Colorado State University

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The Honorable Larry Liston, Chair
The Honorable Spencer Swalm, Vice-Chair
Economic and Business Development Committee
Colorado House of Representatives
Colorado State Capitol
200 East Colfax
Denver, CO 80203

The Honorable Lois Tochtrop, Chair
The Honorable Irene Aguilar, Vice-Chair
Business, Labor and Technology Committee
Colorado Senate
Colorado State Capitol
200 East Colfax
Denver, CO 80203

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. As the new Chair of the Authority, this is my first such report to you. My predecessor as Authority Chair, M.W. Scoggins, President of the Colorado School of Mines, filed prior reports from 2007 through 2010.

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. Despite economically challenging times in 2010, I am happy to report that the Authority and the Collaboratory had a successful year, building strong relationships with private businesses, attracting millions of dollars in federal and industry funding to support renewable energy research in Colorado, and conducting educational activities for businesses and students.

In accordance with H.B. 06-1322, 24-47.5-101 et seq., State matching funds appropriated by the General Assembly to the Authority may be allocated to attract and support funding from federal and other public and private sources. The 2006 legislation appropriated $2 million per year for three fiscal years, ending in June 2009. The Authority has until June 2012 to demonstrate that at least $6 million in grants or contracts for renewable energy research in Colorado have been secured through the Collaboratory programs.

The Authority Board can report with confidence that the $6 million benchmark will be met and greatly exceeded.

- **As of the date of this report, the Collaboratory centers' private members have contributed more than $3.345 million to support the centers' shared (non-exclusive) research.**
- **Private industry has funded or committed to fund $5.27 million in sponsored research by the Collaboratory centers and individual Collaboratory institutions.**
- **The federal government has funded or committed to fund $20.545 million in sponsored research by Collaboratory institutions.**
- **To attract these private and federal funding commitments of more than $29 million, the Collaboratory has expended $5.063 million in State matching funds.**
- **The Collaboratory is generating nearly six dollars in private and federal funding for every one dollar of State matching funds.**
- **In addition, the Collaboratory has helped to attract major employers to Colorado.**

The foresight of the General Assembly and Governor Owens were critical in helping to establish Colorado as a clean energy research leader. It is clear to the leaders of the Authority and of the Collaboratory that 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.

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 hundreds of jobs, and their plans of near-term expansion will generate thousands of additional 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 following paragraphs 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 at Boulder is the lead institution for C2B2, but all four Collaboratory institutions play prominent roles in the activities of the Center.

C2B2 has lost half of its corporate members due to the severe recession, including both large and small companies. C2B2 membership has declined from 27 industry members in 2008, to 22 in 2010, and now to 13 in 2011. 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 a total of 41 research seed grant and postdoctoral fellowship research projects from 2008 through 2010. In addition, C2B2 has supported graduate fellowships and 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 has also supported C2B2's educational programming and research, contributing $275,000 to support 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 $1.77 million in State matching funds to C2B2 in 2007 through 2010. With this State support, C2B2 has attracted $2.1 million in sponsors'

commitments for shared research programs through 2010, and the National Science Foundation awarded $336,000 to support C2B2's Research Experiences for Undergraduates program. ConocoPhillips has funded more than $1.4 million in sponsored research to date, with a commitment for additional funding over the next two years. The four Collaboratory institutions have also generated additional research funding from private and federal sources as a result of C2B2 relationships. In sum, matching funds of $1.77 million have attracted more than $7 million in private and federal commitments.

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 $12.5M to these two C2B2 institutions.

In total, $3.05M in State matching funds have attracted commitments of more than $19.5M in federal and private funding for biofuels research and education in Colorado. This also 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.

Despite this success, C2B2 faces significant challenges. In a weak economy with no additional appropriations of State funds likely in 2011 or 2012, C2B2 is competing directly with large private and federally funded cooperatives with vastly larger financial resources. And 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 of these 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 all four Collaboratory institutions participate in CRSP's research programs and are equally represented in its management structure.

CRSP presently includes 14 corporate members, with major domestic and international companies as well as smaller startups, including several of the world's largest solar photovoltaic manufacturing companies, the world's two largest auto manufacturers, and companies from the aerospace, chemical, and manufacturing equipment industries.

Since 2008, CRSP has received approximately $1.14 million from its member companies. CRSP has also received $1.3 million in federal research funding, part of a larger DOE commitment described below. To date, CRSP has earned $1.4 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 Renewable Energy Materials Research Science and Engineering Center, housed at the Colorado School of Mines. The close collaboration between these two research centers expands the capabilities of both organizations.

In 2010, CRSP signed its first privately sponsored research project. Konarka, a thin-film solar manufacturer based in Massachusetts, is funding research at CSU.

Center for Research & Education in Wind

The third Collaboratory center, the Center for Research & Education in Wind (CREW), 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 Boulder, Colorado. The University of Colorado at 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. In 2010, CREW welcomed two additional small companies, NRG Systems and Catch The Wind. NRG

Systems is a global leader in manufacturing wind energy assessment equipment, such as sensors, loggers, and towers. Catch The Wind is a high-technology company and a leader in precision laser-sensing technology in particular.

In CREW's first operating year, 2009-2010, the four corporate members contributed a total of $120,000 in membership fees, matched with State funds, to support the first year of shared research activities. Fourteen proposals were submitted by faculty from the CREW institutions, five of which were selected as worthy of funding by CREW's industry partners, but CREW could afford to fund only three: aerodynamic behavior of multiple wind turbines, active coating materials for preventing icing on wind turbine blades, and mitigation devices for generated aero-acoustic noise. Vestas also funded more than $200,000 of sponsored research with CREW in 2010.

CREW is also active in training graduate student scientists and engineers in wind power disciplines. A team of highly regarded CREW researchers was invited to submit a full proposal for $3.2M of NSF funding for an Integrative Graduate Education and Research Traineeship, a highly respected and competitive NSF program. Each of the Collaboratory institutions and many industry partners made cash or in-kind commitments in support of this proposal, and the Collaboratory has committed $320,000 in matching funds. The results of this grant competition will be announced in spring 2011.

2009 and 2010 have been challenging years 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

In 2010, Collaboratory teams laid the foundation for two new Collaboratory centers to be launched in 2011. 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 Efficiency and Management Center**: The EEMC 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 percent 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.

- **Solar Technology Acceleration Center**: SolarTAC is a privately owned and operated testing and demonstration facility, closely affiliated with the Collaboratory. SolarTAC, now under construction in Aurora approximately five miles southeast of Denver International Airport, will 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.

Conclusion

2010 was a year of contrasts for the Colorado Renewable Energy Collaboratory. In the dismal economy of late 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, C2B2's three year commitment of matching funds from the Collaboratory expired, meaning that C2B2 suffered the double pain of losing both private and public funding. 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.

2010 also witnessed the Collaboratory's greatest success in competing for major federal research funding. With the help of a $1M State matching commitment, NREL and the Colorado School of Mines won a $9.4M U.S. Department of Energy grant to develop advanced biofuels that are compatible with today's transportation fuel infrastructure. A

separate commitment of $275,000 helped the same institutions bring another $3M to Colorado for research on algal biofuels. By the end of 2010, the Authority had distributed just over $5M to help the Collaboratory institutions bring in nearly $30M in federal and private industry research funding to Colorado.

The Collaboratory's success in attracting private partners and in competing for federal grants over the past four years 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 crisis 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 showing positive growth in Colorado over the past two years. This sector will continue to play a large role Colorado's economic recovery and 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. The 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
BOARD OF DIRECTORS

Anthony Frank, Ph.D., President
Colorado State University
(Chair)

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Governor's Energy Office

M.W. Scoggins, Ph.D., President
Colorado School of Mines

COLORADO RENEWABLE ENERGY COLLABORATORY
Corporate Members – March, 2011

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

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

Center for Revolutionary Solar Photoconversion (CRSP) Member Companies:

- Abengoa Solar
- Applied Materials, Inc.
- Ascent Solar Technologies, Inc.
- DuPont
- Evident Technologies, Inc.
- G24 Innovations, Limited
- General Motors
- Konarka Technologies, Inc.
- Lockheed Martin
- Motech Industries Inc.
- Sharp Corporation
- Tokyo Electron
- Total
- Toyota

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

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