Colorado Renewable Energy Industry

Current Economic Impact and Growth Requirements

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Prepared for Colorado Office of Energy Conservation
by University of Colorado at Boulder
Business Research Division
and
CU Business Advancement Center

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Table of Contents

This report summarizes results of primary research conducted in late 1998 by the University of Colorado's Business Research Division and CU Business Advancement Center to assess the current economic impact and growth requirements of renewable energy activities in the state. The intent of the study, funded by Colorado's Office of Energy Conservation, is to obtain information about the renewable energy [RE] industry in Colorado and to help assess whether policy initiatives are needed to support state participation in global industry growth trends and generate economic benefits to the state economy.

Information in the report is based on published industry literature, secondary data sources, and a survey of Colorado renewable energy [RE] organizations. A detailed report of survey data and methodology are attached as an Appendix.

Colorado Renewable Energy Industry
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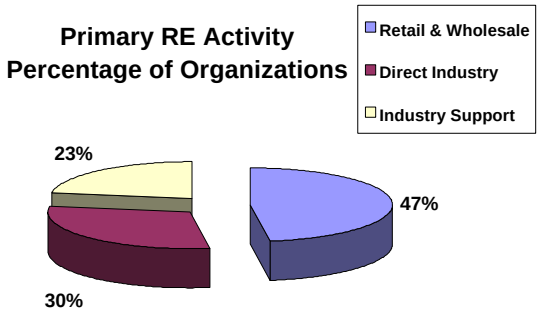
Executive Summary



According to *Environmental Business Journal*, global renewable energy [RE] revenues totaled $6.4 billion in 1997, an increase of $2.5 billion over 1993 revenues for photovoltaic systems, solar thermal, geothermal, wind power, biomass, and related services. *EBJ* estimates worldwide revenues for the industry will reach $7.4 billion in 1999, a 90% growth rate for the seven-year period 1993-1999.

The growth of the RE market is attributed to increased global demand for energy in developing countries, market opportunities created by deregulation of electricity in the United States and Europe, and international agreements to reduce greenhouse emissions caused by past reliance on fossil fuels. In addition, the ability of the RE industry to compete with lower-priced energy alternatives is improving through new technologies, and government policies that help compensate for the environmental cost of fossil fuel based utilities.

Overall, the majority of Colorado RE companies are not currently experiencing growth commensurate with growth trends worldwide. This can be attributed to the small number of manufacturing and other direct RE firms, and the low level of participation and interest in international trade.

The composition of renewable energy industry in Colorado is largely retail, wholesale, and support organizations, with only 30% of organizations involved in direct industry functions such as manufacturing, construction, design, engineering, and R&D. Retail and wholesale functions account for 47% of the Colorado industry, while 23% provide support functions such as trade associations, training, policy, and planning.

Colorado organizations participating in renewable energy activities are small, with 81% having 10 or fewer total employees in 1997 and 50% having only 1 employee involved in renewable energy activities.

About 36% of these organizations generate less than $100K in total annual gross revenue, and for 55%, less than $100K in gross revenue is attributable to renewable energy products and services. The majority [64%] of these organizations generate all of their revenue from RE sources.

Because various segments of the Colorado RE industry overlap somewhat, it is necessary to look at each segment. These segments include the National Renewable Energy Laboratory [NREL]; government, university, electrical producers; and the RE-related companies.

In 1997, the estimated impact of NREL was as follows:

- NREL awarded $21.5 million in purchase orders, research, and subcontracts to Colorado companies and small businesses.

- In addition, NREL employed 750 workers with wages for Colorado employees of approximately $38 million.

In 1997, the estimated impact of the government, university, and electrical producers was 75 RE-related employees with annual wages of $2.6 million.

In 1997, the estimated impact of 237 RE-related companies was as follows:

- Approximately 1,075 RE-related employees have annual wages of $31.4 million.
- These companies have annual estimated RE sales of $97.3 million. Approximately $31.4 million of these sales are within Colorado, while $65.9 million are sales to organizations or end-users outside the state. (These sales amounts include subcontracts and expenditures by NREL.)
- These companies annually spend approximately $36 million for raw materials and supplies, product components, finished products, manufacturing equipment, contract services, and transportation. Approximately $12 million is spent inside Colorado and about $24 million is spent outside Colorado.

The final estimates on the size and composition of the industry in Colorado are based on analysis of ES202 data; extraction of survey data to the projected RE Colorado population; and personal interviews with government, NREL, and university officials. The process of gathering information from these three sources has provided a set of checks and balances to help test the reasonableness of the final numbers.

The Colorado RE industry is very small, with approximately 1,875 RE employees working at 348 organizations. Total 1997 wages for the renewable energy workers are $72 million. The average 1997 annual wage is $38,400, compared to the overall average wage for the state of $30,057. This industry wage is higher than the state average because of the high percentage of research workers.

The annual sales for the RE companies can be determined based on an extrapolation of annual RE sales data provided by companies responding to a survey conducted by the CU Business Research Division. The estimated 1997 RE sales for the 237 companies was $97.3 million. This excludes NREL, the universities and government organizations, and the electric producers. Slightly more than 32% of these sales, $31.4 million, are within Colorado. A majority of the smaller companies sell almost exclusively within Colorado, while the larger companies have more diverse markets. Survey data were also extrapolated to determine that these 237 RE companies spent a minimum of $12 million in Colorado for raw materials and supplies, product components, finished products, manufacturing equipment, contract services, and transportation.

An estimated gross profit margin can be established by reviewing the 1997 Robert Morris and Associates Summary of Annual Statements. By evaluating selected SIC Codes, we can assume that the gross profit margin for the companies in this study is approximately 28%. This allows us to estimate that the 237 RE companies spent approximately $24 million outside Colorado for raw materials and supplies, product components, finished products, manufacturing equipment, contract services, and transportation.

Public and consumer education was identified as the most important factor that could impact profitability. The next most important factor was policies that would increase local market demand. Grants to develop and commercialize RE technologies were also important. Factors of least value to Colorado organizations were RE-specific export assistance, the establishment of an

RE industrial park/incubator, and industrial development bonds. Technical expertise and debt financing are two important and unmet service needs. A total of 45% of RE organizations will change their facilities in the next five years due to the need to lower costs, adapt to changing space requirements or because of personal factors.

Colorado's primary economic advantage appears to be the potential for industrial development based on new technology developed by NREL, universities, and company research. Breakthrough technology that increases the efficiency and lowers the cost of RE products could result in a competitive and profitable product with national and international applications. This would positively impact Colorado's economy, however, only if production of the product is based here.

Colorado Renewable Energy Industry

I. Worldwide Energy Markets

Global renewable energy revenues totaled $6,400 million in 1997, an increase of $2,500 million over 1993 revenues for photovoltaic systems, solar thermal, geothermal, wind power, biomass, and related services. *Environmental Business Journal [EBJ*] estimates worldwide revenues for the industry will reach $7,400 million in 1999, a 90% growth rate for the seven year period 1993-1999. [1]

Renewable energy growth is attributed to increased global demand for energy in developing countries, market opportunities created by deregulation of electricity in the United States and Europe, and international agreements to reduce greenhouse emissions caused by past reliance on fossil fuels. In addition, the ability of renewable energy to compete with lower-priced energy alternatives is improving through new technologies, and government policies that help compensate for the environmental costs of fossil fuel based utilities.

Current limitations on market growth in the U.S. include deregulation that opens new markets, but also pressures utilities to purchase lowest cost energy sources such as natural gas and western coal. In addition, the renewable industry has limited capacity and requires time to develop the capabilities to meet projected demand. Futhermore, while technological advances in some areas are creating cost-competitive renewable energy products, R&D financing continues at low and even declining levels, slowing future advances.

According to a recent report in *Environmental Business Journal*, "Renewable energy has ... emerged as a healthy export market for U.S. based firms. The following factors are driving growth:

- Demographic pressures from burgeoning populations in developing countries in Asia and Latin America;
- Activist policies in European economies stimulating energy conservation and shifts from fossil fuels;
- Privatization of electric utilities overseas leading to upgrades of generating capacity and promotion of off-grid electrification programs;
- Multilateral agencies utilizing broader environmental criteria in financing transactions; and lastly, and perhaps most importantly,
- Renewable energy systems have dramatically fallen in cost per unit generated since the oil price collapse in 1986 due to technology advances and manufacturing volume increases." [2]

"A worldwide 'power gap' has already caused a doubling of solar and wind power system production in the 1990s and is expected to create opportunities for renewable energy in Asia, South America and Eastern Europe. Electricity restructuring in both the U.S. and in Europe, now scheduled for mid 1999, may provide new openings for alternative power. Environmental energy markets have grown steadily since 1990, despite the fact that competing oil prices since the Gulf War have slumped to historic lows." [2]

[1] "Global Demand for Renewable Energy Booming," *Environmental Business Journal*, Vol. XI, No. 3, March 1998.
[2]"Global Demand for Renewable Energy Booming," *EBJ*, March 1998

Energy demand is expected to rise 50% or more over the next 20 years and deregulation of the gas and electricity markets will open up a $300 billion-a-year market in North America and $250 billion-a-year market in Europe.[3]

Global environmental energy revenues show steady increases in most renewable energy industry areas.

Global Environmental Energy Revenues
1993 to 1999

Global Sales ($mil)	1993	1995	1997	1999
Photovoltaic Systems	$800	$1,200	$1,500	$1,800
Solar Thermal	$400	$300	$400	$300
Geothermal	$1,000	$1,800	$1,500	$1,600
Wind Power	$800	$1,500	$2,000	$2,600
Biomass (not wood)	$500	$600	$700	$800
DSM Services	$400	$200	$300	$300
Total	$3,900	$5,600	$6,400	$7,400

Source: *Environmental Business Journal*, March 1998

Wind

"Wind energy continues its sharp updraft, particularly in Europe, and is often paired with diesel generators to cover slack breeze times. Over 1,560 MW was installed worldwide in 1997 according to the American Wind Energy Assn." [4] Worldwide sales of wind turbines were over $1.2 billion in 1996. Studies show that wind energy could produce 20% of electricity demand in the U.S. [5]

Alternative Fuels

"Advances in alternative fuels, e.g. biodiesel, new entrant A-55 (a naptha-based fuel emulsion) and others for co-firing with coal, plus biomass and other fuels are continuing with commercialization modes being engineered and demonstrated.…Prices are coming down as volumes rise….While biomass generation overall appears to be up only slightly, this decade, industrial usage of wood wastes, primarily in the pulp and paper industries, has grown 50% in the 1990s to over 64,000 KWH in 1996. This has offset reduced biomass usage by electric utilities that are being driven to shift to lowest cost natural gas and cheaper Western coal. Nevertheless, as Clean Air Act emission standards tighten in the year 2000, co-firing of biomass is being studied and implemented by more than twenty coal burning utilities in the U.S. This should drive biomass utilization back up in the next decade, requiring engineering for fuel blending and retrofits." [6]

Geothermal

"Geothermal generation is gaining overseas, though declining in the U.S. as electricity sales contracts with utilities expired over the last several years." [7]

[3] "Natural Gas Central to World's Future Energy Mix," *Oil & Gas Journal*, Vol. 95, n. 32, p. 37, August 11, 1997.
[4] "Global Demand for Business Booming," *Environmental Business Journal*, Vol. XI, No. 3, March 1998.
[5] "DOE awards record wind energy contracts," *Electric Light & Power*, p. 43, October 1997.
[6] "Global Demand for Business Booming," *Environmental Business Journal*, Vol. XI, No. 3, March 1998.
[7] "Global Demand for Business Booming," *Environmental Business Journal*, Vol. XI, No. 3, March 1998.

Photovoltaic (PV) Market

"Worldwide solar system sales totaled $1.4 billion in 1997, of which $1.2 billion was from photovoltaic cells, according to Scott Sklar, the Solar Energy Industries Associations (SEIA) (Washington) executive director. Recent advances in technology, government incentives, people-driven initiatives, and the deregulation of the U.S. electricity industry are beginning to make solar power a practical alternative. Industry already is using PV cells-semiconductors that convert light into electricity—in applications ranging from backup power systems to lighting. They also are used to power telecommunications and security systems. Other types of solar systems are being used to heat air and water in manufacturing facilities."[8]

"Because of a growth spurt in the solar industry, industrial applications for solar systems are beginning to make more sense. With an annual growth rate estimated at about 20%, the industry is mushrooming, especially outside of the U.S. where 75% of the market for solar products exists. The industry's growth has been driven, in part, by the massive demand for electricity in developing nations. In countries where there is little access to grid-connected systems, solar power provides a logical alternative. With two billion people in the world still without electricity, the potential for solar's growth is immense."[9]

"The decreasing cost of producing solar power also is making it a favorable choice for off-grid applications. Thanks to automation and other advancements in technology, the cost of solar power has plummeted. U.S. manufacturers, which now claim 50% of the global market for PV cells, experienced a record growth spurt in 1997. According to SEIA, four new automated solar manufacturing plants opened last year, and six more are scheduled to open this year. Several major oil companies are investing millions of dollars in new facilities." [10]

"Solar Energy Industries Association trade group reported that solar-panel sales have increased 25% a year for five years. The group predicted that solar-panel industry sales of $395 million in 1996 should grow at over 30% a year through December 31, 1999." [11]

"Solar Energy is making an increasing impact in Asia and cell manufacturers Sharp and Sony are stepping up production, mainly in response to growing demand from the Japanese domestic sector. Bangladesh has also just seen the installation of a $1.6 million solar facility which will provide power for 21 villages on an island in Narshingdi district." [12]

Still, worldwide solar power capacity represents only 1% of global power supplies. Increases in solar availability will depend on research that is making solar energy production more energy-efficient and cheaper and on government policies that support solar industries as a way of decreasing green house emissions agreements reached at the Kyoto accord.

[8, 9,10] "Solar Shines Brighter," *Industry Week*, Vol. 247, n. 8, p. 24, April 20, 1998.
[11] "Massachusetts Solar-Cell Firm's Stock Soars After Years of Struggles," *Boston Globe* (MA), October 8, 1997.
[12] "Solar Energy," *Automotive Environment Analyst*, n. 30, p. 17, July 1, 1997.

Competitive Position

While the higher cost of renewable energy continues to limit its competitive position relative to hydroelectric, natural gas, and fossil fuel energy sources, several factors are beginning to mitigate this relationship. Most importantly, technical advances and production volumes are decreasing the cost of renewables [see chart]. In addition, recognition of the environmental cost savings of renewable energy is beginning to be factored into pricing decisions through governmental action.

"Today, inexpensive natural gas limits the market for renewable energy. Yet substantial opportunities for renewable remain; the availability of gas is uneven across the world and accelerating climate change will require a conversion to carbon-free energy source….Competition from natural gas presents a major threat to the required growth of the renewable industry. Following deregulation of the gas market in the U.S., the price of gas dropped precipitously and heightened the price difference between the two sources for grid supplied electricity, a difference that is exaggerated by increasing competition in the electricity industry. As other nations deregulate their gas and electricity markets, renewables will face a similar challenge wherever gas is widely available….Post deregulation markets should allow renewables to improve their competitive position in the U.S….A renewable energy industry capable of serving billions of people will...require an extended period of sustained and rapid growth. Natural gas can provide a cheap and reasonably clean bridge to a renewable energy future."[13]

Energy Costs by Source

Cents per KWH	1995	2000	2005	2010
Wind	5.3	4.1	3.9	3.5
Geothermal	5.2	4.0	3.8	3.7
Photovoltaic	21.8	16.4	13.1	8.7
Solar Thermal	10.5	8.6	8.1	8.1
Biomass	8.5	8.1	7.5	7.2

Source: NREL, 1995.

As a result of [December 1997] global climate conference in Kyoto, Japan, 159 nations agreed to "reduce output of carbon dioxide and other greenhouse gases to 5.2% below 1990 levels by 2012." As a result, Germany is supporting solar manufacturing plants, and incentives that cover up to 60% of funding for solar systems. [14]

"Japanese homeowners receive 30% of the cost of installing rooftop solar cells from their government, which expects to install solar power for 10,000 homes this year…." [15]

[13] "Renewables and Natural Gas: Friends or Foes?" *Power Economics*, Vol. 1, n. 9, p. 37, November 1997.
[14] "Solar Shines Brighter," *Industry Week*, Vol. 247, n. 8, p. 24, April 20, 1998.
[15] "Solar Power May Get Day in the Sun," *Chicago Tribune*, p. 1, January 19, 1998.

Another example of government involvement in utility pricing is the United Kingdom's Non Fossil Fuel Obligation policy (NFFO). The intent of NFFO, introduced in 1990, is to "develop economically attractive and environmentally acceptable renewables." The policy "requires regional electricity companies to purchase specified amounts of power from 'green' sources. In addition, government support for NFFO is funded by a Fossil Fuel Levy on such electricity sales, guaranteeing that power produced under this scheme will be bought at economic rates for the length of the NFFO contract." [16]

Examples of government involvement in the U.S. include a "Department of Energy request of $4 million in fiscal 1999 for the renewable energy production incentive program, which covers landfill gas projects.…" In addition, the U.S. Environmental Protection Agency has set a national goal of 35% of waste diversion by 2005 and targets landfill gas projects through a Landfill Methane Outreach Program. [17]

"The grid-connected sector is the fastest-growing part of the PV industry with the largest markets being driven by incentives provided in Japan, followed by Germany and the U.S." "Other than getting a 10% federal tax credit, commercial users of electricity in the U.S. have had little incentive to switch to solar power. That is beginning to change. President Clinton announced a plan [June 1997] that could result in the installation of solar systems on the roofs of one million homes and businesses by 2010. Called the *Million Solar Roofs Initiative*, the program will be run by the DOE, which will work with partners in the building industries, local governments, state agencies, the solar industry, electric-service industries, local governments, state agencies, the solar industry, electric-service providers, and other organizations. Business owners will be able to apply for loans to install solar energy systems.…" [18] Congressional action in October 1998 authorized the Initiative and provided $1.5 million to support its activities.

"California is allotting $540 million to help promote present, new and emerging renewable technologies. Around $54 million of the total is expected to be utilized for rebates to electricity customers who install small wind, solar and fuel cell equipment." [20]

[16] "Championing the Cause of Small Hydro," *International Water Power & Dam Construction*, p. 14, March 1998.
[17] "EPA seeks 6% More for 1999 Budget," *Waste News*, Vol. 3, n. 39, p. 2, February 9, 1998.
[18] "Solar Shines Brighter," *Industry Week*, Vol. 247, n. 8, p. 24, April 20, 1998.
[19] "I'm Greener Then You," *Forbes*, Vol. 161, n. 5, p. 45, March 9, 1998.
[20] "Solar Shines Brighter," *Industry Week*, Vol. 247, n. 8, p. 24, April 20, 1998.

Technological Advances

Many new research activities show significant potential to produce cost competitive energy sources; however, the industry lacks the level of financing needed to rapidly move these technologies into commercial applications. "Overall renewable energy research funding fell from 1995 to 1997 due to general budget cutting in the U.S. and Europe. Solar thermal has lost the biggest share as R&D has shifted to systems and storage. U.S. FY 1998 funding saw a reversal of cutbacks as budget cutting pressures moderated. With a 1997 budget of $179 million, the National Renewable Energy Laboratory continues to make improvements to its wind, solar, transportation fuels, geothermal, hybrid vehicle and energy efficient building technologies." [21]

Government R&D Expenditures on Renewable Energy ($ Millions)

Country	SolPV	SolTh	Wind	Bmass	GeoTh	Hydro	Other	Sys/Stor	Total
U.S. 97	$60.0	$23.0	$29.0	$55.3	$30.0	$1.0	$16.0	$32.0	$214.3
U.S. 95	87.5	125.2	47.1	59.6	37.8	4.9	0.0	0.0	362.1

Source: *Environmental Business Journal*, March 1998.

Solar and PV Research

"Japan spends about $220 million annually on solar research, while Germany spends about $100 million. The U.S. government currently has a solar research budget of $60 million, less than a third of what it spent in the late 1970s." [22] "The lack of funding stretches development time by a decade or more….Currently companies active in this technical area are not making the level of profit that would support accelerated investment in internal R&D. Current national spending on PV research and development is roughly $30 million." [23]

"Although the use of PV cells has been increasing, the cost of solar power compared with other energy sources still is preventing its widespread growth. With the introduction of thin-film technology, however, the cost of PV cells is dropping. Thin film cells, while only about 9% efficient can be produced in a highly automated and inexpensive manner." [24]

A Japanese company is producing a hybrid silicon solar cell, using a layer of single crystal silicon sandwiched between layers of amorphous silicon, to reduce energy loss and increase conversion efficiencies. A German research institute is developing methods to cut cell costs by growing silicon on an inexpensive substrate to reduce the amount of silicon used. [25]

"The steady push to develop photovoltaic technology for practical applications is generating offshoots that could address a variety of application areas in addition to solar-power generation. Two recent innovations are electrochemical solar cells and a new approach to fossil-fuel power generation called thermal photovoltaics (TPV)." [26]

[21] *Environmental Business Journal*, Vol. XI, No. 3, March 1998.
[22] "Solar Power May Get Day in the Sun," *Chicago Tribune*, p. 1, January 19, 1998.
[23] "Breakthroughs Lead to Economic Mass-Manufacturing –Confab sees Rise in Photovoltaic Usage," *Electronic Engineering Times*, p. 35, October 20, 1997.
[24] "Solar Shines Brighter," *Industry Week*, Vol. 247, n. 8, p. 24, April 20, 1998.]
[25] "Hybrid Solar Cell Enters Production," *Modern Power Systems*, Vol. 17, n. 10, p. 12, October 1997.
[26] "Photovoltaics Progress Spawns Thermal, Chemical Spin-offs," *Electronic Engineering Times*, p. 35, October 20, 1997.

Wind Research

In late 1997 NREL was awarded $20 million in cost-shared subcontracts to develop technologies for utility-scale wind turbines of up to 1,000-kilowatt size. The next generation wind turbines will be installed in locations with moderate wind speeds of 13 to 15 miles an hour and will produce electricity for about 2.5 to 3.5 cents a kilowatt-hour by the year 2001. [27]

People-Driven Demand

Another important factor in the growth of renewable energy business is the increasing public support for alternative energy sources. "Numerous utilities across the U.S. are making the purchase of energy from renewable sources an option….In one program offered by the Public Service of Colorado, companies such as IBM Corp. and Adolph Coors Co. are voluntarily paying higher rates in order to support renewable-energy programs." [28] Residential demand in for green energy is also strong in Colorado.

According to Scott Sklar, Executive Director, U.S. Export Council for Renewable Energy, "More work-at-home consumers, small businesses and industries are investing in backup and off-grid electricity. Because of increased dependence on computers, telecommunications, production machinery, they cannot tolerate power interruptions. Also,'net metering' is approved in 23 states including CA, TX, NY, PA, OK, MN, New England and the Northwest. Net metering allows consumers, chiefly residents, to run their power meters backwards by generating electricity via whatever renewable means at home." [29]

"Some consumers are willing to pay more for electricity if it comes from an environmentally friendly source," according to a July 1997 report in the *Wall Street Journal*, which estimates that some households could pay $5.50 a month extra for electricity containing renewable sources. [30]

Petroleum Companies Enter Market

One indicator of the revenue potential and competitive environment for the renewable energy industry is the degree to which large energy companies, based in the petroleum industry, are entering the market.

British Petroleum is one example of a large energy company diversifying into renewables. Under its wholly owned subsidiary, BP Solar, the firm opened a 65,000 square foot plant in Fairfield, California, in January of 1998. The plant expects to be one of the largest producers of thin-film photovoltaic cells, employing 100 people by the end of 1998. "With solar sales at approximately $80 million last year, BP expects revenues to increase to $1 billion a year in another decade." [31]

[27] "DOE Awards Record Wind Energy Contracts," *Electric Light & Power*, p. 43, October 1997.
[28] "Solar Shines Brighter," *Industry Week*, Vol. 247, n. 8, p. 24, April 20, 1998.
[29] "Global Sweep of Renewables Reveals Most Openings are Overseas," *Environmental Business Journal*, March 1998.
30 "For Sale: Environmentally Correct Electricity," *Wall Street Journal*, Eastern Edition, Vol. 230, n. 16, p. B1, July 23, 1997.
[31] "Solar Shines Brighter," *Industry Week*, Vol. 247, n. 8, p. 24, April 20, 1998.

"The Royal Dutch/Shell group is to invest $500 million in the next five years to establish a new arm, to be called Shell International Renewables (SIR). The company said that it expected renewable energy to account for half of the world's power sources by the middle of the next century." Shell's renewable business will include solar photovoltaic, biomass energy, and offshore wind farms. [32]

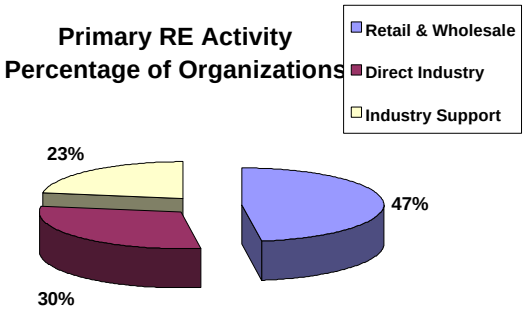
"Solarex, a joint venture of Amoco Corp. and Enron Energy, opened a $35 million dollar advanced solar cell manufacturing plant in Virginia to produce thin-film photovoltaics, which can build solar cells that are cheaper than traditional silicon-wafer cells and can be utilized as dual-use building material." [33]

Spire Corp in Bedford, Massachusetts, produces solar-panel manufacturing equipment. The firm reported an expected increase in revenues to $9.5 million in 1997, and $30 to $60 million within five years. [34]

[32] "Shell Plans Major Thrust Into Green Energy Market," *Power Economics*, Vol. 1, n. 9, p. 11, November 1997.
[33] "Solar Power May Get Day in the Sun," *Chicago Tribune*, p. 1, January 19, 1998.
[34] "Massachusetts Solar-Cell Firm's Stock Soars After Years of Struggles," *Boston Globe*, October 8, 1997.

II. Profile of Colorado Renewable Energy Business

Based on responses to a 1998 survey, the composition of renewable energy industry in Colorado is largely retail, wholesale and support organizations, with only 30% of organizations involved in direct industry functions such as manufacturing, construction, design, engineering, and R&D. Retail and wholesale functions account for 47% of the Colorado industry, while 23% provide support functions such as trade associations, training, policy, and planning.



Direct industry activities would presumably present the most potential for Colorado participation in global economic opportunities. Only 3.6% of Colorado-based operations identify product manufacturing and assembly as the primary business activity, while 12.8% identify it as a secondary business function. Another 20% of in-state operations involve primarily construction, installation, design, and engineering. The potential for industry growth based on new technology is represented by 5.4% of organizations showing R&D as a primary activity and 10.3% of organizations that list it as a secondary activity.

Based on employment levels, however, the industry composition looks much different. In 1997 the direct industry organizations accounted for about 83% of the industry employment, while retail and wholesale organizations make up slightly more than 13% of the total. Data provided by 117 renewable energy organizations verify overall in-state employment in 1997 of 4,866 workers, with 24%, or 1,166, employees actually involved in renewable energy activities. Of these, 882 are involved in direct RE industry activities. These companies estimated RE employment growth of about 10% a year through 2000.

In terms of number of employees, Colorado organizations participating in renewable energy activities are small, with 81% having 10 or fewer total employees in 1997 and 50% having only 1 employee involved in renewable energy activities.

About 36% of these organizations generate less than $100K in total annual gross revenue, and for 55% ,less than $100K in gross revenue is attributable to renewable energy products and services. The majority [64%] of these organizations generate all of their revenue from RE sources.

On average, almost 73% of the organizations indicated that Colorado was their primary market in 1997. Almost 39% reported that 100% of their 1997 sales were in the state. A total of 79% of organizations had no international sales in 1997, a percentage that is expected to decrease to 66% in 2000 as more organizations pursue international opportunities.

The industry in Colorado is relatively young, as nearly 45% of RE organizations are in their first eight years of existence. One-third of the organizations have been in business five years or less. Slightly more than 31% started their business during the 1980s and almost 16% started business in the 1970s. Only 8% were in business before 1970.

Photovoltaics represent the largest share of Colorado's renewable energy activity. A little over 33% of organizations are active in this area, including .9% in fuel cell with PV.

Almost 28% identify solar as their primary RE business activity, with 13.5% in passive solar, 13.5% in solar thermal, and .9% in solar thermal electric. Wood pellet fuel equipment is approximately 15% of the total industry in the state, followed by wind energy at 9% of primary activity.

In addition to the primary RE activity, organizations show diversity in other secondary RE categories. While photovoltaics is still the largest secondary sector at 31.6%, wind-related activities are next largest at just over 29%. A total of 6.8% are active in solar thermal electric, 3.4% in fuel cell with PV, 8.5% in biomass to fuel, and 3.4% show landfill gas as a secondary activity.

III. Economic Impact in Colorado

The National Renewable Energy Laboratory [NREL] and Colorado universities have provided a strong foundation for the RE industry and are responsible for a majority of the RE industry's impact on the Colorado economy. The following estimate of the size, composition, and economic impact of RE is based on data from these organizations and RE companies, as well as secondary data sources.

National Renewable Energy Laboratory [NREL]

At this time the NREL is the focal point for the Colorado RE industry. In 1997 NREL had more than 750 employees and paid $38.9 million in salaries, including out-of-state salaries. Since 98% of NREL's employees live in Colorado, most of this money is pumped back into the Colorado economy. In 1997, NREL awarded $15.4 million in purchase orders and subcontracts to Colorado companies. A total of $3.5 million was earmarked for research, while the remainder was used for construction, business services, and supplies. In 1997, an additional $29.5 million in procurements, subcontracts, and research agreements were awarded to small businesses, with $6.1 million going to Colorado small businesses.

NREL also has a strong indirect impact on the state's economy. It provides support to Colorado business development efforts by regularly providing technical expertise to Colorado small businesses and incubators. Fifteen Colorado companies have been formed from NREL-developed technologies, and 10 Cooperative Research and Development Agreements (CRADA) with Colorado companies have been completed, totaling $13.5 million. NREL has also been involved in several energy efficiency projects, including DIA, JeffCo Jail, residential construction in Pueblo, the South Platte River irrigation project, and the Federal Express Building solar wall.

Colleges and Universities

A survey of Colorado universities, colleges, and community colleges determined that approximately $2,789,000 in RE research or curricular contracts or grants was expended by these organizations during 1997. The institutions that received sponsored funding during 1997 were the University of Colorado at Boulder, Colorado State University, and the Colorado School of Mines. The University of Denver did not receive funding during 1997; however, they received a $49,000 National Science Foundation [NSF] grant to be applied to their Renewable Energy Policy curricular activities for the contract period of August 1998 to July 1999.

Colorado School of Mines

A majority of the state's RE research was conducted at Colorado School of Mines [CSM]. CSM's renewable/alternative energy research sponsorship totaled more than $1.6 million in fiscal year 1997 and nearly $1.5 million in fiscal year 1998. Specific project areas have included alternative fuels, hybrid vehicles, photovoltaic materials, fuel cells, biomass, solar cells and batteries, bioreactors, solar energy soil remediation, advanced electronic materials, decision-making modeling, and policy.

NREL is a major sponsor at CSM, contributing an average of $700,000 annually for research in the last three years. NREL-related projects totaled about $511,000 in 1997 and nearly $1 million in 1998.

Colorado State University

Colorado State University has received 26 RE-related grants extending from 1991 to 1999. These grants totaled slightly more than $2.5 million. Approximately 35% of this work, $885,000, was completed during 1997. About one-third of the 1997 total was from NREL funding.

University of Colorado at Boulder

At the University of Colorado at Boulder the majority of work is conducted through the Department of Electrical and Computer Engineering. CU-Boulder has received 13 RE-related grants totaling more than $794,000 that covered various periods during 1997 and 1998. NREL contributed more than $460,000 in funding. Approximately $304,000 of this amount can be appropriated to 1997 and about $490,000 to 1998.

University RE Research and Curricular Contracts

	Estimated 1997
Colorado School of Mines	$1,600,000
Colorado State University	$ 885,000
University of Colorado at Boulder	$ 304,000
Total	$2,789,000

RE Industry Analysis Using SIC Codes

The diverse nature of the RE industry makes it difficult to determine the size of the industry and easily track industry activity. There are no Standard Industrialization (SIC) Codes that allow for easy identification of industry organizations. A review of the SIC Codes reveals that it is possible for organizations to be included in 15 different SIC codes. Colorado has organizations operating in 13 of these groups.

SIC Code 4911 (Electric power generation, transmission, or distribution). In 1997 there were 105 organizations in the 4911 group compared to 100 organizations in 1992. This group showed minimal growth in employment. In 1997, employees totaled 5,219 employees compared to 5,166 in 1992. The dominant company in this group is Tri-State Generators. Only a small percentage of activity of organizations in this category relate to RE power sources.

SIC Codes 3629 and 2679 (Electrical industrial apparatus, NEC [not elsewhere classified]; converted paper, NEC). A variety of functions are performed in these two groups, including electrochemical generators (fuel cells) and fuel cell forms. In 1997 a maximum of 10 Colorado companies were working in these SIC codes that may include RE-related work. These companies employed 140 workers.

SIC Codes 5989, 2499, 5719, and 2861. The description for these SIC codes follows:

- SIC 5989 (Fuel Dealers, NEC – Wood dealers, fuel, retail),
- SIC 2499 (Wood products, NEC – Firewood and fuel wood),
- SIC 5719 (Miscellaneous home furnishings – Woodburning stoves – retail), and
- SIC 2861 (Gum and wood chemicals – Ethanol and methanol).

Most of these SIC code categories contain a number of organization types in addition to those mentioned above. In 1997 a maximum of 61 Colorado companies were working in these SIC codes that may include RE-related work. These companies employed 752 workers. A majority of the companies and employees are from SIC 5719. There were 47 companies and 575 employees from this very broad category.

SIC 9611 (Administration of general economic programs). For the purposes of this study the only governmental agencies included will be the Office of Energy Conservation and NREL. The employment level for these organizations has been determined through other means.

SIC Codes 3511, 3433, 3574, 5074, and 1711. The description for these SIC codes follows:

- SIC 3511 (Steam, gas, and hydraulic turbines – Wind powered generators; windmills),
- SIC 3433 (Heating equipment – Solar energy collectors, solar heaters),
- SIC 3674 (Semiconductors and related devices – Photovoltaic cells, photovoltaic devices),
- SIC 5074 (Plumbing and heating equipment and supplies – Solar heating panels and equipment), and
- SIC 1711 (Plumbing, heating and air conditioning – Solar heating apparatus contractors).

A review of SIC codes 3511 and 3433 shows that in 1997 a maximum of 6 Colorado companies may have performed RE-related work. These companies employed 56 workers.

A review of SIC 3674 is less insightful. In 1997, the 42 companies in this group employed about 7,000 workers. Virtually all of these companies manufacture semiconductor or optic-related products. No evidence of a significant base of photovoltaic-related manufacturers in SIC 3674 exists.

It is difficult to extract any meaningful data from an analysis of SIC 5074 and SIC 1711. About 1,500 companies employ approximately 19,000 workers in these two categories. Most likely, a majority of these companies perform work that is generic in nature. Because of the difficulty in extracting RE-related data from these SICs, it seems reasonable to fall back on the survey conducted by the CU Business Research Division to determine the size of this segment of the industry.

Industry Size Based on Interviews, SIC Analysis, and Survey Results

The final estimates on the size and composition of the industry in Colorado are based on analysis of ES202 data; extraction of survey data to the projected RE Colorado population; and personal interviews with government, NREL, and university officials. The process of gathering information from these three sources has provided a set of checks and balances to help test the reasonableness of the final numbers.

The Colorado RE industry is very small, with approximately 1,875 RE employees working at 348 organizations. Total wages for the renewable energy workers are $72 million. The average 1997 annual wage is $38,400, compared to the overall average wage for the state of $30,057. This industry wage is higher than the state average because of the high percentage of research workers at universities and federal laboratories.

The annual sales for the RE companies can be determined based on an extrapolation of annual RE sales data given in the survey conducted by the CU Business Research Division. The estimated 1997 RE sales for the 237 companies was $97.3 million. This excludes NREL, the universities

and government organizations, and the electric producers. Slightly more than 32% of these sales, $31.4 million, are within Colorado. A majority of the smaller companies sell almost exclusively within Colorado, while the larger companies have more diverse markets. Survey data were also extrapolated to determine that these 237 RE companies spent a minimum of $12 million in Colorado for raw materials and supplies, product components, finished products, manufacturing equipment, contract services, and transportation.

An estimated gross profit margin can be established by reviewing the 1997 Robert Morris and Associates Summary of Annual Statements. By evaluating the previously mentioned SIC codes, we can assume that the gross profit margin for the companies in this study is approximately 28%. This would allow us to estimate that the 237 RE companies spent approximately $24 million outside Colorado for raw materials and supplies, product components, finished products, manufacturing equipment, contract services, and transportation.

The following two tables segment the Colorado RE industry based on the primary RE sector and business function of the organizations.

Estimated Size of RE Industry by Organization and RE Sector

Organization	Number of Organizations	1997 RE Employees	1997 RE Wages ($ Millions)
NREL	1	725	$38.0
University and Government	5	50	1.4
Electric Producers	105	25	1.2
Solar Companies	58	250	7.4
Photovoltaics Companies	77	325	11.9
Other Companies	102	500	12.1
Total	348	1,875	$72.0

Estimated Size of RE Industry by Organization Function

Organization	Number of Organizations	1997 RE Employees	1997 RE Wages ($ Millions)
NREL	1	725	$38.0
University and Government	5	50	1.4
Electric Producers	105	25	1.2
Retail and Wholesale	110	500	11.5
Direct Industry	63	325	12.7
Industry Support	64	250	7.2
Total	348	1,875	$72.0

While the RE industry does have a positive impact on the Colorado economy, the following table shows that the RE industry represents substantially less than 1% of the state's employment, number of establishments, and total wages.

RE Industry as a Percentage of State Totals

	RE Industry	State	RE as % of State
Number of Establishments	348	133,319	0.3%
Employment (thousands)	1.875	1,953	0.1%
Wages ($ millions)	$72.0	$58,701	0.1%

Summary of Impact

Because various segments of the Colorado RE industry overlap somewhat, it is necessary to look at each segment. These segments include NREL; government, university, electrical producers; and the RE-related companies.

In 1997, the estimated impact of NREL was as follows:

- NREL awarded $21.5 million in purchase orders, research, and subcontracts to Colorado companies and small businesses.
- In addition, NREL employed 750 workers with wages for Colorado employees of approximately $38 million.

In 1997, the estimated impact of the government, university, and electrical producers was 75 RE-related employees with annual wages of $2.6 million.

In 1997, the estimated impact of 237 RE-related companies was as follows:

- Approximately 1,075 RE-related employees have annual wages of $31.4 million.
- These companies have annual estimated RE sales of $97.3 million. Approximately $31.4 million of these sales are within Colorado, while $65.9 million are sales to organizations or end-users outside Colorado. (These sales amounts include subcontracts and expenditures by NREL.)
- These companies annually spend approximately $36 million for raw materials and supplies, product components, finished products, manufacturing equipment, contract services, and transportation. Approximately $12 million is spent inside Colorado and about $24 million is spent outside the state.

IV. Industry Growth Requirements

Global change in renewable energy industry is driven by global demand for energy in developing countries, deregulation of electricity in the United States and Europe, and international agreements to reduce greenhouse emissions caused by past reliance on fossil fuels. In order to participate in expanding energy markets, renewables are finding ways to compete on a cost per unit basis with oil and natural gas producers. Factors that are improving this competitive position include:

- Technology advances that improve efficiencies and manufacturing volumes
- Government initiatives to increase use of renewables and decrease use of fossil fuels
- Utility deregulation and policies that open electric power grids to a variety of power sources, and
- Programs that create consumer awareness and offer options to purchase "green" energy sources.

For Colorado renewable energy organizations, public and consumer education was identified as the most important factor that could impact profitability. The next most important were policies that would increase local market demand, low cost financing for residential and small commercial systems, PV net metering, and green pricing programs. Grants to develop and commercialize RE technologies were also important. There was significant agreement among respondents in the retail/wholesale, industry support, and direct industry sectors. The only variation was the increased importance of tax incentives for RE production and facilities, which ranked fourth for the direct industry sector.

Top Six Factors Impacting Profitability of RE Companies

Factors	All RE	Direct Industry
Public/consumer education	1	1
Financing residential and small commercial systems	2	2
PV net metering	3	3
Green pricing	4	7
Grants to develop technologies	5	5
Tax incentives for RE production and facilities	6	4

Factors of least value to Colorado organizations are RE specific export assistance, the establishment of a RE industrial park/incubator, and industrial development bonds.

Consistent with these rankings, less than 20% of RE organizations consider export assistance and shared administrative services as important. While marketing assistance is considered important, organizations find this assistance currently available. Design and engineering services, legal assistance, and management assistance are of less importance and are available to most RE organizations.

Technical expertise and debt financing are two important and unmet service needs.

Location Selection and Colorado Strengths

Colorado RE organizations identified natural resources and state climate, general quality of life, positive environmental attitudes, in-state customers, and the healthy state economy as important

in their decision to locate in the state. Companies also perceived these features as strengths in Colorado. No areas were identified by RE organizations as being both important and a state weakness

Direct industry RE organizations chose Colorado for these same reasons except that a healthy state economy was less important to this group. State and local tax structures are not only important to direct RE industry organizations, but are considered a state weakness. While 88% of direct industry respondents considered proximity to federal labs as a strength of Colorado, it was a location factor for only 45%. University RE research was also considered a strength of the state, but was a location factor for only 20%.

Important Location Factors and State Strengths
(as a percentage of responses)

Factors	Important Location Factors	Colorado Strengths
Natural resources and climate	86.4%	98.8%
General quality of life	85.3	95.5
Positive environmental attitudes	79.1	85.4
In-state customers	65.1	83.6
Healthy state economy	55.8	97.4

Colorado Weaknesses and Importance to Location Choice
(as a percentage of responses)

Factors	Strength Rating	Importance
State and local tax structure	22.7%	31.7%
State government leadership	38.0	32.5
In-state suppliers	38.8	23.8
Cost of space	44.6	28.4
Available technical workforce	50.7	40.7

Workforce Issues

A technical workforce for the RE industry is less important to location decisions; however, it is considered a strength in Colorado by only 50.7% of organizations. RE organizations identify workforce needs in high school educated workers, RE training, RE certification programs, and energy or environmental degreed workforce. The following chart demonstrates the unmet workforce need by the difference between importance to RE companies and availability of workers. While there is no apparent lack of availability for college educated employees, RE organizations identify cost as a factor in this labor category.

Unmet Trained Workforce Needs
(as a percentage of responses)

Education Level	Important to RE *	Available to RE*	Workforce Gap
College educated	52.1%	60.0%	None
High school educated	51.7	23.1	28.6
RE training programs	50.0	16.0	34.0
RE certification training	43.0	20.0	23.0
Energy/environmental degrees	44.1	30.0	14.1

* percentage of responses

Labor Affordability Gap (as a percentage of responses)			
Education Level	**Important to RE**	**Affordable to RE**	**Labor Cost Gap***
College educated	52.1%	40.0%	12.1
High school educated	51.7	76.9	-25.2
RE training programs	50.0	84.0	-34.0
RE certification training	43.0	80.0	-37.0
Energy/environmental degrees	44.1	70.0	-25.9

*When the gap is less than zero, there is no labor cost gap.

Facility Requirements

More than 60% of RE organizations consider cost of space as a weakness in Colorado. Slightly less than half of RE organizations will change their facilities in the next five years. The primary reasons for moving are:

- Need to lower the cost of facilities,
- Change in space requirements, and
- Personal factors.

A total of 45% of RE organizations will change their facilities in the next five years, with 25% moving to a facility with larger space and 12% renting or leasing additional facilities. Almost 8% will renovate current facilities.

Of those RE organizations that are planning to move within the next five years, 2% anticipate moving out of state. Slightly more than 68% of the organizations planning to move would relocate in the same county, while slightly less than 30% would locate elsewhere in Colorado.

Eco-Industrial Park

Only 31% of RE organizations responded favorably to the concept of an eco-industrial park/sustainable technology business center. As would be expected, few retail and wholesale organizations [19%] support such a park, while about 41% of direct industry organizations and industry support organizations favor it.

All of the interested companies were attracted to this concept primarily by the prospect of low facility costs. Less than 50% of organizations were interested in other potential benefits offered by such a facility. About 44% were interested in access to research facilities and technical expertise, consistent with the need expressed previously. Although organizations previously indicated that management and marketing assistance are both available and affordable, about 37% were interested in having these services on-site. Few Colorado RE organizations are participating in international market opportunities, and less than 10% of those interested in the incubator viewed proximity to an international airport, location in an international trade zone, or export assistance as benefits. Proximity to rail or to feedstock (biomass) were both of little interest to this group.

Those who were interested in such a park typically indicated that the facility should be near their current location.

Preferred Location for Eco-Industrial Park

Location	Percentage of Respondents Interested in Park
Denver Metro Area	42.4%
Boulder	24.2%
Grand Junction	15.2%
Colorado Springs	12.1%
Fort Collins	6.1%
Total	100.0%

V. Conclusions

The Colorado RE industry is very small, with less than 2,000 employees. The industry's annual wages of $72 million represent less than half of one percent of total state employment and wages. Almost half of the RE employees work at the National Renewable Energy Laboratory, universities, and government, as opposed to businesses. Over half of the RE wages are related to the NREL alone. Average wages for the RE industry are higher than the state norm, primarily because of the high concentration of research that is conducted in Colorado.

Annual nonwage expenditures in Colorado by RE companies are estimated at $12 million, and $21.5 million by NREL.

Overall, the majority of Colorado RE companies are not currently experiencing growth commensurate with growth trends worldwide. This can be attributed to the small number of manufacturing and other direct RE firms, and the low level of participation and interest in international trade.

Colorado's primary economic advantage in RE appears to be the potential for industrial development based on new technology developed by NREL, universities, and private sector research. Strategies that strengthen the development, transfer and commercialization of new RE technologies could build on this advantage. Recent growth in the industry has not been in the large organizations, but rather in a few smaller, younger companies that are using RE-related technology in other products. These companies are growing based on their ability to take advantage of the strong international RE markets.

An overwhelming majority [88%] of direct industry survey respondents considered proximity to a federal lab as a strength of Colorado, and 45% of these firms included this as an important factor in their choice of location. Financing for R&D is necessary to speed product development time to market and is considered by direct RE firms as important to their future growth. Breakthrough technology that increases the efficiency and lowers the cost of RE products could result in a competitive and profitable product with national and international applications. This would result in economic impact for Colorado, however, only if production of the product is based here.

All types of RE companies agree that their future growth would most likely be aided by public education and policies that increase local market demand. Future growth in the wholesale and

retail segment of the industry would be expected to remain minimal without additional government intervention that provides financing for residential and small commercial systems and policies such as PV net metering and green pricing programs. The wholesale and retail segment includes such companies as solar heating contractors or retail outlets that sell wood-burning stoves. These firms sell primarily within the state, drawing limited new dollars into the state economy. It is difficult to assess the actual economic impact of government market intervention, which essentially shifts market demand from one sector to another. In this case, action to increase employment and sales of RE-energy and products will likely *decrease* employment and sales of current *nonrenewable* energy sources. The economic equation, therefore, needs to include the effects and cost of pollution created by petroleum and coal energy sources.

Economic development strategies to attract new companies to the state should promote the five factors that, in the opinion of RE firms already located here, were most important to company choice of location and rated high as Colorado strengths:

- Natural resources and climate,
- General quality of life,
- Positive environmental attitudes,
- In-state customers, and
- A healthy state economy.

In addition, relocation efforts would be more successful if the state could bolster those factors considered by in-state RE companies to be Colorado weaknesses:

- State and local tax structure,
- State government leadership,
- In-state suppliers,
- Cost of space, and
- Available technical workforce.

It should also be noted that, while 45% of existing Colorado RE firms will move in the next five years, only 2% of these are considering a move out of state.

Another economic development strategy explored by the company survey was the concept of an eco-industrial park/business incubator for RE companies. It is doubtful whether this concept would prove economically viable based on Colorado company participation alone. When rated against other growth generating alternatives, companies rated this type of intervention extremely low. Even when presented as a stand-alone option, only 31% of RE companies [36] showed some interest in this concept. In addition, companies wanted such a facility in their current community. Of those interested, 42% [15], would consider a Denver metro location. Another 8 prefer Boulder and could be added to the Denver metro category. More significantly, *all* companies expressing interest were attracted primarily by the presumption of lower facility costs. While a few were interested in access to research facilities and technical expertise in such a facility, the cost of providing this type of support would require significant, on-going government or sponsor subsidy if a below-market space cost were to be offered. It appears that existing technology business incubators located in Lakewood and Boulder, both with proximity and working relationships with NREL, CSM and CU, could effectively serve emerging RE companies.