# Solar Heating and Cooling

## Best Practices in State Policies to Support Commercial and Industrial Market Development

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# Contents

# 1. Introduction

This paper reviews policies and implementation programs that support commercial and industrial (C&I) applications of solar heating and cooling (SHC), also referred to as solar thermal (STH) technologies. First, this paper discusses the inconsistent characterization of SHC technologies as either a renewable energy (RE) technology or energy efficiency (EE) technology and highlights the common policy and funding implications of each characterization. The report also discusses policies and implementation strategies that support SHC including: eligibility within the state clean energy standards; economic incentives to address upfront investment barriers, improve cost-effectiveness, and reduce risk for private investment; permitting and zoning of SHC systems; specification of equipment and installations through technical standards and certifications to ensure quality installations; and public education and workforce training.

Each of these policy elements are highlighted separately and followed by several state implementation examples. A number of states have implemented policies that complement each other to eliminate multiple barriers and advance technology deployment in their state more effectively than implementing any one policy alone, and some of the most comprehensive program examples are highlighted within the document. A number of the policy considerations and best practices that support SHC technologies and are effective in supporting other renewable heating and cooling (RHC) technologies are referenced where applicable.

# 2. Background

States play an important role in supporting renewable energy (RE) deployment and market growth by developing policies, directing funds, and establishing programs that help remove current market barriers. In recent years, there has been a surge in state support for renewable energy technologies, perhaps most visibly through newly established state RE Portfolio Standards (RPS) and other supporting policies—with 30 states enacting RPS-like policies, voluntary goals, or EE resource standards (EERS).[1] By providing policy support for RE and EE, states have experienced environmental benefits and economic growth by developing in-state industries, creating local jobs, and reducing dependence on out-of-state energy sources.[2]

### Clean Energy Portfolio Standards Explained

EPSs are referred to by a host of names, including renewable portfolio standards (RPSs), alternative or advanced energy portfolio standards (AEPSs), or energy efficiency resource standards (EERSs), each indicating a different mix of resources that utilities/energy providers must include in their generation portfolio. Energy providers not meeting their EPS requirements are typically charged Alternative Compliance Payments (ACPs), which set the minimum price of RECs or other credits.

Many RHC technologies – and SHC policies, in particular – have been deployed in military bases, hotels, agricultural operations, dormitories, hospitals, restaurants, car washes, laundries, health clubs, and office buildings, as C&I applications offer great energy savings potential due to the size, consistency, and temperature requirements of these types of facilities.[i] Using RHC technologies for heating and cooling can provide significant EE gains when compared with electric heating and cooling because onsite RHC technologies avoid the large energy losses that are typical when converting heat to electricity. Specifically, SHC offers significant potential to pre-heat water for domestic

[i] Common RHC technologies for C&I applications include geothermal heat pumps, biomass thermal, and combined heat and power technologies which generate useful heat for direct application in heating or cooling. See Appendix A for an overview of these RHC technologies.

hot water uses (i.e. cleaning, bathing) and also for process heat in food processing, manufacturing, and district heating applications. Solar cooling technology is increasingly being deployed to provide large air conditioning and cooling loads.[3] (See Section 6 for an overview of SHC technologies and common applications.)

SHC applications are currently implemented in greater scale in countries outside of the United States.[4] In 2009, the European Union approved an RE directive, and Germany, Austria, and the United Kingdom have each established specific RHC goals and have taken steps towards implementing policies and infrastructure to support research, development, and deployment. In contrast, in 2010, the United States held a mere 1.2 percent of the direct SHC energy capacity (including solar water heating, space heating and cooling, and process heat generation) installed capacity worldwide.

The lack of SHC capacity in the United States can be explained in part by the lower levels of state policy and financial support as compared with electrical generation technologies. To date, the majority of state RPS policies focus on electricity-generating RE technologies, even though heating and cooling energy use accounts for one-third of the United States' energy consumption. Despite the significant heating and cooling demand, RHC technologies—including SHC, ground-source heating and cooling using geothermal heat pumps (GHP), biomass thermal technologies, and renewable-fueled combined heat and power (CHP)—have historically lagged in U.S. policy support.

Another reason for the lag in U.S. adoption of RHC technologies for heating and cooling is the significant market barriers these technologies face. One of these barriers is that measuring the energy output of a thermal (or heat- or cool-producing) system is significantly more complicated than solar photovoltaic (PV) because of the quantity and coordination of the measurement devices required for thermal system monitoring. Other real barriers include high upfront costs, lack of awareness about C&I applications, a negative image of the industry that resulted from technical problems in the 1970s and '80s, and confusion caused by the inconsistent way in which U.S. utilities and states classify SHC; some states treat it as an EE technology, while others classify it as an RE technology, and this distinction affects policies and funding support. (See Table 1).

Despite these barriers, state policy support for RHC technologies is increasing, along with improvements in key market factors such as innovations in financing and business models, education, and technology improvements. For example, Maryland, Washington DC, and New Hampshire have recently added RHC technologies to their RPS, and North Carolina, incorporated SHC into its RPS in 2009, showing that this policy model can be effective in stimulating economic growth. Colorado is among a handful of states that have developed favorable tax credits, rebates, and loans programs and, as a result, is one of the top states in number of SHC installations and has drawn manufacturing jobs to the state.[5] [6] New York, Colorado, and Massachusetts have commissioned studies that have quantified and illustrated societal, economic, and environmental benefits of developing local RHC technologies and markets. One consistent theme was recognition of the disparate policy and incentive support of thermal technologies and electricity generating technologies, the main market barriers mentioned above, and the high potential to expand SHC and other RHC technologies through policy support and market development.[7] States have also begun to develop strategic state-supported economic incentives that address upfront investment barriers, improve cost-effectiveness, and reduce risk for private investment showing that state support can be an effective mechanism to drive market growth.

Though RHC is a relatively nascent area of state policy support, a wealth of examples and early adopters are providing a foundation for informed policy support that is beginning to show results. In 2010, an estimated 35,500 systems (about 0.2 gigawatt, thermal [$GW_{TH}$]) were added across the U.S. (equivalent to market growth of 5 percent).[8]

# 3. Clean Energy Portfolio Standards

State Clean Energy Portfolio Standards (EPS) mandate that utilities or other electricity suppliers meet a certain percentage of their energy demand through RE, alternative energy sources, EE, or a combination of the three; the utility/energy provider can achieve this through generating energy through eligible sources themselves, or through incenting distributed generation (DG) which can be generated at the customer site.

EPSs are a driving force in moving clean energy markets forward. Electric-generating RE and EE technologies that displace electricity have been incented more widely than thermal generating RE technologies and have achieved significant market growth as a result.

Typically, the generation of energy (in megawatt-hours [MWh]) from sources that are eligible under an RPS will qualify for some kind of tradable credit, typically referred to as Renewable Energy Credits (RECs).[ii] To meet the RPS, energy utilities can implement RE projects that produce energy, or they can purchase eligible tradable credits from energy generators for an equivalent amount of energy. These credits create a funding source for the project for a set contract length. In contrast with RPSs, EERSs mandate that utilities or other electricity suppliers meet energy savings goals through demand-side management initiatives such as incentivizing customers to purchase or install energy efficient technologies.

RPSs generally favor least-cost projects when all renewables compete; therefore, states may choose to support higher-cost technologies such as solar, thermal RE, and DG using credit multipliers or set-asides (also referred to as “carve-outs”). A set-aside, or carve-out, requires that the energy portfolio of a state include a certain percentage of a specific type of RE, such as solar energy. New Mexico and Maryland removed their solar multiplier provisions in favor of solar set-asides to provide incentives to a larger volume of projects.[9]

Most states include SHC as an EPS-eligible technology; however, a significant distinction among state EPSs is whether utilities and states classify SHC as an EE technology or as an RE technology. Table 1 shows the potential effects on access to funding, REC generation, administrative expenses, and support of the private markets associated with classifying SHC or other RHC technologies as an EE technology or an RE technology.

[ii] The owner of the REC can claim the property rights to the environmental, social, and other non-power qualities of renewable electricity generation. If the owner sells the REC and its associated attributes and benefits, the entity owns only the underlying physical electricity associated with a renewable-based generation source.
EPA (2012). ”Green Power Market.” http://www.epa.gov/greenpower/gpmarket/rec.htm.

*Table 1. Pros and Cons of States making SHC technologies eligible under Energy Efficiency vs. Renewable Energy Portfolio Standards with state examples.*

| *Classifying SHC as an RE Technology (RPS Inclusion)* | *Classifying SHC as an EE Technology (EERS Inclusion)* |
|---|---|
| **Pros:**<br>➤ **Characterization as an RE technology provides access to funding sources available for RPS-eligible or RE technologies.** The Energy Trust of Oregon's (ETO) enabling legislation treats thermal technologies as EE; ETO could provide higher incentives to encourage SHC deployment if it were considered an RE technology and met the state RPS. This is because ETO determines the RE incentives by the cost differential of the net system cost vs. the value of the energy produced, whereas ETO provides EE incentives for cost-effective technologies based on utility avoided costs. ETO incents SHC because their cost-effectiveness analysis includes a societal benefit component.[10]<br>➤ **REC generation incentivizes development of large SHC projects in the state.** RECs are an important revenue stream for private-sector project development and third-party financing models. (See Section 4.C.2.)<br>➤ **Increases exposure of SHC technologies' suitability for meeting C&I heating and cooling loads.** Increased exposure of the technology should lead to increased deployment. | **Pros:**<br>➤ **Requires potentially fewer administrative costs to measure progress towards meeting EE and conservation goals than to measure progress towards an RPS:** Measuring progress towards an RPS may require metering and monitoring of energy generated or saved, and additional databases for tracking thermal technologies which generate RECs. (See Con under RPS inclusion.) |
| **Cons:**<br>➤ **Requires more administrative expense and systems for tracking credits.** *When Maryland Public Service Commission (PSC) decided to include RHC technologies in their RPS, they had to create a new application platform/portal on the PSC Web site for solar water heating (SWH) project REC applications. Additional staff time is also needed to review the SWH applications which take about 50 percent more staff time than solar PV applications since more paperwork is required.*[11] | **Cons:**<br>➤ **Cost-effectiveness evaluations may compare SHC to lower-cost EE technologies, potentially excluding those technologies from funding.** *EE programs are typically required to meet high cost-effectiveness standards; RE technologies that are considered EE technologies may be compared to less expensive technologies, such as efficient lighting.* |

Currently, 15 states and the District of Columbia (DC) consider specific thermal energy resources as eligible under their EPSs, though not in the same ways. A handful of those states include thermal energy only to the extent that it reduces electricity use, on a par with other demand-side management and EE or conservation technologies. Recently, however, a few states have explicitly included it in their state RPSs despite the challenges of establishing a new accounting method to incorporate thermal energy as an energy generation source; these include Arizona, Massachusetts, Maryland, North Carolina, New Hampshire, DC, and Wisconsin (to the extent it backs down electricity) (See Table 2). Washington, Connecticut, Vermont, and Massachusetts (which includes CHP thermal energy in its advanced energy portfolio standards [AEPSs]) are each exploring the possibility of including renewable thermal technologies in their EPSs.[12 13]

*Table 2: State RPS Eligible Technologies*

| STATE | Biomass | SHC | CHP | GHP |
|---|---|---|---|---|
| AZ | x[a] | x[a] | x[a] | x[a] |
| CA | x | x | x | x |
| CO | x | | x | x |
| CT | x | x[b] | | |
| DE | x | | x | x |
| DC | x | x[a] | x | x |
| HI | x | x | x | x |
| IL | x | | x | |
| IA | x[a] | x | x | |
| KN | x | | x | |
| ME | x | | x | |
| MD | x[a] | x[a] | x[a] | x[a] |
| MA | x | | x[a] | x |
| MI | x | x | x | x |
| MN | x | | x | |
| MO | x | | | |
| MT | x | | | x |
| NV | x | x | x | x |
| NH | x[a] | x[a] | x[a] | x |
| NJ | x | | x | x |
| NM | x | | x | x |
| NY | x | x | x | |
| NC | x[a] | x[a] | x[a] | x |
| OH | x | | x | x |
| OR | x | | x | x |
| PA | x | x | x | x |
| RI | x | | x | x |
| TX | x | x | x | x |
| WA | x | | | x |
| WI | x[a] | x[a] | x | x[a] |

[a] Indicates where thermal energy is credited.
[b] Being considered for RPS eligibility.

States can employ multiple market mechanisms individually or comprehensively to support SHC technologies as an RE generation resource included in the State RPS. Below are some policy elements to consider:

- Include onsite DG SHC in the state RPS, and allow SHC to qualify for RECs or solar RECs (SRECs) by converting thermal energy, which displaces electric and other energy sources, into megawatt-hours. *States that include thermal energy in their RPSs use a conversion rate of 3,412 British thermal units (Btu) per kilowatt-hour (kW).*
- Use carve-outs, tiers, or classes, and RPS requirements to incentivize technologies and sector applications or to support local job or industry growth. *Within an RPS, states can support SHC through a solar carve-out (e.g., North Carolina.), a thermal energy carve-out (e.g., New Hampshire), or a DG carve-out (e.g., Arizona); and include RHC resources in higher tiers or classes, generally Class/Tier I or I. It is possible to have carve-outs for certain technologies within Tiers or Classes (e.g., Maryland has a solar carve-out that distinguishes solar technologies within the Tier I RE resources) though often states use one or the other. In some cases, EE or demand response is Tier/Class III in an RPS or EPS State can consider restricting technologies eligible to generate RECs to in-state generation to spur in state development.*[14]

- Enforce a monetary penalty or include an alternative compliance payment provision for energy suppliers that do not meet RE generation requirements; increase or decrease Alternative Compliance Payments (ACPs) to affect REC or SREC prices. *Higher ACPs, typically assigned for resources that are higher tier/class or meet a resource carve-out, set the price of RECs higher. This offsets costs for eligible RE system owners. Maryland increased their ACP for SRECs to avoid dips in the price of SRECs. (See more in Maryland "Spotlight" below.)*
- Award RECs for SHC systems, which have quality assurance elements such as heat meters and monitoring systems and meet qualified equipment requirements. (*See Section 5.B and 5.C for more information.)*
- Require long-term energy purchase contracts for SRECs, or establish other mechanisms that improve price certainty. *Setting long term price-support mechanisms for RECs assists with providing certainty for investors and access to financing for SHC project developers.*
- Include non-electric utilities in EPSs as well as electric utilities to make EPSs fuel-neutral and encourage RHC deployment in buildings that meet heating and cooling loads through electric or other energy sources. *In some states, non-electric fuel utilities are not required to meet energy reduction targets or an EPS, thereby limiting public, or ratepayer funding, from being used to incentivize technologies that decrease non-electric fuel use. Electric utilities can generally only claim the electric energy savings associated with SHC systems, thus limiting their incentives for a large segment of SHC applications that would supplement non-electric fueled heating and cooling systems. With the cost of natural gas currently very low, SHC is more cost-effective when it is replacing electric or oil heating than natural gas heating.*
- Establish program evaluation methods for the state RPS that captures the societal and multiple monetary benefits of clean distributed energy. *The development of an RPS is a state-specific activity based on a number of complex factors such as resource availability, political environment, cost-effectiveness, and interest in sustaining natural resources. A tool for policymakers aiming to communicate the multiple benefits of an RPS which include RHC technologies may be to ensure that evaluation of the RPS will capture health, societal, and direct and indirect monetary benefits of increasing RE generation in the state.* [iii]

The following examples exemplify the policies and market mechanisms discussed above.

## North Carolina

North Carolina is the first state in the Southeast to adopt a state RPS which includes SHC Solar RECs (SRECs), and is the only state in the southeast with a mandatory RPS. Since 2007 with the passage of the RPS bill, the RPS solar energy set-aside included new solar electric facilities and new, metered energy facilities that use solar hot water, solar absorption cooling, solar dehumidification, solar thermally driven refrigeration, and solar industrial process heat. [15] North Carolina facilities generating RECs are required to conduct independent system meter readings and self-report the energy savings to the North Carolina Renewable Energy Tracking System (NC-RETS). The NC-RETS online system ensures that RECs are produced and sold by registered facilities and prevents double-counting. [16] North Carolina also includes thermal energy from CHP and limited thermal biomass. [17]

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[iii] One resource for the current dialogue on RPS development is the State-Federal RPS Collaborative, a joint project of the Clean Energy States Alliance's (CESA's) States Advancing Clean Energy Group. *Evaluating the Benefits and Costs of a Renewable Portfolio Standard: A Guide for State RPS Programs* provides methods for program managers to evaluate an RPS including the multiple societal benefits of an RPS.

The RPS is spurring new developments. As of November 1, 2012, the Commission had accepted 86 solar thermal facility registrations, including a North Carolina-based turkey processing plant that built a large solar water heating system. There are nearly 10.435 MW of metered SHC energy facilities registered with NC-RETS.[18]

## New Hampshire

One of the most recent inclusions of thermal energy in a state RPS was in New Hampshire. The RPS requires that utilities incorporate at least 23.8 percent of RE into their energy portfolios by 2025. New Hampshire modified its RPS in July 2012 to establish a thermal carve-out, requiring 0.2 percent of Class 1 requirements to be met by "Useful Thermal Energy" in 2013, increasing annually through 2025.[iv]

## Pennsylvania

Pennsylvania's AEPS considers solar thermal technologies that do not produce electricity (e.g., domestic solar water heaters) as Tier II demand-side management resources (EE resource), whereas electricity-generating renewables are eligible as Tier I. The AEPS counts thermal energy generated by solar hot water, solar space heat, geothermal heat pumps, and geothermal direct-use systems as a Tier II resource, and only for the electricity reduced through the technology use. Utilities must pay an ACP of $45 per MWh for shortfalls in Tier I and Tier II resources.[19]

[iv] SB 0218 defines "Useful Thermal Energy" as "renewable energy delivered from class I sources that can be metered and that is delivered in New Hampshire to an end user in the form of direct heat, steam, hot water, or other thermal form that is used for heating, cooling, humidity control, process use, or other valid thermal end use energy requirements and for which fuel or electricity would otherwise be consumed."
State of New Hampshire (2012). "Chapter 272." http://www.gencourt.state.nh.us/legislation/2012/SB0218.html

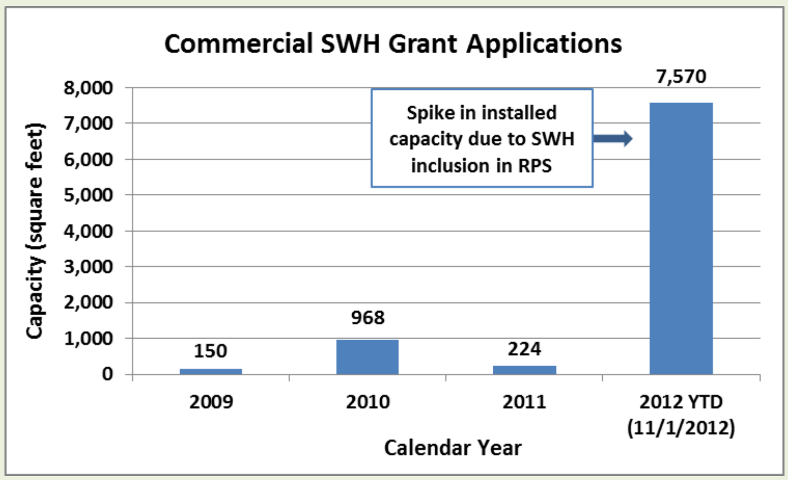
## Spotlight on: Maryland Energy Administration and Public Utility Commission Programs

***Maryland is spurring growth in clean energy industries through a profile of programs that support renewable heating and cooling technologies.***

### Renewable Portfolio Standard

The Maryland RPS requires that electricity suppliers (utilities and competitive retail suppliers) generate 20 percent of their retail sales by 2022 from renewable sources, including solar, wind, geothermal heating and cooling (GHC), and bioenergy. Within the past two years, Maryland has moved rapidly toward including thermal renewable energy resources in its RPS. Maryland allowed metered solar water heating (SWH) systems to qualify as eligible resources to meet the 2-percent solar carve-out, along with solar PV, as of January 1, 2012. [20] The state strategically supported continued growth of the solar energy market in Maryland by accelerating the solar carve-out compliance schedule by two years and increasing the solar ACP rates for 2011 through 2016. Maryland made these adjustments, in part, due to the state achieving its solar goals ahead of schedule and because the Maryland Energy Administration and Public Utilities Commission (PUC) wished to stabilize the price of SRECs by avoiding oversaturation of the RECs market, which would cause dips in the value of RECs. The Maryland PUC has received about 350 SREC applications for SWH projects to date.

In 2011 and 2012, Maryland also approved onsite thermal biomass systems and became the first state to make geothermal system eligible as a Tier 1 renewable energy resource. [21] For all qualifying RHC technologies, the amount of RECs awarded for the system are determined by converting annual Btu saved into annual MWh. [22]




### Commercial Clean Energy Grant Incentives

The Commercial Clean Energy Grant Incentives Program (CEGP) is a capacity-based incentive program that rebates a portion of the installation cost based on system size. MEA adjusted the SWH-installed capacity ranges in 2012 based on project costs and available funds but kept the same total award cap, to encourage larger installed systems.

GHC systems are also eligible for this grant[23] and this program has shown that state incentives can bolster development at marginal costs. For both residential and commercial installations under CEGP, MEA has provided $2,596,216 in incentives since program inception, and the state has seen $15,964,545 in investment in total project costs, putting MEA's cost share at 16 percent. [24] When SWH became eligible in the RPS, the installed capacity of SWH skyrocketed.

### Market Development Programs

The Multi-family Housing: Game Changer Award launched in Spring 2012 encourages multi-family building owners to install one of several highly efficient glazed polymeric collectors and provide MEA with metered solar hot water generation data so MEA can evaluate the efficacy of the technologies. [25] The results will inform future policies and incentives.

### Tax incentives

Maryland has approved a host of tax credits that incentivize RHC and other renewables, including a property tax for high-performing buildings, property tax credit for renewables and energy conservation devices, property tax exemption for solar and wind energy systems, and sales and use tax exemption for renewable energy equipment. [26]

# 4. Financial Incentives

High upfront costs and longer paybacks than EE technologies are some of the most significant barriers to the growth of RE markets. Commercial entities may develop corporate policies or unwritten rules providing for stringent cost-effectiveness or return on investment (ROI) of three years or less that may inhibit investments in clean energy technologies.[27] Additionally, the growth in RHC technology deployment is relatively new, and investors may be less familiar with RHC technologies and financing mechanisms than they are with more established technologies. Strategically developed state-supported economic incentives that address upfront investment barriers, improve cost-effectiveness, and reduce risk for private investment therefore would be effective mechanisms to drive market growth.

Best practices for creating financial incentives include:

- Establish long-term and predictable financial incentives to build the market. *Stop-and-start cycles and inconsistent funding mechanisms may disrupt growth in the industry and undermine the long-term success of the incentive program.*
- Provide a coordinated portfolio of incentives that allow all stakeholders to take advantage of incentives regardless of their tax liability. *Consider direct incentives, establish low-cost loan options, provide credit enhancements to financial institutions, allow generation and trading of RECs, and provide tax incentives.*
- Make financial incentives contingent upon utilizing industry best practices such as metering or monitoring system generation; set minimal requirements for quality equipment and installation or quality assurance checks. *(See Section 5.)*
- Establish a mechanism for tracking the details of program use, costs, and energy savings or production. *A strategically developed tracking mechanism enables program evaluation and improvement.*[28]
- Coordinate with other state programs and relevant stakeholder groups to develop incentives that address real barriers in the state; provide public educate about the technologies and market the incentive program. *(See Section 5.C.)*

A number of parties can administer incentive programs including states, utilities, and localities. Considerable planning will determine which incentive type is most suited to current markets needs and state conditions. Direct incentives or rebates for RHC systems can be issued based on system capacity (size) or a percentage of capital costs, whereas production-based incentives are issues for expected or actual performance (Btu generated). States can provide low-cost loans by collaborating with local financial institutions to offer attractive financing, grants, credit enhancements, and state tax exemptions and leveraging existing federal tax incentives.

Each mechanism has its strengths and potential shortfalls. Production-based incentives may require the system to be financed upfront through cash or loans if the incentive is paid over time. While all funding sources will have finite capacity, cash incentives may be an easy target in times of budget shortfalls and may start and stop if demand exceeds the allocated funding pool. Loan programs, in contrast, may be more politically viable and stable and can even become self-sustaining through a revolving loan fund mechanism, which requires loan repayments to go back into the program and grow with interest. Loan programs have the added benefit of potentially leveraging private funding with more limited public dollars. Direct incentives are available to the end-user regardless of their tax appetite and are issued to the system owner directly after installation, addressing the cash outlays of the customer. While being less attuned to the cash timing needs of the end customer, tax incentives reduce future tax liabilities and do not require a distinct pool of funding, making them less vulnerable to program funding shortfalls.

## 4.A Capacity-Based Incentives and Rebate Programs

Capacity-based incentive programs offer incentives for installing an SHC system based solely on a flat fee per installed watt or Btu; Some incentive programs provider rebates based on a percentage of capital costs. Multiple states employ the capacity-based incentive model because of its relative ease. District of Columbia program example is below.

### District of Columbia

The DC Renewable Energy Incentive Program, funded by the DC Sustainable Energy Trust Fund (a public benefits fund), provides 15 percent of installed cost of a non-residential SWH installation with up to $7,000 per system per program year.[29] The rebate is available for systems that meet a number of quality equipment and installation requirements, including meeting Solar Ratings and Certification Corporation (SRCC) OG-100 certification. The system must also have an onsite Btu meter that meets performance standards established by the International Organization of Legal Metrology International Recommendation (OIML R 75) and carries system warranties. (See more about common standards for equipment and installation in section 5.B.)

## 4.B Performance-Based Incentives

An increasing number of solar programs base incentives on the production of energy rather than on the size or cost of the system.[30] There are two types of performance-based incentives: those based on *estimated* performance, and those based on *measured* performance data. The benefit of performance incentives is that they encourage optimally designed systems and ongoing system maintenance; however, performance incentive programs tend to include multiple program requirements (modeling, metering, and reporting) that may increase costs for system developers and owners, as well as the entity administering the program. An incentive program based on *estimated* performance requires system designers to model SHC system production based on current energy demand.

An incentive program based on *measured* performance data will require system metering and monitoring.[v] Unlike solar PV electric technologies, which display the energy generated through an inverter or single utility electricity meter, SHC technologies require Btu meters to calculate the energy generated from a system or conventional fuel displaced. Metering large C&I systems are often complex; Btu meters can be a significant project cost; and industry standards for metering equipment selection and system integration are few; however, there is growing consensus emerging in the market on Btu system integration as well as an industry consensus that metering and monitoring the system is a best practice despite the cost. (See Section 5.B.2.)

Making data available through metering and monitoring has many benefits for program implementers as well as consumers. It encourages consumers' trust in the operation of the system, identifies performance irregularities, provides data to the program administrators for comparison to the estimated performance values, and helps inform future incentives, program design, and policy. The following examples describe state performance-based incentive programs.

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[v] Metering a system is simply recording the data points. Monitoring performance is aggregating the data collected to allow for evaluation of performance and facilitate system improvements. The Btu meter will generally be connected to monitoring systems through information technology infrastructure to generate performance data.

## California

The California Public Utility Commission (CPUC) states that accurate measurement of system performance under the California Solar Initiative Thermal (CSI-Thermal) program is necessary to ensure cost-effectiveness for system owners and ratepayers and to help evaluate program and technology performance over time. The CSI–Thermal program has two variations of the performance-based incentive, one based on measured energy production and the other on modeled system production. Systems with a capacity of greater than 30 kilowatts, thermal ($kW_{th}$) are calculated using the program calculator based on OG-100 SRCC certified solar panels predicted output, though the systems must have customer performance metering to allow system owners' access to their systems' performance data. With large multi-family/commercial systems with capacity greater than 250 $kW_{th}$, incentives are paid through the "70/30 true-up method" in which the program administrators (PA) pay a portion of the funds upfront and then pay the remaining incentive adjusted to the actual performance of the system captured through metering.[31] PAs meter a sub-sample of all systems for measuring and evaluation (M&E) purposes.

The CSI-Thermal Program balances the need to ensure quality installations and limit installer requirements and paperwork. Requirements for metering only the largest systems (greater than 250 $kW_{th}$) were a compromise between CPUC's desire for metered data and stringency of requirements on installers. Spurred by observing inconsistent metering practices among installers, however, CSI developed metering guidance for many commercial SHC systems receiving funding in the program. [32]

## Arizona

Arizona Public Service's (APS's) Renewable Energy Incentive Program for non-residential solar water heating provides $0.41 per kilowatt-hour (kWh) estimated first year energy savings or the system owner can choose a 10-, 15- or 20-year Performance-Based Incentive and enter into an agreement with APS. This arrangement requires metering and monitoring of the SHC system. Incentives are limited to 50 percent of total system cost.

## Spotlight on: California Solar Initiative Thermal Program

***California takes a comprehensive approach to ensuring quality installations.***

The State of California implements the California Solar Initiative (CSI) Thermal Program, which is administered by four gas and electric utilities, referred to as the Program Administrators (PAs). The program aims to reduce market barriers to SWH adoption in California by addressing high permitting costs, lack of trained installers, and lack of consumer knowledge and confidence in SWH technology.

The program started in October 2007 with a $250-million incentive program to promote the installation of 200,000 solar water heating (SWH) systems by 2017 that displace the use of natural gas. The CSI Thermal Program is based on the successful solar water heating pilot program that ran from July 2007 to December 2009 on a budget of $2.59 million in the San Diego area. The CSI Thermal Program launched in January 2010 with $350 million in funding through 2018 and began accepting applications for multi-family residential and commercial customers in June 2010. [33]

The CSI Solar Thermal program is arguably the most robust and comprehensive program in the country that incorporates many quality equipment and installation elements:

- Installer requirements: The CSI SHC Program requires certification by the California Contractors State Licensing Board (CSLB) and recommends North American Board of Certified Energy Practitioners (NABCEP)-installer certification.63 All CSI SHC contractors are required to take program training and maintain eligibility through installations or attending workshops. [34]
- System inspections: The PAs inspect the first three completed projects that displace 30 $kW_{th}$ or less (462 square feet of collector area) and the first three projects that displace more than 30 kWth, plus random projects thereafter. PAs have developed and submitted a consistent statewide site inspectors' training plan to the California Public Utility Commission's Energy Division, which will be the basis for determining status of personnel as trained.
- System installation and technical requirements:

Systems must be sited so that the minimum allowable average annual solar availability of the collector(s) is 85 percent between 10:00 a.m. and 3:00 p.m. (no more than 15 percent shading). System percent shading above this threshold reduces incentives available to the system.

An energy audit is required for all existing residential and commercial buildings, and commercial buildings must undergo retro-commissioning if they have a benchmark rating of less than 75 in the U.S. Environmental Protection Agency's Portfolio Manager.

Solar system must meet certification (concentrating solar collectors or solar water heaters certified under SRCC OG-100), warranty, and metering requirements for systems over 30 $kW_{th}$.

- Incentives: Multi-family and commercial systems with capacity of 250 $kW_{th}$ or less will receive one-time lump-sum payments. Incentive levels are based on SRCC first-year annual system production estimates using the CSI-Thermal Program incentive calculator. Incentives are based on what fuel the solar water heating system displaces and the incentive decrease in stages as capacity is filled. Systems that displace natural gas receive $19.23 decreasing to $7.05/therm displaced, capped at $500,000, and electric/propane-displacing systems earn $0.37 decreasing to $0.14/kWh displaced, capped at $250,000. Systems larger than 250 $kW_{th}$ receive incentives based on measured performance. [35] (See Section 4.B for performance-based incentive structure.)

As of January 2012, 183 large commercial systems had been installed under the program. Of the commercial customers that participated in the program in 2011, 151 of 183, or about 80 percent, were apartments and condominiums, with the next largest group being coin laundries and restaurants at 3 to 4 percent each. Each of the PAs provide different incentives, which appears to directly correlate with the number of applications that they have received, ranging from 120 commercial and multi-family applications in the Pacific Gas & Electric territory to one application in the Southern California Edison territory. [36] [37]

## 4.C Low-Interest Loans

States have a host of mechanisms that allow them to offer low-interest loans to support deployment of renewable thermal technologies and market growth. To be meaningful, a state program must offer more favorable terms than available private sector loan programs. Some states have capitalized revolving loan funds, which state or quasi-state agencies manage. Other states have used credit enhancement mechanisms to attract financial institutions or private investors into the market, and still other states are linking state clean energy funds with economic development entities, community development finance institutions (CDFIs), or state development authorities, which are involved in lending to industry/businesses and often provide direct loans and/or tax-exempt bonds. Funding for state loan programs can originate from a variety of sources, including annual appropriations, public benefits funds (derived from a surcharge on the electric utility bill), RPS alternative compliance payments, environmental non-compliance penalties, and the sale of bonds. Important features of an effective loan program can include a low-interest rate, a long repayment term (at least 10 years), and minimal fees, as well an easy and concise application process without compromising quality assurance. The following are some examples of state loan programs that leverage private investment.

### Connecticut

The Connecticut Clean Energy Finance Investment Authority (CT CEFIA), formerly the CT Clean Energy Fund (CCEF), has authority over a Renewable Energy Investment Fund, whose primary use will be to provide low-cost financing mechanisms and transition away from direct subsidies to spur RE development in the state.[38] CEFIA is investing in a number of financing mechanisms that will provide access to low-cost capital for commercial building owners.

Connecticut created the nation's first statewide commercial PACE (C-PACE) program on June 15, 2012.[39] CEFIA will have the authority to back PACE bonds, aggregate the PACE transactions (particularly important in a small state), and work with investors and financial institutions to invest them. Additional programs CEFIA is working on are credit enhancements for engaging financiers in loan loss reserves, interest rate buy-downs, and third-party insurance; CEFIA is also considering investment in subordinated debt and Community Reinvestment Act credits.

CEFIA has decided to launch a full solar thermal program based on the success of the American Recovery and Reinvestment Act (ARRA)-funded solar thermal program. Of the solar thermal program projects installed program-wide, commercial solar thermal installations accounted for 25 percent of the projects but 75 percent of the capacity, making a compelling argument for more focused effort on getting large projects installed.[40] Connecticut's investment in its CCEF DG programs (small solar and distributed generation such as fuel cells) has produced impressive economic and societal benefits, including lower business operating costs through increased business competitiveness; lower household living costs leading to additional re-spending within Connecticut; purchases of in-state equipment over out-of-state equipment and fuels; and economic growth through increased orders for firms, manufacturers, and installers supplying goods and services around renewable equipment in Connecticut. The economic analysis showed that the benefits-to-cost ratio was 1.44—the programs returns $1.44 to Connecticut for every $1 spent by CCEF and program participants. Further, the small solar program is predicted to produce a net energy savings of more than $1.9 million by 2027, which is available to households to stimulate the state's economy and generate spin-off economic impacts. [41]

### Nebraska

Nebraska Energy Office administers the Dollar and Energy Savings Loan for EE and RE (including SHC and other RHC) in commercial buildings. The State Energy Office works with Nebraska lenders to purchase 50, 65, or 75 percent of the loan at 0 percent to deliver an interest rate of 5, 3.5, or 2.5 percent, respectively, to the borrower. This innovative strategy has leveraged $218.5 million in loans to date through eligible Nebraska lenders from the State Energy Office's investment of $11.1 million from its revolving fund.[42]

### Others

The Energy Trust of Oregon (ETO) collaborates with Umpqua Bank through GreenStreet Lending to offers preferred loan rate products with no fees. [43] The Kentucky Solar Partnership (KSP) and the Mountain Association for Community Economic Development (MACED) are encouraging development through the Solar Water Heater Loan Program. The Pennsylvania Green Energy Loan Fund if a revolving loan fund which offers low interest loans to EE projects (PA considers SHC EE) that result in an estimated energy consumption reduction of at least 25%.

## *4.C.1 PACE and On-bill Financing*

Though Property Assessed Clean Energy (PACE) financing has dealt with challenges from Fannie Mae and Freddie Mac for residential applications, it is a viable tool for commercial and industrial applications. Local governments establish PACE districts to issue loans to property owners for clean energy work, which places a long-term assessment on the customer's property tax bill or another local bill. The funding is generally from municipal bonds or other similar municipal capital sources. Twenty-one states have enabling PACE legislation. [44]

A few states have supported PACE in innovative ways, including Connecticut, discussed above. The Boulder County (Colorado) Commercial ClimateSmart Loan program funded about $1.7 million in energy improvements beginning in November 2010.[45] Commercial PACE programs through the Energy Upgrade California programs provide funding ($2,500 to $500,000) for solar thermal systems and geothermal heat pumps (in Sonoma County only) as eligible upgrades, along with a number of other EE and RE measures. Interest rates are fixed at or below the rates that participants would otherwise receive from financial institutions and are determined at the time the contract is signed.[46]

Although the PACE structure does address a number of clean energy investment barriers, it is designed for property owners not tenants. A mechanism to provide tenants with investment power is on-bill financing, which can also be property assessed.[47] Since the mid-1990s, the Eugene (Oregon) Water and Electric Board has sponsored a zero-percent on-bill loan as part of its Bright Way to Heat Water program.[48] Though utilities have implemented on-bill financing for residential SHC systems, to date few have made commercial SHC an eligible measure. This issue may be related to the longer payback period than is typical for on-bill financing.

## *4.C.2 Third-Party Financing Development*

Government funding is intended to boost the market, decreasing subsidies from the state as the market stands on its own through private investment. Third-party financing models are becoming a driving force in developing C&I-sector projects with large loads of heating, cooling, and water heating, or pre-heating for process heating. These systems are typically larger than 2,000 square feet.[49] Policies that are particularly supportive of third-party financing models include those that supply depreciation and tax benefits to tax equity investors; provide additional revenue through REC sales in key states; and offset development costs with state, local, and utility incentive programs. California, Hawaii, Maryland, North Carolina, and Washington DC, are some examples of states that host a combination of incentives that drive down costs and spur third-party ownership of systems.[50]

The leasing business model has been effective in increasing deployment of solar PV and is beginning to appear in third-party financing of SWH systems. Lease agreements can be similar to leasing a piece of equipment, though some models include the SWH company developing, owning, and operating the systems on the customer's behalf. To support this arrangement, the Maryland Energy Administration allows leased SHW systems as eligible under the CEGP and REC program, and CEFIA is considering launching a new solar leasing program that includes STH as well as PV.

## 4.D Tax Incentives

Federal tax incentives have played a role in driving the RHC market. Solar water heating installations increased dramatically in the United States in the 1970s and 1980s due to an aggressive federal tax credit. Conversely, the decline of the market in the late 1980s can be attributed, in part, to the expiration of that credit in 1986.[51] Today, about 20 states offer corporate investment tax credits to help offset the cost of purchasing and installing SHC equipment. Tax credits generally range from 10 to 50 percent of project costs, though some states allow up to a 100-percent tax credit, and maximum credit limits in the range of $25,000 to $60 million. An increasing number of states are including quality assurance elements to qualify for tax credits, including Arizona, Georgia, New Mexico, Rhode Island, and Utah.[52] States can also leverage federal tax incentives. Organizations can take advantage of a Federal Business Energy Investment Tax Credit (ITC) that covers 30 percent of the system cost and does not have a limit and is eligible for systems installed before 2016.

Some considerations for state tax credit development are as follows:

- Consider how tax credits can serve to reduce costs in different points in the value chain. Offer tax credits on sales of SHC equipment or on equipment involved in manufacturing it, and on property that has eligible equipment installed on-site.
- Make tax credit eligibility requirements more stringent (similar to SHC incentive programs). States can require applications and pre-approval; certified equipment or from an approved list; and minimum thresholds for system warranties, equipment, and installer qualifications, and orientation and shading. [53]

The following are some examples of tax credit programs that exemplify these approaches.

### Connecticut

Connecticut H.B. 5435 provides a sales tax exemption for purchasers of solar and geothermal systems, as well as a sales tax exemption for equipment machinery and fuels used to manufacture RE systems.[54] Connecticut offers a property tax exemption for Class 1 RE systems, including any passive or active solar water or space heating system or geothermal energy resource regardless of the type of facility the system serves.[55]

### Oregon

Oregon offers various tax credit programs within the Oregon Department of Energy (ODE), one for RE Development and the other for Energy Conservation Projects. (SHC is considered an EE technology under Oregon enabling legislation.) A unique aspect to Oregon's tax credit program is its "pass-through option," which allows a project owner without a tax appetite to sell a percentage of the credit to another entity in exchange for a lump-sum cash payment. The state uses the auction of tax credits, taxpayer contributions, or direct appropriation by the legislature to provide funds to award grants to RE production systems. [56]

While ETO incentives have proven cost-effective and met the PUC standards, the tax credits are available to projects that do not meet ETO cost-effectiveness standards and to all individuals or corporations in the state, as they broadly promote economic development and environmental protection. The tax incentives and direct financial incentives through the ETO complement each other.[57]

RE development grants are funded through the auction of tax credits, where taxpayers can bid to buy the tax credit. Taxpayer contributions or direct appropriation by the legislature are used to provide funds to award grants to RE production systems. [58] RE developers apply to ODE for cash based on the merits of their expected system performance. One benefit for RE project owners is that they do not have to find a pass-through partner or have tax liability.

### Others

North Carolina offers a 35-percent credit for non-residential installations, which is unique in that it is distributed 7 percent per year for five years. The state extended the credit through 2015.[59] Hawaii, too, offers a tax rebate of 35 percent of the actual cost of the RHC and CHP systems, or $250,000, whichever is less.[60]

# 5. Supporting Policies

States can also enact policies that support the success of the market without providing direct financial incentives. Examples include cost-effective permitting and inspection standards, as well as including quality assurance elements in programs. These quality assurance elements are in place to protect the end-user, the installer, the funding agent (i.e., the state) and to increase consumer confidence in the technologies. Such elements also ensure that the state is funding projects that generate savings.

## 5.A Permitting and Inspection Fees and Processes

An increasing number of states are adopting permitting standards that streamline inspection processes and create uniformity across the state or the region. States generally aim this effort to reduce permitting costs as well as the time and resources needed to review each system, while removing barriers to RE development.[61] State and local authorities that enact legislation vary across the country; some states have authority to govern all permitting operations, while other have legal restrictions limiting states to creating guidance and parameters for local governments to establish their own processes. For SHC installations, permitting requirements can vary significantly by jurisdiction, and some require multiple engineering reviews or materials submission by a certified plumber or engineer. These elements, likely developed to ensure system safety, can cause unnecessary project delays and add significantly to C&I project costs. Another barrier to permitting may be that building inspectors may lack the knowledge to assess the technology appropriately. SHC technologies often cross over several types of codes, making compliance and inspection a more complex and difficult process for some jurisdictions. SWH systems can have elements that apply to electrical, plumbing, structural, or other codes.[62]

The following describes multiple approaches that state authorities may pursue depending on their unique situation:

- Establish working groups to facilitate local government consensus or regional efforts to create uniformity.
- Consider capping costs of permitting and requirements for involvement of Professional Engineers (PE).
- Limit time for processing permits.
- Consider alternative approaches to legislative action; provide fast-track permitting, require state review of local permitting standards, or provide advice and guidance to jurisdictions without impinging on their authority.[63]
- Engage organizations in training building inspectors on SHC systems and code applicability.

Some state implementation examples of these approaches are below.

### Arizona and Colorado

In response to utilities developing SHC incentive programs, the Arizona Governor's Solar Energy Task Force developed recommendations to streamline and standardize processes across the state.[64] Because of these groups, Arizona regulates municipality and county permit fees for solar installations and requires written justification for requiring PE approval of a solar system. This law modified the fees that the city of Phoenix could assess based on system value at the time of system installation.

Likewise, Colorado Senate Bill 117 limits the fee for nonresidential application to no more than the lesser of the local government's actual cost to issue a permit, or $1,000, though there are concerns that local jurisdictions are simply setting the cost of the permit at the $1,000 cap and increasing fees for other processes. [65]

### Minnesota

The Minnesota Environmental Quality Board has developed a model policy, "Solar Energy Standards," which provides language to ensure that solar energy installations are an allowed land use accessory within the zoning code and recommends developing regulation incentives for encouraging solar energy development.[66] The Model Solar Energy Standard is a product of a state and local partnership that arose from the U.S. Department of Energy Solar American Cities and Million Solar Roofs grants in Minneapolis and St. Paul.[67][68] Minnesota state law and building codes require that all active solar space-heating and water-heating systems sold, offered for sale, or installed on residential and commercial buildings meet Solar Ratings and Certification Corporation (SRCC) standards. [69]

### California

California has taken both legislative and guidance approaches: the California Solar Rights Act prohibits building or homeowner associations or individuals from barring solar installation for aesthetic reasons[70]; California has developed guidelines to assist local governments with efficient local permitting[71]; and California is looking to expedite changes to building and electric codes that will clarify requirements related to solar systems. [72]

## 5.B Quality Equipment and Installation Elements

To ensure quality equipment is installed correctly, states may mandate equipment standards, request that installers and manufacturers provide adequate system warranties, meter and monitor system performance, require installer certifications, and conduct installed system inspections.[73]

### *5.B.1 Certified Equipment*

Certified equipment is designed to an industry standard and is third-party certified that it meets that standard. The certification means that the system components should perform as predicted if installed following the installation guidelines. The importance of equipment certification gained national attention in the 1970s and 1980s in response to technical issues surrounding SWH systems. In the 1970s, the solar energy industry was provided with numerous state, federal, and utility incentives, spurred by the national energy crises; however, the large incentives attracted many firms without specific SHC technical knowledge, and system failures were common. SRCC certifies equipment and promotes industry best practices to instill consumer confidence. During this time, there was also more importance placed on training and qualifying installers.[74]

The SRCC is the most commonly referenced certification program and national rating standards for SHC equipment. Currently the majority of states that incentivize SHC installations require systems to meet

SRCC standards for program eligibility, specifically the SRCC OG-100-certified panels and SRCC OG-300-certified systems, appropriate for commercial and residential or small business systems, respectively. SRCC standards provide product credibility and standardized comparisons, which provide utility and government entities with a rational basis for incentive calculation and tax credits, and a basis for setting codes and standards.[75] Recently, the CSI-Thermal initiative expanded the residential equipment eligibility to include SWH systems certified by the International Association of Plumbing and Mechanical Officials (IAPMO). [76]

Another important piece of equipment is the heat meter, or Btu meter, which records heat conveying fluid flow and temperature to calculate the energy contributed by a heating or cooling system. ASTM International and IAPMO are in the process of developing a U.S. heat-metering standard that defines the accuracy and operational characteristics of heat meter instrumentation.[77] In the meantime, states and programs such as Washington DC, Maryland, and the California Solar Thermal Initiative require nonresidential solar water heating installations to have onsite energy meters. These meters must meet performance standards established by the International Organization of Legal Metrology International Recommendation (OIML R 75), an international recommendation based on the European standards for accuracy.[78] [79]

### 5.B.2 Metering and Performance Monitoring

In order to account accurately for the energy generated or conventional fuel displaced by the RHC systems, metering and monitoring system performance is required.[vi] RHC technologies require Btu meters for calculating energy output. While metering and monitoring can be complex for commercial systems, collecting performance data has many benefits for program implementers, previously discussed in Section 4.B. Generally, metering and performance monitoring is more cost-effective on commercial systems and is more frequently being required by programs that provide a production-based incentive.

Arizona Public Service (APS), the District of Columbia, Maryland, California, and the Massachusetts Clean Energy Center (MassCEC) Commonwealth Solar Hot Water Program (CSHW) require metering on program-eligible systems.

### 5.B.3 Equipment and System Warranties

Requiring warranties for system and installation work can help reduce system failures and increase consumer trust. Numerous state programs require one to 10-year warranties for various elements including Arizona, New York, California profiled below.

Main solar thermal system components sold or installed in Arizona and Oregon must have a two-year warranty, with the balance of system components requiring a one-year warranty. Manufactures and installers must provide the customer with a written statement of warranty, responsibilities, performance data, and components. Arizona installers must guarantee their installation work for two years.[80] The New York State Energy Research and Development Authority's (NYSERDA's) Solar Thermal Incentive Program requires that all system components be new and have five-year all-inclusive, fully-transferable warranties on system components and installation, protecting against degradation of more than 10 percent from rated output.[81] The CSI-Thermal program requires a 10-year collector manufacturer warranty. The contractor must provide a one-year minimum

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[vi] Metering a system is simply recording the data points. Monitoring performance is aggregating the data collected to allow for evaluation of performance and facilitate system improvements. The Btu meter is generally connected to monitoring systems through information technology infrastructure to generate performance data.

warranty on installation work and a 10-year warranty against more than 15-percent degradation of system performance because of faulty installation.[82]

## Spotlight on: Massachusetts Commonwealth Solar Hot Water Programs

Program requirements ensure that MassCEC funds SWH systems that are technically and structurally feasible, appropriately sized and are a good use of public funding

The Green Jobs Act of 2008 created the MassCEC, a quasi-public agency, solely dedicated to facilitating the development of the clean energy industry. [83] In 2011, MassCEC piloted three Commonwealth Solar Hot Water (SHW) Programs: residential, low-income, and commercial. In July 2012, after a one-year test period, the program was granted $10 Million over four and a half years through the end of 2016. [84] Survey feedback from solar installers consistently voiced that a main market barrier was undependable incentive funding and that MassCEC will engage the private sector to commit resources to the MassCEC program if MassCEC makes a commitment to the long-term future of the program.

Key drivers for the pilot commercial SHW program were developing clean energy businesses, stabilizing fuel costs, reducing energy imports,  and reducing greenhouse gas and air pollutants.58 MassCEC SHW program elements for commercial systems include:

- Feasibility Study Grants provide financial assistance for contractors to conduct a site, structural and economic assessment that would help commercial building owners assess the potential benefits of installing a SHW system. The studies also help to ensure that MassCEC funds the construction of systems that are technically and structurally feasible, appropriately sized and are a good use of public funding (i.e., will reduce a significant portion of the fossil fuel used for water heating). [85]
- Financial assistance is provided through rebates to building owners for installing a solar water heating system.
- No pre-approved contractor list was developed. Rather, the first two systems of any contractor must go through design review and site inspection before being approved for incentives.
- Pre-installation hot water usage metering and post-installation performance monitoring and reporting are required for commercial systems. MassCEC contributes $500 to $1,500 for performance monitoring equipment per system.
- MassCEC engages in marketing and education for the public as well as training for building & plumbing inspectors though local workshops. The Massachusetts Opportunities and Impacts Study (quantified and illustrated societal, economic, and environmental benefits of developing local RHC technologies and markets) highlighted that many inspectors of SHC installations are unfamiliar with appropriate design and safety requirements.

**Benefits**: The pilot program built awareness of MassCEC as a key player in the thermal industry, established technical system and installation requirements, provided technical guidance for installers, developed installer-installer and installer-manufacturer partnerships, and secured funding that has brought business to the state, including five manufacturers of STH components. Performance monitoring has also allowed comparison of how SHC systems actually perform in Massachusetts with predicted energy production. Commercial performance monitoring in MassCEC commercial SWH systems showed 94 percent of predicted energy was produced. There was less variability in production across projects than residential or low-income installations. [86]

### MassSave HEAT Loan program

Massachusetts works with financing institutions through the  MassSave HEAT Loan program to provide businesses with a seven year no-interest up to $100,000 for energy efficiency retrofits. [87]

## 5.C Contractor Requirements and Training

SWH can create local jobs across the value chain in areas such as research and development, engineering, manufacturing, system design, system installation, and business management.[88] However, because C&I SHC systems can be very complex, engineers must design systems to meet established industry best practices to ensure that the systems produce energy that meets their designed output. While SRCC certification can help ensure the equipment meets quality standards, it does not guarantee that systems will not face performance concerns if installed incorrectly. Florida's Solar Weatherization Assistance Program inspected 25 percent of installed systems and noted that the majority of discrepancies were related to craftsmanship and the quality of installation, rather than major system design or materials flaws.[89]

There are various ways that states can ensure that qualified contractors are installing SHC systems. Some approaches and state examples are listed below.

- Provide incentives to contractors on a qualified contractor list to ensure quality installations, are able to communicate the program to consumers, and apply for incentives. *The Energy Trust of Oregon (ETO) requires contractors to be part of the Trade Ally program which involves program competency training as well as installer licenses. ETO has held a number of trainings for plumbers to assist with widespread competence in SHC installations*. [90]
- Require solar licenses which typically take the form of a separate, specialized solar contractor's license under a general plumbing license. *Efficiency Maine's solar thermal water systems installers must be certified by the PUC and must hold a state license as a Master Plumber, a Master Oil Burner Technician, or a Propane and Natural Gas Technician.* [91] *The Connecticut Clean Energy Fund (CCEF) Eligible Solar Thermal Contractor program requires the contractor to hold one of two specialty licenses.*
- Allow contractors to participate without training or meeting requirements, but conduct inspections of their work with the authority to withhold incentives if they do not pass review. *The MassCEC SHW program takes this approach.*

## 5.D Public Education

The general lack of public familiarity in the United States with the benefits of RHC technologies and trust in the integrity of the system installations is a widely identified market barrier. Effective public and industry education about the technologies in conjunction with state or utility incentive program education is an important element in increasing participation in a new program. Generally, education, outreach, and training are an allocation under the total program budget, and the need for these will depend on the education level of the audience. Consumer marketing, if done strategically, can be an effective educational tool.[92] A few innovative ways that states promote programs are listed below.

- An approach gaining momentum is the community based bulk purchase campaigns built from the success of the *Solarize Portland* campaign. These campaigns are beginning to support SHC technologies in addition to solar PV.
    - *The Minnesota Renewable Energy Society recently initiated a volume purchase solar hot water program called "Make Mine Solar H2O" open to all residents and businesses in the Minneapolis/St. Paul area.*[93]
    - *Connecticut has just introduced the "Solarize CT" program. While it is primarily geared toward solar PV, one community has included SHW in the offering, which may prove to be a stimulus to additional SHW deployment in the area.*[94]

- *In Oregon, some of the bulk purchasing efforts have shifted to SWH. The focus to date has been heavily on promoting PV, which has achieved widespread acceptance, and increasing deployment.*

- State programs reward contractors for promoting programs. *ETO relies heavily on contractors selling the program - Trade Allies receive a stipend for advertising the ETO program.* [95] [96]
- An education campaign with a strategic and creative design and branding can strengthen program participation. The *Smart Solar Marketing Strategies Clean Energy State Program Guide* by Clean Energy Group and SmartPower captures a number of best practices geared toward program implementers to make consumer marketing an educational tool that moves people to action. [97]

# 6. Applying RHC Technologies in C&I Applications

Renewable heating and cooling technologies are well suited for a number of commercial and industrial applications.

## 6.A Solar Heating and Cooling

Solar thermal energy systems vary in their fluid temperature—low, medium, or high—which dictates system application: space or water heating, solar cooling, or process heating. In all cases, sunlight strikes and heats a solar thermal collector, which then transfers the sun's heat energy to a heat-conveying medium, such as water or glycol. Incumbent building space or water systems can use this heated fluid to supplement their effectiveness. Solar space cooling, on the other hand, involves the use of solar thermal energy to power a cooling appliance, such as absorption or desiccant chillers. Process heating utilizes solar energy to generate large quantities of heat energy mainly for manufacturing processes, often serving as a pre-heat to an incumbent conventional energy system.

### *6.A.1 Low-Temperature Systems*

Low-temperature collectors provide heat of less than 110 degrees Fahrenheit. Swimming pool heating and low-grade space heating typically use these types of collectors.[98] Low-temperature systems can be used for preheating ventilation air for C&I buildings[99] or in evaporation ponds to extract minerals or chemicals from liquid solutions.

### *6.A.2 Medium-Temperature Systems*

Medium-temperature systems produce temperatures between 140 and 180 degrees Fahrenheit and are classified as either active or passive. Active solar water heaters utilize electric pumps and controllers to circulate fluid whereas passive systems rely on the movement on fluids due to temperature differences. Medium temperature systems can be hybrid systems, meaning they provide multiple services such as providing cooling or additional process-heat services.

While solar thermal systems cannot completely replace boilers and other high-temperature water heaters in industry, they are able to offset significantly existing demand.[100] SHC is particularly well suited for large applications with significant hot water demand during the day, though storage systems can store and allow for use hot water after sunlight hours. Lodging, apartments, health, and restaurant end users have some of the greatest potential because they tend to use hot water during mid-day and into the evening for laundry, cooking, or other domestic tasks, when solar systems are most productive.[101]

### 6.A.3 High-Temperature Systems

A number of SHC systems can reach high temperatures by concentrating solar energy, producing temperatures of 180 degrees Fahrenheit or higher. Industrial end users employ hot water for specific manufacturing tasks, such as producing textiles, chemical pulp and paper, and plastic or rubber components for machinery, or for washing manufactured components. [102] Solar thermal systems can produce hot air for drying crops and products such as grain, coffee, tobacco, fruits and vegetables, and fish.[103] These systems also dry and season timber.[104] The food processing industry is also particularly well suited for both medium- and high-temperature SHC applications. The Lucky Labrador Brewery in Portland, Oregon, uses solar-heated water for its brewing process, and a Frito-Lay plant in Modesto, California, uses concentrated solar power collectors to heat steam for its chip cooker.[105] Solar thermal cooling applications are becoming more common and often utilize a parabolic trough connected to a chiller.

In addition, more than 80 percent of Europe's existing district heating and cooling plants are equipped with flat-plate collectors with large module collector designs. Most also have pressurized collector systems with an anti-freeze mixture of glycol and water.[106] District heating is much less common in the United States but is being considered increasingly for new developments and retrofits.[107]

# Appendix A

## Other RHC Technologies: CHP, Geothermal, and Biomass Commercial Applications

Several states incent the use of thermal energy derived from RHC technologies in their EPSs. See Table 2.

### *Combined Heat and Power*

Combined heat and power (CHP), also known as cogeneration, is the simultaneous production of electricity and heat from a single fuel source. The heat generated because of the electricity generation is not lost; rather it is used in space heating, dehumidification, or process heat applications, or converted to electricity or converted to cooling when coupled with an adsorption chiller. Systems typically achieve total system efficiencies of 60 to 80 percent—compared with less than 50 percent for equivalent separate heat and power systems. CHP is not a single technology, but an energy system that integrates into existing building infrastructure for a variety of technologies, thermal applications, and fuel types. Common fuels used for CHP systems include fossil fuels, biomass or biogas, and in some newer technologies, solar thermal energy.[108] [109]

### *Geothermal Heat Pumps*

Geothermal heat pump systems utilize the constant temperature of the ground (average in the United States is approximately 53 degrees Fahrenheit) as a heat source or heat sink depending on the season. During cold seasons, the GHP pre-heats heating, ventilation, and air conditioning (HVAC) working fluid by running the fluid through pipes in the earth, which is warmer than the winter air. During warm seasons, the system reverses itself to cool the building by pulling heat from the building and placing it in the ground. The heat exchange with the earth makes for very energy efficient HVAC systems, in some places providing more than 70 percent of the energy required to heat and cool buildings. Ground-source heat pumps can be categorized as having closed or open loops and those loops can be installed in three ways: horizontally, vertically, or in a pond/lake. The type chosen depends on the available land areas and the soil and rock type at the installation site. If spatially feasible, these systems can deliver large energy savings to almost any commercial property.

### *Biomass*

Biomass is organic matter that can be combusted for energy or converted into different types of renewable fuels. Where available, combusting solid biomass such as wood, wood harvest/mill residues, or agricultural residues as an alternative to fossil fuels is gaining traction in the United States. Biomass is being used in efficient heating systems and in CHP systems for providing heat for schools, colleges, and commercial buildings, and in whole community heating projects in the United States, Canada, and Europe.[110] *Massachusetts Impacts and Opportunities Study* found significant potential in utilizing biomass pellet systems for space heating and domestic hot water and utilizing biodiesel to supply space heating in commercial and residential facilities.[111] Utilizing biomass thermal energy has greater return on energy invested than utilizing it to produce electricity. Combusting biomass produces about 65 to 90 percent useable energy whereas utilizing biomass for electricity generation only generates 33 percent useable energy.[112]

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