California Public Utilities Commission

California Solar Initiative
Draft Staff Proposal for Research, Development and Demonstration Plan

February 2007

This paper describes a staff-recommended plan to spend up to $50 million on research, development, and demonstration (RD&D)[1] grants as part of the California Solar Initiative (CSI). The paper discusses the role of government in RD&D activities and other R&D programs on solar distributed generation to help put the CPUC's CSI program in context with other efforts. In Section 4, staff describes the purpose of the CPUC CSI RD&D fund, suggests focal areas for California activity, and recommends an implementation strategy for application of the funds to accomplish the CSI goals. The strategy addresses suggested priority targets, guidelines for funding allocation, project solicitation and evaluation criteria, possible administrative structures, and a way to monitor and evaluate the usefulness of the RD&D program expenditures.

1. Introduction

On January 12, 2006, The California Public Utilities Commission (Commission or CPUC) established an RD&D budget for distributed solar under the CSI to help achieve the CSI's 3000 MW goal for solar installations by 2016.[2] The Commission's intent for RD&D is to "explore solar technologies and other distributed generation technologies that employ or could employ solar for power generation and storage or to offset natural gas usage, as well as market development strategies."

On August 21, 2006, the Legislature directed the CPUC in SB1[3] to allocate not more than $50 million to research, development, and demonstration that explores as part of the California Solar Initiative:

1. solar technologies, or
2. other distributed generation technologies that employ or could employ solar energy for generation or storage of electricity or to offset natural gas usage.

The overall goal of the RD&D funds is to help build a sustainable and self-supporting industry for customer-sited solar in California. A clearer way to describe this goal in operational terms might be to say the CSI program needs to achieve two key outcomes:

- Move the market from the current retail solar price of $9/watt or about 30 cents/kWh to levels that are comparable to the retail price of electricity.

[1] Staff proposes to include deployment, which we view as an element of the category "demonstration" that helps to support market adoption of solar.
[2] Up to 5% annually within the then-$2.5 billion total CPUC CSI budget.
[3] Signed by the governor on August 21st, 2006.

- Install increasing volumes of solar DG that build from the current range of 40+MW per year to 350 MW or more per year.

The funds will be used to fill critical needs or gaps in the market to facilitate greatly expanded market penetration of cost-effective solar applications. The RD&D program effort is intended to produce results to ensure achieving the goal of 3000 MW of solar DG and without further ratepayer subsidy beyond 2016.

The Legislature, via SB1, also imposed several requirements on any such Commission program:

1. The program must be developed in collaboration with the California Energy Commission to prevent duplication,
2. The Commission must adopt the program via a rulemaking or other appropriate public proceeding,
3. The program must require that each specific award will be approved by the full Commission at a public meeting, and
4. The Commission must include in its annual assessment of the California Solar Initiative to the Legislature a description of the program, with a summary of each award made, including the intended purpose and results of the award.

2. The Role of RD&D

The overall CSI framework embarks upon a market development strategy that challenges the solar industry to develop and deploy solar technologies in ways that will reduce installed costs, increase system performance and output, and do so at ever-increasing scale of diffusion in a market setting. The role of the RD&D program is to facilitate the industry and market moving through a technology innovation/ diffusion process. Energy technology innovation, similar to other types of innovation, proceeds through a series of phases. While the technology may not necessarily have to pass through each phase in order to reach commercialization, the typical phases of innovation are research and development, demonstration, and deployment.

2.1 Definitions

Research and Development ("R&D")

The phrase "R&D" typically is not separated. For purposes of this program, staff finds it useful to make a distinction between the two. Research includes basic and fundamental research that yield discoveries with potential application to the improvement of energy technologies, and applied research that is directed at the invention or improvement of specific energy technologies.

Development is aimed at converting the fruits of fundamental and applied research into working prototypes of new or improved technologies." [4] For example, "development" activities might be applied to overcome technical barriers to reaching the CSI goals due to the lack of mature technologies or current incompatibility between energy storage and grid safety. Private investors typically include in the term "development" investing in manufacturing or assembly facilities and equipment to support "scaling-up" the production of technologies.

Demonstration

Demonstration projects are ones that bring promising technologies a) closer to market, and b) closer to potential buyers in order to increase chances of adoption. Examples of demonstration activities are: testing new technologies in conditions that approximate real-world applications in order to gain economic and performance data that improve technologies and enhance potential for commercialization; and demonstrating real-world feasibility of new technologies to manufacturers.[5]

Deployment (Market Support)

The next phase in the technology innovation continuum is deployment. Even if the technological feasibility was proven during the demonstration phase, there may be a variety of barriers that make it difficult for the new technology to compete or gain acceptance in the market and thus achieve wide-scale adoption. Deployment activities that help support market penetration can

[4] Gallagher, KS; Holdren, JP; Sagar, AD, "Energy-Technology Innovation," Annual Review Environmental Resource. 2006. 31:193-237.
[5] Ibid

help a new technology reach a "tipping point" into widespread commercialization.[6] Deployment activities can take many forms, including:

- Development of business models for delivery or services activities that can accelerate the "deployment" of solar technologies
- Investments in individual companies to spur economic development support for specific solar businesses.
- Taking already-commercialized products to visible, local applications so as to collect localized performance data or enable interested buyers to "kick the tires" of individual technologies or installation parameters.
- Developing or disseminating specific information that will support "deployment" (e.g. local weather data, insolation data, insurance risk statistics, etc.)

2.2 The "Valley of Death" and the Role for Public Sector Financial Support[7]

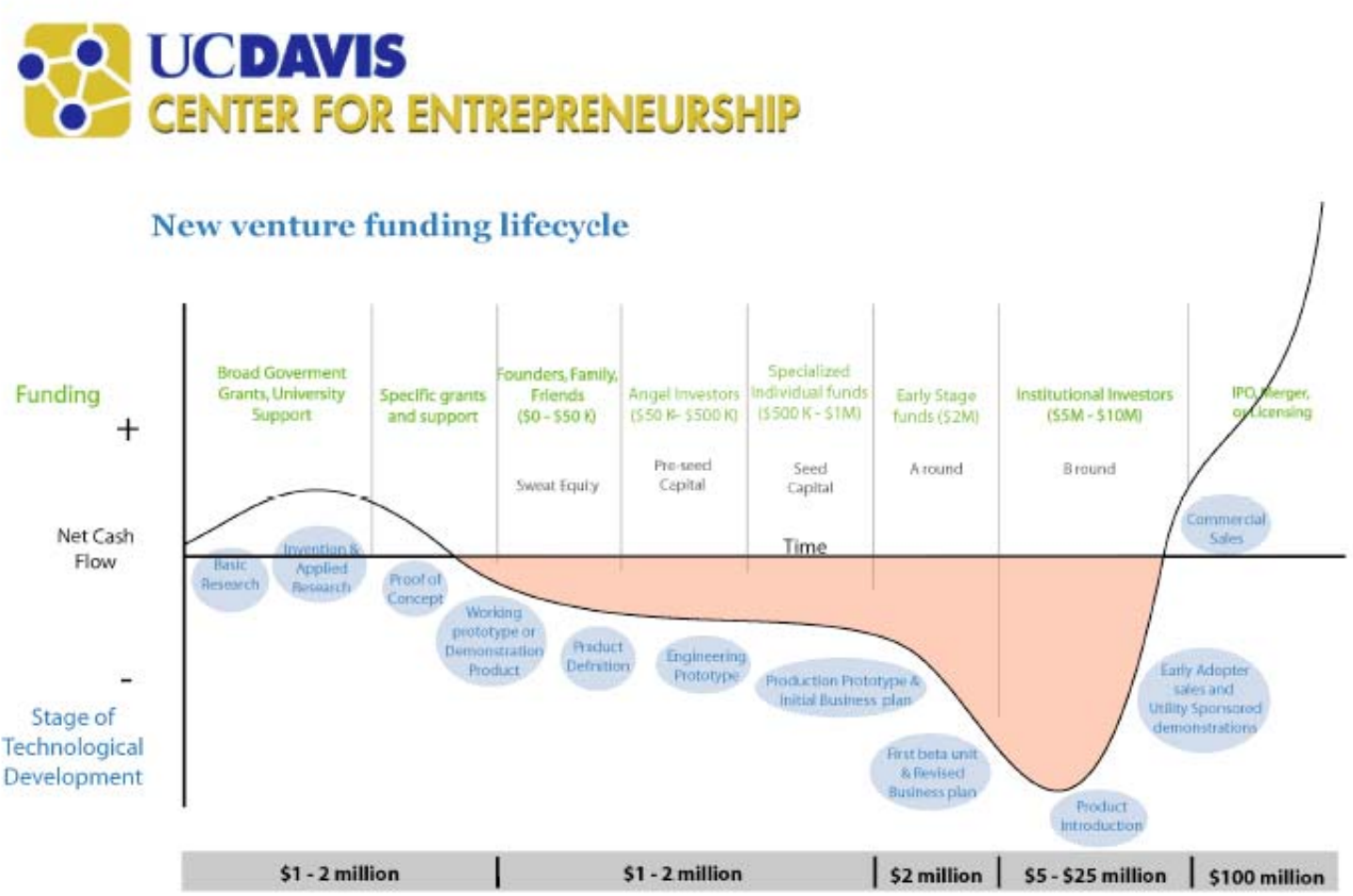
Conventional wisdom holds that government should not play a role in commercialization aspects of development or in demonstration projects, leaving the task of product commercialization up to the private sector. However, investors often do not invest in the demonstration phase of a technology because the returns are low and the risks are high.[8] In order for a technology to be an attractive investment, it needs to be proven, yet it cannot be proven without a track record or period of demonstrated performance. Thus, many technologies fail to make the transition between publicly funded R&D and commercialization. This chasm is often called the cash flow "valley of death" because many promising technologies "die" during this phase, which neither the public nor the private sector views as their responsibility to support (See Figure 1).

[6] Ibid

[7] Adapted from Murphy, LM, Edwards, PL, "Bridging the Valley of Death: Transitioning from Public to Private Sector Funding," NREL/MP-720-34036, May 2003.

[8] "Financing Projects with Unproven Technologies," Project Finance NewsWire, November 2006. Chadbourne and Parke LLP.

Figure 1


UCDAVIS
CENTER FOR ENTREPRENEURSHIP
New venture funding lifecycle
Funding
+
Net Cash Flow
-
Stage of Technological Development
Broad Goverment Grants, University Support
Specific grants and support
Founders, Family, Friends ($0 - $50 K)
Angel Investors ($50 K- $500 K)
Specialized Individual funds ($500 K - $1M)
Early Stage funds ($2M)
Institutional Investors ($5M - $10M)
IPO, Merger, or Licensing
Sweat Equity
Pre-seed Capital
Seed Capital
A round
B round
Time
Basic Research
Invention & Applied Research
Proof of Concept
Working prototype or Demonstration Product
Product Definition
Engineering Prototype
Production Prototype & Initial Business plan
First beta unit & Revised Business plan
Product Introduction
Early Adopter sales and Utility Sponsored demonstrations
Commercial Sales
$1 - 2 million
$1 - 2 million
$2 million
$5 - $25 million
$100 million

Several phases in the "valley of death" could present valuable funding opportunities for the CPUC.[9] Following a technology's successful inception, the public R&D money it has received up to that point tends to dry up, as the government belief is that the task of "picking winners" among a variety of technologies should be left up to the market. However, this withdrawal of public funding often occurs just as the technology's investment needs are growing, due to the high cost of developing and demonstrating a mature business plan. With energy technologies in particular, the costs of commercialization can be particularly high. Fortunately, the public sector, which provides much of the initial R&D funding for promising technologies, is well positioned to foster partnerships with the private sector that will help entrepreneurs bridge the gap from public to private funding.

At every step in a technology's development sequence – from devising proof-of-concept ideas to building a prototype to creating the market and infrastructure for the product – the public sector can play an important role in reducing the magnitude and duration of the cash flow "valley of death." It is able to do so in three significant ways: helping to reduce the information asymmetries that exist between the public sector, private sector, and entrepreneur; encouraging the entrepreneur to focus on the product's business dimension in parallel with its technical dimension; and exploring new public-private co-investment strategies.

First, the public sector, investors, and entrepreneurs are poorly informed of each other's goals and needs. By encouraging interaction among the three parties – for example, by holding workshops or forums to exchange information, or by providing directories of companies looking for investments, or investors looking for investment opportunities – the public sector can significantly reduce the risks that all three parties face during this process. To the extent that is legally permissible, the public funding agency may even consider incorporating the perspectives of private sector investors in its grant application criteria and funding decisions.

Second, technology companies have a tendency to focus almost exclusively on the technical aspects of their product's development, delaying the formulation of a business strategy until they feel the product is "mature." (At times the public sector is even complicit in this strategy, requiring that public funds be used for technology development only.) However, this approach tends to significantly prolong commercialization times, and contributes to the failure of some companies. The public sector can mitigate this problem by staggering its investments in a company, and making these investments contingent upon the development of the product's business strategy in parallel with the technical issues. Alternatively, it could encourage or require funding recipients to take part in business incubator programs in order to gain exposure to the industry's best business development expertise. While this conclusion focuses on individual businesses, the CPUC could instead support research or development of generic solar business models that could be used by multiple businesses.

Third, given that gaps between public and private financing will persist in spite of these efforts, there has been a recent surge in interest in exploring novel financing partnerships. These could take the form, for example, of public-private venture funds in experiments with the U.S. Army and CIA. In this model, initial funding would come from the public sector, while private sector

[9] See Figure 1; Hargadon, Andrew. "Advancing Clean Energy – Moving Innovations from the Lab to the Market," presentation at Clean Energy States Alliance Fall 2006 Meeting, Yountville, CA.

investors would oversee the company. With public and private sector players cooperating in the venture, a more effective collaborative relationship between the two could be fostered, and the "valley of death" would be made smaller and shorter, improving the returns on investment for both sectors. Staff seek public input on the interest for this arrangement under the CSI. While intriguing, this option raises a number of issues over the extent to which output remains in the public realm, each party assumes control on decisionmaking, the decisions are free of Conflict of Interest, intellectual property is controlled, and other contractual and management issues.

Finally, it is important for states to ask the question "Is the U.S. Department of Energy committing sufficient funds for solar R&D?" Relative to other technologies, the cost of commercializing new energy technologies—taking them from scientific or technical concepts on paper, onward to prototypes, then to pilot projects, and finally to the marketplace—is extremely high. The Stern Review, *The Economics of Climate Change,* suggests that governments around the world may not be investing sufficient levels of R&D in low-carbon technologies.[10] The report states:

- Global public energy R&D support has declined by 50% in low-emission R&D between 1980 and 2004.
- The IEA recommends that governments double the public R&D budget from $10 billion to $20 billion per year.
- The R&D efforts going into low-carbon solutions, including renewable energy and storage technologies should all be much larger.
- Untargeted support will favor the more developed technologies, that tend to have a price advantage, to the exclusion of other promising technologies.
- With the urgency of tackling climate change, public policy could support those technologies further from commercialization or having particular strategic importance.

[10] Sir Nicholas Stern, *Stern Review Report on the Economics of Climate Change*, Part IV: Policy Responses for Mitigation. Her Majesty's Treasury, United Kingdom, October 2006.

3. Other Solar RD&D Programs

In defining the CPUC R&D strategy, the CPUC must address three fundamental questions:

1) What types of RD&D should a state agency fund, versus those that should be funded by industry or the federal government?

2) What are the most important RD&D target activities to mobilize the California solar market? and

3) How can the CPUC best leverage its funds to achieve maximum impact toward achieving the statewide goals for solar?

Current solar industry RD&D financial support comes from three sources – federal government; state clean energy funds; and solar corporations as supported by venture capital and other private capital markets. This section provides a brief summary of the solar PV RD&D activities among these various actors. More detailed descriptions of these programs can be found in Appendices A and B.

Basic R&D tends to fall within the purview of industry and the DOE National Renewable Energy Laboratory (NREL). Overall, the PV-related RD&D budgets of the key actors range from $1 million per year to over $100 million per year in the case of DOE and NREL activities. The program emphases vary significantly as well.

With regard to R&D that specifically pertains to the California market, there are at least two major efforts underway in the public domain to identify priorities for solar RD&D: (1) the US DOE's Solar America Initiative; and (2) the California Energy Commission's Public Interest Energy Research program's solar roadmap effort.

3.1 Federal RD&D

The Department of Energy conducts a $148.4 million (requested) Solar America Initiative to promote distributed solar power (see Appendix B for a full description). The SAI comprises:

- Partnerships with States and utilities to catalyze collaboration in the design of regulations and incentives that promote adoption of solar technologies.
- Solar "showcase" projects that will demonstrate novel large-scale market applications of PV, thereby retiring risk and allowing future private financing of similar projects.
- Work with city governments that are combining regulation, training, and other measures on route to becoming desirable locations for establishing solar businesses and marketing solar products.
- Establishing Energy Star labeling for solar hot water heaters to ensure product performance.

- Non-technological barriers to widespread deployment of solar technologies such as codes, standards, certification, and technical training.

Table 1 presents overall funding. Staff posits that most of the NREL funding is a subset of the total budget amounts reported for the DOE Solar America Initiative.

Table 1

Program Name	Program Goals and Objectives	Total Annual Solar Funding	Funding Category	Average cost of Project in each Category	Cost-Share Requirement
DOE - Solar America Initiative	Reduce the average installed cost of grid-tied PV systems to $3.30/W by 2015, bringing down the cost of PV power to $0.09/kWh	$84M in FY06 $148M requested for FY07	"Market Transformation"		N/A
NREL	Support the goals and objectives of DOE's Solar Program (see above)	$52M in FY06 $45M proposed for FY07	Primarily R&D		N/A

DOE has been working on its own solar RD&D agenda under the SAI for the past year, as outlined in the February 5, 2007 *Draft Plan for the Integrated Research, Development, and Market Transformation of Solar Energy Technologies.*[11] Neither the CEC nor CPUC staffs have had time to compare DOE's proposed activity areas with those being identified in California. Clearly, more time and attention will be required to sort out potential funding priorities across the different organizations.

DOE's solar R&D plan appears to focus on:

- Conducting accelerated research and development to improve the materials performance and reduce the cost of advanced photovoltaic (PV) systems
- Developing new manufacturing technology to lower process costs and increase throughput for enabling expanded U.S. manufacturing capability
- Providing technical expertise and building stakeholder consensus to resolve regulatory, institutional, infrastructure, and education-related barriers to technology acceptance
- Accelerating deployment of new solar technologies through promoting demonstrations and early adopter activities consistent with the Energy Policy Act of 2005

[11] Solar America Initiative, *A Plan for the Integrated Research, Development, and Market Transformation of Solar Energy Technologies*, Draft, February 5, 2007. Solar Energy Technologies Program, US Department of Energy, Energy Efficiency & Renewable Energy. (SETP-2006-0010)

- Supporting the demonstration and deployment of energy technologies through collaborative efforts with the private sector and public sector entities

DOE states that it will conduct research and development to reduce cost and expand production of PV by funding industry-led teams collaborating across the value chain. These R&D projects— focused on manufacturing processes and product designs that have the best chance of making PV systems less expensive, more efficient, and highly reliable— will expand U.S. annual domestic PV manufacturing capacity and also focus on reducing the cost of electricity from PV.

The Department will also support early-stage companies as they take promising prototype PV cells from laboratory benches into commercial pilot production, leveraging DOE funding and technical assistance from NREL and Sandia National Laboratory to bring the next generation of PV technologies to market after 2011.

Finally, DOE will facilitate cost reductions in concentrating solar power (CSP) systems by addressing three factors: further technology development, volume production, and scale-up in plant or project size.

Staff relied more heavily on a September 2006 NREL report that addressed *non-technical barriers* to solar energy to support the Solar America Initiative.[12] Table 2 summarizes ten barriers that hinder solar deployment. As a first cut of the CSI strategy, CPUC staff reviewed the ten barriers against three criteria for usefulness in determining priorities for CSI: 1) within the scope of the CSI; 2) money will help overcome barrier; and 3) the barrier is not sufficiently addressed elsewhere. Note that the barriers addressed in this report are not specific to California; moreover, some are outside the scope of the CSI.

[12] Margolis, R., and J. Zuboy, "Nontechnical Barriers to Solar Energy Use: Review of Recent Literature," (September 2006). Technical Report NREL/TP-520-40116 [http://www.nrel.gov/docs/fy07osti/40116.pdf].

Table 2

	Barrier	Criteria: Within the scope of the CSI	Criteria: Money will help overcome barrier	Criteria: Barrier is not sufficiently covered elsewhere
1	Lack of government policy supporting EE/RE	Yes	No. Policymaking does not require money	No. Purpose of CSI is to address this
2	Lack of information dissemination and consumer awareness about energy and EE/RE	Yes	Yes	No. M&O funds will cover, other state and federal agencies may also cover
3	High cost of solar and other EE/RE technologies compared with conventional energy	Yes	Yes	Unsure. CSI incentives address this
4	Difficulty overcoming established energy systems	No. National question of fossil fuel subsidies	Yes	Unsure
5	Inadequate financing options for EE/RE projects	Yes	Yes	Yes
6	Failure to account for all costs and benefits of energy choices	Yes	No. Policymaking does not require investments	No. Cost-benefit methodology will cover this
7	Inadequate workforce skills and training	Yes	Yes	Unsure. M&O funds could cover, other state and federal agencies may also cover
8	Lack of adequate codes, standards, and interconnection and net-metering guidelines	Yes	Yes. Through educational materials only, not through regulation or policy	Unsure. M&O funds could cover, other state and federal agencies may also cover
9	Poor perception by public of renewable energy system aesthetics	Yes	Yes	Unsure M&O funds could cover, other state and federal agencies may also cover
10	Lack of stakeholder/community participation in energy choices and EE/RE projects	Yes	No	No. M&O more appropriate funding source, other state agencies may also cover

According to the three CPUC criteria, Barriers 3, 5, and 7- 9 could be good candidates for the RD&D funds since they all fall within the scope of the CSI, can be overcome with money, and may not be sufficiently covered elsewhere. These barriers relate to:

- High cost of solar technologies

- Inadequate financing options
- Inadequate workforce and skill levels
- Insufficient technical standards, interconnection, and/or net metering solutions
- Poor public perception of solar system aesthetics

These barriers overlay with expected CPUC work in the R&D program as well as CPUC marketing and outreach plans (see Appendix D).

3.2 State Clean Energy Fund RD&D

According to some academics, state clean energy programs need to shift the focus from technology features to benefits; build networks and not the product; and grow the business, not the R&D.[13] State clean energy programs are in a unique position since they do not have the large budgets of federal R&D programs, but can focus on a smaller geographic area and target projects that reap micro- and macroeconomic benefits for the state. Due to these two factors, state funds tend to focus not on basic R&D, but on development, demonstration, and deployment. They do so through assistance to companies seeking to commercialize their technologies, as well as providing incentives to end users who install PV systems.

Table 3 summarizes some of the leading state R&D funds for clean energy. Appendices A and B provide more detail on these programs, including general strategies employed, illustrative projects, award sizes and criteria.

[13] Hargadon, Andrew. "Advancing Clean Energy – Moving Innovations from the Lab to the Market," CESA Fall 2006 Meeting, Yountville, CA.

Table 3

Program Name	Program Goals and Objectives	Total Annual and Source	Total Annual Solar Funding	Funding Category (R, D, D, or D)
California Energy Commission - PIER Program	The mission of the Public Interest Energy Research Program is to conduct public interest energy research that seeks to improve the quality of life for California citizens by providing environmentally sound, safe, reliable and affordable energy services an	$62M	$1-2M	Development and demonstration Navigant study identified four priority target areas: - Production technologies - Grid integration - End use - Market support
Connecticut Clean Energy Fund	MISSION: CCEF develops, invests in and promotes clean energy sources for sustainable energy for the benefit of CT ratepayers. VISION: CT will be a leader in attaining a sustainable balance of energy production, economic growth, and environmental impact	$35M Public benefits surcharge		Primarily demonstration, with some development and deployment
Illinois Clean Energy Community Foundation	ICECF invests in clean energy development and land preservation efforts, working with communities and residents to improve environmental quality in Illinois.	Established in 1999 with $225M endowment from Commonwealth Edison	$3M	Demonstration
Massachusetts Technology Collaborative Renewable Energy Trust	Expand the supply of and demand for renewable energy in Massachusetts while also expanding economic activity in the state's renewable energy industry	~$10M ($47M for Clean Energy, FY06-10)	No "earmarks" for solar, but about half of RD&D funding goes to solar (and half to fuel cells)	Development (business) and deployment (incentives) A new fund currently under development will provide technical development matching grants for relatively high-risk ventures
New Jersey Board of Public Utilities Clean Energy Program	Provides information and financial incentives to help NJ residents, business and communities reduce their energy use, lower costs and protect the environment. Objective is to transform the energy marketplace in NJ toward more energy-efficient and renewabl	$140M		Development and deployment
New York State Research and Development Authority (NYSERDA)	The goals of NYSERDA's renewable energy programs are to encourage new renewable energy businesses, expand existing enterprises, construct the supporting business infrastructure, reduce costs to the consumer, build consumer knowledge of and experience with	$150M Public benefits surcharge (mostly), and from legislature	$10M	RD&D, but most of the money is for deployment (incentives). About $2M/yr for development (primarily business development, infrastructure, and workforce training).
Xcel Energy Renewable Development Fund of Minnesota	Increase the market penetration of renewable energy resources at reasonable costs in the Xcel Energy service territory, promote the start-up, expansion and attraction of renewable energy projects and companies in the Xcel Energy service territory and stim	Varies: $53M awarded since 2001, in two funding rounds; a third is scheduled for 2007 Funded by charge on Xcel Energy for nuclear waste storage	No specific "earmarks" for solar	R&D (40% of funds) Demonstration (60% of funds)

3.3 California Energy Commission Programs

3.3.1 CEC PIER Solar PV R&D

The California Energy Commission (CEC) Public Interest Energy Research (PIER) program has historically dedicated $1-2 million per year to solar distributed generation RD&D. In 2006, CEC PIER hired Navigant Consulting to conduct extensive surveys of industry, government, and other stakeholder on R&D needs in order to help staff identify focal areas for their solar R&D program (see Appendix C for a full description). Their draft report identified a range of optimal milestones, or targeted outcomes for RD&D, among four categories:

- Production technologies (milestones starting with "P")
- Grid-integration (milestones starting with "G")
- End-use (milestones starting with "E") and
- Market support (milestones starting with "M").

According to SB1, "any program that allocates additional moneys to research, development, and demonstration shall be developed in collaboration with the Energy Commission to ensure there is no duplication of efforts." CPUC and CEC PIER staff collaborated over the past six months as each program identified and prioritized its solar PV RD&D plans. The CPUC will use CEC PIER milestones because both solar R&D programs share similar goals.

The majority of stakeholders believed that PIER should focus on grid integration, end-use and market support issues as there is limited research by other organizations in these areas. In contrast, DOE and industry are investing in developing improved PV production technologies.

The need for PIER to fund additional production technology development was a highly debated issue among stakeholders. A few stakeholders strongly supported the continued involvement of PIER in the development of improved production technologies given its importance in helping to reach the overall PV market penetration goals.

The PIER PV Steering Committee determined that it will maintain a primary focus of the research plan on: (1) Grid Integration; (2) End-use support; and (3) Market Support issues. However, stakeholder input convinced the Steering Committee to move the highest ranking Production Technology milestone to a highest priority, given PIER's strong emphasis on the need to reduce PV installation costs.

The Steering Committee used this stakeholder input to rank a draft list of nine Tier 1 (highest priority) and eight Tier 2 (high priority) milestones as follows:

Draft PIER Solar Tier 1 Priorities

- **E4: Synergies between building energy efficiency and PV are identified and business models to encourage synergies in retrofits and new construction are identified by 2008.** A significant amount of research is already available for new construction energy efficiency and PV. To achieve the milestone, there needs to be a

better understanding of retrofits and synergies between energy efficiency and PV. Coordination should take place with PIER Buildings.

- **E5: Potential roles for utilities in solar PV, including attractive business models, are identified and vetted with utility companies by 2008.** The CEC Renewable Energy Program already has a contract with MRW to address this issue, but PIER should continue this research after the MRW work is completed. PIER ZENH and PV Market Assessment work support this issue. The milestone should focus on how to make it work for IOUs and end-users over the long run.

- **E11: Improved PV economics demonstrated using advanced metering, price responsive tariffs (e.g. TOU, DR, Feed-in Tariff) and storage by 2010.** Improving PV economics is an important issue, and there is little research underway to address this. There is a need to understand how advanced metering and storage can benefit IOUS and PV system economics.

- **M1: Updated training for CA installers and building code officials developed and vetted with industry/policy makers by 2007.**This milestone will be addressed by the CEC Renewable Energy Program as part of an incentive package for builders. The CPUC might complement this milestone with training for non-builder stakeholder groups. There is a potential PIER role in developing training for a "needs assessment".

- **M9: Options for including PV as part of CA residential building efficiency standards are developed and vetted with industry and policy makers by 2010.** An effort commenced a year ago for 2008 new construction standards (where PV is an option) and PIER buildings is already supporting the development of Title 24 building standards. There is a need to assess the feasibility of requiring builders to offer PV (this is an SB1 requirement).

- **M8: Building standards established that require sufficient PV-ready roof space in new construction by 2011.**This milestone is part of 2011/2012 standards, not 2008 standards. There is a need to study not just the roof, but integration of PV to other building materials.

- **G2: PV systems with storage or other technologies demonstrate better coincidence with utility system peak load by 2008.** IOUs have expressed the importance of this milestone, but there isn't much research underway. This work is supported by PIER ESI's work with inverters, and PIER IAW is putting together a storage RD&D effort. This milestone is related to technology development, and is distinct from milestone E11, which is an economic assessment.

- **G1: Cost/benefits of net metering (e.g. rate impacts) understood for SB1, as well as impact of raising net metering capacity to accommodate CSI goals by 2008.** There is a limited role for PIER in achieving this milestone, as the CPUC already has a legislative mandate to cover this issue through their program evaluation efforts.

- **P3: PV system design and installation procedures enhanced to more effectively optimize system performance by 2008.** This milestone was moved from Tier 2 to Tier 1 by the Steering Committee because of input received at the stakeholder roundtable, even though industry should already be undertaking this research. There is a need to pay more attention to reducing the installation costs of PV.

Draft PIER Solar Tier 2 Priorities

- **M2: Solar training and educational materials developed for architects, building land-use planning, and roofing personnel by 2007.** This milestone, along with M1, will be addressed by CEC Renewables and the CPUC. This milestone could fit with CPUC marketing and outreach efforts, but priorities are not yet defined. PIER can support this milestone with a market research piece.

- **E2: Drivers that encourage consumer adoption of PV systems are identified and prioritized by 2008.** CEC Renewables is planning to address this issue, and it focused on new residential construction (with a budget of $4.5 million over the next three years). This milestone could fit with CPUC marketing and outreach efforts, but priorities are not yet defined. PIER can support this milestone with a market research piece.

- **M5: Module certification in CA is closely aligned with national and international standards, resulting in more robust and accurate ratings by 2008.** Module certification will be part of CEC Renewables work regarding the New Solar Homes Program (NSHP) guidebook. There will be guidelines outlined in the NSHP guidebook. California is moving toward STC, and it is unlikely that the PTC rating will be used. The Emerging Renewables Program provides a certified equipment list. The CPUC expects the CEC to address this issue (per SB1) and address retrofits.

- **G5: High value locations for DG PV on T&D are identified and the impacts/benefits of large concentrations of DG PV in one location on T&D are assessed by 2008.** PIER Renewables has looked at this issue with regard to all renewables transmission, and this work can be extended to cover PV on the distribution system. PIER ESI has also funded work to demonstrate locational benefits of distributed generation on distribution systems.

- **G8: Economic viability of new PV system storage technologies are demonstrated by 2010.** This milestone complements the storage issues raised in milestones E11 and G2 (both Tier 1), but this milestone has a broader storage technology focus.

- **E7: Lower cost, utility grade PV system control, metering, and monitoring capacity developed consistent with 1% cost parameter established by CPUC for CSI by 2008.** The CPUC assumes the market will work out this milestone under the CPUC program rules and the handbook working group; this will evolve quickly in the market over the next year.

- **E3: New/modified business models create sustained market growth by 2008.** This complements milestone E5 (Tier 1).

- **G7: Utility acceptance of protocols to allow PV system operation during grid outages by 2009.** If the value of solar PV during grid outages was incorporated, this milestone would most likely have ranked higher. It received a low score because consumers today assume PV will be available during a grid outage, even though this is false.

3.3.2 Overlap with Other CEC Resources

The California Energy Commission runs other programs that fund similar types of projects in these milestones. In addition to the PIER solar RD&D, PIER may fund RD&D work in its Buildings, Distribution, or Energy Systems Integration programs. Outside of PIER, the CEC Renewable Energy Program manages the New Solar Home Partnership (NSHP) program that offers incentives for solar power on new residential buildings, with assistance from the CEC Buildings and Appliances Program. The NSHP has administrative and marketing and outreach plans and funds that will overlap with the above milestones.

The CPUC is working closely with the CEC to avoid duplicating efforts. CEC staff are finalizing plans for focal target activities as this paper is released and simultaneous to CPUC staff's prioritization of CPUC R&D activities. Table 4 illustrates potential overlap areas among CEC, PIER, and CPUC plans. Further discussion between the two organizations can help to further define activities beneficial for the CSI funding that will complement or expand upon activities already planned or that may be considered in the future by the CEC.

Other PIER Funding

The PIER Program as a whole and the PIER Renewable Energy program in particular have current and planned activities that address the milestones identified in the Solar PV Research Plan as follows:

Production Technologies

- Existing and newly completed PIER Renewable Energy projects addresses several Production Technologies milestones and may also assist in achieving some of the Grid Integration, End-Use and Market Support milestones. A new proposal for Policy Committee approval seeks to fund projects that address highly integrated Production technology milestones with appropriate milestones from the Grid Integration, End-Use and Market Support platforms.

Grid Integration

- Existing PIER Renewable Energy projects relate to transmission (e.g. the Strategic Value Analysis and the Intermittency Analysis Projects) and planned projects are focused on integration of renewable energy generation on to the grid.

- PIER Energy Systems Integration (ESI), Renewable Energy, and Industrial Agricultural and Water (IAW) programs are planning activities focused on storage technologies for solar end-use and renewable energy Transmission and Distribution applications. These activities address both Grid Integration and End Use milestones.
- PIER ESI is planning to develop tools to locate and analyze the affect of renewables as a distributed resource on the grid.

End Use

- PIER Renewable Energy and Building programs are funding work on the Zero Energy New Homes program which may assist PIER solar's Tier 2 End Use milestones.
- PIER Building is working with the CEC Energy Efficiency Division's Standards program to support new building standards that integrate energy efficiency technologies with renewable electricity generation. These activities address several milestones in both the End Use and Market Support platforms.
- PIER Buildings is funding a new project to develop a tool that allows developers and other potential users to find optimal and near-optimal designs based on building options that reflect realistic construction options for Zero Net Energy (ZNE) homes. ZNE homes produce as much energy as they use on an annual basis, typically through the use of photovoltaic (PV) systems. The project addresses at least one of the high priority End Use milestones.

Market Support

- As described above, the PIER program is conducting or planning RD&D that will integrate activities targeted at some Market Support milestones.

Since the PIER Renewable Energy budget is small for PV ($1-2 million per year), it is unlikely that their funding alone will be able to cover all the milestones that they would like to fund. In such cases, the CPUC will either defer to the PIER program to completely fund an activity, or coordinate with the CEC to combine efforts on a broader or more robust scope of work for that milestone.

Other CEC Offices

The CPUC RD&D and Marketing programs will need to coordinate joint efforts with the CEC Renewable Energy staff when the latter targets some work (but not all) in numerous areas in the course of administering or marketing the New Solar Homes Partnership. Table 4 describes the overlay of their work with PIER's priorities.

Similarly, CPUC R&D program must coordinate with ongoing efforts by the CEC Building and Appliances Office. CEC PV and energy efficiency integration staff is responsible for delivering building standards and responding to technical aspects of SB1 that are related to several of the milestones. With some limitations on the extent that their plans dovetail with NSHP activities or have public support, this Office has identified probable work on a number of overlapping milestones. These staff are also involved in milestones that advance integration of PV and energy efficiency. Note that High value locations for DG PV identified to the extent associated with Time Dependent Valuation (G5) also relates to (P3) PV system design and installation optimization.

Table 4

CSI R&D	Other PIER	CEC RE	CEC Bldgs	
				Tier 1
			X	E4: Synergies between building energy efficiency and PV are identified and business models to encourage synergies in retrofits and new construction are identified by 2008.
X			X	E5: Potential roles for utilities in solar PV, including attractive business models, are identified and vetted with utility companies by 2008.
X			X	E11: Improved PV economics demonstrated using advanced metering, price responsive tariffs (e.g. TOU, DR, Feed-in Tariff) and storage by 2010
			X	M1: Updated training for CA installers and building code officials developed and vetted with industry/policy makers by 2007.
			X	M9: Options for including PV as part of CA residential building efficiency standards are developed and vetted with industry and policy makers by 2010.
			X	M8: Building standards established that require sufficient PV-ready roof space in new construction by 2011
X				G2: PV systems with storage or other technologies demonstrate better coincidence with utility system peak load by 2008.
				G1: Cost/benefits of net metering (e.g. rate impacts) understood for SB1, as well as impact of raising net metering capacity to accommodate CSI goals by 2008. There
X	X			P3: PV system design and installation procedures enhanced to more effectively optimize system performance by 2008.
				Tier 2
		X	X	M2: Solar training and educational materials developed for architects, building land-use planning, and roofing personnel by 2007.
		X	X	E2: Drivers that encourage consumer adoption of PV systems are identified and prioritized by 2008.
			X	M5: Module certification in CA is closely aligned with national and international standards, resulting in more robust and accurate ratings by 2008.
X			X	G5: High value locations for DG PV on T&D are identified and the impacts/benefits of large concentrations of DG PV in one location on T&D are assessed by 2008.
X				G8: Economic viability of new PV system storage technologies are demonstrated by 2010.
X			X	E7: Lower cost, utility grade PV system control, metering, and monitoring capacity developed consistent with 1% cost parameter established by CPUC for CSI by 2008.
X		X		E3: New/modified business models create sustained market growth by 2008.
X				G7: Utility acceptance of protocols to allow PV system operation during grid outages by 2009.

In addition to those activities listed in Table 4, the CEC Renewable Energy Program may address:

- E1-Operational Risks and disputed benefits of PV systems identified (later priority issues to be studied)

In addition to those activities listed in Table 4, the CEC Building and Appliances Program may address:

- E13 Building integral PV products in common use
- M7 Barriers to PBI from capital rebates are addressed (Note: CEC pursuing an EPBI approach for NSHP).

3.4 Additional CPUC CSI Funding Resources

In addition to the RD&D fund, the CSI program budget has reserved funds for Marketing and Outreach (M&O) and Evaluation, Measurement, and Verification (EM&V). The M&O budget is about $60 million dollars over ten years, and the EM&V budget is about $20-30 million dollars over the same period. CPUC staff reviewed the CEC PIER milestones and NREL market barrier targets to identify activities that might be addressed with the CPUC M&O or EM&V funds. Appendix D presents which CSI funds might be called upon for which activity targets. For example, the milestone relating to transmission and distribution benefits[14] could be appropriate for RD&D, EM&V, or both. Staff did not have time to overlay these CPUC resources against Table 4 to review further potential duplication but will do so in preparation for a follow-on public workshop.

3.5 Private Sector RD&D

Private industry investment comes in two forms – corporate donations to university research (such as donations by BP or Exxon to UC Berkeley and Stanford, respectively), and funding to individual private companies. The latter may take the form of venture capital at early stages of technology or company development, and later on in the form of private and public capital market investments in companies.

Using information posted on an MIT Entrepreneurship website, Venture Capital (VC) investment in 2005 in solar companies amounted to roughly $150 million.[15] For Q1-Q3 of 2006, VCs invested approximately $242 million in the U.S. solar industry in 17 companies. If we view this as equivalent to a "development" stage, investments range from $500,000 to $32 million per company, with funds coming from various VC sources. (Some state clean energy funds could be involved via investment companies in these 17 transactions. The typical investment per funding source appears to be around $3 million.

[14] "High value locations for DG PV on T&D are identified and the impacts/benefits of large concentrations of DG PV in one location on T&D are assessed."

[15] This information was obtained at a website for the MIT Entrepreneurship Center http://entrepreneurship.mit.edu/Energy/2006_VC_in_CE.htm. The Center is part of the New England Energy Innovation Collaborative. The website information carries this source disclaimer: "Article graciously provided by Eric Wesoff, SAGE Marketing Partners, publisher of the Venture Power newsletter Consulting and Funding services in Photonics and Alternative Energy, wesoff@mindspring.com, and reproduced with permission."

4. Proposed CPUC CSI RD&D Strategy

Energy Division staff proposes an RD&D funding strategy that includes RD&D program principles, funding guidelines, criteria for project selection, an administrative structure, and a process for program evaluation. The principles, guidelines and criteria will guide project selection. These all are tied closely to the CSI policy goals (create a sustainable, self-supporting solar industry in California over a ten-year period) and desired outcomes (achieve 3000 MW of solar installations, and eliminate ratepayer subsidies after 2016).

4.1 RD&D Strategy Principles

The CPUC R&D strategy should adhere to five key principles:

1. Ensure there is a robust set of solar technologies competing with one another on the basis of cost and performance
2. Focus on California specific-issues that may not be funded by others
3. Take advantage of California's wealth of data from past, current, and future installations
4. Fill gaps in the knowledge platform for successful wide scale deployment of solar DG technologies
5. Overcome significant barriers to technology adoption

Cost remains the single largest constraint to widespread adoption of solar DG technologies. This requires continued adherence to research and development to identify technology breakthroughs and demonstration projects to test and confirm the performance and cost improvements necessary to overcome this barrier.

Second, funding also should be directed towards issues that have a clear relevance to California's energy end-uses, transmission and distribution concerns, and other local needs. This will ensure that California ratepayers who are funding the CSI program will realize benefits from the RD&D program.

A third key principle is to take advantage of the wealth of solar data and experience in California. California has already installed over 15,000 solar projects and will install thousands more through the CSI. The CSI RD&D program should analyze various facets of current installations and the market (California's "natural experiment"), and then apply important lessons in further shaping and expanding California's solar market.

A fourth principle is to maximize RD&D funds by filling in gaps that industry or government agencies are not funding. For example, industry is already making investments in many production technologies in order to lower the costs of a solar cell. The state could therefore focus on other funding categories in order to maximize leverage. All projects should demonstrate an ability to help accomplish the overall goal of 3,000 MW of solar installations in California by 2016, followed by a self-sustaining solar market in the years beyond.

The final principle is to help distributed solar overcome barriers to adoption, particularly across the innovation "valley of death." By targeting R&D activities at those barriers or opportunities that promise high impact, distributed solar applications could become more widespread. Increasing performance and efficiency of solar panels is an important expected outcome. Distributed solar is currently constrained by the size of a roof or available land to site the system. More efficient solar cells, inverters, and wiring solutions will decrease the overall size of the system thus allowing greater potential for more generation.

4.2 Allocation by Phases

There is apparent stakeholder consensus that industry and the national government should handle the bulk of the basic R&D funding, and that states should only enter that arena if there is a particular R&D area that is not being adequately addressed by industry or DOE. For that reason, most state-level RD&D agencies tend to focus on demonstration and deployment activities, and it is expected that the CPUC will focus most of its energies in these areas.

CPUC staff recommends the following breakdown of funding across RD&D areas:

Demonstration

Demonstration is the highest priority for the CPUC RD&D strategy; the CPUC should focus at least 50% of dollars in these activities. The CSI RD&D fund is following the lead of other clean energy state funds and proposes to focus on bridging the "valley of death," where risk is high and return is low for potential investors. Demonstration projects are least likely to be funded elsewhere -- they are not attractive investments to the finance community since they lack prospects for intellectual property and outsize earnings in the future. As a result, investors do not have a strong incentive to invest in these types of projects. The Commission can fund promising solar technologies and bring them closer to market, which will lower the risk of adopting new technologies and bring more competition and lower prices to consumers.

Research

Research should be a secondary aim of the CPUC's CSI program, and viewed as a way to kick-start or supplement national and industry efforts when the potential gains for California are extraordinarily large. However, there may be a need to commit some portion of CSI RD&D funds to Research to ensure adequate attention to totally new forms of solar materials and technologies. A small amount of the budget might be assigned longer-term, higher-risk research activity, seeking breakthrough technologies in terms of cost and/or performance. Because research activities typically are more expensive than demonstration or deployment activities, a research funding allocation of 20% may appear to be larger than the extensive gains possible from other areas with slightly lower funding levels.

Deployment (Market Support)

The CPUC should reserve a modest level of funding for deployment activities that will help build market-volume or scale. The CSI program itself essentially is a deployment program that

gives consumers financial incentives to purchase solar systems. There are still additional crucial deployment activities that the CSI can fund, such as developing new business models to spur widespread and cost-attractive solar installations. Deployment activities are relatively less expensive than research or development, priority activities may be carried out with less funds. Staff does not have a clear basis on which to differentiate cost and priority between development and deployment. Thus, we suggest a rough target of 15% of funds for each, subject to reconsideration during the project solicitation process.

Development

Development is the final focus, and may only need 15% of funds. There appears to be plenty of federal and VC money flowing into solar, deal sizes eat up significant chunks of money, and state funds are unnecessary for business enterprise investments. However, some development activities may have more interest to the local California market. Therefore, the CSI fund should only contribute where it is demonstrated that there is a gap to fill that clearly benefits California.

4.3 Potential Target Activities

Here we distinguish between target activity areas or categories, and then illustrative RD&D projects that might be proposed within each category.

4.3.1 Target Activity Areas

Based upon staff analysis of other federal, state, and industry priorities, we believe the following milestones from the CEC PIER consultant study meet CSI RD&D goals and objectives, and could become target activities for CSI RD&D funding consideration. Appendix D presents a work sheet that CPUC staff used to consider all the milestones identified in the PIER study.

This is an initial "screening list". Staff intend to further refine the list after discussion at a public workshop, further exploration of CEC funding plans (as summarized below), and a closer look at the draft DOE SAI Plan and knowledge of Congressional action on related budgetary support. See Appendix E for examples of illustrative grants that could fit each area. Asterisks denote no known overlap with PIER, CEC Renewable Energy program, or CEC Building and Appliances Program.

Production Technologies - support the commercialization of PV technologies

- Potential changes to PV system design and installation requirements caused by the emergence of alternatives to silicon-based PV over next 15 years understood(P1)
- Key barriers to the development of PV minigrids or central PV are identified (P2)
- PV system design and installation procedures enhanced to more effectively optimize system performance (P3)
- Economic viability of distributed concentrating PV systems demonstrated (P5)

* Building integral PV products become cost competitive with rooftop PV and key technical integration issues are addressed (e.g. spacing/cooling) (P7)

Grid-Integration - enable PV integration with the distribution and transmission system

- PV systems with storage or other technologies demonstrate better coincidence with utility system peak load (G2)
- High value locations for DG PV on T&D are identified and the impacts/benefits of large concentrations of DG PV in one location on T&D are assessed (G5)
- Utility acceptance of protocols to allow PV system operation during grid outages (G7)
- Economic viability of new PV system storage technologies are demonstrated (G8)

Business Development and Deployment - supports the market and end-users

(Note: CPUC staff have combined some of the CEC's "End Use" and ""Market" Milestones into this new combined category that the CPUC finds useful. Additionally, we have moved several CEC milestones relating more to technology or grid to the above two categories.)

- New/modified business models create sustained market growth (E3)
- Potential roles for utilities in solar PV, including attractive business models, are identified and vetted with utility companies. (E5)
- Lower cost, utility grade PV system control, metering, and monitoring capacity developed consistent with 1% cost parameter established by CPUC for CSI (E7)
* Business models developed to address fact that homeowners and renters move frequently (E9)
* Field tests done to quantify operational risks and benefits of PV (work heavily with utilities) (E10)
- Improved PV economics demonstrated using advanced metering, price responsive tariffs (e.g. TOU, Feed-in Tariff) and storage (E11)
* Key relevant results and strategies from Germany and Japan are identified and recommendations made for application in CA (M4)

4.4 Recommended Funding Allocations

This section presents staff's recommendations on funding allocations for three dimensions of funding awards and ideas for managing risk through cost-sharing, partnerships, and/or maximum award sizes. Finally, staff proposes that only the research category of funding be made on a non-competitive basis to one high-risk, long-term focused effort to develop "breakthrough" solar technologies.

4.4.1 Effort Levels

Staff seeks public input on the preferred allocation of effort. We aim to establish robust, public guidelines that direct the correct budget amounts according to the types of work that is

needed in the field. At the same time, staff wishes to avoid overly-prescriptive rules that might limit good, innovative grants. Therefore, staff presents the following three stand-alone allocation guidelines (by phase, activity area, and risk).

Suggested Allocation by Level of RD&D Activity

Research	20%
Development	15%
Demonstration	50%
Deployment	15%

4.4.2 Target Activity Areas

Suggested Allocation by Target Activities

RD&D administration	15-20%
Production Technologies	40%
Grid integration, storage, metering	25%
Business Development and Deployment	15-20%

4.4.3 Risk and Timeframes

The proposed CSI RD&D program aims to achieve measurable results within the next ten years, but should also be open to new ideas and projects with higher risk. The RD&D fund should set aside up to 20% of the funds for higher risk projects. Google, for example, uses the well known "70-20-10 Rule," where staff devote 70% of their time to core business (safe projects), 20% to other related business (medium risk projects), and spend the remaining 10% on areas of their own choosing (presumably higher risk "off the wall" concepts). This type of diversified investment approach is also utilized by the Massachusetts Technology Collaborative, which administers a variety of programs investing in projects at a wide range of commercialization stages—from early stage development, demonstration, deployment, and even a small venture capital fund.

For every three projects that face commercial potential in the next 1-3 years, the CSI could fund one project that has a longer commercialization horizon, such as 4-7 years. In addition, the RD&D fund could put out an open solicitation to capture new ideas that the CPUC and program administrators have not yet thought of.

Suggested Allocation by Risk or Timeline to Results

Highest risk, results 8+ years	20%
4-7 year results horizon	20%
1-3 year results horizon	60%

4.4.4 Additional Ideas for Managing Risk

Cost-Sharing

Cost sharing is an important program component since it encourages project discipline. CSI development and demonstration projects should have a cost-share of at least 25%, and deployment up to 10%. The cost-share requirement may be larger depending on the project. Since deployment activities are geared towards a diffuse group of market participants, cost sharing may not be straightforward. For example, cost sharing is conducive to incentive payments, but may not be conducive to development of new business models. For deployment activities that are not amenable to cost sharing, the CSI can partner with the private sector. If the CSI were to organize a forum to develop new business models for purchasing solar, it could team up with other solar industry groups.

Suggested Cost-Sharing Requirements

Development	25% cost-share
Demonstration	25%
Deployment	0-10%, depending upon nature of project

Joint Funding or Partnership Arrangements

Another approach to consider is whether grant funding can be leveraged through partnerships. Evidence suggests that there are distinct advantages to scale, with larger organizations spending comparatively less on RD&D yet attaining larger benefits.[16] By partnering with other state agencies (e.g. CEC, NYSERDA, or MTC), DOE, or industry, the CPUC may be able to obtain the benefits that scale provides. As noted in Section 2, interest has increased in public-private venture fund partnerships, which could leverage industry and government knowledge and funding to achieve greater results with newer and riskier technologies.

4.4.5 Proposal for a Non-Competitive Research Award

Staff recommends committing 20% of the Solar RD&D program funds ($10 million) to a single, large consortium that will focus on developing break-through solutions to low-cost solar electricity generation technology for homes, businesses, institutions and other distributed locations. This is the Helios Project, a large multi-disciplinary and multi-investigator project led by Lawrence Berkeley National Laboratory and UC Berkeley (See Appendix F for a more detailed description of this project).

The Helios project will focus on research to develop:

- High efficiency, low-cost, high-volume photovoltaic materials and electricity generation for scalable manufacture,

[16] Jaruzelski, B., Dehoff, K., Bordia, R., "Smart Spenders: The Global Innovation 1000," Booz Allen Hamilton, http://www.boozallen.com/media/file/Global_Innovation_1000_2006.pdf

- Solar storage solutions that transfer excess power generated during peak solar hours into chemical fuels that can be stored and used at a later time to produce electricity. This might involve hydrogen, oxygen, methanol, ethanol, or other energy fuels integrated into storage and conversion mechanisms.

Staff believes this project is consistent with the overall goals of the CSI program to achieve 3000 MW of distributed solar power by 2016, and to achieve cost and scale economies that will permit elimination of ratepayer solar subsidies. We believe CSI RD&D funding for Helios will:

- Ensure faster launch of critically-needed longer-term, higher-risk basic research that is needed to achieve low-cost solar photovoltaic electricity production.

- Leverage by more than 10:1 the CSI contribution along with other State of California "cost-sharing" funds which together can command additional federal, corporate, and individual donor sources to establish the research facility.

- Leverage an expected annual budget of $20-30 million from other funding sources for solar research and development, expected from sources such as the California Energy Commission, California Environmental Protection Agency \, US Department of Energy, foundations and corporations.

- Support a multi-disciplinary approach to research and development to achieve complete solutions across materials science, electricity generation efficiencies, grid integration, and competitive market pricing dictates.

- Bring together a wide group of California scientists and experts to collaborate on finding solutions for widespread use of distributed solar electric applications in California.

The remaining 80% of solar RD&D funds would be allocated using the guidance framework explained below. This includes staff's suggested guidelines for funding allocation across phases of RD&D, target solutions areas, degree of risk and timeframes for applying results.

4.5 General Guidelines for Competitive Project Solicitation

4.5.1 Eligible Technologies

Eligible technologies are described by SB1 as "solar technologies and other distributed generation technologies that employ or could employ solar energy for generation or storage of electricity or to offset natural gas usage." All solar technologies and balance of system components that are used for distributed generation are eligible for RD&D grants. Examples of balance of system components are advanced meters, inverters, and storage methods.

4.5.2 Eligible Recipients

Only businesses or organizations located in the state of California should be eligible for funding. Since California ratepayers are the source of the funds, they should also receive the benefits.

4.5.3 Project Location

All projects must be located in California in order to ensure results are consistent with the overall CSI goals, funding principles, guidelines, and award criteria.

4.5.4 Timing of Solicitations and Awards

There should be two or three funding cycles over the term of this program. The first cycle should invite projects that might have any of three time frames (1-3 years, 4-7 years, 8 years or longer).

Then, in perhaps two-year cycles, additional awards should be considered for only those projects that offer results in 1-3 year time frames. For example, if 60% of the funds are to be used for projects offering results in 1-3 years, there might be three cycles of award solicitations, each offering 20% of the RD&D funds.

4.5.5 Size of Awards

The CSI needs to balance making meaningful grants that will have an impact versus funding a larger portfolio of projects. This typically is done by capping the size of awards for any individual project. For example, the Connecticut Clean Energy Fund awards grants up to $750,000 for early stage technologies. The New Jersey Renewable Energy Business Venture Assistance program makes grants ranging from $50,000 to $500,000.

CPUC staff proposes to cap the amount of funding that can be used on any individual project at $750,000 (excluding the research category). Alternatively, different cost caps could be assigned to each stage of funding (development, demonstration, or deployment), or by target areas (technology, grid, business plans). Staff seeks particular guidance on the funding cap.

CPUC staff also request guidance on whether to require a ceiling on the percentage of overhead costs that can be submitted on project proposals.

4.5.6 Project Selection Criteria

The CPUC will apply a set of criteria across all activity categories to evaluate and select projects. Staff proposes the following criteria be used to evaluate applications submitted under the competitive solicitation process:

<u>Project Characteristics</u>

- High priority milestone

- Benefits for California ratepayers
- Amount of funds sought from CSI RD&D funds
- Expected outcome metrics
- Potential to expand PV market opportunities or reduce barriers
- Leverage
- Institutional and regulatory feasibility
- Key project milestones identified
- Probability of commercial success
- Timing of commercialization
- Visibility and educational benefit

Proponent(s) Characteristics

- Proven viability of technology or team
- Professional team, capabilities and qualifications of team members

Project Characteristics

High priority milestone

The proposed project should address a milestone among the CSI activity areas. CPUC chose these milestones because they rank high on the a priority list vetted with the solar industry in the PIER PV priority setting process.

Benefits for California ratepayers

Since the CSI is a program designed to benefit California ratepayers, this is a very important criterion. There are various benefits to consider, such as grid reliability, lower rates, T&D benefits, and environmental benefits.

Amount of funds sought from CSI RD&D funds

Cost is also a critical consideration. The R&D administrator will consider a number of questions, such as "Is the cost reasonable and within the funding range? Does the cost require a large amount of the RD&D budget? Is the project a good investment for the cost?"

Expected outcome metrics

Results should be expressed in one or more of the applicable metrics for the RD&D program: increase solar system performance, decrease costs as $/kWh, enables greater annual installations, and/or applies results within the ten-year program.

Potential to expand distributed solar market opportunities or reduce barriers

In order to reach the 3000 MW goal, the solar industry will need to find a broader customer market.

Leverage
Requested CSI funding contribution relative to other funding and expected benefits.

Institutional and regulatory feasibility
Some projects may require a change in codes and standards that could require changes to state law or regulatory rules. For example, solar installations cannot operate during grid outages due to safety hazards for utility workers. If a new project could provide a technical fix to this problem, the rules may have to change to accommodate this technology.

Key milestones identified
In order to evaluate the proposal, it will need to be very specific in identifying the key milestones, timeline, and project plan. The quality and reasonableness of the project plan should be considered in assessing projects on this criterion.

Probability of commercial success
Again, while the RD&D program should consider some projects with higher risk, the majority should have a medium to high probability of commercial success.

Timing of commercialization
Since the focus of the CSI is only ten years, most projects should have a short-term window for commercialization. Moreover, the public and industry will monitor closely the use of the CSI R&D funds to see that they are producing valuable results that interface well with other concurrent R&D. Staff suggests a one-to three-year window for likely commercialization.

Visibility and educational benefit
Although not critical, visibility and educational benefit would enhance the competitiveness of the project. Since the CSI also strives to educate the California consumers about the benefits of solar, demonstration or other types of projects that involve the public would be an added benefit.

Proponent(s) Characteristics
Proven viability
While the RD&D program should consider some projects with higher risk, the majority of the projects should have proven viability. Definitions of proven viability will depend on where they are on the RD&D continuum.

Professional team, capabilities and qualifications of team members
The team should be professional and have both technical skills and business acumen.

4.5.7 Award Decisions

All award decisions will be made by a public vote of the full Commission, following the regular procedures of public notice and opportunity for comment on proposed Commission decisions.

4.6 Strategy Summary

Principles

1. Ensure there is a robust set of solar technologies competing with one another on the basis of cost and performance
2. Focus on California specific-issues that may not be funded by others
3. Take advantage of California's wealth of data from past, current, and future installations
4. Fill gaps in the knowledge platform for successful wide scale deployment of solar DG technologies
5. Overcome significant barriers to technology adoption

Allocations

Allocation by Level of RD&D Activity

Research	20%
Development	15%
Demonstration	50%
Deployment	15%

Allocation by Target Activity Areas

1. *RD&D Administration* - 15-20%
2. *Production Technologies* – 40%
   - Potential changes to PV system design and installation requirements caused by the emergence of alternatives to silicon-based PV over next 15 years understood(P1)
   - Key barriers to the development of PV minigrids or central PV are identified (P2)
   - PV system design and installation procedures enhanced to more effectively optimize system performance (P3)
   - Economic viability of distributed concentrating PV systems demonstrated (P5)
   - Building integral PV products become cost competitive with rooftop PV and key technical integration issues are addressed (e.g. spacing/cooling) (P7)
3. *Grid-Integration* – 25%
   - PV systems with storage or other technologies demonstrate better coincidence with utility system peak load (G2)
   - High value locations for DG PV on T&D are identified and the impacts/benefits of large concentrations of DG PV in one location on T&D are assessed (G5)
   - Utility acceptance of protocols to allow PV system operation during grid outages (G7)
   - Economic viability of new PV system storage technologies are demonstrated (G8)
4. *Business Development and Deployment* – 15-20%
   - New/modified business models create sustained market growth (E3)
   - Potential roles for utilities in solar PV, including attractive business models, are identified and vetted with utility companies. (E5)
   - Lower cost, utility grade PV system control, metering, and monitoring capacity developed consistent with 1% cost parameter established by CPUC for CSI (E7)

- Business models developed to address fact that homeowners and renters move frequently (E9)
- Field tests done to quantify operational risks and benefits of PV (work heavily with utilities) (E10)
- Improved PV economics demonstrated using advanced metering, price responsive tariffs (e.g. TOU, Feed-in Tariff) and storage (E11)
- Key relevant results and strategies from Germany and Japan are identified and recommendations made for application in CA (M4)

Allocation by Risk or Timeline to Results

Highest risk, results 8+ years	20%
4-7 year results horizon	20%
1-3 year results horizon	60%

Cost-Sharing Requirements

Development	25% cost-share
Demonstration	25%
Deployment	0-10%, depending upon nature of project

General Guidelines for Competitive Project Solicitation

1. Eligible Technologies: solar technologies and other distributed generation technologies that employ or could employ solar energy for generation or storage of electricity or to offset natural gas usage.
2. Eligible Recipients: businesses or organizations located in the state of California
3. Project Location: located in California
4. Timing of Solicitations and Awards: 2-3 funding cycles. First cycle is any of 3 time frames (1-3 years, 4-7 years, 8+ years); Then, 1-3 year time frames considered every 2 years.
5. Size of Awards: $750,000 cap; overhead cap?
6. Project Selection Criteria
    - High priority milestone
    - Benefits for California ratepayers
    - Amount of funds sought from CSI RD&D funds
    - Expected outcome metrics
    - Potential to expand PV market opportunities or reduce barriers
    - Leverage
    - Institutional and regulatory feasibility
    - Key project milestones identified
    - Probability of commercial success
    - Timing of commercialization
    - Visibility and educational benefit
    - Proven viability of technology or team
    - Professional team, capabilities and qualifications of team members

5. RD&D Strategy Administration

This section describes the required functions, necessary qualifications, and administrative options before recommending two administrators for the R&D project as a whole. In SB1, the Legislature intended to hold the Commission accountable for the expenditure of $50 million of ratepayer funds. The Legislature mandated that the Commission use its extant legal and regulatory process, i.e., Commission decisions, to establish the program as well to approve each award of funds. The Legislature's selection of the Commission's decision process also imports the potential for judicial review. The Legislature did not, however, mandate that the Commission and its staff perform all program functions.

5.1 Functions

The essential functions of the administrator include:

- Determine overall goals and objectives.
- Develop specific funding opportunities, consistent with goals and objectives.
- Solicit funding requests.
- Evaluate requests in transparent and timely manner
- Recommend to the Commission specific projects for funding.
- Implement funding of approved projects (technical, contractual, and accounting)
- Oversee project implementation (technical, contractual, and accounting)
- Audit and evaluate project when completed.

The scope of contracting and accounting are broad. Review of the California Energy Commission's PIER program standard agreement and the New York Energy Research and Development Authority (NYSERDA) sample agreement reveal approximately 50-page documents that cover, among others, the following significant topics:

1. Specification of work to be performed and deliverable products
2. Cost sharing, including necessary billing calculations
3. Title to equipment, filing UCC.1 form to secure interest
4. Schedule for progress payments
5. Subcontracting
6. Rights in technical data
7. Patents
8. Royalty payments
9. Annual reports
10. Warranties, indemnification
11. Insurance

12. Termination Provisions
13. Business reorganization
14. Publicity
15. Attachment with Standard Terms and Conditions for State Contracts, i.e., wages, discrimination, tax laws, etc.

5.2 Personnel Qualifications and Experience

The substantive requirements can be broken down into two basic groups – (1) solar technical and (2) contracting/accounting. Overall management of the program will require solid understanding of both of these areas.

The scope of technical issues being considered runs a broad gamut from transmission grid integration to photovoltaic coatings, and may extend to business models and capital financing options. Understanding these issues and remaining up-to-date on emerging solar issues will require an experienced technical expert. This knowledge and experience will be critical to sound evaluations of funding proposals. Technical staffing will also be key to developing overall funding objectives.

The Commission's solar technical staff could be supplemented with work done at other state agencies and private firms. The California Energy Commission has an extensive program for investing in alternative energy sources, including solar, and many private firms offer consulting and other services related to solar energy. While core technical management and some level of analytical support should reside within Commission staff, specialized external resources are available to supplement internal staff as needed or desired.

The Commission does not currently have personnel to perform all of these functions.

5.3 Options for Administrative Arrangements

5.3.1 Institutional Options

Staff present four generic options to explore which entity would administer the project selection process, and implement and manage the awards. While the CPUC has some institutional flexibility regarding who can manage the program, SB1 legislation requires the Commission to approve each proposed project through a public process and full Commission vote. Moreover, the CPUC must follow other statutory requirements on contracting, payments, and other issues. In all four cases, payments to the administrator(s) and for individual RD&D awards would probably need to be made by the utilities, who are the entities collecting CSI funds through distribution rates. Utilities would need to be compensated for their expenses in performing accounting and payment functions. Table 5, below, gives a short description and some pros and cons of each option.

Table 5

Who	Process	Pros	Cons
1 CPUC	1. Commission establishes strategic plan through ruling 2. Select projects through Commission vote 3. Contracts with third party to manage projects	• Less possibility of legal constraints • May cost less	• Requires extensive staff or consultant resources and RD&D expertise • Risk of obtaining legislative budget authority, including for new staff, and recruiting staff. Probably need approval of budget authority to pay for any contract with an administrator.
2 Utilities	1. Commission votes on strategic plan 2. Utilities select and recommend projects based on approved plan 3. Commissioners vote and approve each project 4. Utilities implement and manage projects	• A familiar model, similar to structure for Energy Efficiency programs • Utilities need to make payments from CSI funds anyway • Would require minimum CPUC staff resources	• Interests and goals may not be aligned • Program could become disjointed if responsibility is assigned across 3 utilities. • Utilities' staff may not have special skills or knowledge to conduct the RD&D function
3 Private Third-party	1. Commission votes on strategic plan 2. Direct utilities to competitively select organization that can administer full range of research, development, demonstration, & deployment solicitation with oversight by CPUC. 3. Chosen administrator proposes projects based on approved plan 4. Commissioners vote and approve each project 5. Administrator implements and manages projects with appropriate Commission monitoring and oversight.	• Skills and experience already exist in private organizations • Requires less staff resources	• Would need time to carry out an RFP process • Would need to ensure avoid Conflict of Interest relationships

Who	Process	Pros	Cons
4 University of California	1. Commission sets up sole-source contract with UC (permitted through state contracting laws) 2. Commission votes on strategic plan 3. UC institution proposes projects based on strategic plan and provides regular progress reports to CPUC 4. Commissioners vote and approve each project 5. The UC would manage and administer projects	• Could sole source contract if elect to consider UC system • Have resources and expertise to meet our needs	• For universities beyond UC, more legal review is required on following either the private third-party approach or sole source contracts. • Chosen university would have to agree not to bid on actual projects to avoid conflict of interest • Difficult to get budget authority

5.3.2 Potential advisory board (or stakeholder consultative group)

Depending upon the choice of administrator, an advisory process could take place through: a) semi-annual meetings of all related CEC and CPUC staff, b) public workshops, or c) an advisory group to a non-CPUC administrator.

5.4 Recommended Institutional Structure

Pending further legal review, staff recommends that the Commission outsource the staffing of this program to a competent outside group, with appropriate oversight by CPUC staff. This is a new type of endeavor for the Commission. It will require staff with high-level technical which are not within the usual range for Commission activities, and for a defined period of time.

This recommendation is premised on concerns for legality, time-effectiveness, management experience with R&D grants, public scrutiny, and overhead cost considerations. However, three key findings guide this recommendation:

Complex and Broad Range of Technical Issues
Many of the inherent functions of the Solar Research, Development, and Demonstration program are outside the usual scope of duties for the Public Utilities Commission.

The scope of technical issues being considered runs a broad gamut from distribution grid integration to photovoltaic coatings, and may extend to business models and capital financing options. Understanding these issues and remaining up-to-date on emerging solar issues will require an experienced technical staff and the needed experts may change over time. This knowledge and experience will be critical to sound evaluations of funding proposals. Technical staffing will also be key to developing overall funding objectives.

Short-term and Variable Staffing Requirements
The staffing required for this program will vary substantially over the life of the program. The program also has a limited duration – no more than 10 years. Maintaining a competent technical staff can be more efficiently accomplished at a private firm due to enhanced hiring and contracting flexibility. The outside firm can then report back to the Commission for final approvals, as envisioned in the statute.

Minimum Core CPUC Staff Still Needed
The statutory requirements still necessitate Commission action to establish and oversee the overall program, approve each funded project, and report on results to the Legislature. The Commission must be actively involved in these crucial portions of the program. The Commission may not delegate these duties to others.[17] Therefore, the Commission must have a minimum core management and oversight staff to enable it to perform these non-delegable duties.

5.5 Illustrative Budget and Organization

Assuming the active period of the RD&D program is at least 6-7 years, it seems reasonable that approximately 15- 20% of the total RD&D budget be reserved for internal and external personnel resources and operating expenses. Staffing this function within the CPUC would require some number of staff (perhaps 4-6) and approximately $ 600,000 to $1 million or more per year for labor and benefits alone. There would be additional expenses for outside experts, travel, and reimbursement of utility accounting and payment services. The New York program, for example, annually expends about $30 million for administration (241 person staff) of $360 million of awards. The CEC PIER program has a staff of 60 and a total annual budget of $80 million for administration and RD&D expenditures.

If the administrator is an external organization, salaries may be higher, but the total number of fiscal year-equivalent personnel may be lower by using only portions of different personnel's time.

5.6 Solicitation and Selection Process

The administrator would prepare a Solicitation Requesting Submission of Applications for RD&D Awards. The substantive content for this solicitation will be the final CPUC RD&D plan (Section 4) in particular Metrics, RD&D stages, Target Activity Areas, Overall funding allocation guidelines, and Solicitation criteria. The outline of the RFP content could include the following:

I. Description of Funding Opportunity
- Milestone(s) to be addressed
- Amount to be awarded
- Functional requirements

[17] These requirements preclude outsourcing the entire program to another agency or private firm.

II. Proponent Requirements

- California-based business, work performed here
- Financially viable business
- Funding not available from other sources
- Cost-sharing fraction and Royalty obligations

III. Notice of Funding Opportunity

- Web site, with electronic sign up
- Email list

IV. Submission Deadline

- Public opening of proposals?
- Other state contracting requirements?

V. Evaluation

- Identify evaluating entity
- Written record of evaluation
- Final recommendation to Commission
- Evaluation criteria

VI. Commission Review and Approval

- Agenda formalities
- Potential for staff report (to be determined)
- Determination by Resolution or Decision

VII. Time and Process for Rehearing and Appeal

6. Evaluation

6.1 Evaluation Process

The CPUC will ensure ongoing oversight of individual grants and a formal, biennial evaluation of the entire project.

Ongoing Evaluation:

The administrator will work with CPUC staff to regularly monitor grant progress during the grant duration on all awarded projects, according to the scope of work, milestones, and deliverable schedules outlined in contractual documents for each award.

It is important to understand that some technologies or demonstrations will "fail" (see earlier discussion of risk), although there still can be valuable lessons learned. The R&D administrator will help CPUC staff develop an exit strategy for both for unsuccessful grants (e.g., early termination plans) and successful grants. Like the Stern Review, staff recommends that the administrator recommend suggestions for next steps, disseminating lessons learned, and the extent of approval of the grant's achievements.

Additionally, the grants administrator will support CPUC staff to report on the progress of the RD&D awards to the Legislature and other decision makers on an as-requested basis. As mandated by SB1, "If the commission allocates additional moneys to research, development, and demonstration that explores solar technologies and other distributed generation technologies … the commission shall include in the assessment submitted to the Legislature, a description of the program, a summary of each award made or project funded pursuant to the program, including the intended purposes to be achieved by the particular award or project, and the results of each award or project." The administrator will work with CPUC staff at the outset of the contract to establish these and other data collection and reporting expectations and deadlines.

Biennial Evaluation

Evaluation of the entire R&D project will take place through ongoing advisory process (See Section 5.3.2) and a biennial independent evaluation. Staff recommends using an independent evaluator comprising CPUC staff; related CEC staff; or a UC professor or research staff member. The evaluator will review both the administrator and the R&D grants against evaluation criteria every two years. If suggested in the evaluation, the CPUC will consider directing the R&D project administrator to refocus RD&D milestones within two months of the evaluation.

The evaluator will rely on the following in its review: interviews with stakeholders, individual project progress reports, available program evaluation results, and new information about technologies or the marketplace.

6.2 Evaluation Criteria

The evaluator will consider whether the RD&D portfolio as a whole is demonstrating progress on four dimensions:

- Increase performance and efficiency of solar panels, inverters, and system designs
- Decrease costs on a $/kWh basis
- Contribute to a significantly greater scale of annual installation activity
- Apply results within the ten-year program, and no later than 2017

With regard to individual project evaluation, staff recommends a range of principles, guidelines, and criteria for grantmaking decisions above. The CPUC staff, administrator, and evaluator will consider solicitation criteria and the following criteria in assessing individual grant achievements:

- Benefits for California ratepayers
- Amount of funds obtained from CSI RD&D funds
- Project outcome using CSI RD&D metrics (increase performance and efficiency of solar systems, decrease costs on a $/kWh basis, contribute to greater scale of installations, and/or apply results within the ten-year program)
- How project expands PV market opportunities or reduces barriers
- Leverage from other funding sources
- Institutional and regulatory acceptance of project findings or outcomes

The CPUC will rely upon CPUC evaluation protocols already established for the $100 million energy efficiency program evaluation effort (evaluation the $2 billion of utility energy efficiency programs in the 2006-2008 funding cycle). Specifically, we will draw upon evaluation protocols for:

- The “Emerging Technologies”, and “Information Programs” in evaluating individual projects; and
- The “Market Effects” protocol for evaluating the overall solar RD&D program.

7. Questions for Comment

CPUC Role, Risks, and Priorities

1. State role: Does the proposal suggest appropriate activities for a State agency to fund, versus activities better funded by federal or private sector funds?
2. Are there any concerns about state funding for the suggested types of activities?
3. Are the proposed funding allocations for research, development & demonstration a reasonable balance to develop California's solar market?
4. Are the principles, guidelines, cost-sharing requirements, selection criteria, and evaluation criteria appropriate for the CPUC program? Are they too prescriptive or onerous, or, should they be even tighter?
5. Does the proposal seem reasonable regarding allocation of funds by risk and the associated timeframe of expected results?

Production Technologies

6. Are these suggested target activity areas correct?
7. Does the proposed share of funding seem reasonable? Should this percentage be further broken out by RD&D phases?
8. The suggested criteria focus on technologies promising increased performance and/or decreased cost per kWh. Are these practical criteria for choosing technologies to support?
9. What is the appropriate share of development costs with other funders, and specifically how much should be paid by federal government or private company investment?
10. Are there specific suggestions for administering cost-sharing arrangements?

Grid Integration

11. Are the suggested target activity areas correct? How important will these be to building a market over 10 years? Which can best facilitate building a broader market among potential solar buyers?
12. Are there other critical gaps for widespread installation of solar DG?
13. Does the proposed share of funding seem reasonable? Should this percentage be further broken out by RD&D phases?

Business Development and Deployment

14. Are these suggested target activity areas correct?
15. Does the proposed share of funding seem reasonable? Should this percentage be further broken out by RD&D phases?

16. What should the Commission's role be in stimulating innovation in these areas, versus those of the DOE Solar America Initiative's market transformation strategies, or the solar industry and its financial partners?
17. How should the CPUC focus potential activities across analyzing barriers to market adoption, researching elements of potential new business models, sponsoring symposia to foster their development or adoption of solutions, and/or funding pilot demonstrations of new approaches?

Institutional Structure for Administration

18. Do staff correctly identify the functions that the administrator will need to carry out?
19. Does the strategy correctly identify the kinds and expertise of needed staff? Is it likely the CPUC could recruit these staff?
20. Is it reasonable to budget 20% of total funds for administration and management?
21. Have we identified an appropriate consultative processes to involve stakeholder input to setting priorities and/or to collaboratively execute activities?
22. Do the R&D project and individual grant evaluation process and criteria seem thorough and fruitful?

Appendix A: Overview of National and State-Level RD&D Programs for Distributed Solar Systems

Program Name	Program Goals and Objectives	Total Annual and Source	Total Annual Solar Funding	Funding Category (R, D, D, or D)	Average cost of Project in each Category	Cost-Share Requirement	Evaluation Criteria	Evaluation Process and Structure
DOE - Solar America Initiative	Reduce the average installed cost of grid-tied PV systems to $3.30/W by 2015, bringing down the cost of PV power to $0.09/kWh	$23.9B	$84M in FY06 $148M requested for FY07	"Market Transformation"		N/A		
NREL	Support the goals and objectives of DOE's Solar Program (see above)	$210M	$52M in FY06 $45M proposed for FY07	Primarily R&D		N/A	Ability to help meet DOE's long-term goals for PV, in particular: - Cost ($/W and $/kWh) - Cell efficiency (W/m^2)	
California Energy Commission - PIER Program	The mission of the Public Interest Energy Research Program is to conduct public interest energy research that seeks to improve the quality of life for California citizens by providing environmentally sound, safe, reliable and affordable energy services an	$62M	$1-2M	Development and demonstration Navigant study identified four priority target areas: - Production technologies - Grid integration - End use - Market support	up to $95,000 for hardware projects and $50,000 for modeling projects under the Energy Innovations Small Grant Program (EISG)		For EISG program: -Is the scientific approach sound? - Is the proposed research original and innovative? - Is the proposal practical? - Is the amount of funding requested appropriate? - Are project team members qualified? - Does proposed research target o	For EISG program the evaluation process is: - Initial screening - Technical evaluation - Program & technical review board - Funding recommendations to RD&D committee - Final approval given at a CEC Business Meeting Process should take 20 weeks from the s

Connecticut Clean Energy Fund	MISSION: CCEF develops, invests in and promotes clean energy sources for sustainable energy for the benefit of CT ratepayers. VISION: CT will be a leader in attaining a sustainable balance of energy production, economic growth, and environmental impact	$35M Public benefits surcharge		Primarily demonstration, with some development and deployment	up to $750,000 for demonstration $50,000 for deployment	25%	- Proven viability - Probability of commercial success - New technology - Capacity of > 1 kW - 3 year window for commercialization - Benefits for Connecticut ratepayers - Professional team	Rolling competitive bid process Bids evaluated by CCEF staff of 11, with final decisions subject to CCEF Advisory Board approval CCEF is administered by Connecticut Innovations, a quasi-public authority
Illinois Clean Energy Community Foundation	ICECF invests in clean energy development and land preservation efforts, working with communities and residents to improve environmental quality in Illinois.	Established in 1999 with $225M endowment from Commonwealth Edison	$3M	Demonstration	$115,000 ($13.8M for 121 renewable energy grants)		- Help earn points so buildings achieve LEED silver status - Educate the public about solar power's potential - Demonstrate the viability of emerging technologies - Develop consumer demand for renewable energy	Two-tiered competitive bid process. Bidders first submit letter of inquiry, and if accepted, submit full proposal, which is evaluated by ICECF's staff of seven
Massachusetts Technology Collaborative Renewable Energy Trust	Expand the supply of and demand for renewable energy in Massachusetts while also expanding economic activity in the state's renewable energy industry	~$10M ($47M for Clean Energy, FY06-10)	No "earmarks" for solar, but about half of RD&D funding goes to solar (and half to fuel cells)	Development (business) and deployment (incentives) A new fund currently under development will provide technical development matching grants for relatively high-risk ventures	up to $150,000 in "predevelopment financing" up to $500,000 in loans for business development - 2 awards per year (SEED program) up to $250,000 for design and construction of large onsite systems (incentive program)	25% for predevelopment financing and large onsite programs 50% for SEED program	- Technical feasibility and efficiency - Project risks - Timeframe - Presence of energy efficiency efforts in addition to PV system - Use of commercial technologies new to Massachusetts - Location in electric utility congestion area - Contributes to diver	For large onsite renewables program: - solicitation posted 12/8/06 - applications due 2/28/07 - awards announced 5/07 MTC staff (3-5) and a panel of external consultants go over proposals and present their funding recommendations to the MTC Board of Dir

New Jersey Board of Public Utilities Clean Energy Program	Provides information and financial incentives to help NJ residents, business and communities reduce their energy use, lower costs and protect the environment. Objective is to transform the energy marketplace in NJ toward more energy-efficient and renewabl	$140M		Development and deployment	$50,000 to $500,000	25%	- Experience completing contracts of similar size and scope - Qualifications of team members - Likelihood of success within time limitations - Cost of proposal - Commitment to developing renewable technologies to benefit New Jersey	Proposals are evaluated by third party evaluators with expertise in renewable energy, market development, technology commercialization, and business finance and capitalization
New York State Research and Development Authority (NYSERDA)	The goals of NYSERDA's renewable energy programs are to encourage new renewable energy businesses, expand existing enterprises, construct the supporting business infrastructure, reduce costs to the consumer, build consumer knowledge of and experience with	$150M Public benefits surcharge (mostly), and from legislature	$10M	RD&D, but most of the money is for deployment (incentives). About $2M/yr for development (primarily business development, infrastructure, and workforce training).	$200,000	50% (usually)	Specific criteria for each Program Opportunity Notice. For example: - Contains a financial and management plan, and market analysis and strategies - Project will benefit New York's renewable energy systems market, and create jobs - Likelihood of success -	A Technical Evaluation Panel judges all bids. The TEP usually consists of three NYSERDA staff and four external reviewers from academia, DOE, NYSERDA, and other state agencies Bid solicitations sent out once or twice per year NYSERDA expects to notify p
Xcel Energy Renewable Development Fund of Minnesota	Increase the market penetration of renewable energy resources at reasonable costs in the Xcel Energy service territory, promote the start-up, expansion and attraction of renewable energy projects and companies in the Xcel Energy service territory and stim	Varies: $53M awarded since 2001, in two funding rounds; a third is scheduled for 2007 Funded by charge on Xcel Energy for nuclear waste storage	No specific "earmarks" for solar	R&D (40% of funds) Demonstration (60% of funds)	$1.25M (up to $1M for R&D projects, up to $2M for "Energy Production" projects)		- System reliability and expected performance - Will the project advance renewable energy science, technology, or development? - Project team qualifications - Extent to which project overcomes potential "show-stopping" barriers to market deployment - Econ	An advisory board comprising two representatives of Xcel Energy and two representatives of environmental organizations evaluates all bids From 2003 solicitation: - RFP issued - 12/30/03 - Proposals due - 3/16/04 - RDF Board submits recommendations to MPU

Appendix B: Descriptions of Federal and Other State RD&D funds with Distributed Solar Activities

United States Department of Energy

The U.S. Department of Energy (DOE) recently launched the Solar America Initiative. DOE has been funding solar technologies for many years but with the Solar America Initiative has shifted emphasis away from basic research and development (R&D) and towards market transformation. The mission of the Solar America Initiative is to "accelerate widespread commercialization of clean solar energy technologies by 2015 to give the United States additional electricity supply options while reducing U.S. dependence on fossil fuels and improving the environment."

The Solar America Initiative is focused on both photovoltaics (PV) and concentrating solar power. The goals of the initiative is for PV to be competitive by 2015 through government partnerships and for concentrating solar power to be competitive by 2020 through ongoing and new R&D activities. The proposed budget for fiscal year 2007 is $148 million.

The approach of Solar America Initiative is to pursue activities in systems development and market transformation and to reduce costs through R&D and eliminate barriers through deployment efforts. These goals are very similar to the CSI RD3 fund. A distinction between the two is a federal focus with the Solar America Initiative and a California focus for the CSI.

Funding opportunities within the Solar America Initiative market transformation efforts fall within two categories:

1. Activities that provide technical, regulatory, institutional, financial, and educational solutions to market transformation barriers
2. Activities that accelerate demand for new solar technologies primarily through provision of technical assistance

The Solar America Initiative is also pursuing technology pathway partnerships, which focus on R&D of PV component and system designs, including low-cost approaches for manufacturing. The Initiative has not yet issued any solicitations, but intends to fund university research strategic partnerships.

National Renewable Energy Laboratory (NREL)

NREL has continued to perform fundamental R&D of solar technologies in the areas of PV and solar thermal. Within solar thermal, NREL is pursuing concentrating solar power and solar heating. NREL is also focusing on solar radiation research and data collection in order to provide more knowledge on optimal siting of renewable energy systems.

CEC PIER Program

The California Energy Commission Public Interest Energy Research (PIER) fund was established in 1996 as a result of restructuring California's electricity sector. PIER collects $62 million annually.

Of the renewable energy technologies, solar receives about $1-2 million each year. Earlier this year, PIER Renewables developed an integrated Renewables RD&D Roadmap to identify the RD&D required to help California meet policy goals. The roadmap encompasses most renewable energy resources and technologies viable between 2006-2020. One of the outputs of the Roadmap is prioritization studies of the various technologies. These studies will help PIER prioritize the RD&D milestones in the roadmap. The first prioritization study is for solar PV.

The PV prioritization study interviewed over twenty stakeholders, and based on their ranking of the various priorities, found that California should focus activities on end-use and market support. Some stakeholders asserted that PIER has been too production technology focused and that it needs to shift funding to application-oriented technologies and market transformation. These stakeholders believe that industry will fund production technology improvements, but that government funds should be used on development, demonstration, and deployment rather than research.

The CEC has funded other solar projects, which are mostly development and demonstration projects relating to advanced metering, solar cell tracking devices, direct DC power application for PV installations, BIPV tiles, and thin-film solar cells.

Other State-level RD&D Agencies

A number of other state- and regional-level energy organizations also deal with solar, although they vary in scope and objective. The first type of agency, which tends to have the smallest budget and the fewest resources, focuses exclusively on providing information and assistance to customers seeking to install or learn more about renewable energy systems or energy efficiency projects. Most states have agencies that handle these and other tasks, but examples of agencies that focus *exclusively* in this area include Efficiency Vermont and the Arizona Solar Center.

A second type of state solar energy agency – with significantly more resources at its disposal – focuses on performing RD&D activities itself. Examples of this type of agency include the Florida Solar Energy Center and the North Carolina Solar Center. Although these agencies typically have larger budgets than the consumer support type of agency, their RD&D activities are generally dictated by the source of their funding. These agencies generally obtain the majority of their funds by winning competitive bids from industry or the federal government to perform specific projects. Their discretionary RD&D budgets are typically very small.

The third type of state agency, exemplified by the CEC with its PIER program, is an agency that provides funding to other entities to carry out RD&D activities. Several states have organizations of this nature with varying levels and sources of funding, different objectives, and different processes for selecting projects to fund. Expanded information on several of these state programs follows.

Connecticut Clean Energy Fund

Administered by Connecticut Innovations, a quasi-public state authority designed to accelerate the development of Connecticut's technology sector. CCEF invests in a variety of renewable energy technologies using funds accrued through a surcharge on state customers' electric utility bills. Its objectives are to diversify the state's energy supply, accelerate the development of clean energy technologies in the state, and educate the public about the benefits of clean energy.

CCEF's solar related activities include providing rebates of up to $25,000 to customers who install residential or commercial PV systems (up to 10 kW), awarding R&D grants of up to $300,000 to businesses that collaborate with Connecticut universities, and a variety of development and demonstration programs. The "Operational Demonstration Program" awards grants of up to $750,000 to help companies demonstrate technologies that are within one to three years of being commercialized. It requires a 25% cost-share and features a rolling competitive bidding process conducted by CCEF's staff of eleven, with final grant decisions subject to the CCEF Advisory Board's approval.

The Operational Demonstration Program lists the following criteria for projects seeking funding:

- Proven viability in a laboratory setting
- High probability of commercial success
- Technologies not yet introduced to the marketplace or in beta stage development or new applications of proven technologies.
- Generating capacity of at least 1 kilowatt (or functional equivalent)
- Keen interest in demonstrating commercial viability and economic benefits
- Support of Connecticut host site owner or operator
- 3 yr commercialization window; 5 yrs for fuel cells
- Qualified team of professionals, partners, contractors
- Clearly demonstrable benefits to Connecticut ratepayers

CCEF also sponsors the "Project 100" program to provide grants of $50,000 to companies developing technologies that are ready for deployment, and the "Pre-Seed/Seed" program to provide grants to companies developing technologies in their earlier stages.

Illinois Clean Energy Community Foundation

Established in December 1999 as an independent foundation with a $225 million endowment provided by Commonwealth Edison, ICECF funds activities in energy efficiency, renewable energy, and natural area conservation. Since 2001 ICECF's has awarded a total of $110 million in grants, of which $13.8 was devoted to renewable energy projects, funding 121 grants, 70 of which were related to solar energy. Its solar funding is targeted toward installing BIPV in state buildings to improve their LEED scores, installing PV at K-12 schools to educate the public about renewable energy, and supporting demonstration projects involving emerging technologies (including solar thermal). The latter category of grants utilizes a two-tiered competitive bidding process, where applicants submit a letter of inquiry regarding a grant request, and then have these letters evaluated by ICECF's staff of seven, which then invites some of the applicants to submit a full proposal.

Massachusetts Technology Collaborative, Renewable Energy Trust –

Created by the state legislature in 1998 as a part of electric utility restructuring, MTC administers a variety of renewable energy funding programs, including offering matching grants to communities that install renewable energy systems, and signing long-term REC purchasing contracts in order to remove the uncertainty surrounding the future value of RECs. Under its "Predevelopment Financing Initiative," MTC provides grants of up to $150,000 (for solar) to companies interested in developing grid-connected renewable power systems of at least 1 MW. The funding can be used for feasibility studies or for early stage development work, and is designed to reduce the financial risk to products in early development stages. The budget for the program is $2 million, and projects require at least a 25% cost-share.

MTC has also invested $15 million to create a privately-managed venture capital fund (Massachusetts Green Energy Fund) that will invest in Massachusetts-based renewable energy companies and will hopefully be a source of new company creation and also attract more venture capital funding to the state. Its portfolio currently consists of six companies, one of which is in the solar industry (Konarka Technologies). Through its "Sustainable Energy Economic Development (SEED)" fund, MTC invests up to $500,000 in early stage companies to help them bridge the Valley of Death and commercialize their products. The grants require a 50% cost-share, and are geared toward companies that have completed basic research on a product, but have not yet reached the commercialization phase. Finally, MTC runs a Large Onsite Renewables Initiative (LORI) that provides grants of up to $250,000 to companies to design and construct PV systems of at least 10 kW for onsite use (25% minimum), with a 25% cost-share required. (This is essentially a rebate program, according to Karl Jessen, Economic Development Officer.)

Finally, MTC is in the process of developing an RD&D funding program, just as the CPUC is doing. This program is expected to start out as a $3-$5M/yr program, and eventually become an $8-$10M/yr program. It will fund all renewable technologies, but will likely devote most of its funding to solar and fuel cells. It will be designed to provide matching funds to companies that have already received funding from the federal government (e.g. through SBIRs) or from universities or the private sector. Thus MTC expects to cover about 25% of the costs of the projects it funds. Its investments are likely to be fairly high-risk ones, providing resources to companies that would have a difficult time securing financing from banks or venture capitalists due to their risk-level. Projects will largely be in a technology development stage (whereas the SEED Initiative funds business development loans).

MTC's evaluation process involves in-house staff (approximately 3-5 per RFP, devoting about 10% of their time to the evaluation task) and outside consultants. The SEED Initiative requires about 4-6 months to choose who will receive loans and in what amount, and there is usually a 1-6 month delay after that to get the contract finalized and signed. The time periods for the RD&D grant program likely will be significantly shorter than that (about 2 months for the grant selection process).

MRET's Strategic Plan:

CPUC staff could not find information on how the plan is devised. It appears that a new plan is produced every two years or so. For further information, see: http://www.mtpc.org/renewableenergy/strategic.htm

Project Illustrations:

Through the "Massachusetts Green Power Partnership":

The City of Brockton is developing the Brockton Brightfields project, a 500 kW solar photovoltaic project, at an otherwise unusable Brownfield site on Grove Street (formerly occupied by Brockton Gas Works). The project will consist of a large array of solar photovoltaic (PV) panels which feed electricity directly into the local electric distribution grid. This major solar initiative will enable individual consumers to support solar generated electricity without installing a system on their own home or business, and help educate students and residents about the benefits of renewable energy as it generates electricity to meet local needs with no noise, no pollution and reducing the need for imported fuels.

Through the Massachusetts Green Power Partnership, MTC will provide a put option for 100% of the project's Renewable Energy Certificates in years 9 through 18 of project operation. The put option gives Brockton the right to sell those Certificates to MTC at a predetermined price if Brockton is unable to sell them on the open market. Through this MTC commitment, Brockton will have certainty about future project revenues which will enable the City to issue long-term bonds to finance construction. In return, Renewable Energy Certificates will be made available to Massachusetts ratepayers for inclusion in green power products. MTC is also providing a $1.04 million grant to supplement local investment for purchase and installation of the solar system.

Solar investments through the SEED (Sustainable Energy Economic Development, MTC's convertible loan program) Initiative:

Nanoptek

Grantee	Nanoptek	**Program**	Industry Investment and Development
Project Locations	Maynard	**Funding Type**	Investment
Project Type	Research and development	**Total Funding Amount**	$250,000.00
Renewable Energy	Photovoltaics	**Year Awarded**	2004
Initiative:	SEED Initiative		

Project Description

Nanoptek has developed a Titanium catalyst that can split water into hydrogen and oxygen using only energy directly from sunlight. Nanoptek's unique photocatalyst absorbs 10 times the sunlight of competing photocatalysts, thereby promising efficient, clean, and low-cost hydrogen production from water. Hydrogen is generated wherever there is water and sunlight, thus reducing or eliminating hydrogen transport and storage problems.

SolarOne Solutions

Grantee	SolarOne Solutions	**Program**	Industry Investment and Development
Project Locations	Wellesley	**Funding Type**	Investment
Project Type	Research and development	**Total Funding Amount**	$50,000.00
Renewable Energy	Photovoltaics	**Year Awarded**	2004
Initiative:	SEED Initiative		

Project Description

SolarOne Solutions (Framingham, MA) is developing new circuitry and software that enhances performance and increases customer-oriented features of their line of "intelligent" Solar Powered Solid-State SOLed(TM) lighting systems. By combining the energy efficiency of LED lighting with programmable circuitry and solar power, SolarOne can provide improved lighting solutions at lower costs for installation and maintenance, and virtually no operating or fuel costs. These lighting systems have fixtures that provide only the amount of light necessary and only at the times that it is needed. The lighting systems are suited to meet the demands of many outdoor lighting contexts: street lighting, security lighting, bus stops, livestock lighting.

An investment by the Massachusetts Green Energy (Venture) Fund
(No information on the amount of the investment):
Konarka is an advanced technology development company commercializing a new thin film, roll-to-roll, inexpensive solar photovoltaic manufacturing technology. Due its innovative manufacturing technique, the technology has the potential to reduce PV costs to below the $1/watt mark, bringing electricity production into direct competition with grid power. The Fund joined a Series C financing round led by New Enterprise Associates, and included Draper Fisher Jurvetson, Zero Stage Capital, Vanguard Ventures, Partech International, Prime New Energy, SDL Ventures, Good Energies, and Presidio Venture Partners.

New Jersey Board of Public Utilities Clean Energy Program

The Clean Energy Program operates several incentive and financing programs, including a grant program to encourage the development of large-scale (at least 1 MW) renewable energy facilities. Grants are available for up to 20% of total project costs. The New Jersey Economic Development Authority may also arrange low-interest rate bonds or loans to provide affordable financing for the balance of project costs. Borrowers are required to make a minimum 10% equity contribution to the project. In addition, grants of up to $500,000 are offered through the Renewable Energy Business Venture Assistance program to assist companies with the development, demonstration, and deployment of renewable energy technologies. The program's budget is $5 million, and grants are available in sizes ranging from $50,000 to $500,000, with a 25% cost-share requirement. Proposals are evaluated by third party evaluators with expertise in renewable energy, market development, technology commercialization, and business finance and capitalization. The specific criteria used to evaluate the project applications are:

- The applicant's general approach and plans to meet the requirements of the Program.
- The applicant's detailed approach and plans to perform the services required by the scope of work of this Solicitation.
- The applicant's documented experience in successfully completing contracts of a similar size and scope to those required by this Program.
- The qualifications and experience of personnel assigned by the proposal to the contract with emphasis on documented experience in successfully completing required services of a similar size and scope to those required by this Program.
- The overall ability of the applicant, to gear-up, undertake and successfully complete the contract within the required schedule and on time.
- The cost of the project, taking into account both the applicant's Cost Proposal and the third party in-kind and cash contributions.
- The amount of funding requested as a percentage of the total project cost.
- The ability to perform the scope of work within the timeline proposed.
- Ability for successful implementation in terms of technology, deliverables and implementation team.
- Commitment to developing renewable technologies and services within the State of New Jersey for local use, as well as export to the global marketplace.

New York State Energy Research and Development Authority (NYSERDA)

A public benefit corporation created in 1975 by state law and funded by a charge assessed on the state's investor owned utilities (with some additional money allocated statutorily). NYSERDA provides direct incentives to customers implementing renewable energy and energy efficiency projects, and also operates an RD&D funding program. Its annual RD&D budget is approximately $150 million, of which photovoltaics RD&D receives about $10 million. These funds are awarded to projects based on a competitive bidding process. Bids are assessed by a Technical Evaluation Panel, which is comprised of industry experts from academia, DOE, and other state agencies. Each TEP usually consists of three NYSERDA staff and four external reviewers, who are selected to provide the appropriate technical and business needed to assess the particular proposals. Solicitations for bids typically are sent out once or twice per year, and awards are typically announced within 10-15 weeks from the proposal due date. The length of time to actually contract a project depends on (1) any conditions that may be recommended by the TEP, (2) how many contract packages need to be put together for the given program, and (3) whether or not the company has worked with NYSERDA before.

NYSERDA's development activities encompass a variety of efforts, including participating in business incubator networks to foster local entrepreneurial activity, providing several types of grants to businesses at different stages in the development process (from $40,000 to fund basic concept development to up to $1 million to companies trying to expand their manufacturing capabilities), and providing businesses with access to teams of Navigant Consulting, Inc. management consultants to help with specific business start-up issues.

NYSERDA staff posit that the most important role for states to play in the PV industry is in business development. DOE has not invested much in this area recently. NYSERDA's development activities also include infrastructure projects and workforce development (certification, testing, accreditation training for installers, etc.). Funding allocations for specific research areas in PV are established in NYSERDA's operating plan, which is updated every five years. The great majority of NYSERDA's investments can be characterized as "medium-risk." NYSERDA's rationale is that if a project is low-risk, it may not really need government support, and high-risk projects because they are unlikely to provide any real "return" on the investment in a reasonable amount of time.

NYSERDA's Strategic Plan:

The 2006–2009 Strategic Program Plan describes how NYSERDA is planning to fulfill its mission and achieve its goals and objectives in the coming years. The organizational and program strategies identified in this Plan capitalize on NYSERDA's distinctive capabilities in energy analysis, project management, RD&D, and energy efficiency services deployment for meeting its customers' service needs. Strategic planning is a continual activity at NYSERDA.

The ongoing formal planning structure allows Staff to focus on its mission, core values, and organizational and program goals. The planning process culminates each June with the presentation of a three-year Strategic Program Plan to NYSERDA's Board of Directors. NYSERDA's Energy Analysis Program manages the planning process, which starts with

debriefing sessions with program and administrative staff and support function managers to review the prior year's Plan and process, and to discuss refinements and anticipated initiatives. Staffs from individual program areas hold meetings with external stakeholders to obtain feedback on past efforts and to solicit input on future directions and initiatives. Internal planning sessions are held to obtain input on new initiatives and directions. Periodically, NYSERDA sponsors training and professional development workshops to help managers and Staff refine their strategic planning capabilities. Energy Analysis staff meet regularly with directors, managers, and designated program staff to discuss and evaluate strategic issues and articulate new program directions. Each program-specific section of this Plan was developed using this iterative composition and review process.

The Program Planning Committee composed of NYSERDA Board members is responsible for guiding and providing Board-level input to the planning process. NYSERDA's senior management meets quarterly with the Program Planning Committee and briefs the Committee on programs, strategies, accomplishments, and on intended future directions. An annual guidance document is prepared by senior management which identifies broad planning themes and challenges and provides a schedule for preparing a draft Plan for review by senior management and the Board Program Planning Committee. The Board formally adopts the plan in June.

This Plan is used by NYSERDA's Board to direct and approve corporate initiatives and programs and by management and staff to guide program implementation efforts. It describes NYSERDA's strategic plans for the next three years and anticipates multiple-year funding to implement the programs.

Illustrative Projects

Creating Infrastructure

NYSERDA has been working with industry stakeholders to overcome slow growth in the market for photovoltaic systems. Rather than focusing exclusively on providing financial incentives, NYSERDA has worked to develop market infrastructures – including PV training programs, dealerships, installation firms, and service industries – that will flourish long after government support has ended. At the same time, NYSERDA is giving consumers information to make intelligent choices regarding PV systems.

Providing consumers with good information is one of the first steps in developing a vibrant market. NYSERDA has partnered with educational organizations to develop materials for specific consumer groups such as homeowners, builders, realtors, and farmers. Teachers and students have benefited from NYSERDA's school programs, which have outfitted 48 schools (two more are in the planning stage) with PV systems and instrumentation that provides computerized, real-time performance data. Any school in New York can use the PV data and associated lesson plans by accessing NYSERDA's website.

Installer training has been a top priority for NYSERDA. Initial support was given for establishing in New York the North American Board of Certification for Energy Practitioners

(NABCEP). Once the organization was established locally, certification became a requirement for installers. NYSERDA helps train installers through one-week PV design and installation courses and offers introductory PV workshops. Hundreds of architects, builders, installers, realtors, bankers, contractors, electricians, utility staff, and inspectors have taken these workshops to learn about topics including building-integrated PV design and Occupational Safety and Health Administration safety requirements. NYSERDA has developed accredited training centers and continuing education programs, partnering with SUNY Delhi, the Ulster County Board of Cooperative Educational Services (BOCES), and Cattaraugus-Allegany BOCES.

Maintaining High Quality, Reliable Systems

The PV industry is haunted by the solar thermal system failures of the 1980s. NYSERDA supports the installation and use of high-quality PV systems that will perform reliably for the next 20 years or more. System design reviews and inspections are conducted, and the first three systems installed by each new participating installer are inspected, and random inspections are conducted thereafter. NYSERDA incentive programs now require five-year parts-and-labor guarantees on complete systems and this warranties that the production of each system will not fall below 90 percent of the rated system output. Collecting and reporting data to NYSERDA are required for two years. NYSERDA's vision is to develop and implement the components necessary to make PV a viable mainstream technology. When PV is viewed as a good, long-term investment that is simple to select and purchase, NYSERDA will have succeeded.

Future Directions

NYSERDA's experience could be used as a model by other states to develop programs that promote the long-term use of PV for residential customers. Accredited training, certified installers, quality controls, reduced materials and labor costs, and consumer education will enable those states to build and support markets for PV that can be sustained after government subsidies have ended.

Xcel Energy Renewable Development Fund (RDF) of Minnesota

Since its first round of funding in 2001, RDF has provided $53 million in funding on projects to identify and develop new or emerging renewable energy sources. In its first round of funding in 2001, RDF provided $16 million for 19 projects. Its second round of funding, approved by the Minnesota Public Utilities Commission in 2005, provided $37 million to 29 projects. A third round of funding is planned for March 2007. A renewable fund advisory board comprised of two representatives of Xcel Energy and two representatives of environmental organizations will evaluate and choose winning proposals. The overall mission of the RDF is to increase the market penetration of renewable energy resources at reasonable costs in the Xcel Energy service territory, promote the start-up, expansion and attraction of renewable energy projects and companies in Xcel's service territory and stimulate research and development into renewable technologies that support this mission. The fund was created in May 1999 in accordance with a 1994 Minnesota law that permits storage of spent nuclear fuel in up to 17 steel containers at Xcel Energy's Prairie Island plant near Red Wing. The legislation requires Xcel Energy to annually put $500,000 into the fund for each filled spent-fuel storage container temporarily stored at the plant after January 1, 1999.

Appendix C: CEC PIER Study of Solar PV RD&D Priorities

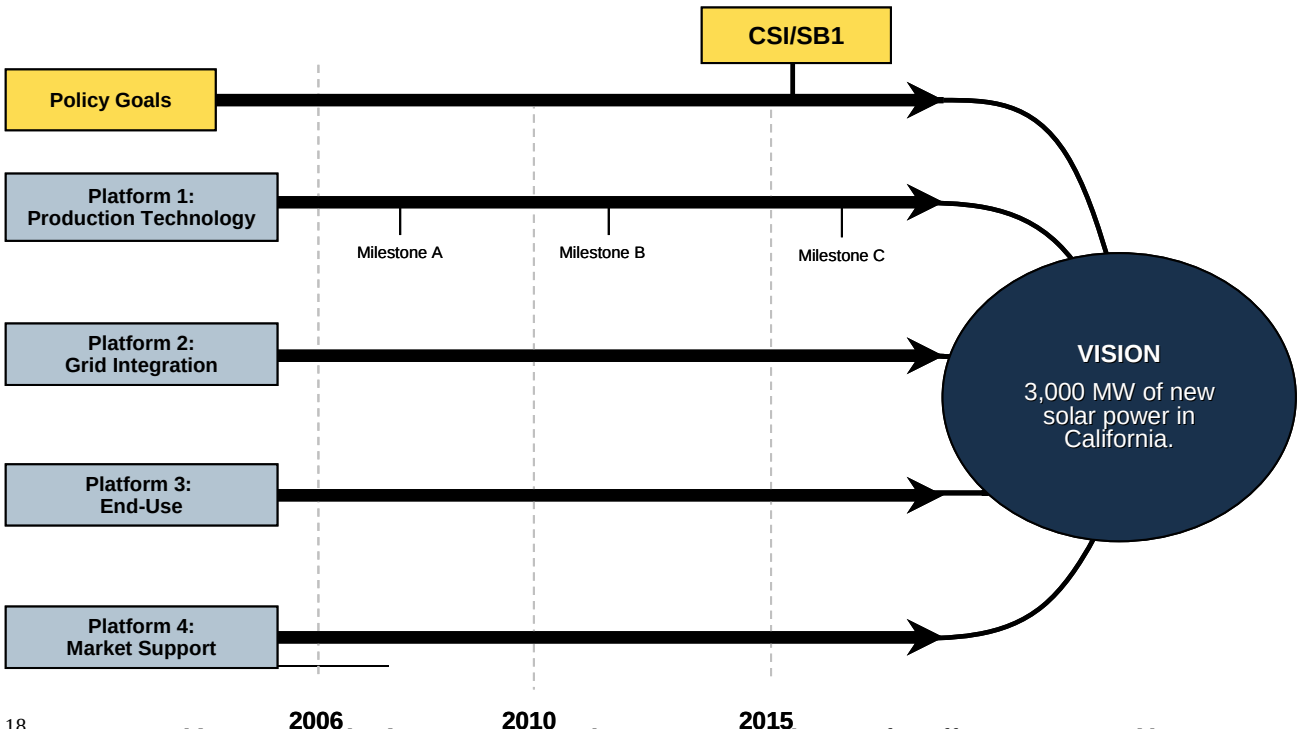
The following material is excerpted from a draft report prepared for CEC staff by a consultant, Navigant Consulting. This content is not yet final, nor has it been endorsed by the California Energy Commission. It is presented to indicate the extensive deliberations underway as to beneficial targets for California RD&D funding priorities.[18]

The work was conducted under the guidance of a CEC Steering Committee. The Steering Committee was formed by senior renewable energy staff at the Energy Commission, including leaders of the PIER program, the Renewable Energy Program, and advisors to the Renewables Committee formed by commissioners Pfannenstiel and Geesman. The Steering Committee also included a key staff member from the CPUC assigned to shape the implementation of the CPUC's CSI policies.

RD&D Roadmap Framework

The "Roadmap" is comprised of four key elements: policy goals, vision, research platforms, and research milestones. To achieve the vision (3000 MW of solar power in California), PIER Renewables has identified RD&D from four research platforms. Each platform contains possible RD&D milestones which are a series of measurable goals. Together, these milestones and the platforms they represent support the State vision. Figure 2 illustrates the Solar PV Roadmap framework including the policy goals, vision, and research platforms.

Figure 2: Solar PV Roadmap Framework



[18] PIER Renewable Energy Technologies Program, *Solar PV Research Plan*, Draft Staff Report, prepared by Navigant Consulting, January 2007.CEC Publication [#[to be assigned once report is complete].

Research "Platforms"

The platforms establish strategic areas of focus for investment and management attention, and indicate areas where PIER Renewables aims to make an impact. The strategic objectives that accompany each platform will help establish priorities for RD&D funding. PIER Renewables developed four platforms to help organize and structure possible research activities: production technology, end-use, grid integration, and market support.

Platform 1: Production Technologies. The strategic objective of the production technologies platform is to support the commercialization of PV technologies. RD&D activities in this platform have traditionally formed the majority of investments made by PIER Renewables, and these tended to concentrate on improving performance, reducing the cost of renewable energy generating technologies, and developing renewable energy resources.

Platform 2: Grid Integration. The strategic objective of the grid integration platform is to enable PV integration with the distribution and transmission system. The grid integration platform includes RD&D activities to effectively connect renewable generation to the electrical transmission and distribution system, including the development of technologies for storage, shaping, and forecasting. Significant RD&D investments in grid integration will be required to accommodate the large amount of new solar PV generating capacity mandated by State policy.

Platform 3: End-Use. The strategic objective of the end-use platform is to support end-user adoption of PV by addressing end-user specific technology and market issues. Like the grid integration platform, PIER Renewables has funded RD&D activities in this platform in the past and it will continue to be important given current State policy goals. For example, meeting CSI goals will require improved performance, ease-of-use and economics of distributed generation (DG) PV systems. RD&D activities that develop end-use technologies and interconnection, such as improved metering, monitoring, storage and electricity conversion are critical for the growing PV market in California. PIER Renewables will also target projects such as building integrated PV (BIPV) technologies which incorporate these technologies more seamlessly into buildings.

Platform 4: Market Support. The strategic objective of the market support platform is to support appropriate market mechanisms and policies that enable sustainable renewable energy growth. This platform contains RD&D activities which encourage renewable adoption by addressing issues that hinder market growth including inadequate policy, outdated regulation and lack of an incentive structure as well as market acceptance of technology. Significant investment in market support RD&D will be necessary to transform the heavily subsidized solar market into the self sustaining market dictated by CSI and SB1.

RD&D "Milestones"

The RD&D milestones contained in the Solar PV Roadmap are a series of measurable goals each with a defined target date that, together could lead to the accomplishment of the strategic objectives and the vision.

Platform	Number	Year	Milestone Description
Production Technology	P1	'07	Potential changes to PV system design and installation requirements caused by the emergence of alternatives to silicon-based PV over next 15 yrs understood
	P2	'07	Key barriers to the development of PV mini-grids or central PV are identified
	P3	'08	PV system design and installation procedures enhanced to more effectively optimize system performance
	P4	'09	Higher capacity factors demonstrated (e.g. 20% vs. 18% for pitched roof, and similar improvements for flat roof mount) to meet CPUC PBI targets for CSI
	P5	'09	Economic viability of distributed concentrating PV systems demonstrated
	P6	'10	Highest silicon cell efficiency in market 22% (field efficiency)
	P7	'11	Building integral PV products become cost competitive with rooftop PV and key technical integration issues are addressed (e.g. spacing/cooling)
	P8	'15	Highest silicon cell efficiency in market 25.5% (field efficiency)
	P9	'15	Nano and/or organic PV economically feasible for grid-connected applications
Grid Integration	G1	'08	Cost/benefits of net metering (e.g. rate impacts) understood for SB1, as well as impact of raising net metering capacity to accommodate CSI goals
	G2	'08	PV systems with storage or other technologies demonstrate better coincidence with utility system peak load
	G3	'08	Possible net metering arrangements defined to facilitate cooperation between homes with solar access and neighbors who have shading and/or limited access
	G4	'08	Synergies between PV systems and plug-in hybrids are estimated
	G5	'08	High value locations for DG PV on T&D are identified and the impacts/benefits of large concentrations of DG PV in one location on T&D are assessed
	G6	'09	Technical and policy analysis complete to support successful expansion of Rule 21 to cover network interconnection
	G7	'09	Utility acceptance of protocols to allow PV system operation during grid outages
	G8	'10	Economic viability of new PV system storage technologies are demonstrated
End-Use	E1	'07	Operational risks and disputed benefits of PV systems identified (later priority issues to be studied)
	E2	'08	Drivers that encourage consumer adoption of PV systems are identified and prioritized
	E3	'08	New/modified business models create sustained market growth
	E4	'08	Synergies between building energy efficiency and PV are identified and business models to encourage synergies in retrofits and new construction are identified
	E5	'08	Potential roles for utilities in solar PV, including attractive business models, are identified and vetted with utility companies.
	E6	'08	PV system risk to homes and businesses quantified and results made available to financial / insurance industries
	E7	'08	Lower cost, utility grade PV system control, metering, and monitoring capacity developed consistent with 1% cost parameter established by CPUC for CSI
	E8	'09	Use of transformerless inverter design is widespread
	E9	'09	Business models developed to address fact that homeowners and renters move frequently
	E10	'10	Field tests done to quantify operational risks and benefits of PV (work heavily with utilities)
	E11	'10	Improved PV economics demonstrated using advanced metering, price responsive tariffs (e.g. TOU, Feed-in Tariff) and storage
	E12	'12	PV inverter cost reduced 30% (due in part to volume production) and performance improved
	E13	'17	Building integral PV products (e.g. PV replacing roofing material or side/curtain walls) are commonly used in new buildings (residential, commercial, industrial)
Market Support	M1	'07	Updated training for CA installers and building code officials developed and vetted with industry/policy makers
	M2	'07	Solar training and educational materials developed for architects, building land-use planning, and roofing personnel
	M3	'07	Barriers identified to the adoption of PV for use on public sector buildings (e.g. state/local government buildings, State water project)
	M4	'08	Key relevant RD&D results and strategies from Germany and Japan are identified and recommendations made for application in CA
	M5	'08	Module certification in CA is closely aligned with national and international standards, resulting in more robust and accurate ratings
	M6	'09	Differences in policies/regulations between Western states are identified and recommendations made to address differences that impede market growth in CA
	M7	'09	Key barriers to moving CA to Performance Based Incentives (PBI - kWh) from capital rebates (kW) are addressed
	M8	'11	Building standards established that require sufficient PV-ready roof space in new construction
	M9	'10	Options for including PV as part of CA residential building efficiency standards are developed and vetted with industry and policy makers

Note: The milestones added during the stakeholder interviews are not included in the priority ranking.

Participating Stakeholders

Navigant prioritized the R&D milestones through a lengthy process to solicit the input of a series of internal and external stakeholders. The first step in the process involved private interviews with a selection of target individuals. An effort was made to draw from a diverse pool of key organizations, including those with responsibility in implementing CSI and SB1. In all, representatives from seventeen organizations were interviewed, including State and Federal government, municipal and investor owned utilities, non-profits, universities, solar companies, industry organizations, and the public at large. In many cases, stakeholders interviewed during the Renewables Roadmap process were solicited again for their input to the Solar PV Research Plan. Navigant interviewed a list of organizations, including:

- Energy Commission Renewable Energy Program
- California Public Utilities Commission (CPUC) staff
- CPUC Commissioner (for general insight, but without any scoring)
- Pacific Gas and Electric (PG&E)
- Southern California Edison (SCE)
- San Diego Gas and Electric (SDG&E)
- Sacramento Municipal Utility District (SMUD)
- U.S. Department of Energy (DOE)
- National Renewable Energy Laboratory (NREL)
- Vote Solar
- Clean Energy States Alliance (CESA)
- Consol
- California Solar Energy Industries Association (CALSEIA)
- SunPower
- PowerLight
- NanoSolar
- University of California, Merced

Prioritization Criteria

Stakeholders prioritized each milestone in the Solar PV Roadmap along two criteria: the milestone's relative impact on meeting the program vision, and on the relative need for PIER Renewables to fund each milestone. The milestone scores were collected and ranked according to these criteria (see Figure 3). The milestones that achieved high scores for both potential impact and need for PIER funding were considered high priority areas for RD&D efforts. The additional milestones added during the stakeholder interview process were not ranked.

In scoring the potential impact of the milestone, stakeholders were asked to consider:

- How important is the RD&D to meet key State solar PV policy goals? (e.g., CSI and SB1)
- If this RD&D milestone is achieved, how transferable will the results be to industry?
- How likely is it that this RD&D milestone will be achieved?
- Is this RD&D milestone important or even critical in terms of other milestones that follow it?

In scoring the milestone's need for funding, stakeholders were asked to consider:

- What is the relative size of the gap between the RD&D required and the recent RD&D activity funded by other organizations (i.e., PIER Renewable Energy staff, other groups in the Commission, DOE and national laboratories, universities, private industry)? Will the milestone be met through those efforts?
- How likely is it that this RD&D milestone will be achieved?
- Is PIER the appropriate agency to fund this research?

Figure 3: Scoring Scale

Potential Impact				
1	2	3	4	5
Milestone will have no impact on helping CA meet CSI and SB1.	Milestone will have small impact on helping CA meet CSI and SB1.	Milestone will have medium impact on helping CA meet CSI and SB1.	Milestone will have large impact on helping CA meet CSI and SB1.	Milestone will be instrumental in helping CA meet CSI and SB1.
Low → Medium → High				

Need for PIER Funding Score				
1	2	3	4	5
No need for PIER to fund; tremendous RD&D in this area already.	Small need for PIER to fund; there are substantial RD&D efforts in this area already.	Limited need for PIER to fund; some RD&D in this area with need for limited additional effort.	Large need for PIER to fund; only small RD&D efforts in this area thus far.	Tremendous need for PIER to fund; no RD&D in this area yet.
Low → Medium → High				

Appendix D: CPUC Draft Target Milestones

CPUC Staff Ideas for Milestones from CEC PIER Prioritization Study that CPUC Might Consider Funding through Three CSI Funding Mechanisms

RD3 = Research, Development, and Demonstration; EM&V = Evaluation, Measurement, and Verification; M&O = Marketing and Outreach
X= CPUC funding expected, O = could be a defined CPUC activity/issue
NOTE: "Overall Rank" represents preliminary ranking as of November 2006, taken from working materials in the CEC study. These ranks may not be the same as those to be reported in final CEC report.
This table was used by CPUC staff as a convenient format for succinctly recording ideas for potential CPUC funding areas.

RD3	E M &V	M&O	Overall Rank	Number	Year	Milestone Description	CPUC Comments
		X	1	E4	'08	Synergies between **building energy efficiency and PV** are identified and **business models** to encourage synergies in retrofits and new construction are identified	We likely will encourage and promote development of new biz models, but may not develop them ourselves
O			2	E5	'08	Potential roles for **utilities** in solar PV, including attractive **business models,** are identified and vetted with utility companies.	
O	X		3	E11	'10	Improved PV **economics demonstrated** using advanced metering, price responsive tariffs (e.g. TOU, TR, Feed-in Tariff) and storage	We will eval advanced metering and price responsive tariffs policies; See Rank #7 for storage.
		X	4	M1	'07	Updated training for CA **installers and building code officials** developed and vetted with industry/policy makers	CPUC to tackle installers; CEC for building officials?
			4	M9	'10	Options for including PV as part of CA **residential building efficiency standards** are developed and vetted with industry and policy makers	CEC task?
			6	M8	'11	**Building standards** established that require sufficient PV-ready roof space in new construction	CEC task?
O			7	G2	'08	PV systems with **storage or other technologies** demonstrate better coincidence with utility system peak load	See also Rank #3
	X		8	G1	'08	**Cost/benefits of net metering** (e.g. rate impacts) understood for SB1, as well as impact of raising net metering capacity to accommodate CSI goals	
		X	9	M2	'07	Solar training and educational materials developed for **architects, building land-use planning, and roofing contractor** personnel	Land-use planning may be appropriate for CEC; PUC could do training/education for roofing personnel
	X	X	10	E2	'08	**Drivers** that encourage consumer adoption of PV systems are identified and prioritized	Would require data collection and market research, appropriate for EM&V
			11	M5	'08	**Module certification** in CA is closely aligned with national and international standards, resulting in more robust and accurate ratings	Role for DOE and CEC?
O	O		12	G5	'08	**High value locations** for DG PV on T&D are identified and the impacts/benefits of large concentrations of DG PV in one location on T&D are assessed	Very important, not sure yet if RD3 or EM&V more appropriate; hasn't CEC studied this before?
O			12	G8	'10	Economic viability of new PV system **storage technologies are demonstrated**	
O?			12	E7	'08	Lower cost, utility grade PV system **control, metering, and monitoring** capacity developed consistent with 1% cost parameter established by CPUC for CSI	PIER?
O		X	15	E3	'08	**New/modified business models** create sustained market growth	PUC could support development of new biz models for financing & O&M

RD3	E M &V	M&O	Overall Rank	Number	Year	Milestone Description	CPUC Comments
O	O		16	P3	'08	PV system **design and installation procedures** enhanced to more effectively optimize system performance	For existing technologies (best practice) or new ones (next gen technologies)?
O?			17	G7	'09	**Utility acceptance** of protocols to allow PV system **operation during grid outages**	Interconnection technical issues. PIER might tackle protocols; RD3 or PIER could fund demo projects
		X	18	M7	'09	Key **barriers to** moving CA to Performance Based Incentives (**PBI** - kWh) from capital rebates (kW) are addressed	
		O?	19	E13	'17	**Building integral PV** products (e.g. PV replacing roofing material or side/curtain walls) are commonly used **in new buildings** (residential, commercial, industrial)	Low priority short-term for PUC M&O focused on market education of technology; role for CEC? Later issue @ CPUC.
O?			20	P7	'11	**Building integral PV** products become **cost competitive** with rooftop PV and key **technical integration** issues are addressed (e.g. spacing/cooling)	Role for CEC or NREL?
			21	G6	'09	Technical and policy analysis complete to support successful expansion of Rule 21 to cover **network interconnection**	if means "radial networks", a low priority
X		X	22	E6	'08	PV system risk to homes and businesses quantified and results made available to **financial / insurance industries**	First need data (Research), then need Deployment; question of timing
O			23	E10	'10	**Field tests** done to quantify **operational risks and benefits of PV** (work heavily with utilities)	T&D, see rank 12 and 17 for concepts and modeling
			24	E8	'09	Use of **transformerless inverte**r design is widespread	Not immediate CPUC priority, unless would cut costs significantly.
			25	G4	'08	Synergies between **PV systems and plug-in hybrids** are estimated	No opinion on this yet
O			26	M4	'08	Key relevant **RD&D results and strategies from Germany and Japan** are identified and recommendations made for application in CA	
	X		27	E1	'07	**Operational risks** and disputed benefits of PV systems identified (later priority issues to be studied)	T&D, see ranks 12, 17, 23. But seems Rank 27 must come before 23?
O			28	P2	'07	Key barriers to the development of PV **minigrids** or central PV are identified	See Rank 12 Item G5; CSI not involved in central PV
			29	E12	'12	PV **inverter cost reduced** 30% (due in part to volume production) and performance improved	
O?			30	P1	'07	Potential **changes to PV system design and installation** requirements caused by the emergence of **alternatives to silicon**-based PV over next 15 yrs understood	Activity might be funded by program administration, when timely. Could do a study
			31	M6	'09	Differences in **policies/regulations between Western states** are identified and recommendations made to address differences that impede market growth in CA	Already part of CPUC oversight & program administration
	X		32	P4	'09	**Higher capacity factors demonstrated** (e.g. 20% vs. 18% for pitched roof, and similar improvements for flat roof mount) to meet CPUC PBI targets for CSI	Market should do it, EM&V will evaluate projects to see at what CF projects perform
			33	G3	'08	Possible net metering arrangements defined to facilitate **cooperation between homes** with solar access and neighbors who have shading and/or limited solar access	See Rank 28 for analysis. Then CPUC policy call.
			34	M3	'07	Barriers identified to the adoption of PV for use on **public sector buildings** (e.g. state/local government buildings, State water project)	See no need for any special activity on this.
X			35	E9	'09	**Business models** developed to address fact that **homeowners and renters move** frequently	Could be development of a concept for deployment activity, but not a CPUC high priority, except for Low Income
			36	P9	'15	**Nano and/or organic PV** economically feasible for grid-connected applications	DOE or California research area?
0	0?		37	P5	'09	Economic viability of **distributed concentrating PV** systems demonstrated	Depends on how would affect price of solar/kWh
			38	P8	'15	Highest **silicon cell efficiency** in market **25.5%** (field efficiency)	Not state-level spending priority, though outcome welcomed
			39	P6	'10	Highest **silicon cell efficiency** in market **22%** (field efficiency)	Not state-level spending priority, though outcome welcomed

Appendix E: Illustrative RD&D Projects

Gap to Fill	Barrier Removed	Activity or Milestone	Potential Projects
Development	Informational	Key relevant RD&D results and strategies from Germany and Japan are identified and recommendations made for application in CA	• Literature review/case study analysis, which would include policy review and interviews (in house or consultant)
	Technical	PV systems with storage or other technologies demonstrate better coincidence with utility system peak load	
	Technical	Third-party or OEM metering, communication, and reporting solutions become more streamlined and less costly.	• Longer life meters, more durable with longer warranties (5 years) • Electronic upload tool from pathfinder to online application
	Technical and Economic	Lower cost, utility grade PV system control, metering, and monitoring capacity developed consistent with 1% cost parameter established by CPUC	• Test less costly materials and configurations
	Technical	Non-silicon technologies become less costly than silicon-based technologies	• Develop materials that are less costly than silicon • Develop materials that have a higher theoretical yield than silicon • Establish testing procedures and facilities for new technologies
Development/ Demonstration	Technical: Incompatibility between energy storage and grid structure	Economic viability of new PV system storage technologies are demonstrated	• Identify most promising storage opportunities and demonstrate most promising ones
		Utility acceptance of protocols to allow PV system operation during grid outages	• Research and demo projects on disconnect and reconnecting after outage • Value of service studies that quantify value of avoided customer outages under different solar performance scenarios • Develop and demonstrate technical fix that meets needs of utility
	Economic/ Technical	Building integral PV products become cost competitive with rooftop PV	
		BIPV technical integration issues are addressed (e.g. spacing/cooling)	• Develop and demonstrate strategies to overcome key technical integration issues
	Financial	PV system risk to homes and businesses quantified and results made available to financial / insurance industries	• Develop model that compares expected versus actual generation and displays discrepancy in graphic form (results could be on monthly bills, CSI website, etc.) • Review current installation procedures, study and quantify factors in system failure, and identify risk factor for each component • Match peak shape to solar output on time

			dependent valuation
	Informational	Key barriers to the development of PV minigrids or central PV are identified	• PV minigrids pilot project
Demonstration	Economic	Improved PV economics demonstrated using advanced metering, price responsive tariffs (e.g. TOU, TR, Feed-in Tariff)	• Commission study to collect solar insolation data at level of granularity necessary to calculate accurate incentives • Study identifying factors that are correlated with differences in demand in each IOU territory • Pilot projects testing new tariffs (such as CEC PBI pilot)
	Informational	High value locations for DG PV on T&D are identified and the impacts/benefits of large concentrations of DG PV in one location on T&D are assessed	• Identify lines that are congested during peaking hours • Pilot project to install multiple PV systems in congested areas through innovative financing schemes: partnerships with EPRI, utilities, third party, industry
	Technical	PV system design and installation procedures enhanced to more effectively optimize system performance	• Integrate/consolidate BOS components • Demonstrate better inverters with longer life and minimal standby loss
	Informational	Field tests done to quantify operational risks and benefits of PV (work heavily with utilities)	• Although written as a milestone, this is actually a project for E6
	Technical	Economic viability of distributed concentrating PV systems demonstrated	• Pilot projects • Give higher incentive for this technology to encourage early adopters
	Technical	Solar DC power designs for PV systems directly providing end use lighting, refrigeration, shaft power (motors), and HVAC	• Develop integration protocols and appliances that accept DC • Pilot projects for early adopters
Deployment	Financial	Potential roles for utilities in solar PV, including attractive business models, are identified and vetted with utility companies	• Convene forums that bring together utilities and financial community • Reward utility for developing and using new business models
	Financial	New/modified business models &/or financing mechanisms create sustained market growth (generic)	• Convene forums • Bring together financial and solar experts • Conduct workshops/learning sessions
	Financial	Solar and roofing companies develop combined business models to integrate products, services, parallel sale of solar & new/replacement roofs	

	Informational	Potential changes to PV system design and installation requirements applied w/ emergence of alternatives to silicon-based PV	• Convene forums that bring together installers and integrators with manufacturers of new technologies
	Financial	Business models developed to deal w/ transience of homeowners and renters	• Hold forums and work with low-income communities

Appendix F: UC Berkeley - LBNL Helios Project

What is the Helios Project?

This is a newly formed large multi-disciplinary and multi-investigator project that is led by Lawrence Berkeley National Laboratory and UC Berkeley. Its goals are to foster solar energy utilization to create new energy sources and to alleviate global warming. The focus is to develop low-cost solar energy conversion using solar panels that rely on photovoltaics made from nanotechnology

The team involves:

- World-class researchers assembled from across LBNL and UC Berkeley's departments of Chemistry, Materials Sciences, Physics and Engineering,
- Specialists whose expertise range from the development of nanoparticles and their assembly into materials, to the generation and conduction of electrons in materials, to the development of the world's highest efficiency photovoltaic materials including the development of new classes of semiconductor materials, to new methods to overcome the current limitations of photovoltaic generation of electrons,
- Expert researchers on manufacturing processes and techniques that promote environmentally friendly manufacturing, and
- Expert partners on the economics of energy systems.

The project site will be located in close proximity to specialized user-facilities including Berkeley Lab's DOE-sponsored state-of-the-art Molecular Foundry for nanomaterials synthesis, the National Center for Electron Microscopy, the Advanced Light Source for visualization, and the computer facilities at LBNL for theoretical and computational modeling to accelerate invention.

How Helios is expected to advance the goal of high-efficiency, low-cost, high volume photovoltaics

The project will investigate and develop the use of abundant, cheap, and nontoxic materials such as iron oxide, zinc oxide, and organic polymers and molecules that have been traditionally discounted for incorporation into bulk or thin-film photovoltaics. The scientific team believes that in the form of nanomaterials such materials could become extremely effective in small, pure, inexpensive but carefully-controlled crystals and structures. Physical arrangements and electrical contacts would become possible on the scale of atoms. This in turn opens up a choice of materials and compatibilities that had not been accessible before for photovoltaics. The team will explore ways to dramatically increase the power efficiency of solar cells.

Nanomaterials-based photovoltaics (or "nanoPVs") offer the opportunity of scalable manufacture by methods similar to those used in manufacturing plastic sheets. This will enable low-cost, high-volume solar cell fabrication. Investigation also will address materials availability, possible manufacturing processes, and secondary economic and other effects of large-size shifts in energy production methods.

Nanomaterials and storage of electricity
Another important part of transitioning to sustainable, CO2-neutral energy is the storage of electrical energy. Helios contains projects that will collect excess electric power generated when the source is strong and use it to produce chemical fuels that could be utilized to produce electricity at a later time. For example, new systems that split water into hydrogen and oxygen, as well as methods for reversibly storing hydrogen will be investigated. Catalysts capable of combining hydrogen with CO2 to generate fuels such as methanol and ethanol will also be sought. These fuels can suitable for large scale storage, which can then be used to generate electricity on-demand.

What are the Funding Requirements of the Helios Project?

The project requirements include a $100-140 million research facility and $20-30 million of annual research funding.

When will the Helios Project produce results?

UC Berkeley and the Berkeley Lab have a strong track record of developing large scale, mission-oriented research programs. The Helios Program works under a Director whose responsibility is to balance creativity and focus so that new opportunities can be rapidly exploited. The Project is milestone and goal-driven, and will produce a range of notable advances in specific sectors within five years, with major breakthroughs appearing in the 5 to 10 year timeframe. The Helios project encourages risk-taking, but ensures the capability of recognizing failure rapidly so that more fruitful research paths can then be quickly embarked upon.