

Clean Energy Economic Development Series

COLORADO'S CLEANTECH JOURNEY



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Prepared by Collaborative Economics
for Environmental Defense Fund

Report prepared for

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ABOUT THIS REPORT

Collaborative Economics has analyzed the clean energy economy in all 50 states for the Pew Charitable Trusts and National Governors Association, and for many states and communities from California to Delaware, from Silicon Valley to St. Louis. Collaborative Economics published the country's only Green Innovation Index, focusing on changes in jobs, companies, financing, and other indicators of innovation in California. As importantly, we have worked directly with practitioners at the state and local levels all across the country to develop strategies to encourage development of clean energy sectors.

We have been struck by the determination with which public and private sector leaders are working together to turn the clean energy opportunity into an economic development "win" for their state or community. They focus on the basic "blocking and tackling" of job creation - encouraging market growth, streamlining permitting processes, making strategic investments, training workers, and helping companies find places to grow.

Through tracking the experience of individual firms in the clean energy sector (see LessCarbonMoreJobs.org), Environmental Defense Fund research continues to show that job creation in the clean energy sector - as in all sectors - must begin with creating customers. A focus on job training that ignores the need to simultaneously create customers may see trained job seekers, but little actual hiring. In contrast, regions that focus on nuts and bolts efforts, particularly in the key areas of market demand (notably creating customers now), seeding innovation, company recruitment and workforce development, are most likely to succeed.

The clean energy economy is growing, state by state, community by community, across the country. Job creation and private investment in manufacturing, installation, R&D, and other services are signs that the market is rewarding innovative, competitive companies. The reason for this success goes well beyond any single public policy, investment, or training program. Indeed, the formula that is working is a mix of federal, state, and local government initiatives, private sector economic development efforts, and industry associations and collaborations. It is also the result of bipartisan efforts to help stimulate market demand, seed innovation, then capture the economic benefits for people and places in these states. While these actions can occur independently, economic growth can be more successful with a multi-faceted approach that involves collaboration across sectors and stakeholders.

Every state and community that has experienced the benefits of a growing clean energy economy has blazed its own trail. Each one has a distinctive energy mix, set of natural assets, and existing industry strengths in manufacturing, agriculture, research, or other areas. What they have in common is the recognition that clean energy is a tangible opportunity for economic growth, just as it was biotechnology, information technology, or other opportunities in years past. In these states and communities, leaders find more reasons to work together on practical steps to promote job creation, than oppose one another to gain political advantage.

Their stories - their journeys - are clearly in the early stages. They would be the first to say they have a long way to go. But, as Colorado, Iowa, Ohio, and others have shown, states and communities can take action and get results in the form of new jobs, companies, and innovation that helps meet immediate needs and set the stage for future economic growth.



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OVERVIEW OF COLORADO'S ECONOMIC JOURNEY INTO CLEANTECH

Colorado has demonstrated that the clean technology (cleantech¹) industry has tremendous potential to contribute to local economies. In recent years, Colorado's cleantech economic activity has surged, establishing the region as a leader in the cleantech industry.

- **Colorado has become a national hub for cleantech innovation**, with robust cleantech research and development (R&D) activities spearheaded by the National Renewable Energy Laboratory (NREL), Colorado universities, and private companies. These stakeholders have leveraged the presence of NREL to establish specialized research centers that drive cleantech innovation in the state. NREL alone creates a \$714 million annual economic impact in the state (Development Research Partners, 2012).
- **Cleantech startups and established companies are increasingly choosing to locate and expand in Colorado**, creating job opportunities for workers across the skills-spectrum. The Metro Denver region alone had about 1500 companies and 18,000 workers in the cleantech sector in 2011 and achieved a 35 percent increase in direct employment growth since 2006. The Metro Denver region ranked 6th of the 50 largest metro areas in cleantech employment concentration in 2011 (7th in total number of workers). Cleantech companies employ about one percent of the region's employment base, which is nearly twice the national average. These jobs generated more than \$1.3 billion from wages in 2010 (Development Research Partners, 2012).²
- **Renewable energy installations have increased sharply to meet local demand**, with total installations of solar and wind nearly doubling between 2007 and 2011 (AWEA, 2012b; Solar Energy Industry Association, 2012).
- **Colorado's leadership in cleantech has been achieved through collaboration.** Colorado stakeholders have worked across party lines and with public and private organizations to advance Colorado's cleantech economy. This supportive environment has been reinforced by the attitudes and behaviors of the people in Colorado.

How has Colorado achieved this cleantech economic activity? Colorado's success in clean technology cannot be attributed to any single effort; stakeholders have worked across jurisdictions, companies, and political party lines to collectively build a robust, diverse clean technology economy. Stakeholders have worked collaboratively to implement actions to stimulate demand for cleantech products and services, foster cleantech innovation, and help the region capture economic benefits from the sector's growth. Building off the state's history as a fossil fuel producer, its talented workforce, and strong energy research expertise, Colorado has successfully diversified its economy and become a leader in the cleantech industry.

Colorado's cleantech economy includes companies across the value chain, ranging from clean technology startups to wind component manufacturers, to solar panel installers. Workers in the cleantech sector are even more varied than the companies themselves; installers, technicians, sales representatives, engineers and scientists all contribute to the cleantech economy. This report will highlight a sampling of activities across the sector to demonstrate the evolution of Colorado's strong cleantech economy.

Given the depth and breadth of activities occurring in cleantech throughout Colorado, this report will focus primarily on the Metro Denver region, which includes the nine county metropolitan area of Denver and Northern Colorado, to illustrate the types of activities occurring in Colorado. This report will first discuss the actions Colorado stakeholders have taken to stimulate market demand, seed innovation, and capture the economic benefits, then show the results of those actions to date.

¹ Note that Colorado uses the term "cleantech" to describe its energy industry subsector. According to Colorado Cleantech Industry Association: Clean technology includes renewable energy manufacturers and providers as well as products and services that make our current energy production and distribution systems more efficient. The sector also includes products and technologies that help consumers and industries use natural resources such as energy, water and waste more efficiently.

² Development Research Partners identifies cleantech companies and workers as those directly related to the energy industry. For a full list of SIC and NAICS codes evaluated for inclusion in the cleantech sector view the full report: http://www.metrodenver.org/files/documents/industries-companies/industries/Energy_2011_9C_012212.pdf

COLORADO'S CLEANTECH ECONOMY ACTIONS

A robust cleantech economy is based on strong customer demand for cleantech products and services with ongoing innovation to advance the sector.

A region can develop all or part of this economy locally through focused actions in three different categories: stimulating demand, seeding innovation, and capturing economic benefits. These types of actions may be focused in just one category, but sector growth can be more successful with a multi-faceted approach that involves collaboration across sectors and stakeholders.

A diverse set of stakeholders play roles in building a strong cleantech economy. These stakeholders can include local, regional, state, and federal government, as well as private companies, academic institutions, and organizations. Colorado stakeholders have worked across sectors to create a unique atmosphere that fosters a growing clean energy economy. The Colorado Action Timeline in Figure 1 exhibits a sample of actions that have helped stimulate demand, seed innovation, and capture the economic benefits in the region of the cleantech industry. Colorado's stakeholders consistently employed strategic actions across all three categories, attracting customers to build a new market as well as pushing local firms to adopt new innovations and incentivizing other firms to locate in their region. These actions are explained in greater detail in the following sections.

ACTIONS TO BUILD THE CLEANTECH ECONOMY

Stimulating Demand – Initiatives that increase consumer demand for clean energy by increasing affordability, removing barriers, or setting standards for clean energy.

Seeding Innovation – Actions to increase local cleantech innovation by investing in research and development, funding new startup companies, or creating supportive networks.

Capturing Economic Benefits – Actions to recruit and support cleantech companies while also promoting and aligning job creation and workforce development.

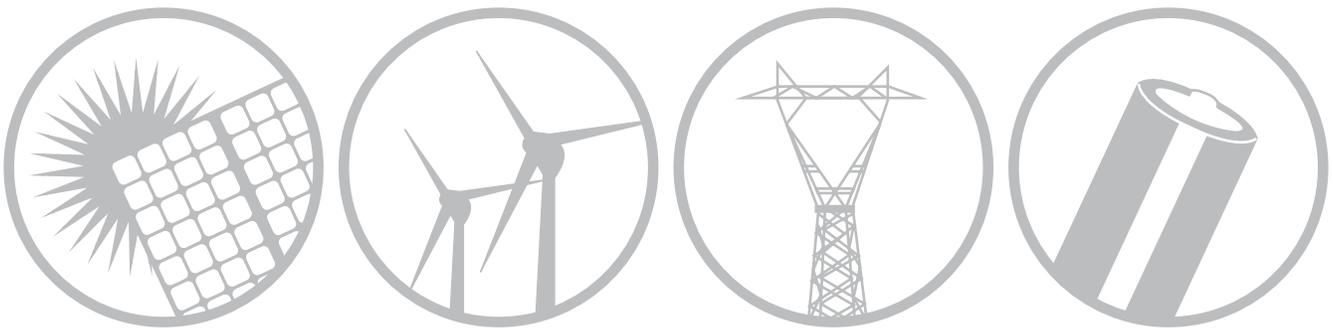
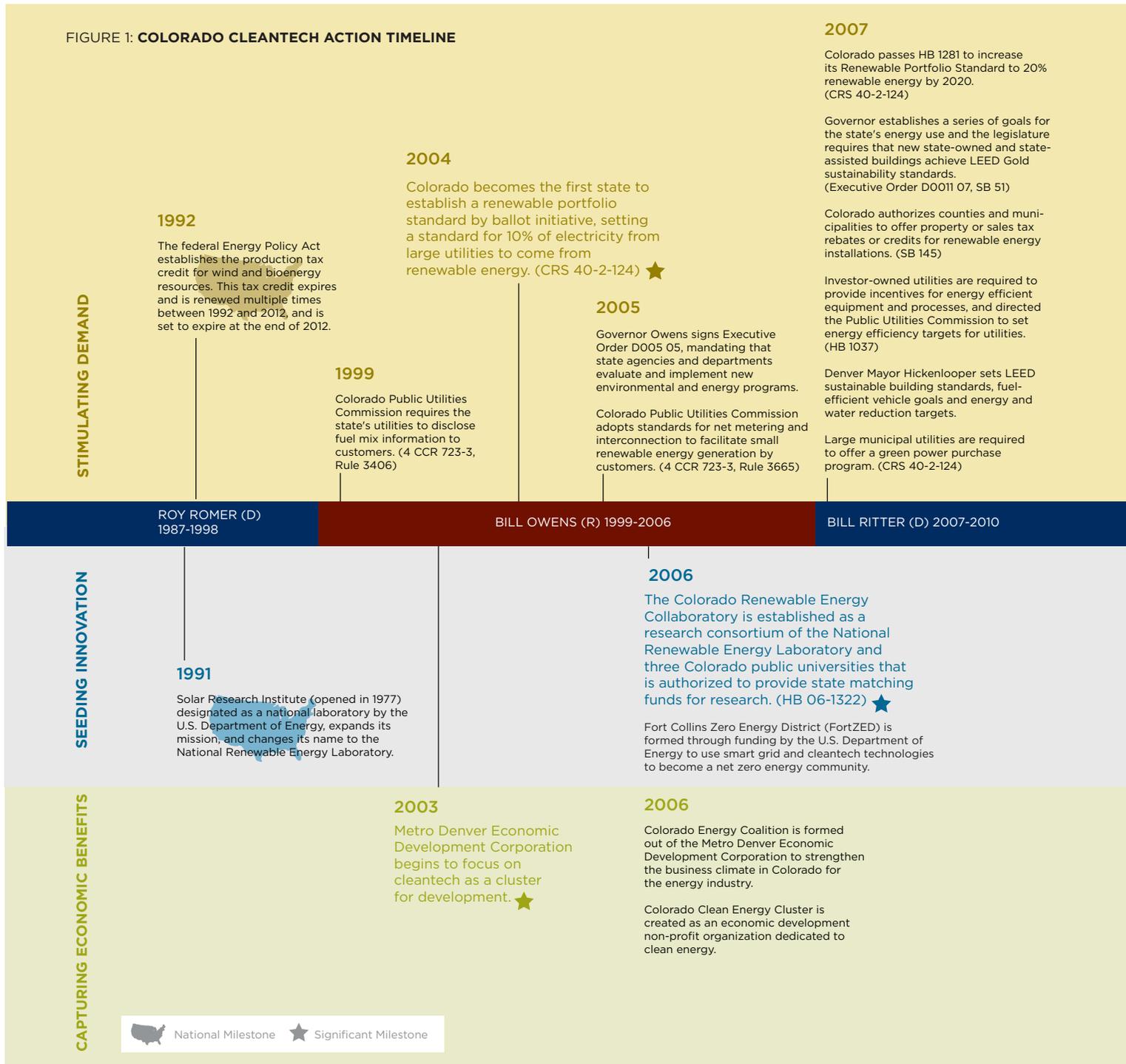


FIGURE 1: COLORADO CLEANTECH ACTION TIMELINE



STIMULATING DEMAND

Stakeholders can increase the cleantech customer base by stimulating demand for products and services. Policymakers could remove regulatory barriers to expand access to clean energy, create financial incentives to increase affordability, or set standards for increased clean energy use. These actions send a market signal to cleantech companies that there will be a local demand for products. Many companies opt to ramp up production of goods and services in response. Colorado's policymakers and organizations have implemented a number of these actions in the past decade to stimulate consumer demand and expand the cleantech market.

Cleantech policies in Colorado have been implemented under both Republican and Democratic administrations. Top-level leaders in the Colorado General Assembly from both parties, as well as the state's U.S. senators and representatives, have helped reduce regulatory hurdles and create incentives to increase cleantech economic development. Republican Governor Bill Owens oversaw a kick start in the state's cleantech economy with actions such as the 2005 Executive Order to mandate government purchasing of cleantech products and services where feasible. Democratic Governor Bill Ritter was instrumental in accelerating cleantech activity through his plan for the

2008

Residential renewable energy systems are exempted from property taxes. (CRS 39-3-102)

Access laws are updated to protect installation of wind turbines (CRS 38-30-168).

Colorado creates a state-wide cap for permit fees or active solar energy devices. (SB 117, CRS 30-28-113)

2009

The American Recovery and Reinvestment Act provides more than \$585 million in funding for Colorado-based clean energy projects.

Colorado exempts renewable energy systems from sales and use tax. (CRS 39-26-724)

Regulations are modified to increase the size of customer solar systems and to allow third parties to sell customer generated solar power. (SB 09-051)

2010

Colorado passes HB 1001 to further increase its Renewable Portfolio Standard to 30% renewable energy by 2020. (CRS 40-2-124)

Colorado passes HB 1365 to retire coal-fired plants and create jobs through construction and services from replacement energy.

The Green Colorado Credit Reserve is established to incentivize private lenders throughout Colorado to make small commercial loans up to \$100,000 for capital improvements that promote energy efficiency and renewable energy.

Colorado creates a \$13 million Direct Lending Revolving Loan Program using Recovery Act funds. This program provides loans at a minimum of \$100,000 for energy efficiency and renewable energy projects.

2012

Regulatory requirements are reduced for host locations of alternative fuel vehicle charging and fueling stations, such as retail or community venues. (HB 1258)

Colorado passes a law to allow wind easements on property. (HB 1105)

JOHN HICKENLOOPER (D) 2011-PRESENT

2010

The Colorado Center for Renewable Energy and Economic Development launches out of NREL to facilitate commercialization of cleantech products and services.

2011

The Innovation Reinvestment Act designates 50% of future growth of income tax withholdings from the cleantech and bioscience industries as seed money for cleantech and bioscience startup companies and inventions. (SB 47)

University of Colorado - Boulder launches CU Cleantech to connect researchers, students, and industry on innovation and commercialization activities.

2012

Metro Denver region successfully wins bid for a new satellite U.S. Patent and Trademark Office.

2008

The Colorado Cleantech Industry Association, an industry-led and industry focused group, is launched to promote the state's cleantech industry.

Vestas opens its first manufacturing facility in Colorado for wind turbine blades.

2009

SunRun, the first of multiple solar leasing companies, expands into Colorado as a result of SB 09-051.

SMA Solar Technology announces it will locate its first manufacturing facility outside of Germany in Colorado.

Ascent Solar opens its world headquarters and a facility to manufacture thin-film photovoltaic modules in Colorado.

2010

Bach Composite Industry, a Danish-based manufacturer, announces it will open a facility in Colorado to supply parts to Vestas.

The Greener Denver program is launched to reduce greenhouse gas emissions and help local green businesses capitalize on these new business opportunities.

2010

Vestas opens two additional wind turbine manufacturing facilities in Colorado.

Ecotech Institute opens as the first and only two-year college to focus on cleantech training.

New Energy Economy launched in 2007, which included actions to support companies and create new jobs in cleantech. Democratic Governor John Hickenlooper spearheaded a number of cleantech initiatives while Mayor of Denver and since becoming governor has supported other energy sectors as well as cleantech.

Colorado established regulatory standards that has helped stimulate demand for renewable energy by sending a market signal to businesses that there will be local customers for such products and that the state is supportive of the sector's efforts. Colorado became the first state to pass a renewable portfolio standard (RPS) by voters in a 2004 ballot initiative, which was a major milestone for Colorado's cleantech economy. The state

has since increased the level twice by legislative actions to the current standard of 30 percent renewable energy by 2020 and has created energy efficiency standards. Eligible technologies under the state's RPS include solar thermal electric, photovoltaics (PVs), landfill gas, wind, biomass, hydroelectric, geothermal electric, recycled energy, anaerobic digestion, and fuel cells using renewable fuels. Governors Owens and Ritter and Mayor Hickenlooper also stimulated demand for purchasing cleantech products with their executive orders to implement energy efficiency, sustainable building, and fuel-efficiency programs. (NC State, 2012).

Colorado has also removed regulatory barriers that limit cleantech market growth. At the state level, energy is

integrated into the mission of state organizations such as the Colorado Office of Economic Development & International Trade and the Colorado Energy Office. State officials work closely with local public and private stakeholders to understand and remove regulatory barriers and stimulate industry growth. The Colorado General Assembly has also removed barriers through legislation. For example, legislators passed a rule to allow third parties to sell customer generated power (SB-091), which led to the expansion of solar leasing companies and solar installations on individual homes (NC State, 2012). More recently, the General Assembly implemented a rule that makes it easier for facilities in the community, such as retail stores or public libraries, to host alternative fuel vehicle charging stations (Colorado Cleantech Industry Association, 2012).

Colorado stakeholders have implemented financial incentives to stimulate consumer demand for clean energy products and services, including a property tax exemption and a sales and use tax exemption for renewable energy systems. The Federal Government has also helped stimulate demand through the American Recovery and Reinvestment Act, which provided the Colorado government and private companies with more than \$585 million in funding for clean energy projects (U.S. Department of Energy,

2010). In addition to cleantech specific policies and actions, Colorado has created other business incentives that have drawn in cleantech companies. For example, Colorado revised its income tax rules to incentivize companies to locate facilities and create jobs in Colorado. The large utility Xcel Energy also provides incentives for customers to install renewable energy systems, including upfront subsidies and generation credits, through its Solar Rewards program. Since 2006, Xcel has provided \$256 million in rebates and credits for about 10,500 commercial and residential solar arrays. These funds came from a two percent renewable energy charge on customer bills (Jaffe, 2012).

Colorado Cleantech Industry Association convenes private sector and public institutions to identify and work toward solutions to expand and strengthen the cleantech economic engine in Colorado. The cleantech industry is recognized in Colorado as an economic development opportunity, not a political one.

Christine Shapard, Colorado Cleantech Industry Association

SEEDING INNOVATION

Colorado has become a leader in cleantech innovation by funding R&D projects, providing mentorship and investment in cleantech startups, and establishing collaborative networks to share R&D resources. The Metro Denver region is home to NREL, which began operating in Colorado in 1977 as the Solar Research Institute and is the only federal laboratory to focus on renewable energy and energy efficiency technologies. The state of Colorado and universities have leveraged NREL's location to build cleantech research capabilities and economic opportunities throughout the region. By leveraging strong local research assets, Colorado has cultivated an atmosphere that fosters innovative technologies and new cleantech companies.

Colorado's innovation activities are led by stakeholders such as:

- **NREL** – which has created organizations including the Colorado Center for Renewable Energy Economic Development (CREED), and is a partner in the Colorado Renewable Energy Collaboratory and Solar Technology Acceleration Center (SolarTAC)

- **State of Colorado** – which passed legislation to create the Collaboratory and to launch an innovation fund, is a partner in CREED, and has state agencies targeting the cleantech industry
- **Colorado Universities** – which are partners in the Collaboratory, CREED, and SolarTAC, in addition to having strong cleantech research programs at each university
- **Business incubators** – which support new startup companies in the cleantech industry

The Solar Technology Acceleration Center (SolarTAC) opened in 2011 and is the largest test facility for solar technologies in the nation. SolarTAC allows members to collaborate in solar energy research and testing for proprietary and public projects. SolarTAC formed under a public-private partnership involving utilities, the city of Aurora, private companies, and universities. The city of Aurora helped ease regulatory hurdles in establishing this center and does not require demolition or other burdensome permits, which makes it easier for companies to test industrial sized devices at the site.

The **Colorado Renewable Energy Collaboratory** was created by legislation in 2006 as a research partnership among the University of Colorado-Boulder, the Colorado School of Mines, Colorado State University, and NREL. The Collaboratory leverages the research strengths and different cleantech perspectives of each institution. The Collaboratory focuses on supporting economic growth in the cleantech market, cultivating commercialization efforts, and educating researchers and technicians to enhance the workforce.

The Collaboratory is built on a foundation of teamwork and trust among institutions, with a scientific director from one institution and administrative lead from another, and researchers from others. The Collaboratory facilitates research with industry partners and among institutions through research centers. Research projects may be funded by industry member fees and matched by the state of Colorado, or sponsored by industry in partnership with one or more institutions.

The Collaboratory currently has three research centers in place and two in development.

- Colorado Center for Biorefining and Biofuels (2007)
- Center for Revolutionary Solar Photoconversion (2008)
- Center for Research and Education in Wind (2010)
- Carbon Management Center (in development)
- Energy Systems and Energy Efficiency Center (in development)

Partners in the Collaboratory have received a total of \$8 million from the state of Colorado over the past five years and have spent over \$6 million to date. This funding has been leveraged to bring in an additional \$37 million into the state in second stage research, in addition to more in further research (Hiller, 2012; Colorado Renewable Energy Collaboratory, 2011).

Colorado got a head start by establishing a clean energy research collaboration in 2007, before most states were looking at clean energy as an economic opportunity. That early start helped the state attract existing clean energy companies, investors to support Colorado startups, and top researchers and students to our labs and universities, laying the groundwork for a self-sustaining cleantech industry.

*David Hiller, Executive Director,
Colorado Renewable Energy
Collaboratory*

In 2006, the Colorado General Assembly took a significant step in seeding innovation by creating the Colorado Renewable Energy Collaboratory, a research consortium of NREL and three Colorado public universities. The legislation also authorized state matching funds for cleantech research. Since its inception, the Collaboratory has been a driver of innovation in the state and is a key player in coordinating cleantech R&D efforts. This new consortium provides a venue for researchers from different institutions to work together on research projects and focus on technology transfer to facilitate innovation and commercialization. The Collaboratory also helps incentivize companies to locate in the region by providing a one-stop shop where companies can find researchers and leverage the strengths of multiple institutions.

In addition to the Collaboratory's own research efforts, Collaboratory partners also provide research capabilities to other organizations and research centers, such as the SolarTAC. The Collaboratory has also partnered with other research institutions, such as the National Center for Atmospheric Research and the National Oceanic and Atmospheric Administration, to

combine research expertise and support joint projects. In addition to being a partner in the Collaboratory, NREL leads other programs that support industry innovation through research, commercialization, and entrepreneur training to make Colorado a cleantech leader. For example, NREL launched CREED in 2010 in partnership with the state. CREED coordinates resources to provide opportunities for entrepreneurs and cleantech companies, open access to capital from investors, and facilitate networking among the public and stakeholders.

NREL also has internal programs such as the Innovation and Entrepreneur Center to facilitate connections within NREL and with outside stakeholders. For example, the Center can help an entrepreneur obtain a license for NREL technology, talk to an NREL expert or create a contract to work with NREL staff. NREL also hosts an annual Industry Growth Forum, which is a cleantech investment event. The Forum includes a business planning competition from emerging cleantech companies in which participants are judged by professional investors (NREL, 2011).

Colorado universities are also creating their own programs to focus on cleantech R&D activities in addition to being partners in the Collaboratory. For example, the University of Colorado (CU) - Boulder launched CU Cleantech in 2011 to connect researchers, students, and industry to spur innovation and commercialization. CU Cleantech assists with market assessment programs, public-private research partnerships, placing students in cleantech companies, and supporting entrepreneurs.

The strong innovation and R&D activity in Colorado has spawned dozens of new startup companies in the cleantech industry. Organizations and incubators have emerged to shepherd those companies through the early stages of company development to become successful. CleanLaunch Technology Incubator and Rocky Mountain Innosphere are two examples of incubators in the Metro Denver region. These incubators can provide a range of support to startups. Rocky Mountain Innosphere, for example helps technology-based startup companies gain access to academic and government researchers, assist with raising capital, build a network of advisors, and other activities to accelerate the development of the new company.

The Colorado Department of Labor and Employment has also started specifically targeting cleantech startups. They developed a program to train, mentor, and support cleantech entrepreneurs through the American Recovery and Reinvestment Act State Energy Sector Partnership grant. The Department gathered industry leaders to analyze existing programs and created training specifically designed for cleantech startups. They are currently training more than 100 participants to be small business owners in the cleantech industry through incubators and other programs (Colorado Department of Labor and Employment, 2011).

The Colorado General Assembly invested in cleantech industry innovation by passing the Innovation Reinvestment Act of 2011, making it one of the few states with an energy specific innovation fund. This legislation diverts 50 percent of future growth of income tax withholding from the cleantech and bioscience industries to be used as seed money for cleantech and bioscience startup companies

and inventions. This new fund will be an important source of financing for cleantech startups to pass early stage commercialization hurdles and will provide seed money for proof of concept stage in business development (Colorado Cleantech Industry Association, 2011).

The region has drawn additional business to support its R&D activity as well. For example, the U.S. Department of Commerce announced in 2012 that they will open a U.S. Patent and Trademark satellite Office in the Metro Denver area. This is expected to create 1000 new jobs and generate \$440 million for the local economy (Sherry, 2012).

Colorado Center for Renewable Energy Economic Development (CREED) is a partnership among NREL, state and local governments, and industry stakeholders. The idea for the center originated in the 2008 proposal to manage the NREL facility. The proposed NREL team wanted to create a center to help speed up the commercialization and deployment of clean technologies to spur economic development.

CREED launched in 2010 and the organization created a facility to co-locate stakeholders ranging from incubators and industry associations to research organizations like the Collaboratory. The stakeholder organizations now have offices in one building to facilitate relationships among stakeholders. CREED provides a conduit for interested parties to have only one spot to find industry associations, research partners, and financing information to support entrepreneurs.

CleanLaunch is a business incubator that supports the creation and growth of cleantech companies in Colorado. CleanLaunch is a hub for researchers, engineers, entrepreneurs, and investors to connect, share resources, and spur the growth of early-stage clean technology ventures. In collaboration with pro bono advisors, CleanLaunch clients develop and refine business plans and go-to-market strategies, address legal issues, and connect with investors in order to position their ventures for growth into market-stage operations. CleanLaunch has seen a significant increase in the cleantech startup community in recent years and have had interest from about 300 early stage companies over the past three years (Miller, 2012).

CAPTURING ECONOMIC BENEFITS

In order to help the region capture the benefits of the growing cleantech economy, public and private stakeholders have worked collaboratively to align job creation and workforce development activities with company recruitment and support. This alignment is a critical strategy to ensure that there are both job opportunities and trained workers in an area, and to capitalize on the positive cleantech business environment created from the stimulating demand and seeding innovation actions. Actions to capture the economic benefits include training a skilled cleantech workforce, recruiting companies to locate and grow in the region, and encouraging the deployment of cleantech products. State and local organizations are working across jurisdictions and with multiple stakeholders to promote cleantech economic development in Colorado and the Metro Denver region.

Colorado has numerous organizations dedicated to supporting the cleantech industry, ranging from economic development organizations to associations focused on increasing cleantech education and awareness. These organizations help create an economic environment in which cleantech companies want to locate and grow. Colorado's cleantech-related organizations include:

- **Local and regional economic development organizations** – such as the Metro Denver Economic Development Corporation (EDC) and Aurora Economic Development Council
- **Private and nonprofit organizations** – such as the Colorado Cleantech Industry Association (CCIA), Colorado Clean Energy Cluster (CCEC), Colorado Renewable Energy Society, and the Colorado Solar Energy Industries Association

Local economic development organizations have demonstrated their commitment to the cleantech sector by targeting it as an industry for development. The Metro Denver EDC has been a critical player in expanding the region's cleantech economy and recruiting national and international companies. Within the Metro Denver EDC, the Colorado Energy Coalition is an advocacy group that represents all sectors within the energy industry, including fossil fuels and renewable resources, and is dedicated to strengthening the energy business climate in Colorado. City organizations, such as the Aurora Economic Development Council, are also targeting the cleantech industry and working with Metro Denver EDC to negotiate a permitting and financial incentives package for the cleantech company to locate in their city.

The **Metro Denver Economic Development Corporation (EDC)**, an affiliate of the Metro Denver Chamber of Commerce, focuses on developing the cleantech sector. The Metro Denver EDC has been in place for over 20 years and includes 70 partner cities, counties, and economic development organizations in nine counties in Metro Denver and Northern Colorado (Metro Denver EDC, 2012).

In 2003, the EDC identified nine innovation clusters, of which cleantech was one, to focus economic activity. The EDC focus on the cleantech cluster enabled them to target companies to cultivate a robust cleantech economy in the region.

The cities and counties in the EDC decided to compete as a region, rather than against each other, to bring cleantech companies to the area and be more responsive to the company's needs. EDC brings together state and local entities to create a recruitment package with tax rebates and financial incentives for companies. EDC has been a critical player in promoting the region, communicating a consistent message, and leveraging local assets to market the region nationally and internationally (Clark, 2012).

The Metro Denver EDC strategy has been to build a cluster of economic activity around cleantech - rather than chasing hot companies we focus on recruiting companies that build the region's supply chain.

Tom Clark, Metro Denver EDC

The **Colorado Cleantech Industry Association (CCIA)** is an industry-led, industry-focused cleantech organization founded in 2008. The organization focuses on common industry issues and is dedicated to advancing the cleantech industry through advocacy, public policy leadership, development, and education. CCIA worked with the industry to develop a Cleantech Action Plan to identify areas where stakeholder time and effort would have the most impact and where resources were needed. CCIA has also had significant policy success, including the 2011 Senate Bill 47 that provides seed funding to commercialize technologies and startups. CCIA also started the Cleantech Fellows Institute to train leaders of cleantech companies or companies looking to make the transition into the cleantech industry (CCIA, 2012).

Private and nonprofit organizations are also helping Colorado capture the economic benefits of growth in the cleantech industry. For example, CCEC is a nonprofit economic development organization with a mission to grow clean energy jobs in Colorado. Another example is CCIA, which is a unique organization that unites all industry players in the cleantech field. CCIA has dozens of member companies and organizations and a board of directors representing diverse segments of the cleantech industry, from venture capitalists to the Collaboratory.

The Colorado Renewable Energy Society is an organization whose members work to increase awareness of the economic and environmental benefits of renewable energy and energy efficiency technology. The Society hosts a number of educational events and also supports policy initiatives to advance renewable energy and energy efficiency projects in the state. Colorado also has technology-specific organizations, such as the Colorado Solar Energy Industries Association, which was founded in 1989. This association is focused on expanding solar markets and generating jobs and prosperity for the people of Colorado. They work with solar business members to advance solar policy, remove market barriers, highlight emerging trends, and promote solar outreach and education.

In addition to building a favorable business environment and enhancing networks, preparing Colorado's workforce for cleantech jobs has also been important to capturing economic benefits of the sector. Across Colorado there have been initiatives undertaken at the regional, academic and state levels in collaboration with colleges and universities to ensure that local workers are equipped for jobs ranging from cleantech R&D to maintenance and installation in the cleantech sector.

Companies are partnering with academic institutions and local and state governments to ensure that they have a trained local workforce to be able to expand their operations. For example, Spirae, a smart-grid company based in Fort Collins, developed relationships with Colorado State University, the Larimer County Workforce Investment Board, Fort Collins Utilities, Front Range Community College, and others to identify training needs and capabilities. As a result of these collaborations, Spirae received funds from

Northern Colorado is an ideal location for Spirae and the Center for Smart Grid Advancement. We enjoy a uniquely synergistic and collaborative environment here in Fort Collins, which contributes to Spirae's ability to develop and deliver smart-grid solutions, as well as educated smart-grid stakeholders and workforce.

Sunil Cherian, Spirae's CEO, upon announcing it was expanding operations into the Rocky Mountain Innosphere building (NCBR, 2011)

the Governor's Energy Office, Colorado Workforce Development Council, and the U.S. Department of Energy to develop a three-course smart grid training program for technicians through the community college and a three-course smart grid training program for engineers through Colorado State University. Spirae and the university are offering their laboratories for hands-on experience, and a Colorado State Energy Sector Partnership grant is enabling more than 750 Colorado students to attend these courses in 2012 (Pfannkuch, 2012).

Colorado colleges and universities are developing specialized classes and programs in cleantech. The three Colorado universities involved in the Collaboratory, for example, offer a range of classes and programs to prepare students for cleantech R&D. The Colorado School of Mines, for example, offers classes in energy economics, engineering, and policy.

Ecotech Institute opened in Aurora in 2010 as the first and only college focused on training students in careers in cleantech. Ecotech offers two-year associate's degrees in renewable energy technology, solar and wind energy technology, electrical engineering and environmental technology, and other programs related to developing the cleantech workforce. Ecotech Institute graduated its first class of 42 students in June 2012 and currently has more than 500 students.

Community colleges are also playing an important role in educating the Colorado workforce. Red Rocks Community College's Renewable Energy Program, for example, offers degrees and certificates in solar, wind, and energy efficiency technologies. Redstone College offers certificates and degree programs for a variety of cleantech careers, including energy specific degrees in wind energy technology and an industrial service training program in heating/ventilation/air conditioning. Arapahoe Community College also offers energy technology programs, including solar technician, energy analyst, and construction supervision programs.

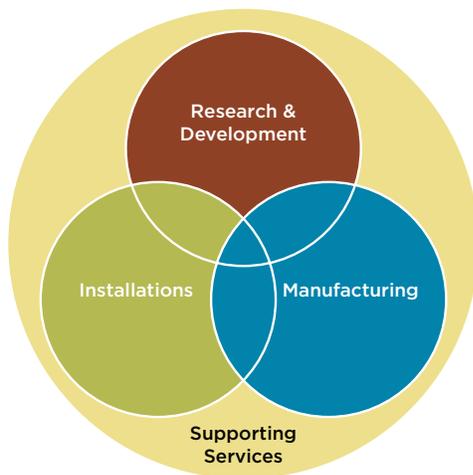
The **Colorado Clean Energy Cluster (CCEC)** is a nonprofit economic development organization with a mission to grow the clean energy jobs in Colorado. CCEC was founded in 2006, and now has over 30 member companies. CCEC focuses on actionable initiatives to build infrastructure to support the industry. For example, through their Clean Energy Supply Chain Initiative they identified four main categories of gaps in the cleantech supply chain, including technology, marketing, workforce, and supply chain specific issues, and are now working with partners on actions to fill those gaps and connect industry players (CCEC, 2012).

CLEANTECH ECONOMY RESULTS

The actions that Colorado stakeholders have taken to build an active cleantech economy have led to impressive results. The region has emerged as a leader in cleantech innovation and has demonstrated strong customer demand for cleantech products and services. In addition, cleantech companies are increasingly choosing the Metro Denver region as a place to locate and grow, bringing significant economic benefits to the area.

COLORADO'S ENERGY TECHNOLOGY VALUE CHAIN

FIGURE 2
ENERGY TECHNOLOGY VALUE CHAIN



The investment and work to stimulate demand, seed innovation, recruit companies, and develop a new workforce has paid dividends across the value chain. Colorado has built a cleantech economy that includes a variety of companies and activities, all of which operate across the energy technology value chain. The segments of the value chain may exist independently, but provide a more robust economic cluster when all segments are developed and work together. Figure 2 illustrates the interaction of the energy technology value chain segments. Colorado now boosts companies that provide each of these activities:

Research & Development (R&D): R&D activities are carried out primarily by research institutions, such as federal laboratories, universities, or private company research divisions. R&D activities foster an environment centered on developing new products and processes so that the region can become a leader in innovation.

Manufacturing: Manufacturing involves production of a technology and includes companies throughout the supply chain, ranging from component suppliers to those assembling complete units for sale to consumers.

Installation: Installation of clean energy technologies, such as developing wind turbine farms, will occur in response to market demand. Companies involved in activities such as site assessment, logistics, transportation, and construction play an important role in installation.

Supporting Activities: A variety of other activities are critical to supporting clean energy technology. These supporting organizations facilitate interactions among players, provide funding, educate consumers, advocate for business friendly policies, or provide technical support and product maintenance services.

DRIVING INNOVATION THROUGH WORLD-CLASS R&D EXPERTISE

Colorado's increased R&D-related activities demonstrate that the state is solidifying its role as a leader in cleantech innovation. These results have been driven by actions that seed innovation and support all segments of Colorado's cleantech economy.

Colorado has some of the highest levels of federally-funded science, research, and engineering laboratories, which have contributed to its R&D activities and the local economy as a whole. The state estimates that its 24 federal laboratories have collectively contributed \$1.5 billion to Colorado's economy in 2010 and employed nearly 16,500 people directly or indirectly. NREL alone has a \$714 million annual economic impact in the state. The Metro Denver region is also home to the National Center for Atmospheric Research, Western Power Administration, and National Institute of Standards and Technology (Development Research Partners, 2012).

Colorado's support for innovation is also demonstrated by the strong cleantech R&D activity at academic institutions. The University of Colorado-Boulder, the Colorado School of Mines, and Colorado State University have a long history in energy R&D and have expanded their activities into cleantech. Colorado ranked 16th in the nation for overall R&D expenditures at academic institutions in fiscal year 2009 (Development Research Partners, 2012).

Colorado's R&D and innovation activity can be demonstrated by the number of patents registered. Figure 3 shows the total number of cleantech patents in Colorado in various technologies. Patent activity has steadily increased over the past 15 years, more than tripling between 1996 and 2011 and significantly jumping in the past two years. Colorado has also increased its cleantech patent activity relative to other states. Table 1 shows Colorado's national ranking in clean energy patents. In 1996, Colorado had no fuel cell patents and is now ranked 16th in the country. Additionally, Colorado has remained strong in solar patents and has remained ranked in the top ten states.

Colorado has cultivated a skilled cleantech workforce, with the second-most highly-educated adult population in the nation (Development Research Partners, 2012). This workforce expertise and concentration of R&D activity is also leading to new cleantech companies. Figure 4 shows the increase in cleantech venture capital investments in the past ten years has increased dramatically. Funding for cleantech companies in Colorado more than tripled over the last decade, with Colorado companies receiving nearly \$80 million in 2000 and over \$362 million in 2011 (in 2012 dollars). Table 2 shows that Colorado has consistently been a leader in cleantech venture capital investments over the last decade, maintaining a position in the top ten states nearly every year, and was ranked third in total investments in 2011. Colorado has also consistently ranked in the top five states for investment per capita since 2000 (CleanTech Group, 2012).

FIGURE 3
CLEAN TECH PATENTS
COLORADO

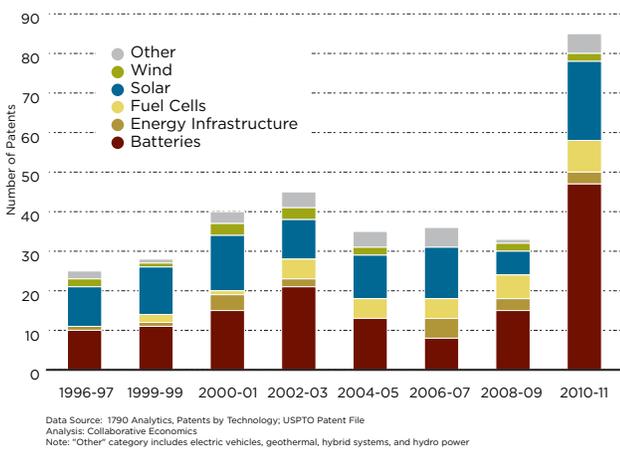


TABLE 1
COLORADO NATIONAL RANKING IN CLEAN ENERGY PATENTS

	1996-97	2010-11
Batteries	21	13
Energy Infrastructure	27	18
Fuel Cells	50*	16
Solar	4	7
Wind	6	25**
Other	18	15

* CO had zero fuel cell patents in 1996-97, therefore tied for last in national rank.
** CO has maintained roughly the same number of wind patents over the years, though some states such as New York and South Carolina have drastically increased wind patent activity over this time.
DataSource - Table 1: 1790 Analytics, Patents by Technology; USPTO Patent File
DataSource - Table 2: Clean Tech Investments from August 6, 2012, Bureau of Labor Statistics

FIGURE 4
VENTURE CAPITAL INVESTMENTS IN CLEAN TECHNOLOGY
COLORADO AND THE U.S. STATE AVERAGE (2012 REAL DOLLARS)

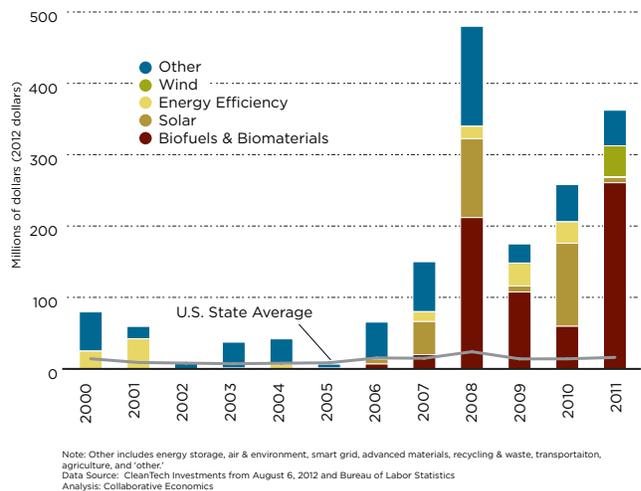


TABLE 2
COLORADO NATIONAL RANKING IN CLEAN TECH VC INVESTMENTS

	2000	2011
1	California	California
2	Washington	Massachusetts
3	Massachusetts	Colorado
4	Connecticut	Texas
5	Colorado	Oregon

MANUFACTURING COMPANIES RESPONDING AND GROWING

Cleantech companies are increasingly choosing to locate and expand in the Metro Denver region because of the area's collaborative actions to advance the economy. Colorado has become home to a variety of cleantech manufacturing companies ranging from those that produce wind turbines to those that specialize in biofuels. Cleantech companies have been actively recruited by economic development organizations. These organizations help companies realize the benefits of Colorado's many local assets including, world class research and testing capabilities, collaborative environment, political support, financial incentives, and workers with skills ranging from research experts and plant managers to assemblers and welders.

Manufacturing in the cleantech industry has increased in recent years with new startups and international companies locating in the region. Colorado's wind manufacturing industry is centered on the major international wind company Vestas. Vestas opened its first manufacturing facility in the Metro Denver region in 2008 and now has four manufacturing facilities on three campuses. A variety of factors attracted Vestas to Colorado, including the nearby testing facilities and experts at NREL, focused support from the state and regional governments, proximity to the wind corridor, and an international airport with flights to Denmark. Vestas has created a market for other companies in the wind supply chain that have moved to the region,

such as Danish manufacturing companies Aluwind and Bach Composite Industry, Connecticut-based Hexcel Corporation, and distributed generation wind turbine manufacturer Southwest Windpower. The American Wind Energy Association (AWEA) estimates that there are 3,000 jobs in wind manufacturing and 4,000-5,000 direct and indirect jobs in Colorado's wind supply chain in 2011 (AWEA, 2012a). While Colorado has attracted a number of wind companies, the uncertainty about the renewal of the federal Production Tax Credit has impacted the entire wind industry and has caused slowing across the board.

The Metro Denver region is also home to solar manufacturing companies that span a variety of unique technologies. Germany-based SMA America, for example, is the world's largest solar inverter manufacturer that opened its domestic branch in the area in 2010. Other solar manufacturers, such as SkyFuel, Inc and Ascent Solar, are creating products ranging from large utility-scale solar thermal systems to consumer products like cell phone solar chargers.

Colorado has a variety of other cleantech companies producing at small and large scales, including energy efficient product companies such as Coolerado, smart grid companies such as Spirae, and biofuel companies such as Gevo. The entrepreneurial and innovative environment is also starting to produce dozens of new cleantech companies every year.

Coolerado manufactures and markets innovative, high-efficiency air conditioners that use up to 90% less energy than traditional AC units. Based in Colorado, the company sells its air conditioners across the US and in 26 countries around the world. Federal tax credits as well as strategic venture capital investments have helped Coolerado increase production capacity to meet growing domestic and international demand for efficient air conditioning (White, 2010).

SMA Solar Technology, the world's largest manufacturer of solar panel inverters, opened its first manufacturing facility outside of Germany in Denver in 2010. The plant is the largest solar inverter production facility in the US, supplying inverters to the growing US market. The decision to locate in Denver was motivated by its proximity to key transportation hubs as well as the region's strengths in clean energy research. Economic incentives from state and local governments also helped Denver beat twenty other cities across the country that also competed for the SMA plant (Svaldi, 2009).

The **Federal Production Tax Credit**, which provides an income tax credit for the production of electricity from utility-scale wind turbines, is set to expire at the end of 2012. As of October 2012, uncertainty about its renewal still loomed, and Martha Wyrsh, head of Vestas-American Wind Technology, Inc., stated that "The U.S. wind industry has slowed, largely due to the uncertainty surrounding the Federal Production Tax Credit extension" (Reuters, 2012). In consequence, Vestas has decreased its Colorado manufacturing workforce by about 500 employees in 2012 through layoffs, attrition, and relocations, bringing its total Colorado workforce to about 1,200 employees (Longeteig, 2012).

The forward thinking environment, spirit of innovation and general support for renewable energy in the area made Broomfield attractive to us as a company. There's also tremendous potential for collaboration with nearby institutions such as NREL, University of Colorado at Boulder and the Colorado School of Mines.

Scott Brown, Interim CEO of Southwest Windpower, on opening an additional facility for its distributed generation wind turbines in Broomfield, Colorado (Southwest Windpower, 2011).

CLEAN ENERGY INSTALLATIONS

Actions to stimulate demand for renewable energy system installations have helped Colorado companies dramatically increase deployment of cleantech products and services in recent years. For example, the state's RPS, which mandates 30 percent renewable energy by 2020, has incentivized installation of solar and wind power in the state to meet that goal. Figure 5 shows that at the end of 2011 Colorado had more than 200 megawatts (MW) of solar PV power installed, compared to only 12 MW in 2007. By the end of 2011, Colorado became fifth in the nation in installed solar capacity and continues to have more cumulative installations than the average U.S. state (Solar Energy Industry Association, 2012).

Wind installations have also increased in recent years. Colorado is the 12th windiest state in the U.S. and is currently 9th in installed wind capacity. Figure 6 displays Colorado's growth in wind capacity, which reached 1,805 MW by the end of 2011 (AWEA, 2012b).

Colorado is one of only six states that have exceeded 10 percent of state generated electricity coming from wind (Wiser and Bolinger, 2012).

Colorado has achieved this installation activity without sacrificing overall economic progress. Figure 7 shows that Colorado's electricity bill compared to gross domestic product (GDP) has continued to decline. Colorado's GDP has continued to outpace changes in electricity bills even while renewable energy installations increased.

Utilities are actively involved in clean energy installations, stimulating the local economy and creating installation jobs. The large utility Xcel Energy has become an active supporter of cleantech, even going so far as supporting the legislation to increase the state's RPS. Xcel Energy is meeting its renewable energy goals by pursuing large utility-scale installations as well as smaller distributed

FIGURE 5
INSTALLED GRID-CONNECTED SOLAR PV CAPACITY COLORADO

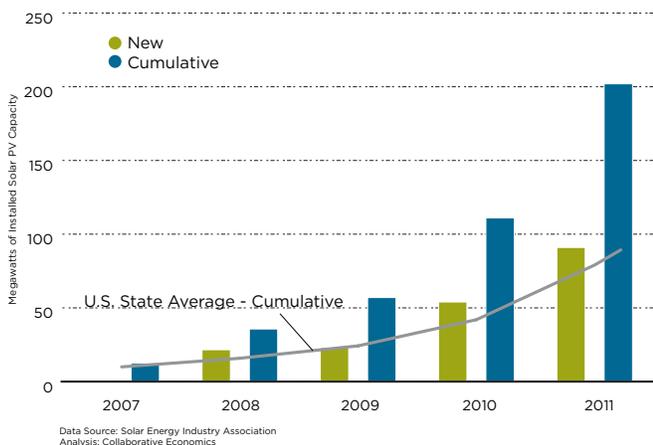
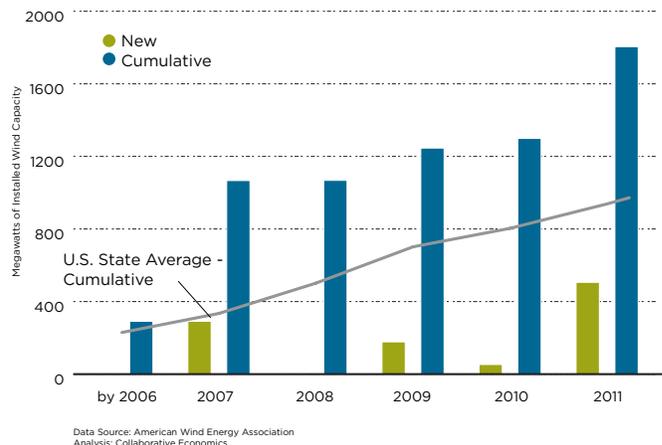


FIGURE 6
INSTALLED WIND CAPACITY COLORADO



generation projects such as rooftop solar panels. Xcel Energy currently uses a majority of the wind power in Colorado and achieved a national benchmark in 2012 when they used wind to supply 57 percent of their total electricity use for a few hours (Hargreaves, 2012). Xcel Energy has been adding large wind farms in Colorado to take advantage of the cost-competitive price of wind compared to other energy sources (Xcel Energy, 2011).

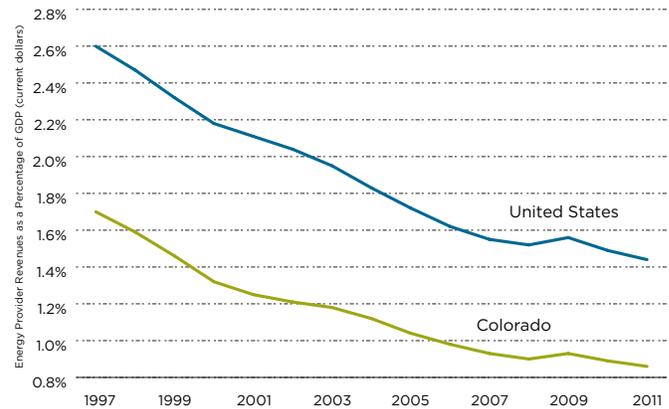
Private companies are also helping stimulate demand for cleantech installations. Many of Colorado's ski resorts, for example, have installed wind and solar energy systems to generate power at the resort or purchase off-site renewable power for the resorts. The resorts are also reducing their energy use by upgrading to energy efficient technologies for building operations. Steamboat Ski & Resort and Park City Mountain Resort, for example, are upgrading resort equipment to more efficient units and purchasing renewable energy certificates to offset electricity use.

Many companies have moved to the region to support the increase in clean energy installations. For example, solar leasing companies, including SunRun, SolarCity, and Sungevity, have expanded into Colorado as a result of the policy revisions from Senate Bill 09-051, which allowed third parties to sell customer generated solar power. These companies offer homeowners the

opportunity to install solar panels though alternative financing and minimal upfront costs.

Renewable energy installations are often installed in rural areas, which adds economic value to the landowners and counties that opt to participate in the market. The wind industry, for example, contributes \$10 million in annual property tax payments by wind project owners and \$5.4 million in annual land lease payments for wind turbines (AWEA, 2012a).

FIGURE 7
ELECTRICITY BILL AS A PERCENTAGE OF GDP
COLORADO



Data Source: U.S. Department of Energy, Energy Information Administration; U.S. Department of Commerce, Bureau of Economic Analysis
Analysis: Collaborative Economics

COLORADO'S CLEANTECH ECONOMY RESULTS SUMMARY

In summary, Colorado's value chain segments (R&D, manufacturing, installation, and supporting services) have grown substantially in response to collaborative efforts to expand the sector. Table 3 shows the nine-county region's cleantech economy as determined by Development Research Partners for Metro Denver EDC. Most of Colorado's cleantech employment is located in this region, including 18,000 jobs and 1,500 companies directly involved in cleantech in 2011, making the region 6th of the 50 largest metro areas in cleantech employment concentration (7th in absolute employment). Table 4 shows the top seven metro regional areas in total cleantech employment.

- **Metro Denver** ranks on par with large metro areas such as New York City and San Francisco in total number of cleantech workers.
- **Metro Denver** had a 35 percent increase in direct employment from 2006-2011, compared to an average 11 percent increase in the U.S.

- **Cleantech companies** employ about one percent of the region's total employment base, nearly twice as much as the national average of 0.5 percent.
- **In 2010**, the average annual salary for a cleantech job in the Metro Denver area was nearly \$75,000 for a total regional annual payroll of nearly \$1.3 billion (Development Research Partners, 2012).

These outcomes show the growth and strength of Colorado and the Metro Denver region's cleantech economy.

TABLE 3
METRO DENVER CLEANTECH ECONOMY

Direct Jobs (2011)	18,000
Direct Companies (2011)	1,500
Average annual salary (2010)	\$74,410
Regional annual payroll (2010)	\$1.3 billion
Five-Year Direct Employment Growth (2006-11)	35%

DataSource: Development Research Partners, 2012

CONCLUSION

Colorado's cleantech economy has grown as a result of collaborative, multi-stakeholder actions to stimulate demand for cleantech products and services, foster cleantech innovation, and help the region capture economic benefits from the sector's growth. R&D activity, cleantech manufacturing, and renewable energy installations have all substantially increased in Colorado. This progress demonstrates Colorado's success in creating a diverse, robust cleantech economy and establishing the region as a leader in the cleantech industry.

- **Colorado has pioneered actions to help stimulate consumer demand for cleantech products and services.** Colorado voters made the state the first to pass an RPS by ballot initiative and policymakers created financial incentives for cleantech, which helped show the state is supportive of the cleantech industry.
- **Colorado has become a hub for cleantech innovation.** Research institutions and private companies are working together to advance cleantech R&D and commercialization through organizations such as the Collaboratory. In addition, programs to foster new cleantech companies, such as efforts by CREED, are helping those innovative technologies reach consumers.
- **Colorado stakeholders have taken action to capture the economic benefits of the cleantech industry growth locally.** Organizations such as the Metro Denver EDC and CCIA have worked with companies to help them locate and grow in the region. These efforts have created job opportunities for workers across the skills-spectrum, resulting in 35 percent increase in direct employment growth in cleantech between 2006 and 2011.

Colorado, like other states, is vulnerable to market uncertainties such as those surrounding the federal wind production tax credit. However, stakeholders are confident that the robust cleantech sector activity will continue through collaboration and support from local, state, and federal stakeholders. The time is ripe for Colorado to lead cleantech innovation and foster strong economic activity to support the cleantech sector.

ACRONYMS

AWEA - American Wind Energy Association
CCIA - Colorado Cleantech Industry Association
CCEC - Colorado Clean Energy Cluster
CREED - Center for Renewable Energy and Economic Development
EDC - (Metro Denver) Economic Development Corporation
GDP - Gross Domestic Product
MW - Megawatts
NREL - National Renewable Energy Laboratory
PV - Photovoltaic
R&D - Research and Development
RPS - Renewable portfolio standard
SolarTAC - Solar Technology Acceleration Center

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Stephen Miller - CleanLaunch Technology Incubator
Tom Morgan and Carol Craig - CO Department of Labor and Employment
Tracee Bentley - CO Energy Office Legislative and Policy Director

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