SHARED CLEAN ENERGY FACILITIES

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A REPORT BY

THE CONNECTICUT ACADEMY OF SCIENCE AND ENGINEERING

FOR

THE CONNECTICUT GENERAL ASSEMBLY
ENERGY AND TECHNOLOGY COMMITTEE

Shared Clean Energy Facilities

A Report By

The Connecticut Academy of Science and Engineering

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This study was initiated at the request of the Connecticut General Assembly on September 18, 2014. The project was conducted by an Academy Study Committee with the support of staff of the Connecticut Economic Resource Center, Inc., serving as the study management team with assistance from study advisors Joel Gordes and David Pines, PhD. The content of this report lies within the province of the Academy's Energy Production, Use and Conservation Technical Board. The report has been reviewed by Academy Members A. George Foyt, ScD and Med Colket, PhD. Martha Sherman, the Academy's Managing Editor, edited the report. The report is hereby released with the approval of the Academy Council.

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LIST OF ACRONYMS

CGA	Connecticut General Assembly
DEEP	Connecticut Department of Energy and Environmental Protection
DRIPE	Demand Reduction Induced Price Effect
EDC	Electric Distribution Company
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
IREC	Interstate Renewable Energy Council
ISO-NE	Independent System Operator – New England
ITC	Investment Tax Credit
kW	Kilowatt
kWh	Kilowatt Hour
LREC	Low-Emission Renewable Energy Credit
MW	Megawatt
MWh	Megawatt Hour
NREL	National Renewable Energy Laboratory
PURA	Public Utility Regulatory Authority
PV	Photovoltaic
REC	Renewable Energy Credit
RMI	Rocky Mountain Institute
RPS	Renewable Portfolio Standard
SCEF	Shared Clean Energy Facility
ZREC	Zero Emission Renewable Energy Credit

EXECUTIVE SUMMARY

At the request of the Connecticut General Assembly's (CGA) Energy and Technology Committee, the Connecticut Academy of Science and Engineering (CASE) conducted this study of the issues related to the development and use of Shared Clean Energy Facilities (SCEFs) in Connecticut, including an overview of anticipated benefits and costs.

During the CGA's 2014 legislative session, the Energy and Technology Committee considered proposed bills (HB-5412: *An Act Concerning Shared Clean Energy Facilities;* and SB-353: *An Act Concerning the Development of Class I Renewable Energy Source Projects*, and working draft amendments [LCO-3885 and LCO-4100]), but did not recommend a bill for vote by the CGA. Issues regarding proposed legislation were raised by stakeholders including the Connecticut Department of Energy and Environmental Protection (DEEP), utilities, clean energy advocates and organizations, and the general public at a public hearing on March 4, 2014 and in discussions with the leadership of the Energy and Technology Committee.

This study provides an overview of SCEFs and issues regarding their development and use in Connecticut. The study report includes the following sections: Overview and Related Benefits, The Regulatory Framework, Project Models, Case Studies, Focus Group Sessions: Summary, Components of the Value of Clean Energy Analysis and SCEF Financial Costs, and Findings and Recommendations.

BRIEF STATEMENT OF PRIMARY CONCLUSION

Key goals of Connecticut's energy policy include increasing the amount of electricity generated from clean energy resources and diversifying the state's energy supply mix. Based on the success of the state's residential solar PV program and Connecticut's relatively high electricity rates, it is expected that a Shared Clean Energy Facility Program will be of interest to ratepayers seeking to reduce their electricity expense, while helping to achieve these goals.

Implementation of a Connecticut Shared Clean Energy Facility Program requires adoption of legislation and program rules. The program should allow for multiple business models to maximize opportunities for facility development, competition, and choice for all interested participants. Furthermore, a value of clean energy analysis should be conducted to assure rate fairness for all business interests and classes of ratepayers including low-income populations.

Transforming the energy landscape for the 21st century requires that several broader issues be addressed to achieve a cleaner, safer, and more reliable system related to the anticipated increase in distributed generation, including: fairness in overall rate design to achieve the greatest value from clean distributed energy resource generation—with a goal of reducing the overall cost of electricity; development of utility business models to adapt to the evolving operating environment; and technology challenges to assure that the intended benefits of distributed generation are achieved.

RECOMMENDATIONS

The CASE Study Committee's recommendations relate to the adoption of legislation to provide a framework for a SCEF program; requirements related to SCEF program operation and administration; a mandate for DEEP to engage in the rulemaking needed to develop detailed Program Rules for SCEF operations, and conduct a value of clean energy analysis proceeding[1]; and the need for additional examination of related issues and legislative considerations.

Adopt SCEF Legislation and Program Rules

A review of the development of SCEF projects in other states revealed that a legislative framework is needed for developers, organizations, and subscribers to invest in SCEF projects in Connecticut. Therefore, legislation should be adopted that is consistent with the current interconnection and siting requirements, and that is based on relevant aspects of the state's successful residential solar PV program and the Interstate Renewable Energy Council's (IREC) Model Rules. Additionally, the legislation should direct DEEP to:

- Develop SCEF Program Rules that contain the detailed provisions for the development, operation and administration of SCEFs.
- Adopt the SCEF Program Rules and initiate the SCEF Program within six months from enactment of SCEF legislation. DEEP should also be required to review the Program Rules at least once every three years, and to report on program results to the General Assembly periodically.
- Develop the methodology for and conduct a proceeding to, determine the value of clean energy by type of resource used in Connecticut for the purpose of establishing SCEF billing credit rates.

Legislation should permit the development and operation of SCEFs that utilize any Class I renewable energy resource for electricity generation. Moreover, the legislation should provide flexibility to accommodate different business models to own and operate SCEFs, such as for-profit and not-for-profit organizations and the state's electric distribution companies (EDCs). Specific provisions that support the legislative framework for a SCEF program should be adopted, including the following:

- A definition of key terms
- The SCEF must have at least two Subscribers.
- Subscribers of an SCEF and the SCEF must be physically located within the same EDC service territory.
- Subscriptions sold from a single SCEF cannot exceed 100% of the SCEF's nameplate capacity.
- SCEFs must comply with existing standards and requirements for siting and interconnection of distributed renewable energy electricity generating facilities based on their nameplate capacity. Legislation should not provide a SCEF capacity size limit.

1 *2014 Integrated Resource Plan for Connecticut*, Connecticut Department of Energy and Environmental Protection (Hartford, CT) (Draft for Public Comment, December 11, 2014) 112

- The SCEF Organization, as generator, shall own the renewable energy credits (RECs) for electricity generated from the facility unless or until transferred by contract to others.
- The EDC shall be required to enter into a Power Purchase Agreement for the electric energy produced by any SCEF located within its service territory consistent with the SCEF Program Rules, including that the term of such agreement shall be for the life of the SCEF.
- Using the billing credit rate as determined by the value of clean energy analysis and ratemaking process, SCEF Subscribers shall receive a billing credit on their monthly electricity bill for their share of energy generated from the SCEF as reported by the SCEF Organization to the EDC. A Subscriber's excess billing credit, if any, shall be carried over month to month to the end of the annual solar billing cycle and paid out as a cash credit on the next monthly bill.

  However, an interim billing credit rate shall be used for SCEFs established prior to adoption of SCEF Program billing credit rates based on the results of the value of clean energy analysis for clean energy resources by type.

  - The state's existing net metering program for its residential solar PV program shall be used as the interim billing credit rate. The interim billing credit rate shall apply to a SCEF upon its execution of a power purchase agreement with an EDC and successful SCEF registration with the state as specified in the SCEF Program Rules.

    Additionally, Subscribers of SCEFs established in advance of adoption of the SCEF Program billing credit rates shall be grandfathered to receive whichever rate is higher—the interim billing credit rate or the SCEF Program billing credit rate—for the life of the SCEF.
- SCEF Unsubscribed Electricity Generation: For a two year period following the effective date of SCEF registration with the state as specified in the SCEF Program Rules, the Subscriber Organization will receive the rate that is, or would be, paid to Subscribers for unsubscribed electricity generation. After this initial two-year period, the Subscriber Organization will receive the rate for unsubscribed generation as determined through the value of clean energy analysis and ratemaking process; however, until such time as the rates are set by this process a SCEF will receive the avoided cost rate of wholesale power.
- DEEP shall incorporate low-income household participation into the SCEF program along with possible incentives for utilities that aid in meeting this goal.

Value of Clean Energy Analysis

The 2014 Draft IRP states that DEEP's plan is to conduct "a proceeding to evaluate the value of distributed generation [value of clean energy analysis]."[2] Legislation should direct DEEP to conduct the value of clean energy analysis and that such analysis shall be completed within one year of enactment of the legislation. A value of clean energy analysis should be conducted for each type of Class I clean energy renewable resource, but the first phase of the study should be

2 DEEP Draft 2014 IRP 112

conducted for solar PV generation, since that is likely to be the most widespread type of SCEF developed, at least initially.

This proceeding should be a transparent process, involving all stakeholders. The legislation should mandate that the Public Utility Regulatory Authority (PURA) use the results of the DEEP value of clean energy analysis to conduct a ratemaking process to establish billing credit rates by type of resource for SCEFs, as well as for other types of clean distributed energy resource generators. Such analysis should also be used to inform a ratemaking process for the existing residential/commercial solar PV programs. The value of clean energy SCEF billing credit rates shall apply to all projects initiated after the ratemaking process has been completed. For SCEF projects established prior to that date, whichever rate is higher—the interim billing credit rate or the value of clean energy billing credit rate—shall apply.

Mandate DEEP to Adopt SCEF Program Rules

To provide additional guidance and a regulatory framework to support all stakeholders in SCEF development and operation and administration for the purpose of implementing the legislation authorizing SCEFs, DEEP should develop and adopt detailed program rules consistent with such legislation that include, but are not limited to, consideration of the following:

- Requirements for SCEF Organization registration, including filing the SCEF Organization's prototype Subscriber Agreement and the SCEF/EDC power purchase agreement with PURA
- Requirement for an EDC to enter into a power purchase agreement with a SCEF
- Applicable facility siting and interconnection requirements
- Safety, performance and interconnection standards
- Control, testing and inspection requirements
- The maximum size of a SCEF Subscriber's subscription shall not exceed 120% of the Subscriber's average monthly electricity consumption for the most recent 12 months. This limit is based on the IREC Model Rules and best practices of other states, and helps to mitigate a SCEF having unsubscribed electricity generation. Additionally, Subscribers should have the option to increase or decrease SCEF subscription shares no more frequently than quarterly, based on availability and terms and conditions of transferability and portability provisions of the SCEF Program and the Subscriber Agreement.
- Subscription transferability that enables a SCEF Subscriber to transfer interest in a SCEF to another entity eligible to be a Subscriber for any reason.
- Timely reporting of SCEF Subscriber information by the SCEF Organization to the EDC
- Subscription portability that enables a SCEF Subscriber to retain a Subscription upon relocation within the same EDC service territory
- Billing credit rates for SCEFs shall be established based on the results of the value of clean energy analysis for each type of clean renewable energy resource. Until such time

as the SCEF billing credit rates are adopted, the applicable billing credit rate for SCEFs and SCEF Subscribers shall be the interim billing credit rate as set forth in the SCEF legislation.

- REC ownership provisions as set forth in legislation
- Consumer protections and disclosures should be developed by DEEP in consultation with the Office of the Consumer Counsel and the Department of Consumer Protection. The IREC Model Rules and best practices (i.e., 16 CFR Part 260: Environmental Marketing Guidelines, "Green Guides") should be used as guidance. SCEFs should be required to provide potential subscribers with this information prior to purchase of a Subscription, as well as including it in the Subscription agreement.
- A recent energy home or business efficiency audit should be required for a SCEF Subscriber to be eligible to participate in the SCEF program. For homeowners, this requirement is the same as for the Connecticut Green Bank's (CGB) residential solar PV program. For renters, a modified program should be created.
- Develop a low-income household component of the SCEF program. Several low income programs developed by others are referenced in the Case Studies section of this report.
- Reporting requirements to the legislature regarding SCEF program outcomes.

Also, DEEP should create a website that includes all SCEF Program information to assure that interested stakeholders and potential SCEF Subscribers have accurate and timely information about the program. In addition, it is recommended that DEEP develop financing and incentive options in collaboration with the CGB, to encourage SCEF development and participation — including low-income household participation — as a way to meet the state's renewable energy resource electricity generation goals. The CGB's current programs should be considered for expansion or modification to include eligibility for SCEF owners and SCEF Subscribers.

Other Related Issues to be Considered

The following issues related to SCEFs and increasing penetration and use of clean energy resource generators, and intermittent clean distributed energy resources, and other distributed energy resources, should be considered:

- General rate design, including ratepayer fairness considerations and reducing peak demand
- Locating distributed energy resources to create the most system value, such as reducing system congestion and improving grid stability, reliability, resiliency, safety and security
- Development of innovative EDC business models with performance incentives for supporting deployment and use of distributed generation (such as what currently exists for energy efficiency programs)
- Ongoing monitoring of other states' experiences and cooperating with initiatives of regional entities such as the ISO-NE Distributed Energy Resource Working Group

- Identify and plan to implement technical solutions, including advanced inverters and energy storage, if necessary, to assure grid stability and reliability with regard to transient loads and other technical issues, especially in areas with high levels of penetration and use of intermittent clean energy resources and other distributed energy resources. A study on complementary technologies, if authorized by legislation, as recommended in this report, will inform these efforts.

Additional Legislative Considerations

In addition to recommendations specific to the SCEFs, several other related legislative initiatives were identified for consideration by the General Assembly.

- Allow EDCs to develop additional clean renewable energy resource generation facilities for specific permitted purposes including, but not limited to, enhancing the distribution system to reduce congestion, and to increase reliability, resiliency, safety and security.
- Direct the Siting Council to review MW capacity siting requirement for various types of clean energy resources based on facility characteristics and to conduct an evaluation to revise requirements based on the results.
- Commission a study to evaluate the benefits and costs of using complementary technologies including, but not limited to, storage and advanced inverters for enhancing the value of intermittent Class I clean energy resources on the grid.
- Revise the Clean Energy Options Program[3] to provide that funds collected are used to construct clean energy resource electricity generation facilities in Connecticut. Projects would be proposed and owned by EDCs and others for the benefit of ratepayers. DEEP would manage the proposal process for selection of projects for PURA's consideration. Projects should be for the purpose of enhancing the reliability or performance of the distribution system, thereby providing the most value to the system and ratepayers. Ratepayers who currently participate in the program would be given 60 days to choose to stay with current company that they had selected; if the ratepayer makes no election by the end of that period, default enrollment would shift to new program. Participants who chose to remain with the company selected (old program) and not move to the new program would have the option to shift participation into the new program at any time. The voluntary financial support of ratepayers will be used to help Connecticut achieve its clean energy goals for the benefit of all Connecticut ratepayers.

3 A voluntary program that provides ratepayers an option to pay extra on their electricity bill by selecting one of two companies that purchase clean energy or build clean energy generating facilities (anywhere in the US or Northeast). Currently about 25,000 Eversource Energy and UI customers participate in the program, with annual contributions of approximately $2.5 million.

1.0 INTRODUCTION

At the request of the Connecticut General Assembly (CGA), the Connecticut Academy of Science and Engineering (CASE) was asked to conduct this study to provide an understanding of the issues related to the development and use of Shared Clean Energy Facilities (SCEFs) in Connecticut, including an overview of anticipated benefits and costs.

During the CGA's 2014 legislative session, the Energy and Technology Committee considered proposed bills (HB-5412: *An Act Concerning Shared Clean Energy Facilities;* and SB-353: *An Act Concerning the Development of Class I Renewable Energy Source Projects*, and working draft amendments [LCO-3885 and LCO-4100]), but did not recommend a bill to authorize the development of SCEFs in Connecticut for vote by the CGA. Issues regarding proposed legislation were raised by stakeholders including the Connecticut Department of Energy and Environmental Protection (DEEP), utilities, clean energy advocates and organizations, and the general public at a public hearing on March 4, 2014 and in discussion with leadership of the Energy and Technology Committee.

The National Renewable Energy Laboratory (NREL), in "A Guide to Community Shared Solar: Utility, Private, and Nonprofit Project Development," defines a community shared solar energy system as "a solar-electric system that provides power and/or financial benefit to multiple community members." Based on this definition, a SCEF is a system that utilizes clean renewable energy (such as biomass, fuel cells, geothermal, hydroelectric, ocean/tidal, solar, wind, among others) to provide power and/or financial benefit to multiple users. For reference, a Glossary of Terms related to the development and use of SCEFs is provided in Appendix A.

Renewable energy technologies for electricity generation include solar photovoltaic (PV) devices, wind, geothermal, biomass, biogas (landfill gas and wastewater treatment digester gas) and low-impact hydroelectricity.

However, each state has its own regulatory definition of what is defined as a renewable energy source. In Connecticut, General Statute §16-1(a) sections (26), (27), and (44) defines Class I, Class II, and Class III renewable energy sources.

While several types of clean renewable energy sources can be used for generating electricity from a SCEF, solar PV systems have been the principal source used in other regions and are expected to be the most likely energy resource used for SCEFs in Connecticut. While solar PV type SCEFs are the focus of this study, the concepts and issues discussed are applicable for other types of SCEFs.

Appendix B provides an overview of renewable energy electricity generation technologies.

1.1 PROJECT OVERVIEW AND METHODOLOGY

This study provides an overview of SCEFs and issues regarding their development and use in Connecticut. Potential SCEF impacts on populations that participate versus those that do not are discussed.

Study research methods included the following:

- Review and analysis of current and relevant literature, including best practices and case studies, to provide a context and understanding regarding the development and use of SCEFs in Connecticut.
- Review and analysis of Connecticut's 2014 proposed legislation and public hearing testimony on HB-5412, and review of legislation adopted in other selected states.
- Analysis of SCEF project models to develop an understanding of their applicability for use in Connecticut.
- Focus group sessions and interviews with energy sector leaders and decision-makers to gain perspectives involving guiding principles, stakeholder roles, legislation vs. rulemaking, pilot program vs. longer-term program, cross subsidization, rate design and value of clean energy, access for low-income households, and environmental considerations.
- Guest Speaker Presentations from experts who provided presentations on study issues to the CASE Study Committee. The data and information presented has been incorporated into the study report as appropriate. Guest speaker presentation information is available electronically, as noted in Appendix C.

The study report includes the following sections:

- Overview and Related Benefits
- The Regulatory Framework
- Project Models
- Case Studies
- Focus Group Sessions: Summary
- Components of the Value of Clean Energy Analysis and SCEF Financial Costs
- Findings and Recommendations

1.2 STUDY COMMITTEE AND RESEARCH TEAM

A Study Committee was appointed by CASE to oversee and guide the study effort. The Connecticut Economic Resource Center, Inc., was engaged by CASE to conduct the research for the study, with support from CASE study advisors.

2.0 OVERVIEW OF SHARED CLEAN ENERGY FACILITIES AND RELATED BENEFITS

2.1 INTRODUCTION

The development and use of SCEFs could provide a variety of benefits to Connecticut residents and businesses. This section highlights several potential benefits to the state, including

- increasing access to clean energy for more residents and businesses;
- providing tangible economic benefits to SCEF owners and subscribers;
- providing grid design and improvements that move toward decentralization to foster resiliency and security, offer locational benefits, defer future upgrades and high marginal costs, and avoid system losses;
- furthering renewable energy goals, including meeting the state's renewable portfolio standards (RPS); and
- improving environmental quality and helping to attain greenhouse gas goals.

Although this section addresses the benefits of SCEFs, it is also important to recognize potential transmission and distribution system technical issues and other costs associated with SCEF facilities, such as grid instability, that may be associated with increased penetration and use of other distributed energy resources.

2.2 INCREASED ACCESS

Access to renewable energy technologies could be expanded to more Connecticut residents and businesses through the use of SCEFs. SCEFs are designed to meet the energy needs of multiple users with electricity generated from clean renewable energy technologies at a location for multiple dispersed housing or business units. This is accomplished by providing subscribers, those that invest in a share of a SCEF, with a credit on their electricity bills (based on their share of the electricity generated from the SCEF) to offset the cost of the electricity that they use.

The SCEF models differ from the most common model of renewable energy system installations that are deployed on individual residential and commercial properties in Connecticut. Typically, residents or businesses that choose to produce electricity from renewable energy install solar panels on the rooftops of their homes or businesses, or wind turbines on their properties. Most Connecticut residents and businesses, however, either are not able to or elect not to invest in an individual property installation for a variety of reasons such as high installation costs, unsuitable rooftop orientation, shaded property, or because they rent instead of own their properties. It is estimated that only approximately 25% of US residential units are suitable for solar rooftop installation.[1] Furthermore, 33.7% of total occupied housing units

1 Model Rules for Shared Renewable Energy Programs. Interstate Renewable Energy Council (2013).

in Connecticut are occupied by renters.[2] Also, although solar PV system installation costs have decreased sharply in recent years and financing opportunities have expanded rapidly, individual property installation is still considered to be unaffordable by many residents. For participants in the Residential Solar Investment Program of the Connecticut Green Bank (CGB)[3], net of state and federal tax credits, the median cost of a residential solar rooftop installation was $22,160 in Connecticut between 2012 and 2014 for a 7.02 kW sized system.[4]

SCEFs are an option that can be used to overcome these access barriers. SCEFs could facilitate access for more consumers through the key characteristics of group purchasing, economies of scale, optimal siting, tax incentive policies, and potential financing options.

Achieving economies of scale would result in greater consumer access to clean renewable energy generation. Evidence shows that as system capacity size increases, the marginal cost of installation decreases. In a report presenting US pricing trends in the solar PV system installation market, the Lawrence Berkeley National Laboratory found that in 2013, for residential and commercial properties[5] the median price to install solar PV systems greater than 1000 kW was $3.10 per watt, which was 35% lower than the cost to install a system less than 2 kW ($4.80 per watt).[6]

If a facility is designed to achieve the benefits of economies of scale, it should result in lower subscriber investment cost, which would appeal to a greater number of residents, businesses, and state and municipal governments. Residents or business owners could organize under a subscriber organization and use the projected economies of scale to negotiate volume discount purchases. In fact, the concept of volume discount group purchasing has already been shown to result in cost savings in the residential solar PV market, most notably in the national Solarize campaigns, including CGB's Solarize Connecticut program. Massachusetts has used solar clean energy facilities to reduce energy costs for low-income housing authorities.[7]

By offering additional siting choices, SCEFs could also expand access to more Connecticut consumers. Some residents and businesses may not take advantage of the benefits of a renewable energy technology system because they do not want an installation on their rooftops or on their properties. A SCEF could expand access to these users because it can be placed in another location that does not disrupt the aesthetic integrity of one's residential property.

SCEFs could also expand access to more Connecticut residents through tax incentives. The Business Energy Investment Tax Credit (ITC) is a federal tax credit equal to 30% of installation expenditures for solar (includes solar energy used to generate electricity, to heat or cool a structure, and hybrid solar lighting), fuel cell, and wind projects, and 10% of installation expenditures for geothermal, microturbine, and combined heat and power projects. Investor-owned utilities and special purpose entities are eligible for the ITC to develop facilities. The ITC for geothermal, hybrid solar lighting, small wind, fuel cells, microturbines, and combined heat and power expires December 31, 2016; also as of that date, the solar (not including hybrid solar lighting) credit will be reduced from 30% to 10%.

2 United States Census Bureau, American Community Survey 2013 One Year Survey

3 CGB was created in 2011 through Public Act 11-80 "An Act Concerning the Establishment of the Connecticut Department of Energy and Environmental Protection and Planning for Connecticut's Energy Future" to encourage the growth of clean, reliable energy in the state.

4 Renewable Solar Investment Program, Information on Installers and Cost, 2012-2014.

5 For the purposes of their analysis, Berkeley Labs defined residential and commercial properties as systems with less than 2 MW in size.

6 Barbose, Galen, et al. "Tracking the Sun VII: An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2012" (2013). Lawrence Berkeley National Lab. Web. 11 Dec 2014.

7 SunEdison to Deliver $60 million in Utility Savings to Massachusetts Low Income Housing Authorities. Energycentral/PR Newswire. 4 Dec 2013.

The residential and commercial ITCs have been transformational in expanding solar PV system deployment. Since the ITC inception in 2006, solar PV system installations grew by 1,600% in the United States.[8] The ITC could be used to offset SCEF development costs, thus making SCEFs more affordable and accessible to consumers.

Also, if the development of SCEFs is authorized in Connecticut, financing tools could be created or enhanced to expand access to more Connecticut residents. CGB's Residential Solar Investment Program provides financial incentives for residential solar PV system installations up to 20 kW, and low-interest financing options. Renewable energy financing options currently offered by CGB could be packaged for SCEF development purposes in Connecticut.

2.3 TANGIBLE ECONOMIC BENEFITS TO USERS

SCEFs could be an effective tool for providing tangible economic benefits to Connecticut residents and businesses. A SCEF subscriber will be able to offset their monthly electricity cost with credit for their share of the electricity generated from the SCEF, which can also serve as a hedge against future electricity price increases throughout the term of the SCEF subscription. Cost savings are typically provided through a bill credit on the subscriber's monthly electricity bill. The net economic benefit to a subscriber takes into consideration the cost of the investment for the purchase of a share of the SCEF and the credits from the share of energy generated from the SCEF over the term of the participation agreement. In addition to the value created from electricity generation, depending on project design, facility owners could benefit economically from their ownership of renewable energy credits (RECs). RECs are tradable assets from renewable energy production, and demand for these credits comes from those needing to meet a renewable portfolio standard. SCEF owners could also use RECs to lower SCEF investment costs to attract more subscribers.

It is also noted that in an overall analysis, the development and use of SCEFs has the potential to drive not only employment, but leave individuals and businesses with more discretionary income, some of which will be spent on other goods and services that result in state revenue collections and economic development.

At $ 0.1974 per kWh (September 2014), Connecticut has the second-highest residential electricity rate in the United States.[9] Connecticut households spent an average of $126.75 on monthly electricity expenses in 2012, which was 18% higher than the national average.[10] Further, it is estimated that low-income households in the United States spend approximately 8.3% of their income on electricity expenses, whereas non-low-income households spend 2.9% on average.[11] Connecticut residential electricity rates have consistently outpaced US average retail electricity rates, increasing by approximately 60% between 2000 and 2012, whereas US rates increased by approximately 40%.

8 "Solar Investment Tax Credit (ITC)." Solar Energy Industries Association (SEIA).Web. 22 Dec 2014. http://www.seia.org/policy/finance-tax/solar-investment-tax-credit

9 "Electricity Power Monthly." US Energy Information Agency. Web. 14 Jan 2014. http://www.eia.gov/electricity/monthly/

10 "2012 Average Monthly bill – Residential." US Energy Information Agency. Web. 22 Dec 2014. http://www.eia.gov/electricity/sales_revenue_price/pdf/table5_a.pdf

11 "State Policies to Increase Low-Income Communities' Access to Solar Power." Center for American Progress. Web. 22 Dec. 2014. https://www.americanprogress.org/issues/green/report/2014/

High, volatile electricity prices in Connecticut can be partially attributed to regional market and infrastructure challenges related to the procurement of natural gas. Connecticut is highly dependent on natural gas to meet its energy needs. According to the Independent System Operator - New England (ISO-NE)—the independent, not-for-profit corporation responsible for the electricity wholesale prices and grid for the six New England states—challenges such as inadequate pipeline infrastructure, unreliable fuel arrangements, limited storage capacity, and market imbalances all play a role.[12] Many of the challenges related to natural gas consumption require long-term solutions, but they will continue to negatively impact Connecticut residents in the short term, in the form of sustained high electricity rates.

SCEFs could help to counter high electricity rates and hence create economic benefits for Connecticut ratepayers. The levelized costs of clean energy resources are becoming more competitive with fossil fuel energy sources such as natural gas.[13] For example, in many parts of the country, wind power is now cost competitive, and the cost to install solar PV systems has decreased significantly in recent years (Figure 2-1). These trends may continue, thus making SCEFs more cost effective and accessible to residents and businesses.

SCEFs may also help diversify the energy resource and financial funding base for electricity generation, and potentially put downward pressure on system-wide generation costs, reducing vulnerability to system-wide cost volatility.

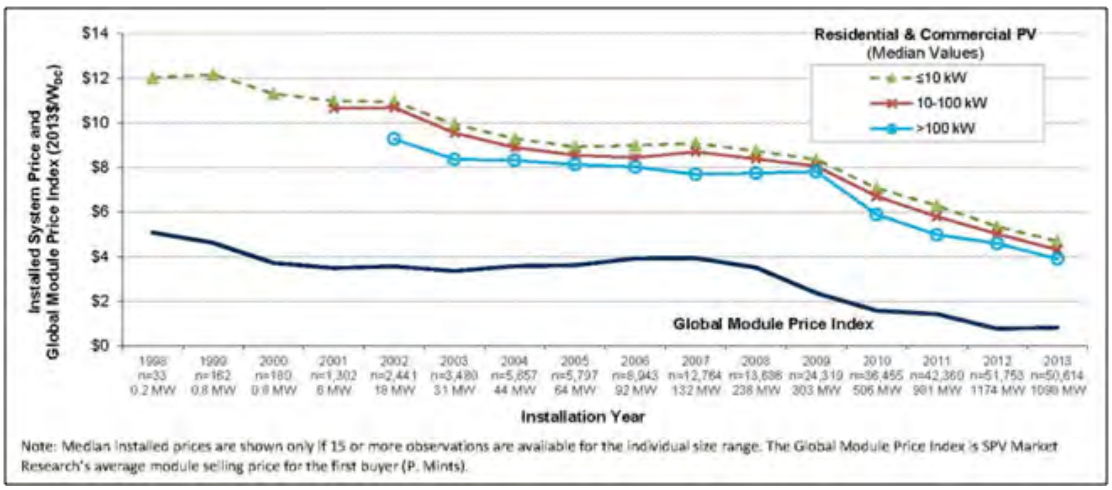


FIGURE 2-1. MEDIAN REPORTED INSTALLED PRICES OF RESIDENTIAL AND COMMERCIAL SOLAR PV SYSTEMS OVER TIME (SOURCE: PHOTOVOLTAIC SYSTEM PRICING TRENDS: HISTORICAL, RECENT, AND NEAR-TERM PROJECTIONS, 2014 EDITION; SUNSHOT US DEPARTMENT OF ENERGY, SEPTEMBER 2014; HTTP://WWW.NREL.GOV/DOCS/FY14OSTI/62558.PDF)

2.4 GRID IMPACTS

SCEFs, as distributed renewable energy systems, could also enhance the electric grid system. Renewable energy systems could provide benefits to the grid system in terms of

12 ISO New England Annual Report. ISO-New England. Web. 13 Dec. 2014. http://www.iso-ne.com/aboutiso/fin/annl_reports/2000/2014_reo.pdf

13 Annual Energy Outlook 2014. US Energy Information Agency. Web. 17 Dec 2014. http://www.eia.gov/forecasts/aeo/electricity_generation.cfm

- generation, transmission and distribution capacity;
- grid support services;
- reliability, resilience and security;
- avoided energy costs; and
- avoided system losses.

Although renewable energy systems could improve grid functionality, it is important to recognize that, at a certain high level of penetration, there are potential costs and challenges that need to be addressed in connection with the use of distributed energy resources, including distributed renewable energy resources. Increased penetration of distributed renewable energy systems, such as SCEFs, could induce interconnection, reliability, and transmission and distribution costs. These issues represent challenges for regulators and utilities to consider in connection with SCEF size and siting, in order to mitigate negative impacts and secure the most benefit from deployment of distributed energy resources.[14]

SCEFs will enhance the grid system by replacing generation capacity and energy produced from centralized power plants. As renewable energy system capacity and generation increases, generation capacity and energy produced from less efficient, relatively costly power plants may not be necessary to meet demand. This scenario, however, is dependent on the underlying characteristics of the renewable energy technology. For example, the generation capacity of solar is time variant and thus may not always be available to meet all peak demand as compared to the generation capacity of fossil fuel and nuclear power plants that is not time variant. While SCEFs are not technically dispatchable, they are highly predictable and available (especially solar PV, which has few moving parts), and predictability and availability will increase as the geographic diversity of SCEF sites increases. A discussion of the possible benefit that renewable distributed energy resources can bring to the grid is timely given the future capacity challenges that have been predicted by ISO-NE. Based on ISO-NE's analysis, 6,246 MW of capacity must be replaced by 2020 due to the expected retirement of several coal- and oil-based power plants in the region. Replacement of these power plants is also projected to reduce regional greenhouse gas emissions.[15]

SCEFs could also reduce costs incurred by utilities to transmit and distribute electricity. Distributed renewable energy systems are typically located close to load, which differs from the traditional utility structure of locating generation relatively farther from load. This locational advantage of renewable energy systems allows for possible decreased transmission and distribution capacity and costs. If distributed renewable energy systems can provide consistent electricity closer to load, the need for transmission and distribution capacity diminishes, especially when energy storage is used or where smart microgrids are installed.

Related to this benefit is a distributed renewable energy system's ability to improve reliability. Based on an analysis of grid data, SCEFs can be sited to maximize the value to the grid, to address local distribution constraints and possibly help to defer grid infrastructure investments. Distributed renewable energy systems that are located close to load could mitigate the possibility of brownouts and blackouts by relieving transmission and distribution congestion during high demand periods. In addition, solar energy has the potential to correlate energy production with energy demand. Further, an increase in the use of distributed renewable

14 http://www.raponline.org/featured-work/teach-the-duck-to-fly-integrating-renewable-energy

15 Sheilendranath, Akarsh. "Strategic Transmission Analysis: Generation Retirements Study." December 2012. PowerPoint Presentation.

energy systems that are typically close to load could help to reduce energy losses that occur when electricity is generated and transmitted across transmission and distribution systems from a central power plant.[16]

However, transmission and distribution system disruptions can result in distributed renewable energy systems tripping offline, especially in areas with high penetration of these resources. However, new “Ride Thru” inverter standards may be authorized under IEEE 1547 to prevent losses of power produced from solar PV systems and other distributed renewable energy systems that are caused by other grid interruptions. These potential issues should be addressed to maximize grid reliability and minimize grid constraints. Hawaii, which has dealt with grid issues related to high solar PV generation penetration levels in certain areas, has employed solutions such as storage, cost-effective demand response, installation of distribution circuit monitors, and interconnection queues.

Depending on the clean energy resource that is used by an SCEF, some may provide power on a 24/7 basis and others will only be available on an intermittent basis. Therefore, when available, other possible grid benefits of SCEFs include improvements to grid support services, especially during periods of high peak demand, which include reactive supply, frequency regulation, energy imbalances, and operating reserves, and reduced grid wear and tear.

Although distributed generation such as SCEFs could bring many benefits to the grid, there are potential costs that must be examined, such as interconnection issues, transmission and distribution costs, and reliability issues due to the intermittent nature of many renewable energy technologies.

2.5 POTENTIAL BENEFIT OF USING SCEFS TO MEET CONNECTICUT’S COMPREHENSIVE ENERGY STRATEGY AND RENEWABLE PORTFOLIO STANDARD (RPS) GOALS

SCEFs would help Connecticut reach its comprehensive energy strategy goal of expanding in-state clean energy generation capacity to meet its RPS requirements in a more cost effective manner.

The Connecticut RPS mandates that Connecticut electricity providers (Connecticut electric suppliers and electric distribution company wholesale suppliers) obtain a minimum percentage of their retail load from renewable energy sources. Electricity providers are required to reach 27% by 2020 (20% Class I renewable energy sources, 3% (additional) Class I or Class II renewable energy sources, and 4% Class III renewable energy sources).[17] Electricity providers can satisfy this requirement by purchasing renewable energy credits (RECs) from in-state or out-of-state producers. Many states have implemented RPS programs as a mechanism to deter electricity providers from either generating or procuring energy derived from fossil fuel sources, and to encourage innovation and competition among renewable energy producers.[18]

16 Hanson, Lena. “A Review of Solar PV Benefit & Cost Studies.” April 2013.

17 “Connecticut Renewable Energy Portfolio Standards Overview.” Connecticut Department of Energy & Environmental Protection. Web. 22 Dec. 2014. http://www.ct.gov/pura/cwp/view.asp?a=3354&q=415186

18 Lyon, Thomas P., Yin, Haitao. “*Why do States Adopt Renewable Energy Portfolio Standards*.” The Energy Journal Vol 31. No. 3. Web. 14 Dec. 2014. http://webuser.bus.umich.edu/

In 2010, only 11% of the Class I requirements that contributed to Connecticut's RPS originated from electricity generation in Connecticut.[19] Seventy-nine percent of the Class I renewable requirement was satisfied by purchasing RECs from biomass plants in Maine and New Hampshire. This statistic represents a transfer of Connecticut money to support renewable energy producers in other states. If Connecticut electricity providers purchased more RECs from Connecticut suppliers, it could help build a stronger in-state renewable energy generation infrastructure and aid local economies. Electricity generation in Connecticut could also help to mitigate the risk of increases in the price of renewable energy, as RPS goals in the New England region will continue to increase and the purchase of out-of-state RECS is expected to rise.

The development of SCEFs in Connecticut could help to meet the state's comprehensive energy strategy goals and RPS requirements. The development of SCEFs could help the state reach its comprehensive energy strategy goals by expanding in-state generation of electricity from renewable energy resources. Further, SCEF owners could enter into the zero emission renewable energy credit (ZREC) or low-emission renewable energy credit (LREC) markets, and could sell RECs to electricity providers to meet RPS requirements.

An added benefit of SCEF participation in the ZREC/LREC market would be that electricity providers could save money by reducing their forecasted alternative compliance payments. If Connecticut utility companies are unable to meet Connecticut's RPS requirements, they must pay the alternative compliance payments —a penalty of $55 per megawatt hour (MWh). The DEEP estimates that Connecticut electricity providers face a future shortfall in the number of RECs they can purchase to meet RPS requirements.[20] If more in-state generation occurred through the development of SCEFs, then Connecticut electricity providers would be more likely to avoid alternative compliance payments penalties.

2.6 ENVIRONMENTAL QUALITY

SCEFs could also be important for Connecticut because they emit zero or low carbon emissions, improve air quality, and could lead to environmental revitalization.

Traditional power plants burn fossil fuels such as oil, coal, and natural gas to generate electricity. In addition to producing electricity, power plants create the byproduct of carbon dioxide, which is linked to global warming. Fossil fuel-burning power plants also emit air pollutants that endanger human health. For example, nitrogen oxide and sulfur dioxide can trigger asthma and other respiratory illnesses. SCEFs and distributed renewable energy systems in general could help to replace, or limit the use of, centralized fossil fuel power plants. On a macro level, this would help to address global warming and protect residents against harmful air pollutants.

Furthermore, optimal siting of a SCEF could also improve the environment and enhance a community's aesthetics. For example, initiatives exist to repurpose brownfields, including contaminated lands, for use by renewable energy facilities. Also, the Environmental Protection

19 "Restructuring Connecticut's Renewable Portfolio Standard." Connecticut Department of Energy and Environmental Protection. Web. 22 Dec. 2014. http://www.ct.gov/deep/lib/deep/energy/rps/rps_final.pdf

20 "2013 Comprehensive Energy Strategy for Connecticut." Connecticut Department of Energy and Environmental Protection. Web. 22 Dec 2014. http://www.ct.gov/deep/lib/deep/energy/cep/2013_ces_final.pdf

Agency's (EPA) RE-Powering America's Land Initiative was created to assess the feasibility of using contaminated brownfields for renewable energy facilities. Unlike other re-uses, siting facilities on brownfields comes with the added benefit of facility development prior to and during contamination cleanup, according to EPA.[21] Further, the Interstate Renewable Energy Council's (IREC) *Model Rules for Shared Renewable Energy Programs* note that carbon-emitting power plants are often located in low-income communities, which has resulted in adverse health effects for those nearby. Siting SCEFs and other distributed clean energy resources in low-income communities could help to reverse this trend.[22]

21 "*Handbook on Siting Renewable Energy Projects While Addressing Environmental Issues.*" U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response's Center for Program Analysis. Web. 12 Dec 2014. http://www.epa.gov/oswercpa/docs/handbook_siting_repowering_projects.pdf

22 Model Rules for Shared Renewable Energy Programs. Interstate Renewable Energy Council. (2013)

3.0 THE REGULATORY FRAMEWORK

3.1 INTRODUCTION

The nation's utility sector is massive and complex, combining ownership, management and regulation in myriad ways designed to achieve the goals of both reliable and inexpensive electric service. When considering possible changes to the utility regulatory framework in Connecticut, it is helpful to understand the industry's history and organization and the pivotal role that regulation has played. This section contains a broad overview of utility regulation generally and utility regulation in Connecticut in particular.

Utility companies in the United States are either consumer owned or investor owned.[1] The electric utilities in Connecticut are investor owned. Approximately 25% of US households are served by consumer-owned utilities[2] and the other 75% are served by investor-owned utilities, which are private companies financed by shareholder equity and bondholder debt.[3]

SCEFs can operate in states served by either type of utility and can enter into agreements for the purchase of power with either type. However, in entering into business arrangements with SCEFs, investor-owned electric utilities like those in Connecticut need to make a determination that such arrangements are consistent with the utility's goal of attracting and retaining capital through prudent management for its shareholders and bondholders.[4]

Regardless of whether they are consumer owned or investor owned, utilities may be structured as either vertically integrated or distribution-only companies.[5] Vertically integrated utilities are permitted by regulators to generate, transmit and distribute power, and the companies may either own their power plants and distribution lines, or contract for their use. Vertically integrated utilities may directly own, or invest in, generation facilities such as SCEFs, without limit.

Prior to 1998, utilities in Connecticut were vertically integrated. In the early 1980s, with prices rising sharply, large industrial electricity users in New England and elsewhere began to push for the ability to buy electricity at wholesale prices. This push led, after roughly two decades, to states such as Connecticut "restructuring" the industry by separating the electric generation and supply function from the distribution network. This was done on the theory that only the distribution function was a natural monopoly; lower electricity costs could result from permitting more competition with respect to the generation function. In 1999, in connection with restructuring, Connecticut utility companies were required to sell their power generation plants, and electricity generation became the purview of competing non-utility suppliers.

1 *Electricity Regulation in the US: A Guide*, The Regulatory Assistance Project, Montpelier, Vermont (RAP) (March, 2011) 9

2 These facilities are owned by organizations such as co-operatives, public utility districts, municipalities and native tribes.

3 RAP *Electricity Regulation* 9

4 RAP *Electricity Regulation* 42

5 RAP *Electricity Regulation* 10

As a result of restructuring, distribution-only utilities, known as electric distribution companies (EDCs), now purchase power from wholesalers and transmit and distribute it to consumers. Consumers have the choice to purchase electricity either from their EDC (who has purchased it from a supplier) or directly from a non-utility supplier. If a consumer does not elect otherwise, power purchased from the EDC is the default option. Either way, the consumer receives the electricity via the EDC's transmission and distribution lines.

Distribution-only utilities, such as those in Connecticut, are not permitted to own generation facilities[6], except in very limited circumstances.

3.2 REGULATION OF ENERGY GENERATION, TRANSMISSION AND DISTRIBUTION

Federal regulation governs the interstate transmission of electricity, the sale of wholesale electric power, and the system interconnections needed for large-scale electricity generation. The states, in turn, regulate retail rates and terms of service, quality of service standards, and the siting of larger generation facilities. Local governments are also generally involved in facility zoning and siting.

The primary regulator at the federal level is the Federal Energy Regulatory Commission (FERC). FERC regulates the interstate commerce aspects of electric power, mainly the prices and terms of bulk power transmission services, interconnections and the wholesale electricity market. FERC also has the responsibility to approve siting for certain transmission facilities.[7]

As noted, state regulation of the electric power industry involves approving retail rates and overseeing all aspects of electricity distribution. Although SCEFs can be established without enabling state legislation, it has taken years of research for developers to establish projects in states where there was no legislative framework provided. In addition, significantly fewer projects have been completed in restructured states, where the utility companies are prevented from playing a major role in developing, owning and operating SCEFs.

Some states interested in promoting the development of renewable resources have begun to adopt legislation to promote group renewable energy generation projects that individuals and businesses can own, lease, finance or subscribe to, in exchange for utility bill credits, environmental benefits, or other compensation. The structure of these state laws has varied, and IREC's Model Rules were developed to assist legislatures and facilitate SCEF implementation. The Model Rules are based on stakeholder input and the identification of best practices. They outline provisions that states should consider for inclusion when adopting SCEF legislation.[8]

3.3 INTERSTATE RENEWABLE ENERGY COUNCIL MODEL RULES.

According to IREC, a state's consideration of potential legislative changes to accommodate the development and operation of SCEFs should begin with a review of IREC's Model Rules. IREC first published its Model Rules in 2010, with the stated purpose of assisting the development

6 RAP *Electricity Regulation* 10
7 RAP *Electricity Regulation* 15, 64
8 Model Rules for Shared Renewable Energy Programs, Interstate Renewable Energy Council (2013)

of SCEFs as a way to permit more consumer access to renewable energy. According to IREC, "Experience has shown that energy consumers are keenly interested in greening their energy supply through programs that result in new generation, provide them with tangible economic benefits and result in clean energy facilities located near their communities."[9] IREC's 2010 Model Rules were based on the experience of early SCEF states such as California, Colorado, Massachusetts, and Washington.

IREC reissued its Model Rules in 2013, citing the declining costs of renewable energy generation, and the growing numbers of consumers wanting to increase their support of green energy projects as reasons for more states being interested in adopting legislation to promote the development and use of SCEFs. IREC also noted that only about 25% of electricity customers have the right siting or the ability to take advantage of renewable resource generation, and that even if the site is oriented properly and otherwise suitable, an individual or business may not own the building or may have other reasons for not wanting an on-site installation. So, according to IREC, there is great, untapped potential for the growth of SCEFs across all regions of the United States, and states should adopt SCEF legislation as a significant way to tap that potential.

In releasing its Model Rules, IREC articulated several guiding principles:

- As a matter of equity, all energy consumers should have ways to benefit from renewable energy.
- Participants (subscribers) should receive tangible benefits in the form of credits on their utility bills as a clear, intuitive method analogous to common net metering and a way to hedge energy price fluctuations.
- Program design should be flexible to accommodate different business models and consumer preferences.
- Program benefits should mirror, to the extent possible, benefits received by participants in the state's other, more established, renewable energy programs.
- New programs should be additive to, and supportive of, existing programs; the development of SCEFs should not negatively impact other types of renewable energy project investments, such as utility-run programs and incentive programs.[10]

The 2013 IREC Model Rules are designed to promote single facilities that can serve more than one consumer and provide them benefits on their utility bills. The 2013 Rules are similar to the version released in 2010, except that they eliminate the previously recommended SCEF size limit of 2 MW or less. The 2 MW limit had been set at a size large enough to achieve economies of scale but small enough to avoid costs of interconnection with a utility's distribution system. The 2013 Rules eliminate reference to a size limitation, relying instead on market forces and developers' determination of the best size to achieve environmental and business objectives.

The Model Rules contain definitions, administrative and legal requirements, and bill credit and valuation provisions.

9 IREC Model Rules 7

10 Low and Zero Emissions Renewable Energy Credits, Green Tariffs, energy efficiency programs and group purchasing programs such as "Solarize" in Connecticut.

3.3.1 Definitions

- A Shared Clean Energy Facility (called a "Shared Renewable Energy Facility") must have at least two subscribers (called "participants").
- A Subscriber (Participant) is a retail customer of a utility that owns a subscription and has identified one or more meters to which the subscription shall be attributed.
- A Subscription is an interest in a SCEF that will be at least one solar panel, provided that the subscription is sized to produce no more than 120% of the subscriber's average annual consumption.

3.3.2 General Provisions

- Each subscriber can change its account for crediting, but no more frequently than quarterly.
- New subscribers can be added at the beginning of each billing cycle.
- The owner or agent of the SCEF must give a list of subscribers and their proportionate interests to the EDC, but no more frequently than monthly.
- The EDC may require subscribers in a SCEF to have their meters read on the same billing timetable.
- If generation is not fully subscribed, the EDC will purchase the unsubscribed generation at the full value of generation, that is, at avoided cost, taking into consideration locational benefits.
- Subscribers may transfer or assign their interest back to the subscriber organization or to any person or entity that is eligible to be a subscriber.
- If a subscriber ceases to be a customer of the EDC, the subscriber must transfer or assign their subscription back to the subscriber organization or to any person or entity that is eligible to be a subscriber and the EDC need not compensate the subscriber for any unused credits.
- For the purpose of qualifying for any state or local incentive programs, a SCEF is deemed to be located on the premises of each subscriber.
- Neither owners of, nor subscribers to, a SCEF shall be deemed a public utility solely by reason of their subscription.
- Prices of subscriptions are not subject to regulation by [the agency having regulatory oversight].
- Subscribers own their share of RECs produced by the SCEF unless otherwise contracted to another entity.
- Dispute resolution procedures available to parties in the EDC's interconnection tariff shall be available to subscribers for any disputes involving bill credits.

3.3.3 Bill Credits and Valuation

- Any credits unused at the end of a billing period may be carried over to the next period until all credits are used or the distribution service is terminated.
- Any unused credits should not be used to reduce a subscriber's fixed monthly charges.
- Bill credits shall be valued either (i) by multiplying the subscriber's interest by the subscriber's retail rate, adjusted for costs and benefits including locational benefits and [the agency having regulatory oversight] shall ensure that any costs included in the analysis are not already being recovered from the subscriber by the EDC through other charges, (so-called "embedded cost based method") or (ii) by multiplying the subscriber's interest by the value of the electricity produced, as determined by [the agency having regulatory oversight], taking into account the costs and benefits of the SCEF, and in this determination, the benefits of the SCEF shall include, but not be limited to
    - avoided cost of generation;
    - capacity benefits;
    - avoided line losses;
    - avoided investment in transmission and distribution;
    - environmental benefits;
    - avoided environmental compliance costs; and
    - other locational benefits (so-called "value-based method").

3.4 STATES' REGULATION OF SCEFS

SCEFs are not typically built to the large scale requiring an ISO-approved interconnection, so their development and operation are generally governed primarily by state legislation and state agency rulemaking. State legislation describing the requirements for SCEF development and operation has generally fallen into one of two categories. It has either been included within a state's net metering or virtual net metering legislative provisions, or it has been enacted in a separate category, typically called "solar garden" or "community solar" enabling legislation. The virtual net metering legislation usually encompasses all forms of renewable energy, whereas solar garden legislation contains provisions authorizing PV installations only.

Virtual net metering typically allows credits from generation or production at one location to be utilized to offset the costs of consumption at another location. At least five states have adopted legislation authorizing virtual net metering, including California, Connecticut, New Hampshire, Pennsylvania and West Virginia. Legislation in these states is summarized as follows:

- California: In 2008, virtual net metering was authorized for municipalities and some multi-tenant properties. In 2011, the state's Public Utility Commission extended it to cover all multi-tenant customers.

- Connecticut: In 2011, virtual net metering was authorized for municipalities, with installations permitted up to 3 MW capacity. In 2013, agricultural and state-owned sites were included in the virtual net metering program.
- New Hampshire: In 2013, legislation was passed authorizing a customer to become a virtual net metered group host with respect to non-customer generators.
- Pennsylvania: In 2007, virtual net metering for properties located in close proximity to a non-customer generator was authorized.
- West Virginia: This action was taken by the Public Service Commission rather than the legislature, but the virtual net metering authorized was for the same close proximity arrangements as permitted in Pennsylvania.[11]

Community solar legislation allows multiple consumers to purchase shares in a single solar net metered facility, either located off-site or on-site ("behind the meter"). This legislative paradigm has worked well for the development and operation of SCEFs. At least nine states and the District of Columbia have adopted community solar or community solar net metering legislation, including California, Colorado, Delaware, Maine, Massachusetts, Minnesota, New Hampshire, and Vermont.[12] The District of Columbia legislation most closely tracks the IREC Model Rules.

The states that have adopted SCEF legislation, whether through virtual net metering or community solar gardens laws, recognize their interest in promoting distributed generation for its environmental benefits. In addition, they recognize that not all customers own properties favorable for on-site energy generation, and participation in an SCEF is one way that these otherwise excluded customers can "green" their energy use by investing and participating in renewable energy generation.

A review of SCEF legislation in these states shows common features:

- Eligible technologies: Whether geared toward solar or distributed energy from all forms of renewables (solar, wind, ocean tides, hydro, biomass, geothermal, etc.), the types of technologies eligible are delineated. While legislation in some states includes all renewables, as a practical matter, only solar facilities have been developed to date.
- Same service territory: Legislation in all states specifies that SCEF subscribers and the SCEF must be located in the territory of the utility service provider that serves both the subscribers and the SCEF.
- Number of subscribers: The minimum, and sometimes maximum, number of subscribers in a single SCEF is typically specified.
- Subscription size: includes the fractional capacity or kW capacity for which a subscriber can contract.
- Facility size: The maximum output size of a SCEF is typically specified and sometimes the minimum is specified.

11 http://www.ncsl.org/research/energy/net-metering
12 http://www.ncsl.org/research/energy/net-metering

- System size: Some states have a limit on the size of the overall SCEF program.
- Bill credits: Legislation typically addresses unused credits and the period that they can be rolled over, along with what happens at year end—either continued roll over, payout, or forfeit.
- Bill credit valuation: Most states tie credit valuation to retail rates, but most permit the EDC to recoup some costs of distribution. States provide for monetary bill credits, rather than credits in kWh.
- Unsubscribed credit valuation: Some states specify that generation not "subscribed for" will be valued at the avoided cost rate and paid to the subscriber organization.
- Ownership of RECs: Generally states specify that the RECs associated with SCEF generation are the property of the subscriber organization or subscribers, unless otherwise separately contracted for. This is sometimes addressed in rulemaking.
- Consumer protections: These may be addressed in legislation or rulemaking. Generally, they require contract and bill disclosures in plain language and financial protections.

Appendix D provides a state-by-state summary of legislative provisions applicable to SCEFs.

3.5 ROLES OF CONNECTICUT STAKEHOLDERS

In addition to understanding the context of proposed state legislation regarding SCEFs, it is also helpful to consider the responsibilities of certain stakeholders who play a role in the development and operation of SCEFs in Connecticut:

- **ISO New England:** Established in 1997, ISO-NE is an independent nonprofit authorized by FERC to perform three main functions for the region that spans the six New England states, including most of Maine, and serves approximately 14 million residents.[13] The three functions are: to operate a reliable high voltage system in the six states, to administer the wholesale electricity markets and to engage in planning for the region's power system.

  Approval for grid interconnections that are greater than 5 MW capacity are required by ISO-NE. They also have requirements for backup supply to accommodate peak power demands in three categories: spinning, 10 minute startup and 30 minute startup. As of January 5, 2015, wholesale electricity was being generated by 1,110 generators in the region, who sell electricity through the wholesale market managed by ISO-NE or directly to the utilities and competitive suppliers. The electricity then moves via 8,500 miles of high voltage transmission lines to substations, where it is stepped down in voltage so that it can be distributed through distribution lines. ISO-NE is fuel and technology neutral; it does not favor one type of resource over another in the marketplace.[14]

- **Connecticut Siting Council:** The Council was first established in 1972 as the Power Facility Evaluation Council. In 1981, the general assembly's Public Act 81-369 expanded the Council's jurisdiction to include hazardous waste facilities in addition to power facilities and transmission lines and renamed it the Connecticut Siting Council. It also now has jurisdiction over telecommunications and other types of infrastructure.

13 http://www.iso-ne.com
14 http://www.iso-ne.com

The Council provides environmental standards for the location, design, construction and operation of public utility facilities, balances the need for reliable utility services at low cost with environmental concerns and requires annual forecasts of electricity demand, among other functions. The Council has jurisdiction over transmission lines of 69 kV or more, and facilities fueled by renewable energy sources that are designed to produce 1 MW or more.

- **Department of Energy and Environmental Protection:** DEEP was established in 2011 with the consolidation of the Department of Environmental Protection, the Department of Public Utility Control and energy-related staff from other agencies of the executive branch of state government. DEEP is charged with conserving and protecting Connecticut's resources and environment and promoting affordable, clean and reliable energy for the state. In particular, DEEP is responsible for encouraging the development and use of clean energy technologies.
- **Public Utilities Regulatory Authority:** In 2011, PURA was formed to replace the former Department of Public Utility Control. PURA, along with the Bureau of Energy and Technology Policy, comprise the Energy Branch of DEEP. PURA is responsible for regulating the rates and services of the electric, natural gas, water and telecommunications companies in Connecticut. The public's right to safe and reliable utility services at reasonable rates is balanced with the need for reasonable rates of return for utility company's investors in PURA proceedings. PURA is also responsible for equity among competitors and consumer protections.
- **Office of Consumer Counsel:** An independent state agency, the Office of Consumer Counsel has statutory authority to represent customers in matters that involve Connecticut's public service (electric, natural gas, water and telecommunications) companies. The Office of Consumer Counsel is an automatic party to all contested proceedings at PURA, and works with the Connecticut General Assembly, through its Energy and Technology Committee, to develop utility-related legislation that is in the best interests of Connecticut consumers.
- **Connecticut Green Bank:** The Connecticut Clean Energy Finance and Investment Authority, whose name was changed in 2014 to the "Connecticut Green Bank," was the first clean energy finance authority in the nation. Its mission is to utilize public and private funding to facilitate the development of renewable energy and energy efficiency programs by homeowners, companies, municipalities and other institutions. CGB offers low-cost financing and incentives designed to promote both a clean environment and a secure energy supply.

3.6 SCEF LEGISLATION IN CONNECTICUT

3.6.1 Background

Connecticut has a long history of legislative interest in promoting renewable energy, dating back to the 1970s. At that time, the General Assembly passed Public Act 78-262, including section 16a-35k of the Connecticut General Statutes which stipulated legislative findings and

Connecticut's renewable energy policy that "…the state must…develop[ing] renewable energy sources…Therefore the general assembly declares it to be the policy of the state of Connecticut to…(3) develop and utilize renewable energy resources, such as solar and wind energy, to the *maximum practicable extent*…[and] (7) ensure that low-income households can meet essential energy needs…" (Emphasis added).[15]

Since that time, the General Assembly has been active in adopting legislation designed to promote the development and use of renewable energy sources. Certain legislative initiatives are particularly relevant to proposed SCEF legislation:

- **Public Act 98-28**[16] adopted Renewable Portfolio Standards, adopted net metering effective July 1, 1998, and established the Energy Conservation and Load Management Fund (now known as Connecticut Energy Efficiency Fund).
- **Public Act 03-135**[17] expanded the definition of Class I renewable energy resources, revised certain RPS measures and further revised net metering.
- **Public Act 07-152**[18] authorized a ratepayer charge to support the Renewable Energy Investment Fund (now called the Connecticut Clean Energy Investment Fund).
- **Public Act 07-242**[19] amended Public Acts 98-28 and 03-135 on net metering and allowed municipalities to establish energy independence districts.
- **Public Act 08-98**[20] mandated greenhouse gas reductions of 10% below 1990 levels by 2020 and 80% below 2001 levels by 2020.
- **Public Act 11-80**[21] expanded the use of net metering to virtual net metering by municipalities; established DEEP and the Connecticut Green Bank, and charged it with implementing financing and incentive programs for residential solar development; established several important programs such as LREC/ZREC; and, under section 127, allowed EDCs to submit proposals to DEEP to build, own or operate one or more generation facilities using Class I renewables. Each such facility must be at least 1 MW in capacity size but not more than 5 MW, and aggregate ownership per EDC shall not exceed 10 MW, with an overall program limit of 30MW. In addition, the legislation instructed DEEP to give preference to projects that make efficient use of existing sites and supply infrastructure. The Act also mandated that DEEP prepare a Comprehensive Energy Strategy for Connecticut every three years.
- **Public Act 13-61**[22] exempted from property tax commercial and industrial energy generation facilities using renewable energy sources.

15 Conn. Gen. Assembly Public Act 78-262 , *An Act Establishing a State Energy Policy* (1978)
16 Conn. Gen. Assembly Public Act 98-28, *An Act Concerning Electric Restructuring* (1998)
17 Conn. Gen. Assembly Public Act 03-135, *An Act Concerning Revisions to the Electric Restructuring Legislation* (2003)
18 Conn. Gen. Assembly Public Act 07-152, *An Act Concerning the Renewable Energy Investment Fund* (2007)
19 Conn. Gen. Assembly Public Act 07-242, *An Act Concerning Electricity and Energy Efficiency* (2007)
20 Conn. Gen. Assembly Public Act 08-98, *An Act Concerning Connecticut Global Warming Solutions (2008)*
21 Conn. Gen. Assembly Public Act 11-80, *An Act Concerning the Establishment of the Department of Energy and Environmental Protection and Planning for Connecticut's Energy Future* (2011)
22 Conn. Gen. Assembly Public Act 13-61, *An Act Concerning Property Tax Exemptions for Renewable Energy Sources* (2013)

- **Public Act 13-298**[23] expanded virtual net metering for use by state facilities and agricultural customers and implemented findings of the DEEP 2013 Comprehensive Energy Strategy for Connecticut.
- **Public Act 13-303**[24] modified RPS, provided that wholesale suppliers must pay alternative compliance payments to EDCs if they fail to meet RPS and that those payments must be turned over to the Clean Energy Fund within the Connecticut Green Bank for Class I renewable resources development.[25] The Act also authorized DEEP to direct EDCs to enter into long-term contracts for electricity and RECs from Class I resources with generators selected through a competitive bidding process.

3.6.2 2014 SCEF Proposed Legislation

In 2014, the Energy and Technology Committee of the General Assembly considered further expansion of the use of virtual net metering, with a proposal to permit the development and operation of SCEFs. In "An Act Concerning the Development of Class I Renewable Energy Source Projects," DEEP was directed to establish a SCEF program, in consultation with the CGB and the EDCs. However, the Energy and Technology Committee did not vote to recommend a SCEF bill for vote by the General Assembly, as agreement was not reached with respect to certain SCEF program provisions before the session ended.[26]

The proposed legislation would have required DEEP and OCC to develop a request for proposals to be disseminated to subscriber organizations seeking to develop SCEFs in Connecticut. DEEP and OCC were to include certain program criteria in the request for proposals. Criteria such as required consumer protections and the disclosures to be made when subscriptions were sold were to be included.

The program, as described in Senate Bill 353, updated by LCO-4100, would have included several key provisions:

- It was to be designated as a "pilot" program.
- Combined capacity of SCEFs was not to exceed 6 MW under the pilot program.
- Billing credits to subscribers were set at $0.14 per kWh or less.
- The billing credit period was set at 15 years or less.
- At least one SCEF was to be located in each EDC's service territory.

In addition, under the definitional provisions, all of a SCEF's subscribers had to be located within the same EDC territory as the individual meters for subscriptions; a SCEF had to have a capacity of no more than 2 MW; and it had to have at least two subscribers. Subscribers were defined as the retail end users of the EDC, who had contracted for a subscription and had identified a meter for credit attribution. Such subscribers could not subscribe to an amount expected to exceed 100% of their own annual electricity consumption, based on the prior 12 months' usage.

23 Conn. Gen. Assembly Public Act 13-298, *An Act Concerning Implementation of Connecticut's Comprehensive Energy Strategy and Various Revisions to the Energy Statutes* (2013)

24 Conn. Gen. Assembly Public Act 13-303, *An Act Concerning Connecticut's Clean Energy Goals* (2013)

25 RPS requires that EDCs and suppliers obtain 27% of their retail load from renewable energy and energy efficiency by 2020. Years until 2020 have lesser percentage mandates. In 2013, the Clean Energy Fund within the Connecticut Green Bank received $215,000 in RPS noncompliance payments

26 Conn. Gen. Assembly House Bill 5412 (LCO No. 1906); Senate Bill 353 (LCO No. 4100)

Subscriber organizations that owned or operated one or more SCEFs would have been authorized to contract for subscriptions, either as percentage interests in the amount of electricity produced or as a set amount of the electricity produced. In addition, the proposed legislation specified that subscriber organizations, or third parties under contract with them, were the owners of the RECs associated with the electricity produced by the SCEF, unless the RECs were otherwise contracted for.

PURA was directed to review for approval, in a contested proceeding, each project proposal submitted by a DEEP-selected subscriber organization. It was specified that PURA's decision must be rendered within sixty days and must include required billing procedures and consumer protections.

One key provision of the proposed legislation directed DEEP to initiate a proceeding to determine the costs and benefits to electric ratepayers, including both participants and nonparticipants, as a result of the expected addition of distributed energy resources. Such proceeding was directed to include factors such as the value of electricity delivery, transmission and distribution capacity, line losses, environmental values, the benefits associated with siting SCEFs in high value or stressed locations, and how rate design should accommodate these various components. In particular, it was directed that rate design should consider the fair and reasonable allocation of costs and benefits and the impact that distributed energy resources may have on the equitable collection of volumetric charges, such as the federally mandated congestion and other charges.

According to the proposed legislation, PURA was to be directed to utilize the results of this DEEP proceeding when considering any rate designs or amendments. In addition, any EDC contracting with a SCEF would have been entitled to recover administrative and other costs incurred in connection with the program, through the federally mandated congestion charges. Finally, DEEP was required to submit a report containing its recommendation regarding whether a permanent SCEF program should be established and, if so, provisions for such legislation.

3.6.3 Testimony and Comments on Proposed Legislation

A Public Hearing was held on March 4, 2014 on House Bill 5412 "An Act Concerning Shared Clean Energy Facilities," predecessor to Senate Bill 353 outlined above. Representatives of the utilities, solar industry, state agencies and other interested parties testified on the proposed legislation. A summary of key points from the testimony from the Public Hearing follows. A transcript of the Public Hearing and written testimony submitted on the bill is available on the General Assembly's website.[27]

Arguments against passage of the SCEF legislation were the following:

- A study is needed to inform the rate structure most appropriate for SCEFs. There is concern that if ratepayer/subscribers receive full retail rate for their subscribed electricity, they will not be paying enough for the other services they are receiving from the electric distribution companies.

27 Public Hearing Testimony:
http://www.cga.ct.gov/asp/menu/CommDocTmyBillAllComm.asp?bill=HB-05412&doc_year=2014;
Public Hearing Transcript: http://search.cga.state.ct.us/adv/

- The customer protections in the bill are inadequate.
- Experience with virtual net metering approved in P.A. 13-298 should be reviewed before virtual net metering is expanded further.
- One class of ratepayers will be utilizing the electric delivery system but not paying for it, forcing other ratepayers to subsidize.

Arguments in favor of passage of the SCEF legislation were the following:

- SCEFs will act as microgrids, helping during power emergencies.
- While participants may not be paying traditional transmission and distribution charges, they are benefiting the utility and the state by reducing demand during peak times.
- It is important for the success of the program to keep project design elements as simple as possible.
- The program will boost economic development and create jobs.
- Renters, condo owners, those with shady yards and others have been making payments for clean energy on their monthly utility bills [thru the Combined Systems Benefit Charge] and should be able to receive the benefits.
- SCEFs should be exempt from property taxes, similar to on-site business and residential installations.
- Subscriptions should be expressed in percentage or fractional shares rather than set in kWh, because generation is variable.

In addition, correspondence concerning the successor bill, Senate Bill 353, updated by LCO-4100, was reviewed. The review indicated that aspects of that proposed legislation found objectionable by certain stakeholders were the following:

- The categorization of the program as a "pilot" will discourage developers from setting up operations in Connecticut.
- The bill credit price, set not to exceed $0.14, does not allow for the inflation or cost of living adjustment needed to finance projects.
- The bill credit duration of 15 years is far less that the useful life of 25 - 35 years for a typical SCEF installation; this will not be as attractive for investors as programs in other states.
- Significant rate changes could be made outside of a general rate case and would therefore shortcut the stakeholder process needed for changes that can affect all ratepayers.

4.0 PROJECT MODELS

4.1 INTRODUCTION

When considering the potential scope and structure for a SCEF program in Connecticut, it is useful to consider the elements of the state's successful residential solar program, as well as various program models that have been developed by others. Section 3 of this report included a review of IREC's Model Rules and guiding principles for SCEFs. Two of the principles cited are

1. A state's SCEF legislation should be informed by the success of that state's existing renewable energy program.
2. SCEF legislation should allow for the maximum flexibility in program design.

This section addresses these guiding principles through a review of the relevant provisions of Connecticut's current net metering and residential solar programs, and a profile of the types of SCEF program models that have been developed in other states. It will also explore program design considerations and the potential for new business models and strategies.

4.2 RESIDENTIAL SOLAR INVESTMENT PROGRAM

According to the recent Draft Integrated Resource Plan for Connecticut (IRP), the CGB's Residential Solar Investment Program has been popular and should be extended to further support the development of additional in-state Class I renewable energy generation at the lowest cost to ratepayers.[1]

The CGB Residential Solar Investment Program was established in 2011 with a goal of installing at least 30 MW of residential solar PV generation capacity by 2020. This goal was exceeded in July 2014, and as of February 2015, CGB had authorized residential solar PV projects totaling 60.1 MW of generation capacity.[2]

The IRP recommends continuation and refinement of the CGB Residential Solar Investment Program. CGB is in the process of revising the program to enable it to enter into 15-year contracts for the purchase of solar PV RECs by the EDCs.[3]

Several features that have contributed to Residential Solar Investment Program's popularity include the following:

- CGB provides attractive financial incentives to offset investment costs.
- Residents can buy or lease a solar PV system.
- Federal tax incentives in the form of investment tax credits that are available until the end of 2016 unless renewed by Congress.

1 *2014 Integrated Resource Plan for Connecticut*, Connecticut Department of Energy and Environmental Protection (Hartford, CT) (Draft for Public Comment, December 11, 2014) vii
2 IRP 110
3 IRP 110

- Low-cost loans have been available, such as the CT Solar Loan and Smart E-Loan.
- Group discount programs for equipment purchases, such as the Solarize Connecticut program, have been available to reduce system cost.
- Net metering kWh credits are applied directly to the customer's monthly utility bill. Net excess generation (NEG) is carried over as a kWh credit to the next month's bill. At the end of the annual solar PV billing cycle (March 31), the EDC pays the customer for any remaining NEG at the avoided cost of wholesale power.[4]

IREC suggests that the terms and provisions of a state's existing related programs, such as the Residential Solar Investment Program in Connecticut, should be considered for use in development of its SCEF program.

4.3 TYPES OF SCEFS

IREC advises states to provide flexibility in designing a SCEF program. Flexibility in project technologies, locations, and ownership models will allow developers and utilities to design SCEFs that are aligned with the needs of consumers.[5] As an example, IREC found that consumers are very motivated to participate in SCEFs if they are located in or proximate to their neighborhoods or communities.[6]

The type of ownership structure selected is usually a function of consumer demand and the economics of a given SCEF. Factors such as the types of funding and incentives available; the owner's credit rating; the ability to utilize tax deductions, depreciation and credits; and the investment return required can play an important role in decision making. There have been a wide range of business models utilized for the SCEFs that have been created in the United States, but they can generally be categorized into three broad types: utility sponsored, nonprofit -managed, and special purpose entity.[7]

4.3.1 Utility Sponsored

Utility-sponsored projects are the predominant business model for SCEFs in the United States.[8] Approximately 80% (30 of 38) of the SCEFs developed in the United States as of March 2013 were sponsored directly or indirectly by a utility.[9] Of these, the large majority have been projects developed by publicly owned utilities.

Given the complexity of SCEF administration—including business model design, marketing and subscriber enrollment, subscriber management, facility operation and maintenance and energy contracting—utilities, with their expertise and administrative systems designed for

4 http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=CT01R&re=0&ee=0
5 IREC Model Rules 4
6 IREC Model Rules 4
7 *A Guide to Community Shared Solar: Utility, Private and Nonprofit Project Development*, National Renewable Energy Laboratory (NREL), (May 2012) 6
8 IREC Model Rules 7
9 IREC Model Rules 7 According to an IREC analyst, the percentage of utility-sponsored programs is even higher currently, although exact percentage figures are not available. Personal correspondence from Erica Schroeder McConnell, IREC Counsel, January 30, 2015.

complex energy program management, are good candidates to develop, manage, and operate SCEFs. In addition, a utility's business knowledge and industry expertise will be useful for making SCEF development decisions such as siting and optimal generating capacity for the purpose of enhancing overall grid stability, reliability and security.

In addition to the general administrative advantages that utilities have, in restructured states like Connecticut, the administrative challenges can be even greater, due to subscribers being able to select a supplier for the purchase of electricity generation. Retail choice requires an exchange of data between the retail suppliers and the EDC. Both sides must maintain a clear and current record of each subscriber's choice of supplier; the EDC will have the sophisticated administrative systems needed for billing on behalf of the retail suppliers.

In restructured states, administrative challenges could arise for retail suppliers with SCEF subscriber customers. Retail suppliers typically aggregate retail loads in the wholesale market and submit bills under large portfolios, rather than individually. However, a SCEF subscriber needs to have electricity usage reported separately to the EDC under the terms of the SCEF's power purchase agreement, and this could present an administrative burden.[10]

This may be a more theoretical than actual concern, however, because most retail choice customers in restructured states are larger commercial and industrial energy consumers. The smaller customers, who represent the more typical SCEF subscribers, usually opt to stay with their EDC rather than electing to utilize a competitive retail supplier.[11]

In the utility-sponsored model, the utility or a utility-contracted third party, owns the SCEF. The subscribers do not have an ownership stake; instead, their purchased subscription represents a proportionate right to the benefits of the electricity generated by the SCEF.[12] The utility customer typically has the option to purchase a set amount of electricity at a fixed rate for a long term, such as 20 years. The renewable energy rate may be higher than the current retail rate, but the contract can be used as a hedge against future price increases.

Although the utility-sponsored model has proven to be the most widespread in the United States, it is not an option in Connecticut under the current legislative framework. The terms of the state's restructuring required that utilities divest themselves of generation facilities. If SCEFs could be developed, operated and owned by the EDCs in Connecticut, that could serve as a significant driver for the development of these types of projects.

4.3.1.1 UTILITY-SPONSORED MODEL: TUCSON COMMUNITY SOLAR

The Bright Tucson Community Solar Program of Tucson Electric Power, an investor-owned utility, is a prototype example of a utility-sponsored SCEF. The following are key features of its SCEF program:

- Most customers in the utility's service area are eligible to participate, except those who are already enrolled in net metering.[13]

10 IREC Model Rules 16

11 IREC Model Rules 17

12 NREL Guide 3, 8. These projects should not be confused with utility-owned distributed generation projects, which are not "shared" projects in that they do not involve a voluntary election by subscribers to participate.

13 *Utility Community Solar Design Handbook*, Solar Electric Power Association, Report 01-13 (December, 2013) 18

- Customers can purchase blocks of 150 kWh of generation per month to offset some or all of their household usage.
- Each block purchased adds $3.00 to a subscriber's electric bill, but program blocks are exempt from carbon surcharges otherwise applied: Renewable Energy Standard Tariff and Purchased Power and Fuel Adjustment Clause.
- Each block at $3.00 per month replaces the equivalent amount of conventional electricity.
- Rate for a block is set for 20 years.
- There are no upfront expenses or costs to participate.
- A customer pays the charge for the blocks purchased in full each month, regardless of actual electricity used.
- If the amount purchased exceeds usage, a credit is carried forward to the next month.
- If a credit remains at the end of the September billing cycle, it is paid out in full on the next bill.
- An online solar calculator helps potential purchasers decide on the number of blocks to purchase.
- Blocks can be cancelled at any time.
- Subscribers can change the number of blocks purchased only once per 12-month period.
- Associated RECs are owned by Tucson Electric Power.
- Electricity is generated by solar PV systems around the Tucson area.
- As local generating capacity is increased, more subscriptions are offered.[14]

4.3.2 Nonprofit Managed

In the nonprofit model, donors typically contribute to a SCEF that is, or will be, owned by a charitable organization. Schools and churches have been the recipients of projects spearheaded by local citizens interested in assisting a charity or nonprofit organization and receiving a tax deduction while also promoting the use of renewable energy resources.[15]

4.3.2.1 NONPROFIT-MANAGED MODEL: BAINBRIDGE ISLAND, WASHINGTON

The Sakai Intermediate School on Bainbridge Island, Washington, is an example of this type of project. A nonprofit organization, Community Energy Solutions, raised a large portion of the funds needed for a solar PV installation on the rooftop of the school.

The installed cost of $50,000 was financed through $30,000 in tax-deductible contributions from individuals and businesses, with the remainder coming from a grant from a local utility, Puget Sound Energy.[16]

14 http://www.tep.com
15 NREL Guide 27
16 NREL Guide 31

The generation capacity of 5.1 kW benefits the school, which owns the SCEF as well as all of its output and environmental attributes. This model represents a win-win-win outcome where a valuable long-term gift inures to the benefit of a nonprofit while the donors receive charitable deductions and the community and state receive the environmental benefits of increased renewable energy generation.[17] In the case of a public school or other public facility such as a library or senior center, the local community also receives the benefits of reduced facility operating costs.

4.3.3 Special Purpose Entity

The special purpose entity model involves individuals joining in a business enterprise formed for the purpose of developing a SCEF. Under most state laws, business entities such as corporations, limited and general partnerships, and limited liability companies could be suitable vehicles.[18]

Given the complexities of starting a SCEF business, it is not surprising that companies such as Clean Energy Collective, LLC, have created a business model with a turnkey administrative operation that has been utilized for at least 31projects in seven states, including three in Massachusetts, to date.[19]

4.3.3.1 SPECIAL PURPOSE ENTITY MODEL: CLEAN ENERGY COLLECTIVE, LLC (CEC)/MULTIPLE PROJECTS

CEC has developed a special purpose entity model that it has replicated for the many shared solar projects it has developed. CEC is a privately held, for-profit company. Its SCEF special purpose entity model has the following characteristics[20]:

- Individual subscribers purchase panels.
- Subscribers must be local utility customers (located in the service territory of the EDC in which the SCEF is also located).
- Subscriptions cannot exceed the number of panels needed to offset 120% of average annual consumption.
- CEC utilizes the federal investment tax credit, and the cost of subscriptions is lowered to reflect the value of the credit.
- Benefits of ownership are portable (subscription can be continued if a subscriber wants to allocate it to a new meter in the same EDC service territory).
- Benefits of ownership are transferable. Subscription can be gifted or sold to another person or entity eligible to be a subscriber, it can be sold back to CEC at fair market value, or it can be donated to a nonprofit.
- CEC, as the subscriber organization, represents the subscribers with the EDC.

17 NREL Guide 31
18 NREL Guide 55
19 http://www.easycleanenergy.com
20 NREL Guide 22

- CEC receives subscription fees from the subscriber to cover capital investment and ongoing operations expenses, including insurance, maintenance, administration and operations[21]
- The RECs associated with the electricity produced by the SCEF are owned by CEC as the subscriber organization with the benefits passed through to subscribers.

4.3.3.2 SPECIAL PURPOSE ENTITY MODEL: CEC/HOLY CROSS ENERGY

Holy Cross Energy in Western Colorado represents a prototype CEC project in a state with community solar legislation authorizing SCEFs. Developed in 2010, the Holy Cross Energy Mid Valley Solar project was CEC's first community solar project. It was built with CEC's private capital and CEC's investment was recouped as subscriptions were sold.

Features of the project include the following:

- 78kW array on land leased by CEC from Mid Valley Metropolitan District.
- Sold out all 338 solar PV panels before the start of construction.
- Contract between subscribers and CEC states that monthly credits will be received for a term of 50 years.
- It is a turnkey operation for Holy Cross Energy. CEC utilizes its administrative software, *Remote Meter* ™, to calculate monthly bill credits for individual EDC customer accounts and to link with the EDC's billing system to apply the credits.
- Subscribers purchase panels, which cost $725 each after rebates and incentives.
- Cost to customers: $3.15/watt, includes effects of all rebates, RECs and credits taken by CEC.
- Subscribers receive monetary credits on their monthly utility bill for electricity generated by their panel(s).
- CEC has entered into long-term contracts with Holy Cross Energy for Holy Cross' purchase of the SCEF output.[22]
- Holy Cross Energy purchased the rights to the RECs from CEC for $500/kW installed (paid upfront).[23]

4.4 SCEF PROJECT DEVELOPMENT CONSIDERATIONS

In addition to determining the appropriate business model for developing SCEFs, there are additional considerations that must be taken into account.

21 "In order to provide 'utility-grade' long term power to the utility, a percentage of the monthly power credit value and the initial sale price fund equipment insurance, operations and maintenance escrows." NREL Guide 17

22 Holy Cross Energy has entered into community solar contracts with CEC totaling 2.6 MW as of January 8, 2015. http://www.easycleanenergy.com and Hois, Emily, "*Colorado Utility Leads the Way for Community Solar*" http://www.renewableenergyworld.com

23 http://www.easycleanenergy.com

4.4.1 Tax Considerations

Several tax considerations, important determinants in the design of SCEF business models and financing structures, are discussed in this section. Federal tax incentives and other federal and state tax policies that favor the deployment of renewable energy resources have been effective in advancing SCEF projects.

Although SCEFs cannot take advantage of the renewable energy tax credits available for residential projects, if formed as special purpose entities or utility sponsored, they are generally able to utilize the federal investment tax credit (ITC).[24]

Internal Revenue Code Section 48 sets forth the investment tax credit provisions, which permit commercial, industrial and utility owners of solar systems to take a one-time tax credit equal to 30% of qualifying installed costs. Investor-owned utilities can utilize the ITC; however, certain accounting rules that pertain to them require that the ITC benefits be spread throughout the solar PV project's useful life. By contrast, private developers can utilize the entire ITC upfront and pass corresponding benefits through to subscribers, thus giving special purpose entities a potential pricing advantage over the utilities.[25]

When structuring a business model for a SCEF project, an important consideration is to determine whether any benefit received by subscribers could be deemed to be taxable income under definitions in the Internal Revenue Code. Credits received directly on utility bills, as opposed to the issuance of separate check payments, reinforces that those payments are commodity price adjustments tied to consumption rather than separate transactions involving income to the subscribers. Limits that tie the size of subscriptions to actual household usage, and require that no more than 100% of a facility's output is contracted for, also support this analysis.

The federal tax code also permits commercial enterprises to depreciate renewable energy resource project investments on an accelerated basis. Under these provisions, private enterprises can record expenses associated with solar PV installations that generally have decades-long useful life over a period of five years.[26]

There are other tax considerations that should be considered, such as those that relate to whether property and sales taxes apply to the purchase of solar equipment or subscriptions, and if so, who will be responsible for them. Most state sales taxes apply to the purchase of equipment, but exempt the sale of electricity. However, states often exempt solar equipment from both sales and property taxes.[27]

4.4.2 Securities Considerations

Any transaction that involves an investment of money in a shared venture with the expectation of profits to come from the efforts of others raises the issue of whether it falls within the definition of a "security,"[28] thus triggering the disclosure and other requirements of federal and state securities laws.

24 NREL Guide 39
25 NREL Guide 9
26 NREL Guide 39
27 NREL Guide 42
28 A "security" includes an "investment contract", which is "an investment of money in a common enterprise with profits to come solely from the efforts of others." *S.E.C v. Howey Co.*, 328 U.S. 293 (U.S. 1946)

It is important when considering SCEF business model features to avoid inadvertently triggering these requirements, which can be significant. Subscriber agreement terms and conditions that tie subscriptions to the purchase of physical assets and emphasize the purchase of a commodity for personal consumption should avoid subscriptions being deemed to be securities. In particular, limiting subscription size to 120% of the average annual personal electricity consumption and requiring that no more than 100% of a facility's output be subscribed are helpful factors in this determination, along with the generation of income issue previously noted. In addition, avoiding the use of subscribers' funds in the upfront project development, beyond that needed to purchase equipment, is an important consideration.

4.4.3 New SCEF Business Models

A recent study by RMI examined business models that have been used for existing shared solar PV projects in the United States.[29] The study noted that, while policies in many states have supported the growth of SCEFs, problems have arisen in connection with these "early market" policies.[30]

In particular, under existing business models, utilities have come to associate SCEFs with certain negative factors such as added transaction costs, grid operation challenges, and loss of revenue. EDCs argue that existing policies have tilted toward individual subscribers and third party solar developers to the detriment of nonsubscribers and EDCs.

RMI argues that it is an opportune time to reevaluate existing business models for utilities and SCEFs, as state net metering caps are being achieved and available incentive funding is being exhausted. In addition, the expiration of the residential homeowner solar PV tax credit and the phase out of the commercial investment tax credit from 30% to 10% at the end of 2016 provide further impetus for the reexamination of current policies.[31]

In order to continue to grow the nation's use of shared renewable energy generation, RMI finds that it is necessary to examine the interests of all stakeholders and find ways to realign those interests for the benefit of all.

RMI cites the rapid improvement of the economics of solar energy, along with the development of complementary technologies such as advanced inverters and storage capabilities, as presenting a new landscape. Solar companies, utilities and regulators must work hand in hand to determine the value of distributed generation to society and to develop strategies and new long-term, efficient business models based on that value. This is the essential next step, in order to harness and maximize the power of solar to produce the clean, reliable and affordable electricity that will be needed in coming years.

29 *Bridges to New Solar Business Models*, Rocky Mountain Institute (Boulder, Colorado) (November, 2014) http://www.rmi.org

30 RMI Study 5

31 RMI Study 5

5.0 CASE STUDIES

5.1 INTRODUCTION

Over the last several years, states in the United States and other countries have implemented policies to facilitate deployment of renewable energy resources, including SCEFs (typically solar PV) that allow for broader residential and business participation. This section provides findings from case studies regarding legislative, regulatory, and facility deployment processes for use in developing a Connecticut SCEF program.

The case studies that were chosen and a theme describing a key finding from each are as follows:

- Colorado: One of the first states to pass legislation and implement a program
- Germany: The implications of Germany's *Energiewende* policy, including increased penetration of renewables on the electric grid, feed-in tariffs, and storage
- Minnesota: Development of a "value of solar" methodology
- Massachusetts: Implications from the substantial deployment of renewable energy
- Washington, D.C.: The use of the IREC model rules as a basis for legislation and rulemaking; and low-income program recommendations
- California: Insights for the implementation of the Single Family Affordable Solar Home Program (SASH) and the Multifamily Affordable Solar Housing (MASH) program

5.2 COLORADO

5.2.1 Background

Colorado was one of the first states to implement SCEF legislation, the Community Solar Gardens Act of 2010. The Act was passed in response to interest in facilitating greater residential and business access to solar energy, and the need for legislation to support solar garden development.

The Act provides key guidelines that established a workable framework for the development of solar gardens in Colorado, including the definition of a solar garden and provisions for the minimum number of subscribers, ownership, and utility transactions.

5.2.2. Legislative and Rulemaking Process

The Act required Colorado's Public Utility Commission to construct programmatic rules. Key stakeholders involved in the rulemaking process included Xcel Energy, the major Colorado utility, and solar advocacy organizations. The rulemaking process was intended to take a couple of months, but was prolonged due to some highly debated issues, including the following:

- Rebates to reduce upfront facility costs, and REC compensation. Colorado's largest utility, Xcel Energy, administers the Solar Rebate program, which provides rebates to lower the upfront costs of solar installation. Because the Act defines a solar garden subscription as being on a subscriber's premises, solar garden subscribers are eligible for solar rebates. Xcel Energy proposed to decrease solar rebates, a measure to which solar advocates objected. However, an agreement was eventually reached under which the rebate would be reduced and REC compensation would increase over time. Solar advocates agreed to this because it provided more financial assurance over the useful life of the solar garden.

  This debate is important because it highlights issues concerning incentive design. A higher upfront rebate may attract more subscribers. Further, an upfront rebate may be particularly helpful for attracting subscribers to small-scale facilities, which are usually more costly to build and maintain, on a per watt basis, compared to larger facilities. In contrast, a model that is more heavily based on REC payments over time could help ensure project longevity. Consideration should be given to different incentive designs in order to produce intended outcomes.

- Strategies to increase subscriber participation. The Public Utility Commission initially imposed a subscriber ownership limitation of 40% of the size of the facility to ensure broad participation. However, key stakeholders contended that the limitation could discourage subscriber organizations from developing facilities because of the time needed to market a project and attract subscribers, especially in the beginning stages. An agreement was reached whereby the 40% limitation would be waived for the first 18 months of facility development to provide a subscriber organization with time to secure subscribers.

  A key takeaway is that if a SCEF policy goal is to expand participation, it can be useful to impose a SCEF ownership limit percentage for an individual subscriber to maximize subscriber participation. However, it is also important to recognize that securing subscribers for a project may take time. Therefore, during the nascent stage of a project's development, the subscriber organization may own a percentage of the SCEF shares and the unsubscribed energy generated from the facility.

- Legislative mandate for utility to purchase electricity from small SCEFs. A key element of the Act included a provision that required Xcel Energy to purchase 50% of its community solar garden electricity from gardens with a nameplate capacity of 500 kW or less until 2013. Also, it required that subscribers to small-scale SCEFs receive the same bill credit rate as subscribers to large SCEFs, even though the subsidy for small-scale SCEFs would be greater than that for large SCEFs. These provisions were included in the legislation to ensure support for small installers that may only have the capacity to develop small-scale SCEFs, and to stimulate the local solar industry.

5.3 GERMANY

5.3.1 Background

Germany has implemented several energy policies to support its broader goal of expanding renewable energy resource generation. Germany's Energiewende, a term first coined in the

1980s, consists of a series of energy policies intended to shift from an energy system dependent on fossil fuels and nuclear power to one that relies on increased use of renewable energy resources. Energiewende policy goals include the following:

- Nuclear energy power plant phaseout completed by 2022
- Greenhouse gas emissions reduction of 40% by 2020 (base year 1990)
- Renewable energy production to constitute 18% of total energy production by 2020
- Energy consumption reduction of 20% by 2020 (base year 2008)[1]

Germany adopted its *Energiewende* policy for several reasons. The nuclear reactor disaster at the Fukushima nuclear plant in Japan compelled Germany to adopt a more aggressive energy policy, which included the phaseout of its nuclear plants. Furthermore, the German people have been an instrumental force behind policy actions by lobbying the government in support of renewable energy policies.

5.3.2 Economic and Technical Implications

Although Germany's *Energiewende* policy has provided benefits to Germany, it has been a source of economic and technical challenges as well.

- **Feed-in tariff policy**. In an effort to develop its renewable energy resource generation market, Germany first implemented a feed-in tariff policy in 1991 that was subsequently revised in 2000 and 2012. The feed-in tariff policy of 2000 set specific tariff rates for each renewable energy technology, and guaranteed payment to producers for 20 years at a de-escalating rate. The government reconciled the feed-in tariff by adding a surcharge to ratepayer bills.

  The feed-in tariff of 2000 helped to foster significant renewable energy resource growth in Germany. To illustrate, renewable energy resource power generation tripled from approximately 33 billion kWh in 1988 to 100 billion kWh in 2010.[2] The tariff also helped to create a viable renewable energy industry in Germany, employing 370,000 individuals in Germany (2010).

- **Capacity oversaturation.** Although the feed-in tariff policy of 2000 was a catalyst for renewable energy resource growth, it was also the source of economic challenges because the tariff did not include a MW generation capacity cap on overall deployment. The certainty of payment for electricity generation compelled many people to enter the renewable energy generation business. The influx of new generators coupled with new fossil fuel power plant investments by utilities led to a capacity oversaturation in the electricity market, and customer surcharge increases.[3]

  Capacity oversaturation has created electricity price volatility and decreasing profits for utilities. For instance, the price of electricity turns negative when renewable energy

1 Buchan, David. "The Energiewende – Germany's Gamble." The Oxford Institute for Energy Studies, University of Oxford. Web. 27 Jan 2014.
http://www.oxfordenergy.org/wpcms/wp-content/uploads/2012/06/SP-261.pdf

2 Ibid 14.

3 "What Has Gone Wrong with Germany's Energy Policy?" The Economist. 14 Dec. 2014.
http://www.economist.com/blogs/

facilities are at peak production. Negative prices have severely affected non-renewable energy producers. Renewable energy generators are given priority access to the grid and receive the feed-in tariff guaranteed rate. In contrast, non-renewable generators must pay for the right to transmit electricity onto the grid.[4] Many German utilities still operate non-renewable generation plants; consequently, oversaturation has decreased their profit margins. Part of the oversaturation is also due to a lack of North-South transmission lines, which limits the area where wind actually provides power to the northern areas of the country.

Further, surcharge increases were met with opposition, especially from energy-intensive businesses. In 2012, the German government eventually yielded to the opposition by reducing feed-in tariff payments to renewable energy generators and setting a capacity limit on solar PV of 52,000 MW.[5] The government cited the maturation of the renewable energy market as justification for the changes. However, as a result of feed-in tariff cuts, many high profile renewable energy businesses filed for bankruptcy. This series of events called into question the sustainability of Germany's feed-in tariff policy.

The feed-in tariff story underscores a larger policy question that should be considered when developing a renewable energy policy, which is determining the percent of renewable energy in the total energy production portfolio that makes economic sense at any given time. Germany suffered from creating a feed-in tariff strategy that rapidly incentivized renewable energy generation to an extreme level rather than fully considering the economic ramifications of its goal, and the strategy needed to reach the goal.

Similar to Germany, Denmark started to phase out all fossil fuel resources in favor of renewable energy resources. As a result, Denmark also experienced crashing electricity prices, which forced many of its power plants to close. In retrospect, Denmark realized its dependency on fossil fuel power plants to provide reliability. Fortunately, Denmark has grid connections with Sweden and has relied on their grid system for electricity produced from nuclear power. However, Sweden also intends to phase out nuclear power in favor of renewables, which may result in challenges for Denmark.[6] Countries that border Germany expect that Germany will rely on their grids for electricity generated from nuclear power.

- **Grid management and infrastructure challenges.** As a result of the electricity generated onto a grid from the increased penetration of renewable energy resources, Germany also faces grid management and infrastructure challenges. The majority of Germany's nuclear plants that are scheduled to be decommissioned are located in the southern part of the country, while its wind capacity is concentrated in the north. The government has proposed new transmission capacity investments throughout the country to avoid capacity shortages in the south, however only a fraction of these investments have actually occurred.

  This challenge highlights the importance of capacity planning and its relationship with renewable energy resource technologies. Some renewable technologies are more

4 "Energiewende: Two Energy Lessons for the United States from Germany." Scientific American. 7 Oct. 2014. http://blogs.scientificamerican.com/plugged-in/

5 Brown, Phillip. "*European Union Wind and Solar Electricity Policies: Overview and Considerations*." Congressional Research Service, August 2013.

6 Gillis, Justin. "*A Tricky Transition from Fossil Fuel.*" The New York Times. 10 Nov. 2014. http://www.nytimes.com/2014/11/11/science/earth/denmark-aims-for-100-percent-renewable-energy.html?_r=2

productive when sited in particular locations. If there is a capacity shortage in a location far from the renewable energy generation site, transmission lines with adequate capacity are needed to meet demand where it is needed.

Additionally, Germany's increased penetration of renewables onto its grid has negatively affected its neighboring countries due to significant transmission congestion, which at certain times has impacted the grid systems of surrounding countries. Poland, Czech Republic, and the Netherlands have invested in special transformers to prevent disruptions to their grids.[7] This issue indicates that regional coordination of energy policy is critical when considering the placement and use of renewable energy resources.

5.3.3 Energy Storage

Germany has made significant progress in the use of energy storage for the purpose of abating challenges associated with high renewable energy resource penetration. Even though cost barriers exist that limit the scaling of storage, it is projected that in this decade, storage prices will decline below the price of electricity in Germany, rendering it relatively affordable.[8] The deployment of storage in Germany has economic and technical implications that could help to transform the energy market. Lessons from Germany's experience could be considered by others interested in developing an energy storage policy.

As part of its *Energiewende* policy, Germany requires that 80% of its total electricity production be derived from renewable energy resources by 2050.[9] Although this goal will certainly provide benefits to Germany, a high level of renewable energy resource penetration requires technological advancements, especially in the area of storage capacity due to the intermittent nature of the renewable energy resources, specifically solar PV and wind.

Energy storage is a solution that can overcome the challenges, including system reliability, associated with intermittent electricity generation from renewable energy resources by storing energy from renewable energy resources for use generating electricity at another time when it is needed. There are a variety of energy storage options including batteries, compressed air energy, flywheel energy, and hydroelectricity from pumped storage plants that can be scaled.[10] In Germany, the technology with the most commercial potential for synchronization with renewable energy resources is batteries because of higher efficiency rates, relatively lower costs, and longer lifecycles.[11]

Energy storage can also provide technical enhancements to Germany's electric grid by providing ancillary services to reduce transmission congestion, such as frequency regulation, reserve capacity, variable reactive power, and load following.[12] Energy storage can also help

7 Buchan, David. "The Energiewende – Germany's Gamble." The Oxford Institute for Energy Studies, University of Oxford. Web. 27 Jan 2014. http://www.oxfordenergy.org/wpcms/wp-content/uploads/2012/06/SP-261.pdf

8 Parkinson, Giles. "Energy Storage: Generators to be the Biggest Losers" Renew Economy." 1 Oct. 2014. http://reneweconomy.com.au/2014/

9 Dickens, Adam et al. "Energy Storage: Power to the People." HSBC Global Research. Sept 2014. Web 28 Jan. 2014. http://www.qualenergia.it/sites/default/files/articolo-doc/Energy%20Storage.pdf

10 Ibid 18.

11 Ibid 19.

12 Akhil, Abbas A., et al. "DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA." Sandia National Laboratories. July 2013. http://www.sandia.gov/ess/publications/SAND2013-5131.pdf

mitigate Germany's transmission congestion caused by the mismatch in generation and load locations.[13]

Although energy storage provides benefits, storage costs are still considered to be relatively high. While the cost of storage has sharply declined in recent years due to technological advancements, it is still not fully commercially viable. A HSBC report titled, *Energy Storage: Power to the People,* estimates the cost of a battery storage system at $220 - $1,000 per kWh, and the levelized cost to operate is estimated to be $230 - $1,150 per MWh.[14]

Germany has implemented policies aimed at building the competitiveness and accessibility of storage. For example, in 2011 Germany created a €200 million fund to finance the development of large-scale hydro pumped storage projects. Additionally, in 2013, Germany introduced the creation of a 30% subsidy for residents to purchase lithium ion batteries.[15] Since the program started, more than 4,000 energy storage systems have been installed, which is a significant portion of the estimated 15,000 households that have energy storage systems. Further, between the 1st quarter of 2014 and year end 2014, the price of storage has dropped by 25% in Germany, indicating increased demand and technological advancements have impacted storage price.

Also, because of the structure of electricity markets, Germans see the potential economic value of energy storage when coupled with a solar PV installation. The feed-in tariff policy has significantly increased the retail cost of electricity to the point where many Germans would prefer to be independent of the grid. A renewable energy system complemented with battery storage could provide that capability.

5.4 MINNESOTA

5.4.1 Background

In 2013, Minnesota passed legislation authorizing the development of utility-sponsored community solar gardens. Also, additional legislation directed the Minnesota Department of Commerce to submit for approval a value of solar methodology to the Public Utility Commission the purpose of having the utilities use the methodology to determine a value of solar rate that would be used for subscriber bill credits. The legislation defined the "value of solar" as "the value to the utility, its customers, and society for operating distributed solar photovoltaic resources interconnected to the utility system."[16]

In early 2014, Minnesota Department of Commerce released its value of solar methodology. However, because of concerns it had with the value of solar methodology, Xcel Energy, the major utility in Minnesota, elected not to use the methodology to develop a value of solar rate, and instead adopted the average retail rate with the approval of the Public Utility

13 Babrowski, Sonja, et al. "Electricity Storage Systems and Their Allocation in the German Power System." Karlsruhe Institute of Technology (KIT), Institute for Industrial Production, Hertzstr, 2014.

14 Dickens, Adam et al. "Energy Storage: Power to the People." HSBC Global Research. Sept 2014. Web 28 Jan. 2014. http://www.qualenergia.it/sites/default/files/articolo-doc/Energy%20Storage.pdf

15 Wesoff, Eric. "Germany's Energy Storage Subsidy is No Solar Miracle." Greentech Efficiency. 24 July 2013. http://www.greentechmedia.com/

16 Staff Briefing Papers (CSG Rate). Minnesota Public Utilities Commission. August 2014.

Commission.[17] Xcel Energy was able to adopt that rate because under the legislation, a utility company was permitted to use the average retail rate as an interim billing rate until it submitted a value of solar tariff to the Public Utility Commission for approval. However, as of the publication of this report, Xcel Energy had not submitted a value of solar tariff to the Public Utility Commission for approval.

The following is an explanation of the process that led to Xcel Energy's adoption of the average retail rate instead of the value of solar rate, as well as key findings from the applicable rule-making process that can be useful to others considering conducting a value of solar analysis.

5.4.2 Rulemaking Process

The Minnesota Department of Commerce hired a consultant, Clean Power Research, to develop a methodology for the value of solar calculation. This methodology includes an analysis of the following to determine the value for the avoided cost of fuel, plant operation and management, generation capacity, reserve capacity, transmission capacity, distribution capacity, and environmental effects.[18]

The methodology was structured to calculate a levelized value of solar rate over a 25-year time frame that included inflationary adjustments.[19]

The methodology was approved and issued by the Public Utility Commission in April 2014. Xcel Energy then calculated the value of solar to be $0.147/kWh on a levelized basis (and $0.114/kWh with inflation adjustments) for 2014, but filed a petition with the Public Utility Commission to use the average retail rate ($0.12/kWh) instead of the value of solar. The Public Utility Commission ruled in favor of Xcel Energy's motion to use the average retail rate because of language in the community solar garden statute stating that the utility could elect to use an interim rate.

Xcel Energy had several concerns with the value of solar methodology and provisions in the community solar garden statute. Xcel Energy claimed that the value of solar methodology appeared to include an incentive to foster solar development in Minnesota. Xcel Energy argued that the inclusion of an incentive would be unfair to impose on utility ratepayers. Furthermore, Xcel Energy contended that because the community solar garden program is uncapped, developers could be motivated to build an unlimited number of facilities, which could significantly affect ratepayer costs and interconnection procedures.

Xcel Energy corroborated its proposal to adopt the average retail rate by stating that the average retail rate is more flexible than the value of solar rate. In contrast to the value of solar rate, the average retail rate would not be locked in for 25 years and could be adjusted each time the utility filed a rate case with the Public Utility Commission. Furthermore, Xcel Energy argued that when coupled with compensation for the RECs, the average retail rate would provide adequate financial assurance for facility developers.

17 "*Minnesota Regulators Side with Utility in Value-of-Solar Case*." Midwest Energy News. 7 August 2014. http://www.midwestenergynews.com/2014/08/07/minnesota-regulators-side-with-utility-in-value-of-solar-case/

18 The methodology also mentions the components of Voltage Control and Solar Integration cost, however a methodology of how to value these components was not submitted. It was recommended that a methodology be developed for these components in the future.

19 "Minnesota Value of Solar: Methodology." Minnesota Department of Commerce, Division of Energy Resources, April 2014.

Other stakeholders who submitted comments on the Xcel Energy proposal to the Public Utility Commission initially objected to Xcel's motion to adopt the average retail rate. They opined that the adoption of the value of solar rate was in the public's best interest. However, most of the stakeholders who were initially opposed to using the average retail rate eventually agreed to the proposal because they recognized that the levelized value of solar rate could not reconcile facility development and operation costs. In a separate analysis, Minnesota Department of Commerce determined that a rate of $0.15/kWh was needed to achieve project feasibility and that the proposed value of solar rate was below this rate threshold. As a result, most stakeholders agreed to the Xcel Energy proposal, but with some adjustments including creating a floor price for the RECs and an annual adjustment to the average retail rate.

In summary, the issue underlying the debate between Xcel Energy and other stakeholders stemmed from conflicting directives in the community solar garden statute and the value of solar statute. In the community solar garden statute, a provision asked for the creation of a value of solar rate that "reasonably allow[s] for the creation, financing, and accessibility" of community solar gardens, whereas value of solar statute asks for a quantification of the net value solar brings to the electric grid, customers, and society.

5.5 MASSACHUSETTS

5.5.1 Background

Massachusetts initiated a Community Shared Solar (CSS) program after adoption of *An Act Relative to Green Communities* (GCA) in 2008. The GCA is a multi-faceted energy policy that consists of provisions aimed to improve energy efficiency, update the state's RPS, and expand net metering and virtual net metering rules.[20]

The GCA has been a driving force behind solar industry growth in Massachusetts. Before the Act was implemented, only 3.7 MW of solar capacity existed (2007); however, as of October 2014, 580 MW of solar capacity had been installed, representing a 155% increase. Massachusetts is now considered to be at the forefront in developing a robust renewable energy program and market. It has received national accolades, including ranking 5th among all states in total solar installed capacity and an award from the American Council for an Energy-Efficient Economy for ranking 1st among all states for having the most energy efficient policies and programs.[21]

Although Massachusetts' GCA policy and programs have garnered success, the state faced challenges in implementing the CSS program that are described as follows.

20 "Massachusetts Green Communities Act (S.B. 2768.)." M.J. Bradley & Associates. Web. 29 Jan. 2015, https://www.mjbradley.net/_sis/documents/EPTS/Summary_of_MA_SB_2768.pdf

21 "Green Community Act." *Massachusetts' Business for Clean Energy: Business Leadership for our Energy Future.* Web. 28 Jan. 2014. http://www.mabizforcleanenergy.com/ma-supports-clean-energy/green-communities-act/

5.5.2 Project Implementation

While Massachusetts adopted the GCA policy to expand solar capacity, existing legislation limited the deployment of solar projects by capping the percentage of solar projects eligible for net metering contracts with investor-owned utilities at 5% of a distribution company's peak load for publicly owned projects and a 4% for private projects. Until recently, the caps were even lower for both types of projects. However, in 2014 legislation was adopted to increase the cap because utilities were close to reaching the net metering caps. Additionally, the Massachusetts Department of Public Utilities passed a "System of Assurance of Net Metering Eligibility" rule in 2012 which established a queue for net metering so that potential customers will know in advance if they qualify for net metering.[22] The ability for Massachusetts to achieve its adopted goal of deploying 1,600 MW in solar PV capacity by 2020, however, may require the legislatively mandated cap to be raised again.

Also, current administrative processes that may hinder solar PV deployment include the following:

- The interconnection administrative process that is administered by the utilities has not kept pace with the rapid deployment of solar PV in recent years. This has delayed the development of some distributed energy resource projects, as project developers must seek interconnection approval before the start of a project.
- Utility software systems have been unable to accurately record net metering bill credits on a timely basis, creating billing confusion for CSS subscribers.
- The Massachusetts Department of Revenue recognizes a property tax exempt status for solar systems, or other energy systems, that offset the load of a particular property. However, because a CSS facility is not offsetting the load of a particular property, the department interprets this to mean that CSS facilities/sites are subject to property tax collection by local municipal authorities.[23] In a report titled, *Community Shared Solar: Review and Recommendations for Massachusetts Models,* it was indicated that there is no uniform methodology to assess the taxable value of a CSS facility/site. Because municipal assessors currently do not know how to value the CSS property, developers may be uncertain about the final cost to develop and operate a facility. Consequently, this could impact interest in the development of CSS projects until the issue is resolved.

5.6 WASHINGTON, DC

5.6.1 Background

In 2013, the Council of the District of Columbia passed the *Community Renewable Energy Act* that authorized the development of community renewable energy facilities (CREF) by permitting

22 "*Massachusetts: Incentives and Policies for Renewable and Efficiency*". Database of State Incentives for Renewable and Efficiency, US Department of Energy. Web. 10 Feb 2014.
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MA01R

23 "Community Shared Solar: Review and Recommendations for Massachusetts Models." Massachusetts Department of Energy. Web. 28 Jan. 2015
http://www.mass.gov/eea/docs/doer/renewables/solar/community-shared-solar-model-frameworks-032813.pdf

virtual net metering.[24] The Act was enacted to help the District meet its RPS of 255 MW by 2020, to expand access to clean energy technologies for renters and low-income residents, and to mitigate environmental challenges linked to reliance on the fossil fuel-related energy systems.[25]

The Public Service Commission of the District of Columbia issued a proposed rulemaking for the CREF program in September 2014. Several interested parties submitted comments that focused on providing clarification and streamlining the program's administrative rules. As of the publication of this report, the rulemaking was not finalized. However, the following is a discussion concerning the issues that emerged during the program's legislative and rulemaking processes.

5.6.2 Legislation

The CREA legislation that was adopted included guiding principles and legislative provisions that were recommended in IREC's *Model Rules for Shared Renewable Energy Programs*. For example, the District adopted the minimum participation requirement of two subscribers, provisions for the portability and transferability of subscriptions, and the stipulation that a subscriber cannot exceed a consumption level more than 120% of their previous 12 month average consumption.

Furthermore, similar to the IREC model rules, significant emphasis was placed on creating a program that would encourage low-income participation. The legislation states that the CREF program is intended to "facilitate market entry for all potential subscribers, while prioritizing those persons most sensitive to market barriers."[26] Although the rules for a low-income program have not been finalized, the inclusion of this provision has fueled ideas for potential program structure. For example, the DC SUN, a District-based organization whose mission is to make solar PV more accessible and affordable, already hosted a symposium focused on brainstorming ideas to encourage low-income participation in the CREF program. Ideas that have been discussed include a subsidy program funded by alternative compliance payments and a loan guarantee program with the purpose of transferring credit risk away from low-income participants.[27]

It is important to note that the originally proposed legislation included a unique approach to encourage low-income participation. A provision stated that if a CREF subscriber had excess bill credits at the end of the April billing cycle, the credits would be transferred to the Low Income Housing Energy Assistance Program for use by low-income households. However, this provision was not included in the legislation that was adopted. Comments were submitted by the Public Service Commission during the legislative process that identified the fact that the proposed method conflicted with net metering regulation already in place, which states that subscriber bill credits continually roll over and never expire.[28]

24 "Community Renewables Energy Act of 2013." DC Solar United Neighborhoods. Web. 28 Jan. 2015. http://www.dcsun.org/community-renewables-energy-act-of-2013/

25 "Committee Report." Council of District of Columbia: Committee on Government Operations. Web. 28 Jan 2014. http://dcclims1.dccouncil.us/images/00001/20130726113102.pdf

26 DC Code § 28:1-101

27 Ronen, Amit. Consensus Recommendations on How to Catalyze Low-Income Solar in DC. 3 June. 2014.

28 "Committee Report." Council of District of Columbia: Committee on Government Operations. Web. 28 Jan 2014. http://dcclims1.dccouncil.us/images/00001/20130726113102.pdf

5.6.3 Rulemaking

In its rulemaking, the Public Service Commission stated that:

- Credits for energy generated from the unsubscribed shares of a CREF purchased by the EDC be distributed among existing CREF subscribers. However, this provision conflicts with the principal purpose of a CREF program, which is to offset a CREF subscriber's electricity consumption. Distributing credits for the share of unsubscribed energy generated from the CREF among subscribers implies that subscribers are participating in a CREF program for the purposes of investing, which could subject subscribers to security-related issues.
- When the number of subscribers falls below the minimum of two, the EDC must be notified within 24 hours. After notification, the EDC would have the authority to disconnect the facility from the grid. However, it was suggested in submitted comments that a longer period of time be allowed before a subscriber organization is required to notify an EDC about changes to its subscriber roster.
- The EDC must create a procedural manual as a guide for those participating in a CREF and prospective participants. The development of a procedural manual could help to provide clarity and transparency regarding project development and operation. It was also suggested that links to the manual should be made available online on the EDC website or other stakeholder websites.

5.7 CALIFORNIA SINGLE FAMILY AFFORDABLE SOLAR PROGRAM (SASH) AND MULTI-FAMILY AFFORDABLE SOLAR PROGRAM (MASH)

5.7.1 Background

In 2006 California passed the California Solar Initiative, which is a ten-year, $2.2 billion policy aimed at stimulating growth in the solar industry. Recognizing that historically solar has only been accessible to relatively affluent households, the initiative included a provision stating that 10% ($216 million) of funds allocated for the initiative would be designated for solar installations for low-income housing. In 2007, the California Public Utilities Commission established the SASH and MASH programs to utilize the California Solar Initiative funding provided for these initiatives.[29]

The SASH and MASH programs are considered to be examples of successful low-income programs. The programs provide high rebates to cover upfront costs for low- to moderate-income families and benefits of solar to low-income families by allocating incentive rebates on a per watt basis. The MASH program, which uses virtual net metering to provide benefits to multi-tenant unit participants, distributes a rebate of about $1.90/watt, and the SASH program participants receive an incentive rebate of $4.75 - $7.00 per watt. From 2009 - 2012, the SASH program provided benefits to approximately 4,000 families for solar installations. As of 2014, the MASH program includes 323 projects serving approximately 6,400 tenants.[30]

29 "Greschner, Stanley L. and Nichols, George L. "*Successful Solar Incentive Programs Grow Solar Penetration Within Low-Income Communities.*" District of Columbia Sustainable Energy Utility/Grid Alternatives. Web 28 Jan 2014.

30 "*Multifamily Affordable Solar Housing Semiannual Progress Report." California Public Utilities Commission.* 30 June 2014. http://www.cpuc.ca.gov/

A unique aspect of the California Solar Initiative is that in addition to providing benefits for solar technology installations, it also provides job training opportunities. Low-income neighborhoods often have higher unemployment rates in comparison to other neighborhoods. Grid Alternatives, an organization that administers the SASH and MASH programs, established partnerships with over 70 job training organizations to provide solar installation training to people who live in low-income neighborhoods. Not only does this workforce component help job growth in low-income neighborhoods, it also supports growth in the California solar industry overall.

Furthermore, the SASH and MASH programs are based on the principle of environmental justice for low-income communities. Fossil fuel-burning power plants are often sited in low-income communities, which adversely affects community health. Building solar projects in low-income communities can help to reverse this trend.

6.0 FOCUS GROUP SESSIONS: SUMMARY

CASE convened two focus group sessions involving stakeholders and other interested parties to gather input and discuss issues raised in connection with the potential development of SCEFs, particularly solar PV, in Connecticut. Representatives from the following organizations participated in the sessions: Clean Energy Collective; Connecticut Fund for the Environment, CGA's Energy & Technology Committee, CGB, DEEP, Earthlight Technologies, Encon Solar, Environment Connecticut, Eversource Energy, Office of Consumer Counsel, Renewable Energy and Efficiency Business Association, SmartPower, Solar Connecticut and United Illuminating.

Although participants expressed a variety of views, several common themes emerged from the sessions, including

- state policy goals and guiding principles;
- proposed legislation (including rate design and billing credits);
- issues of equity; and
- role of utility companies.

6.1 STATE POLICY GOALS AND GUIDING PRINCIPLES

Participants expressed interest in having the state consider increasing the use of distributed energy resource generation in Connecticut. They discussed the need to move into the next phase of solarizing Connecticut, as the individual residential roof-top solar program is maturing and possibly "maxing out," as expressed by one participant. It was noted that there are a variety of ways to increase participation to help the state meet its renewable energy goals.

In considering guiding principles, participants cited

- the need to meet the state's RPS goals, and
- the state's need to consider development of clean energy resources for their proven environmental benefits, as well as for distributed generation's potential contributions to system stability, reliability and security.

6.2 PROPOSED LEGISLATION

Discussion developed around the important role of enacting legislation to kickstart a SCEF program in Connecticut. A framework containing enough specificity to attract developers to initiate projects was articulated as one reason for adopting legislation.

Participants, recognizing the important role that legislation should play, discussed the reasons why the 2014 SCEF proposed legislation was not moved out of the Energy and Technology

Committee for vote by the General Assembly, and how proposed legislation this year could address the concerns that were raised. Principally, the controversial provisions concerned

1. the program being adopted as a "pilot";
2. the rate paid to the SCEF subscriber organization by an EDC for the electricity generated and credited back to the SCEF's subscribers; and
3. the duration of the rate agreement.

Significant interest in the second of these provisions was expressed—what is a fair valuation and pricing model for the electricity being generated by a SCEF? That is, what amount should be credited back to SCEF subscribers for their proportionate share of the energy generated?

It was noted that the recent DEEP Draft Integrated Resource Plan states that DEEP plans to conduct a comprehensive study of all aspects of the value of renewable distributed energy resource generation to the state and its residents. It is anticipated that the results of this study will inform the proper valuation of the use of clean energy resources. Such valuation can be used for establishing billing credits.

It was pointed out that, because the DEEP study may take a year or more to complete, legislation outlining requirements for SCEF development should contain a bill credit formula applicable to any projects developed before the valuation study is completed and consequent legislative provisions are enacted. To encourage developers to invest, any such projects should be grandfathered in, according to some participants.

Discussion ensued as to what that interim credited billing rate should be, with participants suggesting several concepts:

- Crediting the full applicable retail rate
- Cost of generation
- Retail rate, adjusted to deduct only the costs of transmission and distribution

It was noted that in Massachusetts, the full electricity retail rate is provided as the billing credit for SCEF projects. However, this model is now being reexamined in response to concerns expressed by the EDCs that it is not sustainable over time.

It was agreed that implementation of appropriate pricing will be key to the long-term success and widespread development of a Connecticut SCEF program, as the citizens are seeking "to be environmental, but to save money at the same time" as one participant noted.

The first provision of the 2014 proposed legislation—the classification of the new program as a "pilot"—was also the subject of some discussion. It was apparent to participants that the uncertainty created by classifying the new program as a pilot would inhibit project development and investment. No participants strongly advocated for this aspect of the legislation, particularly after it was noted that the DEEP study would pave the way for a reevaluation of the bill credit paradigm.

6.3 ISSUES OF EQUITY

The equity discussions revolved around how to charge and credit for SCEF-generated energy in a manner that is fair to both participants and nonparticipants. It was noted that in some states where SCEFs are operating, such as Massachusetts, SCEF subscribers receive a billing credit equal to the retail electricity rate. This has raised the concern that the cost to serve a SCEF subscriber customer is greater than the amount that the subscriber pays for the electricity for which they are billed. Others have raised the point that the opposite may be the case—that is, that the cost to serve the SCEF subscriber is actually less than that paid for the total value provided when all factors are taken into consideration. The equity issue that was raised involves possible misalignment of the recognition and allocation of the benefits and costs associated with the use of clean distributed energy resource generation.

It was noted that the results of the planned DEEP valuation study would be useful in gaining an understanding of the full benefits and costs to determine the total value of clean distributed energy resources, with the results being used to determine fair pricing for services provided by the utility and the SCEF customer.

Another equity issue raised was the need to broaden the availability of benefits of clean energy resource generation, since all ratepayers already contribute to the cost through payment of the required Combined Systems Benefit Charge[1] on their electricity bills. Offering the opportunity to ratepayers to participate in a SCEF will give all ratepayers an opportunity to receive benefit from charges they already pay.

Lastly, broadening the availability of renewable energy resource generation could benefit low-income households. Other states with SCEF projects are looking for ways to target benefits to these households.

6.4 ROLE OF UTILITY COMPANIES

Participants discussed how traditional utility business models and rate designs "in place for the last 100 years" will need to change to reflect the expanding use and integration of distributed renewable energy resource generation.

The utilities cited the projects enabled by legislation adopted in 2011 that allowed renewable distributed energy resource generation projects to be developed and/or operated, to a limited degree, by the EDCs in the state. It was noted that these types of projects are examples of cost-effective renewable energy installations where all ratepayers pay for them and all receive the benefits from them. The United Illuminating project in Bridgeport consisting of a PV solar array and a fuel cell project was cited as an example of a utility-sponsored clean energy resource project.

1 The Combined Public Benefits Charge represents three charges formerly known as: Conservation and Load Management Charge, Renewable Energy Investment Charge and Systems Benefits Charge. This charge also includes the Conservation Adjustment Mechanism approved by the Public Utilities Regulatory Authority in Docket No. 13-11-14; Source: Sample CL&P bill; Web Link: https://www.cl-p.com/Rates/AverageBill/Average_Bill/?MenuID=4294984980

There was further discussion among participants as to whether projects such as the ones in Bridgeport can be classified under the SCEF definition. It was generally concluded that such projects, while they represent great potential for the development of clean energy generation, do not qualify as SCEFs because they do not involve the essential component of voluntary participation, subscriber choice as to which specific projects to support, and price hedging. It was emphasized that such projects could be pursued in parallel with a SCEF program. “We should really be doing both—pursuing the Bridgeport type projects while also promoting community solar” according to one participant.

Some participants noted that the EDCs in Connecticut are engaged in strategic planning that includes the growth of renewable distributed energy resource generation and how this can be integrated into future utility business models to provide significant contributions to the strength of the transmission and distribution system as a whole. The experiences of other jurisdictions with substantial renewable energy resource generation, such as Arizona, Hawaii and Germany, are being actively studied for lessons applicable to Connecticut, according to some participants.

7.0 COMPONENTS OF THE VALUE OF CLEAN ENERGY ANALYSIS AND SCEF FINANCIAL COSTS

7.1 BACKGROUND

The case for the development and use of SCEFs in Connecticut is grounded in the viewpoint that SCEFs, and clean distributed energy resources in general, create net economic value for a number of stakeholders and society as a whole. Several studies have theorized and quantified the net economic value of clean energy in the form of monetary savings for utilities and ratepayers; savings derived from hedging strategies for subscribers and owners of clean distributed energy resources; and health related savings and net economic development for society.

Although many studies point to the net economic value that clean distributed energy resources provide, there is ongoing debate regarding the cost of increased clean distributed energy resource deployment onto the electric grid. Some stakeholders have concerns that the magnitude of costs has not been properly quantified.

This section provides a brief review of the studies that have developed methodologies to value clean energy. A summary of the generally accepted components of the value of solar, the most typically deployed clean energy resource, is presented to provide insight into the potential economic benefits that SCEFs can bring to Connecticut utilities, subscribers and owners of clean distributed energy resource systems, and society. Additionally, financial cost information regarding the development and operation of SCEFs is discussed because of its importance as a core determinant of economic value and for investment decisions by SCEF developers and potential subscribers.

7.2 SCEF FINANCIAL TRANSACTIONS AMONG STAKEHOLDERS

The financial transactions that occur between a SCEF and other clean distributed energy resources, utilities, and society are complex and mapping these transactions can be helpful in constructing an economic model that is appropriate and equitable. Figure 7-1 provides an example of financial transactions that occur between typical entities. However, based on an SCEF’s organizational structure, the entities shown may not all be necessary, and in some cases other entities could be involved.

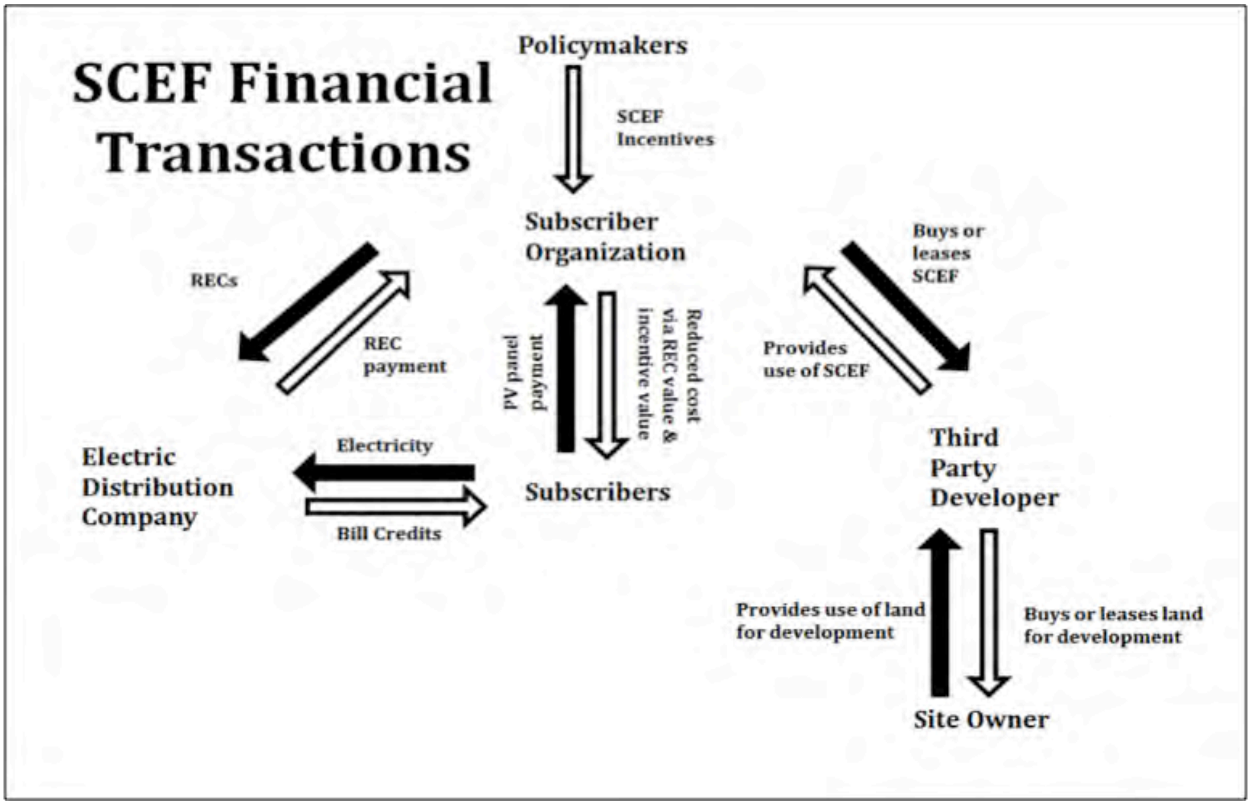


FIGURE 7.1. AN EXAMPLE OF SCEF FINANCIAL TRANSACTIONS

7.3 REVIEW OF THE VALUE OF SOLAR

Studies on the value of clean distributed energy resources have typically focused on the value of solar because solar PV is the most typically deployed clean energy resource used for distributed generation in the United States. As previously noted in this report, Minnesota, one of the first states to conduct this type of analysis, adopted legislation defining the value of solar as "the value to the utility, its customers, and society for operating distributed solar photovoltaic resources interconnected to the utility system."[1] Using this definition as an example, value of solar calculations typically focus on components that measure a distributed solar PV system's effect on the electric grid, the environment, and owner finances.

Factors, assumptions, and methodologies employed in value of solar analyses that have been conducted vary greatly, and have resulted in significantly different value of solar calculations. Although differences exist, there are generally accepted approaches that can be reviewed and utilized to construct analyses to determine the value of solar and other clean energy resources in Connecticut.

Typically a value of solar analysis quantifies the following components:[2]

1 *Staff Briefing Papers (CSG Rate).* Minnesota Public Utilities Commission. August 2014.
2 *A Review of Solar PV Benefit & Cost Studies*, Rocky Mountain Institute, April 2013.

- Avoided Energy Costs
- Avoided Generation Capacity
- Avoided System Losses
- Avoided Transmission Capacity
- Avoided Distribution Capacity
- Ancillary Services
- Avoided Financial Risk
- Security: Resiliency and Reliability
- Avoided Environmental Costs
- Economic Development

These components were identified from the Rocky Mountain Institute (RMI) study, *A Review of Solar PV Benefits & Cost Studies,* which provides a comprehensive overview of value of solar studies that have been conducted. Also, the IREC guidebook to valuing distributed solar generation is a resource for conducting Connecticut's value of clean energy analysis.[3]

There is general agreement regarding how to quantify the components of avoided energy costs, avoided generation capacity, avoided system losses, and avoided transmission and distribution capacity; however, there is debate about how to measure a distributed solar PV system's effect on ancillary services (grid support services), avoided financial risk, reliability and resiliency, and societal impacts (environmental and economic development).

Further, many studies have recognized that there are local factors affecting all study outcomes that should be considered during the analysis. The generally accepted factors include

- level of solar penetration;
- weather patterns;
- generation fuel mix of geographic area;
- interconnection location of distributed solar system on the grid;
- utility market structure; and
- distributed solar PV system characteristics (i.e., fixed or tracking system).

7.3.1 Description of Value of Solar Analysis Components

The main components of the value of solar analysis, including a description of each as well as the methodology employed to value each component, are as follows.

3 *A Regulators Guidebook: Calculating the Benefits and Costs of Distributed Solar Generation*, http://www.irecusa.org/a-regulators-guidebook-calculating-the-benefits-and-costs-of-distributed-solar-generation/, Interstate Renewable Energy Council, October 2013.

Avoided Energy Costs

Distributed solar PV generation creates value to a grid if it replaces electricity produced by fossil fuel sources. Depending on its correlation with customer load, distributed solar PV generation could displace marginal resources used to meet peak load, which is often expensive generating capacity, although it may be less or more emissions-intensive than average. The general approach to valuing avoided energy cost is to calculate the avoided cost of natural gas (usually the marginal resource) by using data from the New York Mercantile Exchange natural gas forward market and forecasting future natural gas prices. The value of the avoided energy costs typically depends on underlying assumptions such as fuel price forecasts, heat rates, operating and maintenance cost projections, and the merit order of generation plants (i.e., the order that plants are dispatched from lowest to highest cost).

Avoided Generation Capacity

Distributed solar PV generation can provide value if it replaces centralized capacity, which is commonly measured by the capital investment costs needed to build and operate a gas combustion turbine (the most common marginal capacity resource). The method most commonly employed to measure this component is the effective load carrying capacity (ELCC), which measures the amount of additional load that can be met with the same level of reliability after adding distributed solar PV generation to the grid. Distributed solar PV generation's ability to replace central capacity depends on its production coincidence with peak load, and the type of asset being replaced. It is important to note that distributed solar PV generation will create more value when it replaces peaking generation, which is generally more expensive than a base load power plant on a per kilowatt hour basis.[4]

Avoided System Losses

Distributed solar PV generation could provide value to the utility grid by reducing system energy losses due to electricity resistance of wires carrying the current across transmission and distribution systems. According to RMI, approximately 9% of electricity generated from a power plant is lost through transmission and distribution before it reaches its end user.[5] Distributed solar PV generation could decrease system energy losses because it is typically sited close to load, thus reducing the amount of electricity that must travel across utility wires. Most studies use a loss factor calculation to measure system losses. A loss factor is typically used to account for system losses. RMI recommends calculating marginal system losses as opposed to calculating average system losses because system losses change when there are temporal system load changes. Typically, studies measure the impact of solar PV on system losses either as a standalone component, or incorporate it into energy and capacity calculations. Care should be taken to avoid double-counting with other aspects of the analysis.

Avoided Distribution Capacity

Distributed solar PV generation creates value for a grid if it defers future distribution system capital investments. Some value of solar studies, however, point out that distributed solar PV generation only provides value to the distribution system if it is interconnected in a congested

4 Contreras, J.L., Frantzis, L., Blazewicz, S., Pinault, D., Sawyer, H., "*Photovoltaics Value Analysis.*" Navigant Consulting, February 2008.

5 *A Review of Solar PV Benefit & Cost Studies*, Rocky Mountain Institute, April 2013.

distribution system[6] and if the interconnection is close to a feeder load center.[7] According to the study, *Cost and Benefits of Distributed Solar Generation on the Public Service Company of Colorado System,* additional challenges that may occur when distributed solar PV generation is interconnected to the distribution system include system feeders exporting power and voltage fluctuations. These issues may require additional distribution system maintenance, which may increase costs. The value of distributed solar PV generation to the distribution system is usually determined by measuring the dependable capacity of distributed solar PV generation to reliably defer capital investment. ELCC simulations are usually performed to estimate this value.[8]

Avoided Transmission Capacity

Distributed solar PV generation could create value for utilities if it defers future transmission capital investments. Many studies note that there are similarities between measuring distributed solar PV generation's impact on the transmission and distribution systems. This value is determined using a methodology by which the dependable capacity of distributed solar PV generation, usually performed with an ELCC simulation, is determined.[9]

Ancillary Services

Distributed solar PV generation could strengthen ancillary services by providing reliability when coupled with complementary technologies such as advanced inverters and energy storage capacity. Distributed solar PV generation could provide benefits to the ancillary components of reactive supply and voltage control, frequency regulation, energy imbalance, operating reserves, and scheduling and forecasting. However, it is important to note that debate exists around the value that distributed solar PV generation provides to some of these services. The majority of studies indicate that distributed solar PV generation would actually exacerbate ancillary service costs, while some studies acknowledge that distributed solar PV could enhance ancillary services by reducing system load.[10] No uniform methodology has been employed to calculate distributed solar PV generation's value to ancillary services.

Avoided Financial Risk

Distributed solar PV generation could create value by mitigating financial risk with the creation of a financial hedge against future electricity prices derived from fossil fuels. Because of changing market forces, fossil fuel prices can be volatile. Clean distributed energy resource systems can act as a hedge against volatile fossil fuel prices because the present value of their financial costs is relatively more certain. A method used to estimate the value of the financial hedge is to utilize New York Mercantile Exchange natural gas futures contract data compared to distributed solar PV generation costs. RMI notes that the value of the financial hedge is dependent on the type of marginal fossil fuel resource and whether utilities already employ a hedging strategy.

6 Contreras, J.L., Frantzis, L., Blazewicz, S., Pinault, D., Sawyer, H., "*Photovoltaics Value Analysis.*" Navigant Consulting, February 2008.
7 Xcel Energy, Inc. "Costs and Benefits of Distributed Solar Generation on the Public Service Company of Colorado System". May 2013.
8 SAIC. 2013 "*Updated Solar PV Value Report.*" Arizona Public Service. May, 2013.
9 Ibid.
10 *A Review of Solar PV Benefit & Cost Studies*, Rocky Mountain Institute, April 2013.

Further, distributed solar PV generation could create value if its production volume has the ability to place downward pressure on electricity prices from a centralized generation power plant. The common term used to describe this value is Demand Reduction Induced Price Effect (DRIPE). The logic behind this theory is that an increase in distributed solar PV generation decreases demand for electricity produced from central generation power plants, thus putting downward pressure on electricity prices and creating value for all ratepayers, not just SCEF subscribers. One study used a market calibration factor to measure this value.[11]

However, it is noted that there is debate regarding whether solar PV generation can help to decrease electricity prices. Some studies note that the penetration level of distributed solar must be high to affect electricity pricing. Further, some studies only analyze the initial market effect and do not analyze potential subsequent market responses. For example, if electricity prices are lower due to distributed solar PV generation supply, demand may increase again due to the lower electricity prices.

Another potentially avoided financial risk is that distributed resources, which in general are installed in small increments of cost, can defer the need for upgrades in distribution and transmission that usually result in substantially larger project costs. If a more distributed grid architecture becomes favored, as appears to be the case in New York, some expensive transmission projects have the potential to become stranded cost to ratepayers, who bear the ultimate risks. Beginning to integrate increased levels of distributed energy resources may inform and, by potentially deferring traditional transmission and distribution investments, even reduce the cost of grid modernization if Connecticut were to follow a similar path.

Security: Resiliency and Reliability

Most studies agree that distributed solar PV generation has the capability to increase system reliability particularly when coupled with energy storage and advanced inverter technologies, but have not quantified its value because of the difficulty in doing so. However, in the study, *The Value of Distributed Solar Electric Generation to New Jersey and Pennsylvania*, the value of security is quantified using an estimated cost of outages in the United States ($100 billion, 2004), and modeling a value based on this cost.[12] It is noted that this study assumed a 15% solar PV penetration, which is significantly greater than that which is expected to be deployed in Connecticut in the near future. Another way that this value could be determined would be to employ “willingness to pay”[13] studies that have been used in the past to determine some environmental values, including the following ones.[14]

Environmental

Distributed solar PV generation can create value to society if it displaces negative environmental impacts associated with fossil fuel-burning power plants. Although many studies focus on distributed solar PV generation’s ability to displace carbon emissions, the RMI

11 Ibid 36.

12 Perez, R., Norris, B., Hoff, T., “*The Value of Distributed Solar Electric Generation to New Jersey and Pennsylvania.*” Clean Power Research, 2012.

13 Willingness to pay studies are a method to value items and even intangibles (such as environmental externalities) or other, usually unarticulated benefits and/or costs that may be used as economic inputs as to cost-effectiveness of competing alternatives. Often this is accomplished using focus groups.

14 Ottinger, Richard, Wooley, David, et al. *Environmental Cost of Electricity*. Pace University Center for Environmental Legal Studies. Oceana Publications. 1990. Pp. 65-67.

study,[15] provides a comprehensive list of environmental effects including carbon, criteria air pollutants, water, and land.

Most studies use carbon compliance costs or fees to determine the value that distributed solar PV generation has on reducing carbon emissions. However, the carbon price used in each study varies significantly. Further, because of possible federal action on carbon regulation, there is uncertainty surrounding future carbon prices. It is noted that the federal government uses a baseline price for carbon of $38/ton (in 2015 dollars) for agency rulemakings (usually with a lower and higher estimate based on different discount rates).[16]

Criteria air pollutants such as nitrogen oxide and sulfur oxide produced by power plants have adverse effects on health. Determining solar PV generation's value in decreasing air pollutants includes analyzing pollutant compliance costs and medical expenses associated with asthma and other related health conditions.

Distributed solar PV generation can also add value to society by displacing power plants that use large amounts of water for operation. No study has valued this component; however, RMI recognizes its potential value in their study. Lastly, RMI indicates that distributed solar PV generation can impact land costs in three ways: change in property values, land requirements for solar PV installation, and ecosystem impacts.[17] In its study, RMI indicates that to date no study has attempted to value distributed solar PV generation's impact on land costs.

Economic Development

Distributed solar PV generation can create value to society if its production results in net job growth (no job displacement). This benefits society by adding to aggregate income, decreasing unemployment, and increasing tax revenues for government entities. Studies that calculate an economic development value usually measure direct, indirect and induced job creation (typically with results including a job multiplier), and impact on government tax revenues. According to RMI, the job multiplier results for the value of solar studies that have been conducted vary significantly.

7.4 FINANCIAL COSTS OF SCEFS

A significant aspect of the financial decision-making process for SCEF developers and subscribers as to whether to participate in an SCEF project involves quantifying and analyzing the costs associated with facility development and operation. Analyzing SCEF development and costs can provide an understanding of SCEF financial feasibility. SCEF developers and subscribers are willing to invest in SCEFs if they perceive the revenue stream (bill credits, RECs, and/or policy incentives) is providing a return on investment. The following provides an overview of some of the financial costs associated with the development and operation of SCEFs typically borne by SCEF developers and subscribers.

15 *A Review of Solar PV Benefit & Cost Studies*, Rocky Mountain Institute, April 2013.

16 Aldy. Joseph; Adler, Matthew; Anthoff, David; Cropper, Maureen; Gillingham, Kenneth; Greenstone, Michael; Murray, Brian; Newell; Richard; Richels, Richard; Rowell; Arden; Waldhoff, Stephanie; Wiener, Jonathan. "*Using and Improving the Social Cost of Carbon*." Science 5 December 2014 Vol 346. No. 6214. Web. 17 Feb 2014. http://www.sciencemag.org/content/346/6214/1189.summary

17 *A Review of Solar PV Benefit & Cost Studies*, Rocky Mountain Institute, April 2013.

7.4.1 Description of Development and Operation Costs

The following is a list of the major costs associated with SCEF development and operation:

- Hard Costs (Modules, Inverters, Mounting Hardware)
- Land Acquisition (includes site preparation)
- Labor
- Operation & Maintenance
- Marketing/ Customer Acquisition
- Permitting and Inspection
- Interconnection
- Insurance
- Sales Tax
- Installer Profit

The following summarizes the costs that are considered to be significant as well as costs that could be significantly reduced by the deployment of SCEFs.

Module Costs

Module costs are a significant part of total system costs. In the Berkeley Lab 2014 report, "Tracking the Sun," the average crystalline silicon module price for utility-size developments (defined as utility developments of more than 5 MW capacity) in the United States was $3.70/watt (AC) in 2013. [18] Module prices have decreased significantly in recent years due to the significant decrease in the world price of silicon. Silicon is the semiconductor material used to build crystalline silicon modules, which comprise 85% of the module market. Figure 7.2 displays the decrease in cost of crystalline silicon photovoltaic costs from 1977 - 2013.

18 *Tracking the Sun VII: An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 - 2012* (2013). Lawrence Berkeley National Lab. Web. 11 Dec 2014

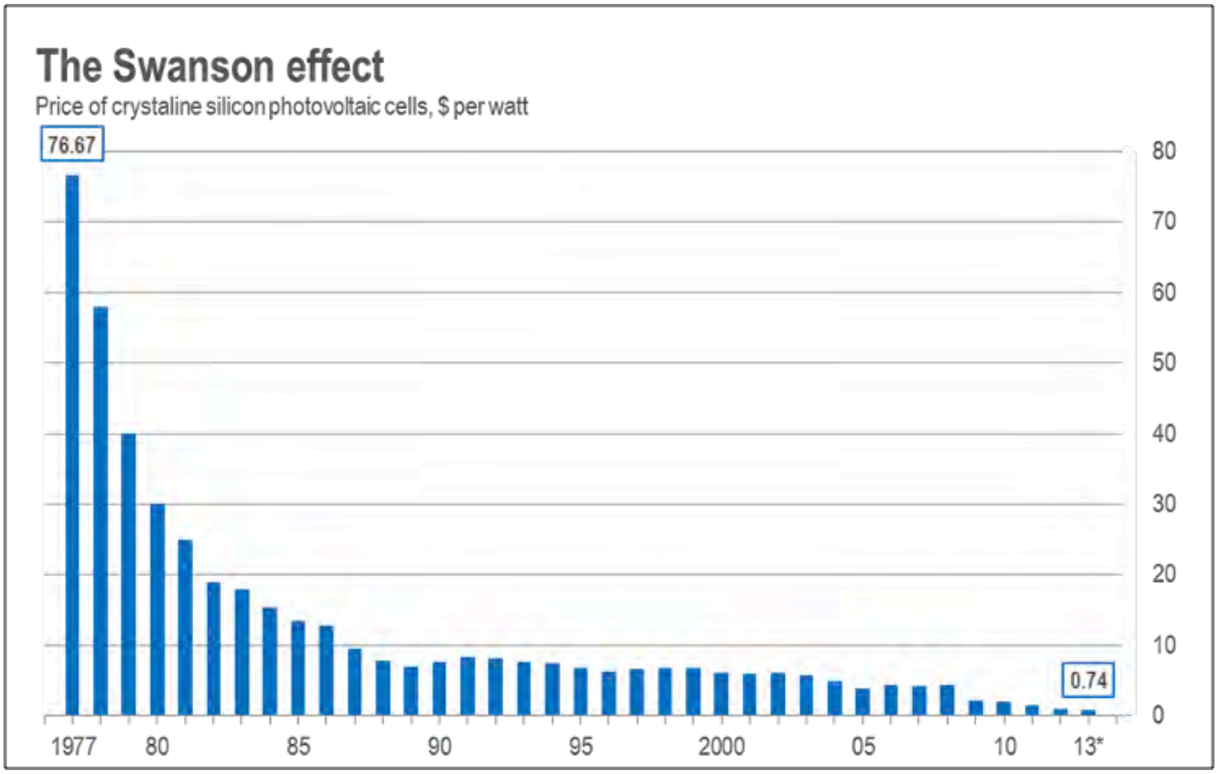


Figure 7.2: The Swanson Effect: Price of Crystalline Silicon Photovoltaic cells ($ per watt). Source: Bloomberg New Energy Finance

According to the DOE's report titled, "The SunShot Vision Study," a number of technical challenges such as the simplification and modification of cell properties must occur before there are further substantial reductions in solar PV module costs. It is important to note that due to the larger size of SCEFs as compared to individual roof-top solar PV systems, economies of scale can be exploited to reduce module purchase costs for SCEFs. For example, in 2012 small systems (<10 kW) had module prices of $5.30/watt. In contrast, much larger systems (>2000 kW) had modules prices of $3.50/watt. [19]

Land Acquisition

A National Renewable Energy Laboratory report, *Land-Use Requirements for Solar Power Plants in the United States*, estimated that a small solar PV system sized between 1MW – 20MW capacity would require approximately 5.9 acres/MW in direct area and 8.3/MW acres in total area for the system. Also, the report noted that the land use area needed for solar PV varied based on the type of technology used.[20]

Options for locating SCEFs include vacant land, as well as on buildings, or as canopies at parking lots. Also, underutilized land such as brownfield sites and closed landfills may be cost-effective sites to consider. According to EPA, remediation costs are relatively low for SCEF development on brownfields. Furthermore, local governments could benefit from the use of underutilized property if it is suitable for SCEF development.

19 *"Community Shared Solar: Expansions Underway in Solar America Communities."* US Department of Energy, SunShot Initiative, September 2014.

20 http://www.nrel.gov/docs/fy13osti/56290.pdf

Operating & Maintenance Costs

Operating and maintenance fees last over the lifetime of a project, and therefore will be an ongoing cost for subscribers. For this reason, subscribers may be particularly sensitive to operating and maintenance costs. According to the "Tracking the Sun" report, operating and maintenance costs for solar PV installations were estimated to be $20-$40/kW (AC), or $10-$20/MWh in 2013. SCEFs could help to reduce operating and maintenance costs for residents and businesses because there may be economies of scale in operating and maintenance since it is carried out at the centralized facility location. In contrast, residential and commercial solar PV operating and maintenance is relatively more costly because it requires the recruitment, site analysis, and management of several, dispersed sites.

Permitting

Site permitting is another cost that could potentially hamper investment in solar PV systems. For example, a 2012 study by Clean Power Finance found that more than one-third of solar installers avoided selling solar PV systems in viable markets because of permitting cost issues.[21] However, permitting costs for SCEFs are projected to be significantly lower than permitting for residential and commercial solar PV installations based on the premise of consolidation. Permitting officials only have to visit one site that serves multiple customers. In Connecticut, permitting costs for residential solar PV projects vary by town and have been as high as $921 (average is $401).[22] SCEF development can help to reduce per kW permitting costs through economies of scale. Also, it has been suggested that consideration be given to having municipalities waive permitting fees to encourage solar PV system adoption.

Customer Acquisition/Marketing

Customer acquisition/marketing costs are another major soft cost in the overall solar PV system portfolio. In a study that breaks down the costs of residential solar PV systems, customer acquisition was estimated to be the third highest cost, at $0.48/watt in 2013.[23] To reduce customer acquisition costs, the SunShot Initiative has focused efforts on reducing upfront customer costs in order to make solar PV systems more attractive to prospective owners or subscribers. Further, the SunShot Initiative emphasizes that the SCEF model provides subscribers with flexibility that would otherwise not be available to an owner of a residential or commercial solar PV system. Typically, SCEF policies allow for the sale, portability and transferability of facility shares. These rules render the adoption of solar more attractive to prospective subscribers because it provides for flexibility and does not necessarily require a long term financial commitment.

7.4.2 Sample Financial Model

The following is a sample Massachusetts community shared solar financial model (Figure 7-3). The model helps to provide an understanding of system costs and how much each subscriber pays that can provide insight on future system costs in Connecticut.

21 Ibid.

22 Clean Energy Finance and Investment Authority. "Residential Solar Investment Program: Post 30 MW and Public Policy Support." November 2014. Power Point Presentation.

23 "*Community Shared Solar: Expansions Underway in Solar America Communities.*" US Department of Energy, SunShot Initiative, September 2014.

Economic Benefit ($) = Net Metering Credits ($) + SREC Revenue ($)

Example

Project organizers estimate that the project will generate $20,921 worth of net metering credits and $35,910 from the sale of SRECs each year. Twenty participants are anticipated to take an ownership stake in the CSS project.

Annual SREC Revenue ($) = $35,910
Annual Value of Net Metering Credits ($) = $20,921
Anticipated Number of Participants = 20
Economic Benefit ($) = $20,921 + $35,910 = $56,831
Assuming that each participant owns an equal share of the project (that is, 5.25 kW of the 105 kW project), the annual economic benefit to each participant is $2,842.

Investments ($) = Lifetime Cost ($) – Incentives ($)

Example – Estimating Participants' Investment

To estimate participants' combined investment, project organizers subtract the incentives from the lifetime cost.

Anticipated Number of Participants = 20
PV System Installed Cost = $420,000
Operations and Maintenance and Other Costs = $100,000
Monetized Tax Benefits = $147,000
MassCEC Rebate = $42,000

Lifetime Cost ($) = $420,000 + $100,000 = $520,000
Incentives ($) = $147,000 + $42,000 = $189,000
Participants' Investment ($) = $520,000 = $189,000 = $331,000

Assuming that each participant owns an equal share (that is, 5.25 kW of the 105 kW PV system), the required one-time, up-front investment from each participant is calculated to be $16,550.

FIGURE 7-3: PARTICIPANT OWNERSHIP FINANCIAL MODEL IN MASSACHUSETTS
SOURCE: COMMUNITY SHARED SOLAR: IMPLEMENTATION GUIDELINE FOR MASSACHUSETTS COMMUNITIES

For the example shown, the report estimates that revenue from the sale of RECs and the value of bill credits amount to $56,831 per year for all participants. It then shows total system costs to be $331,000 (installed costs and operating and maintenance) after applying tax incentives and rebates. The payback time is calculated to be 5.8 years ($331,000/$56,831), which is much before the predicted 25+ years useful life of the system.

7.4.3 Financial Modeling Resources

Solar Technical Assistance Team (STAT): Gathers NREL solar technology and deployment experts to provide unbiased information on solar policies and issues for state and local government decision makers. This information is used as a resource for developing the market for solar PV technologies.[24]

NREL Community Solar Scenario Tool (CSST): Provides an analysis of different shared solar program options for utility-sponsored models. The model enables users to estimate how inputs such as system size, location, and project costs impact the economics of a project from both a potential customer's perspective as well as that of the sponsoring utility.[25]

NREL System Advisor Model (SAM): Provides a more in-depth financial analysis of different shared solar program options.[26]

24 http://www.nrel.gov/tech_deployment/state_local_governments/stat.html
25 http://www.nrel.gov/tech_deployment/tools_community_solar.html
26 https://sam.nrel.gov/

8.0 FINDINGS AND RECOMMENDATIONS

8.1 FINDINGS

8.1.1 State Policy Goal: Increase Amount of Electricity Generated from Clean Renewable Energy Resources in Connecticut

Increasing clean energy capacity and the amount of electricity generated from clean energy resources in Connecticut is a policy goal of the State of Connecticut. This policy, as expressed in legislation, and energy planning and strategy documents, provides the framework for consideration of the development and use of Shared Clean Energy Facilities (SCEFs) in Connecticut to help achieve the state's goals.

- The Connecticut Department of Energy and Environmental Protection's (DEEP) *2013 Comprehensive Energy Strategy for Connecticut* "builds on the fundamental premise that the public's interest in and ongoing commitment to clean energy depends on the emergence of new technologies that compete with fossil fuel alternatives."[1]
- Connecticut's Renewable Portfolio Standards (RPS)[2] require that electricity providers obtain a minimum percentage of their retail load by using renewable energy resources. The RPS include annual percentage goals, with a requirement of achieving 20% Class I renewable energy, 3% Class II or Class I (additional) renewable energy, and 4% Class III renewable energy, for a total of 27% electricity generation by 2020.
- The Connecticut General Statutes include the following:
    - o *Planning and Energy Policy; Chapter 298: Energy Utilization and Conservation; Section 16a-35k: Legislative Findings and Policy*, mentions "…the General Assembly declares that it is the policy of the state of Connecticut to…develop and utilize renewable energy resources, such as solar and wind energy, to the maximum practicable extent…diversify the state's energy supply mix…ensure that low-income households can meet essential energy needs…"[3]
    - o *Chapter 446c: Air Pollution Control; Section 22a-200a: Reduction of Greenhouse Gas Emissions: Mandated Levels*, states that Connecticut "shall reduce the level of emissions of greenhouse gas: (1) Not later than January 1, 2020, to a level at least ten per cent below the level emitted in 1990; and (2) Not later than January 1, 2050, to a level at least eighty per cent below the level emitted in 2001."[4]

1 DEEP, 2013 Connecticut Comprehensive Energy Strategy, http://www.ct.gov/deep/lib/deep/energy/cep/2013_ces_final.pdf, page ii.

2 PURA, Connecticut Renewable Portfolio Standards Overview, http://www.ct.gov/pura/cwp/view.asp?a=3354&q=415186

3 CT General Statutes: Planning and Energy Policy; Chapter 298: Energy Utilization and Conservation; Section 16a-35k: Legislative Findings and Policy, http://www.cga.ct.gov/2013/pub/chap_298.htm#sec_16a-35k

4 CT General Statutes: Chapter 446c: Air Pollution Control; Section 22a-200a: Reduction of Greenhouse Gas Emissions: Mandated Levels, http://www.cga.ct.gov/current/pub/chap_446c.htm#sec_22a-200a

- DEEP's *2014 Draft Integrated Resource Plan (IRP)* mentions a warning regarding the state's RPS goals: "Procuring renewables to address the gas infrastructure constraint would have the added benefit of helping to remedy the shortage of Class I supply that is projected in the 2014 Draft IRP as RPS targets increase in Connecticut and across the New England region."[5] The IRP provides notice that the 2020 Class I RPS goal may not be achieved.[6] As RPS goals increase, it will be more difficult to purchase clean energy from other states at competitive prices, thereby increasing energy costs.[7] In addition, DEEP "welcomes comment on proposals to establish a community solar program on a pilot basis, as well as other policy or regulatory changes that should be evaluated to ensure that all interested customers have meaningful, equitable access to DER [distributed energy resources]."[8]

  Also, three critical policy objectives identified in the IRP are "(1) to ensure that Connecticut and the New England region retain adequate capacity resources to meet summer peak electric demand; (2) to resolve the region's natural gas infrastructure constraints; and (3) to secure additional Class I renewable generation to meet RPS requirements in Connecticut and the New England region."[9]

SCEFs, along with other state programs and incentives currently in use and under consideration, will help increase electricity generation from clean renewable energy resources in Connecticut. This can reduce or eliminate RPS goal non-compliance and achieve RPS targets at competitive prices. Additional potential benefits include:

- Increasing access to clean energy for more residents and businesses;
- Providing tangible economic benefits to SCEF owners and subscribers;
- Providing grid design and improvements that move toward decentralization to foster resiliency and security, offer locational benefits, defer future upgrades and high marginal costs, and avoid system losses; and
- Improving environmental quality and helping to attain greenhouse gas goals.

8.1.2 Focus on Solar PV with All Class I Clean Renewable Energy Technologies Eligible for SCEFs

While several types of Class I clean renewable energy resources (see Appendix B for a listing of clean renewable energy resources) can be used for generating electricity from a SCEF, solar PV systems have been the primary type of SCEF used in other states and regions and are expected to be the most likely clean energy resource used for SCEFs in Connecticut. The concepts and issues discussed in this report focus primarily on solar PV, but are applicable to other types of clean energy resources that can be used for SCEFs, as well.

5 http://www.ct.gov/deep/lib/deep/energy/irp/2014_irp_draft.pdf, page 98
6 Ibid, pages 46-47.
7 Ibid, page 47.
8 Ibid, page 114.
9 Ibid, page 115-116.

8.1.3 Current Legislation

Existing Connecticut legislation does not prohibit the development or operation of nonprofit-managed and special purpose entity SCEFs. However, developers would generally be reluctant to develop projects in Connecticut as a practical matter without legislation that provides a framework and rules that set forth the details for a SCEF program.

Although the utility-sponsored model has proven to be the most widespread in the United States, this model is currently not an option in Connecticut under existing legislation. The terms of the state's utility restructuring required that utilities divest themselves of generation facilities. However, recently the electric distribution companies have been authorized by legislation to own and operate some clean renewable distributed energy resource generation facilities. Legislation would be needed to allow utility-sponsored SCEFs to be developed, operated and owned by the electric distribution companies in Connecticut.

Also, current state statutes should be reviewed to determine if any changes are needed to avoid conflicts between existing laws and any proposed SCEF legislation.

The following key findings provide the foundation for the study recommendations with respect to SCEFs and related issues:

- Connecticut's statutes and energy planning and policies identify the need to increase the amount of in-state generation of electricity from clean renewable energy resources.
- Based on the success of the state's residential solar PV program and Connecticut's relatively high electricity rates, it is expected that SCEFs will be of interest to ratepayers as an opportunity to reduce their electricity expense, while fulfilling the state's policy goal of increasing in-state clean renewable energy generation.
- Certainty in the design of the SCEF program is needed in order to attract SCEF developers.

8.2 RECOMMENDATIONS

The CASE Study Committee's recommendations relate to the adoption of legislation that is needed to provide a framework for a SCEF program; requirements related to SCEF program operation and administration; a mandate for DEEP to engage in the rulemaking needed to develop detailed Program Rules for SCEF operations and administration, and conduct a value of clean energy analysis proceeding[10]; and the need for additional examination of related issues and legislative considerations.

8.2.1 Adopt SCEF Legislation and Program Rules

A review of the development of SCEF projects in other states revealed that a legislative framework is needed for developers, organizations, and subscribers to invest in SCEF projects in Connecticut. Therefore, legislation should be adopted that is consistent with the current interconnection and

10 *2014 Integrated Resource Plan for Connecticut*, Connecticut Department of Energy and Environmental Protection (Hartford, CT) (Draft for Public Comment, December 11, 2014) 112

siting requirements, and that is based on relevant aspects of the state's successful residential solar PV program and the Interstate Renewable Energy Council's (IREC) Model Rules.

Additionally, the legislation should direct DEEP to:

- Develop SCEF Program Rules that contain the detailed provisions for the development, operation and administration of SCEFs, including but not limited to those outlined in Section 8.2.2 (Mandate DEEP to Adopt SCEF Program Rules).
- Adopt the SCEF Program Rules and initiate the SCEF Program within six months from enactment of SCEF legislation. DEEP should also be required to review the Program Rules at least once every three years, and report on program results to the General Assembly periodically.
- Develop the methodology for, and conduct a proceeding to, determine the value of clean energy by type of resource used in Connecticut for the purpose of establishing SCEF billing credit rates.

Legislation should permit the development and operation of SCEFs that utilize any Class I renewable energy resource for electricity generation. Moreover, the legislation should provide flexibility to accommodate different business models to own and operate SCEFs, such as for-profit and not-for-profit organizations and the state's electric distribution companies (EDCs).

Specific legislative provisions that support the legislative framework for a SCEF program should be adopted, including the following:

- A definition of key terms (Shared Clean Energy Facility, Subscriber, Subscriber Organization, Subscription, and others)
- The SCEF must have at least two Subscribers.
- Subscribers of an SCEF and the SCEF must be physically located within the same EDC service territory.
- Subscriptions sold from a single SCEF cannot exceed 100% of the SCEF's nameplate capacity.
- SCEFs must comply with existing standards and requirements for siting and interconnection of distributed renewable energy electricity generating facilities based on their nameplate capacity. Therefore, legislation should not provide a capacity size limit for SCEFs.
- The SCEF Organization, the generator, shall own the renewable energy credits (RECs) for electricity generated from the facility unless or until transferred by contract to others.
- The EDC shall be required to enter into a Power Purchase Agreement for the electric energy produced by any SCEF located within its service territory consistent with the SCEF Program Rules, including that the term of such agreement shall be for the life of the SCEF.
- Using the billing credit rate as determined by the value of clean energy analysis and ratemaking process, SCEF Subscribers shall receive a billing credit on their monthly electricity bill for their share of energy generated from the SCEF as reported by the

SCEF Organization to the EDC. A Subscriber's excess billing credit, if any, shall be carried over month to month to the end of the annual solar billing cycle and paid out as a cash credit on the next monthly bill.

However, an interim billing credit rate shall be used for SCEFs established prior to adoption of SCEF Program billing credit rates based on the results of the value of clean energy analysis for clean energy resources by type.

- o The state's existing net metering program for its residential solar PV program shall be used as the interim billing credit rate. The interim billing credit rate shall apply to a SCEF upon its execution of a power purchase agreement with an EDC and successful SCEF registration with the state as specified in the SCEF Program Rules.

  Additionally, Subscribers of SCEFs established in advance of adoption of the SCEF Program billing credit rates shall be grandfathered to receive whichever rate is higher—the interim billing credit rate or the SCEF Program billing credit rate—for the life of the SCEF.

- SCEF Unsubscribed Electricity Generation: For a two-year period following the effective date of SCEF registration with the state as specified in the SCEF Program Rules, the Subscriber Organization will receive the rate that is, or would be, paid to Subscribers for unsubscribed electricity generation. After this initial two-year period, the Subscriber Organization will receive the rate for unsubscribed generation as determined through the value of clean energy analysis and ratemaking process; however, until such time as the rates are set by this process, a SCEF will receive the avoided cost rate of wholesale power.
- DEEP shall incorporate low-income household participation into the SCEF program along with possible incentives for utilities that aid in meeting this goal.

8.2.1.1 VALUE OF CLEAN ENERGY ANALYSIS

The 2014 Draft IRP states that DEEP's plan is to conduct "a proceeding to evaluate the value of distributed generation [value of clean energy analysis]."[11] Legislation should direct DEEP to conduct the value of clean energy analysis and that such analysis shall be completed within one year of enactment of the legislation. A value of clean energy analysis should be conducted for each type of Class I clean energy renewable resource, but the first phase of the study should be conducted for solar PV generation, since that is likely to be the most widespread type of SCEF developed, at least initially.

This proceeding should be a transparent process involving all stakeholders. The legislation should mandate that the Public Utility Regulatory Authority (PURA) use the results of the DEEP value of clean energy analysis to conduct a ratemaking process to establish billing credit rates by type of resource for SCEFs, as well as for other types of clean distributed energy resource generators. Such analysis should also be used to inform a ratemaking process for the existing residential/commercial solar PV programs. The value of clean energy SCEF billing credit rates shall apply to all projects initiated after the ratemaking process has been completed. For SCEF projects established prior to that date, whichever rate is higher—the interim billing credit rate or the value of clean energy billing credit rate—shall apply.

11 DEEP Draft 2014 IRP 112

8.2.1.2 MANDATE DEEP TO ADOPT SCEF PROGRAM RULES

To provide additional guidance and a regulatory framework to support all stakeholders in SCEF development and operation and administration for the purpose of implementing the legislation authorizing SCEFs, DEEP should develop and adopt detailed program rules consistent with such legislation that include, but are not be limited to, consideration of the following:

- Requirements for SCEF Organization registration, including filing the SCEF Organization's prototype Subscriber Agreement and the SCEF/EDC power purchase agreement with PURA
- Requirement for an EDC to enter into a power purchase agreement with a SCEF
- Applicable facility siting and interconnection requirements
- Safety, performance and interconnection standards
- Control, testing and inspection requirements
- The maximum size of a SCEF Subscriber's subscription shall not exceed 120% of the Subscriber's average monthly electricity consumption for the most recent 12 months. This limit is based on the IREC Model Rules and best practices of other states, and also helps to mitigate a SCEF having unsubscribed electricity generation. Additionally, Subscribers should have the option to increase or decrease SCEF subscription shares no more frequently than quarterly, based on availability and terms and conditions of transferability and portability provisions of the SCEF Program and the Subscriber Agreement.
- Subscription transferability that enables a SCEF Subscriber to transfer interest in a SCEF to another entity eligible to be a Subscriber for any reason, such as reducing the size of the Subscriber's SCEF Subscription based on electricity usage or moving out of the EDC territory.
- Subscription portability that enables a SCEF Subscriber to retain a Subscription upon relocation within the same EDC service territory
- Timely reporting of SCEF Subscriber information by the SCEF Organization to the EDC
- Billing credit rates for SCEFs shall be established based on the results of the value of clean energy analysis for each type of clean renewable energy resource. Until such time as the SCEF billing credit rates are adopted, the applicable billing credit rate for SCEFs and SCEF Subscribers shall be the interim billing credit rate as set forth in the SCEF legislation.
- REC ownership provisions, as set forth in legislation
- Consumer protections and disclosures should be developed by DEEP in consultation with the Office of the Consumer Counsel and the Department of Consumer Protection. The IREC Model Rules and best practices (i.e., 16 CFR Part 260: Environmental Marketing Guidelines, "Green Guides") should be used as guidance. SCEFs should be required to provide potential subscribers with this information prior to purchase of a Subscription, as well as including it in the Subscription agreement.
- A recent energy home or business efficiency audit (Home Energy Solutions –Core Services and Income-Eligible Programs – or similar program for businesses and others)

should be required for a SCEF Subscriber to be eligible to participate in the SCEF program. For homeowners, this requirement is the same as for the Connecticut Green Bank's (CGB) residential solar PV program. For renters, a modified program that covers efficiency actions that could be taken by renter should be created.

- Develop a low-income household component of the SCEF program. Several low-income programs developed by others are referenced in the Case Studies section of this report (Section 5).
- Develop reporting requirements for SCEF program outcomes, and report results periodically to the General Assembly. Requirement for providing data and information for reporting from the EDCs, Public Utility Regulatory Authority and SCEF Organizations should be specified.

Also, DEEP should create a website that includes all SCEF Program information to assure that all interested stakeholders and potential SCEF Subscribers have accurate and timely information about the program.

In addition, it is recommended that DEEP develop financing and incentive options in collaboration with the CGB, to encourage SCEF development and participation—including low-income household participation—as a way to meet the state's renewable energy resource electricity generation goals. The CGB's current programs should be considered for expansion or modification to include eligibility for SCEF owners and SCEF Subscribers.

8.2.2 *Summary of Stakeholder Roles*

- Connecticut Green Bank
    - Collaborate with DEEP to provide support for SCEF program; similar to CGB role for existing residential & commercial clean energy programs
    - Consider modifying loan and incentive programs for use in supporting SCEF development
- Connecticut Siting Council
    - Review and approve SCEF siting as required
    - Review MW capacity siting requirement for various types of clean energy resources and revise as appropriate
- Department of Consumer Protection
    - Collaborate with DEEP regarding the development of SCEF program consumer protections and disclosure requirements
- DEEP
    - Adopt SCEF Program Rules
    - Collaborate with the Department of Consumer Protection and the Office of the Consumer Counsel regarding the development of SCEF program consumer protections and disclosure requirements

   - Conduct the value of clean energy analysis proceeding
   - Report on program results
   - Monitor distributed energy resource penetration and electricity generation
   - Track results of use of value of clean energy billing credit rates
   - Study fairness in utility rate design
   - Consider innovative utility business models
   - Oversee technical solutions, including setting inverter standards
   - Utilize CGB and PURA, and others for SCEF implementation and support
   - Request PURA dockets for approvals as required
- ISO New England
   - Assure system stability and monitor effects of increased penetration and use of distributed energy resource electricity generation in Connecticut and throughout New England, including generation resource forecasting
- Office of the Consumer Counsel
   - Collaborate with DEEP regarding the development of SCEF program consumer protections and disclosure requirements
   - Review and participate in DEEP value of clean energy analysis proceeding
- Public Utility Regulatory Authority
   - Utilize the DEEP value of clean energy analysis results to conduct proceedings as required to approve rates and Program Rules regarding the SCEF program, and other related initiatives and projects.
   - Utilize these results to inform relevant rate cases
   - Maintain SCEF registration system
   - Report on program results in accordance with Program Rules
- SCEF Owner/Operator
   - Develop SCEFs and comply with regulatory mandates
   - Share best practices regarding SCEFs and the use of clean distributed energy resources with other stakeholders
   - Report on program results in accordance with Program Rules
- SCEF Subscribers
   - Purchase SCEF subscriptions
   - Based on terms and conditions of subscription agreement with SCEF:
      - ◊ Receive billing credits for electricity generated from a SCEF

- ◊ Pay share of operation and maintenance of SCEF
- ◊ Receive share of REC credits for electricity generated

- Utilities/Electric Distribution Companies
  - Provide data to support DEEP value of clean energy analysis proceeding
  - Develop SCEFs and other clean energy resource electricity generation facilities, as permitted
  - Cooperate with state, ISO-NE and regional efforts designed to improve the grid system through the utilization of distributed energy resources
  - Enter into power purchase agreement for electricity generated from SCEFs and provide billing support for SCEFs
  - Report on program results in accordance with Program Rules

8.2.3 *Other Related Issues to be Considered*

The following issues related to SCEFs and increasing penetration and use of clean energy resource generators, and intermittent clean distributed energy resources and other distributed energy resources, should be considered:

- General rate design, including ratepayer fairness considerations and reducing peak demand
- Locating distributed energy resources to create the most system value, such as reducing system congestion and improving grid stability, reliability, resiliency, safety and security
- Development of innovative EDC business models with performance incentives for supporting deployment and use of distributed generation (such as what currently exists for energy efficiency programs)
- Ongoing monitoring of other states' experience and cooperating with initiatives of regional entities such as the ISO-NE Distributed Energy Resource Working Group
- Identify and plan to implement technical solutions, including advanced inverters and energy storage, if necessary, to assure grid stability and reliability with regard to transient loads and other technical issues, especially in areas with high levels of penetration and use of intermittent clean energy resources and other distributed energy resources. The study on complementary technologies, if authorized by legislation as recommended in this report, will inform these efforts.

8.2.4 *Additional Legislative Considerations*

In addition to recommendations specific to the SCEFs, several other related legislative initiatives were identified for consideration by the General Assembly.

- Allow EDCs to develop additional clean renewable energy resource generation facilities for specific permitted purposes, including but not limited to enhancing the distribution system to reduce congestion, and to increase reliability, resiliency, safety and security.

- Direct the Siting Council to review MW capacity siting requirement for various types of clean energy resources based on facility characteristics and to conduct an evaluation to revise requirements based on the results
- Commission a study to evaluate the benefits and costs of using complementary technologies including, but not limited to, storage and advanced inverters for enhancing the value of intermittent Class I clean energy resources on the grid.
- Revise the Clean Energy Options Program[12] to provide that funds collected are used to construct clean energy resource electricity generation facilities in Connecticut.
    - Projects would be proposed and owned by EDCs and others for benefit of ratepayers.
    - DEEP would manage proposal process for selection of projects for PURA's consideration.
    - Projects should be for the purpose of enhancing the reliability or performance of the distribution system, thereby providing the most value to the system and ratepayers.
    - Ratepayers who currently participate in the program would be given 60 days to choose to stay with current company that they had selected; if the ratepayer makes no selection by the end of that period, default enrollment would shift to new program. Participants who chose to remain with the company selected (old program) and not move to the new program would have the option to shift participation into the new program at any time.

The benefit to participants in the program is that their voluntary financial support will be used to help Connecticut achieve its clean energy goals for the benefit of all Connecticut ratepayers.

12 The Clean Energy Options Program is the voluntary program that provides ratepayers an option to pay extra on their electricity bill by selecting one of two companies that purchase clean energy or build clean energy generating facilities (anywhere in the US or Northeast). Currently around 25,000 Eversource Energy and UI customers participate in the program, with annual contributions being approximately $2.5 million.

APPENDIX A
GLOSSARY OF TERMS

The following section contains a selection of key definitions of terms related to the development and use of SCEFs and the renewable energy technologies market that are used in this report.

Avoided Cost Rate: The Avoided Cost Rate is the rate that a utility pays for wholesale power. For Connecticut's Solar Net Metering program, at the end of the solar year (March 31), the EDC pays the Solar PV customer for any remaining net energy generation accumulated over the year at the avoided cost of wholesale power rate.[1]

Business Energy Investment Tax Credit (ITC): The federal business energy investment tax credit was enacted in 2005 by Congress with the purpose of encouraging the development of renewable energy systems. Provisions include a tax credit that is equal to 30% of expenditures with no maximum credit. Eligible solar energy project property includes equipment that uses solar energy to generate electricity, to heat or cool (or provide hot water for use in) a structure, or to provide solar process heat. Hybrid solar lighting systems, which use solar energy to illuminate the inside of a structure using fiber-optic distributed sunlight, are also eligible. Also included are fuel cell (credit limited to $1,500 per 0.5 kW of capacity) and small wind turbine projects. Further, it includes tax credits equal to 10% of expenditures for geothermal system, micro turbine, and combined heat and power (CHP) projects. The tax credits for equipment that uses solar energy to generate electricity, to heat or cool (or provide hot water for use in) a structure, or to provide solar process heat will decrease from 30% to 10% on December 31, 2016. The credits for geothermal, hybrid solar lighting, small wind, fuel cells, micro-turbines, and CHP will expire on December 31, 2016.[2] Another federal incentive is the Production Tax Credit (PTC) that provides financial support for the development of renewable energy facilities.

Class I, II, and III Renewable Energy Sources (Connecticut specific): Energy resources that are naturally replenished without depleting the resource.3 In some cases energy resources may be classified as renewable that do not strictly fit this criteria, such as fuel cells in Connecticut, which are classified as a Class I renewable energy resource.

- A Class I renewable energy source consists of electricity generated by solar power, wind power, a fuel cell, geothermal, landfill methane gas, anaerobic digestion or other biogas derived from biological sources, thermal electric direct energy conversion from a certified Class I renewable energy source, ocean thermal power, wave or tidal power, low-emission advanced renewable energy conversion technologies, a run-of-the-river hydropower facility that began operation after July 1, 2003, and has a generating capacity of not more than thirty megawatts. Class I renewable energy resources are also considered to be clean energy resources.
- A Class II renewable energy source consists of energy derived from a trash-to-energy facility; a biomass facility that began operation before July 1, 1998, provided the average emission rate for such facility is equal to or less than .2 pounds of nitrogen oxides

1 http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=CT01R&re=0&ee=0
2 http://energy.gov/savings/business-energy-investment-tax-credit-itc
3 http://www.eia.gov/tools/glossary/index.cfm?id=R

per million BTU of heat input for the previous calendar quarter; or a run-of-the-river hydropower facility provided such facility has a generating capacity of not more than five megawatts, does not cause an appreciable change in the river flow, and began operation prior to July 1, 2003.

- A Class III renewable energy source consists of electricity output from combined heat and power systems with an operating efficiency level of no less than 50% that are part of customer-side distributed energy resources developed at commercial and industrial facilities.[4]

Clean Energy: Clean energy is energy produced from sources that emit little or no pollution or emissions.[5]

Distributed Generation*:* Refers to renewable energy and non-renewable energy that is generated on a relatively small scale (in Connecticut per state statute up to 65 MW) and is located close to load, or where the electricity is consumed. It is also sometimes defined as generation interconnected at system levels below transmission. It may operate in either centralized or decentralized modes. The distributed generation model differs from the traditional utility model of large-scale, centralized generation that is generally located far from load. Only distributed generation that is capable of totally islanding or operating in a microgrid that islands can be called decentralized.

Feed-in Tariff*:* A policy tool designed to encourage growth in the renewable energy technologies sector in the form of a long-term contractual agreement between a government entity or utility, and a renewable energy producer. A long-term contract is made to protect the renewable energy producer against market risks and to secure a long-term revenue stream to encourage further renewable energy technology innovation. Feed-in tariff is similar to a standardized power purchase agreement. Rather than being individually negotiated, it is a contract for sales open to all providers of a certain type.

Generation Capacity and Nameplate Capacity*:* The maximum power output that an electric generator can supply, commonly expressed in MW. Closely related to the definition of capacity is nameplate capacity, which is the maximum capacity that a generator can produce under conditions specified by the manufacturer.[6]

Green Tariff: A premium paid by electricity consumers to an electricity utility for electricity specifically produced from renewable energy, such as solar or wind power. The proceeds from the premium are often directed to the development of renewable energy technologies.

Interstate Renewable Energy Council (IREC): IREC is a national leader and resource regarding clean energy issues. IREC seeks to expand consumer access to clean energy; generates information and objective analysis based on best practices and standards; and leads national efforts to build a quality-trained clean energy workforce.[7]

4 "Connecticut Renewable Energy Portfolio Standards Overview" Department of Energy & Environmental Protection. Web. 22 Dec. 2014. http://www.ct.gov/pura/cwp/view.asp?a=3354&q=415186

5 http://www.masscec.com/about-clean-energy

6 http://www.eia.gov/tools/glossary/index.cfm?id=G#gen_nameplate

7 http://www.irecusa.org/about-irec/

Net Metering*:* Net metering is a billing method for utility customers who use a distributed energy generation system to offset electricity provided by a utility company. Net metering involves utilizing a meter that is able record both electricity flowing from a utility to a building and from a distributed energy generation system into the distribution system, or alternatively, a meter on the generator sited behind the utility revenue meter. The excess electricity produced from the distributed energy generation system that is provided to the distribution system is subtracted from the electricity provided by the utility that is used, with the customer paying for the net amount of electricity used each month. Typically, excess electricity produced above consumption is carried over as a credit month to month; in some cases, after a true-up period (e.g., one year), the excess credit will be paid to the owner of the distributed energy generation system at a specified rate.

Peak Demand: Peak demand describes the maximum power requirement of an electricity system at a given point in time to supply consumers when the need is greatest. A peak demand period describes the highest level of electricity demand over a period of time, such as during a day.

Portability of Participation*:* Refers to a situation in which a SCEF subscriber has the right to change the meter to which the subscription is assigned in the electricity provider's territory in which the SCEF is located (e.g., subscriber moves from one location to another).

Reliability: Reliability is a measure of the performance of the electricity system when under stress. It involves the electricity system's ability to continue to operate when some lines or generators are out of service.[8]

Renewable Energy Credits [certificates] (RECs): Renewable energy credits or certificates are tradable instruments that represent the property rights to the underlying environmental, social and other non-power attributes of renewable electricity generation. The RECs are sold separately from the physical energy generated from the renewable energy generation source.[9] RECs are used as a method of tracking compliance with tradable credit systems used to implement renewable portfolio standards. RECs are often used as a tool to spur competitiveness, and possibly innovation, in the renewable energy market.

Renewable Portfolio Standard (RPS)*:* A RPS is a policy usually set by states that mandates that electricity providers obtain a certain minimum percentage of their overall electric load from renewable energy sources, such as wind and solar.[10] The percentage that needs to be obtained is typically identified by state policy and may include periodic increases. Currently, Connecticut has annual RPS goals through 2020.[11] From the beginning, the purpose of the RPS has been to break down market failures/barriers and foster innovation for new, renewable energy sources, and they have become a common policy instrument for meeting environmental or other policy objectives. RPS systems often use RECs to track compliance.

Renewable Energy Project Investment*:* Refers to the funding used to develop, build, and maintain a SCEF. There are many funding structures that can be implemented, including

8 http://www.eia.gov/tools/glossary/index.cfm?id=R
9 http://www.epa.gov/greenpower/gpmarket/rec.htm
10 http://www.eia.gov/todayinenergy/detail.cfm?id=4850
11 http://www.ct.gov/pura/cwp/view.asp?a=3354&q=415186

investments made by a limited liability company (LLC) or donations made to a nonprofit organization charged with facility *development.*

Resiliency*:* The ability of the electric grid system to return to normal operation after loss of service.

Shared Clean Energy Facility (SCEF): A SCEF is a Class I renewable energy resource, such as solar, that provides power and/or financial benefit to multiple subscribers. Typically, subscribers and the SCEF are located within the same EDC service territory. SCEF ownership and management models include special purpose entity (business model), utility-sponsored, and nonprofit entities. SCEF subscribers purchase subscriptions that represent an ownership or lease interest in the facility. The concept of a SCEF is grounded in the reality that many people cannot or will not install a clean energy system on their personal property for reasons such as cost, improper rooftop orientation, space, or aesthetic reasons. A visual representation that demonstrates one possible model of how SCEF stakeholders may interact with one another is provided in Figure A-1.

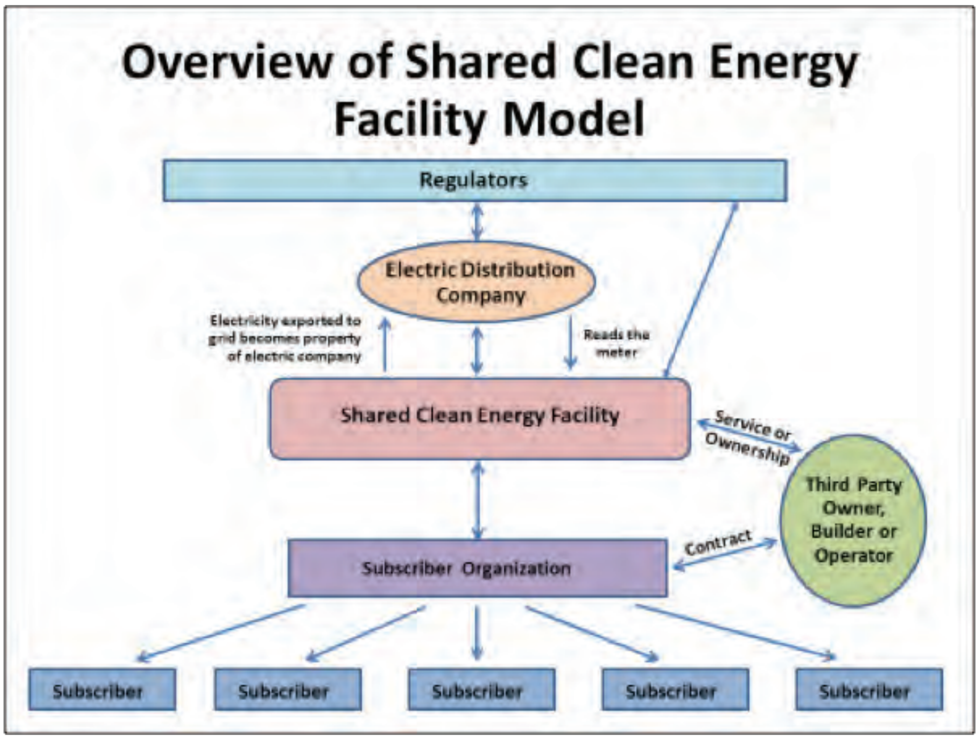


FIGURE A-1: VISUAL REPRESENTATION OF A POSSIBLE SCEF MODEL

Subscriber: A person who purchases an interest in a SCEF.

Subscriber organization: The organization that owns and/or manages the SCEF. A subscriber organization can be a for-profit or not-for-profit entity. Common subscriber organization models include the utility model, the special purpose entity model, and the nonprofit model.

Subscription: Represents an interest in a SCEF. The subscription can either represent an ownership interest, a leased interest or the right to a pro rata share of the SCEF's output.

Transferability of Participation: Refers to the situation in which a SCEF subscriber is no longer a customer of the electricity provider in which the SCEF is located (e.g., moves outside of the electricity provider's territory). Transferability of participation provides the subscriber with the right to transfer or assign their subscription back to the subscriber organization or to any person or entity that is eligible to be a subscriber.

Vendor: A person or organization that develops the SCEF.

Virtual Net Metering: Virtual net metering is a billing method that allows subscribers of a qualified energy generation facility to receive credits on their monthly electricity bill from one meter that records the electricity generated by the facility. The subscriber's monthly electricity bill credit is based on the subscriber's share of the electricity generated by the facility at a rate that is usually determined by agreement between the subscriber and the subscriber organization/facility owner and in compliance with a state's virtual metering rules.

APPENDIX B

RENEWABLE ENERGY ELECTRICITY GENERATION TECHNOLOGIES

Renewable energy technologies for electricity generation include solar photovoltaic (PV) devices, wind, geothermal, biomass, biogas (landfill gas and wastewater treatment digester gas) and low-impact hydroelectricity. However, each state has its own regulatory definition of what is defined as a renewable energy source. In Connecticut, General Statute §16-1(a) sections (26), (27), and (44) defines Class I, Class II, and Class III Renewable Energy Sources, respectively, as:

- Class I
    - Solar Power
    - Wind Power
    - Fuel Cell
    - Geothermal
    - Landfill Methane Gas, Anaerobic Digestion or Other Biogas Derived from Biological Sources
    - Thermal Electric Direct Energy Conversion from a Certified Class I Renewable Energy Source
    - Ocean Thermal Power
    - Wave or Tidal Power
    - Low Emission Advanced Renewable Energy Conversion Technologies
    - Run-of-the-River Hydropower
        - Generating capacity of not more than 30 MW
        - Shall not be based on a new dam or a dam identified by the DEEP commissioner as a candidate for removal
        - Shall meet applicable state and federal requirements, including applicable site-specific standards for water quality and fish passage
        - Began operation after July 1, 2003
    - Sustainable Biomass Facility
        - Average emission rate is equal to or less than 0.075 pounds of nitrogen oxides per million BTU of heat input for the previous calendar quarter, except for a facility with a capacity of less than 500 kW that began construction before July 1, 2003

- Class II
    - Trash-to-Energy Facility
    - Biomass Facility
        - Average emission rate is equal to or less than 0.2 pounds of nitrogen oxides per million BTU of heat input for the previous calendar quarter
        - Began operation before July 1, 1998

    - Run-of-the-River Hydropower
        - Generating capacity of not more than 5 MW
        - Does not cause an appreciable change in the riverflow

        - Began operation prior to July 1, 2003

- Class III
    - Electricity Output from Combined Heat and Power Systems
        - Operating efficiency level of no less than 50%
        - Part of customer-side distributed energy resources developed at commercial and industrial facilities in the state
        - Operational on or after January 1, 2006
    - Waste Heat Recovery System
        - Produces electrical or thermal energy by capturing preexisting waste heat or pressure from industrial or commercial processes
        - Installed on or after April 1, 2007
    - Electrical Savings Created in Connecticut
        - Conservation and load management programs begun on or after January 1, 2006
            - Eligible programs include any demand-side management project awarded a contract pursuant to section 16-243m shall remain eligible for the term of such contract
            - Ineligible programs include those projects supported by ratepayers overseen by the Energy Conservation Management Board or third-party programs pursuant to section 16-245m on and after January 1, 2014

The following provides an overview of the Class I renewable energy resources, which are also considered to be clean energy resources. In addition, a summary of complementary technologies including advanced inverters and energy storage technologies is provided for background purposes.

Solar Power

Photovoltaic (PV) cells convert sunlight (i.e., photons) directly into electricity. Traditional or first-generation solar cells are made from silicon into flat-plate panels. Thin-film solar cells made from amorphous silicon or non-silicon materials such as cadmium telluride that are only a few micrometers thick are classified as second-generation PV cells. These cells can be manufactured into roof shingles and building facades because of their flexibility. Third-generation PV cells are made of new non-silicon materials such as solar inks using conventional printing press technologies, solar dyes, and conductive plastics.[1]

Solar PV systems convert both direct and scattered light into electricity. The amount of radiation measured in units of kWh/m[2] is dependent on the geographic location, time of day, season, local landscape, and weather. Figure B-1 shows the solar distribution across the United States with the Southwest receiving the greatest amount of solar energy.

[1] (http://www.nrel.gov/learning/re_photovoltaics.html)
[2] https://openpv.nrel.gov/rankings

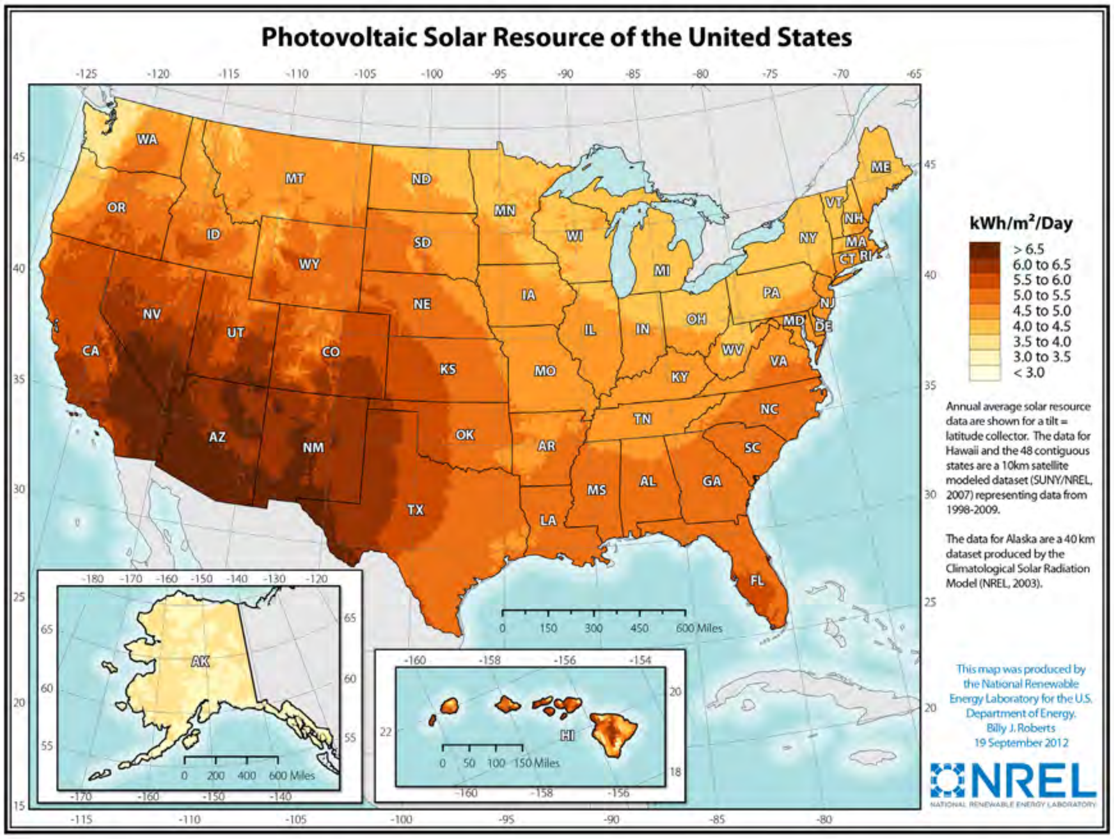


Figure B-1. Photovoltaic Solar Resource of the United States
(Source: http://www.nrel.gov/gis/solar.html)

The average annual solar radiation for Hartford, Connecticut, is listed in Table 1 for fixed flat panels, south-facing fixed panels with a tilt equal to Hartford's latitude of 41.9°, 1-axis east-west tracking with a south tilt equal to Hartford's latitude of 41.9°, and 2-axis tracking.

Table B-1. Average Annual Solar Radiation for Hartford, Connecticut
(Source: http://rredc.nrel.gov/solar/old_data/nsrdb/1961-1990/redbook/sum2/14740.txt)

Panel Orientation	Average Annual Solar Radiation ($kWh/m^2/day$)
Flat Plate	3.8
Fixed South Facing Panel with Tilt Equal to Latitude of 41.9°	4.4
1-Axis East-West Tracking with South Facing Tilt Equal to Latitude of 41.9°	5.4
2-Axis Tracking	5.6

The average monthly distribution of solar radiation for the four referenced types of panels is compared in Figure B-2.

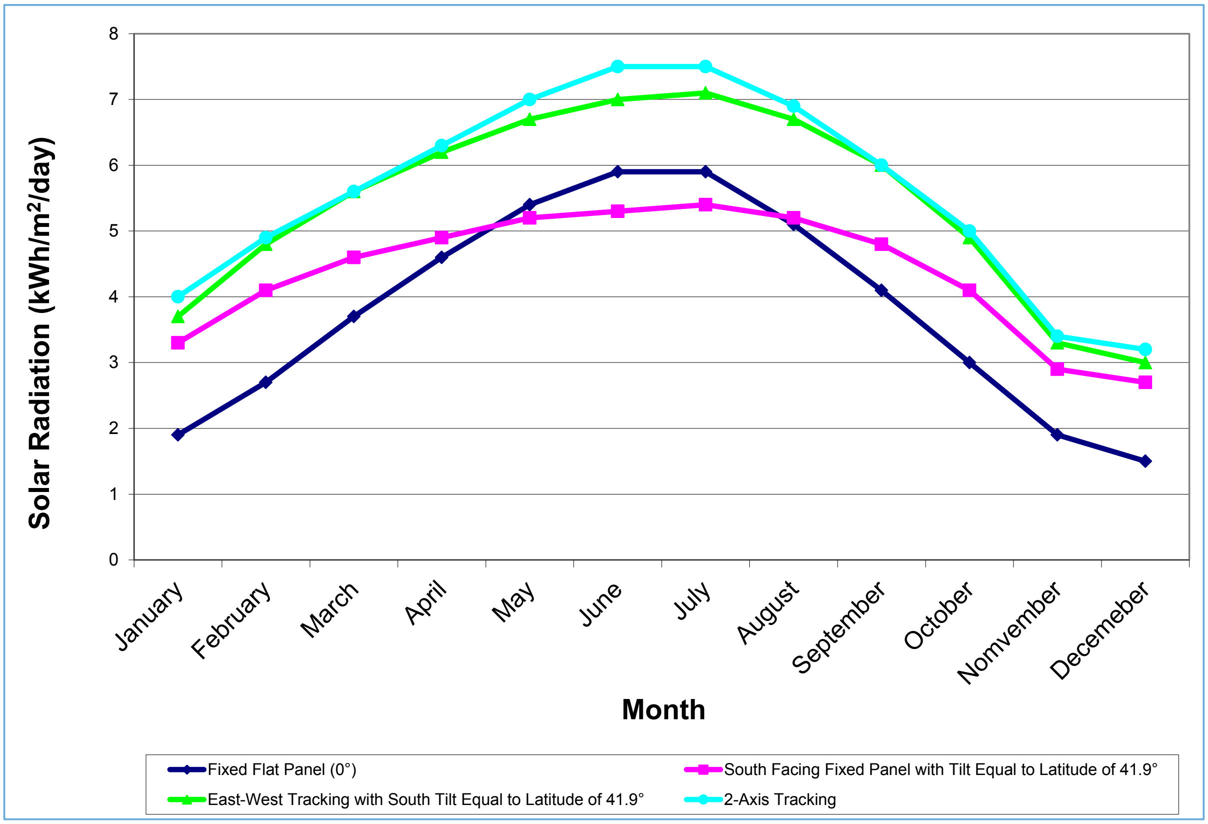


Figure B-2. Average Hartford, CT Monthly Solar Radiation for Fixed and Tracking Panels (Source: http://rredc.nrel.gov/solar/old_data/nsrdb/1961-1990/redbook/sum2/14740.txt)

The efficiency of a solar PV system in converting solar radiation into electricity depends on several factors, including PV cell characteristics and if the solar array tracks the sun or is fixed. The differences in annual energy production as a function of time of day for a simulated one kW solar PV system in Los Angeles, California, for tracking and fixed solar arrays titled in different direction is shown in Figure B-3. A dual-axis tracking solar array that maximizes the incident daily and seasonal solar radiation generates 25% - 30% more energy than a south-facing fixed array. If the objective is to reduce the peak electricity demand, time-of-day energy production is more important than total energy production. In this case, a west-facing fixed array is more advantageous than a south-facing fixed array because it generates more electricity between 2 pm - 6 pm (red line above dark blue line) even though the total annual energy production is 10% - 15% less.

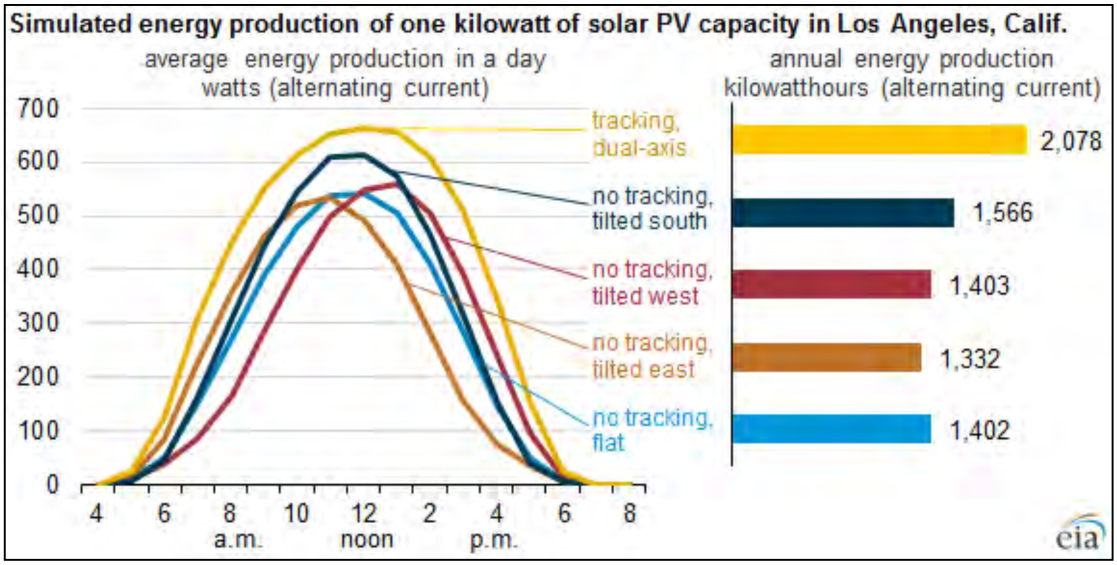


Figure B-3. Simulated Energy Production of 1 kW of Solar PV Capacity in Los Angeles, CA (Source: http://www.eia.gov/todayinenergy/detail.cfm?id=18871)

Connecticut ranks 5th for the total number of solar PV installations (8,238) and 12th in capacity (105.74 MW) according to the Open PV Project amongst the 50 states, Washington, DC, and Puerto Rico as of January 2015. The Open PV Project is a comprehensive database managed by the National Renewable Energy Laboratory (NREL) that provides an up-to-date snapshot of the US solar power market.[2] This demonstrates the importance of public policy in providing incentives that promote renewable energy technologies considering that many states receive more solar radiation than Connecticut. By far, California has the most installations (134,759) and capacity (1893.06 MW) in the United States.

To increase the adoption of solar power, the US Department of Energy (DOE) instituted the SunShot Initiative in 2013 to make solar energy cost-competitive with other forms of electricity by reducing the price to about $0.06/kWh by 2020. By achieving this 75% reduction in cost from 2010 costs, it is expected that solar-generated power can meet 14% of US electricity demand by 2030 and 27% by 2050.[3] Overall, the objectives of the SunShot Initiative are to

- Make clean, low-cost, reliable solar energy available for home owners, communities, businesses, and government;
- Reduce emissions of greenhouse gas and other pollutants; and
- Create US jobs through domestic solar manufacturing and distribution.

The median installed price of residential and commercial solar PV systems since 1998 through 2013 are shown in Figure B-4. Over this time, the solar PV system prices have fallen on average by 6% - 8% annually in terms of real 2013 dollars per Watt-DC.

[2] https://openpv.nrel.gov/rankings
[3] http://energy.gov/eere/sunshot/about

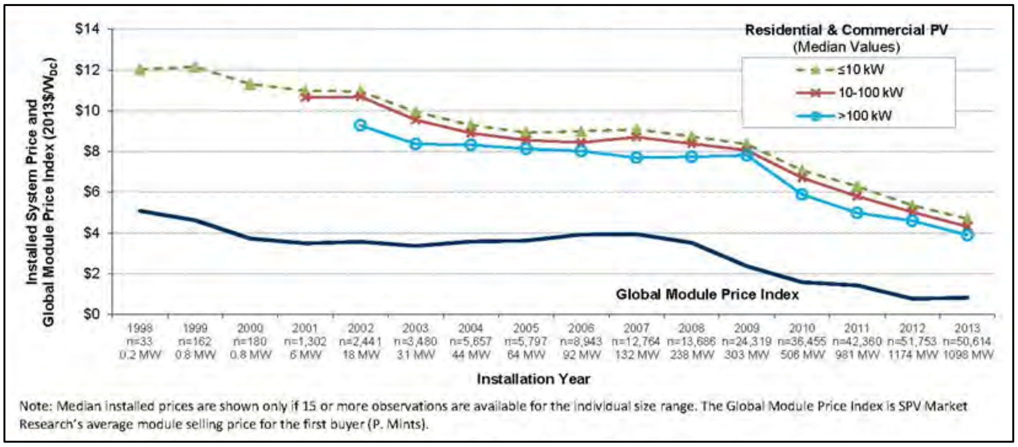


Figure B-4. Median Installed Price of Residential and Commercial Solar PV Systems from 1998 – 2013 in 2013 dollars per Watt-DC (Source: http://www.nrel.gov/docs/fy14osti/62558.pdf)

NREL has also modeled the price of solar PV systems as shown in Figure B-5 for residential (5 kW), commercial (223 kW), and utility systems (185 MW). These prices are lower than the median reported prices because:

- a large percentage of the solar PV systems have been installed in California and other high-priced markets;
- inefficient pricing (i.e., value-based pricing); and
- project characteristics (e.g., high-efficiency panels with single axis tracking).

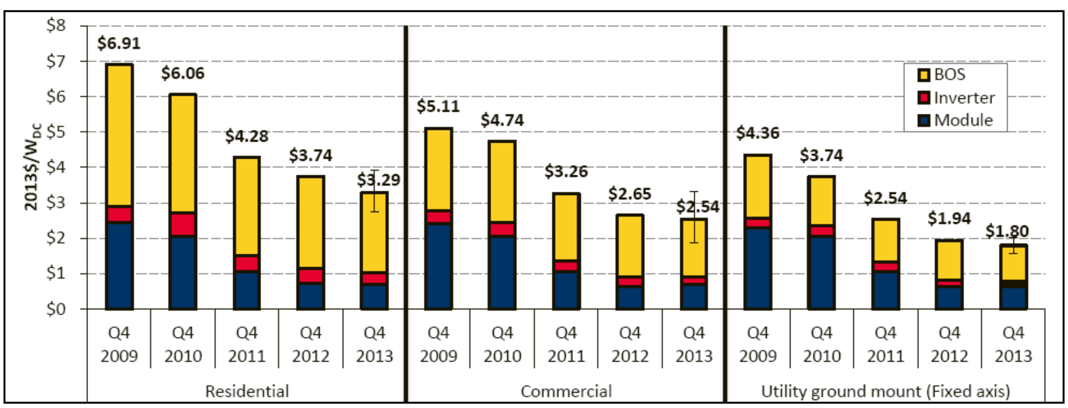


Figure B-5. Bottom-Up Modeled System Price of Solar PV Systems by Sector from 2009 – 2013 (Source: http://www.nrel.gov/docs/fy14osti/62558.pdf)

The median and range of global solar PV panels or modules is shown in Figure B-6. There was a sharp decrease in cost from 2011 to 2013, but global module price is expected to remain relatively constant, with the projected cost in 2016 to be between $0.55/W - $0.65/W. However, current and pending US tariffs on Chinese and Taiwanese solar products may cause prices to be considerably higher in the United States.

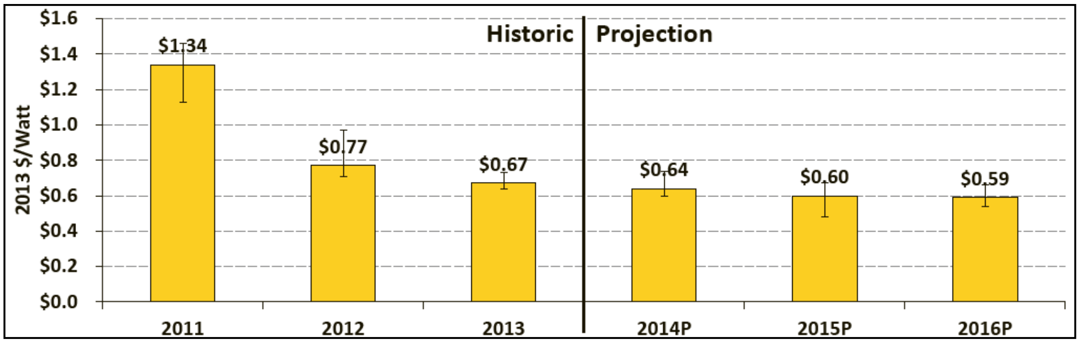


Figure B-6. Median and Range of Analyst Expectations of Global Module Average Selling Price from 2011-2013 and Projections for 2014 – 2016
(Source: http://www.nrel.gov/docs/fy14osti/62558.pdf)

Any future decrease in system price will likely come from decrease in the balance of system since solar PV module cost is expected to remain constant. Given that installed prices in the United States are high compared to other major international markets (see Figure B-7 for comparison of US and Germany residential solar PV systems), there is potential for installed price reductions in the United States.

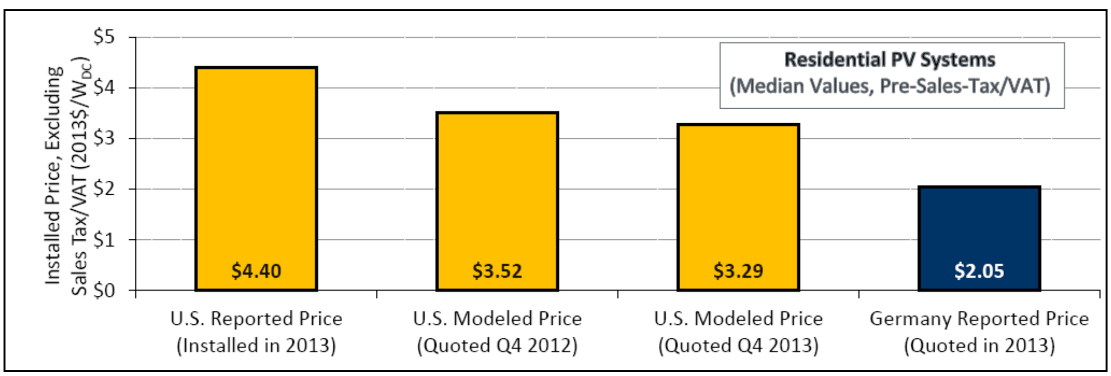


Figure B-7. Installed Prices for Residential Solar PV for US and Germany
(Source: http://www.nrel.gov/docs/fy14osti/62558.pdf)

Solar PV is a commercially developed technology that is technically viable for a SCEF in Connecticut.

Wind Power

Wind projects can be classified based on size as small, community, or commercial wind. The Massachusetts Community and Commercial Wind Project Manual[4] defines these types of wind projects as follows:

[4]http://images.masscec.com.s3.amazonaws.com/uploads/programdocs/CommWind%20Program%20Manual.pdf

- **Small Wind:** A wind project that utilizes wind turbines with nameplate power capacities of less than 100 kW.

- **Community Wind:** A wind project that utilizes one or more wind turbines with power capacity of 100 kW and greater and typically (1) serves a load that is located on the project site, (2) will have a net-metering agreement with a utility company or (3) will serve the load requirements of a host municipal light department.

- **Commercial Wind:** A wind project that typically serves the ISO-NE wholesale electricity market or a municipal light plant system, or has an on-site load that does not qualify for net metering. Commercial Wind projects typically have three or more turbines.

Since wind speed typically increases with altitude, commercial-scale wind development projects use large wind turbines with 80-140 m hub heights, community-scale use mid-size wind turbines with 50-60 m hub heights, and small-scale wind turbines have hub heights of 15-40 m.

Wind speeds of between 3 - 4 m/s are typically required to provide sufficient torque to make the turbine blades rotate. This minimum wind speed is referred to as the cut-in speed. As the wind increases, the power generated is proportional to the cube of the wind speed as shown in Equation 1.

$$P = \frac{1}{2} C_p \rho U^3 \frac{\pi d^2}{4} \qquad \text{(Equation 1)}$$

Where P = Power (watts)
C_p = Power Coefficient or Efficiency
ρ= Air Density (kg/m^3)
U = Wind Speed (m/s)
d = Rotor Diameter (m)

The power output reaches a limit at 12 - 17 m/s and is the rated power output of the wind turbine (Figure B-8). At higher wind speeds, the blade angle is usually adjusted to keep the power output constant. The forces on the turbine structure at wind speeds greater than about 25 m/s can damage the rotor. Thus, a braking system is used to bring the rotor to a standstill. This is called the cut-out speed.

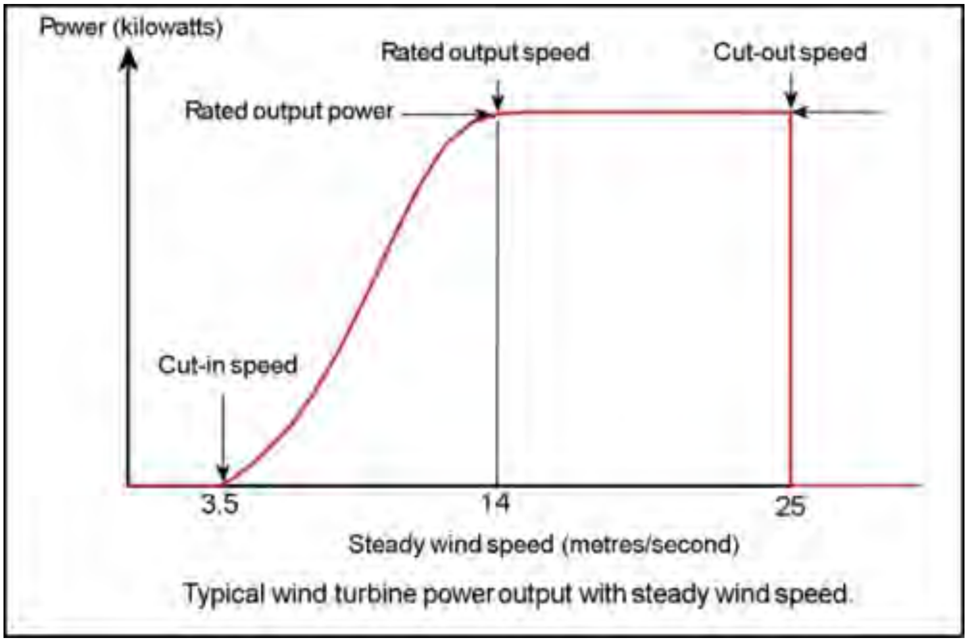


Figure B-8. Wind Turbine Power Output with Steady Wind Speed
(Source: http://www.wind-power-program.com/turbine_characteristics.htm)

Commercial Wind

In general, Connecticut has limited commercial wind resources. At 80 m, average wind speeds in Connecticut are less than 5.5 m/s as shown in Figure B-9. In comparison, significant parts of the middle of the country ranging from North Dakota to Texas have average wind speeds greater than 8.5 m/s. Four of the five states with the largest generation of electricity from wind in 2013 were from this region (Texas, Iowa, Oklahoma and Illinois).[5]

[5] http://www.eia.gov/energyexplained/index.cfm?page=wind_where

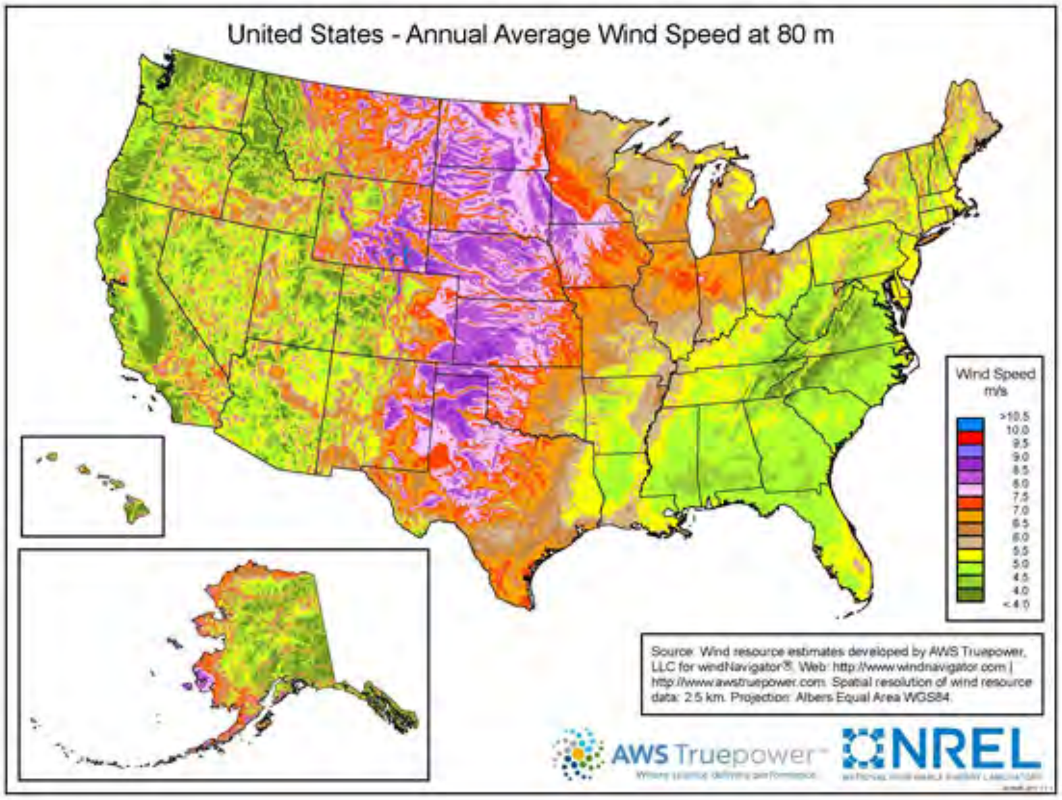


Figure B-9. Annual Average Wind Speed at 80 m
(Source: http://www.eia.gov/energyexplained/images/charts/US_wind_resource_map-large.jpg)

The average wind speeds given in Figure B-9 are model-derived estimates that may not be the true wind speed for a specific location. Actual wind speeds may be different because of small terrain features, vegetation, buildings, and atmospheric effects. Also, wind speeds vary throughout the day and from season to season at any given location. Thus, wind maps are a good tool for estimating the potential of wind energy, but site-specific wind speed data is needed for determining the power output and viability of a wind project.

Community Wind

The potential for community wind projects in Connecticut that use a 50 m hub height can be seen in Figure B-10. (DOE's Wind Program and NREL developed this map from an economic development, policy, and jobs perspective by classifying the wind based on wind speed frequency distributions and air density. From this analysis, locations were given a class ranging from lowest (Class 1) to highest (Class 7) potential. In general, Class 4 or higher was determined to be useful for generating wind power using a 250-kW to 750-kW turbine. With improvements in wind energy technologies, Class 3 or lower wind sources may now be cost competitive. Therefore, DOE no longer uses a wind power classification system and only reports wind speeds. In Connecticut, the best opportunities for community wind are on the ridge crests in the northwestern part of the state, as well as some Class 3 regions that are located along the southern shoreline of Long Island Sound.

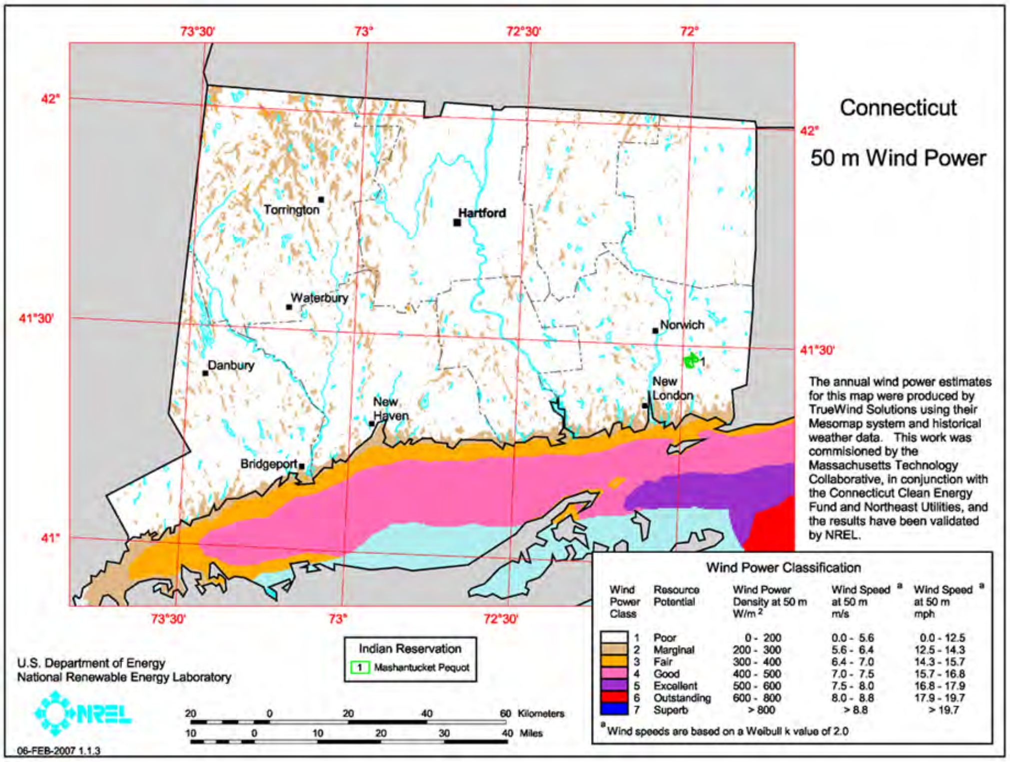


Figure B-10. Connecticut Wind Power Classification at 50 m
(Source: http://apps2.eere.energy.gov/wind/windexchange/images/windmaps/ct_50m_800.jpg)

Small Wind

The DOE/NREL wind resource map at 30 m for Connecticut is shown in Figure B-11. In the past, areas with good exposure to prevailing winds at 4 m/s or greater were considered suitable for small wind projects with turbines typically 15 - 40 m high. With improvements in technology, locations with lower wind speeds may now, or in the future, be suitable for wind development. Similar to community wind, the best locations in Connecticut for small wind projects are along ridge crests and Long Island Sound shoreline.

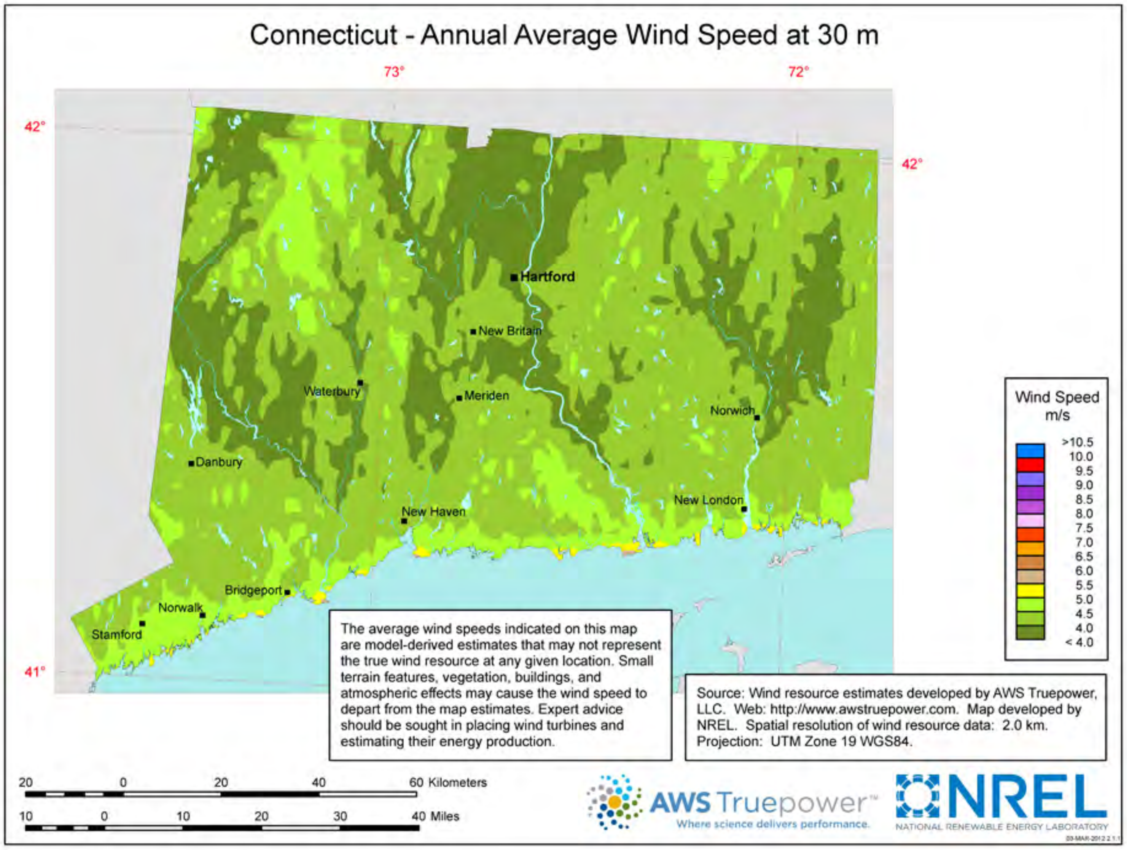


Figure B-11. Annual Average Wind Speed at 30 m in Connecticut (Source: http://apps2.eere.energy.gov/wind/windexchange/windmaps/residential_scale_states.asp?stateab=ct)

Fuel Cells

As previously stated, in Connecticut fuel cells are classified as a Class I Renewable Energy Source. Fuel cells can operate on biogas produced by the anaerobic digestion of organics such as agricultural waste, manure, municipal waste, sewage, or food waste, but more typically use natural gas as a fuel source. The natural gas or biogas (i.e., methane) is converted to hydrogen via a steam reforming reaction. The hydrogen gas is then converted to a positively charged ion and negatively charged electron at the anode. The freed electrons create the electric current while the positively charge ions travel through the electrolyte to the cathode. Oxygen is then typically introduced at the cathode to produce water by combining with the positively charged ion and the previously freed electrons.

There are different types of fuel cells based on the type of electrolyte. These include phosphoric acid, molten carbonate, solid oxide, and proton exchange membrane and range in size from 5 kW to 2.8 MW.[6] Electrical efficiency of fuel cells ranges from 40% - 60% and can be as high as 85% when the waste heat is utilized for cogeneration. Unlike wind or solar, which deliver an

[6] http://www.nrel.gov/hydrogen/proj_fc_systems_analysis.html

intermittent source of power, fuel cells can generate electricity on demand in either a continuous or load-following mode, thus providing a differing value as a distributed energy resource. However, the primary challenge that must be overcome to increase the market penetration of fuel cells is capital cost and the need and cost of periodic replacement of stack materials. The current cost is about $4,000/kW, while the installed cost of a stationary fuel cell needs to be reduced to $1,500/kW or less in order to make them competitive with other technologies.[7] Even with the high current cost of fuel cells, there are 39 units installed in Connecticut, with a total capacity of 28.6 MW. The largest installation is in Bridgeport where there are 5 units with a combined capacity of 14.9 MW that went online in 2013.[8]

Geothermal

Geothermal energy can be used as a renewable energy resource for the following applications:

- Electricity generation power plants — these require water or steam at high temperature of 150° C - 375°C, which is typically within 1 – 2 miles of the surface.
- Geothermal heat pumps — these use stable ground or water temperatures near the Earth's surface to control building temperatures above ground.
- Direct use and district heating systems — these use hot water from springs or reservoirs near the surface.

The most common application in Connecticut is for cooling and heating of buildings. In the northern United States, the stable ground or water temperature of 7°C - 12°C at a depth of about 6 m (20 feet) is used to increase the operational efficiency of a heat pump. Prior to the recent advances in variable speed compressor technology, geothermal, or ground-source heat pumps, were 40% - 50% more efficient as compared to air-source heat pumps. Today, the efficiency of the best variable-speed air-source heat pumps can be equivalent to that of many geothermal heat pump systems when used in less extreme climates where the temperature occasionally goes below about -5°C. While many factors must be considered when deciding between geothermal and variable-speed air-source heat pumps, typically geothermal heat pumps are more cost effective for more extreme climates, larger buildings, and for buildings with minimum insulation.

For electricity generation, active geothermal resources with high temperature water or steam of 150° C - 375°C is required. These active geothermal resources are usually found where earthquakes and volcanoes are located, such as the Ring of Fire which encircles the Pacific Ocean. As can be seen in Figure B-12, the majority of the geothermal resources are in the western United States. Therefore, there are limited, if any, opportunities for geothermal electricity generation in Connecticut.

[7] http://www.nfcrc.uci.edu/3/FUEL_CELL_INFORMATION/FCexplained/challenges.aspx
[8] Hydrogen and Fuel Cell Development Plan –Roadmap; Northeast Electrochemical Energy Storage Cluster (January 2015)

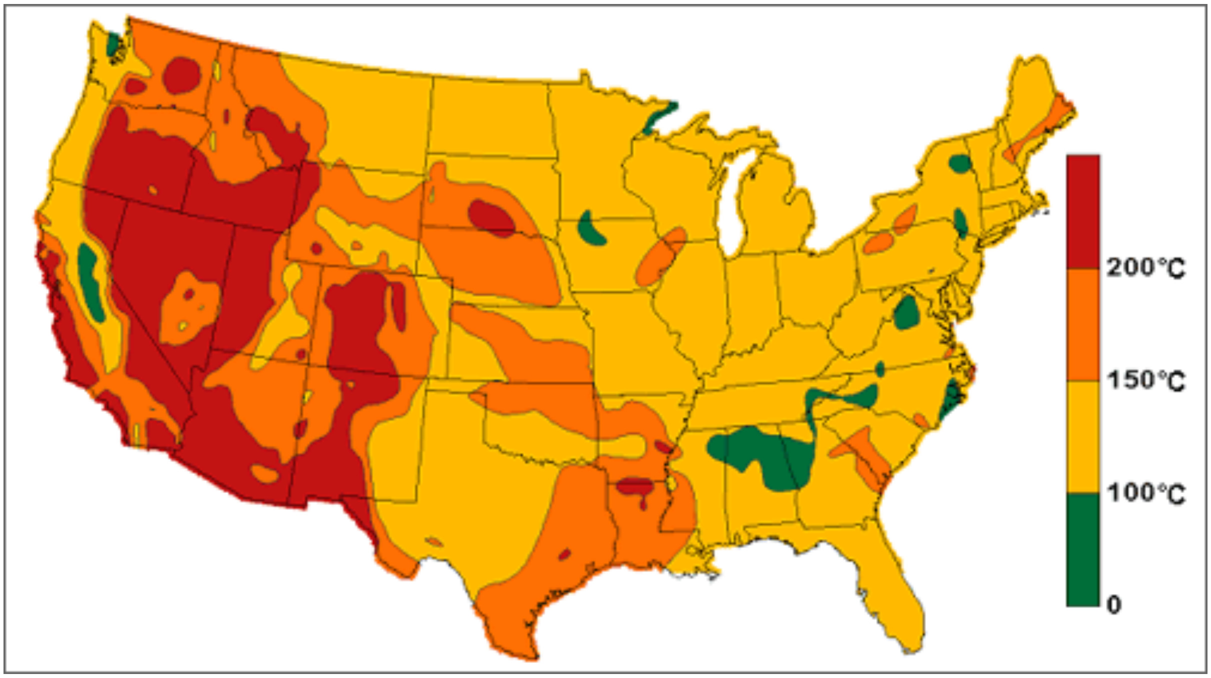


Figure B-12. US Geothermal Resource Map
(Source: http://www.eia.gov/energyexplained/index.cfm?page=geothermal_where)

Methane Gas from Landfills

Landfill gas consists of about 50% methane and 50% carbon dioxide and is produced in landfills as solid waste decomposes. The generation of landfill gas goes through four phases, with the last phase being the steady state generation of methane and carbon dioxide by methanogenic bacteria under anaerobic conditions (see Figure B-13). This typically occurs within one year after disposal of the solid waste, with peak generation after 5 - 7 years. The landfill will then continue to produce gas for approximately 20 - 30 years.[9]

[9] http://www.epa.gov/lmop/documents/pdfs/pdh_chapter1.pdf

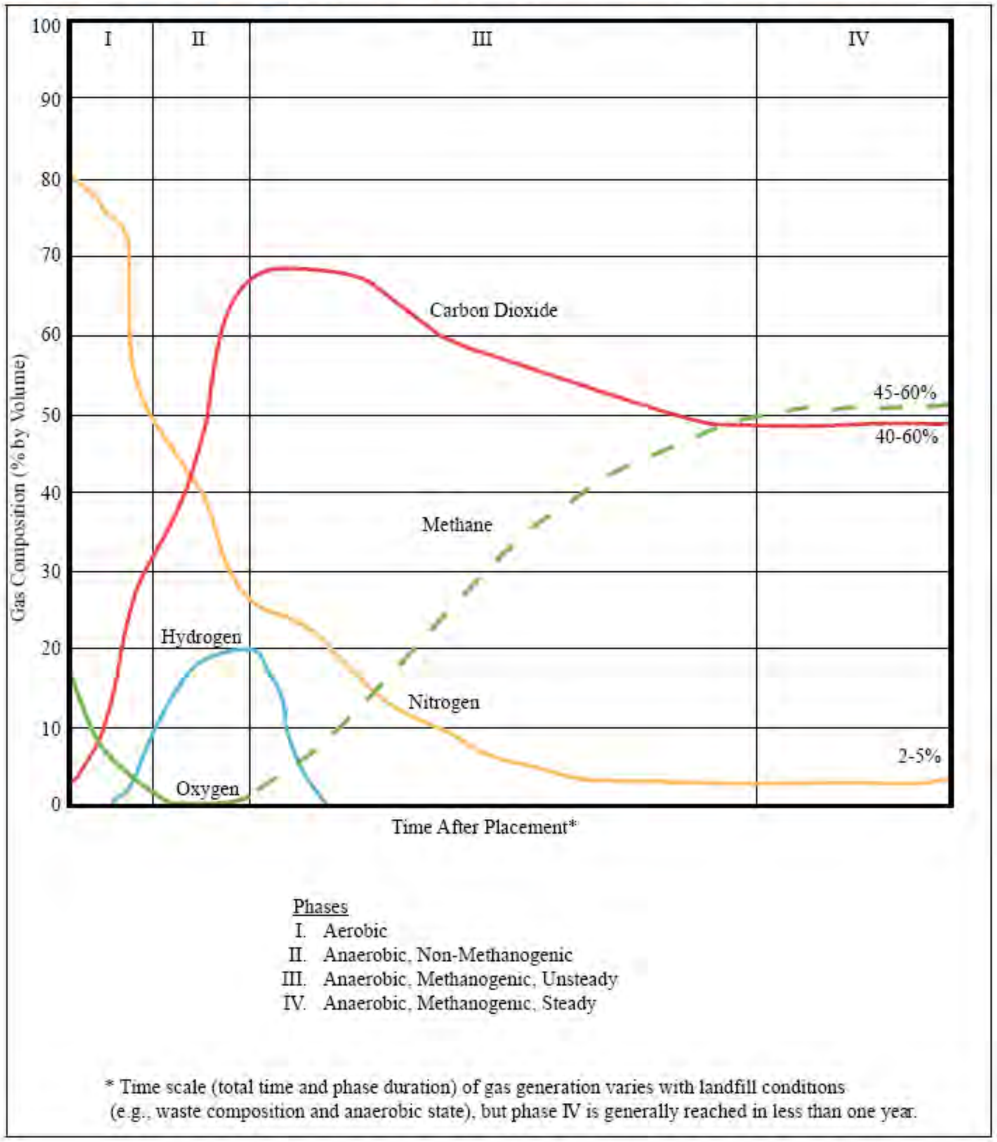


Figure B-13. Changes in Typical Landfill Gas Composition after Waste Placement
(Source: http://www.epa.gov/lmop/documents/pdfs/pdh_chapter1.pdf)

In 2008, approximately 250 million tons of municipal solid waste (MSW) was generated in the United States, with 54% being disposed of in landfills. For each one million tons of MSW, 432,000 ft^3/day of landfill gas is produced with a heating value of 500 BTUs per standard cubic foot. However, the quantity of MSW disposed of in landfills in Connecticut is significantly less than the national average. In FY2005, only 4% was disposed of in in-state landfills, while 57% was burned at six regional MWS Resource Recovery Facilities, 30% was recycled, and 9% was disposed out of state as shown in Figure B-14.

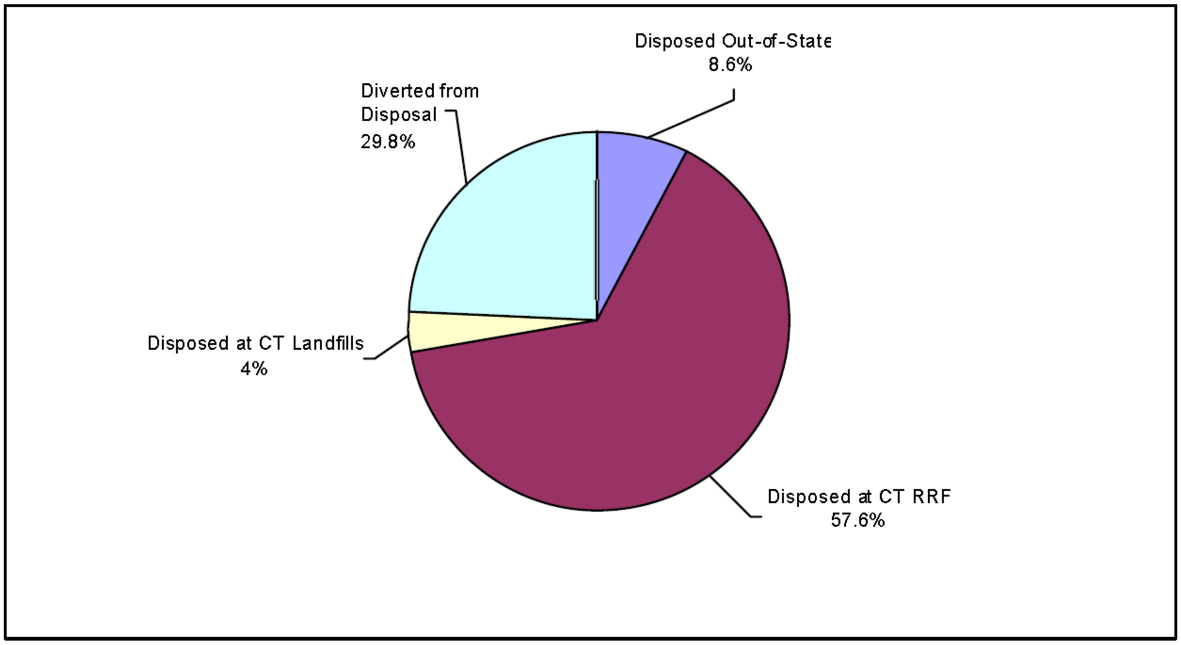


Figure B-14. Management of Connecticut MSW, FY2005; MSW Generated is Estimated at 3,805,000 tons (Source: Estimated by R.W. Beck based on FY2003 & FY2004 Data Reported to CT DEP and Estimate of Non-reported Recyclables
(Source: http://www.ct.gov/deep/lib/deep/waste_management_and_disposal/solid_waste_management_plan/swmp_final_chapters_and_execsummary.pdf)

There were 28 active landfill sites in Connecticut as of June 2013. A summary of the type of waste received at the active landfills is listed in Table B-2.

Table B-2. Summary of Active Landfill Sites in Connecticut as of June 2013
(Source: http://www.ct.gov/deep/cwp/view.asp?a=2718&q=325462&deepNav_GID=1646)

Type of Waste	Number of Active Landfills
Bulky Waste	20
Bulky Waste & Municipal Solid Waste	1
Bulky Waste & Special Waste	1
Ash	1
Special Waste & Ash	2
Special Waste	3

Closed landfills still present a significant opportunity for capturing landfill gas and generating electricity. As of 2012, MSW landfills accounted for 18.2% of human-released methane emissions in the United States and were the third largest source behind the natural gas and petroleum industry and agriculture.[10] The benefits of capturing landfill gas are

- reduction in methane emissions, a potent greenhouse gas;
- reduction in the use of non-renewable resources such as coal, natural gas, and oil through the use of a renewable resource;
- reduction in local air pollution and odors; and
- creation of jobs and local revenue.

To encourage the capture and use of landfill gas as a renewable energy source, EPA developed the Landfill Methane Outreach Program in 1994. As of October 2012, there were 605 operational energy projects in 48 states and the program estimates that another 400 additional landfills are good candidates for energy projects. Approximately 70% of the landfill gas projects generate electricity via internal combustion engines, turbines, and microturbines. Annually, landfill projects generate about 15 billion kWh of electricity and 100 billion ft^3 of landfill gas for direct use. Internal combustion engines with a generating capacity of less than 1 MW typically cost $2,300/kW to install and $210/kW for annual maintenance. Larger internal combustion systems cost about $1,700/kW to install and $180/kW annually to maintain.[11]

In Connecticut, there is 13 MW of installed landfill gas capacity. The 2014 Draft Integrated Resource Plan (IRP) predicts that no new landfill gas facilities will be constructed over the next 10 years.[12]

Run-of-the-River Hydropower

The three types of hydropower facilities are impoundment, run-of-the-river (or diversion), and pumped storage. Because of the negative environmental impact of hydropower facilities with impoundments, they are not classified as a Class I renewable energy resource and are not discussed in this section. Pumped storage is not a renewable energy resource but an energy storage technology that can provide advantages such as providing power during peak demand and supporting stability of the gird. It can also be used to complement intermittent energy resources such as solar and wind power to provide a consistent source of electricity generation.

Hydropower facilities have high capital costs but very low operating costs, with the total cost of producing power over the lifetime of the facility typically less than that of fossil fuel power plants. Within limits, hydropower facilities can increase or decrease their power production to meet changes in electricity demand. Hydropower facilities do not produce any air pollution or emit carbon dioxide. Furthermore, their "cradle to grave" greenhouse gas emissions, which include emissions related to construction and operation, can be less than most other types of electrical generation. Most of the detrimental effects of hydropower are focused on facilities

[10] http://www.epa.gov/methane/lmop/basic-info/index.html
[11] http://www.eesi.org/papers/view/fact-sheet-landfill-methane
[12] http://www.ct.gov/deep/lib/deep/energy/irp/2014appendices/2014_irp_appxd_draft.pdf

that have impoundments that are not associated with run-of-the-river facilities.[13] A run-of-the-river facility channels a portion of a river through a canal or penstock as shown in Figure B-15.

Figure B-15. Run of the River Hydropower Facility

(Source: http://energy.gov/eere/water/types-hydropower-plants)

As of 2010, there were 10 hydropower facilities in the state with generating capacities ranging from 70 kW (Bantam 1) to 41.5 MW (Shepaug 1).[14] The DOE considers a hydropower facility large if it is greater than 30 MW.

In 1995, DOE identified and assessed 68 hydropower sites in Connecticut. The study found that the potential capacities ranged from 6.5 kW - 10 MW with most of the sites having a capacity less than 1 MW.[15] Currently 5 MW of small hydropower capacity is installed in Connecticut, and no additional capacity is expected over the next 10 years according to the 2014 Draft IRP.[16]

Sustainable Biomass Facility

Biomass such as wood, plants, and agricultural waste can be used as a fuel sources for generating electricity using processes similar to those used with fossil fuels. These include the following:

[13] http://cga.ct.gov/2010/rpt/2010-R-0401.htm
[14] http://cga.ct.gov/2010/rpt/2010-R-0401.htm
[15] http://hydropower.id.doe.gov/resourceassessment/pdfs/states/ct.pdf
[16] http://www.ct.gov/deep/lib/deep/energy/irp/2014appendices/2014_irp_appxd_draft.pdf

- Direct Fired: This is the most common system, where biomass is directly burned to produce steam which then drives a turbine.
- Co-Fired: These systems mix biomass with fossil fuels in conventional power plants after some modification of the existing equipment.
- Gasification: Pyrolysis of the solid biomass converts it to a synthetic gas that is then burned in a conventional boiler or used in a gas turbine to generate electricity.

The advantages of biomass technologies[17] are:

- Biomass is available throughout the United States in locations where other renewable energy resources may be limited.
- Biomass can be transported and stored until use, so it can complement intermittent renewable energy resources such as solar and wind.
- Biomass facilities may be an attractive option for rural communities.

Proven technologies are available for using biomass as a fuel source for generating electricity from a SCEF in Connecticut. According to DEEP, there are two proposed biomass facilities in Connecticut. They are the Plainfield Renewable Energy project and the Watertown project.[18] There may be other opportunities for developing a biomass SCEF in Connecticut.

Wave or Tidal Power

Tidal and wave energy can be harnessed to generate electricity where changing tides, waves, or currents move a significant volume of water. DOE estimates that this resource has a potential of generating 1,400 terawatt hours of electricity per year (e.g., one terawatt hour is enough electricity to power 85,000 homes).[19]

In August 2013, DOE provided $16 million to fund 17 projects to increase reliability of wave and tidal devices by developing new drivetrain, generator, and structural components as well as software models that predict ocean conditions for optimizing power production, and gathering data on how devices interact with the surrounding environment.[20]

While wave or tidal power may in the future provide a valuable source of renewable distributed energy for use in coastal communities where the electricity is generated, it is presently not a viable commercial alternative.

Ocean Thermal Power

Ocean thermal energy conversion uses the heat stored in oceans to generate electricity. The process works best when the temperature difference between the warmer surface layer and the

[17] http://www.energy.gov/sites/prod/files/2014/04/f14/biopower_factsheet.pdf
[18] http://www.ct.gov/deep/cwp/view.asp?a=2708&q=323872&deepNav_GID=1763
[19] http://energy.gov/articles/energy-department-invests-16-million-harness-wave-and-tidal-energy
[20] http://energy.gov/articles/energy-department-invests-16-million-harness-wave-and-tidal-energy

colder, deep ocean water is about 20°C. These conditions exist in tropical coastal areas between the Tropic of Capricorn and Tropic of Cancer.[21]

Therefore, this is not a viable alternative for Connecticut and currently is not a viable commercial alternative even in tropical areas.

Complementary Technologies

Advanced Inverters

Solar inverters convert direct current (DC) power produced by PV cells to alternating current (AC) that is utilized by the electric grid. Traditional inverters have several shortcomings that can negatively impact the resiliency and reliability of the electricity system. Advanced, or smart, inverters include the following functionality to address the shortcomings of traditional inverters:

- Advanced inverters can distinguish between minor disturbances in voltage and frequency from a serious disturbance. Thus, a smart inverter will only disconnect when a severe change in voltage or frequency is detected. In contrast, traditional inverters will trip when a minor fluctuation in voltage or frequency is detected as required by Institute of Electrical and Electronics Engineers (IEEE) 1547 Interconnection Standard. This can lead to widespread and sudden disconnections that can destabilize the grid.
- Advanced inverters can produce and absorb reactive power along with real power. This increases the resiliency of the transmission network because voltage fluctuations that are detected at the distribution level can be counteracted, as compared to traditional inverters that can cause voltage fluctuations that may lead to damage of distribution and transmission assets.
- Advanced inverters provide real-time communication between grid operators and distributed solar PV installations. This enables grid operators to remotely disable functions and change voltage and frequency set points, thus increasing the resiliency of the grid.

The major barrier to deployment of advanced inverters on new projects and for upgrading existing solar PV installations has been the adoption of an updated IEEE 1547 standard. The original standard does not differentiate between traditional and advanced inverters so it requires all inverters to disconnect from the grid when a minor fluctuation in voltage or frequency is detected. To address this issue, a workshop was held in mid-2012 where it was agreed that IEEE 1547 would first be amended to address the top three highest priorities of voltage regulation, voltage ride through, and frequency ride through. Amendment 1 was published in May 2014 and now allows distributed energy resources to support these functions. This is accomplished by requiring a manufacturer to first specify the characteristics of its

[21] http://energy.gov/eere/energybasics/articles/ocean-thermal-energy-conversion-basics

inverter equipment and how the inverter will respond to changes in real and reactive power to support the grid. Operators of the distribution grid and the distributed energy resources then develop an operational plan where the distributed energy resources actively participate in regulating voltage when there are changes to real and reactive power. This will increase power quality and provide for a more robust grid because the operation of the distributed energy resource will be integrated with utility operating practices.[22]

The importance of adopting IEEE 1547 Amendment 1 and mandating advanced inverters for new solar PV installations is illustrated by the challenges and expense faced by Germany, where a significant penetration of distributed solar PV resources threatened to destabilize the grid. Instead of proactively mandating the use of advanced inverters that cost about $150 more than traditional inverters, millions of dollars were spent doing a mass replacement of traditional inverters with advanced inverters.[23]

Energy Storage Technologies

There are numerous energy storage technologies that are being developed that can increase electrical grid stability, reliability, and resilience. Historically, pumped-storage hydroelectricity (PSH) has been used to take advantage of the difference between the low value of electricity during nighttime hours and high value during peak demand periods. Today, advances in energy storage technologies have the potential to provide the following electrical grid benefits:

- Renewables Integration
    - Output variability (clouds, wind speed)
    - Time-related mismatch between generation and demand
- Electrical Grid Operations
    - Reserves or Back-Up Power
    - Momentary and hourly reconciliation reconciliation of electricity supply and demand to stabilize the AC frquency
    - "Voltage support" that is required to maintain grid voltage
- Electrical Grid Infrastructure
    - Reduces need for transmission and distribution equipment
- Off-Grid Electrication
- Electrification of the Transporation Sector

Types of Energy Storage Technologies

Energy storage technologies are generally divided into the following categories:

[22] http://www.osti.gov/scitech/servlets/purl/1166677
[23] http://cleanenergytransmission.org/wp-content/uploads/2014/08/Smart-Solar-Inverters.pdf

- Electrochemical – rechargeable batteries, flow batteries, and supercapacitors
- Other Chemical – hydrogen and power-to-gas
- Electrical – electromagnetic storage
- Mechanical – pumped-storage hydroelectricity, compressed air energy storage (CAES), flywheel energy storage

Table B-3 provides a description of each of these technologies and its efficiency, initial investment, and deployment examples. The range of market maturity is shown in Figure B-16 from early stages of research and development to demonstration and deployment to commercialization. The only electricity storage technology that is considered to be in the commercialization phase is PSH, with 140,000 MW capacity of global installed, grid-connected storage as of 2010. All of the other technologies combined have less than 1,000 MW capacity of grid-connected storage (Figure B-17).

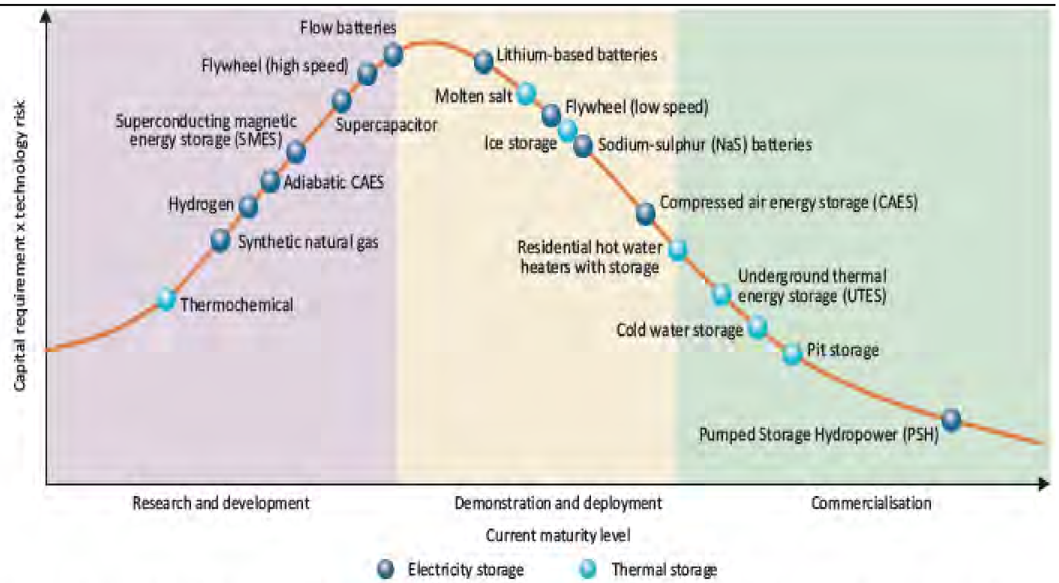
Table B-3. Energy Storage Technologies

(From: Dickens, Adam et al. "Energy Storage: Power to the People." HSBC Global Research. Sept 2014. Web 28 Jan. 2014. http://www.qualenergia.it/sites/default/files/articolo-doc/Energy%20Storage.pdf)

Classification	Method	Description	Efficiency (%)	Initial Investment (USD/kW)	Example Projects
Electrochemical	Rechargeable Battery	A rechargeable battery, also called a storage battery or accumulator, comprises one or more electrochemical cells, and is a type of energy accumulator	75-95	300-3500	NaS batteries (Presidio project, USA and Rokkasho Futamata Project, Japan), Vanadium redox flow (Sumimtomo's Densetsu, Japan), Lead-acid (Notrees Wind Storage Project, USA), Li-ion (AES Laurel Mountain, USA and Canada)
	Flow Battery	A flow battery is a type of rechargeable battery where recharge ability is provided by two chemical components dissolved in liquids contained within the system and separated by a membrane. Ion exchange occurs through the membrane while both liquids circulate in their own respective space.			
	Super-capacitors	Supercapacitors store the most energy per unit volume or mass among capacitors. They support volts up to 10,000 times that of electrolytic capacitors, but accept less than half as much power per unit time	90-95	130-515	Hybrid electric vehicles (R&D phase)
Other Chemical	Hydrogen	Hydrogen is not a primary energy source, but a portable energy storage method, because it must first be manufactured by other energy sources in order to be used. With intermittent renewables such as solar and wind, the output may be fed directly into an electricity grid.	22-50	500-750	Utsira Hydrogen Project (Norway), Energy Complementary Systems H2Herten (Germany)
	Power to Gas	This technology converts electrical power to a gas fuel. There are 2 methods; the first is to use the electricity for water splitting and inject the resulting hydrogen into the natural gas grid. The second is to convert carbon dioxide and water to methane. The excess power generated by wind generators or solar arrays is then used for load balancing in the energy grid.	22-50	130-515	E.ON/RWE/National Grid

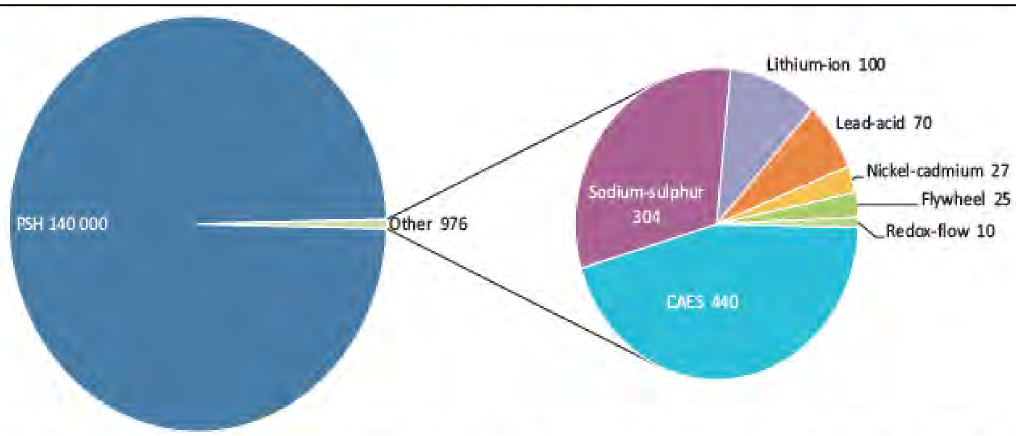
Electrical	Electro-magnetic Storage	Superconducting Magnetic Energy Storage (SMES) systems store energy in a magnetic field. Due to the energy requirements of refrigeration and the high cost of superconducting wire, SMES is currently used for short duration energy storage. Therefore, SMES is most commonly devoted to improving power quality. If SMES were to be used for utilities, it would be a diurnal storage device, charged from baseload power at night and meeting peak loads during the day.	90-95	130-515	D-SMES (US)
Mechanical	Pumped-Storage Hydro Electricity	This system works by accelerating a rotor (flywheel) to a very high speed and maintaining the energy in the system as rotational energy with the least friction loss possible. When energy is extracted from the system, the flywheel's rotational speed is reduced; adding energy to the system increases the speed of the flywheel.	50-85	500-4600	SSE Glendoe, GDF Dinorwic (Wales), Goldisthal Project (Germany), Okinawa Yanbaru Seawater PSH Facility (Japan), Pedreira PSH Station (Brazil)
	Compressed Air Energy Storage	This technology stores low-cost off-peak energy, in the form of compressed air, in an underground reservoir. The air is then released during peak load hours and heated with the exhaust heat of a standard combustion turbine. This heated air is converted to energy through expansion turbines to produce electricity.	27-70	500-1500	McIntosh (Alabama, USA), Huntorf (Germany)
	Flywheel Energy Storage (low speed)	At times of low demand, excess generation capacity is used to pump water from a lower source into a higher reservoir. During higher demand, water is released back into a lower reservoir through a turbine, generating electricity. Worldwide, pumped-storage hydroelectricity is the largest-capacity form of grid energy storage.	90-95	130-500	PJM Project (USA)

Source: IEA (2014a), Energy Technology Perspectives, forthcoming, OECD/IEA, Paris, France. IEA (2011), Technology Roadmap: Energy Efficient Buildings: Heating and Cooling Equipment, OECD/IEA, Paris, France. Black & Veatch (2012), "Cost and performance data for power generation technologies", Cost Report, Black & Veatch, February. EPRI (Electric Power Research Institute) (2010), "Electrical Energy Storage Technology Options", Report, EPRI, Palo Alto, California. Eyer, J. and G. Corey, (2010), "Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide", Sandia National Laboratory, Albuquerque, NM, United States. IEAETSAP and IRENA (2013), "Thermal Energy Storage" Technology Brief E17, Bonn, Germany. IEA-ETSAP (Energy Technology Systems Analysis Programme) and IRENA (International Renewable Energy Agency) (2012), "Electricity Storage", Technology Policy Brief E18, Bonn, Germany. "Power Tower Technology Roadmap and Cost Reduction Plan", Sandia National Laboratories (2011), Albuquerque, NM and Livermore, CA, United States.



Source: Decourt, B. and R. Debarre (2013), "Electricity storage", *Factbook*, Schlumberger Business Consulting Energy Institute, Paris, France and Paksoy, H. (2013), "Thermal Energy Storage Today" presented at the IEA Energy Storage Technology Roadmap Stakeholder Engagement Workshop, Paris, France, 14 February.

Figure B-16. Maturity of Storage Technologies
(Source: Dickens, Adam et al. "Energy Storage: Power to the People." HSBC Global Rese
Sept 2014. Web 28 Jan. 2014.
http://www.qualenergia.it/sites/default/files/articolo-doc/Energy%20Storage.pdf



Source: IEA analysis and EPRI (Electric Power Research Institute) (2010), "Electrical Energy Storage Technology Options", Report, EPRI, Palo Alto, California.

Figure B-17. Current Global Installed Grid-Connected Electricity Storage Capacity (M
(Source: Dickens, Adam et al. "Energy Storage: Power to the People." HSBC Global Rese
Sept 2014. Web 28 Jan. 2014.
http://www.qualenergia.it/sites/default/files/articolo-doc/Energy%20Storage.pdf

Batteries

Lead-acid, lithium-ion, sodium-sulfur, and vanadium-redox are the the most developed of the battery storage technologies. A summary of the life-cycle stage, installation cost, levelized cost of energy (LCOE), energy density, cycle life, and its advantages / disadvantages are listed in Table B-4. In general, the installation cost and operating cost of LCOE are relatively high despite the sharp reduction in these costs over the last few years. For example, the average installation cost for battery storage has decreased from $8,000/kW in 2009 to $4,500/kW in 2013 to $3,300/kW in the first quarter of 2014. The DOE's SunShot Initiative has targeted an installed cost of $1,500/kW for rooftop solar PV and $1,000/kW for utiliy-sized systems. Currently, lithium batteries tend to be less expensive to install, but have higher LCOE because of lower usable storage capacity, higher maintenance cost, and degradation of capacity. Sodium sulfur batteries have lower LCOE, but have safety concerns related to their high operating temperature.

Power Applications and Energy Supply/Demand Management

An energy storage system can also be classified based on whether it provides power application benefits (e,g., fast response, frquency regulation and voltage support), energy supply and demand management (e.g., peak demand for electricity is reduced to relieve supply pressures, or supply availability is time-shifted to better match demand profiles), and/or distributed energy storage. The power applications required are very short-term response times of seconds, while the energy supply and demand management require long-term response times of minutes to hours. The discharge time and size for various energy storage technologies are described as follows (also see Figure B-18):

- Short-term storage technologies include supercapcitors and superconducting magnetic energy storage (SMES) and flywheels. These energy storage devices in general have high power densities and high cycle life but low energy densities. Thus, they are best suited for supplying short bursts of electricity into the grid for power applications.

- Long-term storage technologies include PSH and CAES. There are two operating commercial CAES systems. One is in McIntosh, Alabama, where flue gas from a natural gas power plant is used for preheating the compressed air to increase the overall power plant efficiency during peak load hours. Hydrogen storage is also a long-term storage technology where electricity is converted to hydrogen via electrolysis. This technology has high energy density, quick response times, and potential for large-scale energy storage applications. However, hydrogen storage technologies have high capital costs, low efficiencies, and lack of infrastructure for large-scale applications (e.g., hydrogen storage for fuel-cell vehicles).

- Disbributed battery storage technologies can be used for both short- and long-term applications. The benefits are that the battery storage systems are highly scaleable, efficient, can be installed throughout the electrical grid system, and have achieved limited deployment in distributed and centralized systems for both mobile and stationary applications. Current challenges to further use are energy density, power performance, lifetime, charging capabilites, and cost.

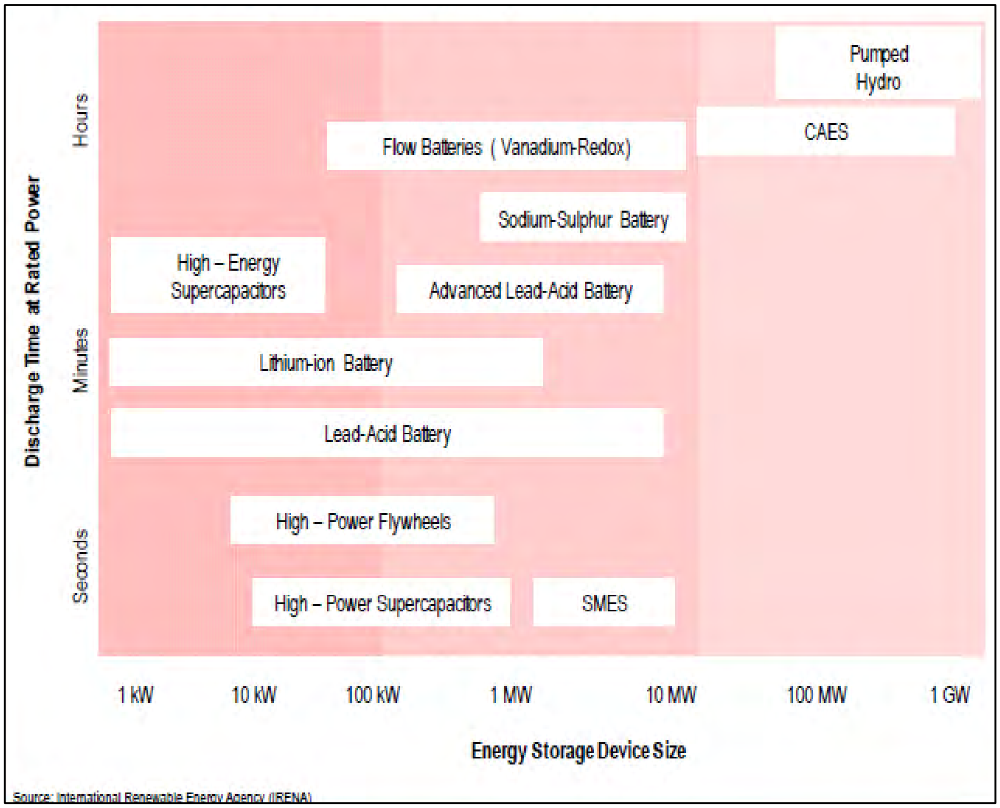


Figure B-18. Energy Storage Technology Size and Discharge Time
(Source: Dickens, Adam et al. "Energy Storage: Power to the People." HSBC Global Research. Sept 2014. Web 28 Jan. 2014. http://www.qualenergia.it/sites/default/files/articolo-doc/Energy%20Storage.pdf)

Table B-4. Battery Storage Technologies

From: Dickens, Adam et al. "Energy Storage: Power to the People." HSBC Global Research. Sept 2014. Web 28 Jan. 2014; http://www.qualenergia.it/sites/default/files/articolo-doc/Energy%20Storage.pdf

Source: International Energy Agency, European Association for Storage of Energy, DOE, Electric Power Research Institute installation costs are the rounded numbers calculated from EUR/kWh data

Type of Battery	Life-cycle Stage	Installed Cost (USD/kW)	LCOE (USD/ MWh)	Duration (hrs)	Efficiency	Energy Density (Wh/L)	Lifetime (cycles)	Advantages	Disadvantages
Lead-Acid	Most mature, most applied	3,700 - 10,500	230 - 600	5	70-85	60-100	800-1,500	Low installation cost; Raw material abundance; High recycle content	Usable capacity reduces when power is discharged; Lead is considered a hazardous material
Lithium-Ion	Mature but relatively new	1,500 - 7,500	640 – 1,150	0.25 - 1	90-95	150-450	800-3,000	Highest efficiency among technologies; Any discharge time from seconds to weeks can be realized; hence a flexible and universal technology	High running cost due to special packaging and internal overcharge protection circuits; Safety considerations
Sodium-Sulfur	Recently developed	5,750 - 6,550	260 - 295	6	85-90	120-180	4,000-5,000	Relatively high efficiency; Fast response to changing loads	To maintain operating temperature, a heat source is required, which uses the battery's own stored energy, partially reducing the battery's performance
Vanadium-Redox	Relatively mature among the still developing flow batteries	6,100 – 9,200	440 - 810	5	70-75	75-80	10,000	Longest lifetime cycles; Use of ions of the same metal on both sides of the battery ensures reduced degradation of electrolytes	Not mature for commercial scale development; Complicated design

APPENDIX C
STUDY COMMITTEE MEETINGS AND GUEST SPEAKERS

The following is a list of study committee meetings, including presentations given to the CASE study committee by guest speakers and the CASE Research Team. In the electronic version of this report, links to meeting presentations are highlighted in blue.

October 24, 2014 – MEETING 1

- **Welcome, Introductions, and Study Overview**
  Richard H. Strauss, Executive Director, CASE
- **Presentation – Research Team**
  Alissa DeJonge, Study Manager and Vice President of Research, CERC
  - Research Plan Overview
  - Overview of Shared Clean Energy Facility Model
  - 2014 CT Legislative History
  - Discussion on Best Practices

  Presentation Materials
- **Study Committee Member Karl Rabago**, JD, Executive Director, Pace Energy and Climate Center, Pace Law School and **Jordan Gerow**, Energy and Climate Law Advisor
  Topic: Key Points to Consider and Guidance to Share – Presentation Materials
- **Guest Speakers, Massachusetts Department of Energy Resources**
  Emma Krause, Program Coordinator, Rooftop Solar Challenge – Presentation Materials
  Topic: Current Community Shared Solar Program; Rooftop Solar Challenge
- **Mike Judge**, Associate Renewable Portfolio Standard Program Manager
  Topic: Design of MA's Community Shared Solar Program in SREC-II
  Presentation Materials
- Committee Discussion and Next Steps

November 18, 2014 – MEETING 2

- **Welcome and Introductions**
  Richard H. Strauss, Executive Director, CASE
- **Guest Speaker, Anna Brockway,** SunShot Fellow, Solar Technologies Office**,** US Department of Energy – Presentation Materials
  Topics: Community Shared Solar: Federal Initiatives, Best Practices, and Issues to Consider

- **Guest Speaker, John Farrell,** Director of Democratic Energy, Institute for Local Self-Reliance – Presentation Materials
  Topic: Community Solar Power: Obstacles and Opportunities
- **Guest Speaker, Jason Coughlin**, National Renewable Energy Laboratory, Deployment and Market Transformation – Presentation Materials
  Topic: Summary - A Guide to Community Shared Solar
- **Research Team Update: Alissa DeJonge,** Study Manager – Presentation Materials
- Next Steps

December 19, 2014 – MEETING 3

- **Welcome and Introductions**
  Richard H. Strauss, Executive Director, CASE
- **Guest Speakers,** ISO New England
  Mary Louis "Weezie" Nuara, External Affairs Representative
  Eric Wilkinson, Senior External Affairs Representative
  Topic: ISO New England – Presentation Materials
- **Research Team Update, Alissa DeJonge,** Study Manager – Presentation Materials
- **Guest Speaker, Richard Perez,** PhD, Atmospheric Sciences Research Center**,** University of Albany – Presentation Materials
  Topic: Community Shared Solar - Current Research
- **Guest Speaker, Erica Schroeder McConnell, Esq.,** Keyes, Fox & Wiedman LLP on behalf of the Interstate Renewable Energy Council, Inc. – Presentation Materials
  Topic: Best Practices for Community Shared Solar
- **Next Steps**

January 5, 2015 – MEETING 4

- Welcome and Introductions
  Richard H. Strauss, Executive Director, CASE
- **Guest Speakers,** Eversource Energy – Presentation Materials
  Einat Dorobantu, Director, System Resiliency and Strategy
  Charles Goodwin, Director, Rates & Forecasting
  Camilo Serna, Vice President Strategy & Policy
  Topic: Eversource Energy*'s Perspectives on Distributed Energy Resources in Connecticut*
- **Guest Speaker,** United Illuminating – Presentation Materials
  Roddy Diotalevi, Senior Director of Sales and Business Development
  Topic: UIL Holdings Presentation

- **Research Team, Dave Pines, Study Advisor,** Professor, Civil and Environmental Engineering, University of Hartford – Presentation Materials
  Topic: Shared Clean Energy – Review of Class 1 Renewables

- **Study Committee**
  Richard H. Strauss, Executive Director, CASE
  Topic: Brainstorming Discussion – Preliminary Recommendations

- Next Steps

January 23, 2015 – MEETING 5

- Welcome and Introductions
  Richard H. Strauss, Executive Director, CASE

- **Guest Speaker, Lena Hansen**, Principal, Rocky Mountain Institute
  Presentation Materials
  Topic: Bridges to New Solar Business Models: Opportunities to Increase and Capture the Value of Distributed Solar Photovoltaics

- **Research Team Update, Alissa DeJonge, Study Manager** – Presentation Materials

- **Guest Speaker, Tom Hunt,** Director of Research and Government Affairs, Clean Energy Collective - Presentation Materials
  Topic: Implementation of Shared Clean Energy

- **Guest Speakers**, Hawaii State Energy Office, Department of Business, Economic Development and Tourism -
  Mark Glick, Hawaii State Energy Office Administrator
  Veronica Rocha, Renewable Energy Branch Manager
  Rocky Mould, Energy Analyst
  Topic: Supporting Hawaii's Clean Energy Transformation
  Presentation Materials

- **Study Committee**
  Richard H. Strauss, Executive Director, CASE
  Topic: Brainstorming Discussion Continued – Preliminary Recommendations

- Next Steps

APPENDIX D
STATE BY STATE COMPARISON OF SCEF LEGISLATIVE PROVISIONS

STATE: CALIFORNIA

Year: 2011 (with 2013 explicit addition of community net metering in Senate Bill 43)
Eligible Technology: Renewables
Utilities ownership: Yes; utilities may own SCEFs/can use SCEF credits to meet Renewable Portfolio requirements
Third party ownership: Yes
Same utility service territory: Yes
Limit on # of SCEFs (system size): Total generation limited to 2 GW
Entry size: At least 2 participants. Electric company owner must have 100K or more service connections in service area
Single SCEF size limit: 20 MW or less
Credits: Monetary bill credit
Credit price set: No
Credit valuation: Based on retail rate until value-added method study done
REC ownership: Not addressed
Limits on bill offset: Up to full bill offset, any overage must be carried over to next month
Disposition of excess unsubscribed SCEF generation: Electric company must purchase at "current default load aggregation point"
Disposition of Subscriber's excess credits: Must be carried over to next billing cycle
Portability: Yes
Transferability: Yes
Financing: Not addressed
Economic incentives: Not addressed
Consumer protections: Extensive; Participant (Subscriber) organization must disclose to consumer: estimate of annual kWh to be delivered; plain language description of bill credit method, transfer/sale of credits, and costs/benefits expected based on participant's (subscriber's) current usage. Electric company must comply with commercial free speech requirements
Low-income subscribers: Not addressed
Pilot program: Not addressed
Program duration: Electric companies meeting entry size above must offer net metering until program limits are reached or July 1, 2017, whichever comes first
Other notes: California Public Utilities Commission recently adopted multi-tenant rules for expanding program to affordable housing, to be offered until 2019
State: Colorado
Year: 2010 (Community Solar Gardens Act) (Colorado House Bill 10-1342)
Eligible Technology: Solar
Utilities ownership: Yes; utilities may own SCEFs
Third party ownership: Yes
Same utility service territory: Yes
Limit on # of SCEFs (system size): Not addressed

Entry size: At least 10 subscribers; at least 1 kW each
Single SCEF size limit: 2 MW or less
Credits: Monetary bill credit
Credit price set: No
Credit valuation: Based on retail rate but utility may make reasonable charges for delivery, integration and administration costs
REC ownership: Not addressed
Limits on bill offset: No more than 120% of average annual consumption of each subscriber
Disposition of unsubscribed SCEF generation: Utility shall purchase it (and corresponding RECs) at "average hourly incremental cost of electricity supply over the immediately preceding calendar year"
Disposition of Subscriber's excess credits: Indefinite carryover
Portability: Yes
Transferability: Yes
Financing: Rulemaking must address financing, i.e., minimum capitalization, limits on ownership, leasing terms etc.
Economic incentives: Utilities may be eligible for any incentive payments as set by the Colorado Public Utilities Commission
Consumer protections: Not addressed
Low-income subscribers: 5% of each project has to be available to low-income customers. Each utility that wants to invest needs to submit a plan for how it will include low income customers as subscribers
Pilot program: Not addressed
Program duration: Not addressed

STATE: CONNECTICUT (PROPOSED; NOT ADOPTED)

Year: Proposed 2014 (Senate Bill 353)
Eligible Technology: Renewables
Utilities ownership: Not addressed
Third party ownership: Yes
Same utility service territory: Yes. At least one selected SCEF shall be located in each electric company's service territory*
Limit on # of SCEFs (system size): 6 MW in the aggregate*
Entry size: At least 2 subscribers
Single SCEF size limit: 2MW or less
Credits: Monetary bill credit
Credit price set: Billing credit shall not exceed $0.14 per kWh*
Credit valuation: DEEP and CGB to study cost/benefits and PURA to use that study when setting rates
REC ownership: Subscriber organization or third party under contract with subscriber organization, unless separately contracted for
Limits on bill offset: Limit of 100% of subscriber's own consumption, based on prior 12 months; Period of the billing credit shall not exceed 15 years*
Disposition of unsubscribed SCEF generation: Not addressed
Disposition of Subscriber's excess credits: Not addressed
Portability: Not addressed
Transferability: Not addressed
Financing: Not addressed

Economic incentives: Not addressed
Consumer protections: DEEP is to consult with OCC to establish these (especially disclosures to be delivered when selling/reselling subscriptions) for the pilot program*
Low-income subscribers: Not addressed
*Pilot program: DEEP, CGB and electric distribution companies shall establish a pilot program
Program duration: DEEP and CGB shall report to the General Assembly by January 1, 2016, including a recommendation as to whether a permanent program for SCEF should be established
Other notes: Billing credits and other costs of the pilot program shall be recoverable by the EDC through federally mandated congestion charges

STATE: DELAWARE

Year: 2010
Eligible Technology: Renewables (solar, wind, ocean, geothermal, hydro, fuel cell from renewables)
Utilities ownership: Not addressed
Third party ownership: Yes
Same utility service territory: Yes
Limit on # of SCEFs (system size): Not addressed
Entry size: Not addressed
Single SCEF size limit: SCEF shall not exceed the sum total of the net metering capacity limits applicable to individual customers participating as subscribers: 25 kW for residential customers and 2 MW per meter for non-residential customers. Also, design limit of 110% of host customer expected consumption
Credits: kWh bill credit or electric company may elect to make a direct monetary payment. At the end of annual billing period, host community may request direct monetary payment for outstanding credits
Credit price set: No
Credit valuation: According to host customer account's supply service rate schedule, but excluding any fixed charges
REC ownership: Individual customers own RECs unless they have otherwise contracted
Limits on bill offset: 110% of host customer's expected consumption, based on the past two 12 months of usage. For new construction, an estimate of 110% based on usage by units of similar size and type
Disposition of unsubscribed SCEF generation: Not addressed
Disposition of Subscriber's excess credits: at the end of annualized billing period host customer may request payment for excess credits
Portability: Not addressed
Transferability: Yes
Financing: Applicant must demonstrate minimum unencumbered $100K cash or cash equivalents
Economic incentives: Not addressed
Consumer protections: Extensive. Financial (disclose prior bankruptcies), operational, managerial and technical abilities must be demonstrated; terms of contracts/ individual bills required; no telemarketing
Low-income subscribers: Not addressed
Pilot program: Not addressed
Program duration: Not addressed

Other notes: Requirements necessary to permit interconnections between SCEF and electric supplier shall be considered using IREC interconnection rules and DOE best practices. Electric suppliers shall not require installation of excessive controls, performance or payment for unnecessary tests or excessive liability insurance.

JURISDICTION: DISTRICT OF COLUMBIA

Year: 2013; Community Renewable Energy Act of 2013
Eligible Technology: Renewables
Utilities ownership: Not addressed
Third party ownership: Yes
Same utility service territory: Yes
Limit on # of SCEFs (system size): Not addressed
Entry size: 2 or more subscribers (retail customers)
Single SCEF size limit: 5 MW. No SCEF may sell subscriptions totaling more than 100% of its energy
Credits: Monetary bill credit
Credit price set: No
Credit valuation: Shall be equal to the standard offer service rate for General Service Low Voltage Non-Demand customer class, as determined by the District of Columbia Public Service Commission
REC ownership: Subscriber organization owns RECs, unless they were separately contracted for
Limits on bill offset: No limit on carry forward, but may not exceed 120% of subscriber's consumption over last 12 months
Disposition of unsubscribed SCEF generation: Becomes property of electric company, purchased at "locational marginal price, adjusted for ancillary service charges"
Disposition of Subscriber's excess credits: No limit on carryforward
Portability: Yes
Transferability: Yes
Financing: Not addressed
Economic incentives: Not addressed
Consumer protections: Mandated disclosures to potential subscribers includes good faith estimate of annual kWh to be generated from subscriber's interest, and plain descriptions of bill credit calculation, subscription sale or transfer rights and the contract's costs and benefits based on current usage and tariff. Also, subscribers shall continue to receive credits from generation, regardless of bankruptcy or default of subscriber organization or another subscriber.
Low-income subscribers: District Department of the Environment shall encourage developers to promote interest ownership and participation by low- to moderate-income retail electric customers
Pilot program: Not addressed
Program duration: Not addressed.
Other notes: District of Columbia Public Service Commission shall establish additional rules regarding safety and performance standards and may adopt rules for control and testing requirements for SCEFs, to protect public safety and system reliability

STATE: MAINE

Year: 2009 (as later expanded by Maine Public Utilities Commission rulemaking)
Eligible Technology: Renewables (solar, wind, biomass, hydroelectric, geothermal electric, fuel cell, solid waste, tidal energy, etc.)

Utilities ownership: Not addressed. But Maine differentiates between investor-owned and consumer-owned utilities; the former type is required to permit shared ownership in net billing arrangements and the latter may permit them but is not required to do so
Third party ownership: Not addressed
Same utility service territory: Yes
Limit on # of SCEFs (system size): A utility shall notify the Maine Public Utilities Commission if cumulative generation reaches 1.0% of peak demand. The commission will then determine whether net billing should be continued or modified
Entry size: SCEF may designate up to 10 accounts for shared ownership net energy billing
Single SCEF size limit: 660 kW for SCEF in service territory of an investor-owned utility and 100 kW for SCEF in service territory of a consumer-owned utility
Credits: Monetary bill credit
Credit price set: No
Credit valuation: Credits are based on kWh usage and all other non-usage charges for the rate class apply
REC ownership: Not addressed
Limits on bill offset: No limit, but credits must be used within 12 months; after 12 months, any remaining net generation is granted to the utility, with no compensation to the customer
Disposition of excess: Excess credits are transferred to the utility
Disposition of unsubscribed SCEF generation: Excess credits are transferred to the utility
Disposition of excess credits to Subscriber at end of the annual billing cycle: Excess credits are transferred to the utility
Portability: Not addressed
Transferability: Not addressed
Financing: Not addressed
Economic incentives: Not addressed
Consumer protections: Net billing is specifically exempt from sales and use taxes
Low-income subscribers: Not addressed
Pilot program: Not addressed
Program duration: Program reassessed for each utility after 1% of peak demand reached
Other notes: By February 15, 2015, Maine DPUC must prepare a report regarding the value of distributed solar energy generation. Shared ownership customers must have a legally enforceable ownership interest in the SCEF in order to take part in the benefits of the SCEF's output.

STATE: MASSACHUSETTS

Year: 2008 (with 2014 update *H. 4185: An Act Relative to Net Metering and Solar Power)*
Eligible Technology: Renewables; Net Energy Metering (by Group Host) Green Communities Act
Utilities ownership: Net metering facility may not be an electric utility or generator as defined in Act
Third party ownership: Yes
Same utility service territory: Yes
Limit on # of SCEFs (system size): Not addressed
Entry size: For neighborhood net metering program, at least 10 residential customers
Single SCEF size limit: 2 MW or less
Credits: Monetary bill credit
Credit price set: No

Credit valuation: Utility can exclude distribution costs from retail rate credit
REC ownership: Not addressed
Limits on bill offset: Credits may carry forward with no expiration
Disposition of unsubscribed SCEF generation: Electric distribution company can elect (for facilities over 1 MW) to apply credits to accounts or make payment to host customer
Disposition of Subscriber's excess credits: Credits may carry forward with no expiration
Portability: Not addressed
Transferability: Not addressed
Financing: Not addressed
Economic incentives: Not addressed
Consumer protections: Not addressed
Low-income subscribers: Not addressed
Pilot program: Not addressed
Program duration: Not addressed
Other notes: The 2014 update established the Commonwealth Solar Incentive Program, setting a goal of 1,600 MW generation by December 31, 2020. A Net Metering task force must deliver recommendations by March 31, 2015. Commonwealth of Massachusetts Department of Public Utilities charged with studying net metering electricity from small hydro facilities.

STATE: MINNESOTA

Year: 2013
Eligible Technology: Solar "Community Solar Garden"
Utilities ownership: Yes; utilities may own SCEFs
Third party ownership: Yes
Same utility service territory: Yes
Limit on # of SCEFs (system size): Not addressed
Entry size: At least 5 subscribers, with no subscriber having more than a 40% interest
Single SCEF size limit: 1 MW or less; each subscription must be at least 200 W
Credits: Monetary bill credit
Credit price set: No
Credit valuation: Not addressed, but utility may charge reasonable interconnection fees. House Bill 729 enacted in 2013 requires the Department of Commerce to develop a "value of solar" model for the Minnesota Public Utilities Commission to utilize REC ownership:
Limits on bill offset: No more than 120% of current bill
Disposition of unsubscribed SCEF generation: Public utility must purchase at distributed solar value, or, until that rate has been approved, at applicable retail rate
Disposition of Subscriber's excess credits: Credits carry over for 12 months, then at the end of February, "balance will be eliminated" and new cycle started March 1
Portability: Not addressed
Transferability: Not addressed
Financing: Minnesota Public Utilities Commission must consider and reasonably allow for financing of community solar gardens
Economic incentives: Same as residential program: "value of solar" tariff, solar energy incentive program, and made in Minnesota solar energy production incentive
Consumer protections: Any plan must include proposed consumer disclosures information
Low-income subscribers: Not addressed
Pilot program: Not addressed
Program duration: Not addressed

STATE: NEW HAMPSHIRE

Year: 2013
Eligible Technology: Not specified; Net Energy Metering (by Group Host)
Utilities ownership: Not addressed
Third party ownership: Not addressed
Same utility service territory: Yes
Limit on # of SCEFs (system size): Total of 50 MW times the utility's proportion of 2010 peak demand
Entry size: Up to 100kW in peak output
Single SCEF size limit: Up to 100 kW in peak output
Credits: Monetary bill credit
Credit price set: No
Credit valuation: Rate-based or based on utility's avoided costs for energy and capacity, as New Hampshire Public Utilities Commission determines
REC ownership: Property of the consumer-generator until sold or transferred
Limits on bill offset: Not addressed, but commission may set credit requirements
Disposition of unsubscribed SCEF generation: Group host must be paid for surplus generation, at utility's avoided cost or default service rate
Disposition of Subscriber's excess credits: By agreement between Subscriber and group host
Portability: Not addressed
Transferability: Not addressed
Financing: Not addressed
Economic incentives: Renewable energy credits are the property of the consumer-generator until they are sold or transferred
Consumer protections: Not addressed
Low-income subscribers: Not addressed
Pilot program: Not addressed
Program duration: Not addressed

STATE: VERMONT

Year: 2011 (Vermont Energy Act of 2011, H.56, enacted May 25, 2011); Net Energy Metering (by Group Host)
Eligible Technology: Renewables
Utilities ownership: Net metering not available to Host Customer who is an electric company
Third party ownership: Not addressed
Same utility service territory: Yes
Limit on # of SCEFs (system size): 4% of the distribution company's highest peak load
Entry size: For residential program, 2 or more customers
Single SCEF size limit: Class I 500 kW or less; Class II and III 2 MW or less
Credits: Monetary bill credit
Credit price set: $0.20 minus the highest residential rate per kWh charged by the company, unless modified by the public service board
Credit valuation: Rate-based; distribution company may include default service charge, distribution charge, transmission charge and transition charge.
REC ownership: Customer owns, but any contract may permit all or a portion of RECs to be transferred to electric company
Limits on bill offset: No limit but credit can only be carried forward for 12 months

Disposition of unsubscribed SCEF generation: Distribution company must issue credits to each member of the group; excess reverts to electric company
Disposition of Subscriber's excess credits: Credits can be carried forward 12 months, then unused revert to electric company, with no compensation
Portability: Not addressed
Transferability: Not addressed
Financing: Clean Energy Development Fund; Property-Assessed Clean Energy (PACE) Program financing allows borrowing for energy improvements. Amount typically repaid via 20 year special assessment.
Economic incentives: Not addressed
Consumer protections: Not addressed
Low income subscribers: Not addressed
Pilot Program: Not addressed
Program Duration: Each system shall receive credits for not less than 10 years after the date of offer acceptance
Other notes: Vermont legislation contains renewables targets expressed as a percentage of each retail electricity provider's annual sales, and in 2032 energy from renewables should make up 75% of each such provider's annual electricity sales.

MAJOR STUDIES OF THE ACADEMY

2015

- Methods to Measure Phosphorus and Make Future Predictions

2014

- Energy Efficiency and Reliability Solutions for Rail Operations and Facilities
- Connecticut Biomedical Research Program: Analysis of Key Accomplishments
- Peer Review of a CL&P/UConn Report Concerning Emergency Preparedness and Response at Selective Critical Facilities
- Connecticut Disparity Study: Phase 2

2013

- Analyzing the Economic Impact of Transportation Projects
- Health Impact Assessments Study
- Connecticut Disparity Study: Phase I
- Connecticut Stem Cell Research Program Accomplishments

2012

- Strategies for Evaluating the Effectiveness of Programs and Resources for Assuring Connecticut's Skilled Workforce Meets the Needs of Business and Industry Today and in the Future
- Benchmarking Connecticut's Transportation Infrastructure Capital Program with Other States
- Alternative Methods for Safety Analysis and Intervention for Contracting Commercial Vehicles and Drivers in Connecticut

2011

- Advances in Nuclear Power Technology
- Guidelines for the Development of a Strategic Plan for Accessibility to and Adoption of Broadband Services in Connecticut

2010

- Environmental Mitigation Alternatives for Transportation Projects in Connecticut
- The Design-Build Contracting Methodology for Transportation Projects: A Review of Practice and Evaluation for Connecticut Applications
- Peer Review of an Evaluation of the Health and Environmental Impacts Associated with Synthetic Turf Playing Fields

2009

- A Study of the Feasibility of Utilizing Waste Heat from Central Electric Power Generating Stations and Potential Applications
- Independent Monitor Report: Implementation of the UCHC Study Recommendations

2008

- Preparing for Connecticut's Energy Future
- Applying Transportation Asset Management in Connecticut
- A Study of Weigh and Inspection Station Technologies
- A Needs-Based Analysis of the University of Connecticut Health Center Facilities Plan

2007

- A Study of the Feasibility of Utilizing Fuel Cells to Generate Power for the New Haven Rail Line
- Guidelines for Developing a Strategic Plan for Connecticut's Stem Cell Research Program

2006

- Energy Alternatives and Conservation
- Evaluating the Impact of Supplementary Science, Technology, Engineering and Mathematics Educational Programs
- Advanced Communications Technologies
- Preparing for the Hydrogen Economy: Transportation
- Improving Winter Highway Maintenance: Case Studies for Connecticut's Consideration

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Connecticut Academy of Science and Engineering

The Connecticut Academy is a non-profit institution patterned after the National Academy of Sciences to identify and study issues and technological advancements that are or should be of concern to the state of Connecticut. It was founded in 1976 by Special Act of the Connecticut General Assembly.

Vision

The Connecticut Academy will foster an environment in Connecticut where scientific and technological creativity can thrive and contribute to Connecticut becoming a leading place in the country to live, work and produce for all its citizens, who will continue to enjoy economic well- being and a high quality of life.

Mission Statement

The Connecticut Academy will provide expert guidance on science and technology to the people and to the State of Connecticut, and promote its application to human welfare and economic well-being.

Goals

- Provide information and advice on science and technology to the government, industry and people of Connecticut.
- Initiate activities that foster science and engineering education of the highest quality, and promote interest in science and engineering on the part of the public, especially young people.
- Provide opportunities for both specialized and interdisciplinary discourse among its own members, members of the broader technical community, and the community at large.

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