

Colorado Cleantech Action Plan

A roadmap to guide the development of Colorado's clean technology industry

Prepared for:

Colorado Cleantech
Industry Association (CCIA)

Colorado Economic Development
Commission

Colorado Governor's Energy Office

Colorado School of Mines

Colorado State University

Colorado Workforce Development Council

Metro Denver Economic Development Corporation

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This Report was Prepared Under an Award
from the U.S. Department of Commerce Economic Development Administration
EDA Project Number: 05-69-04951,
October 11, 2010

Colorado Cleantech Action Plan

ABSTRACT

This plan summarizes the actions that the cleantech industry in Colorado will implement in the next three to five years to drive economic development as measured by increases in jobs, revenue, and tax base generated by the cleantech industry. The Colorado Cleantech Industry Association commissioned this report as the state's cleantech industry has grown faster than the Colorado economy as a whole and in the face of competition from other states, which have identified cleantech as an area of rapid growth. Colorado has established its leadership position from two core strengths: innovation and policy leadership. Commercialization of innovation drives the supply of new products and services while policy leadership has played a key role in driving market demand. To advance the cleantech industry, Colorado must build on these foundational strengths while continuing to build core strengths in each of four priority sectors: wind, solar, smart grid, and bio-derived. This plan outlines the critical actions to advance the foundational strengths and the four priority sectors while also outlining a set of actions that will support the growth of the industry as a whole. Additional supporting data is available in a separate set of appendices.

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University of Colorado
U.S. Economic Development Administration

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This publication was prepared by Navigant Consulting, Inc., for the Colorado Cleantech Industry Association. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the Economic Development Administration.

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Acronym List

Acronym	Description
AMI	Advanced Metering Infrastructure
ARRA	American Recovery and Reinvestment Act
BNSF	Burlington Northern Santa Fe Railway
C2B2	Colorado Center for Biorefining and Biofuels
CCIA	Colorado Cleantech Industry Association
CDPHE	Colorado Department of Public Health and Environment
CEDA	Clean Energy Development Authority
COGA	Colorado Oil and Gas Association
CORE	Connected Organizations for a Responsible Economy
CREED	Center for Renewable Energy and Economic Development
CREW	Center for Research and Education in Wind
CREZ	Competitive Renewable Energy Zone
CRSP	Center for Revolutionary Solar Photoconversion
CSM	Colorado School of Mines
CSP	Concentrated Solar Power
CSU	Colorado State University
CU	University of Colorado
DOE	U.S. Department of Energy
DSM	Demand-Side Management
EDC	Economic Development Corporation
EE	Energy Efficiency
EERE	Office of Energy Efficiency and Renewable Energy (DOE)
EPAct	Energy Policy Act of 2005
G&T	Generation and Transmission
GEO	Governor's Energy Office
HAN	Home Area Network
IP	Intellectual Property
LBNL	Lawrence Berkeley National Laboratory
LQ	Location Quotient
MAP	Market Assessment Plan
MOU	Memorandum of Understanding
MW	Megawatt
MWh	Megawatt-hour
NAABB	National Alliance for Advanced Biofuels and Bio-Products
NABC	National Advanced Biofuels Consortium
NCAR	National Center for Atmospheric Research
NGV	Natural Gas Vehicle
NIST	National Institute of Standards and Technology
NREL	National Renewable Energy Laboratory

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Acronym	Description
O&M	Operations and Maintenance
OEDIT	Office of Economic Development and International Trade
POCg	Proof-of-Concept Grant
POCi	Proof-of-Concept Investment
PPA	Power Purchase Agreement
PUC	Public Utilities Commission
PV	Photovoltaic
R&D	Research & Development
RASEI	Renewable and Sustainable Energy Institute
RD&D	Research, Development, and Demonstration
RDSI	Renewable and Distributed Systems Integration
RECO	Renewable Energy Coordination Offices
REDI	Renewable Energy Development Infrastructure
RES	Renewable Energy Standard
ROA	Return on Asset
RTD	Regional Transportation District
SCORE	Service Corps of Retired Executives
SolarTAC	Solar Technology Acceleration Center
TT	Technology Transfer
VC	Venture Capital

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Steering Committee Membership

The project team would like to thank the Steering Committee for their contributions to and support of the development of the Colorado Cleantech Action Plan. Steering Committee members provided direction and input critical to the development of this plan. They have committed to supporting the implementation of this plan and will work closely with the Colorado Cleantech Industry Association going forward.

Member	Affiliation
David Allen	University of Colorado
Clarke Becker	Colorado Department of Labor and Employment
Ron Bernal	New Enterprise Associates (NEA)
Sandy Butterfield	Boulder Wind Power
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Executive Summary

Colorado's cleantech industry has established a place at the forefront of the global industry, but it will face challengers that have also recognized the opportunities presented by the cleantech industry. Other states and countries are investing internally to shift their economies to serve the growing market for cleantech. This plan outlines the areas in which the investment of stakeholder time, funding, and expertise can have the most significant impact on Colorado's ability to sustain and grow a leadership position in the cleantech industry that will drive the state's economic growth in the coming decades.

Cleantech Is Growing in Colorado and Creating Thousands of Jobs.

Cleantech in Colorado is an established and growing part of the state's economy. Between 1999 and 2009, Colorado's cleantech industry grew at an annualized rate of 18 percent, more than twice the rate of the Colorado economy as a whole (8 percent).¹ Today, it includes more than 20,000 workers employed by over 1,700 companies.² Since 2007, Colorado has created more than 5,000 cleantech jobs through a diverse set of cleantech company operations.³

Colorado's Key Strength Is in Innovation.

The strength of Colorado's energy-focused research capabilities is widely cited as one of the state's greatest cleantech assets. With the National Renewable Energy Laboratory (NREL) at its center, Colorado's cleantech research cluster includes the state's major research universities as well as other federal laboratories such as the National Institute of Standards and Technology, whose work complements and supports the cluster's cleantech focus. As the only U.S. Department of Energy (DOE) lab focused exclusively on DOE's Office of Energy Efficiency and Renewable Energy programs, NREL captures a large share of DOE's clean energy-related funding.

Colorado's Leadership in Cleantech Policy Is Critical in Growing the Industry.

Colorado's leadership in the policy and political arenas has bolstered the state's attractiveness for the development of renewable energy projects and provided the certainty needed to attract other cleantech businesses. Colorado's renewable energy standard remains one of the most ambitious in the country. In addition, the Governor's Energy Office and other partners have actively promoted Colorado's "New Energy Economy" and the state's Climate Action Plan as drivers of economic development. This demonstrates the type of leadership that creates a stable policy environment for cleantech companies.

Innovation and Policy Support Drive Manufacturing and Project Development.

Colorado's strength in innovation drives new development in the manufacturing and deployment segments of the cleantech industry. The results generated by the innovation segment of the economy attract product development and manufacturing operations to the state. The proximity to both incremental and game-changing innovations enables these companies to optimize their operations and produce better products for their customers. In parallel, new products that result from the innovation centers in Colorado can be deployed in the state during the pilot and demonstration stages through university and DOE test facilities and utility programs. These testbeds enhance the state's leadership role in innovation while creating jobs and new implementation expertise.

¹ Pew Center on the States. 2009. *The Clean Energy Economy: Repowering Jobs, Businesses, and Investments Across America.*

² Pew Center on the States. 2009. *The Clean Energy Economy: Repowering Jobs, Businesses, and Investments Across America.*

³ State of Colorado Office of the Governor. 2010 "New Energy Economy: Creating Jobs, Attracting Businesses, and Strengthening Our Economy."

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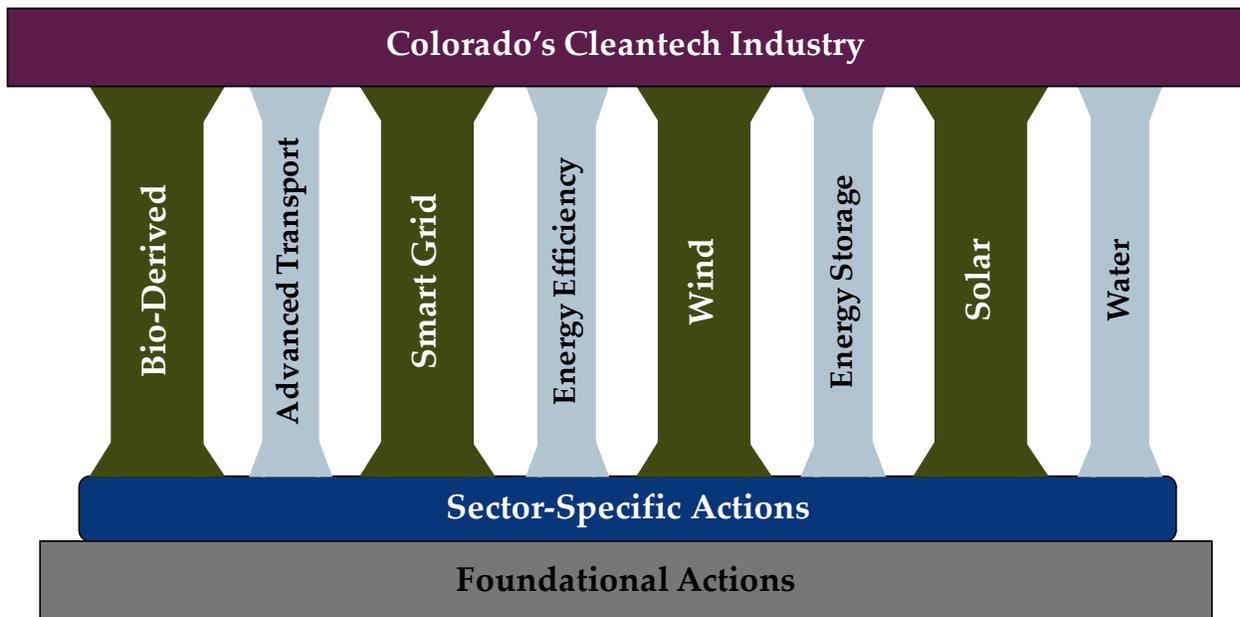
Leading Cleantech Companies Are Present in the State and Driving Industry Growth.

Colorado is home to leading cleantech companies across sectors and across the value chain. These include global companies such as Vestas, GE Energy Controls, Abengoa, RES Americas, SMA Solar, Conoco Phillips, and Bach Composite Industry. These companies are creating a draw for supply-chain partners to locate in Colorado, as six Vestas suppliers have already done. In addition, there are many cleantech companies that started in Colorado, such as Abound Solar, Ascent Solar, Solix Biofuels, PrimeStar Solar, and Advanced Energy Industries.

The Wind, Solar, Smart Grid, and Bio-Derived Sectors Are the Pillars of Colorado's Cleantech Industry.

Through a deliberate and thorough screening process and with data from Navigant Consulting, Inc.'s independent analysis, the Colorado Cleantech Industry Association (CCIA) Steering Committee identified the wind, solar, smart grid, and bio-derived sectors as Colorado's priority cleantech sectors. This action plan is designed to serve the entire cleantech industry in Colorado, although the set of actions was developed through the lens of the priority sectors. Because the priority sectors were identified as those with the most potential to sustain and grow Colorado's leadership in cleantech, priority was placed on understanding and addressing the opportunities and challenges in those sectors. Four other sectors were identified as emerging sectors, which are anticipated to play an important role in Colorado's cleantech industry in the mid- and longer-term; these sectors are advanced transport, energy-efficient buildings, energy storage, and water. The actions in this plan address the critical challenges of the priority sectors in depth, and nearly all the actions can benefit other cleantech sectors.

Figure ES-1. Building Colorado's Leadership Position in Cleantech



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Capital and Leadership Are the Foundation for Commercializing Colorado's Cleantech Innovations.

Leveraging innovation to drive job gains in manufacturing and deployment requires a stronger focus on the resources needed to convert innovation into products, namely, capital and leadership. The commercialization of technologies involves connections between the researchers that develop the ideas and the market experts that understand how the ideas can serve the market. Navigating the commercialization process requires capital and leadership, both of which are limited in Colorado's cleantech industry. To address these challenges, this plan proposes the following actions that are foundational for growing the state's priority cleantech sectors:

- » Increase funding for seed and technology acceleration
- » Increase funding for early-stage companies, including the establishment of a fund of funds
- » Strengthen cleantech company incubators and accelerator programs
- » Boost executive leadership training programs

Each Cleantech Sector Has Its Own Priority Actions, Though Many of These Priorities Overlap.

Many cleantech manufacturers with plants in Colorado, particularly those in the wind and solar sectors, need support to attract more of their component suppliers. Yet, the state of Colorado faces competition from other states and regions that offer more compelling incentives to locate in their states. This plan proposes that the state prioritize and actively recruit the companies it wants to add to Colorado's cleantech industry.

Less mature technologies such as those in the smart grid and bio-derived sectors need test and scale-up facilities to prove their viability on a larger scale before entering large-scale industrial production. Although NREL, SolarTAC and InteGrid Laboratory provide facilities for testing and scale-up, further test-bed infrastructure and incentives for deployment are needed in Colorado. This plan recommends the strengthening of such infrastructure and accompanying support for Colorado companies to access these facilities.

In-state developers of large-scale wind and solar plants report that delayed transmission construction is a major impediment to development. Although SB07-100, the SB07-91 task force, and the Renewable Energy Development Infrastructure (REDI) have established the foundations for a transmission system expansion that benefits renewable energy, this plan proposes an effort to accelerate transmission and renewable energy project approvals.

Supporting Actions Are Also Needed to Grow Colorado's Cleantech Industry.

Finally, a set of supporting actions will help grow each of the state's four priority sectors as well as the cleantech industry as a whole. Developing an integrated statewide energy plan will enable more informed decision making by state government and the business community in terms of how the value of wind, solar, smart grid, and bio-derived can be fully captured within Colorado's overall energy landscape. Collaborating with the state's sizeable natural gas industry may identify potential new applications, end markets, and enablers for cleantech—such as using photovoltaics to supply power at well pads. Enhancing commercialization efforts within the state's universities and federal labs will help ensure that the most promising technological advances in cleantech make it out of the labs and into the market. Finally, preparing the state's workforce to build and service wind turbines or deploy smart grid technology through internships and job retraining programs is critical to ensure further scale and growth in these sectors.

Section 1: Introduction

Cleantech in Colorado is an established and growing part of the state's economy. Between 1999 and 2009, Colorado's cleantech industry grew at an annualized rate of 18 percent, more than twice the rate of the Colorado economy as a whole (8 percent).⁴ Today, it includes more than 20,000 workers employed by over 1,700 companies.⁵ Those companies have attracted more than \$1 billion in federal support in the past year⁶ and over \$330 million in venture capital in the past two years.⁷ On an annual basis, the research institutions, universities, and private laboratories attract more than \$660 million in federal research and development (R&D) funds for cleantech projects.⁸ Colorado is home to 1,248 megawatts (MW) of wind power (ninth in the U.S.)⁹ and to 59 MW of solar power (fifth in the U.S.).¹⁰

This report sets forth an action plan to drive continued growth of a diverse and robust cleantech industry in Colorado. It will serve as the plan for the entire state, not for any single group or agency. The state plan focuses on a three- to five-year time frame, which allows time for addressing longer-term efforts as well as immediate needs. During and at the end of that time frame, the success of this plan will be measured in terms of the number of cleantech jobs created, the revenue earned by cleantech companies in the state, and the amount by which the tax base is expanded by companies with cleantech products and services.

What is cleantech?
For the purposes of this report, cleantech includes **renewable energy generation** as well as technologies that allow for **cleaner and more efficient use of traditional energy and natural resources.**

The development of this state plan was directed and funded by diverse groups of stakeholders. The Colorado Cleantech Industry Association (CCIA) commissioned this report as part of its mission to promote cleantech in Colorado and to provide leadership on public policy, development, and education in the cleantech industry.

- » The state plan was funded by the Colorado Economic Development Commission, the U.S. Department of Commerce Economic Development Administration, the Metro Denver Economic Development Corporation (EDC), the Governor's Energy Office, the Colorado Workforce Development Council, Colorado School of Mines (CSM), Colorado State University (CSU), and the University of Colorado (CU).
- » A 25-member Steering Committee represented interests ranging from start-up companies, investors, utilities, the oil and gas industry, economic development, workforce development, universities, and research institutions. These groups have agreed to lead the implementation of the state plan.

⁴ Pew Center on the States. 2009. *The Clean Energy Economy: Repowering Jobs, Businesses, and Investments Across America.*

⁵ Pew Center on the States. 2009. *The Clean Energy Economy: Repowering Jobs, Businesses, and Investments Across America.*

⁶ Johnston, N. 2010. "Obama Announces Loan Guarantees for Solar Firms Abengoa, Abound." *Bloomberg Business Week.*

⁷ National Venture Capital Association and Thomson/Reuters. 2010.

⁸ Includes funding from NREL, CU, CSU, and CSM. NREL: NREL. 2010. "Overview." CU: Lesser, S. 2010. "Top 10 Cleantech Universities in the U.S. for 2010." Cleantech Group, LLC. CSU: Colorado State University. 2010.

"CleanEnergy Supercluster: Mission."

⁹ American Wind Energy Association. July 2010. "U.S. Wind Energy Projects."

¹⁰ American Council for Renewable Energy. 2010. "Renewable Energy in Colorado." *Renewable Energy in America.*

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State Planning Objectives

The three objectives established for the state planning process are designed to put Colorado's cleantech industry on the path to serving as a primary driver of economic development in Colorado. The three objectives are as follows:

1. To define Colorado's competitive advantages in cleantech
2. To describe the critical path forward to sustain and expand on the competitive advantages
3. To outline a set of actions that will support the cleantech industry over the mid- and long-term

This report complements the *Resource Rich Colorado* report, which is produced by the Metro Denver EDC. *Resource Rich Colorado* provides an annual snapshot of the broader energy industry and business climate in Colorado. The documentation in that report provides additional data about Colorado's rankings in a variety of areas and the types of policies in place to promote commerce. The 2010 update is expected to be released in November 2010.

Organization of the State Plan

The remainder of this plan explains the process used to develop it and identifies the steps needed to advance Colorado's cleantech industry. The appendices provide additional detail about all areas of this plan.

- » Section 2 summarizes the methodology used to develop this plan; additional details on the methodology can be found in Appendices A–D.
- » Section 3 describes the foundations of Colorado's cleantech industry, including those strengths and gaps that cut across multiple cleantech sectors; see Appendices E–I for additional details.
- » Section 4 describes the strengths, gaps, and actions needed to strengthen the pillars of Colorado's cleantech industry, and the sectors in which Colorado has the strongest competitive advantage and the greatest potential to expand; see Appendices E–I for additional details.
- » Section 5 provides an overview of the actions that will support the cleantech industry as a whole, supporting both the priority sectors of the cleantech industry and enabling other sectors that may develop into leaders over time; see Appendices E–I for additional details.
- » Section 6 describes the steps that are being taken to implement this plan.

Section 2: Methodology

The process used to develop this state plan relied on data-driven analysis coupled with frequent engagement with key industry stakeholders. Drawing on Navigant Consulting, Inc.’s (Navigant’s), broad and deep knowledge of the cleantech industry, the project team reviewed and analyzed data that represented Colorado’s competitive positioning in a variety of market areas. In addition, the project team engaged with more than 100 representatives of the cleantech sectors in Colorado to ensure that the analysis reflected the on-the-ground experience of companies already doing business in Colorado or seeking to do so in the future. This approach is consistent with those used by Navigant in other state plans around the country.

The 25-member Steering Committee provided direction for this project. Members’ interests ranged from investment, to entrepreneurship, to economic development, to workforce development and policy-making. Their expertise crossed the cleantech sectors and included utilities, the conventional energy industry, national laboratories, and universities. These individuals reached out to their networks to vet the results of the analysis and refine the action plan. Their guidance was critical to this planning process.

A four-step approach was used to develop the state plan. The Steering Committee was consulted at each stage, and its members’ input incorporated into the analysis and into the next step in the process. A brief summary of each step is included in the remainder of this section.

Step 1: Establish Project Goals and Clarify Scope.

The Navigant team met with the Steering Committee to set the direction for the project. The Steering Committee determined that the state plan should advance the economic development of the state of Colorado by increasing jobs, revenue, and tax base created by the cleantech industry. More than 35 subsectors were included in the initial examination in Step 2; a comprehensive list of these sectors is included in Appendix B. In addition, the Steering Committee agreed upon the criteria that would be used to select the priority sectors in Step 2; these criteria and their relative weightings are shown in Table 1. Additional detail on these rankings is included in Appendices B and C.

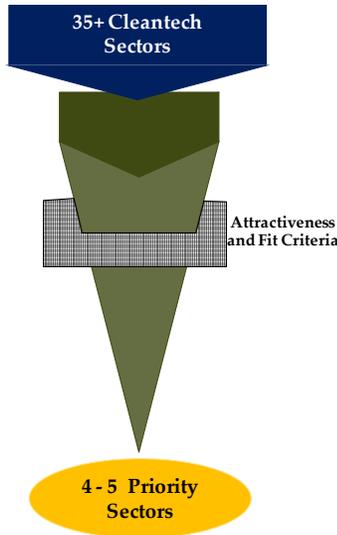
The Steering Committee determined that the state plan should advance the economic development of the state of Colorado by **increasing jobs, revenue, and tax base** created by the cleantech industry.

Table 1. Attractiveness and Fit Criteria

Attractiveness Criteria	Weighting	Fit Criteria	Weighting
2015 Global Market Size (Revenue)	20%	Innovation – R&D/Bridge to Success Support	20%
Sensitivity to Policy	20%	Infrastructure to Support Sub-Segment	10%
Colorado Revenue Potential (2015)	20%	Natural Resources to Support Sub-Segment	5%
Colorado Income Creation (# jobs * average wage)	20%	Workforce Skill Sets (incl. other sector skills)	35%
Sustainability of Competitive Advantage	20%	Governance (Incentives, Taxes, Policy, Regulatory Alignment)	5%
		Critical Mass – Location Quotient (LQ): Total Segment Employment/National Average	25%

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Figure 1. Selection Process



Step 2: Select Priority Sectors

Starting with the list of more than 35 cleantech sectors and the selection criteria established in Step 1. A select set of information was gathered and reviewed, including reports from the U.S. Department of Energy (DOE), national industry associations, the U.S. Department of Labor, the U.S. Patent Office, the Pew Center on the States, and a variety of other public and private organizations. The project team selected four priority sectors and four emerging sectors to investigate in more detail and recognized these eight sectors as the pillars of Colorado's cleantech industry. This plan focuses on the priority sectors but includes some additional detail on the emerging sectors in Section 4.

- » Priority sectors: wind, solar, smart grid, bio-derived
- » Emerging sectors: advanced transportation, energy-efficient buildings, energy storage, water

The rationale for selecting the priority sectors is compelling.

The size of the global wind sector in 2009 was \$63.5 billion.¹¹ Within the state of Colorado, wind turbine deployment is growing quickly, as the state's renewable energy standard (RES) of 30 percent by 2020 is among the most aggressive in the country.¹² In most states, including Colorado, regulated entities frequently meet most of their RES targets with wind energy, given its low cost relative to other renewable resources. As evidence, Xcel Energy, Colorado's largest electric utility, has more wind energy on its network (including service territories outside of Colorado) than any other utility in the U.S., totaling 3,176 MW in 2009.¹³ Not only is Colorado well positioned to capitalize on a growing local wind market, the state is strategically located within 750 miles of the top 13 windiest states which, together, comprise 94 percent of the total U.S. wind potential.¹⁴ In recent years, the wind sector has taken notice. Vestas, the world's largest producer of wind turbines, now has four production facilities in Colorado, which employ approximately 1,200 workers.¹⁵ In addition, many of the world's leading wind farm developers have offices in the state. In terms of wind energy innovation, Colorado is a leader as well. NREL's National Wind Technology Center (NWTC) is the DOE's premier wind energy research and development facility. The NWTC received \$10 million in American Reinvestment and Recovery Act (ARRA) funding, helping Colorado place third among states in wind energy grants.¹⁶ Both Vestas and Siemens have or are planning wind R&D facilities near the NWTC in Boulder County.

In 2009, the global solar photovoltaic (PV) sector had \$36.1 billion in revenue.¹⁷ Colorado is favorably located within 750 miles of 10 of the top 12 states in terms of solar resource potential.¹⁸ Within the U.S., Colorado ranks fifth in solar resource potential¹⁹ and fifth in cumulative installed solar PV.²⁰ Although

¹¹ Pernick, R. 2010. *Clean Energy Trends 2010*.

¹² Database of State Incentives for Renewable Energy (DSIRE). 2010. "Colorado Incentives/Policies for Renewables and Efficiency: Renewable Energy Standard."

¹³ AWEA 2010. *U.S. Wind Industry Annual Market Report: Year Ending 2009*.

¹⁴ Pacific Northwest Laboratory. August 1991. "An Assessment of the Available Windy Land Area and Wind Energy Potential in the Contiguous United States." Navigant analysis.

¹⁵ Proctor, C. 2010. "Economic Growth in the Wind for Vestas." *Denver Business Journal*.

¹⁶ U.S. DOE. 2010. "Energy.Gov/List of Awardees."

¹⁷ Pernick, R. April 2010. *Clean Energy Trends 2010*.

¹⁸ NREL. 2008. "Center to Research New Ways to Convert Sunshine to Power and Fuels." Navigant analysis.

¹⁹ NREL. 2008. "Center to Research New Ways to Convert Sunshine to Power and Fuels."

²⁰ American Council for Renewable Energy. 2010. "Renewable Energy in Colorado." *Renewable Energy in America*.

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manufacturing of the majority of solar modules occurs in Asia, Colorado is home to the manufacturing operations of companies such as Abound Solar, which received a DOE loan guarantee for \$400 million in July 2010.²¹ In addition, Colorado is home to the first U.S. production site for the world's largest manufacturer of inverters for solar photovoltaic modules, SMA Solar Technology AG. In terms of solar innovation, Colorado plays host to SolarTAC, the largest solar test facility in the U.S.,²² as well as the Center for Revolutionary Solar Photoconversion (CRSP), and other research centers. Due to NREL's location in the state, Colorado won nearly one-fourth of all solar-related ARRA funding, totaling \$28 million.²³

The global smart grid market in 2010 is anticipated to be worth \$23 billion.²⁴ In Colorado, two major smart grid pilot projects, SmartGridCity and FortZED, have placed the state among the top ten in leading smart grid research and development.²⁵ Under ARRA, the City of Fort Collins received \$18.1 million in funding for FortZED. Black Hills Energy-Colorado Electric received \$6.1 million, and NREL received an additional \$19.1 million.²⁶ In addition to these pilot projects, Colorado is home to InteGrid Laboratory, among the world's most advanced centers for test and development related to renewable energy, distributed generation, and power system management.²⁷ Although Colorado's major telecommunications companies (e.g., Qwest and Level 3 Communications) have not ventured far into smart grid, their employees' knowledge base represents a notable opportunity to leverage existing expertise to grow this sector in Colorado; metropolitan Denver and Northern Colorado's telecommunications and broadcasting cluster was ranked fourth out of 50 metro areas for its concentration of employment in 2009, with more than 1,700 companies and more than 40,000 employees.²⁸ The parallels between smart grid and telecom—complex, large-scale network architecture and operations with high reliability requirements—position Colorado's skilled workforce to make a significant impact on smart grid deployment.

According to a report by Clean Edge, Inc., the size of the 2009 global market for biofuels was \$44.9 billion.²⁹ Although Colorado is not very rich in terms of bio-based feedstocks, the state is very strong in R&D. Colorado-based companies and institutions received more than \$87 million in ARRA funding for 33 bio-related projects, more funding than any other state except for California.³⁰ The state has a leading research collaborative in the Colorado Center for Biorefining and Biofuels (C2B2), which has Fortune 500 sponsoring members such as Chevron, ConocoPhillips, General Motors, and Valero.³¹ NREL's world-class biomass facilities enable private-sector companies to affordably explore multiple biofuels pathways, creating an attractive draw for the bio-derived sector to Colorado. In addition, NREL is the co-leader of and the Colorado School of Mines is a participant in the DOE's National Advanced Biofuels Consortium (NABC), a \$34 million public-private collaboration to develop advanced "drop-in" biofuels that can supplement petroleum-derived fuels within the existing transportation infrastructure. Finally, as a leader

²¹ Abound Solar. 2010. "Abound Solar Offered \$400 Million Conditional Commitment for Loan Guarantee by U.S. Department of Energy."

²² SolarTAC website. 2010.

²³ U.S. DOE. 2010. "Energy.Gov/List of Awardees."

²⁴ Visiongain. 2010. *The Global Smart Grid Market 2010-2020*.

²⁵ GTM Research. 2009. "Smart Grid Leadership: The Top Ten 'Smartest' States in 2009." *Greentechmedia.com*.

²⁶ U.S. DOE. 2010. "Energy.Gov/List of Awardees."

²⁷ InteGrid website. 2010.

²⁸ Metro Denver Economic Development Corporation. 2010. "Metro Denver and Northern Colorado Key Industry Clusters."

²⁹ Pernick, R. April 2010. *Clean Energy Trends 2010*.

³⁰ U.S. DOE. 2010. "Energy.Gov/List of Awardees."

³¹ Colorado Center for Biorefining and Biofuels website. 2010.

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in beer production, Colorado has access to large-scale fermentation expertise that is critical to commercializing biochemical fuel-production platforms.

Step 3: Define Colorado's Competitive Position

The Navigant team led the “deep dives” into the priority sectors, whereas the CCIA led limited reviews of the emerging sectors. During this step, the project team examined Colorado’s cleantech assets and barriers in more detail. The project team considered those assets and barriers in the context of the states that will compete with Colorado to build a strong cleantech industry, considering the opportunities and threats posed by those competitors. The analysis included the review of a broader set of information, including resources developed by economic development agencies, utilities, NREL, nationally recognized news agencies, Colorado organizations, and energy policymakers and regulators from throughout the U.S. One important source was the list of companies included in Connected Organizations for a Responsible Economy’s (CORE’s) *Colorado Cleantech Cluster Analysis*³², which provided a useful reference in the definition of Colorado’s existing strengths. The Navigant team conducted five focus groups (one for each priority sector and one for a cross-cutting group of investors and policymakers) and nearly a dozen follow-up meetings to gain the perspective of more than 70 industry participants.

Step 4: Develop Action Plan

The development of the action plan itself represents the most significant step of the state planning process. The remainder of this section provides more detail on the approach used to craft the action plan in order to describe the rationale used to develop and organize the actions. An overview of the final actions is also provided.

Synthesize data and develop unified set of actions: The first step in the development of the action plan involved synthesizing all of the information gathered in Steps 1–3 and developing concrete actions to move Colorado toward its goals of economic development in the cleantech industry. Understanding Colorado’s competitive positioning and the leading practices implemented in other jurisdictions enabled the team to identify the key gaps that prevent the state from increasing its leadership in cleantech.

This action plan was designed to serve the entire cleantech industry in Colorado, although the set of actions was developed through the lens of the priority sectors. Because the priority sectors were identified as those with the most near- and mid-term potential to sustain and grow Colorado’s leadership in cleantech, priority was placed on understanding and addressing the opportunities and challenges in those sectors. The actions in this plan address the critical challenges of those sectors, but nearly all of them can benefit other cleantech sectors. For example, the acceleration of transmission development is critical to the advancement of the wind and solar sectors in Colorado, but the transmission developed will not benefit only wind and solar projects. The plan focuses on presenting a unified set of actions rather than developing a separate action plan for each cleantech sector.

Group actions into initiatives: Following the development of the actions, the project team created a framework for considering the actions. The actions were grouped into the six major initiatives below. Together, these initiatives will provide the resources needed to grow the cleantech industry.

³² CORE and Evenson & Associates. 2009. *Colorado Cleantech Cluster Analysis 2009: Cleantech Altitude: Colorado’s Leadership Advantage*.

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Colorado Cleantech Initiatives

- A. Increase the amount of **capital** available for cleantech in Colorado
- B. Enhance the **leadership** capacity of cleantech company executives
- C. Strengthen Colorado's cleantech innovation **ecosystems**
- D. Develop and implement **regulatory and policy** initiatives that accelerate cleantech project development
- E. **Attract** cleantech companies' strategic operations to Colorado
- F. Prepare the **workforce** for the cleantech economy in a coordinated manner

Prioritize actions: Although the collective set of actions contained in this plan addresses the challenges faced by Colorado's cleantech industry as a whole, some actions are of higher priority for some sectors than for others. Steering Committee members ranked the actions that were most critical for each sector. Three levels of priority emerged from this exercise:

1. **Foundational actions:** Actions considered high priority by all of the priority sectors
2. **Sector-specific actions:** Actions considered high priority by a subset of priority sectors
3. **Supporting actions:** Actions considered of lower priority relative to the foundational and sector-specific actions

Successful implementation of the actions that are considered "sector-specific" can benefit other sectors besides those that identified the action as a high priority.

Table 2 includes the comprehensive list of actions developed, along with their classification as foundational, sector-specific, and supporting actions. It also indicates the rankings assigned to each action by the priority sectors.

Industry buy-in: Before finalizing the plan, the project team vetted the recommendations with key participants in the Colorado cleantech industry, ensuring widespread support for the plan moving forward. The plan that is presented in this report has gained support from a broad set of stakeholders who have committed to participating in its implementation.

Colorado Cleantech Action Plan

Table 2. Comprehensive List of Actions Needed to Advance Colorado's Cleantech Leadership

A: Increase the amount of capital available for cleantech in Colorado			Wind	Solar	Smart Grid	Bio-Derived
A1	Increase Funding for Seed and Technology Acceleration	Foundational				
A2	Increase Amount of In-State Capital Available to Early-Stage Companies	Foundational				
B: Enhance the leadership capacity of cleantech company executives			Wind	Solar	Smart Grid	Bio-Derived
B1	Strengthen Cleantech Company Incubators and Accelerator Programs	Foundational				
B2	Boost Leadership Training Programs	Foundational				
C: Strengthen Colorado's cleantech innovation ecosystems			Wind	Solar	Smart Grid	Bio-Derived
C1	Enhance Cleantech Commercialization Within Universities and Federal Labs	Supporting				
C2	Expand and Develop Pilot and Demonstration Facilities	Sector-Specific				
C3	Collaborate with Colorado's Natural Gas Industry	Supporting				
C4	Connect Cleantech Companies with Utilities	Sector-Specific				
C5	Partner with Other States on Renewable Fuels and Chemicals Value Chain	Sector-Specific				
D: Develop and implement regulatory and policy initiatives that accelerate cleantech project development			Wind	Solar	Smart Grid	Bio-Derived
D1	Accelerate Transmission and Renewable Energy Development	Sector-Specific				
D2	Strengthen Incentives for Utilities to Invest in Cleantech	Sector-Specific				
D3	Develop State Energy Plan	Supporting				
E: Attract cleantech companies' strategic operations to Colorado			Wind	Solar	Smart Grid	Bio-Derived
E1	Establish Statewide Priorities for Company Recruitment	Sector-Specific				
E2	Package and Promote Colorado's Benefits to Attract Cleantech Companies	Sector-Specific				
F: Prepare the workforce for the cleantech economy in a coordinated manner			Wind	Solar	Smart Grid	Bio-Derived
F1	Align Retraining Priorities with Industry Needs	Supporting				
F2	Expand and Promote Colorado's University Cleantech Curriculum	Supporting				
F3	Transfer Knowledge to the Next Generation of the Cleantech Workforce	Supporting				

Key:	High Priority	Medium Priority	Low Priority
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Section 3. Strengthening Colorado's Cleantech Foundations

This section describes the fundamental character of Colorado's cleantech industry, which is defined by its competitive advantage in innovation, its proximity and access to robust markets for cleantech, and the base of companies already located in Colorado. Each of these characteristics is described in more detail in this section. The strengths, challenges, and foundational actions that strengthen these aspects of the cleantech industry are presented as well.

Colorado's Fundamental Competitive Advantage Is Innovation.

The strength of Colorado's cleantech-focused research capabilities is widely cited as one of the state's greatest cleantech assets. Development Research Partners ranks Colorado fourth in the nation for renewable energy and energy research employment.³³ With NREL at its center, Colorado's cleantech research cluster includes major research universities (CU, CSU, and CSM) and other federal laboratories (e.g., the National Institute of Standards and Technology [NIST] and the National Center for Atmospheric Research [NCAR]) whose work complements and supports the cluster's cleantech focus. As the only DOE lab focused exclusively on DOE's Office of Energy Efficiency and Renewable Energy (EERE) programs, NREL captures a large share of DOE's related funding, with \$476 million of the EERE Office's \$1.2 billion budget in fiscal year 2009.³⁴

As a result of the innovative nature of Colorado's economy, the state is home to a robust technical workforce. The telecommunications, information technology, aerospace and satellite, agriculture, and bioscience industries are all well-established incumbent employers in the state. These industries have developed a well-trained workforce with much of the knowledge and many of the skills required for emerging cleantech opportunities. As a result, Colorado ranks high among states in terms of technical occupations as a percentage of the workforce in several categories (#3 in engineers, #4 in architecture/engineering, and #6 in computer specialists).³⁵ In addition, Colorado's universities have established nationally leading cleantech education programs (e.g., University of Colorado's Building Systems Program) while the state's community colleges offer diverse cleantech training programs in areas such as solar PV installation and wind energy.

Colorado Has Access to a Robust Market for Cleantech.

Colorado has access to a robust set of in-state and regional markets for renewable energy. In-state solar and wind resource potential are ranked fifth³⁶ and eleventh nationally, respectively, and the state is geographically positioned at the juncture of the nation's solar-rich Southwest and the strong winds of the Great Plains.³⁷ Coupled with proximity to major electric transmission lines, this provides local companies with favorable access to renewable energy markets. From a supply-chain perspective, Denver's position as a major railway (Union Pacific and Burlington Northern Santa Fe Railway [BNSF]) and air transportation hub enables ready access to suppliers and to end markets. Denver International Airport provides easy access for business travel, with the fifth highest passenger count in the U.S.³⁸ and existing direct flights to Europe and direct flights to Asia anticipated.³⁹

³³ Development Research Partners. 2010. "Metro Denver 2010 Economic Forecast."

³⁴ National Renewable Energy Laboratory. 2009. "Annual Report: A year of Energy Transformation."

³⁵ National Science Foundation. 2009. "Science and Engineering State Profiles."

³⁶ NREL. 2008. "Center to Research New Ways to Convert Sunshine to Power and Fuels."

³⁷ Vallin, G. 2010. "Colorado – A Leader in Wind Energy." *Renewable Energy World*.

³⁸ Airports Council International. 2010. *World Airline Report*.

³⁹ Day, K. 2010. "State of the Airport 2010."

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Colorado's established industries also represent a potential end market for distributed renewable energy generation. Historically ranked among leading states in conventional energy production (fifth in number of fossil fuel industry workers)⁴⁰, the Colorado conventional energy sector is the largest consumer of energy in Colorado.⁴¹ A variety of cleantech applications may enable more efficient use of energy or further use of abundant renewable energy resources (e.g., solar PV for well pads). The state's research universities, led by CSM, have been instrumental in the conventional energy industry's growth, and programs such as CSU's Engines and Energy Conversion Center continue to foster new innovations in areas such as engine efficiency. In addition, the state's high concentration of military installations provides potential opportunities for large-scale demonstration projects given the U.S. Department of Defense's focus on renewable energy.⁴²

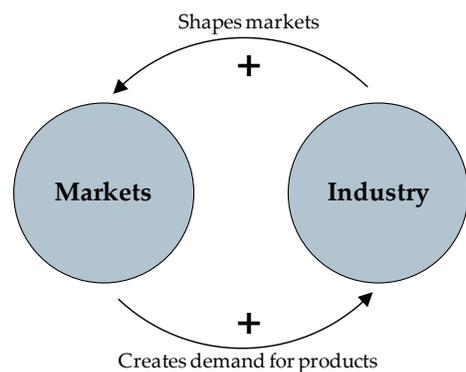
In parallel, Colorado's leadership in the policy and political arenas has bolstered the state's attractiveness for the development of renewable energy projects and provided the certainty and signals needed to attract other cleantech businesses. Colorado's renewable energy standard—the first and only such measure in the U.S. passed by popular vote—remains one of the most ambitious in the country. In 2010, elected officials further expanded this mandate to the current goal for the amount of electricity sourced from renewable sources by 2020 (30 percent for investor-owned utilities and 10 percent for some cooperative utilities). In addition, the Governor's Energy Office and other partners have actively promoted Colorado's "New Energy Economy" and the state's Climate Action Plan as drivers of economic development. This demonstrates the type of leadership that creates a stable policy environment for cleantech companies.

Innovation and Access to Markets Have Attracted a Base of Cleantech Companies.

Policy, particularly the RES, has played a central role in driving the development of markets in and around Colorado. Given the robust demand for renewable energy resulting from those policies, project developers have located in Colorado to serve those markets. The demand for equipment and services created by those developers has combined with Colorado's other assets to attract manufacturers and their service providers. The continuation of this virtuous cycle will play an important role in the future growth of Colorado's cleantech industry.

The combination of research institutions, highly educated technical workers, and strategic location has resulted in the formation of new companies and attraction of global corporations. Alumni from NREL and the universities have spun off or joined successful, Colorado-based cleantech start-ups (e.g., OPX Biotechnologies, Boulder Wind Power, and Spirae). At the same time, the strength of the state's research and development resources has contributed to several industry players' decisions to locate private-sector research centers in the state (e.g., Vestas, Siemens, and those participating in the Solar Technology Acceleration Center).

Figure 2. Markets and Industry Are Closely Connected.



A positive feedback cycle between the creation of markets and the development of an in-state industry are at the heart of Colorado's success to date in the cleantech industry.

⁴⁰ Dun & Bradstreet, Inc. Marketplace database. July-Sept. 2003-2009. Development Research Partners.

⁴¹ Navigant. 2010. *2010 Colorado Utilities Report*. Governor's Energy Office.

⁴² Rosenthal, E. 2010. "U.S. Military Orders Less Dependence on Fossil Fuels." *New York Times*.

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Further, Colorado has created more than 5,000 cleantech jobs through a diverse set of cleantech company operations since 2007.⁴³ The jobs range from manufacturing, to sales, to research and development, to consulting. These companies include global firms such as GE Energy Controls, RES Americas, SMA Solar, and Bach Composite, in addition to companies that started in Colorado, such as Abound Solar, Ascent Solar, Solix Biofuels, PrimeStar Solar, and Advanced Energy Industries. These companies are creating a draw for supply-chain partners to locate in Colorado, as six Vestas suppliers have already done.

Colorado's Cleantech Strategy Builds from These Fundamental Strengths.

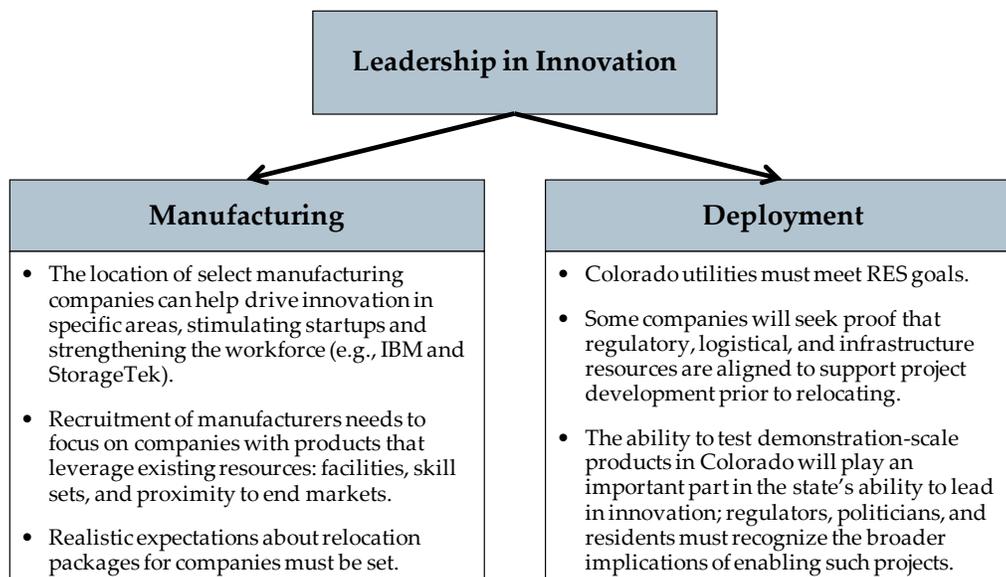
In the next three to five years, Colorado will strengthen its cleantech industry by leveraging its greatest strengths. Colorado is well positioned to focus on innovation given its proximity to NREL and other research institutions and the high concentration of highly educated technical workforce in the state.

Colorado has already proven its ability to export innovation to other markets and has attracted the attention of global firms that want to put that expertise to work within their organizations.

Colorado's combination of innovation, access to markets, and industry base puts the state in a *unique competitive position* relative to other states.

As it has in the past, Colorado's strength in innovation will drive development in the manufacturing and deployment segments of the cleantech industry. The results generated by the innovation segment of the economy will attract product development and manufacturing operations to the state; the proximity to both incremental and game-changing innovations enables these companies to optimize their operations and produce better products for their customers. In parallel, new products that result from the innovation centers in Colorado can be deployed in the state during the pilot and demonstration stages, enhancing the state's leadership role in innovation while creating jobs and new implementation expertise. The experience gained by manufacturers and technology deployment experts in the state can then be fed back into the innovation centers, enabling advancements that require a tight connection between end users and innovators. Colorado has seen success with this model in the high-tech sector, with Hewlett-Packard and StorageTek driving innovation locally.

Figure 3. Core of Colorado's Cleantech Strategy



⁴³ State of Colorado Office of the Governor. 2010 "New Energy Economy: Creating Jobs, Attracting Businesses, and Strengthening Our Economy."

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More emphasis will be placed on the manufacturing and deployment components of the value chain for specific cleantech sectors, as discussed later in this report. Strengthening the innovation component of the value chain, however, will provide benefits across many of the cleantech sectors. In this way, Colorado will establish a firm foundation for the entire cleantech industry on which the manufacturing and deployment components of the value chain can also be expanded and fortified.

Furthering Leadership in Cleantech Requires Bridging Gaps in Capital and Leadership.

Leveraging innovation to drive job gains in manufacturing or deployment requires a stronger focus on the resources needed to convert innovation into products, namely capital and leadership. The commercialization of technologies involves connections between the researchers that develop the ideas and the market experts that understand how the ideas can serve the market. Ideas may be tested in the laboratory in one application but needed in the marketplace in a different application. In other cases, the applications may be the same, but the marketplace requires significant product development efforts to turn the technology into a product that an end user will buy.

Navigating the commercialization process requires both capital and leadership, both of which are limited in Colorado's cleantech industry:

- » Current levels of state, federal, and private funding for commercialization are insufficient to support an economy based on innovation and commercialization in the following areas:
 - » *Proof-of-concept stage*: SB09-31 was signed into law to provide \$3.3 million per year for five years for grants to start-up cleantech companies, proof-of-concept grants, and matching funds for research, but it was passed without appropriation. CU's Proof-of-Concept grants (POCg) and Proof of Concept Investment (POCi) grants have been scaled back significantly since 2009 due to lack of funds; more than \$11 million had been awarded under these programs since 2002.⁴⁴ CSU has awarded more than \$3.5 million through nearly 100 proof-of-concept grants to university-generated technologies since 2007.⁴⁵
 - » *Seed stage*: Nearly all research (85 percent of all Colorado research institution funding) is peer-reviewed and funded by federal agencies; less than 1 percent of federal research funding supports technology commercialization.
 - » *Venture capital (VC) stage*: Unlike software and Internet start-up companies, most early-stage cleantech companies require substantial capital commitments and longer product development cycles that do not fit preferred investment profiles for most angel investors and VCs. Further, distance from VC firms puts Colorado cleantech companies at a disadvantage relative to start-ups on the coasts; none of the 50 most active cleantech VC firms are located in Colorado.⁴⁶
- » Out-of-state investors perceive a shortage of executive leadership with previous successful start-up experience in the cleantech industry in Colorado. Because Colorado lacks significant on-the-ground investment capital for the cleantech industry, this perception is a barrier to obtaining the funding needed to move technologies beyond the lab. Several programs in the state provide training to bridge this gap (including CU-Denver's Global Energy Management Program, CSU's MBA in Global Social and Sustainable Enterprise, and the incubators throughout the state). The current capacity of the academic programs and funding for the incubators, however, are insufficient to support the type of training needed to secure outside funding.

⁴⁴ CU Technology Transfer Office. 2010. Personal communication from David Allen.

⁴⁵ CSU Technology Transfer Office 2010. Personal communication from Jeremy Nelson.

⁴⁶ PricewaterhouseCoopers and National Venture Capital Association. 2010. *MoneyTree Report*.

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Addressing these capital and leadership gaps will strengthen the foundation of Colorado’s cleantech industry. The following foundational action items will ensure that Colorado’s innovation community has the fuel needed to spark further growth. These action items were considered of high priority by each of the four priority sectors and fall under initiatives A and B, presented in Section 2:

- » A: Increase the amount of **capital** available for cleantech in Colorado
- » B: Enhance the **leadership** capacity of cleantech company executives

Key Actions: Strengthening the Foundations of Colorado’s Cleantech Industry

A1. Increase Funding for Seed and Technology Acceleration
A2. Increase Funding for Early-Stage Companies
B1. Strengthen Cleantech Company Incubators and Accelerator Programs
B2. Boost Leadership Training Programs

Action A1: Increase Funding for Seed and Technology Acceleration			
Description	Provide proof-of-concept and seed-stage funding for early-stage technologies to help them to traverse the “valley of death.”		
Key Steps	<ul style="list-style-type: none"> » Secure funding for the Clean Technology Discovery Evaluation Grant Program (SB09-31). Ensure inclusion of proof-of-concept funding and matching funds for start-ups. » Work with federal delegation to authorize funding for Technology Commercialization Development Fund Program – part of the Energy Policy Act of 2005 (EPAAct). 		
Proposed Lead	Legislature	Funding Required	\$10-50M
Metrics to Evaluate Success	<ul style="list-style-type: none"> » Private-sector funding leveraged through awards from the Clean Technology Discovery Evaluation Grant Program » Successful re-authorization of the Technology Commercialization Development Fund Program with funds for Colorado 		
Examples	<ul style="list-style-type: none"> » Colorado’s Bioscience Discovery Evaluation Grant Program » Texas Emerging Technology Fund 		

Action A2: Increase Funding for Early-Stage Companies			
Description	Leverage additional state funds to assist Colorado cleantech companies and to attract out-of-state capital. In addition to providing funds for seed stage and technology acceleration (A1), commit state funds to assist established companies in scaling up their operations and increasing market penetration of their products. Such funds can be used to build both companies and markets.		
Key Steps	<ul style="list-style-type: none"> » Establish a fund-of-funds. Leverage the capability of a state bonding authority to attract additional venture capital to the state. » Enact a meaningful tax credit (e.g., 7–10 years) for companies with in-state tax liability that use technologies developed in Colorado. 		
Proposed Lead	Legislature	Funding Required	\$50M+
Metrics to Evaluate Success	<ul style="list-style-type: none"> » # of Colorado start-ups receiving investment each year through fund-of-funds. » # of jobs created by companies supported by the fund-of-funds » \$ in tax revenue created by companies receiving investment through fund-of-funds. 		
Examples	<ul style="list-style-type: none"> » Ohio Capital Fund » Massachusetts 10-Year Intellectual Property Tax Holiday 		

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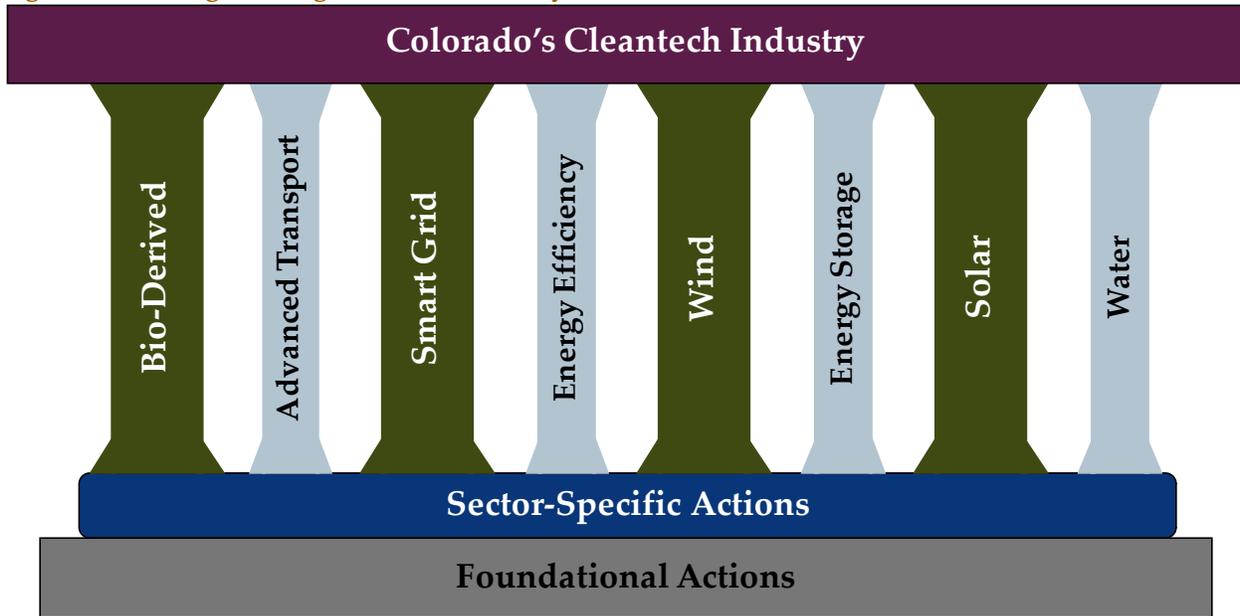
Action B1: Strengthen Cleantech Company Incubators and Accelerator Programs			
Description	Build on the foundations of the existing ecosystems in the state to provide business support to early-stage companies and small businesses. Strengthen individual organizations and promote collaboration among Colorado’s cleantech innovation ecosystems. Ensure continuous and consistent funding to promote growth over time.		
Key Steps	<ul style="list-style-type: none"> » Secure continuous and consistent funding for existing incubators and accelerators. » Coordinate the cleantech incubators and accelerator programs across the state to share best practices and make connections among companies with related products. 		
Proposed Lead	CCIA/Center for Renewable Energy and Economic Development (CREED)	Funding Required	\$1-10M
Metrics to Evaluate Success	<ul style="list-style-type: none"> » # of cleantech companies served by incubators and accelerator programs each year. » Revenue and jobs generated by companies 1, 3, and 5 years after “leaving” programs. » \$ funding awarded to companies that use the services of the state-level business assistance staff position. 		
Examples	<ul style="list-style-type: none"> » McKinstry Innovation Center » Austin Clean Energy Incubator 		

Action B2: Boost Leadership Training Programs			
Description	Enhance Colorado’s set of leadership training programs in the cleantech industry, focusing on executive-level programs for proven business leaders from around the country. Increase size of programs, depth of curriculum, and engagement with the Colorado cleantech industry.		
Key Steps	<ul style="list-style-type: none"> » Identify institution to house the program and program leadership. » Secure funding for and implement the program. 		
Proposed Lead	CREED	Funding Required	\$1-10M
Metrics to Evaluate Success	<ul style="list-style-type: none"> » # and % of program participants completing program in first year and accepting employment in Colorado cleantech industry within one year of program completion. 		
Examples	<ul style="list-style-type: none"> » New England Clean Energy Council’s Fellowship and Executive Education Program 		

Section 4. Building the Pillars of Colorado’s Cleantech Industry

Colorado has unique opportunities in four sectors of the cleantech industry: wind, solar, smart grid, and bio-derived. These priority sectors are the pillars of Colorado’s cleantech industry; their strength will create the structure that enables the development of sectors throughout the cleantech industry. Because of its unique attributes in these four sectors, the cleantech industry is uniquely positioned to drive job growth, revenue creation, and tax base expansion in Colorado.

Figure 4. Building a Strong Cleantech Industry in Colorado



This section describes the action plan for each of the four priority sectors. The discussion of each sector begins by defining the context in which the sector exists today, identifying its strengths and the gaps that must be filled in order to continue to build Colorado leadership in it. Then, the most critical actions needed to advance that sector are described. As mentioned in Section 2, the project team developed a unified set of actions for Colorado’s cleantech industry, from the collective perspective of the priority sectors. Then, the Steering Committee prioritized the actions for each specific sector.

The actions outlined in this section build on the foundational actions outlined in Section 3. The steps needed to strengthen the innovation component of Colorado’s cleantech industry will benefit all four of the priority sectors. In Colorado, all four sectors rely on a firm foundation of innovation to drive growth, although these four sectors are at different stages of maturity; wind and solar are more mature than smart grid and bio-derived. The actions described in this section reflect the highest priority steps that can be taken to build these pillars of the Colorado cleantech industry.

Similarly, the supporting actions, which will be addressed in Section 5, will help grow each of the four priority sectors. For example, developing an integrated statewide energy plan will enable more informed decision making by state government and the business community in terms of how the value of wind, solar, smart grid, and bio-derived can be fully captured within Colorado’s overall energy landscape. Collaborating with the state’s sizeable natural gas industry could identify potential new applications, end markets, and enablers for cleantech—such as using photovoltaics to supply power at well pads. Enhancing commercialization efforts within the state’s universities and federal labs will help ensure that

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the most promising technological advances in cleantech make it out of the labs and into the market. Finally, preparing the state's workforce to repair wind turbines or deploy smart grid technology through internships and retraining programs is critical to ensure further scale up and growth in these sectors. Additional detail on these supporting actions is available in Section 5.

Advancing Colorado's Wind Sector

Colorado's wind sector includes activity throughout the value chain, including research and development, manufacturing, and project development. These components of the value chain are strong, in large part due to the foundations established earlier—a strong innovation base, access to markets, and a base of wind companies with operations in Colorado. The innovation and project development in the wind sector have driven growth in manufacturing; the manufacture of wind turbines and components now employs more workers in Colorado than either the research of wind technologies or the development of wind projects.⁴⁷

This section summarizes Colorado's most significant strengths in the wind sector, identifies the major challenges facing the sector, and outlines a plan to enable the wind sector to continue to drive economic growth in the state.

Colorado's Wind Sector Is Rooted in Research, But Some Types of Technical Skills Are Limited.

CU, CSU, and NREL have active research programs focused on wind technology. The Center for Research and Education in Wind (CREW) is a research center of the Collaboratory that focuses on the development of new wind technologies that improve the reliability and efficiency of wind power generation.⁴⁸ NREL is currently home to the only federally funded, full-scale blade test facility in the U.S. at the NWTTC.⁴⁹ In addition, NCAR is involved in leading-edge research to improve the tools that enable the forecasting of wind resources.⁵⁰

Beyond these strong research institutions, however, the demand for cleantech and energy-specific expertise is outpacing the supply among Colorado's highly ranked engineering and technical workforce. The wind sector has identified specific needs for power engineers, electromagnetic engineers, and maintenance technicians. Colorado universities and schools are developing programs and curricula to create a layer of energy expertise across disciplines (e.g., CU's Renewable and Sustainable Energy Institute), but the process is slow and programs are not yet operating at sufficient scale to meet industry's needs.

Colorado's Wind Sector Is Anchored by Vestas, Yet Additional Commitment Is Needed to Attract More Jobs.

As the world's largest wind turbine manufacturer and the third-largest supplier to the U.S. market, Vestas' \$1 billion investment puts Colorado on the map in terms of cleantech manufacturing.⁵¹ Vestas currently employs approximately 1,200 workers among its four plants and anticipates more than doubling that number by the time its second blades facility in Brighton opens in 2011.⁵² The presence of Vestas attracts suppliers (e.g., Creative Foam and Hexcel) to the state and helps Colorado retain them.

⁴⁷ State of Colorado Office of the Governor. 2010 "New Energy Economy: Creating Jobs, Attracting Businesses, and Strengthening Our Economy."

⁴⁸ Colorado Renewable Energy Collaboratory. 2010. "Center for Research and Education in Wind (CREW)."

⁴⁹ NREL. 2010. "Wind Research Facilities."

⁵⁰ National Center for Atmospheric Research (NCAR). 2009. "NCAR Forecasts Will Help Xcel Energy Harness Wind." University Corporation for Atmospheric Research (UCAR).

⁵¹ AWEA 2010. *U.S. Wind Industry Annual Market Report: Year Ending 2009*.

⁵² Proctor, C. 2010. "Economic Growth in the Wind for Vestas." *Denver Business Journal*.

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Since Vestas made its commitment to locating facilities in the state, six Vestas suppliers have located in Colorado, bringing with them 400 jobs.⁵³

Vestas has publicly stated that it selected Colorado for its major U.S. manufacturing facilities for the following reasons:

- » Easy access to railroad and highway infrastructure
- » Available land
- » Large pool of competent workers
- » Proximity to universities
- » Colorado's strong support of renewable energy⁵⁴

Vestas makes this case to its investors, to its suppliers, and to its workers. In 2009, Vestas purchased 100 acres of land near its facilities to reserve space for the sub-suppliers that it is working to recruit to Colorado.⁵⁵

Colorado Has Significant Wind Resources, Yet Further Development Is Hindered by Transmission Constraints.

Colorado ranks eleventh nationally in wind resource potential⁵⁶ and ranked ninth nationally in 2009 for installed wind capacity with 1,246 MW.⁵⁷ The state is strategically located within 750 miles of the top 13 windiest states, which, together comprise 94 percent of the total U.S. wind potential.⁵⁸ Many wind developers have established a presence in Colorado, including Iberdrola Renewables, Horizon Wind Energy, and RES Americas. These developers have national and global portfolios of projects that compete for capital investment; they allocate resources to the markets with the fewest barriers and the lowest costs of doing business.

In-state developers report that delayed transmission construction is a major source of the slowdown in development (e.g., in Baca County) in addition to the financial crisis, which has affected wind development across the country. Between January and mid-September 2010, only 1.8 MW of new wind generation have come online in Colorado.⁵⁹ Several measures enacted by the legislature and signed by Governor Ritter established the foundations for a transmission system expansion that benefits renewable energy, including the following:

- » SB07-100 requires utilities to undertake annual transmission planning and report on priority zones for renewable energy development.
- » The task force formed by SB07-91 completed a report that characterized the renewable energy resources in Colorado.
- » The Renewable Energy Development Infrastructure (REDI) report presented key issues facing the transmission infrastructure in the state.

This preparation resulted in a coordinated plan for expanding transmission in Colorado. Xcel Energy and Tri-State Generation and Transmission (Tri-State G&T) have approved nearly \$2 billion in capital expenditure dedicated to transmission investments. Yet, the regulatory approval process for transmission

⁵³ Metro Denver EDC. 2010. Personal Communication with Mary Jeffreys.

⁵⁴ Vestas 2010. *Vestas Blades: Capital Markets Day, Brighton, CO.*

⁵⁵ Ministry of Foreign Affairs of Denmark. 2009. "Vestas Buys Extra Land to Attract Its Sub-Suppliers to Locate in U.S."

⁵⁶ Vallin, G. 2010. "Colorado – A Leader in Wind Energy." *Renewable Energy World.*

⁵⁷ American Wind Energy Association. 2009. *Year End 2009 Market Report.*

⁵⁸ Pacific Northwest Laboratory. August 1991. "An Assessment of the Available Windy Land Area and Wind Energy Potential in the Contiguous United States"; Navigant analysis.

⁵⁹ AWEA. 2010. "Projects."

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projects is slow. For example, the review of the Southern Colorado Transmission line (a line that will more directly affect solar than wind) entered the regulatory process in May 2009, but is still unresolved as of the end of September 2010.

The Wind Sector Needs Resources to Enable Development, Company Attraction, and Workforce Development.

To take advantage of its significant wind resource moving forward, Colorado must accelerate the transmission approval process. In terms of manufacturing, the state needs to identify and actively recruit critical wind component suppliers to set up operations in the state to support Vestas and other potential anchor tenants. Finally, although Colorado is very strong in wind R&D, as evidenced by the numerous federal, state, and private R&D centers in the state, Colorado’s universities and schools must accelerate the development of programs and curricula to educate a greater number of power engineers, electromagnetic engineers, and maintenance technicians, careers highly demanded by the wind sector. The three actions described below address the critical issues preventing the Colorado wind sector from advancing its leadership.

Key Actions: Strengthening Colorado’s Wind Sector

- D1. Accelerate Transmission and Renewable Energy Development**
- E1. Establish Statewide Priorities for Company Recruitment**
- F2. Expand and Promote Colorado’s University Cleantech Curriculum**

Action D1: Accelerate Transmission and Renewable Energy Development			
Description	Enable development of transmission projects that have been identified in previous transmission planning efforts. Fast-track regulatory approval to enable utilities to achieve legislative timelines, accelerating the development of renewable energy projects in the state. Provide funding to support last-mile transmission for renewable energy projects.		
Key Steps	<ul style="list-style-type: none"> » Enact legislation with target timelines for public utility commission (PUC) approval of transmission projects constructed by utilities. » Fund the Clean Energy Development Authority (CEDA). 		
Proposed Lead	CCIA, GEO	Funding Required	\$10-50M
Metrics to Evaluate Success	<ul style="list-style-type: none"> » MW of renewable energy coming online as a result of transmission projects » MW installed per year using CEDA funding » % increase in reliability/stability of the grid resulting from new projects 		
Examples	» Renewable Energy Coordination Offices (RECOs)		

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The following section reviews Colorado’s primary strengths in the solar sector, identifies the key challenges facing the sector, and outlines a plan to enable the state’s solar sector to drive further economic growth.

Colorado Research and Development Capability in Solar Power Is Strong

The members of the Colorado Renewable Energy Collaboratory have established several research centers focused on solar technology. Together, Collaboratory members established the CRSP, whose members include DuPont, Sharp, Abengoa, and Toyota, among others. CSU’s Photovoltaics Research Lab aims to understand the differences between thin-film poly-crystalline solar cells and their single-crystal counterparts. The Advanced Coatings and Surface Engineering Lab at Colorado School of Mines serves as an industry-driven research development center for advanced thin films and coating systems. NREL, which was originally named the Solar Energy Research Institute, has retained its focus on solar with a variety of solar-focused research centers, including the National Center for Photovoltaics.

In addition to laboratory research, Colorado is home to the Solar Technology Acceleration Center (SolarTAC), the nation’s largest private-sector test facility for solar technologies. The facility allows members (including Xcel Energy, Abengoa Solar, and SunEdison) to sponsor common, proprietary, or public research. The center offers 74 acres of land with more than 300 days of sunshine each year and is available to test both PV and CSP technologies. The members of the Colorado Renewable Energy Collaboratory (NREL, CU, CSU, and Colorado School of Mines) are participating organizations in the center.⁶⁰

Colorado Has a Strong Base of Solar Manufacturers, Though Challenges Still Remain in Recruiting Supply-Chain Partners.

Although Colorado is not a manufacturing center like Ohio or China, major solar companies have manufacturing operations in Colorado. Similar to the role of Vestas in the state’s wind sector, the presence of larger solar manufacturers (e.g., SMA and Abound) can help attract other suppliers and companies to the local market. SMA, the world’s largest producer of solar inverters, has its only production facility outside of Germany and the largest solar inverter manufacturing center in the U.S. at Stapleton’s Enterprise Park in Denver. SMA’s plant will initially have around 300 employees with capacity to increase to 700.⁶¹ Abound Solar, a thin-film module manufacturer, built upon 15 years of development at CSU with support from NREL, created more than 400 jobs in the state and received a commitment for a \$400 million loan guarantee from DOE in July 2010.⁶² Abound is headquartered in Loveland and operates a manufacturing facility in Longmont.

Table 3. Select Colorado Solar Companies

Solar Value Chain Category	Major Companies
Inverters	Advanced Energy; SMA
Thin-film manufacturers	Abound; Ascent; Primestar
CSP Manufacturers	SkyFuel; Abengoa
Project development, installation & finance	Abengoa; SolarCity; SunEdison; SunRun; Main Street Power

Despite the state’s strengths in the solar sector, current manufacturers have had difficulty convincing supply-chain partners to locate in the state. This difficulty goes beyond the state’s constrained set of financial resources for recruiting companies, although that constraint plays a major role. The manufacturers need a concise set of materials that details Colorado’s value proposition for their supply-chain partners. Although pieces of this information are available through different websites, agencies,

⁶⁰ SolarTAC website. 2010.

⁶¹ Svaldi, A. 2009. “German solar company SMA to open plant in Denver.” *Denver Post*.

⁶² Abound Solar. 2010. “Abound Solar Offered \$400 Million Conditional Commitment for Loan Guarantee by U.S. Department of Energy.”

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and individuals, current manufacturers lack a comprehensive set of collateral materials that they can share with their supply-chain partners.

Colorado Has Considerable Solar Resources, Yet Transmission and Permitting Hurdles Hinder Further Development.

Colorado ranks fifth nationally in solar resource potential⁶³ and ranked fifth nationally in 2009 in terms of installed capacity.⁶⁴ In addition, Denver is a major metropolitan area centrally located to solar-rich Arizona and New Mexico. The strategic nature of Colorado's location, together with the state's robust RES, has drawn many solar project developers and installers to the state. Two of the nation's leading residential solar service providers, SolarCity and SunRun, have chosen Colorado as one of the five states in which they operate. Abengoa Solar, a leading large-scale solar developer based in Spain, located its U.S. headquarters in Lakewood. SunEdison, with a regional office in Westminster, activated an 8.2-MW solar plant in Alamosa County in the San Luis Valley in late 2007, the largest such plant in the U.S. at the time.⁶⁵ SunPower, Iberdrola, Tessera Solar, and Cogentrix are planning even larger installations in the county. Solar developers in all segments report an adequate supply of well-trained Colorado workers to install and maintain projects.

Some projects in the San Luis Valley, however, are stalled due to lack of transmission to carry the power to the grid. Xcel and Tri-State have plans to develop a transmission line to the valley. This plan, however, has been met with opposition from a local landowner whose land the proposed transmission line would cross.⁶⁶ The state, as well as the state's major utilities, has taken many steps to advance the transmission planning process, as discussed in the previous section on Colorado's wind sector. Yet, obstacles to development still exist.

For distributed generation projects, permitting challenges also exist. Local permitting requirements vary considerably from one local government to another. Different municipalities require different paperwork and procedures and provide different timelines for approval. Project developers must adapt their own processes to these differences, resulting in longer project development timelines and additional costs.⁶⁷

The Solar Sector Needs Resources to Enable Project Development and Strengthen the Supply Chain.

The solar sector in Colorado has made significant progress in recent years in several parts of the value chain, including R&D, manufacturing, and project development. To capitalize on the strengths of the sector today, Colorado can reduce barriers to project development and increase the level of focus on recruiting additional supply-chain partners for the state's solar anchor tenants. Concrete improvement in two key areas will enable continued growth in Colorado's solar sector.

Key Actions: Strengthening Colorado's Solar Sector

D1. Accelerate Transmission and Renewable Energy Development

E1. Establish Statewide Priorities for Company Recruitment

⁶³ NREL. 2008. "Center to Research New Ways to Convert Sunshine to Power and Fuels."

⁶⁴ American Council for Renewable Energy. 2010. "Renewable Energy in Colorado." *Renewable Energy in America*.

⁶⁵ Sun Edison. 2010. "Alamosa; Largest U.S. Photovoltaic Power Plant deployed for Xcel Energy."

⁶⁶ Jaffe, M. 2009. "Battle lines drawn over San Luis Valley electric-transmission plans." *DenverPost*.

⁶⁷ Governor's Energy Office. 2009. *Renewable Energy Development Infrastructure (REDI) Report*.

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Action D1: Accelerate Transmission and Renewable Energy Development			
Description	Enable development of transmission projects that have been identified in previous transmission planning efforts. Fast-track regulatory approval to enable utilities to achieve legislative timelines, accelerating the development of renewable energy projects in the state. Provide funding to support last-mile transmission for renewable energy projects.		
Key Steps	<ul style="list-style-type: none"> » Enact legislation with target timelines for PUC approval of transmission projects constructed by utilities. » Establish fast-track local permitting processes for distributed generation projects. » Resolve differences with stakeholders interested in transmission project approval. 		
Proposed Lead	CCIA, GEO	Funding Required	\$100k-1M
Metrics to Evaluate Success	<ul style="list-style-type: none"> » MW of renewable energy coming online as a result of transmission projects » % increase in reliability/stability of the grid resulting from new transmission projects 		
Examples	<ul style="list-style-type: none"> » Texas' Competitive Renewable Energy Zones (CREZs) » RECOs 		

Action E1: Establish Statewide Priorities for Company Recruitment			
Description	Clearly define Colorado's statewide priorities for attracting cleantech companies. Commit resources to attracting those companies.		
Key Steps	<ul style="list-style-type: none"> » Gather input from relevant stakeholders to identify priority technologies/sectors; include anchor tenants and economic development organizations focused on cleantech. » Identify and prioritize strategic companies based on criteria such as ability to create jobs, to attract other companies, and to serve the needs of current Colorado companies. » Assess which benefits would attract the target cleantech companies to establish operations in Colorado (e.g., tax abatement, access to in-state RD&D facilities). » Establish and utilize Economic Development Closing Fund (and other competitive recruitment tools) to incentivize companies to locate in Colorado. 		
Proposed Lead	CCIA, economic development entities	Funding Required	\$100k-1M (plan) \$10-50M (fund)
Metrics to Evaluate Success	<ul style="list-style-type: none"> » New capital investment and jobs created per year by new or expanded cleantech business facilities. 		
Examples	<ul style="list-style-type: none"> » Texas Enterprise Fund » Michigan Renaissance Zone Program 		

Advancing Colorado's Smart Grid Sector

The smart grid sector is comprised of a variety of different technology types that seek to enhance the utilities' ability to operate the grid and end users' ability to make informed decisions about their energy use. The key types of technology included in the smart grid sector can be characterized as follows:

- **Transmission and Distribution Automation:** Deploying technologies such as sensors and actuators on transmission and distribution infrastructure to achieve results such as integrating distributed and centralized renewables, enabling self-healing functionality of the grid, and improving the efficiency of the electricity delivery system.
- **Advanced Metering Infrastructure (AMI):** Deploying smart meters, two-way communications infrastructure, and data management systems to provide greater information to utilities and their

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customers around energy usage and pricing and to provide utilities with better outage detection and power restoration capabilities.

- **Home Area Network (HAN):** Deploying smart appliances, in-home energy displays, and controls to enable utility customers to have greater and more transparent control over their energy usage.

Colorado has already established a position in the smart grid sector globally with its smart grid pilot and demonstration projects, such as SmartGridCity and FortZED. In addition, NREL's planned Energy Systems Integration Facility will enable testing of a variety of smart grid technologies. The initial forays into smart grid in Colorado can be leveraged to attract further investment in the sector; the existing telecom workforce and company base are also critical. Although some Colorado utilities have been leaders in deploying smart grid technology, utilities need additional incentives to 1) share non-customer-specific network data with technology developers, 2) earn a rate of return on smart grid investments, and 3) provide pricing signals to customers in a way that changes energy usage behavior.

Colorado is a Leader in Smart Grid Demonstrations and Pilots, But Policy and Regulation Limit Further Deployment.

Two major smart grid pilot projects, SmartGridCity and FortZED, have placed Colorado among the top ten states leading smart grid research and development.⁶⁸ Xcel Energy's Boulder-based SmartGridCity project was one of the most comprehensive smart grid efforts at the time of its 2008 launch.⁶⁹ The SmartGridCity brand is well known internationally, and the project is hailed as a groundbreaking effort that provide important lessons for the smart grid sector. FortZED (Zero Energy District), a public-private partnership in Fort Collins and its DOE-funded Renewable and Distributed Systems Integration (RDSI) project are testing technologies to reduce peak energy use and integrate renewable energy into the electric system. Both projects have helped bolster the in-state market for smart grid technology and service providers.

Despite these successful demonstrations, existing policies and utility regulations hinder the realization of smart grid's potential benefits. As in many states in the U.S., the return-on-asset (ROA) rate structure for Colorado utilities provides utilities a rate of return on assets they own; however, this ROA structure is not conducive to investments in demand-side management (DSM) and similar applications enabled by smart grid technologies. Furthermore, the restricted availability of variable (i.e., time-of-use) pricing and Colorado's relatively low cost of electricity give consumers little incentive for changing consumption patterns or pursuing smart grid technologies. As of early October 2010, the Colorado PUC has yet to approve comprehensive rate recovery for smart grid investments, and the pending decision regarding cost recovery for Xcel's SmartGridCity project may be a key influence on future smart grid demonstration and pilot activity in the state.

Beyond Current Utility-Sector Collaboration, Additional Data Sharing Would Enhance Product Development.

Xcel's SmartGridCity pilot in Boulder includes work with Tendril as well as Ventyx, both of which have operations in Colorado. The FortZED smart grid pilot involves a myriad of organizations with a Colorado presence, including Spirae, Platte River Power Authority, IBM, and City of Fort Collins Utilities. However, as in most states, Colorado utilities are not required to share their non-customer-specific network information, which is a critical input to practical smart grid product development. Although Xcel Energy will issue a Value Proposition Evaluation Report at the end of 2010, it has not yet provided network performance data outside of the SmartGridCity project team. Without access to data from grid operators, smart grid product developers will continue to operate within a constrained product design

⁶⁸ GTM Research. 2009. "Smart Grid Leadership: The Top Ten 'Smartest' States in 2009." *Greentechmedia.com*.

⁶⁹ Jaffe, M. 2009. "Fort Collins, Pueblo get smart-grid grants." *DenverPost*.

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environment. Each electricity grid system has unique characteristics that are essential for enhancing smart grid product development. At a minimum, product developers would benefit from access to wholesale and retail prices as well as measures of congestion, fuel mix, customer usage, utilization rates, and reliability.

Colorado's Smart Grid Sector Is Poised to Leverage the Existing Telecom Presence and Workforce.

Although Colorado's major telecom players (e.g., Qwest and Level 3) have not ventured far into smart grid, their employees' knowledge base represents a notable opportunity to leverage existing expertise to grow this sector in Colorado. Metro Denver and Northern Colorado's telecommunications and broadcasting cluster was ranked fourth out of 50 metro areas for its concentration of employment in 2009 with more than 1,700 companies and more than 40,000 employees.⁷⁰ The parallels between smart grid and telecom—complex, large-scale network architecture and operations with high reliability requirements—position Colorado's skilled workforce to make a significant impact on smart grid deployment.

Promoting Colorado's Smart Grid Brand Equity and Providing Further Incentives for Utilities to Engage in Smart Grid Projects Can Grow the State's Smart Grid Sector.

The path forward for Colorado's smart grid sector focuses on leveraging the state's reputation for testing smart grid technologies and the specialized knowledge held by the state's telecom workforce. The state's 57 electric utilities—including investor-owned utilities, municipal utilities, and co-operative utilities—play a central role in the action plan, as they have access to the infrastructure and information that technology companies need. The regulatory, investment, and risk profile borne by each type of utility provides different opportunities for smart grid companies in Colorado to advance their products and services. The three actions described below address the critical issues preventing the Colorado smart grid sector from advancing its leadership.

Key Actions: Strengthening Colorado's Smart Grid Sector

C4. Connect Cleantech Companies with Utilities

D2. Strengthen Incentives for Utilities to Invest in Cleantech

E2. Package and Promote Colorado's Benefits to Attract Cleantech Companies

⁷⁰ Metro Denver Economic Development Corporation. 2010. "Metro Denver and Northern Colorado Key Industry Clusters."

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Action C4: Connect Cleantech Companies with Utilities			
Description	Connect Colorado's 57 utilities with cleantech companies to further familiarize the utilities with the companies' products and the companies with the utilities' needs. Create opportunities for exchanging information that facilitate cleantech product development. Increase the number of cleantech pilot/demonstration projects conducted in Colorado.		
Key Steps	<ul style="list-style-type: none"> » Make the connection between Colorado utilities and in-state cleantech companies by: <ol style="list-style-type: none"> 1) Creating a forum for Colorado companies and utilities to interact, leveraging existing events/networks and 2) Establishing Colorado pilot/demonstration project fund for projects that use Colorado technologies in Colorado utilities. » Facilitate utility sharing of data that enables smart grid product development while protecting sensitive customer information and grid security. 		
Proposed Lead	Utilities (focus on Munis/Co-ops)	Funding Required	Connections: \$100k-\$1M Project fund: \$1M-\$10M
Metrics to Evaluate Success	<ul style="list-style-type: none"> » # of new community-scale projects in years 1 and 2 » % of state's population within communities with cleantech demonstration/pilot projects 		
Examples	<ul style="list-style-type: none"> » Xcel/Abengoa CSP solar demonstration » Texas Department of Rural Affairs 		

Action D2: Strengthen Incentives for Utilities to Invest in Cleantech			
Description	Create further incentives for utilities to embrace cleantech. Pursue the appropriate legislative or regulatory changes needed to create a market framework for cleantech that promotes adoption. Recognizing the utilities' responsibilities to their ratepayers, members, and shareholders, strengthen the business case for cleantech.		
Key Steps	<ul style="list-style-type: none"> » Pursue a market framework that rewards utilities for providing energy as a service rather than for the amount of electricity that is sold. » Consider additional options for accelerating adoption (e.g., differential pricing). » Fund proof-of-concept testing for cleantech products and services to feed the pipeline of technologies. Consider options such as allocating a portion of existing system benefits charge. » Promote the successes of municipal and cooperative utilities in cleantech investments: programs, projects, pilots. 		
Proposed Lead	PUC/Legislature	Funding Required	Market framework: (\$100k-\$1M) Differential pricing: (\$10M+) System benefits charge: (\$100k-\$1M) Promotion of utility investments: (<\$100k)
Metrics to Evaluate Success	<ul style="list-style-type: none"> » # of customers to whom variable pricing is available » # of products tested by utilities that enter utility incentive programs 		
Examples	<ul style="list-style-type: none"> » California's Risk-Reward Incentive Mechanism » New York State Energy Research and Development Authority (EE and proof-of-concept funding) 		

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Action E2: Package and Promote Colorado’s Benefits to Attract Cleantech Companies			
Description	Refresh Colorado’s cleantech brand and promote it to priority target audiences. Strengthen brand equity by promoting the brand to target markets both within and outside the state. Consider multiple channels for communicating the message.		
Key Steps	<ul style="list-style-type: none"> » Refresh Colorado cleantech brand, positioning appropriately relative to competition within the sector and resolving competition of existing brand frameworks. » Develop promotion strategy. Consider various market strategies, including road shows, ad campaigns, and existing Colorado companies. 		
Proposed Lead	Office of Economic Development and International Trade (OEDIT), economic development entities	Funding Required	\$1-10M
Metrics to Evaluate Success	<ul style="list-style-type: none"> » % of companies approaching OEDIT/Metro Denver EDC with awareness of the Colorado brand » # of companies that locate in the state of Colorado 		
Examples	<ul style="list-style-type: none"> » Oregon for Biz website » Colorado Tourism Office’s “Let’s Talk Colorado” Campaign 		

Advancing Colorado’s Bio-Derived Sector

Colorado’s bio-derived sector is distinct from the other three priority sectors in more than one way. To begin with, it is composed of a set of technologies that use a more diverse set of production methodologies than the other priority sectors. Second, a variety of feedstocks are used: algae, starches (e.g., corn, wheat, and soybeans), cellulosic materials (e.g., stover, switchgrass, and woodchips), and waste streams (e.g., agricultural waste and sewage residue), among others. In addition, the bio-derived sector includes three segments that use varied technologies to convert those feedstocks into energy and co-products⁷¹:

1. Biofuels
2. Bio-derived products and chemicals
3. Biomass to electricity

Most of the growth opportunities in Colorado fall into the first two areas. This further differentiates the bio-derived sector from the other three priority sectors in Colorado because the focus is not exclusively on the electricity end market. The fuels, chemicals, and products sub-sectors involve different business models, structures, and market participants.

The bulk of the companies in this sector in Colorado are still in the early stage, distinguishing the bio-derived sector from the other three priority sectors. Some of these companies used technologies developed at the universities: OPX Biotechnologies (CU) and Solix Biofuels (CSU). Other companies used technologies developed outside of the state’s research institutions (e.g., Zechem, Gevo, and Bye Energy) or evolved unique business models to serve end markets (e.g., Community Power, Rocky Mountain Sustainable Energy).

Despite these differences from the other priority sectors, the most important strengths of, challenges to, and action items for the bio-derived sector are closely related to the foundational issues outlined in Section 3 because of the early-stage focus. This section provides some additional details of these features for the bio-derived sector while also highlighting issues that are unique to the bio-derived sector because of the focus outside of the electricity end market.

⁷¹ More detail on the related value chains can be found in Appendix D.

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Bio-Derived Is Built on a Strong Research Base and a Unique Combination of Skill Sets in Colorado.

Colorado's start-ups and research institutions conduct extensive research to address all elements of the bio-derived value chain, from feedstock production to end use. Together, they have attracted substantial federal funding to the state, including \$87M in ARRA funding for 33 bio-derived projects.⁷² NREL's world-class biomass facilities enable private-sector companies to affordably explore multiple biofuels pathways, creating an attractive draw for the bio-derived sector to Colorado. In addition, NREL is the co-leader of and the Colorado School of Mines is a participant in the DOE's National Advanced Biofuels Consortium, a \$34 million public-private collaboration to develop advanced "drop-in" biofuels that can supplement petroleum-derived fuels within the existing transportation infrastructure.

The strength of Colorado's biotech and brewing industries provides valuable expertise that can be leveraged in developing the biochemical pathways that produce bio-derived fuels and specialty chemicals. The state has been ranked among the top-five for life science research and development,⁷³ a sector with valuable expertise for microorganism strain development and other key skills for the bio-derived products industry. In addition, in 2007, Colorado surpassed California as the nation's top beer-producing state;⁷⁴ the presence of Coors, Anheuser-Busch, and New Belgium Brewery provides access to large-scale fermentation expertise that is critical to commercializing biochemical fuel-production platforms.

The Acute Challenges for Bio-Derived Focus on the Transition from Product Development to Full-Scale Deployment.

Colorado has a strong base of early-stage companies, but it risks losing these companies' future operations to other states due to insufficient capital, infrastructure, and natural resources needed to grow their companies. The challenge of capital was described well in Section 3. The infrastructure challenges relate to the availability of demonstration-scale test facilities that can be used by multiple companies. The resource challenges are focused on the availability of a robust set of feedstock resources upon which companies can rely when building full-scale production facilities. This section provides additional detail on the infrastructure and resource issues.

The infrastructure required to test bio-derived fuels at demonstration scale requires significant capital investment. It is typically not cost-effective for a single company to support the development of such facilities because they are only useful for a specific use during a specific phase of product development. Companies that plan to develop demonstration facilities independently assemble a range of financial resources, including federal, state, and private sources; such as what Lakewood-based ZeaChem is doing in Oregon⁷⁵ and what Fort Collins-based Solix is doing in southwest Colorado. Without stronger incentives to support companies through this demonstration phase, Colorado risks losing the intellectual capital and future jobs created by these companies. NREL already houses the Integrated Biorefinery Research Facility and the Biochemical Pilot Plant in the Alternative Fuels User Facility; it is prepared to conduct tests at the pilot scale but not at the demonstration scale.⁷⁶

Colorado lacks sustainable feedstock resources to support long-term, in-state production of bio-derived products. Compared to other biomass resource-heavy states, Colorado's agricultural industry is relatively small, accounting for only \$2.5 billion, or one percent of state GDP.⁷⁷ Of that amount, less than 30 percent

⁷² U.S. DOE. 2010. "Energy.Gov/List of Awardees."

⁷³ *Site Selection*. 2007.

⁷⁴ Beer Institute. 2007 *Brewers Almanac*.

⁷⁵ ZeaChem. 2010. "ZeaChem Celebrates Groundbreaking Of Biorefinery in Boardman, Oregon."

⁷⁶ NREL: Biomass Research. 2010. "Integrated Biorefinery Research Facility."

⁷⁷ State of Colorado. 2010. *Colorado Data Book*.

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is from the grain crops considered as potential biomass feedstocks; nearly 60 percent of the value of the state’s agricultural commodities is derived from livestock.⁷⁸ As the seventh driest state⁷⁹, Colorado is limited in its ability to expand the existing crop base. Beetle kill pine, of which supply is abundant, is presently difficult to access on federal lands due to U.S. Forest Service regulations and only offers a relatively short-term feedstock. In addition, transportation and forest management plans create challenges. Colorado’s dairy and livestock waste may also represent an untapped resource for power or fuel production.

Innovative Partnerships Can Address Current Challenges in the Bio-Derived Sector.

Creative partnerships can help to address the challenges faced by Colorado’s bio-derived sector. Such partnerships may involve multiple companies, agencies, and states. Building on the unique strengths of each partner, innovative solutions can be developed to address Colorado’s limitations in infrastructure and feedstock. These are major undertakings that will require significant effort and determined leadership. They can build on existing efforts already underway in the bio-derived sector to examine these sector-wide issues, such as NREL’s research facilities and ARRA-funded biofuels consortia.

Key Actions: Strengthening Colorado’s Bio-Derived Sector

C2. Expand and Develop Test and Scale-Up Facilities

C5. Connect with Other States on Renewable Fuels and Chemicals

Action C2: Expand and Develop Test and Demonstration Facilities			
Description	Leverage national leadership in testbeds. Enhance Colorado’s cleantech companies’ access to existing facilities. Develop new multi-user demonstration-scale facilities that serve the needs of Colorado’s bio-derived sector.		
Key Steps	<ul style="list-style-type: none"> » Establish co-funding mechanisms for multi-user pilot facilities or testbeds to make Colorado an undisputed national leader for test and scale-up facilities. » Increase awareness about the existence, operating parameters, and access fees necessary for emerging Colorado cleantech companies to use these facilities. 		
Proposed Lead	CCIA, GEO	Funding Required	\$50M+
Metrics to Evaluate Success	<ul style="list-style-type: none"> » # of Colorado technology programs advancing to next stage following the use of testbed and scale-up facilities » # of Colorado companies using testbed and scale-up facilities 		
Examples	<ul style="list-style-type: none"> » CableLabs (Louisville, CO) » NIST’s National Wireless Electronic Systems Test Bed » LBNL Test Bed (funded by DOE) 		

⁷⁸ National Agricultural Statistics Service. 2007. *2007 Census of Agriculture: Colorado State Profile*. U.S. Department of Agriculture.

⁷⁹ Frisbie, P. 2010. *Peak to Valley Weather*. National Weather Service Grand Junction.

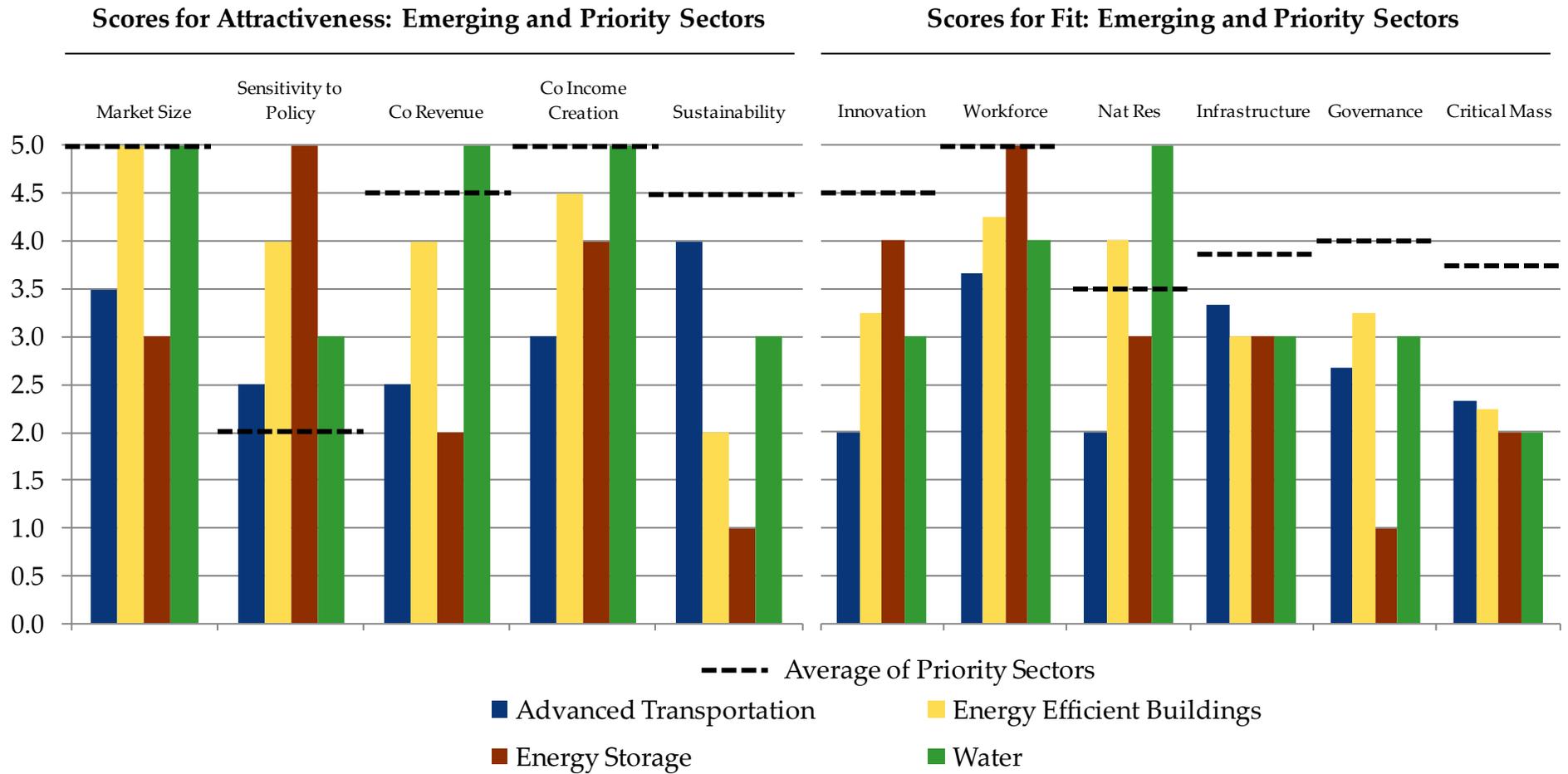
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Action C5: Connect with Other States on Renewable Fuels and Chemicals			
Description	Develop a collaboration plan with other states pursuing renewable fuels. Leverage unique strengths and competitive advantages of participating states to promote every element of the fuel and chemical production value chain (feedstock growth and logistics, conversion, distribution, end use).		
Key Steps	<ul style="list-style-type: none"> » Create bio-derived working group comprised of industry, academic, and government stakeholders in Colorado to inform state position regarding interstate partnerships. » Connect with energy agencies from states with complementary value chain strengths. Leverage existing participation in the two major biofuel/specialty chemical consortia (National Alliance for Advanced Biofuels and Bioproducts [NAABB] and NABC). » Identify areas of mutual interest and unique competitive advantage and develop a plan that incorporates both. Secure funding as needed. 		
Proposed Lead	GEO	Funding Required	<\$100k per state initially Further funds for implementation
Metrics to Evaluate Success	<ul style="list-style-type: none"> » # of states that sign a memorandum of understanding (MOU) and commit funds to implementation. » \$ of funding secured to implement the plan after 1, 3, 5 years. 		
Examples	<ul style="list-style-type: none"> » Western Governors Association » New England Clean Energy Council 		

Advancing Colorado's Emerging Sectors

As discussed in Section 2, the results of the priority sector selection revealed a second tier of sectors that currently play or are positioned to play an important role in the growth of Colorado's cleantech industry. These four sectors are advanced transportation, energy-efficient buildings, energy storage, and water. The scoring conducted as part of the priority sector selection revealed these sectors to be somewhat less favorably positioned in the next three to five years relative to the priority sectors. Figure 5 presents the results of the scoring, identifying the scores for each of the four emerging sectors relative to the average score for the four priority sectors. Although some emerging sectors scored better in certain areas than the "average" priority sector did, the overall scores for the priority sectors were somewhat stronger than the emerging sectors.

Figure 5. Attractiveness & Fit Scores for Emerging Sectors Relative to Average Leading Sector Scores



Source: Navigant analysis, 2010.

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In parallel to the Navigant-led assessment of the priority sectors, CCIA led a preliminary investigation into the barriers and opportunities facing the four emerging sectors. A brief summary of the findings for these sectors is provided in the remainder of this section.

Emerging Sector: Advanced Transportation

Colorado's clean and advanced transportation technology market emerged in the early 1990s with the implementation of low-emission vehicle purchasing policies and other incentives. As natural gas vehicles (NGVs) and biofuels such as ethanol became more prevalent, Colorado's fueling infrastructure for clean-fuel vehicles was considered a national model. Concurrent advanced transportation investments were made by the Regional Transportation District (RTD) and the Denver International Airport (e.g., natural gas hybrid electric buses). The policies supporting this market have changed over the years but continue to play an important role. From an innovation perspective, CSU operates the Engines & Energy Conversion Laboratory, and NREL has built a diverse advanced vehicle technology research and deployment group. With long-time sector pioneers such as Longmont's UQM Technologies, Fort Collins' Woodward Governor, and Arvada's Proterra, the industry cluster has grown to include innovative green vehicle services (e.g., Green Garage), vehicle efficiency technologies (e.g., Vandyne and Lightning Hybrids), vehicle-to-grid components (Eetrex), and entire vehicle platforms (e.g., Boulder Electric Vehicle).

Transitioning Colorado's advanced vehicle sector into a center of excellence will require stronger links between industry and the research community and additional policy support. By forming an advanced transportation research center, the Collaboratory could facilitate more cooperative access for local industry to research center staff, facilities, and equipment while engaging global automotive technology companies in co-funded R&D. State government and leading utilities should consider new financial incentives, an integrated transportation plan (including RTD), and the removal of other barriers to electric vehicles and high-occupancy transit (e.g., complicated permitting for at-home car charging). Such changes would allow deployment on a scale that would reduce the state's carbon and criteria pollutant footprint while building new markets for local companies.

Emerging Sector: Energy-Efficient Buildings

Colorado's energy efficiency sector is one of the nation's strongest and most developed, with key thought leaders, strong local investment in weatherization and retrofitting, green building and architectural expertise, and a handful of technology product companies. Similar to other technology areas, Colorado's research institutions represent a key asset, with particular leadership provided by NREL's Building Research program and CU's Architectural Lighting and Building Systems Programs. The state's robust building efficiency industry comprises a diversity of engineering, construction, analytical, and product manufacturing companies, including global leaders such as CH2M Hill and Merrick, alongside smaller start-ups such as Ravenbrick, Terralux, Albeo Technologies, and Sunflower Daylighting.

The energy efficiency sector would benefit most directly from an increased policy and regulatory focus at the state level. This could include the creation of a power purchase agreement (PPA) for efficiency, an energy efficiency rebate similar to renewable energy, an incentive for utilities to decouple, implementation of a feed-in tariff, creation of appliance efficiency standards similar to California's, and residential and industrial building code standards that increase energy efficiency. Additionally, the energy-efficient building sector's growth is inhibited by a lack of affordable, in-state contract manufacturers for product developers.

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Emerging Sector: Energy Storage

Energy storage technologies are essential to the long-term success of other cleantech sectors, including smart grid, advanced transportation, and renewable power generation. As in these other sectors, Colorado's energy storage expertise is rooted in strong research and higher-education institutions, including such dedicated programs as CSM's Colorado Fuel Cell Center and CU's Colorado Power Electronics Center. As part of its electrical and gaseous fuels energy storage research programs, NREL also conducts field demonstrations that couple intermittent renewable power generation with fuel cell energy storage in partnership with Xcel Energy. These research programs have contributed both to the founding of start-ups (e.g., Prieto Batteries at CSU) and the growth of other local companies into national and international leaders (e.g., CoorsTek, Ice Energy, Versa Power, and Nilar), creating an emergent Colorado energy storage cluster. Although these companies benefit from the state's large technical workforce, they are struggling to attract top executive talent to Colorado. Similarly, stakeholders suggest that limited Colorado-focused venture capital resources result in emerging energy storage companies having to relocate to coastal markets rather than maintaining operations in Colorado.

As with most cleantech sectors, energy storage innovation and commercialization benefits from strong ties between industry and the research community, even after intellectual property is licensed. Access to research facilities and computer modeling capabilities are vital to companies' development of new technologies; the Collaboratory and institutional technology transfer offices must continue to streamline these relationships and processes. Further, ensuring a constant flow of federal research funding to these institutions will facilitate continuity in the innovation process while supporting joint research programs with area companies. Finally, opportunities exist to build relationships with and leverage the skill sets of companies in other established Colorado industries (e.g., aerospace) that are already championed by the state's economic development programs.

Emerging Sector: Water

Colorado has a long history of leadership in the regulation, management, and protection of water resources. The state was instrumental in the development of water laws, and half of the world's water ministers graduated from Colorado schools. Due to the state's headwaters designation, its agriculture industry, and urban growth, Colorado provides other states with replicable models for water storage, efficient use, quality, and flow. This deep history has contributed to the more than 100 water technology and engineering firms located in Colorado, some homegrown (e.g., Stewart Environmental, Symbios Technologies) and others attracted from other states (e.g., CH2M Hill and MWH Global). Additionally, the state's robust oil and gas production industries and environmentally-progressive beverage companies (e.g., New Belgium and Coors) have recognized the need to innovate around water treatment, mitigation, and re-use. Colorado's universities are recognized as worldwide leaders in water technology and engineering development, including CSM's process engineering program and CSU's Colorado Water Institute. One of the growing topics among the sector's academic and professional community is the convergence of the energy-water nexus, characterized by the large amounts of water used in biofuels production or the possibility of using wastewater as an energy source.

The barriers to expanding Colorado's water technology sector primarily lie in the regulatory arena, and therefore necessitate actions of a political nature. For example, Colorado regulation limits the Colorado Department of Public Health and Environment's ability to invest in innovation. Furthermore, the state has limited funds for public education around water usage and dated regulations restricting the implementation of water re-use and other efficiency measures.

Section 5. Supporting Colorado's Cleantech Industry

This section addresses the actions needed to support the growth of Colorado's cleantech industry as a whole. Although they are not part of the critical path, as are the foundational actions from Section 3 and the priority actions for each of the priority sectors in Section 4, they are still important to the further development of the state's cleantech industry. Without them, key aspects of the industry's success such as workforce development and technology commercialization could fall behind. Using an example from gothic architecture, the supporting actions described in this section serve as the "buttresses" of Colorado's cleantech industry, sustaining ever upward growth.

The discussion of these buttresses of Colorado's cleantech industry builds on the previous two sections:

- » Section 3 identified the foundations of Colorado's cleantech industry. With additional capital and leadership, Colorado's strength in innovation will continue to grow and drive development in the manufacturing and deployment segments of the cleantech industry. This section identified four specific actions for increasing the amount of capital and cleantech leadership in the state that will help grow the cleantech industry as a whole.
- » Section 4 discussed the strengths of each of the priority sectors (wind, solar, smart grid, and bio-derived) as well as the challenges facing each sector. Section 4 discussed the high-priority actions needed to build on the strengths and overcome the challenges of each sector.

The project team identified five actions needed to support Colorado's cleantech industry as a whole:

Key Actions: Supporting Colorado's Cleantech Industry

- C1. Enhance Cleantech Commercialization within Universities and Federal Labs**
- C3. Collaborate with Colorado's Natural Gas Industry**
- D3. Develop State Energy Plan**
- F1. Align Retraining Priorities with Industry Needs**
- F3. Transfer Knowledge to the Next Generation of the Cleantech Workforce**

The rest of this section briefly describes these supporting actions and the drivers behind them. Further detail is provided in Appendix H.

Action C1: Enhance Cleantech Commercialization Within Universities and Federal Labs

If Colorado is to sustain its competitive advantage in cleantech innovation, it must reinforce technology commercialization efforts within universities and federal labs. Universities' and laboratories' missions are typically focused on research and teaching. As a result, insufficient resources are allocated to commercialization. Less than 1 percent of federal research funding, which is the source of 85 percent of Colorado universities' funding, supports technology commercialization. As building relationships with local industry is not a priority for most researchers, it is difficult for industry to access the knowledge within the research institutions. Although NREL and the universities have begun efforts to improve the commercialization process (including the NREL Commercialization Assistance Program, Technology Commercialization Portal, CU's Proof of Concept and Market Assessment Programs, and CSU's seed funding), the new programs do not have sustainable funding and are inadequately funded at present.

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Action C1: Enhance Cleantech Commercialization Within Universities and Federal Labs	
Description	Continue to strengthen research institution technology transfer capacity and collaboration with transparent, business and investigator friendly service and well-funded operations.
Key Steps	<ul style="list-style-type: none"> » Broad-based support for continued investments in university technology transfer (TT) operations. » Within each institution build mechanisms that will induce broader faculty TT involvement » Within each institution support approaches that integrate the cleantech business community into IP assessment, creation of technology roadmaps, market viability analyses, and faculty/industry collaboration.

Action C3: Collaborate with Colorado’s Natural Gas Industry

As mentioned in Section 3, Colorado’s conventional energy sector is the largest consumer of energy in Colorado. A variety of cleantech applications may enable more efficient use of energy or further use of abundant renewable energy resources (e.g., solar PV for well pads). The state’s research universities, led by Colorado School of Mines, have been instrumental in the conventional energy industry’s growth, and programs like CSU’s Engines and Energy Conversion Center continue to foster new innovations in areas such as engine efficiency. A deliberate plan for collaboration between the CCIA and COGA will likely identify attractive opportunities for both the state’s cleantech and conventional energy sectors.

Action C3: Collaborate with Colorado’s Natural Gas Industry	
Description	Identify areas of common interest. Establish a joint committee to develop strategies to pursue potential business opportunities. Leverage working groups/committees that already exist where possible.
Key Steps	<ul style="list-style-type: none"> » Establish a joint CCIA-COGA committee to explore areas of common interest and business opportunity for cleantech and natural gas. » The following are three areas of potential exploration: 1) Natural gas industry as an end market for cleantech, 2) Cleantech used in the natural gas industry, and 3) Natural gas as an enabler of cleantech.

Action D3: Develop State Energy Plan

Clean energy technologies do not exist in a vacuum but rather as part of the broader energy landscape. The majority of Colorado’s energy is still derived from non-renewable sources such as coal, natural gas, and oil and will continue to be for many years to come.⁸⁰ As the percentage of the state’s energy derived from clean technologies increases, however, addressing the state’s energy priorities in a more integrated manner will become more important. Most of the energy-focused plans developed in the state, such as the REDI report, the Colorado Climate Action Plan, and Xcel’s Colorado Resource Plan, address specific aspects of energy. An integrated statewide energy plan will enable more informed decision making by state government and the business community.

⁸⁰ Navigant. 2010. *2010 Colorado Utilities Report*. Governor’s Energy Office.

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Action D3: Develop State Energy Plan	
Description	Develop a vision for Colorado’s 20-year energy future that guides future policy, regulation, and funding. Be clear about goals, strategies, and priorities to facilitate decision making during the planning period. Provide certainty for investors about the future markets in Colorado. Update the plan periodically (e.g., every three to five years) to ensure that it reflects changes in the market.
Key Steps	<ul style="list-style-type: none"> » Establish legal grounding for the plan. » Assemble a task force to develop the plan. » Develop the plan. » Update the plan every 3–5 years.

Action F1: Align Retraining Priorities with Industry Needs

The demand for energy expertise is outpacing supply among Colorado’s highly ranked engineering and technical staff. Post-secondary schools evolve programs too slowly to meet the training needs of industry; curriculum development is starting to occur (e.g., RASEI), but specialized training programs are even slower to develop. Industry has identified specific needs in power engineering, electromagnetic engineering, and technology-specific skills (e.g., operations and maintenance [O&M] for smart grids). A few programs already exist to train workers for the energy industry, but they do not operate at a scale that will meet the needs of the industry. Colorado’s cleantech industry must work with organizations such as the Colorado Workforce Development Council and local community colleges to gain alignment on cleantech training needs.

Action F1: Align Retraining Priorities with Industry Needs	
Description	Facilitate retraining, in cleantech careers, for existing technical workforce in state in a way that is aligned with industry needs.
Key Steps	<ul style="list-style-type: none"> » Engage cleantech industry in the assessment of anticipated workforce needs, recognizing that industry timelines do not align with workforce development timelines. » Address unmet industry needs identified in Step 1 by increasing the throughput/capacity of existing training programs or by developing new training programs, as appropriate. » Increase emphasis on placement to ensure that retrained workers actually obtain cleantech jobs. » Establish statewide forum for periodically assessing alignment of training/re-training efforts with near-term and longer-term industry needs.

Action F3: Transfer Knowledge to the Next Generation of the Cleantech Workforce

This action addresses the group of workers on the cusp of entering the workforce, the group between those affected by university curriculum changes (F2) and those affected by retraining (F1). This action leverages the expertise of current and retired energy workers and facilitates the transfer of their knowledge to the next generation of the cleantech workforce. The risk of losing a generation’s worth of knowledge held by today’s aging energy workforce is mitigated by this approach while enabling the next generation of workers to benefit from the experience of their predecessors.

Students attending Colorado primary and secondary schools are in real need of the type of mentorship and guidance provided through the proposed programs. Declines in student performance and investment have been visible. As of 2009, Colorado ranked ninth lowest in the nation for spending on K-

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12 education as a share of personal income.⁸¹ In addition, reading proficiency of eighth graders in Colorado now ranks in the lower half of the 50 states (26th), dropping more than 10 spots since 2003.⁸² The state’s public high school graduation rate ranks 29th in the country.⁸³ The types of programs proposed in this action can be deployed for university-level students as well as high school students.

Action F3: Transfer Knowledge to the Next Generation of the Cleantech Workforce	
Description	1) Create formal, continuous, cleantech internship programs in the state (with co-funding); focus on universities and community colleges. 2) Leverage volunteers/retirees with expertise in clean energy to mentor new entrants into the industry, largely undergrads and graduate students.
Key Steps	<ul style="list-style-type: none"> » Internships: 1) Secure supplemental funds (\$2-3/hour) from the state to encourage sourcing of interns from in-state universities and community colleges, 2) Connect cleantech companies with Colorado operations with career centers. » Volunteer/Retiree Mentorship Program: 1) Assess whether existing mentoring programs (e.g., SCORE, Cleantech Open, Incubators) can meet the needs of Colorado’s cleantech entrepreneurs, 2) If existing programs are insufficient, in terms of cleantech expertise or in terms of Colorado business context, consider expanding existing programs or creating a new mentorship program.

⁸¹ Development Research Partners. 2010. *Toward a More Competitive Colorado, Sixth Edition*. Metro Denver Economic Development Corporation.

⁸² Development Research Partners. 2010. *Toward a More Competitive Colorado, Sixth Edition*. Metro Denver Economic Development Corporation.

⁸³ Development Research Partners. 2010. *Toward a More Competitive Colorado, Sixth Edition*. Metro Denver Economic Development Corporation.

Section 6. Accelerating Cleantech Industry and Market Development

CCIA and the Steering Committee that directed the development of this plan will lead its implementation in the next three to five years with help from a diverse set of partners. CCIA's leadership will serve as an important driver behind policy initiatives, working groups, and outreach efforts. The Steering Committee's ties to a diverse set of companies, organizations, government agencies, and trade associations across industries will enable the connections that are critical to the success of this plan.

CCIA already has developed working groups for each of the priority sectors. The working groups include representatives of a wide variety of interests, including entrepreneurs, manufacturers, project developers, government agencies, and others. Drawing on their knowledge of the sectors, these groups have helped shape the plan to date and will support the pursuit of the sector-specific actions. Participation in the working groups is open to all CCIA members. Additional working groups will be formed around specific action items as they become top priorities; CCIA will coordinate the formation and facilitate the work.

CCIA will conduct reviews of the progress made towards the goals outlined in this action plan and adjust the plan as necessary. At the end of years 2, 4, and 5, CCIA will document the steps taken to achieve the goals in this action plan and assess the improvement made, using the metrics outlined in this plan and detailed in Appendix H. As appropriate, CCIA and its partners will re-prioritize the actions needed during these review cycles to ensure that the state responds to changes in the market and in the industry. CCIA plans to commission an updated plan in four to five years.

As CCIA and its partners implement the plan, they will continue to strengthen the reinforcing relationship between the industry and the market for cleantech products. A strong policy that promotes cleantech and enables investment in this industry will fortify the market for cleantech in Colorado, both in the priority sectors and across the other cleantech sectors. Project developers will seek to create profitable investments in the state and in the region to capitalize on the market opportunities. Manufacturers and service providers that support the project developers and end users will continue to grow their presence in the state. Colorado's innovation base will become stronger as a result of the closer connection with the manufacturers and service providers that ultimately deploy their technologies.

Colorado's cleantech industry is starting from a position of strength, but it will need to be diligent about protecting and advancing its leadership position. Other states have recognized the opportunity held by the cleantech industry, and they are investing internally to shift their economies to serve the growing market for cleantech. This plan outlines the areas in which the investment of stakeholder time, funding, and expertise can have the most significant impact on the state's ability to sustain a leadership position in the cleantech industry that will drive the state's economic growth in the coming decades.

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