resources applications in space and district heating and in agricultural applications and of geothermal heat pumps that rely on the even lower, nearly consistent shallow ground temperature.

We estimate that in 2007, revenues in the geothermal industry in Colorado totaled about $30 million and that there were about 150 FTE jobs in the geothermal industry in the state.

Biomass

The Biomass sector consists of ethanol, biodiesel, and biomass power.

Ethanol

In 2007, Colorado had four ethanol biorefineries in operation with a capacity of about 125 million gallons per year and several more in various planning stages. We estimate that in 2007, revenues generated in the ethanol industry in Colorado totaled about $250 million and that there were about 500 FTE jobs in the ethanol industry in the state. This accounted for a little over one percent of the U.S. ethanol industry.

Biodiesel

In 2007, Colorado had five of the nation's 90 biodiesel companies and about two dozen biodiesel stations that were selling an average of 5,000 – 40,000 gallons of biodiesel product per month. We estimate that in 2007, revenues in the biodiesel industry in Colorado totaled about $20 million and that there were about 200 FTE jobs in the biodiesel industry in the state. This accounts for about five percent of the U.S. biodiesel industry.

Biomass Power

In 2007, Colorado biomass power accounted for about 0.1 percent of the U.S. biomass power industry – about 31,000 kWh. We estimate that in 2007, revenues in the biomass power industry in Colorado totaled about $25 million and that there were about 80 FTE jobs in the industry in the state.

Fuel Cells and Hydrogen

We estimate that in 2007, fuel cell and hydrogen revenues in Colorado totaled about $40 million and that there were about 150 FTE jobs in the industry in the state. This accounts for about two percent of the U.S. industry. These estimates were derived from national and state industry sources and from telephone interviews conducted with senior staff from the Colorado Fuel Center and NREL. Most of the jobs in Colorado consist of employees involved in fuel cell projects at CoorsTek, Proponics (formerly Mesoscopic), Versa Power Systems, Fuel Cell Propulsion Inst., Protera, Inc. (formerly Mobile Energy Solutions), Barber-Nichols, Inc., Vairex Corp., the Colorado School of Mines and NREL.

Federal Government

Federal renewable energy activities in Colorado are dominated by the National Renewable Energy Laboratory (NREL), located in Golden. In 2007, NREL had about 2,230 total FTE staff, including 130 U.S. Department of Energy employees, about 1,250 NREL employees, and about 850 resident contractor employees. NREL's 2007 budget totaled about $382 million, including $360 million from the DOE Office of Energy Efficiency and Renewable Energy, $11 million from the DOE Office of Science, and $11 million from non-DOE sources. These data were obtained from the DOE and NREL budget and program offices.

State and Local Government

We estimate that in 2007, Colorado state and local governments spent about $2 million on RE activities and that about 20 FTE state and local government employees were involved. These estimates were obtained in discussions with industry sources.

Other Sectors

Other renewable energy activities in Colorado include those being conducted by universities, trade and professional associations, non-government organizations (NGOs), consultants, investment company analysts, etc. On the basis of discussions with Colorado RE association staff and others, we estimate that in 2007 there were about 50 FTE involved with budgets totaling about $5 million.

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A.2. Derivation of the Energy Efficiency Industry Estimates

The Colorado energy efficiency industry estimates are presented in Table 2.

The 2007 Colorado Energy Efficiency Industry

Industry Segment	Industry Revenues/ Budgets[1] (millions)	Industry Jobs[2]	Total Jobs[3]
ESCO[4]	110	500	1,175

[1]Revenues for private industry; budgets for non-industry organizations.
[2]Full time equivalent (FTE) jobs in Colorado in the renewable energy industry. An FTE job is defined as 2,080 hours worked in a year's time, and adjusts for part time and seasonal employment and for labor turnover. Thus, two workers each working six months of the year would be counted as one FTE job.
[3]Total number of jobs in Colorado generated by renewable energy. Derived using the U.S. Department of Commerce, Bureau of Economic Analysis, Regional Input-Output Multipliers for Colorado.
[4]An energy service company (ESCO) is a professional business providing designs and implementation of energy savings projects that allow building owners to perform projects to upgrade their building assets. The ESCO performs an in-depth analysis of the property, designs an energy efficient solution, installs the required elements, and maintains the system to ensure energy savings during the payback period. The savings in energy costs is used to pay back the capital investment of the project over a five- to twenty-year period, or reinvested into the building to allow for capital upgrades that may otherwise be unfeasible. If the project does not provide returns on the investment, the ESCO is usually responsible for paying the difference. Researchers estimate that, in 2007, U.S. ESCO industry activities totaled approximately $3.8 billion. We estimate that, based on ESCO activities and contractors in Colorado, in 2007 ESCO activities in the state totaled about $110 million and employed about 500 FTE workers.

Recycling, reuse, & remanufacturing[1]	1,900	8,800	19,800
Vehicles[2]	170	350	830
Household appliances and lighting[3]	180	650	1,550
Windows and doors[4]	200	800	1,850

[1]The recycling, remanufacturing, and reuse sector is an elaborate network of public institutions and private companies. Recycling is an integrated system that starts with collection of materials by individuals, businesses, and municipalities, involves processing of recycled materials, and leads to manufacturing of new products with recycled content. Five major industries account for over half of the economic activity of the sector: Paper mills, steel mills, plastics, converters, and iron and steel foundries. However, this sector also includes companies that are filling market niches, including computer recyclers, wood reuse (e.g. pallet rebuilders, etc.), tire retreaders, electronic appliance de-manufacturers, organics composters, plastic lumber manufacturers, and others. EPA funded studies have identified 26 different types of recycling, remanufacturing, and reuse institutions, organizations, and industries, and the reuse and remanufacturing sector encompasses a large number and a diverse mix of establishments. It is thus a very large sector, and is orders of magnitude larger than the traditional "recycling" concept. In 2007, U.S revenues the recycling, reuse, and remanufacturing sector totaled approximately $290 billion and employment totaled about 1,372,000. All of these revenues and jobs are included in the EE industry. Appling these concepts and estimates to the analogous sectors and industries in Colorado, we estimate that in 2007 this sector in the state had about $1.9 billion in revenues and about 8,800 in employment. This represented about six percent of the U.S. total.

[2]In 2007, revenues in U.S. vehicle industry totaled approximately $475 billion – about two percent less than in 2006. Clearly, some portion of this should be included in the definition of the EE industry. Energy efficiency in cars and other light duty vehicles was assessed using EPA data on the adjusted fuel economy and improvements in ton-miles per gallon and information regarding the application of new, fuel-saving vehicle technologies. Half of the vehicles sold in the U.S. are SUVs or light trucks, which cannot be considered to be energy efficient vehicles. Of the remaining vehicles sold, we classified those that get at least 10 percent better mpg than the CAFE mileage as energy efficient vehicles. Industry statistics indicate that about 18 percent of new U.S. vehicles sold in 2007 are classified as small or hybrid – hybrid sales increased 40 percent in 2007. Therefore, we estimate that the portion of U.S. new vehicle sales accounted for by EE vehicles is about 18 percent -- about $86 billion. We estimated the 2007 Colorado portion of this be about $170 million and about 350 jobs.

[3]In order to determine what should be counted as an investment in efficiency in this sector, we made extensive use of ENERGY STAR data. The EPA/DOE ENERGY STAR program rates the energy efficiency and sales of numerous products, including a wide variety of household appliances, commercial equipment, heating and ventilation equipment, and others. We disaggregated the Electric Lighting and Household Appliance industry into "Lighting" and "Household Appliances" and handled each separately. We had to determine which portion of the Lighting industry and which portion of the Household Appliances industry should be included as part of the EE industry. We used the ENERGY STAR ratings for lighting products and for household appliances to accomplish this. The market penetration of EE lighting and household appliances varies widely; for example, we found that the ENERGY STAR market penetration in selected product areas is: i) CFL, about 5 percent; ii) clothes washers, ~30 percent; dishwashers, ~80 percent; refrigerators and freezers, ~33 percent; room AC; ~35 percent. Total U.S 2007 sales of the electric lighting and household appliance industry were approximately $115 billion. We estimated that the EE portion of the 2007 electric lighting and household appliance industry is about 30 percent -- about $35 billion. We estimate that the corresponding 2007 Colorado share of this sector was about $180 million and 650 jobs.

[4]Windows and doors are major sources of heat gain in the summer and heat loss in the winter. For example, energy-efficient windows can reduce energy use by 20-30 percent. According to DOE, the energy efficiency, or thermal performance, of a window is a function of six factors: The number of panes, the space between the panes, the type of material between the panes, the emissivity of the glass, the frame in which the glass is installed, and the type of spacers that are used to separate the panes of glass. U.S. 2007 sales in the window and door industry totaled approximately $30 billion. We had to determine what portion of this industry should be allocated to the EE industry. We found that the market share of Energy Star windows is about 55 percent, and the market share of Energy Star doors is about 35 – 40

Computers, copiers, FAX machines, etc.[1]	600	2,800	6,400
TV, Video, and Audio equipment[2]	700	2,900	6,700
HVAC systems[3]	240	900	2,100
Industrial and related machinery[4]	160	600	1,450
Miscellaneous durable manufacturing[5]	1,900	6,400	14,600
Nondurable manufacturing[6]	2,200	5,900	13,200
Utilities[7]	26	80	200
Construction[8]	730	4,700	11,150

percent. Therefore, we estimate that the EE portion of the 2007 window and door industry is about 45 percent -- $13 billion. In Colorado in 2007, we estimated corresponding industry revenues of about $200 million and industry employment of about 800.

[1]We found that the ENERGY STAR market penetration in selected product areas is, for electronics, TVs -- 85 percent, DVD Players -- 52 percent, and VCRs -- 90 percent; for office equipment: printers -- 99 percent, monitors -- 95 percent, scanners -- 75 percent, PCs -- 97 percent, and audio electronic equipment -- 50 percent; home office: printers -- 99 percent, monitors -- 95 percent, scanners -- 75 percent, and PCs -- 75 percent. Applying these and related market penetration rates to the 2007 expenditures on the relevant products and industry sales, we estimate that the U.S. energy efficiency portion of the computers, printers, copies, etc. sector totaled about $105 billion. Using similar methodology to derive the estimates for Colorado, we estimate that, in 2007, the energy efficiency portion of the computers, printers, copies, etc. sector had revenues of about $600 million and created about 2,800 jobs in the industry.

[2]Derived using the same methodology and data bases as described in footnote 10.

[3]Studies indicate that the national market penetration of energy efficiency heating, ventilation, and air conditioning (HVAC) equipment is about 35 percent. For example, we found that the condensing furnace (developed by Lennox) market share is already more than 30 percent. For the U.S., this translates into about $13 billion and 47,000 jobs. For Colorado, the corresponding 2007 estimates are about $240 million and 900 jobs.

[4]Total U.S. 2007 industrial and related machinery industry sales were about $200 billion. In 2007, EE had slightly more than a ten percent market penetration, and thus the EE portion of this industry totaled about $21 billion. The corresponding 2007 Colorado share of this sector was estimated at $160 million and about 600 jobs.

[5]Miscellaneous durable goods include those durable goods not analyzed separately, including the following sectors: Wood product manufacturing, Nonmetallic mineral product manufacturing, Primary metal manufacturing, Fabricated metal products, Machinery manufacturing, Electronic products, Electrical equipment manufacturing, Miscellaneous transportation equipment manufacturing, Furniture and related product manufacturing, and Miscellaneous manufacturing. The 2007 U.S. estimate of the energy efficiency components of these sectors totals about $110 billion. Colorado's 2007 share of these sectors is estimated to total about $1.9 billion and about 6,400 jobs.

[6]Nondurable goods include the following: Food manufacturing, Beverage and tobacco product manufacturing, Textile mills, Textile product mills, Apparel manufacturing, Leather and allied product manufacturing, Paper manufacturing, Printing and related support activities, Petroleum and coal products manufacturing, Chemical manufacturing, and Plastics and rubber products manufacturing. The U.S. nondurable sector in 2007 totaled about $700 billion, of which energy efficient products had about a 30 percent share – approximately $218 billion. Colorado's 2007 share of this sector is estimated to total about $2.2 billion and about 5,900 jobs.

[7]U.S. utility EE spending in 2007 totaled approximately $2.2 billion. All of these are included in the EE industry. In Colorado, researchers have estimated that spending on utility energy efficiency programs in 2007 totaled approximately $26 million, and energy efficiency spending as a fraction of utility revenues was about 0.7 percent. Utility EE spending in Colorado thus comprises about one percent of the U.S. total.

[8]Energy efficiency expenditures in buildings include investments made in building new, energy-efficient structures and in renovating old structures in ways that make them more energy efficient. The value of U.S. construction put in place in 2007 totaled approximately $1.14 trillion – about five percent less than in

Total, Private Industry[1]	9,116	35,380	81,005
Federal government[2]	2	15	35
State and local government[3]	9	50	115
Total Government	11	65	150
Other sectors[4]	2	25	55
TOTAL, ALL SECTORS	$9,129	35,470	81,210

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

2006. 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, from ACEE, and from other sources to determine which portion of the industry should be classified within the EE industry. Using the concepts, data, and sources referenced above, we estimate that about 3.5 percent of the U.S. construction industry can be classified within the EE industry – about $39 billion. In Colorado in 2007, we estimate that that the energy efficiency portion of the construction sector totaled about $730 million and about 4,700 jobs. This sector includes activities and jobs in the insulation sector, since it is difficult to separate these activities from overall construction and building activities.

[1]The Industrial energy efficiency estimates are based on numerous sources. These include information on investments in the more energy-intensive industries available through DOE's Save Energy Now Program, data on small to medium sized industries available through the Industrial Assessment Center Database, information provided by the Manufacturing Energy Consumption Survey (MECS), an American Council for en Energy Efficient Economy (ACEEE) Delphi survey of energy efficiency experts, other ACEEE and Alliance to Save Energy (ASE) work, Oak Ridge National Laboratory, NREL, DOE, EPA, and other sources. Efficiency investments in the industrial sector include investments in replacing or retrofitting preexisting technologies as well as adding new technologies that allow for increased efficiency. These include programs as diverse as new lighting to new industrial processes and process controls that reduce the amount of energy needed per unit of output.

[2]The 2007 Federal EE budget totaled approximately $1 billion. All of these are included in the EE industry. Federal 2007 climate change spending (including tax expenditures) totaled approximately $7.1 billion. From this we deducted the approximately $1 billion federal EE budget and the approximately $0.6 billion RE budget to derive a net of approximately $5.5 billion. We assume that about half of this $5.5 billion – $2.8 -- billion relates to EE and is thus part of the EE industry. Therefore, we estimate that federal EE spending in 2006 totaled approximately $3.8 billion. In Colorado, most Federal EE spending is included in the NREL budget, and is included in the RE estimates.

[3]We estimate that 2007 Colorado state and local government EE spending totaled about $9 million and 50 FTE jobs.

[4]Other energy efficiency activities in Colorado include those being conducted by universities, trade and professional associations, non-government organizations (NGOs), consultants, investment company analysts, etc., that have not been included elsewhere in either RE or EE activities. On the basis of discussions with representatives of EE trade and professional associations and NGOs we estimate that in 2007, Colorado EE trade and professional associations, NGOs, etc. had budgets totaling approximately $2 million and about FTE 25 jobs.

Energy efficiency can be conceptualized in two ways:

- Expenditures for goods and services that are made in order to reduce the amount of energy needed for the delivery of a particular energy service (whether or not the investment was made for the expressed intention of achieving energy efficiency)
- The difference in the costs associated with efficient versus inefficient goods and services

Thus, a consumer or business that decides to purchase more energy-efficient equipment must pay for the total cost of the equipment, which can be disaggregated into two components: The cost of new, inefficient equipment plus the cost of the added efficiency. The base plus the premium equals the total investment in efficiency.

Adding to the complexity, the means of increasing energy efficiency vary widely. Efficiency gains are often embedded within existing technologies and practices and tend to be difficult to measure. In business and industry, efforts to increase energy efficiency or energy productivity can be ingrained in everyday operations and management practices, design decisions, and long-term capital investments. For individuals and households, investments in efficiency include choices in appliances and consumer electronics, home improvements, and new car purchases. Further, increases in energy efficiency are often bundled with other benefits of new technologies such that efficiency might be one of several considerations that result in technology adoption or behavioral change. Thus, the weight of energy efficiency as a decision-making criterion may vary dramatically from the primary motivation, to a minor role, to no role at all. In the case of industry, for example, the larger concern for productivity improvements may lead to cost-effective energy savings as manufacturers reduce material inputs and waste. In household and business settings energy may be saved as concerns for personal comfort and convenience stimulate the purchase of new technologies.

It is very difficult to identify and estimate all of the areas in which efficiency gains are made when they are so fragmented throughout industries, businesses, households, and transportation. Additional factors add to the difficulty in estimating efficiency expenditures, as illustrated by the following set of questions:

- Should efficiency-related expenditures only include purchases of long-lived products, or should they also include the purchases of services that also yield a return in energy savings?
- Should efficiency-related investments only include technologies made with the express purpose of saving energy, or should they also include equipment and appliances made for other purposes that also yield energy savings?
- Should efficiency-related investments be calculated so as to include the entire cost of the new, more energy-efficient product or simply the incremental costs when compared to a less efficient product on the market?

- Which products should be considered efficient? Should an absolute or relative standard be used in determining which products should be counted as efficient and which should not? For example, should we think of consumer appliances only if they meet ENERGY STAR specification, or would they be included if they merely improve existing energy use patterns?

Thus, as discussed in Chapter II, specifying and estimating the size of the EE industry is much more difficult than estimating the size of the RE industry. The RE industry is fairly well defined and consists of distinct sectors such as wind, PV, biomass, hydro, geothermal, etc. The EE "industry," on the other hand, is much more nebulous and difficult to define, specify, and estimate. There are specific elements that are clearly part of the EE industry, such as federal and state EE programs, utility EE spending, ESCOs, the recycling industry, etc. However, most EE spending is included in partial segments of large industries, such as vehicles, buildings, lighting, electronics, appliances, etc. Below we summarize how this task was addressed.

ESCO

An energy service company (ESCO) is a professional business providing designs and implementation of energy savings projects that allow building owners to perform projects to upgrade their building assets. The ESCO performs an in-depth analysis of the property, designs an energy efficient solution, installs the required elements, and maintains the system to ensure energy savings during the payback period. The savings in energy costs is used to pay back the capital investment of the project over a five- to twenty-year period, or reinvested into the building to allow for capital upgrades that may otherwise be unfeasible. If the project does not provide returns on the investment, the ESCO is usually responsible for paying the difference.

Researchers estimate that, in 2007, U.S. ESCO industry activities totaled approximately $3.8 billion. We estimate that, based on ESCO activities and contractors in Colorado, in 2007 ESCO activities in the state totaled about $110 million and employed about 500 FTE workers.

Recycling, Reuse, and Remanufacturing

The recycling, remanufacturing, and reuse sector is an elaborate network of public institutions and private companies. Recycling is an integrated system that starts with collection of materials by individuals, businesses, and municipalities, involves processing of recycled materials, and leads to manufacturing of new products with recycled content. Five major industries account for over half of the economic activity of the sector: Paper mills, steel mills, plastics, converters, and iron and steel foundries. However, this sector also includes companies that are filling market niches, including computer recyclers, wood reuse (e.g. pallet rebuilders, etc.), tire retreaders, electronic

appliance de-manufacturers, organics composters, plastic lumber manufacturers, and others.

EPA funded studies have identified 26 different types of recycling, remanufacturing, and reuse institutions, organizations, and industries:

- Private and government staffed collection centers
- Compost and miscellaneous organics producers
- Material recovery facilities
- Recyclable material wholesalers
- Glass container manufacturing plants
- Other glass product producers
- Nonferrous secondary smelting and refining mills
- Nonferrous foundries and product producers
- Paper and paperboard mills/deinked market
- pulp producers
- Paper-based product manufacturers
- Pavement mix producers (asphalt and aggregate)
- Plastics reclaimers and converters
- Rubber product manufacturers
- Steel mills
- Iron and steel foundries
- Organics
- Glass
- Nonferrous Metals
- Plastics
- Paper
- Ferrous Metals

The U.S. recycling, reuse, and remanufacturing sector is highly diverse in terms of which recovered materials are utilized, average establishment size, and which technologies are employed. The 26 recycling and reuse industry categories can be grouped into the following sectors based on the general types of activities undertaken:

- Recycling collection
- Recycling processing
- Recycling manufacturing
- Reuse and remanufacturing

The recycling sector thus includes long-established sectors like paper and steel making, as well as new entrepreneurial ventures such as composting and plastic and rubber product manufacturers. The reuse and remanufacturing sector encompasses a large number and a diverse mix of establishments. It is thus a very large sector, and is orders of magnitude larger than the traditional “recycling” concept.

In 2007, U.S revenues the recycling, reuse, and remanufacturing sector totaled approximately $290 billion and employment totaled about 1,372,000. All of these revenues and jobs are included in the EE industry.

Appling these concepts and estimates to the analogous sectors and industries in Colorado, we estimate that in 2007 this sector in the state had about $1.9 billion in revenues and about 8,800 in employment. This represented about six percent of the U.S. total.

Specific Sectors and Programs of Which Only a Portion is Included in the Energy Efficiency Industry Definition

The Industrial energy efficiency estimates are based on numerous sources. These include information on investments in the more energy-intensive industries available through DOE's Save Energy Now Program, data on small to medium sized industries available through the Industrial Assessment Center Database, information provided by the Manufacturing Energy Consumption Survey (MECS), an American Council for en Energy Efficient Economy (ACEEE) Delphi survey of energy efficiency experts, other ACEEE and Alliance to Save Energy (ASE) work, Oak Ridge National Laboratory, NREL, DOE, EPA, and other sources. Efficiency investments in the industrial sector include investments in replacing or retrofitting preexisting technologies as well as adding new technologies that allow for increased efficiency. These include programs as diverse as new lighting to new industrial processes and process controls that reduce the amount of energy needed per unit of output.

Industrial Sector

The industrial sector accounts for a little more than a third of total U.S. energy consumption, and energy efficiency in the industrial sector includes investments made in manufacturing and non-manufacturing establishments. Manufacturing firms of all sizes invest in energy efficiency in order to minimize energy costs and material waste while increasing productivity. Nearly 80 percent of the energy efficiency gains and efficiency investments in industry were made in the manufacturing sector.

Volatile energy prices and problematic energy supplies have heightened industrial interest in energy efficiency as a resource. Industrial managers are also increasingly concerned about what is coming to be seen as impending U.S. legislation regarding global climate change as well as learning to manage carbon dioxide restrictions in overseas operations. As a result, an increasing number of firms are actively seeking to reduce the energy intensity of their production practices. Data from the *Manufacturing Energy Consumption Survey* indicate that of the more than 200,000 firms represented by the survey, 40 percent had reported participating in at least one efficiency activity while 18 percent had reported having an energy audit performed. These numbers represent significant increases over earlier participation rates.

When asked to report on which investments were made with the primary purpose of improving energy efficiency, the largest percentage of firms reported having invested in compressed air systems, direct machine drives, HVAC systems, and facility lighting. A large percent of total investments in manufacturing occurred in a relatively small subset of those industries with the highest levels of energy intensity, including the chemical industry, the iron and steel industry, and the forest products industry. These industries have been the focus of the DOE's Industries of the Future Program. The goal of the program is to identify and research common problems within these industries with the goal of increasing investments in energy- saving solutions that can be applied across companies. Another government-funded program, Industrial Assessment Centers, is oriented to helping small- and medium-sized manufacturing firms achieve greater energy efficiency. These government-sponsored programs help expand interest in and implementation of energy efficiency activities throughout the manufacturing sector.

Total non-manufacturing industrial investments in energy efficiency were estimated to comprise approximately 20 percent of total industrial investments.

We analyzed the industrial sector in a manner similar to that we used for the building industry and other industries. As noted, The ENERGY STAR program is the primary vehicle promoting energy-efficient residential and commercial appliances, electronics, office equipment, and other products, and its rating system of appliances and electronics serves as the bases for assessment of efficiency investments in the appliances and electronics market. The ENERGY STAR program labels are available for clothes washers, dishwashers, refrigerators, freezers, room air conditioners and air cleaners, dehumidifiers, exhaust fans, and ceiling fans. Home electronics and office equipment are also evaluated by the program, including televisions, DVD players, VCRs, cordless phones, printers, copiers, scanners, personal computers, monitors, and other products. In all, more than 40 categories of ENERGY STAR products have been evaluated for their energy efficiency, and investments in these products comprise a large portion of total investments in the efficiency infrastructure.

The ENERGY STAR designation for efficient appliances and electronics has created an important mechanism for making energy efficiency a marketable characteristic of an increasing number of appliances and electronics, thereby accelerating the development and dissemination of increasingly efficient equipment. According to the EPA, since 2000, awareness of the government's ENERGY STAR label has grown from 40 percent to more than 60 percent nationwide, and 30 percent of U.S. households report that they knowingly purchased an ENERGY STAR-qualified product. In addition, the ENERGY STAR label has considerable influence in purchasing decisions. EPA has found that the ENERGY STAR label ranks among the highest level of influence on product purchases among all consumer emblems, similar in ranking to the Good Housekeeping Seal and *Consumer Reports*.

The program has continued to expand the number of product categories that are eligible for the ENERGY STAR label as well as strengthen the criterion used to evaluate the energy efficiency of ENERGY STAR products. Nevertheless, ENERGY STAR market ranges dramatically, depending on the product in question, and market share for office equipment tends to be much higher than market share for most residential appliances. Similarly, price differentials for the more efficient ENERGY STAR products also vary by product category. In the residential sector, clothes washers and dishwashers are among the appliances that offer the most dramatic efficiency differentials. When compared to standard new products, ENERGY STAR certified clothes washers are estimated to save nearly 40 percent of energy demand while dishwashers are estimated to more than 25 percent. More recent estimates based on revised ENERGY STAR standards (effective in January 2007) indicate that new resource-efficient models can reduce energy and water use by half or more.

Since most of the energy used in clothes washers and dishwashers (70 to 90 percent for clothes washers and even higher for dishwashers) is used to heat the wash and/or rinse water, new technologies have focused on reducing the amount of water used. For example, front-loading washing machines tumble clothes through a small amount of water rather than using an agitator in a full tub of water. Energy-efficient motors are also used to spin clothes faster, extracting more water, reducing dryer times and using less energy.

Significant variation in energy use can also be found in home electronics and office equipment. Energy use in more efficient electronic devices including televisions, VCRs, audio equipment, and DVD players can be as much as 70 percent lower than in standard equipment. Similarly, energy use in computer equipment can vary by as much as 50 percent.

Vehicles

Light vehicles consume the most energy (in excess of 60 percent of all transportation-related energy) and have also experienced large investments in fuel efficiency technologies. Energy-efficient engine technologies include direct fuel injection, integrated starter/generator systems, turbochargers and superchargers, cylinder deactivation systems, and variable valve timing. According to the EPA and the National Research Council of the National Academies of Science (NRC/NAS), each of these technologies can increase energy efficiency by 5 to 13 percent. Several transmission technologies can also increase fuel economy. Continuously Variable Transmission technologies and automated manual transmissions can improve energy efficiency by 6 to 7 percent each.

Thus, in the vehicle market, a variety of innovative engine and transmission technologies have resulted in significant efficiency gains. For example, the engine, transmission, and vehicle technologies summarized below are either currently available or are likely to be available within the next decade. Some are already available, are

well known to manufacturers and their suppliers, and could be incorporated in vehicles once a decision is reached to use them. Others are under development.

Engine Technologies

The engine technologies summarized below improve the energy-efficiency of engines by reducing friction and other mechanical losses or by improving the processing and combustion of fuel and air.

Engine Friction and Other Mechanical/hydrodynamic Loss Reduction. Continued improvements in engine component and system design, development, and computer-aided engineering tools offer the potential for continued refinement of component weight reductions, thermal management, and hydrodynamic systems that improve overall brake specific efficiency. An improvement in fuel efficiency of 1 to 5 percent is considered possible, depending upon the state of the baseline engine.

Variable Valve Timing (VVT). Variation in the cam phasing of intake valves has gained increasing market penetration, with an associated reduction in production cost. Earlier opening under low-load conditions reduces pumping work. Under high-load, high-speed conditions, variations in cam phasing can improve volumetric efficiency (breathing) and help control residual gases, for improved power. Improvements in fuel efficiency of 1 to 2 percent are possible with this technology.

Cylinder Deactivation. An additional feature that can be added to variable valve lift mechanisms is to allow the valves of selected cylinders to remain closed, with the port fuel injection interrupted. This approach, which is sometimes referred to as a "variable displacement engine" creates an "air spring" within the cylinder. Although both frictional and thermodynamic losses occur, they are more than offset by the increased load and reduced specific fuel consumption of the remaining cylinders. However, engine transient performance, idle quality, noise, and vibration can limit efficiency gains and must be addressed. Improvements in fuel efficiency in the range of 3 to 6 percent are possible.

Engine Downsizing and Supercharging. Additional improvements in fuel efficiency can be gained by reducing engine displacement and increasing specific power, while maintaining equal performance, by enhancing the engine (turbocharger or mechanical supercharger. Degraded transient performance (turbo-lag) typically associated with turbochargers, can be significantly offset by incorporating variable geometry turbines or mechanical (positive displacement) superchargers. Improvements in fuel efficiency of 5 to 7 percent are possible with this approach, at equivalent vehicle performance. However, when this concept is combined with multivalve technology, total improvements of about 10 percent are possible.

Camless Valve Actuation (CVA). A further evolution of fast acting, completely variable valve timing is represented by electromechanical solenoid-controlled, spring-mass valve (EMV) systems and high-pressure hydraulic actuated valves with high-speed, digital

control valve technology. In addition to a reduction in pumping losses, this technology facilitates intake port and cylinder deactivation and allows the use of conventional TWC after-treatment.

Transmission Technologies

The technologies summarized below involve improvements in the efficiency with which power is transmitted from the engine to the driveshaft or axle.

Continuously Variable Transmission (CVT). Several versions of continuously variable transmissions are offered in production in Europe and Japan, and a few in the United States (by Honda and Toyota). Historically, these transmission types have used belts or chains of some type to vary speed ratios across two variable-diameter pulleys. The major production units utilize compression belts or tension chains, and other approaches are also being pursued. Depending on the type of CVT and the power/speed range of the engine, this technology can improve fuel efficiency by about 4 to 8 percent.

Five-Speed Automatic Transmission. The use of a five-speed automatic transmission permits the engine to operate in its most efficient range more of the time than a 4-speed. A fuel efficiency improvement of 2 to 3 percent is possible, at constant vehicle performance, compared to a 4-speed automatic.

Automatic Shift Manual Transmission (ASM/AMT). To reduce mechanical losses, manufacturers are developing new generations of automatic transmissions that eliminate the hydraulic torque converter and its associated pump, to be replaced by electronically controlled clutch mechanisms. This approach offers two basic possibilities: The torque from different gear sets can be intermittently interrupted (as in a conventional manual transmission) through the use of a single electronically controlled clutch, or the torque can be continuously controlled, without dropout, through the use of two electronically controlled clutches. Improvements in fuel efficiency of 3 to 5 percent over a conventional-speed automatic transmission are possible.

Vehicle Technologies

Hybrid Electric Vehicles. Hybrid electric vehicles of various types are in the market (e.g. the Prius), in advanced stages of development, and are the focus of extensive research by all major automotive manufacturers. They include so-called “mild hybrids” (with regenerative braking, ISG, launch assist, and minimal battery storage); “parallel hybrids” (with the engine powering either or both a mechanical drivetrain and an electric motor/generator serving as additional propulsion to recharge the battery); and “series hybrids” (in which the engine does not drive the wheels but always drives a electric motor/generator to propel the vehicle, recharge the battery, or perform both functions simultaneously). The method and extent of hybridization depends on the vehicle type, anticipated use, accessory package, type of battery, and other considerations. The

range of anticipated improvements in fuel efficiency can therefore vary from about 15 percent for certain mild hybrids to about 30 percent for parallel hybrids.

Vehicle Estimates

In 2007, revenues in U.S. vehicle industry totaled approximately $475 billion – about two percent less than in 2006. Clearly, some portion of this should be included in the definition of the EE industry. Energy efficiency in cars and other light duty vehicles was assessed using EPA data on the adjusted fuel economy and improvements in ton-miles per gallon and information regarding the application of new, fuel-saving vehicle technologies – such as those described above.

Half of the vehicles sold in the U.S. are SUVs or light trucks, which cannot be considered to be energy efficient vehicles. Of the remaining vehicles sold, we classified those that get at least 10 percent better mpg than the CAFE mileage as energy efficient vehicles. Industry statistics indicate that about 18 percent of new U.S. vehicles sold in 2007 are classified as small or hybrid – hybrid sales increased 40 percent in 2007. Therefore, we estimate that the portion of U.S. new vehicle sales accounted for by EE vehicles is about 18 percent -- about $86 billion. We estimated the 2007 Colorado portion of this be about $170 million and about 350 jobs.

Electric Lighting and Household Appliance Industry

In order to determine what should be counted as an investment in efficiency in this sector, we made extensive use of ENERGY STAR data. As noted, the EPA/DOE ENERGY STAR program rates the energy efficiency and sales of numerous products, including a wide variety of household appliances, commercial equipment, heating and ventilation equipment, and others.

We disaggregated the Electric Lighting and Household Appliance industry into "Lighting" and "Household Appliances" and handled each separately. We had to determine which portion of the Lighting industry and which portion of the Household Appliances industry should be included as part of the EE industry. We used the ENERGY STAR ratings for lighting products and for household appliances to accomplish this.

The market penetration of EE lighting and household appliances varies widely; for example, we found that the ENERGY STAR market penetration in selected product areas is:

- CFL: About 5 percent
- Clothes washers: ~30 percent
- Dishwashers: ~80 percent
- Refrigerators and freezers: ~33 percent
- Room AC: ~35 percent

Total U.S 2007 sales of the electric lighting and household appliance industry were approximately $115 billion. We estimated that the EE portion of the 2007 electric lighting and household appliance industry is about 30 percent -- about $35 billion. We estimate that the corresponding 2007 Colorado share of this sector was about $180 million and 650 jobs.

Window and Door Industry

Windows and doors are major sources of heat gain in the summer and heat loss in the winter. For example, energy-efficient windows can reduce energy use by 20-30 percent. According to DOE, the energy efficiency, or thermal performance, of a window is a function of six factors: The number of panes, the space between the panes, the type of material between the panes, the emissivity of the glass, the frame in which the glass is installed, and the type of spacers that are used to separate the panes of glass. DOE estimates that replacement windows cost from $5 to $50 per square foot of window area, and using spectrally selective glass only adds about an extra dollar per square foot to the cost of a new home.

U.S. 2007 sales in the window and door industry totaled approximately $30 billion. We had to determine what portion of this industry should be allocated to the EE industry. We found that:

- The market share of Energy Star windows is about 55 percent.
- The market share of Energy Star doors is about 35 – 40 percent.

Therefore, we estimate that the EE portion of the 2007 window and door industry is about 45 percent -- $13 billion. In Colorado in 2007, we estimated corresponding industry revenues of about $200 million and industry employment of about 800.

Construction Industry

Energy efficiency expenditures in buildings include investments made in building new, energy-efficient structures and in renovating old structures in ways that make them more energy efficient. Total energy efficiency investments in the residential sector were much larger than are indicated by the largely stagnant level of energy consumption in that sector. While residential energy consumption has been declining relatively little in recent years, many of the efficiency gains associated with EE investments are obscured by increases in the housing stock and the growth in the average size of homes. While the energy use per square foot has generally been lower for newly constructed houses due to more efficient materials and construction practices, consumer preferences for larger houses have offset much of these efficiency gains. And while the average square footage per house has been increasing, a growing proportion of new homes were built according to more stringent energy efficiency standards.

Heating and cooling are responsible for consuming the largest amount of energy in the residential sector. According to DOE, average home can "waste" up to 30 percent of the energy used for heating and cooling as a result of gaps and cracks in the building envelope. A variety of existing technologies can reduce energy loss, making buildings more energy efficient. For example, energy-efficient roofs and walls can prevent air leakage that could otherwise be responsible for as much as 50 percent of heating loads. In addition, some new energy-efficient roof technologies use lighter colored roof materials in hot and humid climates to reduce the solar heat gain associated with standard asphalt shingles. These lighter tiles absorb less heat than the traditional darker tiles, reducing the cooling load in the summer and also increasing the durability of the roof. In this case, the cost differential for the cooler shingles is minimal.

Radiant barriers are also used in roofing to increase the energy efficiency of buildings. When placed between the roof and ceiling, radiant barriers help keep inside temperatures cool in the summer and warm in the winter. Walls can be made more energy efficient by increasing the amount of space for insulation and building walls with tighter joints and seals. Instead of using standard 2-inch by 4-inch studs, efficient buildings are likely to use 2-inch by 6-inch studs and then fill these cavities with high quality insulation.

The commercial sector is responsible for approximately 18 percent of total U.S. energy consumption, or about 15 percent excluding appliances and electronics. Despite investments in efficiency, total annual energy consumption in the commercial sector has increased slightly in recent years. As in the residential sector, efforts to reduce energy consumption in the commercial sector have been partially offset by the growth in total building floor space. While significant efficiency gains have been achieved through innovations in building materials and construction practices, commercial square footage continues to increase. However, in the absence of efficiency investments, commercial sector energy consumption would have increased much more than it has.

Green buildings (sustainable buildings) are defined as structures "designed, built, renovated, or operated, in an ecological and resource-efficient manner," and green buildings include measures to reduce energy consumption and to increase the efficiency of the building envelope. The U.S. Green Building Movement began in 1970's energy crises, and major milestones in the development of green building movement include:

- 1990: American Institute of Architecture (AIA) founded Committee on the Environment
- 1992: AIA published the Environmental Resource Guide
- 1992: Department of Energy launched Energy Star program to promote energy efficiency.
- 1993: U.S. Green Building Council (USGBC) formed to promote green building

- 1998: USGBC launched Leadership in Energy and Environmental Design (LEED), the pre-eminent green building rating system
- 2008: U.S. General Services Administration mandates building information modeling

The green building movement has grown rapidly over past decade, and numerous Federal and state government mandates have been enacted over past two decades to "green" government buildings. Characteristics of the U.S. green buildings market include:

- The 2007 U.S. market for all types of green buildings was approximately $38 billion
- About two percent of total U.S. nonresidential buildings market is LEED-certified
- About eight percent of multi-family building market is LEED-certified
- The 2007 residential green building market totaled about $15 billion – nearly four percent of new housing starts
- In some states, such as New York and Washington, green buildings account for 10 percent – 15 percent of new construction
- Green products are nearing 50 percent of some portions of the home remodeling market
- School construction ($53 billion in 2007) is fastest-growing green market
- Buildings represent 70 percent of U.S electricity consumption
- Currently more than 11,000 U.S projects are LEED-certified or in certification process
- Eight percent of the multi-family building market is LEED-certified.
- The U.S. green building market is projected to exceed $60 billion by 2015
- By 2010, the nonresidential green building market will exceed 10 percent of construction starts and will exceed $35 billion
- In 2007, the "efficiency premium" investment in residential buildings was in the range of $8 - $10 billion
- In 2007, the "efficiency premium" investment in residential buildings was in the range of $10 - $15 billion

It is important to realize that, in addition to building-related products, green buildings products and services include a wide range of high-tech and IT components, such as:

- Building automation systems (BAS) and energy management systems (EMS)
- Demand response systems that reduce peak demand
- Internet-enabled HVAC controllers and electronics products
- Web-based energy management software

- Electronic lighting management systems and sensors
- Internet-based facilities management
- Energy information software
- Software for life cycle analysis, modeling, and accounting
- IT systems used to monitor, compare, and test renewable energy options
- Outsourced IT-based energy management
- IT platforms to interactively control equipment and energy consumption
- Software for environmental and sustainability management

Most of these activities are here included in the relevant industry sectors.

The value of U.S. construction put in place in 2007 totaled approximately $1.14 trillion – about five percent less than in 2006. 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, from ACEE, and from other sources to determine which portion of the industry should be classified within the EE industry. Using the concepts, data, and sources referenced above, we estimate that about 3.5 percent of the U.S. construction industry can be classified within the EE industry – about $39 billion.

In Colorado in 2007, we estimate that that the energy efficiency portion of the construction sector totaled about $730 million and about 4,700 jobs. This sector includes activities and jobs in the insulation sector, since it is difficult to separate these activities from overall construction and building activities.

Computers, copiers, FAX machines, etc.

We found that the ENERGY STAR market penetration in selected product areas is:

Electronics

- TVs -- 85 percent
- DVD Players -- 52 percent
- VCR: 90 percent

Office Equipment

- Printers -- 99 percent
- Monitors -- 95 percent
- Scanners -- 75 percent
- PCs -- 97 percent
- Audio electronic equipment: 50 percent

Home Office

- Printers -- 99 percent
- Monitors -- 95 percent
- Scanners -- 75 percent
- PCs -- 75 percent

Applying these and related market penetration rates to the 2007 expenditures on the relevant products and industry sales, we estimate that the U.S. energy efficiency portion of the computers, printers, copies, etc. sector totaled about $105 billion. Using similar methodology to derive the estimates for Colorado, we estimate that, in 2007, the energy efficiency portion of the computers, printers, copies, etc. sector had revenues of about $600 million and created about 2,800 jobs in the industry.

HVAC

Studies indicate that the national market penetration of energy efficiency heating, ventilation, and air conditioning (HVAC) equipment is about 35 percent. For example, we found that the condensing furnace (developed by Lennox) market share is already more than 30 percent.

For the U.S., this translates into about $13 billion and 47,000 jobs. For Colorado, the corresponding 2007 estimates are about $240 million and 900 jobs.

Industrial and Related Machinery

Total U.S. 2007 industrial and related machinery industry sales were about $200 billion. In 2007, EE had slightly more than a ten percent market penetration, and thus the EE portion of this industry totaled about $21 billion. The corresponding 2007 Colorado share of this sector was estimated at $160 million and about 600 jobs.

Miscellaneous Durable Goods

Miscellaneous durable goods include those durable goods not analyzed separately, including the following sectors:

- Wood product manufacturing
- Nonmetallic mineral product manufacturing
- Primary metal manufacturing
- Fabricated metal products
- Machinery manufacturing
- Electronic products
- Electrical equipment manufacturing

- Miscellaneous transportation equipment manufacturing
- Furniture and related product manufacturing
- Miscellaneous manufacturing

The 2007 U.S. estimate of the energy efficiency components of these sectors totals about $110 billion. Colorado's 2007 share of these sectors is estimated to total about $1.9 billion and about 6,400 jobs.

Nondurable goods

Nondurable goods include the following:

- Food manufacturing
- Beverage and tobacco product manufacturing
- Textile mills
- Textile product mills
- Apparel manufacturing
- Leather and allied product manufacturing
- Paper manufacturing
- Printing and related support activities
- Petroleum and coal products manufacturing
- Chemical manufacturing
- Plastics and rubber products manufacturing

The U.S. nondurable sector in 2007 totaled about $700 billion, of which energy efficient products had about a 30 percent share – approximately $218 billion. Colorado's 2007 share of this sector is estimated to total about $2.2 billion and about 5,900 jobs.

Utility Programs

U.S. utility EE spending in 2007 totaled approximately $2.2 billion. All of these are included in the EE industry. In Colorado, researchers have estimated that spending on utility energy efficiency programs in 2007 totaled approximately $26 million, and energy efficiency spending as a fraction of utility revenues was about 0.7 percent. Utility EE spending in Colorado thus comprises about one percent of the U.S. total.

Federal Programs

The 2007 Federal EE budget totaled approximately $1 billion. All of these are included in the EE industry.

Federal 2007 climate change spending (including tax expenditures) totaled approximately $7.1 billion. From this we deducted the approximately $1 billion federal EE budget and the approximately $0.6 billion RE budget to derive a net of approximately $5.5 billion. We assume that about half of this $5.5 billion – $2.8 -- billion relates to EE and is thus part of the EE industry

Therefore, we estimate that federal EE spending in 2006 totaled approximately $3.8 billion.

In Colorado, most Federal EE spending is included in the NREL budget, and is included in the RE estimates.

State and Local Government EE Programs

We estimate that 2007 Colorado state and local government EE spending totaled about $9 million and 50 FTE jobs.

Other Sectors

Other energy efficiency activities in Colorado include those being conducted by universities, trade and professional associations, non-government organizations (NGOs), consultants, investment company analysts, etc., that have not been included elsewhere in either RE or EE activities. On the basis of discussions with representatives of EE trade and professional associations and NGOs we estimate that in 2007, Colorado EE trade and professional associations, NGOs, etc. had budgets totaling approximately $2 million and about FTE 25 jobs.

Sources Used to Derive the Energy Efficiency Industry Estimates

The major sources used to estimate revenues and jobs in the energy efficiency industry include those listed below.

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A.3. Independent Assessment of the ASES/MISI Methodology

As discussed in the report, measures of RE&EE are difficult for a variety of reasons. For example, energy efficiency involves trying to measure resources "not used," few readily available data exist, and the sources of efficiency are disbursed and difficult to define. As a result of these difficulties, our estimates of the size and scope of the EE&RE market rely on the application of multiple research methods in an effort to validate our estimates, as summarized above. We feel confident that our methods provide well-grounded estimates of RE&EE-related spending and jobs, and ACEEE researchers have compared our estimates with those provided by other studies and have verified their credibility.[1]

The ACEEE research was primarily driven by assumptions of future policy impacts, and most of the studies compared were conducted with varying base years for their analytical framework. To normalize the findings with our own, ACEEE standardized the results and converted them to the same year constant dollars.

As is to be expected, ACEEE found a good deal of variability among the studies. This is true with respect to policies and results and in terms of methodologies used to generate the estimates. Importantly, however, ACEEE found that the ASES/MISI methodology and estimating procedures are valid and provide results comparable to similar studies conducted in recent years. This indicates that the current analysis is credible and that it provides a useful foundation for understanding and estimating the economic and job impacts and potential of EE&RE.

[1]Karen Ehrhardt-Martinez and John Laitner, "The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture," American Council for an Energy-Efficient Economy, May 2008.

APPENDIX B
RE&EE JOBS GENERATED IN COLORADO IN 2007 AND IN 2030 UNDER THE ADVANCED SCENARIO BY OCCUPATION

Standard Occupational Classification			Advanced
Number	Title	2007	2030
11-1011	Chief executives	118	807
11-1021	General and operations managers	1,473	10,247
11-1031	Legislators	28	179
11-2011	Advertising and promotions managers	35	229
11-2021	Marketing managers	127	871
11-2022	Sales managers	157	1,078
11-2031	Public relations managers	41	270
11-3011	Administrative services managers	91	622
11-3021	Computer and information systems managers	177	1,219
11-3031	Financial managers	210	1,449
11-3041	Compensation and benefits managers	21	132
11-3042	Training and development managers	17	102
11-3049	Human resources managers, all other	37	240
11-3051	Industrial production managers	60	403
11-3061	Purchasing managers	33	215
11-3071	Transportation, storage, and distribution managers	59	395
11-9011	Farm, ranch, and other agricultural managers	6	24
11-9021	Construction managers	339	2,348
11-9031	Education administrators, preschool and child care center/program	24	151
11-9032	Education administrators, elementary and secondary school	144	990
11-9033	Education administrators, postsecondary	70	470
11-9039	Education administrators, all other	28	182
11-9041	Engineering managers	164	1,130
11-9051	Food service managers	107	732
11-9061	Funeral directors	11	60
11-9081	Lodging managers	35	226
11-9111	Medical and health services managers	133	915
11-9121	Natural sciences managers	55	367
11-9131	Postmasters and mail superintendents	19	115
11-9141	Property, real estate, and community association managers	156	1,070
11-9151	Social and community service managers	59	398
11-9199	Managers, all other	294	2,036
13-1011	Agents and business managers of artists, performers, and athletes	6	26
13-1021	Purchasing agents and buyers, farm products	12	70
13-1022	Wholesale and retail buyers, except farm products	67	443
13-1023	Purchasing agents, except wholesale, retail, and farm products	192	1,293
13-1031	Claims adjusters, examiners, and investigators	165	1,110
13-1032	Insurance appraisers, auto damage	9	48
13-1041	Compliance officers, except agriculture, construction, health and safety, and transportation	133	891
13-1051	Cost estimators	195	1,312

Standard Occupational Classification			Advanced
Number	Title	2007	2030
13-1061	Emergency management specialists	6	29
13-1071	Employment, recruitment, and placement specialists	109	727
13-1072	Compensation, benefits, and job analysis specialists	87	580
13-1073	Training and development specialists	137	915
13-1079	Human resources, training, and labor relations specialists, all other	100	665
13-1081	Logisticians	52	337
13-1111	Management analysts	275	1,859
13-1121	Meeting and convention planners	45	289
13-1199	Business operations specialists, all other	953	6,467
13-2011	Accountants and auditors	950	6,448
13-2021	Appraisers and assessors of real estate	77	510
13-2031	Budget analysts	39	248
13-2041	Credit analysts	46	301
13-2051	Financial analysts	183	1,228
13-2052	Personal financial advisors	70	462
13-2053	Insurance underwriters	65	431
13-2061	Financial examiners	12	70
13-2071	Loan counselors	13	72
13-2072	Loan officers	264	1,779
13-2081	Tax examiners, collectors, and revenue agents	29	181
13-2082	Tax preparers	17	101
13-2099	Financial specialists, all other	119	797
15-1011	Computer and information scientists, research	13	75
15-1021	Computer programmers	198	1,306
15-1031	Computer software engineers, applications	421	2,798
15-1032	Computer software engineers, systems software	423	2,814
15-1041	Computer support specialists	376	2,498
15-1051	Computer systems analysts	287	1,907
15-1061	Database administrators	104	682
15-1071	Network and computer systems administrators	244	1,620
15-1081	Network systems and data communications analysts	160	1,057
15-1099	Computer specialists, all other	189	1,249
15-2011	Actuaries	15	89
15-2021	Mathematicians	4	13
15-2031	Operations research analysts	31	194
15-2041	Statisticians	13	71
17-1011	Architects, except landscape and naval	229	1,535
17-1012	Landscape architects	92	608
17-1021	Cartographers and photogrammetrists	68	443
17-1022	Surveyors	90	594
17-2011	Aerospace engineers	168	1,120
17-2021	Agricultural engineers	6	28
17-2031	Biomedical engineers	20	119
17-2041	Chemical engineers	34	215
17-2051	Civil engineers	519	3,491

Standard Occupational Classification			Advanced
Number	Title	2007	2030
17-2061	Computer hardware engineers	234	1,567
17-2071	Electrical engineers	193	1,289
17-2072	Electronics engineers, except computer	358	2,403
17-2081	Environmental engineers	113	750
17-2111	Health and safety engineers, except mining safety engineers and inspectors	36	229
17-2112	Industrial engineers	235	1,572
17-2131	Materials engineers	54	352
17-2141	Mechanical engineers	219	1,467
17-2151	Mining and geological engineers, including mining safety engineers	31	192
17-2161	Nuclear engineers	8	41
17-2171	Petroleum engineers	44	285
17-2199	Engineers, all other	175	1,165
17-3011	Architectural and civil drafters	179	1,193
17-3012	Electrical and electronics drafters	45	293
17-3013	Mechanical drafters	55	357
17-3019	Drafters, all other	37	238
17-3021	Aerospace engineering and operations technicians	16	92
17-3022	Civil engineering technicians	104	690
17-3023	Electrical and electronic engineering technicians	203	1,357
17-3024	Electro-mechanical technicians	19	114
17-3025	Environmental engineering technicians	60	393
17-3026	Industrial engineering technicians	73	480
17-3027	Mechanical engineering technicians	23	142
17-3029	Engineering technicians, except drafters, all other	101	667
17-3031	Surveying and mapping technicians	106	704
19-1012	Food scientists and technologists	6	28
19-1013	Soil and plant scientists	24	146
19-1021	Biochemists and biophysicists	28	173
19-1022	Microbiologists	17	103
19-1023	Zoologists and wildlife biologists	16	96
19-1029	Biological scientists, all other	27	169
19-1031	Conservation scientists	39	251
19-1032	Foresters	10	55
19-1041	Epidemiologists	4	14
19-1042	Medical scientists, except epidemiologists	23	145
19-2011	Astronomers	4	12
19-2012	Physicists	23	142
19-2021	Atmospheric and space scientists	44	284
19-2031	Chemists	64	424
19-2032	Materials scientists	11	63
19-2041	Environmental scientists and specialists, including health	131	882
19-2042	Geoscientists, except hydrologists and geographers	90	598
19-2043	Hydrologists	23	143
19-2099	Physical scientists, all other	34	214
19-3011	Economists	5	22

Standard Occupational Classification			Advanced
Number	Title	2007	2030
19-3021	Market research analysts	115	769
19-3022	Survey researchers	21	125
19-3031	Clinical, counseling, and school psychologists	70	463
19-3039	Psychologists, all other	11	58
19-3041	Sociologists	5	19
19-3051	Urban and regional planners	34	214
19-3091	Anthropologists and archeologists	14	80
19-3093	Historians	4	14
19-3099	Social scientists and related workers, all other	29	183
19-4011	Agricultural and food science technicians	12	68
19-4021	Biological technicians	98	652
19-4031	Chemical technicians	52	340
19-4041	Geological and petroleum technicians	36	230
19-4061	Social science research assistants	7	34
19-4091	Environmental science and protection technicians, including health	51	332
19-4092	Forensic science technicians	12	67
19-4093	Forest and conservation technicians	49	322
19-4099	Life, physical, and social science technicians, all other	46	301
21-1011	Substance abuse and behavioral disorder counselors	26	168
21-1012	Educational, vocational, and school counselors	89	603
21-1013	Marriage and family therapists	10	54
21-1014	Mental health counselors	73	491
21-1015	Rehabilitation counselors	48	323
21-1021	Child, family, and school social workers	99	673
21-1022	Medical and public health social workers	52	351
21-1023	Mental health and substance abuse social workers	59	398
21-1029	Social workers, all other	44	289
21-1091	Health educators	28	181
21-1092	Probation officers and correctional treatment specialists	47	315
21-1093	Social and human service assistants	108	741
21-1099	Community and social service specialists, all other	77	525
21-2011	Clergy	12	65
21-2021	Directors, religious activities and education	7	33
21-2099	Religious workers, all other	4	14
23-1011	Lawyers	530	3,547
23-1022	Arbitrators, mediators, and conciliators	6	23
23-1023	Judges, magistrate judges, and magistrates	31	191
23-2011	Paralegals and legal assistants	259	1,726
23-2091	Court reporters	25	155
23-2092	Law clerks	15	84
23-2093	Title examiners, abstractors, and searchers	65	423
23-2099	Legal support workers, all other	41	261
25-1011	Business teachers, postsecondary	12	142
25-1021	Computer science teachers, postsecondary	7	58
25-1022	Mathematical science teachers, postsecondary	8	73

Standard Occupational Classification			Advanced
Number	Title	2007	2030
25-1031	Architecture teachers, postsecondary	6	53
25-1032	Engineering teachers, postsecondary	11	116
25-1041	Agricultural sciences teachers, postsecondary	5	36
25-1042	Biological science teachers, postsecondary	8	86
25-1051	Atmospheric, earth, marine, and space sciences teachers, postsecondary	5	41
25-1052	Chemistry teachers, postsecondary	6	55
25-1054	Physics teachers, postsecondary	5	39
25-1061	Anthropology and archeology teachers, postsecondary	4	23
25-1062	Area, ethnic, and cultural studies teachers, postsecondary	4	22
25-1063	Economics teachers, postsecondary	5	33
25-1064	Geography teachers, postsecondary	4	15
25-1065	Political science teachers, postsecondary	5	38
25-1066	Psychology teachers, postsecondary	10	103
25-1067	Sociology teachers, postsecondary	5	29
25-1069	Social sciences teachers, postsecondary, all other	3	9
25-1071	Health specialties teachers, postsecondary	27	357
25-1072	Nursing instructors and teachers, postsecondary	7	66
25-1081	Education teachers, postsecondary	9	96
25-1082	Library science teachers, postsecondary	4	22
25-1111	Criminal justice and law enforcement teachers, postsecondary	4	19
25-1112	Law teachers, postsecondary	4	23
25-1113	Social work teachers, postsecondary	4	17
25-1121	Art, drama, and music teachers, postsecondary	13	152
25-1122	Communications teachers, postsecondary	6	57
25-1123	English language and literature teachers, postsecondary	10	114
25-1124	Foreign language and literature teachers, postsecondary	8	74
25-1125	History teachers, postsecondary	6	45
25-1126	Philosophy and religion teachers, postsecondary	5	36
25-1192	Home economics teachers, postsecondary	4	15
25-1193	Recreation and fitness studies teachers, postsecondary	4	27
25-1194	Vocational education teachers, postsecondary	20	258
25-1199	Postsecondary teachers, all other	30	394
25-2011	Preschool teachers, except special education	47	640
25-2012	Kindergarten teachers, except special education	24	310
25-2021	Elementary school teachers, except special education	167	2,374
25-2022	Middle school teachers, except special and vocational education	94	1,331
25-2023	Vocational education teachers, middle school	3	9
25-2031	Secondary school teachers, except special and vocational education	122	1,723
25-2032	Vocational education teachers, secondary school	10	102
25-2041	Special education teachers, preschool, kindergarten, and elementary school	25	319
25-2042	Special education teachers, middle school	13	147
25-2043	Special education teachers, secondary school	15	186
25-3011	Adult literacy, remedial education, and GED teachers and instructors	7	67
25-3021	Self-enrichment education teachers	30	398

Standard Occupational Classification			Advanced
Number	Title	2007	2030
25-3099	Teachers and instructors, all other	62	857
25-4011	Archivists	3	12
25-4012	Curators	5	34
25-4013	Museum technicians and conservators	5	30
25-4021	Librarians	23	296
25-4031	Library technicians	24	317
25-9031	Instructional coordinators	15	188
25-9041	Teacher assistants	141	2,006
25-9099	Education, training, and library workers, all other	16	202
27-1011	Art directors	17	103
27-1012	Craft artists	12	68
27-1013	Fine artists, including painters, sculptors, and illustrators	9	50
27-1014	Multi-media artists and animators	14	80
27-1019	Artists and related workers, all other	9	48
27-1021	Commercial and industrial designers	18	109
27-1022	Fashion designers	5	17
27-1023	Floral designers	35	223
27-1024	Graphic designers	103	686
27-1025	Interior designers	45	293
27-1026	Merchandise displayers and window trimmers	33	213
27-1027	Set and exhibit designers	8	40
27-1029	Designers, all other	6	23
27-2011	Actors	6	27
27-2012	Producers and directors	39	254
27-2021	Athletes and sports competitors	4	15
27-2022	Coaches and scouts	176	1,186
27-2023	Umpires, referees, and other sports officials	30	193
27-2031	Dancers	22	137
27-2041	Music directors and composers	7	35
27-2042	Musicians and singers	28	174
27-2099	Entertainers and performers, sports and related workers, all other	11	60
27-3012	Public address system and other announcers	6	29
27-3021	Broadcast news analysts	8	37
27-3022	Reporters and correspondents	28	176
27-3031	Public relations specialists	217	1,468
27-3041	Editors	70	464
27-3042	Technical writers	43	278
27-3043	Writers and authors	24	148
27-3091	Interpreters and translators	26	164
27-3099	Media and communication workers, all other	18	107
27-4011	Audio and video equipment technicians	23	140
27-4012	Broadcast technicians	28	178
27-4014	Sound engineering technicians	7	35
27-4021	Photographers	36	231
27-4031	Camera operators, television, video, and motion picture	12	66

Standard Occupational Classification			Advanced
Number	Title	2007	2030
27-4032	Film and video editors	14	80
27-4099	Media and communication equipment workers, all other	20	121
29-1011	Chiropractors	18	107
29-1021	Dentists, general	31	194
29-1023	Orthodontists	5	17
29-1029	Dentists, all other specialists	4	9
29-1031	Dietitians and nutritionists	22	134
29-1041	Optometrists	16	91
29-1051	Pharmacists	95	618
29-1061	Anesthesiologists	14	77
29-1062	Family and general practitioners	43	272
29-1063	Internists, general	14	77
29-1064	Obstetricians and gynecologists	11	62
29-1065	Pediatricians, general	9	45
29-1066	Psychiatrists	16	95
29-1067	Surgeons	26	161
29-1069	Physicians and surgeons, all other	81	526
29-1071	Physician assistants	33	205
29-1081	Podiatrists	4	14
29-1111	Registered nurses	838	5,544
29-1121	Audiologists	9	48
29-1122	Occupational therapists	45	284
29-1123	Physical therapists	77	495
29-1124	Radiation therapists	6	26
29-1125	Recreational therapists	6	26
29-1126	Respiratory therapists	30	187
29-1127	Speech-language pathologists	54	345
29-1129	Therapists, all other	6	29
29-1131	Veterinarians	35	221
29-1199	Health diagnosing and treating practitioners, all other	18	104
29-2011	Medical and clinical laboratory technologists	64	412
29-2012	Medical and clinical laboratory technicians	52	334
29-2021	Dental hygienists	67	433
29-2031	Cardiovascular technologists and technicians	16	89
29-2032	Diagnostic medical sonographers	16	95
29-2033	Nuclear medicine technologists	8	39
29-2034	Radiologic technologists and technicians	63	405
29-2041	Emergency medical technicians and paramedics	69	442
29-2051	Dietetic technicians	11	57
29-2052	Pharmacy technicians	88	570
29-2053	Psychiatric technicians	11	57
29-2054	Respiratory therapy technicians	5	18
29-2055	Surgical technologists	35	217
29-2056	Veterinary technologists and technicians	50	314
29-2061	Licensed practical and licensed vocational nurses	160	1,046

Standard Occupational Classification			Advanced
Number	Title	2007	2030
29-2071	Medical records and health information technicians	72	466
29-2081	Opticians, dispensing	33	208
29-2091	Orthotists and prosthetists	4	15
29-2099	Health technologists and technicians, all other	35	217
29-9011	Occupational health and safety specialists	21	125
29-9012	Occupational health and safety technicians	5	20
29-9091	Athletic trainers	8	39
29-9099	Healthcare practitioners and technical workers, all other	12	66
31-1011	Home health aides	210	1,367
31-1012	Nursing aides, orderlies, and attendants	433	2,829
31-1013	Psychiatric aides	11	58
31-2011	Occupational therapist assistants	9	48
31-2012	Occupational therapist aides	4	12
31-2021	Physical therapist assistants	21	125
31-2022	Physical therapist aides	14	79
31-9011	Massage therapists	44	277
31-9091	Dental assistants	132	854
31-9092	Medical assistants	188	1,217
31-9093	Medical equipment preparers	19	113
31-9094	Medical transcriptionists	42	263
31-9095	Pharmacy aides	12	65
31-9096	Veterinary assistants and laboratory animal caretakers	22	132
31-9099	Healthcare support workers, all other	57	361
33-1011	First-line supervisors/managers of correctional officers	40	224
33-1012	First-line supervisors/managers of police and detectives	58	331
33-1021	First-line supervisors/managers of fire fighting and prevention workers	44	247
33-1099	First-line supervisors/managers, protective service workers, all other	46	257
33-2011	Fire fighters	234	1,361
33-2021	Fire inspectors and investigators	16	82
33-3011	Bailiffs	11	50
33-3012	Correctional officers and jailers	405	2,362
33-3021	Detectives and criminal investigators	94	538
33-3031	Fish and game wardens	14	73
33-3041	Parking enforcement workers	11	55
33-3051	Police and sheriff's patrol officers	485	2,830
33-9011	Animal control workers	19	102
33-9021	Private detectives and investigators	43	237
33-9031	Gaming surveillance officers and gaming investigators	11	53
33-9032	Security guards	802	4,691
33-9091	Crossing guards	78	444
33-9092	Lifeguards, ski patrol, and other recreational protective service workers	170	987
33-9099	Protective service workers, all other	118	680
35-1011	Chefs and head cooks	48	313
35-1012	First-line supervisors/managers of food preparation and serving workers	260	1,772

Standard Occupational Classification			Advanced
Number	Title	2007	2030
35-2011	Cooks, fast food	135	910
35-2012	Cooks, institution and cafeteria	89	598
35-2014	Cooks, restaurant	409	2,795
35-2015	Cooks, short order	51	339
35-2019	Cooks, all other	6	26
35-2021	Food preparation workers	285	1,944
35-3011	Bartenders	182	1,233
35-3021	Combined food preparation and serving workers, including fast food	896	6,140
35-3022	Counter attendants, cafeteria, food concession, and coffee shop	121	819
35-3031	Waiters and waitresses	876	5,999
35-3041	Food servers, nonrestaurant	110	743
35-9011	Dining room and cafeteria attendants and bartender helpers	132	892
35-9021	Dishwashers	185	1,255
35-9031	Hosts and hostesses, restaurant, lounge, and coffee shop	161	1,089
35-9099	Food preparation and serving related workers, all other	16	93
37-1011	First-line supervisors/managers of housekeeping and janitorial workers	123	651
37-1012	First-line supervisors/managers of landscaping, lawn service, and groundskeeping workers	100	526
37-2011	Janitors and cleaners, except maids and housekeeping cleaners	1,520	8,165
37-2012	Maids and housekeeping cleaners	751	4,031
37-2019	Building cleaning workers, all other	18	87
37-2021	Pest control workers	17	82
37-3011	Landscaping and groundskeeping workers	1,040	5,585
37-3012	Pesticide handlers, sprayers, and applicators, vegetation	19	94
37-3013	Tree trimmers and pruners	7	27
37-3019	Grounds maintenance workers, all other	14	65
39-1011	Gaming supervisors	9	44
39-1012	Slot key persons	15	90
39-1021	First-line supervisors/managers of personal service workers	70	461
39-2011	Animal trainers	9	44
39-2021	Nonfarm animal caretakers	73	484
39-3011	Gaming dealers	24	150
39-3012	Gaming and sports book writers and runners	9	46
39-3019	Gaming service workers, all other	6	27
39-3021	Motion picture projectionists	7	33
39-3031	Ushers, lobby attendants, and ticket takers	75	494
39-3091	Amusement and recreation attendants	140	937
39-3092	Costume attendants	5	21
39-3093	Locker room, coatroom, and dressing room attendants	13	75
39-3099	Entertainment attendants and related workers, all other	27	171
39-4011	Embalmers	5	16
39-4021	Funeral attendants	11	60
39-5012	Hairdressers, hairstylists, and cosmetologists	161	1,082
39-5092	Manicurists and pedicurists	18	110
39-5093	Shampooers	5	18

Standard Occupational Classification			Advanced
Number	Title	2007	2030
39-5094	Skin care specialists	21	129
39-6011	Baggage porters and bellhops	22	135
39-6012	Concierges	12	69
39-6021	Tour guides and escorts	20	120
39-6022	Travel guides	5	17
39-6031	Flight attendants	79	522
39-6032	Transportation attendants, except flight attendants and baggage porters	17	101
39-9011	Child care workers	237	1,597
39-9021	Personal and home care aides	304	2,052
39-9031	Fitness trainers and aerobics instructors	182	1,220
39-9032	Recreation workers	147	982
39-9041	Residential advisors	9	44
39-9099	Personal care and service workers, all other	20	124
41-1011	First-line supervisors/managers of retail sales workers	457	3,012
41-1012	First-line supervisors/managers of non-retail sales workers	114	740
41-2011	Cashiers	1,337	8,847
41-2012	Gaming change persons and booth cashiers	15	83
41-2021	Counter and rental clerks	334	2,202
41-2022	Parts salespersons	104	674
41-2031	Retail salespersons	2,140	14,166
41-3011	Advertising sales agents	63	406
41-3021	Insurance sales agents	153	1,003
41-3031	Securities, commodities, and financial services sales agents	171	1,117
41-3041	Travel agents	45	283
41-3099	Sales representatives, services, all other	339	2,235
41-4011	Sales representatives, wholesale and manufacturing, technical and scientific products	212	1,388
41-4012	Sales representatives, wholesale and manufacturing, except technical and scientific products	785	5,188
41-9011	Demonstrators and product promoters	44	276
41-9021	Real estate brokers	52	328
41-9022	Real estate sales agents	89	578
41-9031	Sales engineers	59	375
41-9041	Telemarketers	231	1,514
41-9091	Door-to-door sales workers, news and street vendors, and related workers	6	24
41-9099	Sales and related workers, all other	75	482
43-1011	First-line supervisors/managers of office and administrative support workers	733	4,870
43-2011	Switchboard operators, including answering service	81	525
43-3011	Bill and account collectors	265	1,751
43-3021	Billing and posting clerks and machine operators	292	1,932
43-3031	Bookkeeping, accounting, and auditing clerks	1,260	8,383
43-3041	Gaming cage workers	15	85
43-3051	Payroll and timekeeping clerks	105	688
43-3061	Procurement clerks	48	309

Standard Occupational Classification			Advanced
Number	Title	2007	2030
43-3071	Tellers	328	2,171
43-4011	Brokerage clerks	75	485
43-4021	Correspondence clerks	5	22
43-4031	Court, municipal, and license clerks	134	882
43-4041	Credit authorizers, checkers, and clerks	39	249
43-4051	Customer service representatives	1,398	9,305
43-4061	Eligibility interviewers, government programs	73	475
43-4071	File clerks	133	872
43-4081	Hotel, motel, and resort desk clerks	204	1,344
43-4111	Interviewers, except eligibility and loan	133	872
43-4121	Library assistants, clerical	48	309
43-4131	Loan interviewers and clerks	172	1,133
43-4141	New accounts clerks	75	485
43-4151	Order clerks	209	1,382
43-4161	Human resources assistants, except payroll and timekeeping	95	618
43-4171	Receptionists and information clerks	739	4,910
43-4181	Reservation and transportation ticket agents and travel clerks	137	902
43-4199	All other information and record clerks	224	1,477
43-5011	Cargo and freight agents	25	151
43-5021	Couriers and messengers	57	367
43-5031	Police, fire, and ambulance dispatchers	64	414
43-5032	Dispatchers, except police, fire, and ambulance	124	809
43-5041	Meter readers, utilities	27	163
43-5051	Postal service clerks	58	374
43-5052	Postal service mail carriers	206	1,362
43-5053	Postal service mail sorters, processors, and processing machine operators	142	935
43-5061	Production, planning, and expediting clerks	159	1,048
43-5071	Shipping, receiving, and traffic clerks	381	2,528
43-5081	Stock clerks and order fillers	939	6,245
43-5111	Weighers, measurers, checkers, and samplers, recordkeeping	47	296
43-6011	Executive secretaries and administrative assistants	1,288	8,567
43-6012	Legal secretaries	134	877
43-6013	Medical secretaries	218	1,437
43-6014	Secretaries, except legal, medical, and executive	1,277	8,496
43-9011	Computer operators	73	470
43-9021	Data entry keyers	122	799
43-9022	Word processors and typists	39	249
43-9031	Desktop publishers	22	130
43-9041	Insurance claims and policy processing clerks	139	915
43-9051	Mail clerks and mail machine operators, except postal service	83	540
43-9061	Office clerks, general	1,618	10,770
43-9071	Office machine operators, except computer	81	525
43-9081	Proofreaders and copy markers	13	72
43-9111	Statistical assistants	6	27
43-9199	Office and administrative support workers, all other	165	1,085

Standard Occupational Classification			Advanced
Number	Title	2007	2030
45-1011	First-line supervisors/managers of farming, fishing, and forestry workers	80	486
45-2011	Agricultural inspectors	98	593
45-2041	Graders and sorters, agricultural products	283	1,744
45-2091	Agricultural equipment operators	16	85
45-2092	Farmworkers and laborers, crop, nursery, and greenhouse	473	2,921
45-2093	Farmworkers, farm and ranch animals	520	3,216
45-2099	Agricultural workers, all other	37	219
45-4011	Forest and conservation workers	20	112
45-4021	Fallers	24	139
45-4022	Logging equipment operators	24	139
47-1011	First-line supervisors/managers of construction trades and extraction workers	674	6,035
47-2011	Boilermakers	10	67
47-2021	Brickmasons and blockmasons	110	966
47-2022	Stonemasons	42	353
47-2031	Carpenters	871	7,808
47-2041	Carpet installers	24	199
47-2042	Floor layers, except carpet, wood, and hard tiles	8	53
47-2043	Floor sanders and finishers	24	194
47-2044	Tile and marble setters	62	538
47-2051	Cement masons and concrete finishers	377	3,368
47-2061	Construction laborers	1,103	9,897
47-2071	Paving, surfacing, and tamping equipment operators	73	635
47-2073	Operating engineers and other construction equipment operators	467	4,175
47-2081	Drywall and ceiling tile installers	328	2,924
47-2082	Tapers	61	529
47-2111	Electricians	912	8,176
47-2121	Glaziers	152	1,350
47-2131	Insulation workers, floor, ceiling, and wall	78	684
47-2132	Insulation workers, mechanical	22	174
47-2141	Painters, construction and maintenance	234	2,086
47-2142	Paperhangers	9	63
47-2151	Pipelayers	79	688
47-2152	Plumbers, pipefitters, and steamfitters	458	4,100
47-2161	Plasterers and stucco masons	50	432
47-2171	Reinforcing iron and rebar workers	33	275
47-2181	Roofers	167	1,481
47-2211	Sheet metal workers	145	1,279
47-2221	Structural iron and steel workers	42	357
47-3011	Helpers--brickmasons, blockmasons, stonemasons, and tile and marble setters	93	819
47-3012	Helpers--carpenters	61	529
47-3013	Helpers--electricians	66	573
47-3014	Helpers--painters, paperhangers, plasterers, and stucco masons	23	190
47-3015	Helpers--pipelayers, plumbers, pipefitters, and steamfitters	58	499

Standard Occupational Classification			Advanced
Number	Title	2007	2030
47-3016	Helpers--roofers	26	215
47-3019	Helpers, construction trades, all other	36	301
47-4011	Construction and building inspectors	105	926
47-4021	Elevator installers and repairers	18	137
47-4031	Fence erectors	18	137
47-4041	Hazardous materials removal workers	48	410
47-4051	Highway maintenance workers	128	1,133
47-4061	Rail-track laying and maintenance equipment operators	8	49
47-4071	Septic tank servicers and sewer pipe cleaners	24	194
47-4099	Construction and related workers, all other	62	540
47-5011	Derrick operators, oil and gas	52	450
47-5012	Rotary drill operators, oil and gas	46	397
47-5013	Service unit operators, oil, gas, and mining	49	419
47-5021	Earth drillers, except oil and gas	38	318
47-5031	Explosives workers, ordnance handling experts, and blasters	10	71
47-5042	Mine cutting and channeling machine operators	11	80
47-5049	Mining machine operators, all other	28	234
47-5051	Rock splitters, quarry	11	80
47-5061	Roof bolters, mining	5	22
47-5071	Roustabouts, oil and gas	151	1,336
47-5081	Helpers--extraction workers	74	644
47-5099	Extraction workers, all other	12	89
49-1011	First-line supervisors/managers of mechanics, installers, and repairers	346	2,579
49-2011	Computer, automated teller, and office machine repairers	102	747
49-2021	Radio mechanics	4	15
49-2022	Telecommunications equipment installers and repairers, except line installers	207	1,539
49-2091	Avionics technicians	15	98
49-2092	Electric motor, power tool, and related repairers	27	183
49-2093	Electrical and electronics installers and repairers, transportation equipment	21	142
49-2094	Electrical and electronics repairers, commercial and industrial equipment	119	877
49-2095	Electrical and electronics repairers, powerhouse, substation, and relay	32	221
49-2096	Electronic equipment installers and repairers, motor vehicles	33	230
49-2097	Electronic home entertainment equipment installers and repairers	40	281
49-2098	Security and fire alarm systems installers	52	373
49-3011	Aircraft mechanics and service technicians	117	858
49-3021	Automotive body and related repairers	105	768
49-3022	Automotive glass installers and repairers	17	110
49-3023	Automotive service technicians and mechanics	557	4,161
49-3031	Bus and truck mechanics and diesel engine specialists	193	1,434
49-3041	Farm equipment mechanics	12	75
49-3042	Mobile heavy equipment mechanics, except engines	137	1,013
49-3043	Rail car repairers	17	113

Standard Occupational Classification			Advanced
Number	Title	2007	2030
49-3051	Motorboat mechanics	8	40
49-3052	Motorcycle mechanics	18	120
49-3053	Outdoor power equipment and other small engine mechanics	22	152
49-3091	Bicycle repairers	39	274
49-3092	Recreational vehicle service technicians	17	113
49-3093	Tire repairers and changers	110	807
49-9011	Mechanical door repairers	27	183
49-9012	Control and valve installers and repairers, except mechanical door	43	302
49-9021	Heating, air conditioning, and refrigeration mechanics and installers	241	1,789
49-9031	Home appliance repairers	36	250
49-9041	Industrial machinery mechanics	184	1,363
49-9042	Maintenance and repair workers, general	896	6,711
49-9043	Maintenance workers, machinery	92	674
49-9044	Millwrights	26	176
49-9051	Electrical power-line installers and repairers	108	791
49-9052	Telecommunications line installers and repairers	104	765
49-9061	Camera and photographic equipment repairers	6	27
49-9062	Medical equipment repairers	29	204
49-9063	Musical instrument repairers and tuners	7	36
49-9069	Precision instrument and equipment repairers, all other	15	99
49-9091	Coin, vending, and amusement machine servicers and repairers	28	190
49-9093	Fabric menders, except garment	4	11
49-9094	Locksmiths and safe repairers	23	159
49-9095	Manufactured building and mobile home installers	10	58
49-9096	Riggers	13	77
49-9097	Signal and track switch repairers	7	40
49-9098	Helpers--installation, maintenance, and repair workers	76	555
49-9099	Installation, maintenance, and repair workers, all other	177	1,311
51-1011	First-line supervisors/managers of production and operating workers	854	5,167
51-2011	Aircraft structure, surfaces, rigging, and systems assemblers	7	28
51-2022	Electrical and electronic equipment assemblers	599	3,622
51-2023	Electromechanical equipment assemblers	85	502
51-2031	Engine and other machine assemblers	34	191
51-2041	Structural metal fabricators and fitters	151	905
51-2092	Team assemblers	1,075	6,510
51-2099	Assemblers and fabricators, all other	481	2,908
51-3011	Bakers	342	2,062
51-3021	Butchers and meat cutters	261	1,573
51-3022	Meat, poultry, and fish cutters and trimmers	289	1,744
51-3023	Slaughterers and meat packers	210	1,262
51-3091	Food and tobacco roasting, baking, and drying machine operators and tenders	27	148
51-3092	Food batchmakers	138	828
51-3093	Food cooking machine operators and tenders	68	401
51-4011	Computer-controlled machine tool operators, metal and plastic	167	998
51-4012	Numerical tool and process control programmers	19	106

Standard Occupational Classification			Advanced
Number	Title	2007	2030
51-4021	Extruding and drawing machine setters, operators, and tenders, metal and plastic	64	377
51-4023	Rolling machine setters, operators, and tenders, metal and plastic	22	121
51-4031	Cutting, punching, and press machine setters, operators, and tenders, metal and plastic	187	1,123
51-4032	Drilling and boring machine tool setters, operators, and tenders, metal and plastic	26	145
51-4033	Grinding, lapping, polishing, and buffing machine tool setters, operators, and tenders, metal and plastic	53	308
51-4034	Lathe and turning machine tool setters, operators, and tenders, metal and plastic	50	292
51-4035	Milling and planing machine setters, operators, and tenders, metal and plastic	28	160
51-4041	Machinists	498	3,009
51-4052	Pourers and casters, metal	12	59
51-4061	Model makers, metal and plastic	25	137
51-4071	Foundry mold and coremakers	16	82
51-4072	Molding, coremaking, and casting machine setters, operators, and tenders, metal and plastic	168	1,006
51-4081	Multiple machine tool setters, operators, and tenders, metal and plastic	229	1,379
51-4111	Tool and die makers	51	300
51-4121	Welders, cutters, solderers, and brazers	538	3,250
51-4122	Welding, soldering, and brazing machine setters, operators, and tenders	54	315
51-4191	Heat treating equipment setters, operators, and tenders, metal and plastic	27	152
51-4192	Lay-out workers, metal and plastic	15	77
51-4193	Plating and coating machine setters, operators, and tenders, metal and plastic	45	261
51-4194	Tool grinders, filers, and sharpeners	11	51
51-4199	Metal workers and plastic workers, all other	60	354
51-5011	Bindery workers	133	797
51-5021	Job printers	91	540
51-5022	Prepress technicians and workers	95	564
51-5023	Printing machine operators	376	2,271
51-6011	Laundry and dry-cleaning workers	417	2,520
51-6021	Pressers, textile, garment, and related materials	133	797
51-6031	Sewing machine operators	245	1,472
51-6041	Shoe and leather workers and repairers	11	51
51-6051	Sewers, hand	13	69
51-6052	Tailors, dressmakers, and custom sewers	59	346
51-6092	Fabric and apparel patternmakers	8	36
51-6093	Upholsterers	37	214
51-6099	Textile, apparel, and furnishings workers, all other	32	183
51-7011	Cabinetmakers and bench carpenters	260	1,565
51-7021	Furniture finishers	34	191
51-7041	Sawing machine setters, operators, and tenders, wood	74	440

Standard Occupational Classification			Advanced
Number	Title	2007	2030
51-7042	Woodworking machine setters, operators, and tenders, except sawing	95	564
51-7099	Woodworkers, all other	18	98
51-8012	Power distributors and dispatchers	19	106
51-8013	Power plant operators	92	548
51-8021	Stationary engineers and boiler operators	69	408
51-8031	Water and liquid waste treatment plant and system operators	408	2,461
51-8091	Chemical plant and system operators	59	346
51-8092	Gas plant operators	36	207
51-8093	Petroleum pump system operators, refinery operators, and gaugers	37	214
51-8099	Plant and system operators, all other	44	253
51-9011	Chemical equipment operators and tenders	67	393
51-9012	Separating, filtering, clarifying, precipitating, and still machine setters, operators, and tenders	126	750
51-9021	Crushing, grinding, and polishing machine setters, operators, and tenders	59	346
51-9022	Grinding and polishing workers, hand	58	339
51-9023	Mixing and blending machine setters, operators, and tenders	179	1,076
51-9031	Cutters and trimmers, hand	21	114
51-9032	Cutting and slicing machine setters, operators, and tenders	92	548
51-9041	Extruding, forming, pressing, and compacting machine setters, operators, and tenders	78	463
51-9051	Furnace, kiln, oven, drier, and kettle operators and tenders	19	106
51-9061	Inspectors, testers, sorters, samplers, and weighers	449	2,714
51-9071	Jewelers and precious stone and metal workers	22	121
51-9081	Dental laboratory technicians	61	356
51-9082	Medical appliance technicians	35	199
51-9083	Ophthalmic laboratory technicians	53	308
51-9111	Packaging and filling machine operators and tenders	504	3,048
51-9121	Coating, painting, and spraying machine setters, operators, and tenders	83	494
51-9122	Painters, transportation equipment	112	665
51-9123	Painting, coating, and decorating workers	100	595
51-9131	Photographic process workers	59	346
51-9132	Photographic processing machine operators	89	525
51-9141	Semiconductor processors	85	502
51-9191	Cementing and gluing machine operators and tenders	23	129
51-9192	Cleaning, washing, and metal pickling equipment operators and tenders	12	59
51-9193	Cooling and freezing equipment operators and tenders	14	75
51-9194	Etchers and engravers	36	207
51-9195	Molders, shapers, and casters, except metal and plastic	78	463
51-9196	Paper goods machine setters, operators, and tenders	103	610
51-9198	Helpers--production workers	513	3,102
51-9199	Production workers, all other	284	1,713
53-1011	Aircraft cargo handling supervisors	6	22
53-1021	First-line supervisors/managers of helpers, laborers, and material movers, hand	92	563

Standard Occupational Classification			Advanced
Number	Title	2007	2030
53-1031	First-line supervisors/managers of transportation and material-moving machine and vehicle operators	180	1,111
53-2011	Airline pilots, copilots, and flight engineers	117	720
53-2012	Commercial pilots	27	159
53-2021	Air traffic controllers	32	190
53-2022	Airfield operations specialists	10	50
53-3011	Ambulance drivers and attendants, except emergency medical technicians	10	48
53-3021	Bus drivers, transit and intercity	126	776
53-3022	Bus drivers, school	226	1,401
53-3031	Driver/sales workers	383	2,379
53-3032	Truck drivers, heavy and tractor-trailer	1,044	6,514
53-3033	Truck drivers, light or delivery services	769	4,796
53-3041	Taxi drivers and chauffeurs	79	484
53-3099	Motor vehicle operators, all other	93	566
53-4011	Locomotive engineers	30	174
53-4013	Rail yard engineers, dinkey operators, and hostlers	6	28
53-4021	Railroad brake, signal, and switch operators	18	99
53-4031	Railroad conductors and yardmasters	27	158
53-6021	Parking lot attendants	93	566
53-6031	Service station attendants	57	344
53-6041	Traffic technicians	6	22
53-6051	Transportation inspectors	15	79
53-6099	Transportation workers, all other	97	595
53-7011	Conveyor operators and tenders	28	164
53-7021	Crane and tower operators	32	187
53-7032	Excavating and loading machine and dragline operators	81	495
53-7033	Loading machine operators, underground mining	5	16
53-7041	Hoist and winch operators	7	30
53-7051	Industrial truck and tractor operators	415	2,581
53-7061	Cleaners of vehicles and equipment	247	1,530
53-7062	Laborers and freight, stock, and material movers, hand	1,264	7,888
53-7063	Machine feeders and offbearers	67	404
53-7064	Packers and packagers, hand	408	2,536
53-7071	Gas compressor and gas pumping station operators	5	21
53-7072	Pump operators, except wellhead pumpers	33	196
53-7073	Wellhead pumpers	27	156
53-7081	Refuse and recyclable material collectors	121	743
53-7121	Tank car, truck, and ship loaders	25	142
53-7199	Material moving workers, all other	53	315

Source: Management Information Services, Inc., 2008.

THE AMERICAN SOLAR ENERGY SOCIETY

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The Society is formally organized into eight topical divisions: Concentrating Solar Power, Clean Energy and Water, Resource Applications, Solar Buildings, Solar Electricity, Renewable Fuels and Transportation, Solar Thermal, and Sustainability. In these Divisions are professionals who participate in peer-review activities in support of technical papers for the national conference and provide fact-checking for articles in *Solar Today* magazine. ASES has three standing committees: the Policy Committee, the International Committee, and the Education Committee. It is represented by 24 chapters covering 41 states and four institutions of higher education.

The Society regularly organizes research and policy initiatives and prepares white papers from these activities In publishes *SOLAR* TODAY magazine, and for the past 13 years has hosted the annual National Solar Tour each fall. The nation's largest demonstration of green buildings and solar installations in the country. Headquartered in Boulder, Colorado, ASES represents more than 35,000 professional members, basic members, and chapter affiliates in the U.S. Please visit www.ases.org for more information.

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