Arnold Schwarzenegger
Governor

CALIFORNIA RENEWABLE ENERGY COLLABORATIVE (CREC): STRATEGIC PLANNING AND ORGANIZATIONAL STRUCTURE

PIER FINAL PROJECT REPORT

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DISCLAIMER

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PREFACE

The renewable energy collaboratives established by the California Energy Commission's Public Interest Energy Research Program are actively coordinating their PIER supported activities to more efficiently contribute to PIER and other state energy and environmental goals. This is being accomplished, in part, by placing each of the collaboratives (biomass, geothermal, solar, and wind) within a single administrative structure, the California Renewable Energy Collaborative (CREC). This report describes 1) strategic plans for the four collaboratives identifying research focus areas, organizational development goals, and related management initiatives, including plans for enhancing the collaborative support base, 2) an outline for a renewable energy systems integration effort to deal with cross-cutting issues, and 3) a proposed structure for coordination of the collaborative activities within a single administrative structure.

This report lays the foundation for further efforts that will consider how best to accelerate the contribution of renewable energy technologies to meet PIER efforts that support state-mandated renewable energy goals and greenhouse gas emission reductions. The Energy Commission has funded this work pursuant to the PIER Program Contract Number 500-99-13 between UCOP CIEE and the Energy Commission, Basic Ordering Agreement Work Authorization Number BOA-99-209-P. This project contributes to the Renewable Energy Program area.

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1. PURPOSE

Over the last two years the conceptual framework guiding California's investment in Renewable Energy has added an approach that emphasizes the need to deploy a suite of technological capabilities in different market venues, in addition to the emphasis on isolated R&D challenges within individual technology areas. Adjusting to this additional emphasis in focus requires that the renewable energy collaboratives undertake strategic planning that assures coordination of research, management and funding to most efficiently meet PIER and IEPR goals, especially as they relate to the three renewable energy deployment venues (RE secure communities (RESCO), RE secure buildings (RESB), and utility-scale renewables programs (USRE) including natural gas replacement by renewables, while simultaneously addressing the needs of supporting stakeholders. This document provides the strategic plans for the existing collaboratives that identify key research focus areas, discuss possible funding sources and mechanisms, and outlines potential cross-cutting deployments for which coordinated project management may be required. An administrative structure that would facilitate meeting these strategic goals is also outlined.

2. BACKGROUND

The California Energy Commission Office of Renewable Energy (RE) Research created collaboratives whose purpose is to provide venues for interaction between stakeholders in each renewable energy technology area (biomass, geothermal, solar, and wind) and Commission staff. The collaboratives are intended to enhance the ability of the state to meet goals of the Renewable Portfolio Standard (RPS), AB32, and other state policy instruments such as the Bioenergy Action Plan. The collaboratives accomplish this purpose by supporting Commission staff in identifying and prioritizing research and development needs in each technology area, identifying barriers to market penetration and supporting outreach efforts that would enhance technology development and deployment. The biomass, geothermal, and wind collaboratives have been in operation for five or more years. The solar collaborative is more recently established and began operations early in 2009.

The biomass, geothermal, and wind collaboratives have successfully engaged their respective technology communities, with each collaborative developing a membership of hundreds of stakeholders who have participated in a variety of activities, meetings and research efforts in support of Commission goals. The solar collaborative is also in the process of building stakeholder involvement. However, the development of a new conceptual framework for deploying RE technologies, specifically the RESCO (renewable energy secure communities), RESB (renewable energy secure buildings), and USRE (utility-scale renewable energy) programs place greater emphasis on coordination between the collaboratives, including the need to develop a means to address hybrid or combined technologies and cross-cutting system integration developments.

To meet this need, each collaborative has developed a strategic plan intended to accelerate development of renewable technologies within the RESCO, RESB and USRE initiatives. The strategic plans:

- Identify key research areas that must be addressed in order to satisfy the initiatives including natural gas replacement with renewables.
- Include a roadmap of activities to address the needs identified in each key research area.
- Outline plans for expanding the collaborative funding base.

The draft strategic plans for each RE collaborative are contained in this document. These plans were developed with the purpose of positioning the collaboratives to best respond and support the RESCO, RESB and USRE initiatives. These plans considered the unique needs of each technical area, within the context of supporting the mission of the California Energy Commission's PIER program.

Finally, this document presents a description of how best to coordinate the activities of the respective collaboratives, in order to expand and assure efficient use of research, development and deployment support.

3. CALIFORNIA BIOMASS COLLABORATIVE BIOENERGY DEVELOPMENT PLAN

Over the last several years, the California Biomass Collaborative has engaged in a multi-participant process to identify a series of policies and actions that could be taken or supported by the California Energy Commission and related state agencies and entities to support the sustainable development of biomass energy, in support of the state's policies to reduce greenhouse gases. This process included holding a number of public meetings and annual forums, including the last one May 12/13, 2009, to solicit comments and suggestions and exchange views among diverse, interested parties on the development of biomass energy. The CBC also drafted a Biomass Roadmap highlighting critical actions needed to achieve greater sustainable use of biomass for energy. This DRAFT Bioenergy Development Plan draws on all those sources and summarizes the key points and recommended actions.

3.1 Background

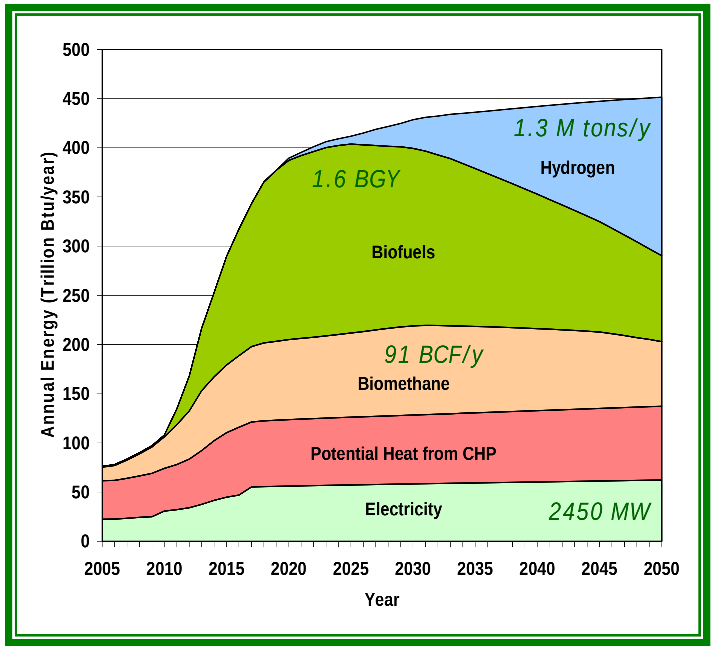
In April, 2006, Governor Schwarzenegger issued his Executive Order S-06-06 calling for California to greatly increase its share of biofuels production and the generation of electricity from biomass. The order stemmed from intensifying public concerns over escalating fuel costs and heavy reliance on petroleum, strong state agency advocacy and commitment for improving resource management and mitigating climate change, legislative actions promoting growth in renewable energy (AB 118: *The Alternative and Renewable Fuel and Technology Program*) and control of greenhouse gas emissions (AB 32: *The Global Warming Solutions Act*), pronouncements at the federal level (*Energy Independence and Security Act*; *The Food Conservation and Energy Act*) signaling greater support for bioenergy, and the promise of new technologies for stimulating economic development, improving environmental performance, and realizing the potential offered by biomass in meeting an increasing share of the state's energy demand. Liquid transportation fuels will be needed for a long time in the future, and biomass sources are the most likely alternatives to petroleum for this purpose.

The governor's executive order (S-06-06) proclaimed the benefits and potentials of bioenergy in helping to meet the future needs of the state for clean, renewable power, fuels, and hydrogen, and called for the state to meet the following targets for biofuel and biopower development:

- By 2010, producing 20 percent of its biofuels within California, increasing to 40 percent by 2020 and 75 percent by 2050, and
- By 2010, producing 20 percent of the renewable electricity generated from biomass resources within the State and maintaining this level through 2020.

The order also specified certain actions by the agencies of the state in attempting to achieve the targets, including coordination on the development of research and development plans. Some of these actions are specified in the state's Bioenergy Action Plan[1].

Fig. 3.1 -- Possible biomass-based energy scenario for California



The executive order was followed in July 2007 by the release of the state's bioenergy action plan which reaffirmed the targets for biofuels and biopower (Figure 3.1), and set out actions for the state agencies in meeting the targets. Among the actions assigned to the Energy Commission through the California Biomass Collaborative was the preparation of a **roadmap** or **bioenergy development plan** to guide future research, development, and demonstration activities. The Energy Commission was also to work with the Hydrogen Highway team to ensure the roadmap evaluated the potential for biofuels to provide clean, renewable sources of hydrogen. The roadmap effort was incorporated into a larger Collaborative strategic planning effort for biomass development.

The roadmap was prepared primarily by the executive board and staff of the California Biomass Collaborative with public input and builds on efforts at both the national and state levels to increase the use of biomass for energy and products.[2,3,4,5] It is intended to inform and guide policy makers, law makers, regulators, investors, researchers, and developers involved with biomass and energy issues in California, but should be of interest to anyone concerned about environmental impacts, sustainable resource management, our current use of fossil fuels, and our future energy strategies. This report summarizes the larger roadmap.

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[1] http://www.energy.ca.gov/2006publications/CEC-600-2006-010/CEC-600-2006-010.PDF.

[2] California Biomass Collaborative, 2005, "*Biomass in California: challenges, opportunities, and potentials for sustainable management and development*", CEC-500-2005-160, California Energy Commission, Sacramento, California.

[3] "*Recommendations for a bioenergy action plan*", 10 April 2006, Final consultant report prepared for the California Bioenergy Interagency Working Group, CEC-700-2006-003-F, California Energy Commission, Sacramento, California.

[4] US DOE. (2002), "*Roadmap for Biomass Technologies in the United States.*" http://www.biomass.govtools.us/pdfs/FinalBiomassRoadmap.pdf.

[5] Western Governors' Association, "*Biomass task force report, Clean and diversified energy initiative*", WGA, January, 2006.

3.2 Energy Potentials

California's energy appetite is huge—peak power demand in excess of 50,000 megawatts with annual electrical energy consumption of 300 billion kilowatt-hours, gasoline and diesel fuel demand approaching 20 billion gallons per year, and natural gas consumption of more than 2 trillion cubic feet per year. Potential contributions from current biomass resources are about five to ten percent of state demand in transportation with similar levels in the electricity and natural gas sectors. Improvements in energy use efficiencies would decrease fossil fuel use thereby increasing the biomass contribution from a fifth to a third of energy supply in selected sectors. Simultaneously, biomass could augment supplies of high-value chemicals, structural materials, and other renewable bio-based products with improved environmental and consumer health attributes. To do this, California will need a combination of supportive public policies, financial and other incentives, and streamlined and integrated inter-agency cooperation.

By 2020, the state could triple its biomass-to-electricity generating capacity and increase its production of biofuels a hundred-fold, both from resources now considered feasible to use as feedstock and through at least a modest increase in dedicated biomass crops. By 2050, if the state shifts to greater use of hydrogen in transportation and other energy sectors, biomass could supply a large amount of renewable hydrogen. Greater use of combined heat and power systems fueled by biomass could reduce demand for natural gas in process and industrial heat and cooling operations, helping to increase overall energy efficiency and reduce carbon impacts of the state.

Major opportunities for in-state biomass development are estimated to include: expansion to nearly 2,500 megawatts of electric power and 18 billion kilowatt-hours of electrical energy, one to two billion gallons per year of biofuels, 100 billion cubic feet of biomethane, and more than a million tons per year of hydrogen.

3.3 Critical Path

The critical path to accomplishing these contributions from biomass involves: (1) stimulating the necessary capital investments to build production capacity and infrastructure like power transmission lines, (2) accessing markets for sales of products at prices justifying investments, (3) identifying and maintaining sustainable supplies of feedstock, and (4) having appropriate technologies and processes for meeting standards for environmental performance.

The intimate association of biomass production and use with other natural resource and waste management concerns leads to a lack of consensus on how best to achieve the potential benefits offered by expanded development. An important challenge is to create a policy process that allows for diverse views, yet finds ways to craft viable outcomes that implement the state's goal to increase fuels and power from biomass. *The creation of a robust negotiation and consensus building processes should be an objective of the Energy Commission with the help of the Collaborative.*

3.4 Barriers and Opportunities

Biomass resources can be used to generate renewable power, to produce renewable fuels such as ethanol, methanol, hydrogen, biodiesel, syngas, synfuels, and biomethane, and as feedstock for products such as plastics, solvents, inks, and construction materials. All of these can help meet the state goals to expand renewable energy, reduce petroleum dependency, provide economic development, and improve environmental quality. Benefits of using biomass may include:

- Improved forest health and reducing the severity and risk of wildfire,
- Improved air and water quality and restoring degraded soils and lands,
- Reduced greenhouse gas emissions,
- Improved management of residues and wastes,
- Reduced dependency on imported energy sources,
- New economic opportunities for agriculture and other industries,
- Improved electric power quality and supporting the power grid.

Despite these benefits, there remain a number of barriers to development:

- High cost of most biomass feedstock
- Difficult financial requirements for funding biomass facilities,
- Expensive and time-consuming siting and permitting processes,
- Utility interconnection and net metering problems,
- Uncertain technology,
- Public awareness and acceptance,
- Inconsistent public policies.

Overcoming these and other barriers will take a concerted effort in technology and policy development as outlined in what follows.

3.5 Biomass Energy Development Roadmap

This report summarizes and modifies the biomass roadmap (**http://biomass.ucdavis.edu/index.html**). A set of objectives centered on the main goals for improving resource production and acquisition and increasing the use of biomass for power, heat, biofuels, and bio-based products have been created. These goals include demonstrating and commercializing new technologies; supporting new bio-based industries that must compete with established conventional suppliers of energy, fuel, and products; recognizing the resource value of biomass in substituting for declining reserves of fossil fuels and reducing greenhouse gas emissions; conducting necessary research, and ensuring that the public is fully informed about the costs and benefits associated with biomass.

Based on the roadmap analysis, the California Biomass Collaborative suggests that the California Energy Commission adopt policies in the five critical areas listed here, to:

1. *Promote resource access and feedstock markets and supply:* Feedstock suppliers need access to biomass resources and must be able to deliver feedstock into biomass markets year round in sustainable ways and at acceptable prices.
2. *Support market expansion, access, and technology deployment:* Power plants, biorefineries, and other biomass converters require access both to firm biomass feedstock supplies and to product markets. Market access in turn requires both physical capacity to deliver product through power lines, pipelines, trucks, and other transport systems, and the ability to price product competitively.
3. *Fund research, development, and demonstration:* New technologies need commercial demonstration and deployment to produce new fuels and additional renewable bio-based products. Continuing advances stemming from well supported basic and applied research should be sought in new product development, improved product quality, increased conversion efficiency, improved environmental performance, and better protection of public and consumer health and safety. Support to help move promising technologies from demonstration to production will help biomass energy develop a more significant role in California.
4. *Carryout education, training, and outreach:* Supporting resource, market, and technology developments must be education, training, and public outreach to develop new information, crops, and technologies, provide skilled personnel, disseminate information and establish public dialog over the many issues of concern.
5. *Create supportive policies, regulations, and statutes:* The state's policies, regulations, and laws will influence public behaviors, technology implementation, resource management, and markets. These need to be comprehensive, allow for effective innovation, and have a vision of the long-term potential. They also need to provide a clear path for permitting new facilities while ensuring public health and safety and environmental quality.

Section 3.7 below provides more detailed recommendations integrated to the barriers and policies identified here.

3.6 Major Actions

A few concrete and significant actions will support and motivate technical and economic changes that will be needed to achieve the roadmap goals.
The most important are:

- *Create and continuously improve greenhouse gas (GHG) regulation and policy:* Through AB 32, AB 118 and other legislation, California is embarked on major initiatives to reduce greenhouse gas emissions and to establish carbon markets. Such markets should provide needed economic support and stimulate increasing investment. **California should work with other states and at the federal level to ensure consistent national policy.**

- *Create standards and best practices for sustainability:* **Establishing and employing** independently **certified performance standards** and **best management practices** implemented through both state and industry enforcement will be necessary to achieve the greatest green house gas reductions from state programs and build consensus and achieve compromise on environmental and public health and safety issues. With respect to forest biomass use, **crediting suppliers and producers who meet sustainability standards** will provide much needed economic support while avoiding other costs arising from fire suppression and mitigating environmental degradation. Sustainability standards necessarily must be research-based and current, implying a commitment to funding research to support these standards and ensure their utility.
- *Strategically support financing and long-term contracting:* Ensuring the ability to finance and support biomass development by **providing state-backed loan guarantees, government procurement programs, long-term contracting and other financial mechanisms supporting biomass projects** commensurate with the benefits created is essential to stimulating the level of investment necessary to build the production capacity and infrastructure needed under the governor's executive order.
- *Facilitate permitting:* Improving communication among agencies and educating developers about regulatory and permit requirements will make the permitting process less arduous. **Consolidating permitting activity within interagency coordinating bodies or through master agency agreements where agencies work under one regulatory framework should be done to create ways to expedite review**, improve communication regarding cross-media impacts, and **reduce permitting costs and the time needed**, both for developers and the agencies. Establishing a clearer permitting pathway will be important to stimulating the needed investment for new facilities to meet the state's objectives.
- *Support research, development, and demonstration:* **Ensuring adequate funding for long-term, basic and applied research** and **conducting well monitored pilot or small commercial scale demonstrations** are critical to bringing new technologies, resources, and products to commercialization and to improving technical and environmental performance while enhancing effective regulatory decision making and public policy.

3.7 Summary of Specific Roadmap Recommendations

Within each of the priority areas identified, we recommend a range of possible actions for the Energy Commission that could help achieve the targets and realize the longer term vision of sustainable development. Actions are further detailed in the main text and in the tables appended at the end of the roadmap report available on line.

3.7.1 Resource Access and Feedstock Markets and Supply

Any long term, sustained use of biomass ultimately depends on stable acquisition practices including growing/collecting and storing the biomass resource and transport to markets or users. Biomass feedstock supplies will expand if policies and technological innovations result in greater competitive status in energy and product markets. Actions to secure access and long-term supply include:

- Requiring the application of best management practices for resource development, production, and extraction to allow industry or state enforcement of standards. Where standards do not yet exist, new standards should be developed. Since best management practices will change over time, rational standards must be based on the best research information available. Sustainability standards imply an on-going funding commitment on the part of the agency for the research needed to keep them up-to-date and effective.
- Support self-reporting and independent certification and monitoring of sustainable practices including::
    - land and water use, and
    - other observable environmental effects.
- Support the development of biomass commodity markets and commodity boards to facilitate:
    - biomass marketing,
    - development of production, collection, transportation, storage, and processing infrastructure,
    - and coordination of sustainable business certification;
- Identification and proper crediting of sustainable feedstock suppliers through tax incentives or subsidies that account for other environmental costs avoided. This will require on-going research and assessment efforts;
- Provide state assistance in funding initial collection and processing efforts;
- Provide access to biomass resource and market information, including current biomass and biomass facility reporting databases.

3.7.2 Market Expansion, Access, and Technology Deployment

For any new biomass capacity added, whether for power, fuels, or bio-products, access to energy markets is crucial. The Energy Commission with help from the California Biomass Collaborative should evaluate ways to support the development of adequate infrastructure for product delivery. This depends on:

- Adequate physical infrastructure including:
    - electricity transmission lines and interconnections
    - gas pipelines and transportation fueling systems
    - feedstock storage, transportation, and processing capacity
- Policies and laws necessary to monetize external benefits and stimulate needed investment through:
    - new opportunities for long term contracting,
    - tax credits,
    - price supports and loan guarantees,
    - carbon markets,
    - robust environmental credits,
    - direct access to electricity markets
    - other financial incentives.

Market expansion can only occur if additional biomass capacity is installed. Near term deployment might include a diverse set of incentives and conditions:

- Upgrading or re-powering existing power plants where needed,
- Adding new power generation capacity including distributed generation,
- Supporting use of distributed residential biomass (i.e., wood/pellet stoves when and where appropriate),
- Expanding landfill gas and other biogas systems to produce power and fuels including the adoption of bioreactor landfills,
- Adding new source separation, waste-to-energy and other conversion capacity for biomass in MSW,
- Expanding the use of biodiesel and other renewable diesel fuels including use as blend stock for conventional diesel,
- Expanding E85 and other biofuel distribution and fueling capability,
- Expanding compressed and liquefied bio-methane capacity,
- Facilitating development, demonstration and use of adequate feedstock collection, separation, and harvesting equipment,
- Supporting pilot projects and demonstrations to provide confidence in the investment community that biomass technologies can be profitable
- Promoting the re-establishment of PURPA SO4-type contracts.

Longer term deployment should be planned in concert with research and demonstration of new technologies and processes. The Energy Commission should pay particular attention to and consider supporting activities related to:

- Siting advanced integrated bio-refineries incorporating both biochemical and thermochemical conversion and producing multiple value-added fuels such as ethanol and Fischer-Tropsch liquids, hydrogen, and products as well as electricity,
- Replacing existing power facilities with more advanced systems such as biomass integrated combined cycles (BIGCC) and increasing use of combined heat and power (CHP),
- Increasing renewable power capacity by creating a hybrid system to take advantage of stored energy in biomass in complementing intermittent renewable power from wind and solar systems,
- Integrating specialized bio-energy and other biomass crops into agricultural systems,
- Integrating crude biomass-derived fuel intermediates as feed stocks to conventional petroleum refinery operations,
- Promoting bio-power for plug-in vehicles,
- Expanding hydrogen distribution systems.

3.7.3 Research, Development, and Demonstration

A substantially increased research effort will be needed as California develops and expands its use of biomass and implements renewable and low-carbon technologies to reduce reliance on petroleum and other fossil fuels. Energy Commission and other state research programs should build on and be coordinated with extensive strategic research plans developed at the state and national level while targeting specific areas of emphasis for California focusing on:

- Comprehensive life cycle green house gas and health risk assessments that systematically compare waste and resource utilization alternatives;
- Identification and quantification of agricultural and forestry best management practices and monitoring environmental, health, and safety impacts from
    - feedstock production
    - feedstock handling and processing
    - conversion technology and manufacturing
    - product utilization
- Basic and applied research to
    - improve sustainability of biomass production systems
    - increase yields
    - reduce water and other agronomic inputs for agricultural biomass
    - increase disease- and pest-resistant biomass crops
    - improve conversion processes and product quality
- Applied research and demonstrating commercial scale biomass conversion and biorefinery techniques
    - biological, physical, chemical, and combined pre-treatment processes
    - lignocellulosic fermentation
    - advanced power generation including integrated gasification combined cycles and fuel cells
    - thermochemical biomass-to-liquids (BTL) processes employing Fischer-Tropsch and other techniques for making renewable diesels, gasolines, alcohols, and other fungible products
    - advanced high-rate anaerobic processes for biomethane production and integrated waste management
    - advanced integrated biochemical and thermochemical biorefineries for improved yields and cost
- Integrated Assessment using modeling, remote sensing, systems analyses, and systems optimization for
    - land use evaluation
    - forecasting climate change effects on biomass and bioenergy systems
    - assessing local and state economic impacts
    - improving feedstock production and acquisition logistics
    - siting and sizing conversion facilities and systems

Greater coordination and facilitation of research and demonstration should be provided by focused efforts with access to state-of–the-art facilities and equipment.

Research centers should be developed through state and industry support to provide enhanced laboratory and pilot capabilities for testing and development of advanced concepts.

3.7.4 Education, Training, and Outreach

Informed citizens, consumers, and decision makers are crucial to the successful adoption of bioenergy and other biomass systems. Well trained professionals will also be needed to carry out the expansion of biomass energy sources envisioned. Greater effort and funding should be directed at:

- educating and informing the public and decision makers about biomass systems and issues in sustainable biomass development,
- conducting outreach to local, state and federal government decision makers, schools, non-governmental organizations (NGOs), sustainability groups, and other public interest groups,
- providing outreach on biomass utilization and establishing early dialog with affected communities where facilities are proposed to ensure environmental justice and direct public involvement,
- holding general and specialized conferences, workshops, and onsite tours to increase information dissemination and encourage public, industry, and scientific interaction,
- conducting hearings and sponsoring field trips for policy makers and regulators to provide relevant information for policy, statutory, and regulatory proceedings,
- providing technical training by and for industry and expanding university curricula and programs to ensure the availability of adequate numbers of skilled professionals and technicians,
- augmenting existing cooperative extension programs to inform and educate farmers, producers, operators, investors, and others of results emerging from research and development efforts,
- providing outreach and coordination with farming organizations and agencies,
- creating grade-level appropriate K-12 curricula and teacher training programs to enhance career preparation and public education.

3.7.5 Policy, Regulations, and Statutes

California needs to establish an efficient process to address policy and regulatory issues in collaboration with the biomass industry. Only with a broad, overall approach will it be possible to address existing constraints and develop new policies, laws and regulations that promote the expanded use of biomass while protecting the state’s environment. Addressing issues related to biomass may require state agencies to change existing policies or develop new ones. In addition, changes in existing laws or regulations may be required before some of the policies can be fully implemented. Meeting the targets as ordered will require support at the highest levels of state government agencies to develop policies, regulations, and statutes to:

- Account for externalities and establishing or augmenting financial incentives, including
    - expanding carbon markets and implementing carbon taxes if necessary to avoid excess leakage across state borders
    - increasing the value of renewable energy credits and designating allowable emission offset credits
    - providing equitable tax credits and production incentives for biomass production and use
    - facilitating long term contracting
    - providing loan and other financial assistance in the absence of private alternatives
- Revise waste management policies and practices including
    - adding extended producer responsibility requirements
    - shifting to disposal-based regulations (e.g., reduce biodegradable material in landfills and reduce per-capita disposal amounts) from the current diversion-based regulations
    - amending laws to revise or eliminate technology and transformation definitions and require greater reliance on performance-based standards and results from comprehensive life cycle assessments
    - changing statutory definitions and permitting authorities to recognize the resource value of biomass in waste
- Require and enforce best management practices where not yet applied; such practices may first require definition for enterprises or activities;
- Revise permitting requirements to enhance interagency communication and create a more simplified and rapid permitting pathway for applicants;
- Establish new or invest in existing enterprise zones with responsibilities and opportunities to support biomass development including:
    - siting assistance
    - local government support
    - environmental review covering multiple projects
    - and appropriate incentives
- Enhance access to transmission lines, pipelines, and other infrastructure, providing equitable policies for net metering, opening direct access, and other incentives intended to stimulate markets
- Expand the renewable portfolio standard (RPS) as needed
- Require greater availability of alternative fuel vehicles or ensure complementary means to address reduction in fuel carbon intensity under the California low carbon fuel standard (and national standard if adopted) and the federal renewable fuel standard (RFS)

3.7.6 Integrated Systems

The California Biomass collaborative in the past has been wholly focused on biomass energy and related bio-products. One characteristic of biomass that lends itself to the consideration of integrated use with other forms of alternative energy that are intermittent like solar and wind, is that it can serve as a consistent or base load source of power that can be combined with intermittent sources to meet community or utility needs. Alternatively, combining diverse sources of power or using locally sourced biofuels for transportation or heavy duty uses within a community may enable communities to meet new standards for sustainability and green house gas reduction. The integration of the CBC with the other alternative energy collaboratives allows for the investigation and creation of new models of community and local utility power that will be developed in the coming years. This new undertaking will lead to unexpected innovation and should be encouraged by the CEC.

3.8 Next Steps

This roadmap provides recommendations for government and industry action but does not fully address implementation of the recommendations. The state and other stakeholders will need to set priorities for actions to be taken over the near-, mid- and long-term and identify responsibilities for implementing the various elements. Some actions will require legislation; others may be handled by executive or administrative order. Some will require budgetary actions while still others must be accomplished by industry, local government, and/or academia. Outreach in the form of workshops and coordination with community, farming, and sustainability advocates would build support for change. Realizing the vision for sustainable biomass development and achieving the state's bioenergy goals requires a continuing process focused on identifying and assigning responsibilities for implementing the roadmap recommendations.

During its next contract period, the Biomass Collaborative will work on several new projects across a range of biomass sectors, including agricultural biomass, forestry materials, food processing residues and municipal solid waste. As part of this work and to support standard setting, the capacity to carry out integrated sustainability assessment will be developed. This includes materials and energy mass balance estimates, life cycle assessment, economic analysis at the scale of the firm, region and state, and environmental quality analysis, particularly wildlife effects. Such assessment will help guide Energy Commission programs like AB 118 and create the most useful and effective sustainability standards possible.

This report will serve to inform and guide upcoming planning meetings and workgroups to address these needs.

4. MISSION AND STRATEGIC OBJECTIVES OF THE CALIFORNIA GEOTHERMAL ENERGY COLLABORATIVE

California possesses the nation's greatest geothermal resource base, according to recent U.S. Geological Survey estimates. Although development of this resource grew at a rate of nearly 10% a year during the 1970s and 1980s, growth in the last decade has fallen to about 1% a year. In order to support the state's RPS and greenhouse gas reduction goals, growth in this large renewable energy resource must accelerate beyond its current growth rate. This section describes specific tasks designed to expand the use of geothermal energy in a timely way.

The *mission* of the California Geothermal Energy Collaborative (CGEC) is to enhance the ability of geothermal energy to contribute to the State of California's renewable energy (RE) goals, as articulated in the Renewables Portfolio Standard (RPS), and greenhouse gas reduction targets, as articulated in Assembly Bill 32 (AB 32).
The *strategic objectives* of the CGEC are:

1. Provide a venue for the geothermal stakeholder community to articulate the challenges and solutions that affect the ability of the geothermal industry to maximize its contribution to the State's RE goals and AB32 targets
2. Provide the Commission with research and development support in its efforts to meet RE goals and AB32 targets
3. Provide potential users of geothermal resources efficient access to up-to-date information
4. Provide educators and the public with suitable educational materials
5. Provide legislators and regulators access to information necessary to develop informed decisions that impact the use of renewable energy resources
6. Acquire support from external entities to sustain the CGEC role.

In 2007-2008, the CGEC undertook an effort that was designed, in part, to identify the key challenges that must be overcome to meet its strategic objectives. A task force was formed with member experts from industry, academia, private business and trade groups to develop a plan for accelerating thoughtful utilization of geothermal resources. The resulting Development Plan identified the key issues that are addressed by the *strategic actions* enumerated below.

4.1 Background: Geothermal Energy in the State of California

Geothermal energy has historically been the most significant renewable energy source in the state. In 2005, 5.0%, or 14,379 gigawatt hours (GWh), of California’s electric energy generation came from geothermal power plants, accounting for nearly half of all renewable energy. At that time, California’s geothermal capacity (2,492.1 megawatt installed) exceeded that of every country in the world.
The size of the geothermal resource base has yet to be accurately established because the resource assessments completed to date have been constrained by insufficient data. There

are three types of resources that must be considered in order to accurately and precisely evaluate the size of the resource base. The potential undeveloped geothermal resource that has already been identified but has yet to be accessed is estimated to be between 2,400 MW and 9,200 MW (Table 1, Identified Resources). The geological characteristics of the state make it certain that there exists an even larger geothermal resource base that has yet to be discovered (Undiscovered Resources in Table 1). The Undiscovered Resource ranges between 3,200 and 25,400 MW. Finally, recent technological advances make it likely that deeper geothermal resources will be accessed within the next ten to 30 years. These deeper resources will require newly applied engineering principles and are called Enhanced Geothermal Systems (EGS). Estimates of California's EGS resource base range between 32,300 and 67,600 MW. Combined, such a baseload capacity can significantly resolve the RPS and greenhouse gas emission reduction goals the state has established.

Table 1. Geothermal resource estimates (U.S. Geological Survey, 2008)

	Identified Resources (MW)	Undiscovered Resources (MW)	Enhanced Geothermal Resources (MW)
Likely minimum	2,422	3,256	32,300
Mean	5,404	11,340	48,100
Likely maximum	9,282	25,439	67,600

California also has a history of utilizing lower temperature geothermal resources in a variety of applications. There are over 120 sites throughout the State where geothermal fluids are being used for aquaculture, greenhouse heating, spa and resort facilities, and district heating. There are an additional approximately 400 ground source heat pump (GSHP) installations for residential, school and commercial building heating and cooling. Facilities of this type (i.e., non-power generating) have the potential to decrease electric loads by displacing electrical demand with low temperature geothermal resources, thus reducing the RPS targets and improving the ability to meet AB32 standards.

In order to meet the ambitious RPS and AB32 goals and targets, it is important that use of geothermal resources grow at a reasonably accelerated pace. However, until recently, growth in the development and use of geothermal energy resources has only been about 1% a year since 2000. Prior to that, the growth rate was as high as ca. 9% a year, which is a rate that would allow the state to meet its goals and targets.

The strategic actions discussed here are focused on addressing ways in which the growth rate of geothermal energy use can approach that required to meet RPS goals and AB32 targets. The action items are derived from discussions and analysis developed and detailed in "A Development Plan For Geothermal Energy in California: Challenges To and Solutions For Meeting California's Geothermal Energy Future" (2008), and is available from the CGEC.

4.2 Strategic Action Items

Four strategic Tasks have been identified that directly address the obstacles to growth in geothermal resource use. Task 4.2.1, is focused on improving the available database to enhance the ability to accurately and precisely estimate the accessible resource. Task 4.2.2 is intended to accelerate data transfer so that all stakeholders can have access to reliable data that will improve research, development and design activities statewide. Task 4.2.3 will develop an analysis of the best means to encourage development of geothermal applications, based on cost-benefit concepts. Task 4.2.4 will identify and pursue funding opportunities to leverage PIER investments in geothermal R&D. The strategic actions listed below are presented in an order that reflects how they will be time-sequenced. It does not reflect the priority given to their importance. Rather, the sequencing is a reflection of the time it would take to accomplish the work, as well as a judgment regarding when funding would be available to undertake each effort.

4.2.1 Establish a Research Program Focused on Key State R&D Needs

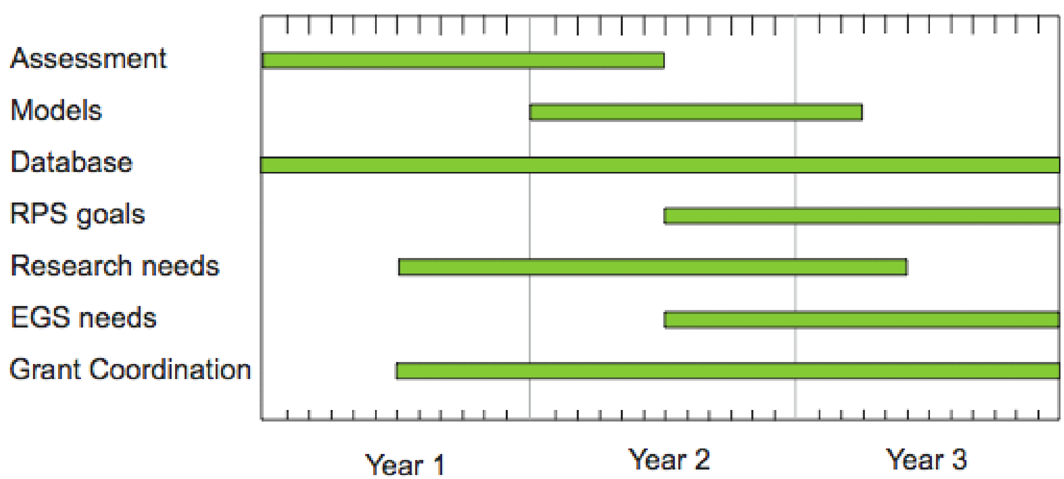
Although it has long been recognized that California is the nation's richest state in terms of geothermal energy resources, it remains unclear what the actual magnitude of that resource is. Estimates of the power generation potential of the state differ by up to an order of magnitude. Such uncertainty hinders definition of research needs and development of target resource areas. The purpose of this strategic action item is to reduce uncertainty in the definition of the resource base, and establish research priorities and efforts addressing the technological developments needed to utilize those resources.

The roadmap for this effort is shown in Figure 1, with the duration of each activity, and its sequencing within this action item indicated.

- Develop a “next generation” assessment of the entire geothermal resource base. Build on the current US Geological Survey effort by extending it to higher resolution coverage of known high temperature resource areas, as well as expand it to include potential EGS, moderate, low temperature and hidden resource areas. Include data and analyses from archived sources, e.g., California State Geologist’s Office, as well as models and concepts that are currently being evaluated. See Task 1 in Figure 1.
- Document the conceptual models that have been developed for each geothermal resource site, identify the data needs required to test the models so that a consensus model for the areas can be developed. Use the models to identify lowest-risk drilling targets, if appropriate. See Task 2 in Figure 1.
- Establish a database and related web-portal that would allow easy access to updated resource assessments. Key the database so that site-specific data can be readily accessed. Assure that the available data are regularly updated and vetted within the geothermal community. See Task 3 in Figure 1.
- Provide access to analysis capabilities that allow real-time analysis of the impact resource use would have on the State’s effort to meet RPS and AB32 goals. See Task 4 in Figure 1.

- Through research with interested participants, evaluate priorities for technology development that will economically address the problem of finding resources that have no surface expression. Include consideration of hybrid remote sensing methods coupled with land-based geophysical measurements, isotopic analyses of soils and waters, and water district historical data records. See Task 5 in Figure 1.
- In coordination with U.S. Department of Energy Office of Geothermal Energy, pursue research that will expedite bringing to market development of "enhanced geothermal systems" (EGS). See Task 6 in Figure 1.
- Coordinate with Commission staff the development of streamlined and effective solicitations for research funds. See Task 7 in Figure 1.

Figure 1: Progress Chart For R & D Needs



4.2.2 Enhance Market Penetration Through Better Dissemination of R&D Results

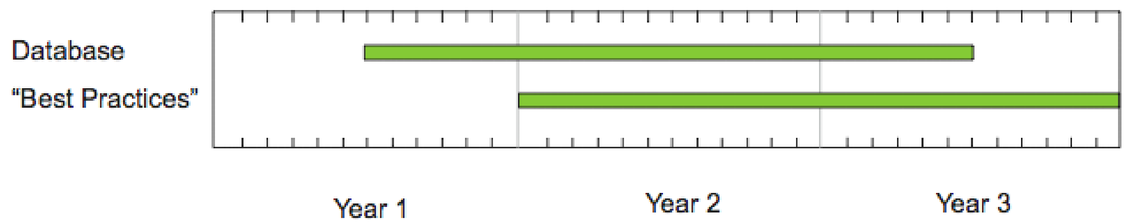
Dissemination of up-to-date research results is crucial for timely development of renewable energy opportunities. Included in this information must be lessons learned that improve the ability to streamline and inform implementation of technology and manage technology. Included in this topic is the intent to provide regulators at all levels with knowledge of lessons learned and "best practices" to assure safe and environmentally sound deployment of technologies. This task will provide the ability to communicate those results.

The roadmap for this effort is shown in Figure 2, with the duration of each activity, and its sequencing within this action item indicated.

- Utilize the results of previous DOE research efforts (e.g., the National Geothermal Collaborative's Outreach Principles and Comment Analysis Report") to design an information-transfer system that would allow schools, architects, training facilities, local administrative and regulatory agencies, and interested individuals

access to relevant information that would meet their respective needs. See Task 1 in Figure 2.
- Research and publish a "best practices" series that would assist permitting entities in developing streamlined permitting processes for all appropriate geothermal technologies. See Task 2 in Figure 2.

Figure 2: Progress Chart Technology Transfer



4.2.3 Improve Communication Between the Stakeholder Community and the Regulatory and Policy Communities Such That Information is Readily Available for Developing Effective Policy and Incentive Efforts

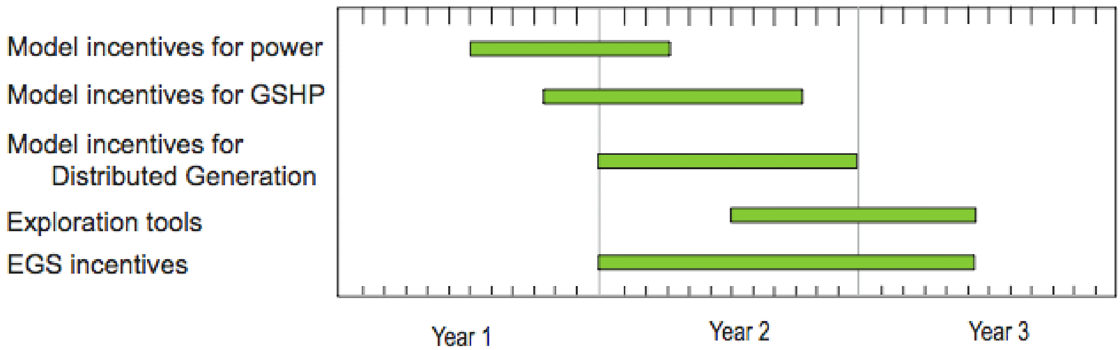
Although policies and incentives put in place in the 1980s effectively spurred the development of geothermal resources for a decade, there has been little success since then at putting in place stimulants that would follow up on that initial success. As a result, growth in the utilization of geothermal resources has stalled. The purpose of this strategic task is to explore policy and incentive development to encourage renewed growth in the use of geothermal energy resources.

The roadmap for this effort is shown in Figure 3, with the duration of each activity, and its sequencing within this action item indicated.

- Based on research results, construct model incentives (rebates, credits, etc) that would be useful for encouraging investment in geothermal power production, installation of ground source heat pumps in buildings and homes, and development of direct use applications. Include cost-benefit analyses and impacts on meeting RPS goals and AB32 targets. See Task 1 in Figure 3.
- Develop prototype policies that encourage using ground source heat pump systems in public buildings. See Task 2 in Figure 3.
- Develop prototype policies that encourage the development of distributed systems in areas that possess geothermal resources but are not advantageously located with respect to transmission infrastructure. See Task 3 in Figure 3.
- Develop prototype incentives that would encourage exploration and development of exploration tools. Include an analysis of the impact these tools would have on bringing to market geothermal energy. See Task 4 in Figure 3.

- Conduct a research program evaluating the most cost-effective and efficient means for incremental development of EGS technology into the California geothermal market. See Task 5 in Figure 3.

Figure 3: Progress Chart For Effective Initiatives



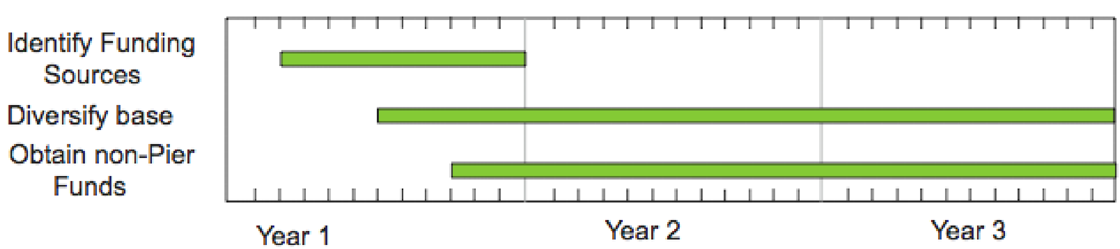
4.2.4 Develop a Funding Base Beyond That Provided by PIER Funds

The goal of this action item is to identify and obtain funding external to PIER, thus expanding the resource base for CGEC activities and allowing the collaborative to pursue efforts not within the purview of PIER efforts.

The roadmap for this effort is shown in Figure 4, with the duration of each activity, and its sequencing within this action item indicated.

- Evaluate opportunities for obtaining funding support external to PIER funds and develop a plan for acquiring those funds. See Task 1 in Figure 4.
- Diversify the population of the CGEC to reflect the broader community of energy consumers, and use that base to identify additional funding opportunities. See Task 2 in Figure 4.
- Obtain funding from non-PIER sources. Task 3 in Figure 4.

Figure 4: Progress Chart Funding Base



5. MISSION AND STRATEGIC OBJECTIVES OF THE CALIFORNIA SOLAR ENERGY COLLABORATIVE

The *mission* of the California Solar Energy Collaborative (CSEC) is to assist the State, key stakeholders, and the Energy Commission in developing and expanding the utilization of solar power in California, consistent with the California Solar Initiative (CSI) which has set a target of installing 3000 MW of solar power generation capacity in California by 2017, and with California's overall renewable energy goals, as articulated in the Renewables Portfolio Standard (RPS), and greenhouse gas reduction targets, as articulated in Assembly Bill 32.

The *strategic objectives* of the CSEC are as follows:

1. Provide a unique forum to collect and critically analyze existing solar research and technology developments, and to develop consensus among key stakeholders
2. Facilitate research in gap areas where existing data are insufficient
3. Track the evolving landscape of research in solar technology in California
4. Develop or provide tutorial and training materials on solar energy technologies for educators and the public
5. Inform policy and RD&D priorities by providing technical review of statewide policy and research initiatives and publicly debated issues; by assisting the evaluation of market trends and growth patterns; and by evaluating the regulatory, economic and financial constraints and barriers impacting the stakeholders
6. Acquire support from external entities to sustain the CSEC's role and enhance activities in basic and applied solar energy research

A kickoff workshop was held at UCSD on June 1, 2009 and brought together stakeholders who assisted in identifying key issues in solar energy research and development, and solar energy implementation in California in order to meet the ambitious goals of CSI and related legislation. A variety of stakeholders from different entities, such as industry, State Government, National Laboratories, Universities and utilities participated in the workshop. The participants of the workshop were divided into four panels. These were:

1. Manufacturing (mainly PV).
2. Utilities and concentrated solar power.
3. Research, tech transfer and commercialization.
4. Policy, standards, implementation, and solar resource/monitoring.

The participants were requested to evaluate the development and deployment of solar energy systems in California (with regards to the specific area of their panel) and write position papers based on their discussions. Ideas and recommendations submitted by the participants to the four panels are included in this document. In the next sections the following items are addressed: background; manufacturing; utilities and concentrated solar power; research, tech transfer and commercialization; policy, standards, implementation and solar resource/monitoring. After discussion of these items, a summary of strategic action items is given.

5.1 Background: Solar Energy in the State of California

The California Solar Initiative (CSI), which was signed into law (Senate Bill 1) in 2007, has set an ambitious target of installing 3,000 MW of solar power in California by 2017. The state Renewable Portfolio Standard (RPS) and the Energy Action Plan (EAP) have also set very aggressive targets for renewable resources, a significant portion of which is expected to be met by solar energy (including both photovoltaic and concentrating solar power). California is at the leading edge in the implementation of solar energy in the United States.

At the same time, the technological and entrepreneurial infrastructure of California is being brought to bear on the development of new technologies with the potential to provide dramatic reductions in the cost of solar electricity and solar energy in all forms, through new materials and manufacturing techniques, advanced device and system technologies, and innovative schemes for financing solar energy systems at the residential to utility scale. These developments are expected to have, on various time scales, a major impact on the economic viability of solar energy and solar power generation, but strategic actions by the CSEC, California Energy Commission, and others could be key facilitators in bridging the gaps that traditionally exist between research advances and commercialization.

Sustained, rapid growth in the installation of solar power generation capacity will be required to meet the target enumerated in CSI: in 2007, only 81 MW of solar power generation capacity was installed in California, and even this represented a 36% growth rate over 2006. The strategic actions discussed here focus on identification of key technology, implementation and policy challenges, and formulation of priorities in RD&D, policy and legislation, and education that will need to be addressed to accelerate the development and utilization of solar power in California.

5.2 Manufacturing

5.2.1: Manufacturing and Technology Optimization

Manufacturing in solar power is currently dominated by direct-illumination PV panels, and the greatest immediate impact that the CSEC can have on solar deployment is to help improve the cost effectiveness of these systems, bringing solar rooftop power towards price parity with other (carbon positive) forms of energy production. Currently, the figure of merit driving production refinements is the cost for peak power ($/Wp), but a better metric to drive technology development that minimizes the cost of solar electricity would be energy generation (in $/kWh). Historically, approximately 50% of the cost of a solar system are the panels themselves, but with module costs declining (e.g., First Solar's announcement in early 2009 of manufacturing costs below $1/Wp, and Trina Solar's recent announcement of a manufacturing cost of $0.79/Wp), it is becoming increasingly important to address the costs associated with installation and the BOS (balance of system): DC-to-AC invertors, power conditioning wiring, enclosures, and potentially energy storage (charge controllers and batteries). The CSEC can help by tracking and reporting the costs and efficiencies in each component in the overall system, supporting a competitive environment where manufacturers and systems integrators can track opportunities for system-level optimization. Analysis of policy initiatives and financial arrangements that provide incentives for end users, and consequently manufacturers of PV panels and associated system components, to optimize for minimum cost of energy generated, as opposed to (for example) minimum initial system cost could be valuable as well.

Thus important aspects that need consideration are:

- use the metric of energy generation in $/kWh
- address the costs associated with installation and the BOS
- track and report the costs and efficiencies in each component in the overall system
- analysis of policy initiatives and financial arrangements that provide incentives for end users

At a larger scale, the grid, system and PV design need to be designed for penetration at a much larger level of penetration (approximately 20% of power generation, as opposed to the ~1% level currently in use). This brings issues with intermittency of generation due to environmental factors. The solar energy generation profile does not necessarily track the electricity demand profile, and so energy storage technologies on a short-term (8hr) time scale are becoming increasingly important. A broad range of approaches, including relatively "low-tech" but very efficient technologies such as heating or cooling water should be formulated and analyzed from the perspectives of the basic technologies involved, cost of implementation, and acceptability to utilities and end users.

5.2.2 Panel Manufacturing Issues

Policy and economics, in addition to technology, dramatically affect manufacturing. California is a high-cost venue for businesses including manufacturing: labor, energy, real estate, taxes are all relatively high, whereas in other locations at least some of the factors are relieved. India has low labor costs. Middle Eastern entities like Kuwait, Mazdar and the United Arab Emirates, provide major incentives and infrastructure. These are very different environments from California, but even a highly developed country like Germany which has high labor costs has relatively low rent and taxes, and a investment-friendly regulatory structure including a simplified (one-page) application process for plant installation and a stable marketplace. As a result, Applied Materials "Sunfab" thin-film solar module production line has had their first installations in India and Germany, but none so far within the US.

United States and California policies are relatively complex, and act as a barrier for adoption. Some states (e.g. NM, OR, FL) have aggressive tax and other incentives to draw manufacturers, but incentives for use of locally manufactured equipment can be counterproductive. Federal stimulus funds for US-built equipment have a short-term impact, but are not optimal. In the longer term, a major factor influencing a sustainable manufacturing infrastructure is an open, competitive market with minimal disruptions; this encourages the large capital investment necessary for manufacturing capabilities. For these and other reasons, a large amount of photovoltaic manufacturing currently occurs outside California and the US. The implications of this, both positive and negative, should be analyzed to provide an appropriate framework for formulation of approaches to foster the manufacture and installation of solar energy systems within the state.

What is needed is:

- provide an appropriate framework for formulation of approaches to foster the manufacture and installation of solar energy systems within the state
- establish a sustainable manufacturing infrastructure that gives an open, competitive market with minimal disruptions

5.3 Utilities and Concentrated Solar Power

5.3.1: Stakeholders

This area of the CSEC deals with large-scale energy production facilities, especially tracked high-concentration solar thermal and photovoltaic plants. The key aspects include energy generation, storage, and transmission, as well as the related land-use and environmental concerns. The CSEC will act as a hub supporting the interests of a wide range of stakeholders, including the following:

- Utilities, including Investor-Owned Utilities: (e.g., SDG&E, SoCal Edison, PG&E)
- Municipal Utilities: (e.g., SMUD, LADWP)
- Energy transmission (California Independent System Operator)
- Facility developers: (e.g., Edison Mission Energy, Sempra Energy, Enexco
- Technology venders (e.g., Brightsource, E-Solar, Solel, Solar Millenium, Solar Reserve, Abengoa, First Solar, Sunpower, Amonix, Nextera Energy Resources)
- National Laboratories (NREL, Sandia)
- Government agencies (DOE, Bureau of Land Management)
- Industrial associations (CalSEIA)
- Environmental organizations (e.g., National Resource Defense Council, Sierra Club)
- Educational and research institutions (the UC and CS systems, the Electric Power Research Institute, as well as nation-wide institutions including Florida Solar Research Center, University of Arizona’s Southwest Regional Energy Center.

5.3.2: Information Collection and Dissemination

One of the most cost-effective ways for the CSEC to promote solar power generation is to help make available the information required for effective development and operation of large scale solar power utilities. Site selection depends on a number of quantifiable factors related to power generation (i.e., models and measured data on the incident solar power – the solar resource map), as well as business factors such as the available electrical power transmission capacity and cost. While some of this information is generated and held privately, much is available from disparate sources worldwide. The CSEC website should provide as much data as possible, as well as links to other sources worldwide, including “best practice” examples of successful plant development with various technologies. The CSEC site can also provide links to commercially available modeling products such as PV*Sol and PVSYST, as well as direct access to software tools such as the Dept. of Energy’s Solar Advisor Model (SAM) and the National Renewable Energy Laboratory’s PVWATTS.

5.3.3: Promoting Effective Research

The CSEC should promote effective use of research efforts by communicating the range of topics which are relevant to large-scale installations. The immediate goal of improving the efficiency and quantity of power production can be supported by comparison and evaluation of competing software tools site solar resource modeling. In addition, the CSEC can help to communicate importance of research into the broader scope of technologies required for large-scale production, including ways to improve energy transmission capabilities (both in terms of raw capacity and efficient utilization of available capacity), and in terms of comparing the merits of the many energy storage options (thermal, electric battery, hydrogen, hydraulic pump storage) under the conditions of increasingly large plant scale.

Thus what is essential are:

- promotion of effective use of research efforts by communicating the range of topics which are relevant to large-scale installations
- communicate the importance of research into the broader scope of technologies required for large-scale production

5.3.4: Education/Outreach

The availability of a skilled labor force in California is critical for effective development of solar energy. The CSEC can help by providing basic educational outreach, identifying curricula for K-12 schools through university courses. At the technical schools, there is already a certification program for PV, but not one for concentrated solar power (solar thermal) which has substantially different technical challenges.

One specific area of education identified as important was in helping local planning departments, who are called upon to regulate the layout and installation of solar power facilities in their communities. Solar power is still an emerging technology, and is unfamiliar territory for the officials involved, so their response to the developer of CSP facility can vary widely. The time needed for the permitting process can range up to 4 years, and the final outcome can be difficult to predict. Developers have a strong interest in dealing with a well-informed community, and will be willing to provide the CSEC with detailed case studies from previous projects. Combining this with input from the communities who were involved will enable the CSEC to provide a balanced perspective of the process. With this material, the CSEC can develop a training seminar which can be recorded and widely distributed.

5.4 Research, Tech Transfer and Commercialization

5.4.1 Research

The CSEC will be responsible for tracking, analyzing and summarizing the major research and developments in solar energy in order to keep abreast with the most promising technologies for rapid commercialization in California. The CSEC will write yearly reports on solar research and technology and provide these reports to the CEC. In the reports, the CEC will make objective recommendations which technologies are attractive to pursue and in what strategic areas additional research is critical to bring technologies to commercialization. In order to accomplish such tasks, input of stakeholders will be sought through meetings and workshops. All aspects of research and developments of solar energy will be reviewed and analyzed. This includes PV, concentrated solar power, direct solar heating and emerging technologies.

5.4.2 Technology Transfer

The CSEC will promote more effective technology transfer. CSEC will evaluate why some grant proposals lead successfully to technology transfer and others do not, using PIER as potential example. More engineers within solar firms must be tapped as reviewers for PIER proposals. CSEC should explore more effective ways to transfer ideas to industry.

The IP policies of State Universities should be reviewed with respect to research in solar energy. For example, the University of California IP policies may very well impede the technology transfer process. Specifically, university policy requires that all IP in a joint project go to the university, even if the ideas originated with company employees. A fifty split between Universities and Companies may be a more desirable approach to facilitate technology transfer. The CSEC should explore more flexible IP policies for solar R&D.

There is too little innovation and technology transfer on the back-end. The back-end includes, DC disconnects, inverters, mounting hardware, energy storage, etc. These pieces are often not standardized and are proprietary, so each company may do it differently. The engineering of these parts is critically important for product deployment. This approach does not motivate innovation in this area. Research funding should be made available for applied engineering of these parts into panels and complete interchangeable systems. Funding should be provided jointly by university researchers and innovative companies. The CSEC should advise PIER to consider a pilot project in this area.

5.4.3 Commercialization

Government may be inadvertently forcing start-up companies to commercialize their products too early. Premature commercialization leads to wasted capital and product failures that will ultimately damage the image of the solar cell industry. The CSEC should analyze the current system and make recommendations for improvement. The government should assist in funding for commercialization of quality products to avoid "opportunistic commercialization." Company leaders need to know that when the product is completely ready, funding will be available. Currently the system is backwards. Funding comes online and start-ups must claim to be ready or lose the chance at getting funding, with no clear scheduled funding opportunity in the near future.

<u>Failure analysis</u> is critical for commercialization and needs to be evaluated through installation. Failure can occur during the installation of the panel this can affect the overall cost of the installed system. Failure analysis will reduce the long-term operation costs for solar power plants. A full analysis is needed to determine maintenance costs. Such analysis must be performed both on the individual panels and the complete operational system. The CSEC should review the needs for failure analysis. (A related educational issue is whether a sufficient number of solar electric repair technicians will be adequately trained to diagnose and repair failures of systems.)

Product and systems engineering is needed. While the focus of the solar industry tends to be on solar panel manufacturing, it is also important to understand how product and system design can to be optimized for the large variety of solar installations. Different solar electric systems will need different system components (inverter, dc disconnects, rack mounting, etc.)

<u>Accelerated Life Testing</u>, correlated with <u>Field Testing</u>, is necessary for solar systems. There are a few facilities that provide these services; however there is currently a bottle neck in evaluating how solar panels will perform in both lab and field testing. Field testing needs to be correlated with accelerated lifetime testing (temperature and humidity) to extrapolate lifetimes up to 20 years with some confidence. Current wait times for testing can be months and the cost of testing is high. This excludes many research groups and start-up companies. A second concern is that most companies do not wish to share knowledge about the initial reliability and lifetime or their products. Fast, low-cost, and anonymous efficiency and lifetime analysis will increase product testing and ultimately the quality of solar products

<u>Standardization</u> is needed for both PV and Solar products that include installation standards, panel quality standards, warrantee standards, and, most importantly permit standards. Currently every municipality in California has different permit requirements for PV installation. By comparison, everyone in Germany uses the same 1 page form for solar permits, even though Germany is composed of 14 states. It is essential that California creates a statewide installation and building permit for PV installation. This

will reduce costs and this will reduce building time. The CSEC recommends the CEC to consider permit standardization.

Evaluate the impact of warranties on commercialization. Does a 20-year warranty unfairly penalize small start ups? Also, warranties currently are only for the panel, but the system performance is also very important. Is a system warranty needed, and if so, what would be the appropriate length/scope of such a warranty?

Storage for solar electric systems needs to be evaluated to promote commercialization. Power consumption, particularly in the evening hours, is increasing which further motivates the need for effective storage. Understanding how power is going to be stored adds uncertainty to solar industry and impedes its adoption. Storage systems will be different for the different solar electric technologies and need to be evaluated, with viable solutions offered, to promote solar installation.

The CSEC will explore the merits of feed-in tariffs (see also section 5.5). A feed-in tariff is a guaranteed price per kw/hour of power produced from a personal solar plant. A feed-in tariff gives individuals incentive to invest in solar technologies because the time for repayment becomes fixed because a high return price for PV power is fixed until the unit has paid for itself. A feed-in tariff will enable more effective commercialization and has launched Germany and Spain as the highest solar installing nations in the world. Feed-in tariffs would open the market to customers that have no onset load. A feed-in tariff is a good idea for California because there is no cash up front from the state. Private individuals must buy and install the solar systems. California only pays the difference between the market and tariff prices for systems that have been installed and are producing power.

The environmental & energy costs of solar systems, particularly, PV needs to be factored into commercialization costs. The costs include land use, recycling, natural resource depletion, transportation, and manufacturing emissions. Public perception of the energy and environmental impact of solar technologies and impedes their acceptance and needs to be evaluated by an independent source to provide accurate information to the public. In order to promote commercialization of most cost effective panels, the costs over the panels' entire life cycle needed to be evaluated. Filling vacant lots within a city or warehouse roofs within a city rather than pristine desert with solar panels may be preferable to most Californians. The CSEC will focus on the real costs involved in solar systems.

5.4.4 Direct Solar Heating

One item often overlooked by the market is the low price of direct solar heating for hot water and solar heating for homes. Perhaps direct solar heating is overlooked because the technology is simple, but at the same time the technology is reliable and inexpensive. Direct solar heating can have a tremendous reduction in the use of electricity in the State of California. Another item that should not be overlooked is energy conservation, particularly electricity conservation. Direct solar heating can have a large impact on electricity conservation. The CSEC and the CEC should look into ways to drastically increase direct solar heating and promote electricity conservation.

5.5 Policy, Standards, Implementation and Solar Resource/Monitoring

5.5.1 Participating Intermittent Resource Program (PIRP)

The development of requirements for solar systems under the PIRP should be a transparent process. Before requirements are adopted Industry and the public should be able to provide extensive comments and feedback. The collaborative can provide assessment of the PIRP to determine whether the requirements set by the PIRP are attainable given the current state of the art.

5.5.2 Resource Assessment and Modeling Capability

The CSEC, with DOE and NREL involvement, can facilitate program development of a template model for standardization for industry use, for predictions and estimates and as a framework for new policy considerations. Models should work for different plant size ranges since power systems range in size and complexity. The ability for resource modeling and projecting power output for different systems needs to be incorporated. Incorporating site specific transients is also highly desirable. Resource and power production models should aid the development of policy for standards because it would be based on transparent information generated by the models.

5.5.3 Feed-in Tariffs

The CSEC should help in determining the pricing of feed-in tariffs based on technology. Some factors that are relevant are:

- Different renewable technologies – even in the realm of solar – should be considered separately
- Separate program outside of California Solar Initiative
- Rates should be based on the economics of the situation
- Consider the a strategic value assessment view point
- Review process for feed-in tariffs
- Consideration of the difference between contract-based feed-in tariffs and project-based feed-in tariffs

Because of the complexity of the issues surrounding the formulation of value-based feed-in tariffs rates, a complex tariff structure may be required. Long-term contracts should be written using a tiered rate structure. In many cases there is a need for annual or multi reevaluations.

5.5.4 Net Metering

The CSEC believes it is necessary to consider raising the cap on net metering. Utilities see this as a proposition for losing customers so they want a cap limit. The CSEC suggests an approach of annual net metering with a rollover or devise payout rates.

5.5.5 Renewable Energy Credit (REC) Bundling and Feed-in Tariffs

Currently RECs are bundled in California, and there is a major effort to unbundle. The CSEC could provide assistance in a REC unbundling feasibility study – consideration of factors involved in energy generation, T&D, carbon offsets, and technology specific value. RECs should consider more than energy production – it should take account of all renewable attributes such as transmission and distribution. Quantizing the avoided energy costs includes other energy infrastructure considerations implying a geographic aspect to RECs. The sale of RECs when bundled with feed-in tariffs poses complexities – this advocates unbundling. Additional complexities lay in geographic differences in energy pricing – the ability to sell RECs independently could affect placing of sites of solar facilities in low power cost areas. Other geographic concerns involve commodity trading. Industry based on fossil energies may raise concern with pricing structure – considerations of interstate commerce. This could pose a state-based emphasis regarding in state RECs as more valuable – "California First". Unifying the bundling and REC standards would require a national grid.

5.5.6 System Level Performance Standards

The CSEC should advice the CEC on the development of policy <u>standards for complete system performance</u>. This may involve something similar to the "Energy Star" rating program for power system components. For solar systems, it is necessary to identify performance level variables, to quantify subsystem performance and to identify the effects of the subsystem on the performance of the whole system. Companies may object to participation in studies of subsystem performance if, for example, company A knows that company B's components outperform theirs. The desire to keep these performance data proprietary could be a source of complications in setting system level standards.

5.5.7 Various Other Considerations

The implementation of <u>pilot projects</u> to help inform policy decisions should be flexible. Costs of patching unsuccessful programs or scrapping them and starting a new program should be weighed when deciding what to do with failed projects.

<u>Warranties</u> on system performance are an important issue in the wind industry. For the solar industry the issue can be more complex because different components are amalgamated to form a system (mostly residential installations). Standards for determining system level warranties should be considered as market penetration of solar increases in scale. This brings up the issue of have licensed installers and inspectors. Without licenses an installer could potentially change their business name and try to avoid liabilities. For a growing solar industry, licensed inspectors will be required. Developing processes for licensing both installer and inspectors will be required for a more regulated industry.

5.6 Strategic Action Items

From the above analysis and discussions, the CSEC recommends the following strategic action items. The participants at the CSEC workshop suggested these action items. Some of the action items can be integrated with the other collaborative especially the California Renewable Energy Collaborative.

5.6.1 Identify Key Needs and Priorities for Accelerated Research, Development and Implementation of Solar Power in California

- Interact with key stakeholders from manufacturing, utility, research, financial, environmental and policy communities to identify major challenges from their perspectives.
- Formulate and evaluate priorities for technology development in both photovoltaic, concentrated solar power and direct solar heating.
- Stay informed on, and assess, emerging technologies that depend on solar energy, e.g. synthetic photosynthesis to produce fuels.
- Identify policy gaps and needs that would facilitate accelerated implementation of all types of solar power in the state, at both residential and utility scales.
- Coordinate with CEC staff the development of streamlined and effective solicitations for research funds.

5.6.2 Develop Mechanisms to Efficiently Transfer the Results of R&D to Enhance Market Penetration of Solar Technology

- Provide periodic opportunities for members of the research, financial/investment, policy and manufacturing communities to interact on “neutral ground”, to facilitate rapid transfer of research results to commercial implementation.
- Identify needs and challenges perceived by end users, e.g., utilities and system installers, to help focus research, development and manufacturing activities in the solar power area.
- Advice on research for further development of product and systems engineering for solar technology.
- Recommend failure analysis and accelerated life testing of products that are already commercially available or are at the stage of entering the market place.
- Facilitate program development of a template model for standardization for industry use, for predictions and estimates and as a framework for new policy considerations.
- Help in determining the pricing of feed-in tariffs based on technology.

5.6.3 Improve Communication Between the Stakeholder Community and the Regulatory, Environmental and Policy Communities Such That Information is Readily Available for Developing Effective Policy and Incentive Efforts

- Identify roadblocks to implementation of solar power systems that could be addressed effectively through appropriate policy or legislative action.
- Develop materials and web sites for analysis and dissemination of this information to a broad range of stakeholders.
- Provide periodic forums at which interaction between stakeholders in the research, development, manufacturing, and utility communities and those in the policy arena can take place.
- Develop courses to educate students and professionals on solar energy.
- Educate the general public on the importance and need of solar energy in all of its forms.
- Provide objective perspective and documentation on solar energy.

5.6.4 Advise on Policy to Facilitate the Commercialization of Solar Energy

- Push for permits standardization for installation of PV modules.
- Push for standards for solar systems.
- Implement direct solar heating as a requirement for all new homes in California.
- Consider feed-in tariffs in California.
- Raise the gap on net metering.
- Set-up a REC unbundling feasibility study.
- Standards for determining system level warranties should be considered as market penetration of solar increases in scale.
- Development of processes for licensing both installer and inspectors will be required for a more regulated industry.

5.6.5 Develop a funding base beyond that provided by PIER funds

- Evaluate opportunities for obtaining funding support external to PIER funds and develop a plan for acquiring those funds.
- Diversify the population of the CSEC to reflect the broader community of energy consumers, and use that base to identify additional funding opportunities.

6. MISSION AND STRATEGIC OBJECTIVES OF THE CALIFORNIA WIND ENERGY COLLABORATIVE

6.1 Introduction

The mission of the California Wind Energy Collaborative (CWEC) is to support the development of safe, reliable, economic, and environmentally sound wind power in California. CWEC performs its mission through a program of engineering research, inter-sector coordination, and education. In doing so, CWEC directly supports the fulfillment of current state, federal, and industry goals for wind power.

In this document, we discuss CWEC's strategic plan within a five-year horizon, including a review of past activities, the framework for future efforts, and how those efforts fit with the Energy Commission's vision for renewable energy.

6.2 A Brief History of Wind Energy in California

With approximately 2.5 gigawatts of wind power, California currently has the third most wind capacity of any state in the USA. Wind generated electricity provides more than six billion kilowatt-hours of electricity to California ratepayers every year (Fig. 6.1).

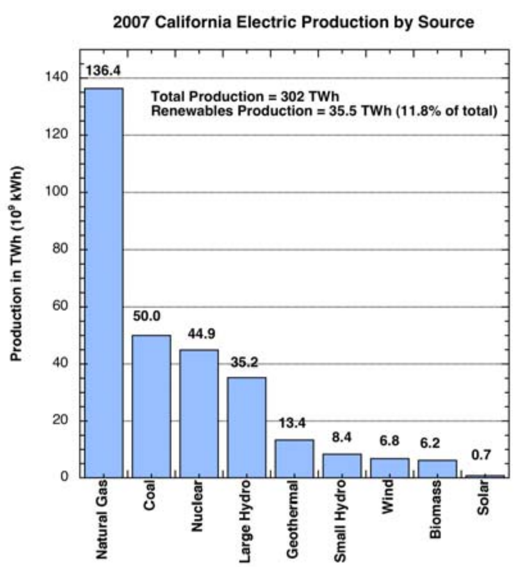


Figure 6.1. California electricity production by source for 2007. RPS eligible production (biomass, geothermal, small hydro, solar, wind) totals 35.5 TWh out of a total of 302 TWh or 11.8%. (Source: CEC-200-2008-002)

These impressive numbers belie a tumultuous history of wind power development in California. Wind developments occurred first in Asia, Europe, and other parts of the United States, but it was not until the early 1980s in California that the first modern wind plants were built. In early 1985, the installed wind-based electric power generation capacity in California was 535 MW. This rapidly increased to more than 1,500 MW by the end of 1990 (**http://ewprs.ucdavis.edu**). At the same time, the total U.S. capacity was only 1,525 MW and the total global capacity was 1,930 MW. Clearly, California was the global leader in wind energy (Fig. 6.2). Unfortunately, as interest in alternatives to fossil fuels faded nationally in the following years, the growth in California slowed and Denmark and then Germany took over the lead. As wind power technology matured and concerns over emissions and global climate change escalated, wind power began a revival in the United States at the end of the 1990's. By the end of 2008, total global capacity soared to 121,000 MW with more than 25,000 MW of this in the United States, including 2,500 MW in California. In 2006, with wind power garnering significant interest and attention as a viable energy source, California lost its leadership in the United States with most of the new capacity going into the Midwest and Texas, as shown in Fig. 6.3.

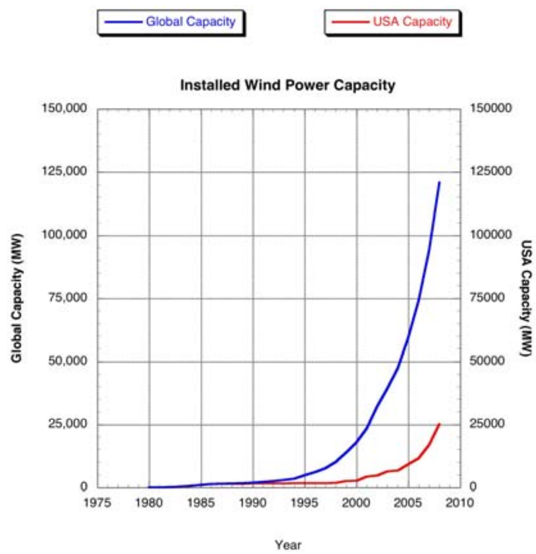


Figure 6.2. Installed wind-based electric power capacity in world and USA.

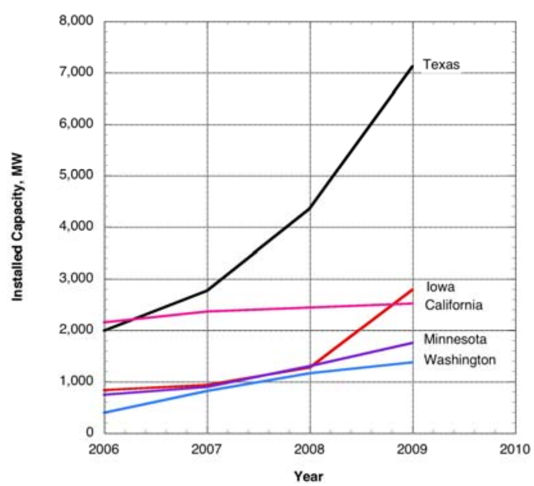


Figure 6.3. Recent growth in installed wind power in states with most capacity.

6.3 California Wind Energy Collaborative: An Historical Perspective

Wind power in California is built through the products and work of numerous contributors. They include domestic and international industry, agencies and offices at all levels of government, large and small utilities, research labs, academia, and many more. A few of these entities work cooperatively, some are competitive, and most simply work relatively independently, with little coordination among one another. California's wind resources could provide up to four times the present wind generating capacity. Developing these wind resources successfully into reliable, valuable, economic, and environmentally sound contributors to the state's electricity system requires coordination among all of these entities.

The California Wind Energy Collaborative was established in 2002 to meet this need for coordination with a statewide perspective. Its mission is to support the development of safe, reliable, environmentally sound, and economic wind power within the state of California. To fulfill this mission, it manages a focused program of scientific research, education, and coordinative activities. These efforts are conducted in close cooperation with the many contributors to wind power in California – commercial, government, and academic – with specific focus on California issues and California based industry to maximize the benefits of the state's wind energy resources for its citizens (Fig. 6.4).

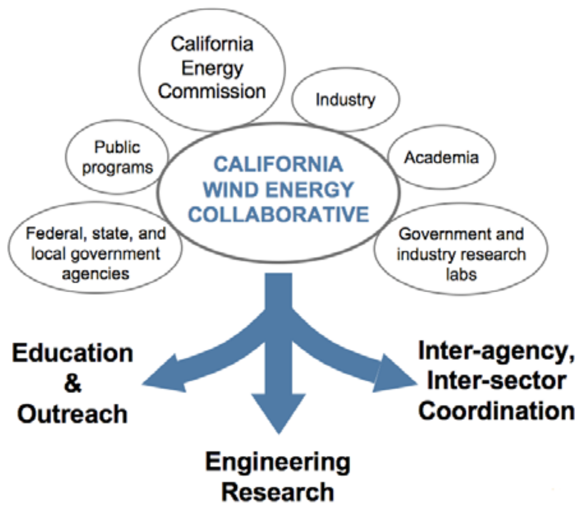


Figure 6.4. The California Wind Energy Collaborative works with a diverse set of entities to support California's wind industry. CWEC's activities can be categorized into three strategic areas: research, education, and coordination.

CWEC is a partnership of the University of California and the California Energy Commission. The California Energy Commission has long recognized the importance of wind energy. It supports research and development in renewable energy including wind through its Public Interest Energy Research (PIER) Program. The University of California, particularly UC Davis, has a history of wind energy related efforts dating back more than twenty-five years. Several of UC Davis' faculty have been working with industry, national laboratories, and other universities on a wide range of wind energy related problems. Many of its graduates have prominent positions throughout the wind industry.

6.4 CWEC Past Activities

Since its inception in 2002, CWEC has engaged in numerous activities. A selection of these activities is briefly discussed below. As shown in Figure 6.4 and discussed further in Section 6.6 our work can be roughly categorized into three strategic areas: research, education, and coordination. Details on individual efforts are available on the CWEC website, **http://cwec.ucdavis.edu**.

6.4.1 Research

CWEC's research activities are divided into four branches: development, conversion technology, grid integration, and operation. These are briefly listed in each subsection below and discussed at greater length in Section 6.6.

6.4.1.a Development

Development, in this context, refers to the development phase of wind plants, during which planning, economic assessment, engineering, procurement, and construction occur. Our work here has focused in two areas, wind resource assessment and permitting. We have performed numerous studies on anemometry; studied the wind resource on and around buildings in an urban environment; examined the physical and engineering bases behind obstruction lighting and setback requirements; surveyed the issues behind repowering California's aging wind fleet; and supported efforts to streamline permitting for small wind systems.

6.4.1.b Conversion Technology

Our work in energy conversion technology has focused on blade/rotor analysis and design, drawing upon our core strengths in aeronautical and mechanical engineering. Our efforts have paralleled advanced research by major wind turbine and blade manufacturers and have been received with significant interest by industry. Projects have included the DOE/Knight & Carver *Sweep Twist Adaptive Rotor* (STAR) blade (passive load alleviation), the DOE/TPI *BSDS* flatback blade (novel airfoil and blade design), and an ongoing series of computational and wind tunnel studies on active load control with Sandia National Laboratories. These efforts have yielded improved modeling tools for in the public domain (CurveFAST), a blade set on a utility scale turbine currently undergoing field testing (STAR), and another blade set nearing completion (BSDS flatback).

We have also worked with a number of companies and agencies, providing technical reviews of turbine and turbine subsystem concepts.

6.4.1.c Grid Integration

CWEC has played key roles in California's ongoing series of grid integration studies. We led the first effort to quantify wind integration impacts, the *California RPS Renewables Integration Costs Study*. This was one of the first of such studies in the nation. We provided coordination and support for the follow-on study, the *Intermittency Analysis Project* (IAP), which has become a model for integration studies for many other states/control areas.

We have also looked at integration issues at a smaller scale, including a series of studies on spatial and temporal wind power generation trends across California and a detailed examination of wind plant data for a small control area. We maintain the *Electronic Wind Performance Reporting System (WPRS)*, a public database of California wind plant performance statistics. The WPRS was initially intended to support development (specifically, financing) of new wind plants, but has become an important open data source for looking at integration issues.

Forecasting is widely recognized as a key factor to integrating high levels of wind. We have studied forecasting including a methodology coupling mesoscale numerical modeling with results from atmospheric boundary layer wind tunnel experiments. Currently, we are working with the California ISO to look beyond forecast generation, at how forecasts are integrated into day-ahead and hour-ahead system operations to facilitate the incorporation of wind energy into the market mechanisms.

6.4.1.d Operation

Operation, in this context, denotes wind plant and wind turbine operation and ownership issues. Some of our activities categorized above as Grid Integration overlap with Operation. Our experience mining large datasets for integration studies has provided an excellent springboard for studying operation issues. This is discussed further in Section 6.6.

6.4.2 Coordination

As a university based organization, CWEC enjoys a certain neutrality, allowing us to provide impartial coordination between many entities and sectors. We leverage this position to address California's wind power issues, most visibly through the California Wind Energy Collaborative Forum. The Forum is our annual symposium to discuss wind power in California. Since 2002, we have held it six times, with session topics such as the Renewables Portfolio Standards, grid integration and intermittency, barriers to development, transmission constraints, advanced turbine technology, technical training, and more. For more information, see **http://cwec.ucdavis.edu/forum**.

We also conduct focused workshops to address specific topics. These have included the Wind Energy Research Plan Workshop for California to collect input toward building a research agenda for the state and the Small Wind Workshop to discuss hurdles to small wind development in California.

Finally, and perhaps most importantly, we convene an advisory board to steer our activities at a strategic level. The advisory board comes from many facets of California's wind landscape: state agencies, federal labs, developers, utilities, manufacturers, and more.

6.4.3 Education

Education is a natural fit to CWEC's priorities given our basis at UC Davis. We regard education as a critical component to ensuring long term success in the wind industry. We engage education at multiple levels, from higher education to technical training to public outreach.

At UC Davis, we have established a graduate level course on wind power engineering. It is a ten-week course providing a technical, engineering overview of wind energy, including topics such as aerodynamics, structures, electrical systems, controls, grid integration, and project development. The course hosts many industry experts as guest lecturers. To date, we have offered the course three times.

In technical training, we directly teach courses and support the development of programs at the California Community Colleges. We offer *Wind Energy: A Technology and Industry Primer* (**http://cwec.ucdavis.edu/training**), a two-day course providing a comprehensive, technical foundation on wind power. This course was initially targeted toward existing wind plant technicians, but it has garnered significant interest form prospective technicians, business office personnel, financiers, engineers, contractors looking to enter the wind industry, and others. To date, we have made three offerings.

We also support the development of full technician training programs at the California Community Colleges. In 2007 and 2008, we traveled throughout the state, addressing community college faculty and administrators to garner campus level support for training programs. We also acted in an advisory capacity and continue to do so, communicating with campuses that have initiated programs.

We have also actively supported K-12 education, partnering with the National Energy Education Development (NEED) program in local workshop for grade school educators. For the general public, we offer *Small Wind Energy Systems* (**http://cwec.ucdavis.edu/smallwind**), a one-day course targeted at prospective small wind system owners. The course covers the science, economics, and ownership issues of small turbines. To date, we have offered it five times.

In addition, we informally provide technical assistance and general information as requested. We have assisted officials and agencies at all government levels, other universities, established and emerging companies, students, job seekers, and concerned citizens.

6.5 Current Policy Drivers for Wind Power

The energy policy targets of California are summarized in Fig. 6.5. The key policy for wind power is the Renewables Portfolio Standard (RPS), requiring that 20% of electric energy from investor owned utilities (IOUs) come from renewables by 2010 and targeting 33% by 2020. In 2007, wind provided 2.2% of the total generation and the other renewables (biomass, geothermal, solar, small hydro) generated an additional 9.6% (Fig. 6.1). In 2008, these percentages slightly improved, mainly because of a drop in electricity demand. From these numbers it is clear that more renewable energy must be developed for the utilities to meet the RPS goals.

In 2008, the U.S. Department of Energy (DOE) published a report that examines the technical feasibility of wind generating 20% of the electric used in the U.S. by 2030. The report, titled “20 Percent Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply”, identifies requirements for achieving this goal including reducing the cost of wind-based electric energy, installing new transmission infrastructure, and enhancing domestic manufacturing capability. At the start of 2009, a total of 25 GW of wind was installed in the U.S. (Fig. 6.2) where it is estimated that an additional 280 GW is required to meet the 20% wind energy goal by 2030. In the 20 Percent Wind Energy by 2030 study, California is listed to have the potential of more than 10 gigawatts or more than four times the current capacity.

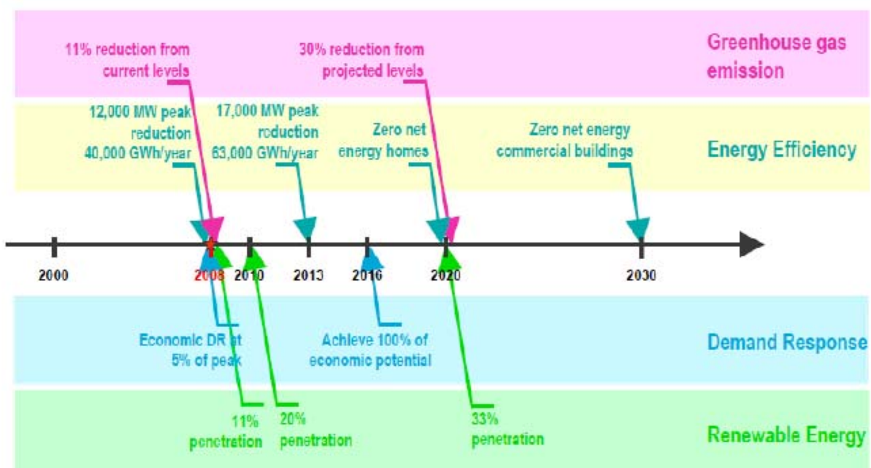


Figure 6.5. California energy policy targets (Source: CEC/PIER)

In the following sections the strategic plan for the California Wind Energy Collaborative is outlined. One reason for developing this plan is to assure coordination of research to meet PIER and Integrated Energy Policy Report (IEPR) goals, especially as they relate to the three renewable energy deployment venues of the PIER renewables program; renewable energy secure communities, renewable energy secure building, and utility-scale renewables. However, the PIER renewables program has limited funds and is unable to support activities across the entire wind energy research spectrum. Also, because PIER is focused on energy RD&D, it may be unable to fund activities in areas such as training. Hence, the second reason for developing this plan is to establish a roadmap for CWEC that goes beyond the PIER and IEPR goals.

6.6 Strategic Plan

As indicated in Figure 6.4, CWEC categorizes its activities into three strategic areas: coordination, education, and research. All three areas are critically important to successfully growing wind power in California. They therefore directly support the fulfillment of CWEC's mission, state policy mandates, and federal wind energy goals.

The following sections outline priorities for work in each of the strategic areas within, approximately, a five-year time horizon.

6.6.1 Research

As part of the University of California, Davis, CWEC's research capabilities are extensive. Starting with a strong foundation in aeronautical and mechanical engineering, we have engaged in a diverse range of wind-related projects (see Section 6.6). Our efforts can be coarsely divided into four branches: development, conversion technology, grid integration, and operation. Note that these branches are not mutually exclusive. Forecasting, for example, has applications during wind plant development, in grid operations, and in wind turbine operations and maintenance. Work on such a research topic could therefore yield far-ranging benefits to the industry.

The California Energy Commission employs a different strategy for categorizing research, using deployment venues: buildings, communities, and utility-scale. Our approach, while markedly different, is complementary. Many of the individual efforts below are focused on utility-scale generation, but are applicable to all venues.

Our research priorities are summarized in Figure 6.6 and detailed further below. Within each branch/subsection, topics are roughly prioritized based on industry and policy relevance and propensity with CWEC's capabilities and experience. The lists are long, but the breadth enables us to flexibly meet the current economic reality of research funding. It may not be possible to secure long term funding for a select, few research topics. However, by considering our broad base of competencies, we can respond to a variety of funding opportunities as they arise. Of course, as we progress, we will attempt to narrow the focus on a limited number of topics, building upon work that we complete.

6.6.1.a Development

Development, in this context, refers to the development phase of wind plants, during which planning, economic assessment, engineering, procurement, and construction occur. Our efforts will focus in two areas: wind resource assessment and permitting.

6.6.1.a.1 Wind Resource Assessment

Because the power in the wind is proportional to the cube of the wind speed, inaccuracies in wind resource assessment result in disproportionately large errors in power. This directly affects both energy production and the loads imposed on wind turbines. Accurate wind resource assessment – both spatially and temporally – are therefore critical to assure that wind plants perform and function as expected.

The industry has established practices and standards for computational wind modeling and on-site anemometry. However, they fail to fully characterize wind resources in several ways, some of which are becoming increasingly important as turbines move into new environments and grow larger and taller. To improve the accuracy of wind resource assessment, CWEC will conduct study on several topics, using computational modeling, wind tunnel testing, and field experiments. These topics include:

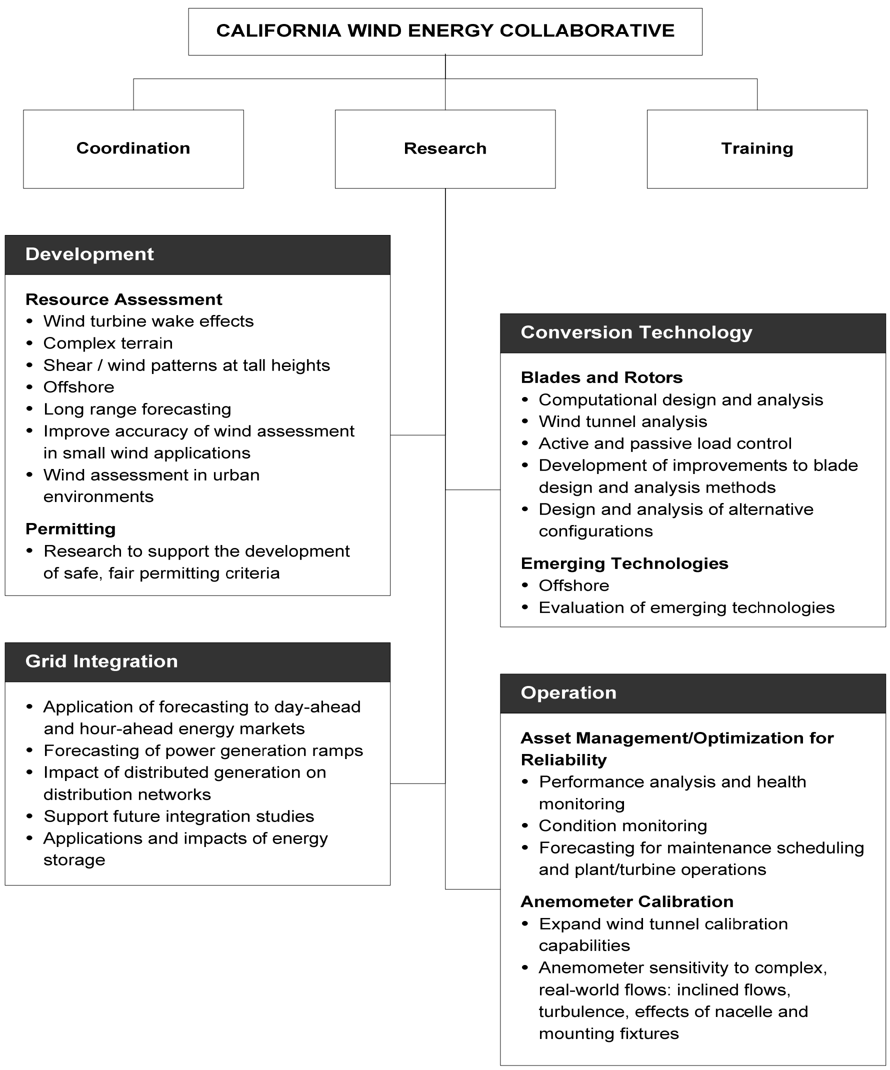


Figure 6.6. CWEC research priorities. A broad range of topics allows us to pursue a variety of funding opportunities as they arise.

Complex terrain: Currently, the industry uses relatively simple assumptions and models to estimate the wind flow field across a wind plant. This can be adequate for simple terrain, as in the Great Plains. However, California's best wind resources are located in mountain passes with complex terrain. In such terrain, the wind can vary significantly over relatively short distances and heights. Turbulence can be very high, impacting both energy capture and the life of wind turbines. Further complicating this matter, the wind through these passes can be driven simultaneously by different mechanisms (sea breezes and mountain winds), resulting in different kinds of winds from different directions at the same time. CWEC already has experience studying wind in complex terrain.

Wake effects: With regards to wake effects, turbines in wind plants require large spacings in the predominant wind direction to minimize performance losses and negative unsteady blade loading effects for downwind turbines. For large utility scale wind turbines, a typical spacing of 10 rotor diameters results in a substantial area of land that becomes unavailable for wind energy generation. Research on off-shore installations has shown that depending on the plant layout, wind direction and atmospheric conditions even larger spacings may be required to sufficiently mitigate these wake effects. However, very little research has been conducted on wake effects in large on-shore installations. When turbines were small (rated power much less than one megawatt) a loss of a few percent in power output due to wake effects was often not very noticeable. But, for a state-of-the-art multi-megawatt turbine, a loss in power output of a few percent due to wake momentum losses translates into a significant amount of lost revenue and the related unsteady flow and aerodynamic loading translates into increased maintenance and reduced lifespan. The resulting negative impact on the cost of energy makes wind less competitive and will make it more difficult to achieve the renewable energy goals.

Shear: Current industry practice uses very simple models for shear, the change in wind speed with height. Shear adversely affects blade loading and, subsequently, wind turbine life. As turbines grow taller and rotors grow larger, shear becomes more pronounced, including directional changes. CWEC will study shear at tall heights in California's wind resource areas and compare it to ongoing studies in other regions.

Offshore: Despite numerous complexities, offshore wind power has retained attractiveness because of the excellent wind resource over water. In recent years, interest in offshore wind applications has grown, driven by continuing improvements in wind power technology and the emergence of supportive policies. California has an excellent offshore wind resource. Focused study is required to properly quantify and characterize this resource.

Urban wind: The complexity of the wind resource becomes even more significant in the urban environment as demonstrated in a recent CWEC study (Fig. 6.7). The wind tunnel based study focusing on the feasibility of wind-based power generation in urban settings shows that each building has its own specific set of wind characteristics, leading to the conclusion that testing of specific sites is recommended if it is desired to locate wind turbines on existing buildings or incorporate wind turbines into a building's design.

Figure 6.7. Wind-tunnel test setup for urban wind resource assessment.

6.6.1.a.2 Permitting

California is somewhat notorious for its stringent permitting requirements. As a result, many developers have shifted their focus to other states with less demanding requirements. In California permitting requirements are dictated locally, generally at the county level with zoning codes, with variations occurring in the state. Because of their long and extensive experience working with wind, California counties such as Kern, Riverside and Solano generally have clearly delineated regulations. However, as wind projects are initiated in parts of the state with little or no experience in wind energy, larger variations in requirements are likely to occur. This may further slow down wind energy development and increase cost. CWEC will continue working with counties throughout the state in their efforts to develop wind ordinances that are transparent, protect the environment, and provide the necessary safety.

6.6.1.b Conversion Technology

Wind turbine technology has matured significantly since the first utility-scale wind plants almost thirty years ago. However, to meet state and federal policy goals, the reliability and economic marks for wind power, although already viable, must be improved further through continuing technological advancements. Within the context of this discussion, conversion technology includes all of the wind turbine and wind plant, from the blades and rotor through the collection system.

The growth in wind energy can be in large part attributed to its competitive cost of energy in comparison to traditional energy sources. Wind energy is consistently cited as being on par with the cost of electric power generation by natural gas, with none of the cost volatility associated with fossil fuels. Modern utility scale wind power started with relatively small and expensive turbines in the 1980s; since then, the cost of energy has dramatically decreased and wind turbines have increased markedly in size. The larger turbines benefit from increased wind power capture through a much larger rotor and from increased wind speeds at the higher hub height. However, the benefits of larger diameter rotors potentially come with increasing wind turbine cost and, hence, cost of energy. Wind power capture is proportional to the square of rotor diameter. Rotor volume – and therefore mass and cost – is proportional to the cube of diameter. Therefore, if all dimensions remain proportional as a rotor is grown in diameter, its mass and cost increase will outpace its increase in power capture.

To keep cost of energy down, mass and stress increases must be carefully managed as rotor diameters grow. This can be achieved through various passive and active load control technologies, ultimately allowing wind turbines to achieve higher capacity factors while limiting cost increases. As discussed in Section 6.4 we have existing experience in passive control of loads and stresses through the application of sweep-twist blade technology (Fig. 6.9) and thick blunt trailing edge (flatback) airfoils in the inboard blade region (Fig. 6.8). Co-developed by CWEC and its industry partners, both technologies show significant promise. We are also engaged in an ongoing series of work on active control systems with devices that locally and rapidly modify blade loading to mitigate fatigue. We will continue to research and develop these and related technologies.

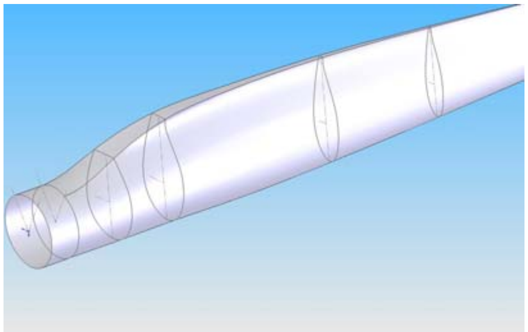


Figure 6.8. DOE/TPI BSDS (Blade System Design Study) blade with inboard flatback section shape, co-developed by UC Davis/CWEC.

Figure 6.9. DOE Knight & Carver STAR (Sweep Twist Adapted Rotor) blade design in field testing in Tehachapi. Co-developed by UC Davis/CWEC.

6.6.1.c Grid Integration

Since the turn of the decade, much of the focus around wind power has shifted from how wind makes electricity to how that electricity gets delivered to the end user. In the context of this discussion, grid integration encompasses all the pieces beyond the wind plant collection station, including the transmission grid, distribution networks, grid/system operations, and power markets.

Our past grid integration work – in concert with a large body of other work performed in the past five years – has shown that large amounts of wind power can be successfully integrated into electric control areas, despite the inherent variability in wind. However, the details of doing so – particularly at the high penetration levels required to meet policy goals – is nontrivial.

We will continue to support ongoing integration studies, contributing our knowledge of California's wind resources and our experience with the datasets needed to drive these studies. We foresee several specific areas of research emerging further in the coming years. First, we will need to look at integration at lower, more specific levels. Instead of just quantifying impacts, we will have to employ system operational/control room strategies to address them. Second, energy storage has emerged as a topic of significant and growing interest. Energy storage plays a part in achieving high wind penetration, but its importance seems to be overstated despite general consensus among integration studies that only a limited amount is needed. Of even greater concern, energy storage is still attributed to the need to "firm up wind", while studies show that its most economical application is as a grid-wide asset. Third, while extensive focus has been committed toward grid level impacts, little research has been done on future distribution networks. Future scenarios reveal more heavily taxed distribution networks with higher electricity demand, more distributed generation, and large numbers of electric/hybrid electric vehicles. Specific modeling and analysis will be needed to quantify the effects of these coming changes.

6.6.1.d Operation

Wind plant operation was once very straight-forward – operators maximized energy generation, running their machines as much as possible. Maintenance was performed as needed. The emergence of megawatt-scale machines changed this simple approach. With each turbine representing a multi-million dollar investment, owners and operators began to look at long term returns instead of just immediate energy capture. CWEC's research interests in operation are discussed below; in this context, operation denotes optimizing the operational performance of wind projects in terms of energy capture, availability, operations & maintenance (O&M) cost, and turbine life.

Considering the cost, complexity, and intended life spans of wind turbines, it is obvious that proper operation and management of a wind plant is essential to realizing its value. Indeed, asset management has become a major topic within the wind industry in recent years, discussed among manufacturers, owners, O&M providers, and government labs.

From the plant owner's perspective, the ultimate goal is simple – to minimize the cost of energy. But it is a difficult optimization, with multiple factors to consider that are frequently in opposition: (1) maximizing energy production, (2) minimizing downtime, and (3) maximizing life. Energy production is important because it is synonymous with revenue production. It is not just a linear relationship; with power purchase agreements that include capacity payments, energy produced at certain times can be worth much more than at others. Downtime negates the possibility of energy production. In the past, the outage of one turbine could be insignificant because its power and revenue generation were small on an absolute scale. With modern, multi-megawatt turbines, this is no longer so. Unscheduled outages can be particularly detrimental, as they can easily become lengthy as a result of delays caused by the lack of replacement components, limited availability of repair equipment (cranes), and weather conditions that prevent repair work. Maximizing life is perhaps the least intuitive consideration, as it occurs over a very long timescale. Wind turbines are reliability-based machines with finite lives limited by the fatigue they accumulate over years of continuous operation. Fatigue cannot be directly measured, but it is very important because of, once again, nonlinearities. Operating in adverse conditions briefly can irreversibly shorten the life of a turbine by a period of time many times longer.

We see a broad array of opportunities associated with asset management including performance analysis through data mining, condition monitoring, modeling for predictive maintenance, and more. These topics leverage our aeronautical/mechanical engineering strengths and data mining experience from our grid integration studies.

Accurate wind measurements are critical to monitor, evaluate, and control wind plants and wind turbines. These measurements are typically made using devices that determine the wind speed from the rotational speed of a small rotor (cup and propeller anemometers, Fig. 6.10) or through ultrasonic pulses and application of the Doppler effect (sonic anemometers). Recognizing the importance of precise wind measurement, the industry has largely moved to using only calibrated anemometers. However, there remains room for improvement for anemometer accuracy. First, anemometers deteriorate over time, requiring periodic recalibration and maintenance. We have taken first steps toward addressing this issue toward our study on anemometer calibration procedures; we will continue to pursue this issue.

Second, a laboratory calibration of an anemometer may still not yield accurate readings in field installations because of flow effects from surrounding terrains and bodies, including the mounting body and fixture. Further study of these effects and other anemometry issues will provide benefits not only in operation of wind plants, but for plant development, too.

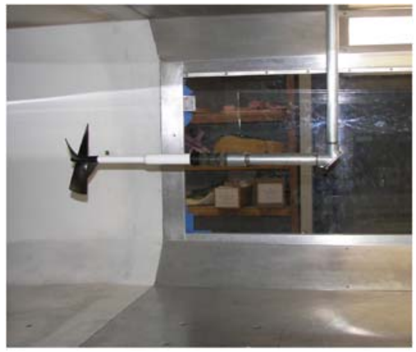


Figure 6.10. Propeller anemometer in wind-tunnel calibration facility.

6.6.2 Coordination

CWEC will continue to provide statewide coordination to discuss current issues, guide future research, and address problems facing the wind energy industry in California. It will continue offering regular Forums to bring together the wind power community and will continue hosting Board meetings to gather feedback and suggestions for future focus areas. Topic-specific workshops will also be utilized to address specific issues. In the near term, CWEC is organizing a workshop for state and local government officials to present the barriers to wind energy development in the State and to discuss possible solutions and remaining concerns.

With the formation of the UC Davis Energy Institute and grouping of the California Renewable Energy Collaboratives (i.e., wind, biomass, geothermal, solar), CWEC is positioned to better coordinate with other renewable energy collaboratives on joint issues affecting the growth of renewable energy in the State.

In summary, CWEC's coordination efforts will focus on:

- Continue hosting Forums, Advisory Board meetings, and workshops
- Lead effort to provide a vision for the future of wind energy in California
- Identify RD&D required to support deployment
- Facilitate collaboration among research sponsors
- Coordinate with other renewable collaboratives (biomass, geothermal, solar, etc.)

6.6.3 Education

Within the past year, public interest in renewable energy has grown substantially, spotlighting CWEC's efforts in education and outreach. As we look into the next five years, education will remain a core piece of CWEC's mission. As previously we look at education in three areas: higher education, technical training, and outreach.

In higher education, we will continue with our graduate level Wind Power Engineering course. Wind Power Engineering already draws heavily upon industry experts as guest lecturers. In the coming year, we will explore collaborations with other universities with wind power focuses. This would bolster our existing course and, possibly lead to new offerings, too.

Of all education areas, technical training has received the most attention in the past two years. Our short courses have provided valuable entry points for many companies and individuals looking to start in the wind industry. We will continue to offer this course, tailoring it as demand evolves. We will also remain supportive of the California Community Colleges' and other technician training programs.

Last, the Collaborative will continue its outreach efforts to the general public. While this area may not have a direct impact on the industry, we believe that we are a vital link between the public and current, correct information on wind power. To do this, CWEC will continue to teach topical short courses, support K-12 programs, provide technical assistance, conduct studies and publish findings, disseminate information through our website, and participate in relevant lectures, seminars, and workshops.

In summary, CWEC's education and outreach efforts will focus on:

- Higher Education
  - Teach university level courses on wind energy
  - Explore collaborations with other universities with wind programs

- Technical Training
  - Offer wind energy technical training short courses as appropriate
  - Support technician training programs

- Outreach
  - Teach short courses (e.g., small wind systems) as appropriate
  - Support K-12 wind energy programs
  - Provide technical assistance when appropriate
  - Further utilize our website to provide general information to the public
  - Conduct studies and publish findings
  - Participate in relevant lectures, seminars, and workshop on wind energy
  - Respond to general public inquiries

7. CALIFORNIA CROSS-CUTTING RENEWABLE ENERGY SYSTEMS INTEGRATION PROGRAM

7.1 Introduction

As enumerated above, the strategic challenges faced by the collaboratives in the four technology areas (biomass, geothermal, solar and wind) are unique to the state of development of each technology, as well as to the organizational structure and history of each collaborative. There are, in addition, a number of challenges common to each technology area ("cross-cutting" challenges). These topics could, in principle, be addressed by the collaboratives separately, but doing so would result in significant duplication of effort, inadequate coordination of complex technical issues, and the likelihood of conflicting results. It is imperative, in the interests of efficiency, cost reduction and timeliness, that the effort to address these "cross-cutting" challenges be undertaken within a single, focused structure. This is particularly true when the success of the collaboratives is viewed from the perspective of the deployment venue approach being pursued by the Commission. The technology area collaboratives have designated a "cross-cutting" effort that will coordinate these efforts.

After considerable discussion, four areas in particular need of urgent action were identified. These are discussed below. These areas are presented in the interest of suggesting the breadth of the subject matter this cross-cutting program must consider, but are not intended to be inclusive. We anticipate other topics will become of interest as technologies mature and evolve. Furthermore, no attempt is made at this point to suggest a strategic plan for addressing these issues. Rather, we anticipate that, as the cross-cutting program develops, it will take on the task of developing a strategic plan, based on the views of its members as well as on the issues that, at the time, are imperative to address.

One of CREC's major contributions is to anticipate needs that may not yet be fully addressed by state policy. Are the four urgent needs discussed below already on the policy radar screen? In three cases, i.e. energy storage, infrastructure integration and permitting, they are, as evidenced by the summary discussion of renewable energy policy drivers in the recently released 2009 Integrated Energy Policy Report.[6] In the fourth

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[6] *"In November 2008, Governor Schwarzenegger raised California's renewable energy goals to 33 percent by 2020 in his Executive Order S-14-08, and in September 2009, Executive Order S-21-09 directed the Air Resources Board to develop regulations by July 31, 2010, for a 33 percent Renewable Energy Standard…*

*…Significant **energy storage** will be required to integrate future levels of renewables, thus allowing better matching of renewable generation with electricity needs. These technologies can also reduce the number of natural gas-fired power plants that would otherwise be needed to provide the characteristics the system needs to operate reliably. However, many **storage** technologies are still in the research and development stage, are relatively expensive, and need further refinement and demonstration….*

*…Governor Schwarzenegger's Executive Order S-14-08… (requires state) agencies to implement specific measures to accelerate **permitting** of new renewable generation and the **transmission facilities** needed to*

case, ocean-based resources, there are a number of questions in need of answers before policy makers can weigh in. They are questions CREC can help answer.

7.2 Subject Areas

Certain emerging topic areas are beginning to be more comprehensively addressed by the collaboratives through the Integrated Renewable Energy Systems (IRES) program implemented in the California Renewable Energy Collaborative (CREC). Early research agendas that were geared more toward near term renewable energy deployment are now driven by policies anticipating high penetration deployment that will be necessary to achieve AB 32 goals. In high penetration scenarios it becomes important to consider not just the utility scale deployment venue but also the community and building scale venues. Likewise, it becomes necessary to explore options to tap more abundant resources than would need to be considered based on current relatively near term goals. For example, ocean-based energy resources off the California coast are not only adjacent to the highest concentrations of California population and load but also quantitatively and qualitatively superior to comparable on shore resources. Engineering and environmental challenges are significant, however, and ocean energy is one area the Collaborative is considering adding to the areas addressed. The topic areas below are not prioritized. Instead, they are presented as an indication of the breadth of topics that must be addressed by cross-cutting efforts.

7.2.1 Energy Storage Technologies

Each technology area faces the challenge of storing energy. Because of variations in load and intermittency, it is a common problem that excess energy conversion will occur throughout a generation cycle, whether it be on a diurnal, monthly or seasonal scale. Substantial research and development efforts are underway to find cost-effective means for storing this energy. It is likely that there will be unique challenges in each technology area, with regard to energy storage requirements, but it is also likely that there are many common challenges that could be most efficiently addressed through coordinated R&D. To most efficiently bring to market the solutions to this challenge within the context of RESCO, USRE and RESB venues, the cross-cutting systems integration program will be the entity within CREC that will address this task.

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*serve that generation. These measures include the elimination of duplication, shortened **permitting** timelines, and planning processes such as the **Renewable Energy Transmission Initiative and the Desert Renewable Energy Conservation Plan** that balance clean energy development and conservation….*

*…The Energy Commission will conduct further analysis to identify solutions to integrate increasing levels of energy efficiency, **smart grid infrastructure**, and renewable energy while avoiding infrequent conditions of surplus generation, or over-generation, in which more electricity is being generated than there is load to consume it…"*

7.2.2 Ocean and Wave Energy

There is considerable interest within the research and industrial deployment communities to pursue energy conversion in the marine environment. Thermal gradient, wave and current energy conversion technologies have been and are being developed, and could have important impacts within the state of California. Much of the research and development in these areas have implications for the other renewable technologies. This area is the subject of a proposed new technology collaborative as a companion to the biomass, geothermal, solar, and wind collaboratives. A new hydro/ocean energy collaborative will provide a venue for the stakeholders in this research area, to assure that adequate communication of needs and results can take place efficiently, and in a way that is supportive of the success of all of the collaboratives. The need for establishing a new collaborative in this area will be addressed initially through the systems integration program.

7.2.3 Integration of Infrastructure, Including Transmission and "Smart Grid" Challenges

Transmission continues to be a daunting challenge that all of the renewable energy technologies must resolve. Changes in grid management, particularly the inevitable deployment of "smart grid" capabilities, will provide important opportunities and challenges to each renewable technology because of their individual unique characteristics. As well, growing interest in distributed generation requires thorough consideration of the technical and resource characteristics of each renewable technology and the challenges they pose for a stable grid. Transmission and similar infrastructure development will be a key area within the systems integration program.

7.2.4 State and Federal Policies and Incentives, Including Permitting

In many areas, such as multi-agency permit jurisdictions or disparate incentive structures, the ability to bring to market a conversion technology can be hampered. Identifying ways in which permitting can be made more transparent, streamlined, coordinated and improved for the renewable technology areas would benefit the state, the consumer and the market. In addition, better coordination of incentive policies (reducing complexity, better analysis of outcomes and impacts, improving short- and long-term stability of incentives) could help accelerate bringing renewables to market. These issues will all be subject to investigations within the systems integration program.

8. CREC STRUCTURE/OPERATIONS

The previous sections outline the strategic plans for the individual renewable conversion technologies as well as a cross-cutting system integration activity. This final component of this strategic plan addresses the structure and operations of the California Renewable Energy Collaborative (CREC) as administered by the UC Davis Energy Institute in the future, with the intent of optimizing the ability of CREC to contribute to the three renewable energy venues.

The UC Davis Energy Institute is, by its establishment within the UC, constrained to operate within the university structure. To achieve the vision of being the research, concept validation, and incubation partner of choice in the sustainable, clean tech industry, the EI and the CREC must have the opportunity to expand activities. One approach that is under consideration is integration of a business-like framework into the current research-oriented culture. Outlined below are some of the considerations that would have to be addressed if such an approach were pursued. Other approaches will also be considered, as they are proposed.

8.1 Requirements

CREC currently is organized as a consortium of resource collaboratives and an integration program funded principally by a single sponsor, the California Energy Commission, and executed by the University of California (UC) through an interagency agreement with UC Davis.. The work is divided into main tasks and deliverables associated with each collaborative and program. The university executes projects through the agency of faculty and students. Funds are applied primarily to labor costs and overhead. However, CREC does not receive an allocation of the overhead funds with which to develop and maintain the organization, e.g. at the most rudimentary level, permanent staffing, office space, web-site development and operations, internally funded travel, development of initiatives and proposals.

Further, and very importantly, because the sponsor’s mission is science and technology advancement, funding for other collaborative services is inadequate, e.g. for outreach, coordination, new program and project development and meaningful participation in an ever-proliferating array of proceedings conducted by the four or five state agencies now addressing renewable energy issues. For example, CREC does not actively engage with the RETI process, and its participation in proposals for stimulus funding was limited.

By contrast, a consulting organization with a comparable span of expertise would have a much higher ratio of overhead to direct costs and would spend a great deal more time and effort engaging with clients and potential clients. The degree of interaction even between CREC staff and Commission counter-parts is so far extremely limited. This would certainly not be the case if CREC were a business with the Energy Commission as its primary client.

So, there is reason to look at alternative models for further CREC development. We believe that business principles do apply, to the extent they are actively applied in the development and management of many other not-for-profit organizations serving the public interest. CREC needs to consider adjustments in order to:

1. Organize and structure like a business while retaining an independent and impartial status in service to the public as well as other stakeholders
2. Integrate a business culture with a research/academic culture
3. Attract and retain the best research and business talent

Organizing and structuring the CREC like a business implies the ability to identify business opportunities, develop market competitive solutions, commercialize the solutions, protect the intellectual property, and to retain the profits. However, the current structure does not enable monetizing the economic value of invention or research coming from the CREC for the purposes of sustaining CREC operations. The extent to which this is possible, and how best to implement such an approach, will be explored in the future.

Possibilities include developing a non-profit 501(c)3 entity, establishing a research-focused foundation enabling individuals and corporations to make donations to further research in renewable energy areas of interest, and other organizational structures that would allow monetization and retention of profits for CREC activities. These structures will enable the world-class capabilities that currently exist at UC Davis, UC San Diego, and other university partners to expand in scope to be highly relevant and influential across the globe. Examples of comparable university structures will be identified and analyzed.

Assuming the financial management challenge is resolved, one must recognize the cultural shift this will present to University leadership, CREC leadership, and to the staff. Today, the predominant culture is one of a research institution, with some elements of business integration. The University is organized in this manner but other elements within the Energy Institute are more directly focused on business and commercialization ventures. In the new vision, research will, in some instances, become the first step in the creation of a commercial enterprise. Evolving the existing mindset and accepting that change as part of the new culture will require time, emphasis, and training of existing leaders and staff.

Part of this culture shift will be the introduction of active, wide-spread recruitment of the world's best talent. The CREC must create an environment and a compensation package that will be attractive to these individuals and their families. This will likely require revisiting the entire compensation structure within the CREC, as existing compensation packages may not compare well with those required to bring in the desired skill sets and experience.

In this particular model of how CREC could be structured, there are numerous other requirements beyond the three requirements discussed above that CREC will face in its mission to achieve its vision. The balance of the requirements and steps in the process will be detailed in the planning process once a specific organizational model is identified and accepted.

The particular approach outlined above directly aligns with the long-term vision for CREC outlined by the CEC PIER R&D Committee:

- Level PIER commitment over next four years
- Diversify funding base
- PIER funding for research on policy driven issues
- Utility and DOE co-funded research addressing RE technical integration issues
- Industry/agency stakeholder co-funded research addressing technology/market barriers
- World-class RE research by CREC teams.

We anticipate identifying other approaches that may equally well-align with the approach discussed here. The selection of a specific strategy will be based on further analysis of the comparative advantages of specific approaches.

8.2 Entity and Operating Structure

The current CREC structure is consistent with goals of management efficiency and increased coordination among the CREC units and programs. Each is under the technical and administrative leadership of a director or directors appointed by UC in consultation with the Energy Commission, each is conducting comparable R&D tasks and each is pursuing comparable outreach and coordination goals. Changing the CREC entity and operating structure would not alter core functions of the individual units, their directional autonomy or the process by which they collaborate and reach consensus decisions on matters that affect them all. Rather, the approach outlined above would enable each to achieve staffing "critical mass" and stability and also would facilitate the goal of broadening the resource based of each unit and CREC as a whole.

The laws governing the research and non-profit operations of California universities are complex and have important impacts on the management and flow of funds. The approach outlined above provides one option for resolving these challenges. Other approaches will be considered as they are proposed.

If the adopted approach were to develop a non-profit entity, its mission could be to partner with entrepreneurs to commercialize research, products, and services developed at the University or in conjunction with one or more business partners. It could administer matters pertaining to intellectual property and business interests for the benefit of the EI/CREC. The best approach to pursue will be developed in consultation with university offices that oversee such efforts.

If a non-profit were to be established, an additional step might be to establish a Foundation that would partner closely with the non-profit. Private support for public higher education is an accepted and firmly established practice throughout the nation. Foundations are established to enhance this practice, to enable institutions to accomplish more than public funding allows. Their private, independent nature can provide the University with the added advantages of dedicated donor services and management flexibility. This model can enable university research organizations to generate “revenue" while maintaining a non-profit status.

If a foundation were established, it's mission could be to provide administrative services to the CREC and the Energy Institute and affiliated organizations. It could administer matters pertaining to real property for the benefit of the EI/CREC. It could also administer gifts, grants, bequests, and devises for the benefit of the EI/CREC.

8.3 Pros and Cons Analysis

The following table details some of the benefits and disadvantages inherent in the approach outlined above. Although extensive, this analysis is not intended to be a definitive statement of the merits of this concept. Rather, it is intended to provide insight into the trade-offs inherent in such an approach. Further work will be required to develop a complete and exhaustive description of the best approaches to accomplish the overall goal of making the CREC function at the highest possible intellectual and economic level.

PROs	**CONs**
Diversifies the funding base for the collaboratives – ties to CEC/PIER R&D Committee stated long term vision	Potentially divergent from the University’s mission
Enables CREC to grow permanent staffing levels to increase industry influence	A non-profit and a foundation will require a management and administrative structure
Will retain focus on highest leverage items	Many people to convince with conflicting views as to utility
Strong enabler of a more integrated Energy Collaborative (vs. isolated departments)	Will cause and require a culture change
Enables equity participation and return on IP developed at the university	
Enables donations from corporate partners without strict limitations on the use	
Enables project/program bidding and costing without excessive overhead.	
Better leverages UC Davis world-class talent	
Insulates from future CA budget cuts/reductions – current dependency is high with education cuts and dependency on CEC grants	
Attracts and retains highest levels of talent by enabling/providing supplemental income sources	

8.4 SUMMARY

Possible business vision: To be the research, concept validation, and incubation partner of choice in the sustainable, clean tech industry.

The business objectives would be:

- Generate sufficient economic value to provide a self-sustaining, world-class sustainable/cleantech consulting effort
- Establish an entity and organizational structure that enables growth and sustainability of the organization, partnering with the university, government organizations, and private industry
- Establish integrated and stand-alone capabilities in:
  - Biomass
  - Geothermal energy
  - Solar energy
  - Wind energy
  - Hydro and Ocean energy
    Energy Efficiency Applicable in:
  - Agriculture
  - Industry
  - Buildings
  - Communities
  - Utility scale
  - Research & development

Possible Implementation: In order to implement this, a business model could potentially be established that complements or is part of a UCD 501(c)3 non-profit. Upon maturation of the non-profit and its surrounding business processes, a foundation structure could be established and associated with the non-profit. This model is similar to that already established by numerous world class public universities.