Colorado State University

February 28, 2012

The Honorable Larry Liston, Chair
The Honorable Spencer Swalm, Vice-Chair
The Honorable Lois Tochtrop, Chair
The Honorable Irene Aguilar, Vice-Chair
Colorado State Capitol
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Denver, CO 80203

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Re: Annual Report from the Colorado Renewable Energy Authority

To the Honorable Chairs and Members of the House Economic and Business Development Committee and the Senate Business, Labor and Technology Committee:

On behalf of the Board of Directors of the Colorado Renewable Energy Authority, I hereby provide this report to you regarding the activities of the Authority over the past year, in accordance with Section 24-47.5-102(3), Colorado Revised Statutes. The principal statutory purpose of the Authority is to direct the allocation of State matching funds to support one or more research proposals of the Colorado Renewable Energy Collaboratory, a research consortium consisting of the Colorado School of Mines, Colorado State University, the University of Colorado at Boulder and the National Renewable Energy Laboratory.

Pursuant to Section 24-47.5-103(1), this 2012 report is of special significance. H.B. 06-1322, 24-47.5-101 et seq., appropriated $2 million per year for three fiscal years, ending in June, 2009. These State matching funds were directed to by the General Assembly to the Authority for allocation to the Collaboratory to attract and support funding from federal and other public and private sources. Under Section 24-47.5-103, the Authority has until June, 2012 to demonstrate that at least $6 million in federal grants or contracts for renewable energy research in Colorado have been secured through the Collaboratory programs.

On behalf of the Directors of the Authority and my colleagues at NREL, Mines, CSU and CU-Boulder, I am pleased to report that the Authority and the Collaboratory have far exceeded the $6 million threshold of Section 24-47.5-103.

A Record of Successful Investment of State Funding

To date, the General Assembly's commitment of $6 million for the benefit of the Collaboratory has attracted federal funding in excess of $22 million, and industry funding in excess of $9 million. In addition, a second generation of research is already being funded by federal and industry sources, following up on fruitful areas of research identified in the first generation of Collaboratory research. However, the second generation of research generally receives no additional matching funds.

The Authority Board therefore reports that the $6 million Benchmark of Section 24-47.5-103 has been greatly exceeded.

- **As of the date of this report, the Collaboratory centers' private members have contributed more than $4.17 million to support the centers' shared (non-exclusive) research.**
- **Private industry has funded or committed to fund more than $5.27 million in sponsored research by the Collaboratory centers and individual Collaboratory institutions.**
- **The federal government has funded or committed to fund more than $22 million in sponsored research by the Collaboratory institutions.**
- **To attract these private and federal funding commitments of more than $31 million, the Collaboratory has expended or committed $5.94 million in State matching funds.**
- **The second generation of federally and industry funded research, following up on first generation Collaboratory research findings, has attracted more than $6 million, with no additional matching fund commitments, bringing the total return on the original appropriation to more than $37 million.**
- **The Collaboratory has generated more than six dollars in private and federal funding for every one dollar of State matching funds.**
- **In addition, the Collaboratory has helped to attract large and small employers to Colorado and has helped to create home-grown businesses with strong roots in Colorado and growing employment rolls, all of which contributes to the state's economy and tax receipts.**

The foresight of the General Assembly and Governor Owens in 2006 was critical in helping to establish Colorado as a clean energy research leader. The General Assembly's commitment of State of Colorado funds for the use of the Collaboratory has been a significant factor in attracting private support for the Collaboratory's centers and in allowing the Collaboratory to successfully compete for federal research funding.

Doing More With Less

The original $6 million appropriation has now been expended, with very successful results, as documented above. Recognizing that the State's own budget has been stretched to the limit for the past several years, the Collaboratory has worked to continue this record of success without seeking a new appropriation. When the recession of 2008 hit, many energy companies reduced their research budgets, and Collaboratory centers lost industry members. In response, the Collaboratory leadership restructured the model for matching funds, preparing for a long, slow evolution of the Collaboratory, instead of the early, explosive growth. The initial $6 million appropriation, expected to last three years, was stretched out to last nearly five.

A new source of funding, separate from the State budget, was provided in 2010, when Governor Ritter created an opportunity for the Collaboratory to earn $2 million in federal State Fiscal Stabilization Funds. Based on the Collaboratory's successful partnerships with private industry, the Collaboratory met the terms of this grant, and these new funds were transferred to the Authority, for the benefit of the Collaboratory, in 2011.

To make sure to get the most from these funds, the Authority and Collaboratory leadership is gradually reducing the level of financial support to the research centers. In the early years of each center, the Collaboratory provided matching funds in an amount equal to industry funding to support shared research activities. In 2011, the Collaboratory leadership reduced matching funds to one-half of industry funding for the two older, better established Collaboratory centers.

The Collaboratory will continue to search for alternative sources of funding and for cost-saving practices to stretch the funds received in 2011. But the Authority and Collaboratory leaders know that matching funds are essential to attract federal and industry funding. Most federally funded energy research grants require some level of matching funds as a precondition for application, and industry partners view state matching funds both as an indicator of state commitment and as a way to stretch their own research investments.

So, despite our best efforts to find alternative sources of funding and to make every matching dollar count, at some point, the Authority and Collaboratory leaders may need to seek another round of state funding.

Helping to Build Colorado's Economy

H.B. 06-1322 recognized that the development and production of renewable energy will advance the economic well-being of Colorado. Since the Collaboratory's launch in January, 2007, we have seen a substantial expansion in Colorado's renewable energy research, development, production and manufacturing capabilities. The Collaboratory, as the most visible symbol of Colorado's renewable energy research capabilities, has played a key role in attracting and supporting homegrown and relocated renewable energy companies. These employers already represent thousands of jobs. We are grateful that the Collaboratory's role in bringing businesses and jobs to Colorado has been acknowledged by State officials, by the Metro Denver Economic Development Corporation and other Colorado economic development agencies and by private employers, such as ConocoPhillips.

The Collaboratory attracts employers to Colorado by building an educational and research cluster that serves industry. By educating undergraduate and graduate students in science, engineering, business and other disciplines, the Collaboratory ensures that renewable energy businesses and their suppliers can find the talent that will help them succeed. And the close partnership between NREL and the universities has also helped to attract world class researchers through joint appointments and other cooperative relationships. Without such close cooperation among the Colorado institutions, many of these nationally recognized researchers would have been hired by our competitors in other states. Renewable energy companies locate where the R&D community can support their needs, and Colorado's R&D community is recognized world-wide.

In the following paragraphs, I summarize the Collaboratory centers that have received State matching funds through the Authority, including a brief overview of each center's research focus and the amount of State, private and federal funds committed. In reviewing the success of these centers, it is worth remembering that each center is managed by a leadership team that includes

representatives from all four of the Collaboratory institutions, with one institution serving as the lead. In short, these centers – and their great success to date – exemplify true collaboration.

Colorado Center for Biorefining and Biofuels

The Colorado Center for Biorefining and Biofuels, known as C2B2, was the first research center launched by the Collaboratory. C2B2 conducts world class research to develop new biofuels and biorefining technologies with the goal of transferring these advances as rapidly as possible to the private sector. C2B2 also trains new researchers for the renewable energy industry in Colorado, and sponsors have the opportunity to recruit future employees. C2B2 offers important value to the State and to the sponsors by providing educational and work opportunities for undergraduate, graduate and post-doctoral students. The University of Colorado - Boulder is the lead institution for C2B2, but all four Collaboratory institutions play prominent roles in the activities of the Center.

C2B2 has lost a significant number of its corporate members due to the severe recession, including both large and small companies. C2B2 membership declined from 27 industry members in 2008 to 14 in 2011, but now numbers 11 with the recent addition of Total American Services. Although smaller in number, C2B2's sponsors still include leaders from the oil and gas, chemical, automotive and manufacturing sectors, ranging in size from Fortune 500 companies to small Colorado renewable energy companies.

The sponsors' funding and State matching funds have supported 66 research seed grant, postdoctoral and graduate fellowship research projects from 2008 through 2011. In addition, C2B2 has supported a summer "Research Experience for Undergraduates" program, helping to develop the scientists and engineers of the next generation, with support from State matching funds. Chevron contributed $275,000 to fund C2B2's educational programming and research specifically through graduate student fellowships. Each year, industry member representatives and Collaboratory research representatives meet to review and discuss graduate and post-graduate research projects, providing an excellent recruiting opportunity for graduate students, post-doc researchers and employers. C2B2 also presents professional "short course" seminars on topics related to biorefining and biofuel production, attracting representatives from member and non-member companies.

ConocoPhillips, a founding member of C2B2, has entered into a sponsored research agreement through C2B2 for $5 million in renewable fuels research. GEVO, an early stage but internationally recognized biofuels company, moved its headquarters, research operations and 50 employees to Colorado from California, to be closer to our research community and to C2B2, in particular. A number of biofuels companies have been spun out of the universities, including Genesis Biofuel, OPX Biotechnologies (recipient of the Governor's Excellence in Renewable Energy Award for 2010), Solix Biofuels and Sundrop Fuels, each of which is based in Colorado and employing Colorado residents.

The Authority provided a total of $2.06 million in State matching funds to C2B2 in 2007 through 2011. With this State support, C2B2 has attracted $2.3 million in sponsors' commitments for shared research programs through 2011, and the National Science Foundation awarded $336,000 to support C2B2's Research Experiences for Undergraduates program. ConocoPhillips has funded more than $2.4 million in sponsored research to date, with a commitment for additional funding over the next two years that will bring ConocoPhillips' sponsored research to a total of more than $5 million. In addition, the four Collaboratory institutions have generated additional research funding from private and federal sources as a result of C2B2 relationships.

In addition to these C2B2 programs, the Authority has also supported Collaboratory institutions in pursuing federal funding for biofuels research programs. In 2010, the Authority committed $1.275M in matching funds to support successful proposals from research teams including NREL and the Colorado School of Mines, bringing more than $12.5 million to these two C2B2 institutions. In 2011, the Collaboratory committed $240,000 in matching funds to support a successful biofuels proposal that will bring $1.5 million to NREL and CSU.

In total, then, matching funds of $3.57 million have attracted more than $23 million in federal and private funding for biofuels research and education in Colorado. And this does not include the substantial economic benefit to Colorado from biofuels companies who have spun out of or who have moved here to work with our powerful research community.

And there is one more important measure of C2B2's success. C2B2 researchers have filed five patents developed through shared and sponsored research, and C2B2 researchers have published more than 13 journal articles and provided over 70 technical presentations at professional scientific conferences. The creation of valuable intellectual property and peer reviewed, published literature confirms the merit of the Collaboratory public/private model and the success of C2B2.

Despite this success, though, C2B2 faces significant challenges. In a weak economy, with no additional appropriations of State funds likely in 2012, C2B2 is competing directly with large private and federally funded cooperatives with vastly larger financial resources. As private sector budgets for education and research university collaboration are downsized, C2B2 sponsors have increasingly expressed the importance of Authority matching funds as a method by which they can justify center membership internally and continue to allocate funds to C2B2. The relatively small "matching" investments made by the Authority in these centers have a dramatic impact on sponsor retention, research and development, and technology transfer into business creation.

Finally, while biofuels and biorefining research (and related employment opportunities) are of greater and greater interest to undergraduate and graduate students and postdoctoral researchers, C2B2 is unable to meet the educational and training needs of all of the interested personnel and students at CU, CSU, Mines and NREL. The more scientists and engineers we

are able to train and graduate, the more successful we will be in building an advanced biofuels industry in Colorado, an industry that can create jobs and tax revenues for our state.

Center for Revolutionary Solar Photoconversion

The Collaboratory's Center for Revolutionary Solar Photoconversion, or CRSP, conducts research with the objective of developing technologies that can produce clean solar fuels and electricity at costs comparable to traditional fuels and electrical power. This objective is composed of two tasks: increasing the efficiency of solar technologies by increasing the portion of solar energy converted to electrical or chemical energy, and reducing the cost of direct solar technologies. The work employs modern disciplines including nanoscale science, photobiology, photoelectrochemistry, photophysics, and inorganic and organic photovoltaics. NREL is the lead administrative institution for CRSP, but, again, all four Collaboratory institutions participate in CRSP's research programs and are equally represented in its management structure.

CRSP presently includes five corporate members, with major domestic and international companies. Since 2008, CRSP has received approximately $1.45 million from its member companies. CRSP has also received more than $3 Million in federal research funding, part of a larger DOE commitment described below. To date, CRSP has earned $1.27 million in matching funds from the Authority.

CRSP's federal research funding was earned through the Center's participation in a multi-institutional team, including NREL and Los Alamos National Laboratory, which was selected by the U.S. Department of Energy for funding as a prestigious Energy Frontier Research Center in advanced photophysics. With the benefit of a commitment of $300,000 in State matching funds, CRSP participating research institutions (including CU-Boulder, CSM, and NREL) will receive a total of $6.6 million over five years from the US DOE.

CRSP also works closely with the National Science Foundation's first – and only – Renewable Energy Materials Research Science and Engineering Center (REMRSEC), housed at the Colorado School of Mines. The REMRSEC is also tightly connected with NREL. The close collaboration between these two research centers and the four institutions magnifies the capabilities of all of these Colorado organizations.

In 2010, CRSP signed its first privately sponsored research project, with Konarka, a thin-film solar manufacturer based in Massachusetts, funding research at CSU. Shortly, a second privately sponsored research project at CSM and NREL will be funded by Total, the French multinational oil and gas – and solar – company.

2011 also marked another milestone for CRSP with the initial steps for filing three patents developed through CRSP sponsored research, a very significant achievement for CRSP and a sign of CRSP's coming of age. After three full cycles of shared research projects, valuable intellectual property is being developed, defined and protected. This momentum will continue to accelerate in the coming years.

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Center for Research & Education in Wind

The third Collaboratory center, the Center for Research & Education in Wind, was publicly launched in August, 2009. CREW is the first Collaboratory center to include additional research institutions beyond the four Collaboratory member institutions. Recognizing the wind industry's interest in atmospheric sciences, CREW invited two of the world's leading atmospheric science research institutions to participate: the National Center for Atmospheric Research and the National Oceanic and Atmospheric Administration, both of which operate laboratories in Colorado. The University of Colorado-Boulder is the lead institution for CREW. CREW's research areas include modeling, design and testing of wind turbines; localized wind forecasting and other atmospheric sciences; design and operational guidance for wind farms; and electrical control systems for wind turbines.

CREW's founding members include some of the world's largest manufacturers and developers of wind power technology and generating facilities: Mitsubishi, RES Americas and Vestas. WindLogics, a leader in consulting services for wind farm developers and operators, is the fourth founding member of CREW. CREW's newest member, NRG Systems, is a global leader in manufacturing wind energy assessment equipment, such as sensors, loggers and towers.

In CREW's first two operating years, from July 2009 to July 2011, CREW's corporate members contributed a total of $390k in membership fees, matched with State funds, to support shared research activities. A total of 24 proposals (14 proposals in 2009 and 10 in 2010) were submitted by faculty and scientists from the CREW institutions. CREW was able to fund 3 of these seed grant proposals in the first year and 4 in the second year. In 2011, CREW received 10 proposals that are currently being reviewed by CREW's industry partners. Topics of research cover a wide range of wind research topics, including: innovative approach to the design and control of wind farms; modeling system and ensemble data assimilation for wind energy predictions; active coating materials for preventing icing on wind blades; and mitigation devices for generated aero-acoustic noise.

Vestas has funded more than $400k of sponsored research with CREW since 2010, and has plans for additional sponsored research through 2013.

These have been challenging years in which to launch a new research center, but CREW has achieved a great deal, and numerous companies in the wind industry see great potential in the center. To provide confidence to industry players that CREW will be a reliable research partner for the long run, CREW will continue to need the full support of the Collaboratory, the Authority and State leaders over the next few years. The wind industry has already contributed a great deal to Colorado, but the industry's best years are still ahead, and CREW will continue to serve as a magnet to attract wind power companies to our state.

Additional Collaboratory Research Centers

The Collaboratory is working to develop two additional research centers. The Carbon Management Center will launch in May, 2012, and the Energy Systems Center will launch in late 2012 or early 2013. In addition, the Collaboratory has a unique relationship with a privately developed solar energy test and demonstration center.

- **Carbon Management Center**: The Collaboratory is focused on renewable energy technologies, but the Carbon Management Center's research and policy analysis will also have direct application to the coal and natural gas industries. The CMC will conduct research on the science and technologies of carbon dioxide capture, commercial re-use of carbon, and carbon sequestration (both deep geologic sequestration and terrestrial sequestration through plants and soils) and will also offer independent and reliable policy analysis. This center will be led by the Colorado School of Mines.

In 2009, the Carbon Management Center received $342,744 in State matching funds to qualify for $1.37 million in federal funding to conduct basic research related to geologic sequestration of carbon dioxide.

- **Energy Systems Center**: The Energy Systems Center will be a smart grid and energy efficiency research center, focused on the research, design and demonstration of the electrical grid of the future, including the technologies to design, build and operate more efficient buildings. Led by Colorado State University, this center will work with private and public partners to develop the hardware, software, processes and demonstration projects to build a more efficient, reliable and secure grid that incorporates more clean and renewable energy. Because buildings use approximately 40% of our nation's total energy consumption, this center will also work to develop the products, technologies and processes for more efficient building design and operation, efficiencies which will contribute to a more reliable and cleaner grid. The Energy Systems Center will benefit from two world class hard-wired grid simulators: the InteGrid Lab, a CSU laboratory in operation since 2006, and the Energy Systems Integration Facility, an NREL laboratory and office structure now under construction. When ESIF is fully operational in early 2013, it will be the world's most powerful smart grid research, test and demonstration facility.

- **Solar Technology Acceleration Center**: SolarTAC is a privately owned and operated testing and demonstration facility, closely affiliated with the Collaboratory. SolarTAC, now in operation in Aurora, approximately five miles southeast of Denver International Airport, is already preparing to expand and will ultimately become one of the world's leading facilities to test and demonstrate solar technologies. The national prominence of SolarTAC is exemplified by its founding members and principal funders – Xcel Energy, Abengoa Solar and SunEdison – and by its additional members – Electrical Power Research Institute (the research arm of the nation's largest electric utilities) and the Alliance for Sustainable Energy (the manager of NREL). The U.S. Department of Energy is also investing in SolarTAC to create a testing and demonstration platform for solar thermal electric storage technologies. Although SolarTAC is not a Collaboratory center, the Collaboratory has been closed tied to SolarTAC since its inception and

will provide research capabilities to support the private and publicly funded activities at the facility.

Looking to the Future

The Colorado Renewable Energy Collaboratory has come of age in trying times. Launched in early 2007, the Collaboratory prospered for a short time before the economy crashed in late 2008. In the dismal economy of 2009 and early 2010, a number of private companies did not renew their membership in the Collaboratory's C2B2 and CRSP centers. At the same time, the limited matching funds available to the Collaboratory meant that the matching funds available to these two centers had to be reduced in order to preserve funding for the centers still in development. But C2B2 survived, leaner and still effective, winning NSF funding for an undergraduate research program, and moving ahead with the second stage of a $5M sponsored research project with ConocoPhillips, and CRSP has demonstrated its value, with patent filings in progress and a growing portfolio of sponsored research.

But, even as the economic slowdown restricted the flow of privately sponsored research, the Collaboratory showed its ability to successfully compete for federally funded research projects. To date, with the essential support of state matching funds, the Collaboratory has attracted more than $22 million in federal research funding to the four institutions.

The Collaboratory's success in attracting private partners and in competing for federal grants over the past four has been due, in significant part, to the availability of State matching funds. Although many other states have much larger pools of matching funds to employ in the competition for research grants and contracts, the Collaboratory's research assets are so strong that the Collaboratory has been able to successfully compete, even with lower levels of matching funds.

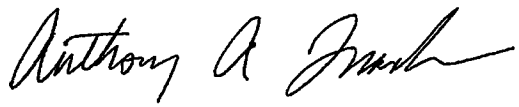
While the Authority Board and the Collaboratory leadership are keenly aware of the budget challenges facing the General Assembly, we respectfully remind the Chairs, Co-Chairs and Committee Members that clean energy manufacturing and the development of clean energy generating facilities represent one of the few sectors that has shown consistent growth in Colorado over the past two years. This sector will continue to play a large role in Colorado's economic recovery, helping to drive the creation of new companies and new jobs. The Collaboratory's reputation for research excellence has been and will continue to be a central factor in attracting and nurturing these companies.

Many states are now competing for leadership in renewable energy research, development and production. Those states that succeed in establishing leadership in this still emerging sector will attract major national and international companies, bringing research, manufacturing, construction, and administrative jobs for the next 25 years. Colorado should not draw back from its demonstrated leadership and commitment to this critical economic sector. If we are to protect and advance Colorado's stature as a leader in clean energy and the integration of renewable and

clean fossil energy sources, it will be essential for the General Assembly to renew and expand the matching funds appropriations for the Collaboratory as soon as the State's budget permits.

The Directors of the Colorado Renewable Energy Authority are grateful for the support of the Colorado General Assembly. We will be pleased to respond to any questions you may have at this time or in the future.

Sincerely,



Dr. Anthony A. Frank
President, Colorado State University
Chair, Colorado Renewable Energy Authority

COLORADO RENEWABLE ENERGY AUTHORITY
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COLORADO RENEWABLE ENERGY COLLABORATORY
Corporate Members – March, 2012

Colorado Center for Biorefining and Biofuels (C2B2) Member Companies:

- Chevron
- Cobalt Biofuels
- ConocoPhillips
- Ecopetrol
- Flad Architects
- Genencor
- General Motors
- Genesis Biofuel
- Gevo
- OPX Biotechnologies
- Rentech
- Shell Global Solutions
- Sundrop Fuels
- Valero

Center for Revolutionary Solar Photoconversion (CRSP) Member Companies:

- Abengoa Solar
- General Motors
- Sharp Corporation
- Tokyo Electron
- Total

Center for Research & Education in Wind (CREW) Member Companies:

- Mitsubishi Power Systems Americas, Inc.
- NRG Systems
- RES-Americas
- Vestas
- WindLogics, Inc.

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PRIVATE AND FEDERAL FUNDING FOR COLLABORATORY RESEARCH [1]
2007 - 2011

Shared Research [2]

- C2B2, CRSP and CREW industry members' contributions for the centers' shared research projects (matched by $3.7 in state funds) **$4.18 M**

Sponsored Research [3]

- Funding for sponsored research by Collaboratory center Industry members $5.27 M
- Federal funding for research by Collaboratory institutions or centers on projects receiving approximately $2.24 M in state matching funds $22.10 M
- Follow-on industry and federal funding to Colorado researchers for proposals based upon prior Collaboratory shared research (no matching funds provided) $6.18 M

SUB- TOTAL SPONSORED RESEARCH
$33.55 M

TOTAL SHARED AND SPONSORED RESEARCH FUNDING FROM PRIVATE AND FEDERAL SOURCES
$37.73 M

Notes:

1. The Collaboratory research centers include:
   - Colorado Center for Biofuels and Biorefining – C2B2
   - Center for Revolutionary Solar Photoconversion – CRSP
   - Center for Research and Education in Wind – CREW
   - Carbon Management Center – CMC (to begin operations in 2012)

2. Shared research is conducted through the Collaboratory research centers and is funded with a combination of industry membership fees and state matching funds. Topical areas for shared research proposals are identified by industry members, and proposals are then submitted by university and NREL researchers. Proposals are selected for funding by industry members and center leaders. If patents result from shared research projects, all industry members of the center are able to benefit from a paid up, non-exclusive license.

3. Sponsored research may be federally or industry funded and may be conducted by one or more Collaboratory institutions directly or under the umbrella of a Collaboratory research center. Federally funded sponsored research generally requires matching funds, provided by the Collaboratory and other

public and private partners. Industry sponsored research generally receives no matching fund support. If patents result from privately sponsored research, the private sponsor generally has the right to negotiate for an exclusive license, consistent with federal law.