POLICIES FOR ACHIEVING ENERGY JUSTICE IN SOCIETY: BEST PRACTICES FOR APPLYING SOLAR ENERGY TECHNOLOGIES TO LOW-INCOME HOUSING

FINAL REPORT

A Renewable Energy Applications for Delaware Yearly (READY) Project

Center for Energy and Environmental Policy
University of Delaware

First Publication in July 2010
Updated December 2010

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Final Report

A Renewable Energy Applications for Delaware Yearly (READY) Project

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Executive Summary

Studies indicate that the energy burden — energy costs as a percentage of annual family income — on low-income families is inordinately high, compared to that of the rest of the population. Rising fuel costs exacerbate this problem. Residential solar energy systems can help address this situation by furnishing a price-stable energy source with the added benefit of reduced greenhouse gas emissions. However, without appropriate incentives, these systems are prohibitively expensive for low-income families. Research of "best practices" in low-income housing across the United States has found that federal and state government assistance programs, private funding, and the efforts of nonprofit organizations, when coordinated through effective policy, can provide a wealth of resources to improve energy affordability. Research further indicates that the development, installation, and maintenance of renewable energy technologies such as residential solar energy (including solar hot water, photovoltaic systems, and passive solar design) can create green job opportunities. Thus, policies that encourage the use of solar energy technologies for low-income families have the ability to foster greater energy justice by mitigating unfair energy burdens for vulnerable populations. These types of policies could be implemented in Delaware through the Sustainable Energy Utility and in accordance with existing state energy policies to mitigate climate change, reduce energy burdens, and create new jobs.

1.0 INTRODUCTION

Conventional energy prices are expected to rise steadily and at times rapidly over the coming decade. There is mounting consensus over the need to lower energy sector emissions in order to reduce climate change. And rising national unemployment has spurred policy interest in a transition to a "green" economy with job growth expected from the diffusion of renewable energy technologies into the economy. These factors have general importance to the U.S. but are especially salient to low-income households who are vulnerable to the risks of energy un-affordability. This report examines how policies promoting solar energy technology in low-income housing can help alleviate some of this burden, while in the process promoting energy justice and creating green jobs.

Low-income energy assistance programs traditionally prioritize financial assistance services to decrease monthly household energy bills or to provide emergency relief in the case of service disconnection. Many states also offer energy-related services such as no-cost weatherization improvements, equipment repair and replacement, and energy budget counseling (U.S. Department of Health and Human Services, 2009). While financial subsidies can reduce energy bills and lessen the disproportionately high costs of energy for low-income households, it represents a short-term or temporary fix. Simply subsidizing energy bills leaves the participant dependent on the assistance program and thus vulnerable to changes in program eligibility requirements and budget shortfalls.

These concerns suggest that a commitment to long-term solutions is necessary to achieve enduring reductions in the energy burden. Such long-term solutions can include weatherization and energy efficiency measures to increase energy productivity and to decrease energy consumption, as well as customer-sited renewable energy installations like solar energy systems, which provide an emissions-free and price-stable energy resource. These investments in sustainable energy resources can be a better investment of federal dollars than subsidy-only approaches. A policy-induced surge in the incentives for new renewable energy systems made available by federal, state and municipal governments is making renewable energy technologies more economically competitive and accessible to residential customers. When integrated appropriately, government policies can create a unique opportunity to provide low-income households with solar energy, energy efficiency, and weatherization assistance, in ways that decrease reliance on conventional energy, and can reduce energy costs to near-zero levels.

It should be noted that solar energy is just one type of several renewable energy resources that could be used to reduce the energy burden on low-income households. Factors such as resource availability, cost, climate, and accessibility (on-site versus off-site generation) should all be considered before selecting an appropriate renewable energy technology for residential energy assistance.

A range of policies may be necessary to reduce the many barriers that exist – to include high technology costs, low and uncertain income levels, and a lack of information, training, and awareness – that presently prohibit fuller use of energy efficiency and renewable energy. This research examines the ways in which existing barriers may be overcome, through a review of state and federal policies that presently work to reduce the energy burden for low-income households. Examined in this regard are the history and current state of policies aimed at addressing energy poverty in the U.S., to identify the strengths, weaknesses, and relationships among existing policies and the role of increased renewable energy consumption in achieving this goal.

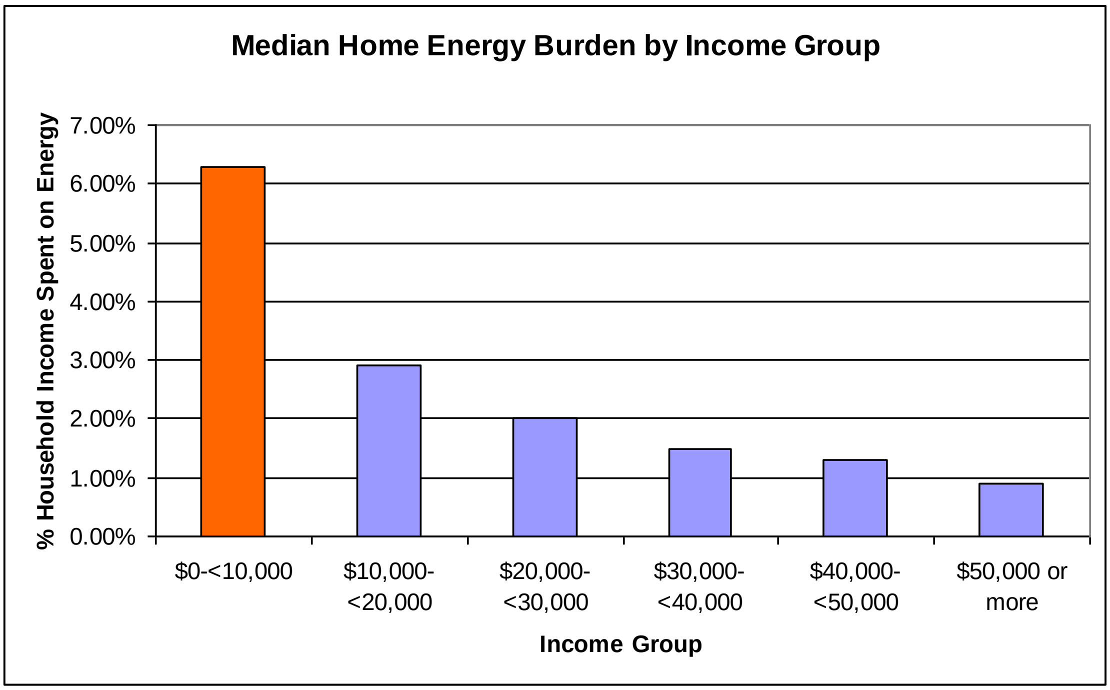
For the purposes of this research study, *low-income households* are defined as families living in owner-occupied dwellings that meet the definitions of "low-income" as defined by their particular U.S. state of residence, in order to be considered eligible to benefit from local low-income renewable energy programs. Typically, these definitions include the federal standard of families with incomes less than 200 percent of the federally stated poverty level. Although some programs identified as embodying sound practices can be utilized by landlords renting to low-income tenants, the study does not focus on this group of households. Policies targeting low-income public housing also fall beyond the scope of this study.

2.0 ENERGY BURDEN THRESHOLD

The issue of energy justice arises when the energy burden on low-income households is disproportionately high. Low- and moderate-income households spend a larger portion of their incomes on energy, compared to higher-income households (Campaign for Home Energy Assistance, 2005). This causes low-income households to be more vulnerable to rising or fluctuating energy prices. This proportion of household income spent on energy is called the *energy burden* (Figure 1).

Energy justice refers to the achievement of a proportionate distribution of energy burdens among low- and moderate-income groups, disadvantaged sections, and minorities when compared to the energy burden falling on the rest of society.

Figure 1. Median home energy burden by income group



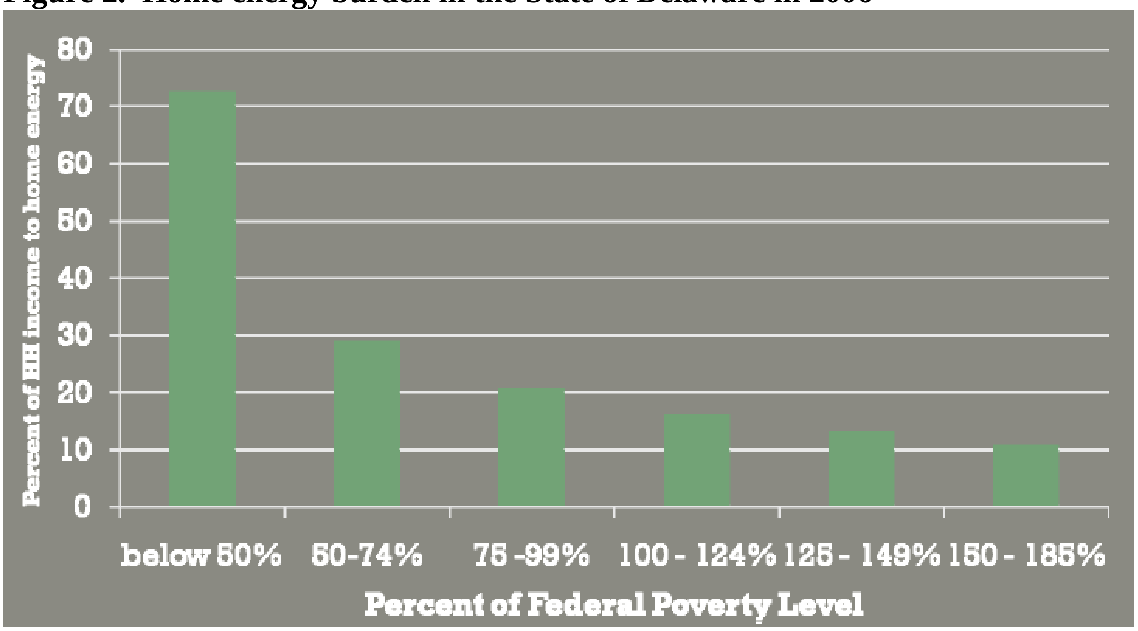
Source: Campaign for Home Energy Assistance, 2005

The *energy burden threshold* represents a percentage of household income set to specify a high-energy burden. The threshold approach is preferred because it allows for change in the number of high burden households, depending on the increase or decrease in energy prices (Campaign for Home Energy Assistance, 2005). However, defining the energy burden threshold is not straightforward because different studies consider different percentages as the threshold for a high-energy burden. For instance, one Low Income Home Energy Assistance Program (LIHEAP) study considers an expenditure of 4.3 percent of annual income on energy as translating to a high-energy burden (U.S. Department of Health and Human Services, 2005). Meanwhile, an analysis conducted by the American Gas Association (2007) identifies that an average family spends about 6-7 percent of its total income on household energy, meaning that a high energy burden would entail an excess of 6-7 percent of household income going to energy costs.

Regardless of these differences in defining the energy burden threshold, it is clear that an energy burden exists in U.S. society. A study on the home energy affordability gap in Delaware shows that households in the state with an income below 50 percent of the federal poverty level spend 72.5 percent of their annual income on energy-related expenses (Fisher, Sheehan & Colton, 2007).

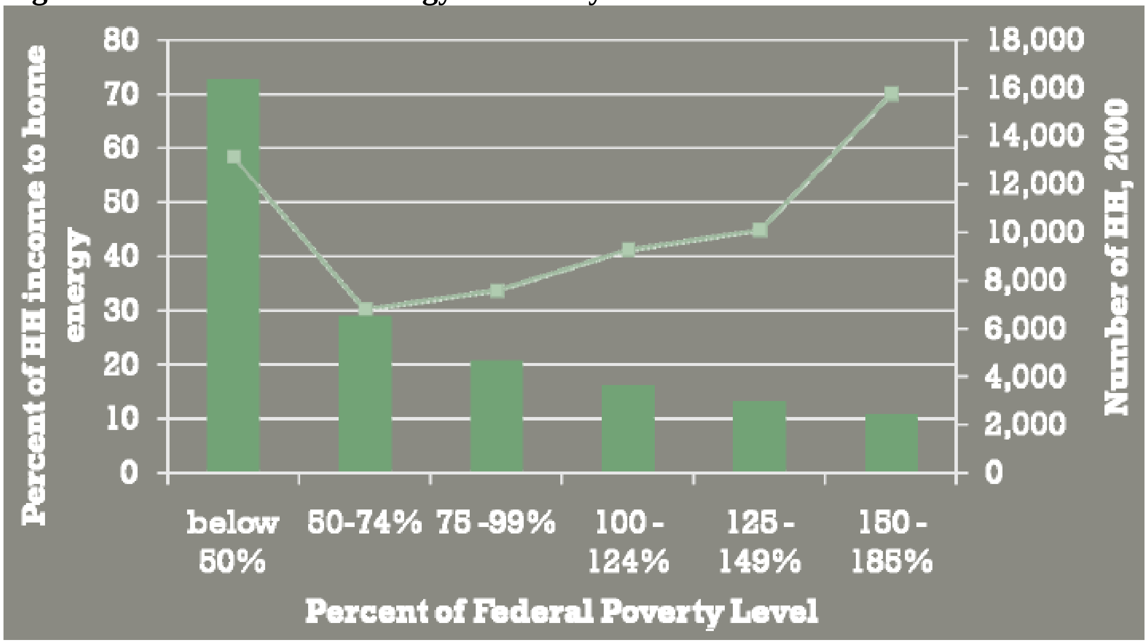
Figure 2 indicates a sharp contrast between the energy burden on the population below 50 percent of the federal poverty level and the population above this level. Furthermore, according to the 2000 U.S. Census, the number of Delaware households categorized as being 50 percent below the federal poverty level exceeds 13,000 (Figure 3). This represents 21 percent of the total number of households in the state.

Figure 2. Home energy burden in the State of Delaware in 2006



Source: Fisher, Sheehan & Colton, 2007

Figure 3. Delaware home energy burden by number of households

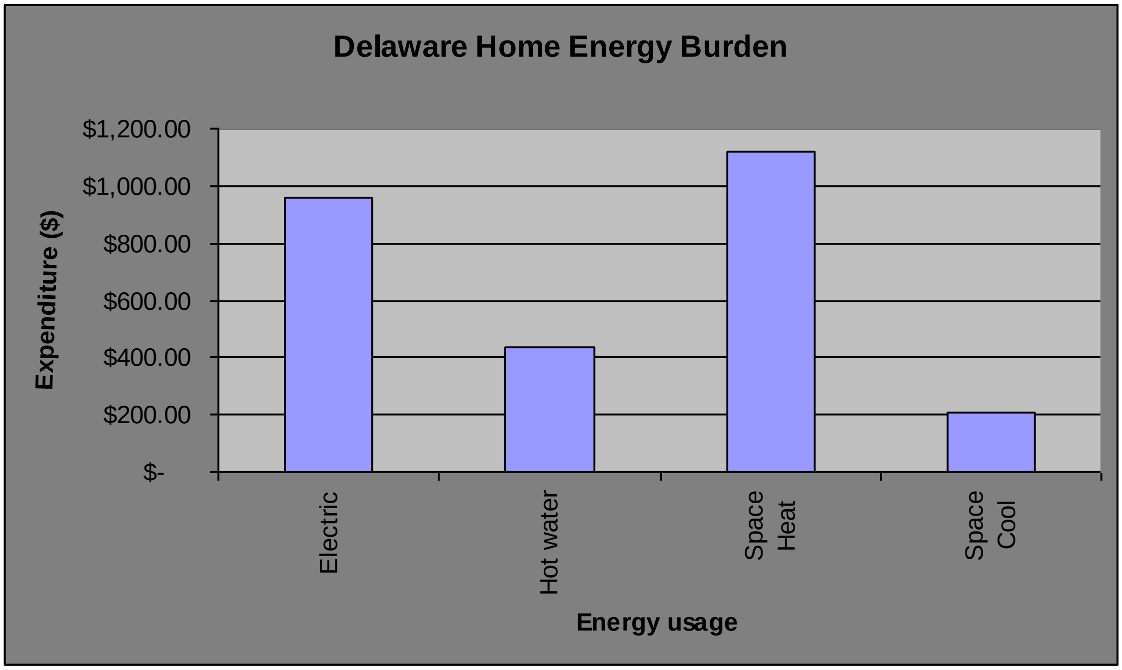


Source: Fisher, Sheehan & Colton, 2007

Additionally, the total home energy affordability gap for the State of Delaware increased by $48.8 million from 2002 to 2006, while the federal LIHEAP allocation to Delaware increased by only $0.8 million in the same period (Fisher et al, 2007). The home energy affordability gap, as characterized by the home energy affordability gap index, has increased 77.2 percent in the same period. Clearly, the federal LIHEAP allocation to assist in mitigation of the home energy affordability gap for the State of Delaware is inadequate to meet current needs. Recently, the U.S. Department of Energy dramatically increased its support for state weatherization programs. In Delaware's case, federal funding rose from approximately $500,000 in FY 2007 to nearly $14 million for FY 2009-12 (Davis, 2010).

Space heating and electricity usage account for the bulk of energy usage in the State of Delaware (Fisher et al, 2007). Yet as Figure 4 indicates, the energy affordability gap in Delaware is not created exclusively by any single type of energy use. Electricity consumption accounts for over 35 percent of the energy burden, and hot water requirements account for more than 16 percent. Together, these usages constitute over 50 percent of the total energy burden faced by Delaware households.

Figure 4. Delaware home energy burden by type of energy usage



Source: Fisher, Sheehan & Colton, 2007

Most of the energy demand in Delaware could be met with solar energy systems. However, suitable policy intervention is required to overcome the financial and psychological barriers that exist regarding this technology, including upfront costs and lack of consumer awareness. The next section outlines federal and state policies for energy assistance, which have been tailored in various ways to promote and accommodate solar energy systems toward the achievement of greater energy justice.

3.0 PROGRAMS FOR ENERGY JUSTICE

Policy to address the energy burden has been implemented in many forms at all levels of government. While the level of funding provided for energy justice issues has fluctuated between and within administrations, support for these programs has remained constant, in recognition of the need to assist low-income households facing disproportionately high energy costs.

3.1 Federal Energy Assistance Programs

Energy assistance programs in the U.S. for low-income households can essentially be placed into two categories. The first type includes those that assist recipients with utility bill payments. The second type entails those that help to improve energy efficiency and to reduce energy demand, thus helping to lower energy costs. The federal government has implemented policies that fall under both of the above categories. However, the increasing impacts of climate change and the nonrenewable nature of fossil fuels have joined to make programs under the second category more favorable.

Federal energy assistance programs were first created as a response to the national energy crises and oil shortages of the 1970s. Two major federal programs include the Low Income Home Energy Assistance Program (LIHEAP) and the Weatherization Assistance Program (WAP). The LIHEAP was founded in 1981 to provide funds for home heating, weather-related emergencies, and medically necessary home cooling (U.S. Department of Health and Human Services, 2008). The U.S. Department of Health and Human Services (HHS) distributes federal funding through LIHEAP to individual states in the form of block grants. These block grants are distributed to the states based on a formula that weighs relative cold-weather conditions to households living in poverty (Campaign for Home Energy Assistance, 2005). Funds are then disbursed to low-income households through programs administered by state and/or county governmental agencies, which include community action programs, welfare agencies, and area agencies on aging.

Unfortunately, LIHEAP only reaches about one in six eligible low-income households (Center on Budget and Policy Priorities adapted from the National Energy Assistance Director Association, 2008). Between 2002 and 2007, the number of households eligible for LIHEAP assistance increased by 15 percent. In September 2007, the American Gas Association reported that households receiving aid through LIHEAP are spending 33 percent more of their income on energy costs, compared to 1998 (American Gas Association, 2007). Meanwhile, the portion of income required by non-low-income households to pay energy bills has not changed significantly during this time period.

Another critical concern with LIHEAP is that this type of program does not address the issue of climate change. With the exception of the now abandoned Residential Energy Assistance Challenge Program (REACH),[1] funds used under LIHEAP do not help to

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[1] REACH funds were taken out of the LIHEAP leveraging incentive funds, and were used to assist communities that submit plans to help pull LIHEAP recipients out of their vulnerable energy affordability situations. REACH proposals were awarded funds in the year 2007, but not in 2008 (U.S. HHS, 2008).

ensure that recipients of such funds become independent of assistance in subsequent years. By contributing to the payment of utility bills, energy assistance programs such as LIHEAP forgo the opportunity to help low-income families reduce their dependence on fossil fuels (a prime agent in the release of greenhouse gases) in a more permanent way, as these households may find themselves in the same predicament year after year.

The WAP retains a slightly different purpose. It was established with the intent to "increase the energy efficiency of dwellings owned or occupied by low-income persons, reduce their total residential expenditures, and improve their health and safety, especially low-income persons who are particularly vulnerable such as the elderly, persons with disabilities, families with children, high residential energy users, and households with high energy burden" (Federal Register, 2000, in Kaiser et al, 2004). The WAP assists low-income households with energy needs *and* reduces the extent to which a family must depend on fossil fuel generated heating and cooling. Created in FY 1976 within the U.S. Department of Energy (U.S. DOE), WAP has provided 5.6 million households with assistance since it was established (U.S. DOE, 2001). Table 1 provides a timeline of the evolution of the WAP program through 2001.

Table 1. Evolution of the Weatherization Assistance Program

1973	Oil crisis creates fuel shortages
1976	Congress creates the Weatherization Assistance Program focusing on emergency and temporary measures
1980	Emphasis on more cost-effective and permanent measures
1984	Space and water heating improvements authorized
1985	Furnace and boiler replacements approved
1990	Development and implementation of advanced audits
1994	Cooling measures for warm climates included
2000	Advanced energy audits in use nationwide
2001	Five million homes served

Source: U.S. DOE, 2001

The benefits realized from WAP far exceed those realized by assisting families with their utility bills, for several reasons. First, the financial benefits associated with WAP last longer, thereby benefiting the family as well as the government in fulfilling its obligation to provide assistance year after year. Additionally, the diminished energy requirement for heating and cooling reduces the carbon footprint of a weatherized residence. Studies have also shown that low-income households participating in WAP have experienced a significant number of indirect benefits (Schweitzer and Tonn, 2002; Schweitzer et al, 2003). They include the following:

- Decreased bad debt
- Lower carrying costs on arrearages
- Reduced notices and customer calls received
- Fewer utility shut-offs and reconnections due to delinquency
- Less emergency gas service calls
- Reduced transmission and distribution calls
- Insurance savings
- Property value enhancements
- Reduced mobility/greater stability
- Generation of local jobs
- Retaining money and expenditures in local community

A study by Oak Ridge National Laboratory shows that, for the year 2001, the non-energy benefits of weatherization were worth $3,346 and energy savings due to weatherization were worth $3,174, while the average weatherization cost per household was $1,779 (Schweitzer and Tonn, 2002). A recent study (Schweitzer, 2005), evaluating weatherization efforts in 19 U.S. states from 1993 to 2005, found that estimated energy savings per household approximated 23 percent of the pre-weatherization usage of natural gas, across all end uses. For space heating specifically, per household energy savings were estimated to equate to 32.3 percent of the natural gas consumed during the time frame preceding weatherization. Meanwhile, with regard to houses heated by natural gas targeted by the WAP, the benefit-cost ratios were found to be 1.34 (based on a narrow program perspective, considering only energy benefits) and 2.53 (based on a larger societal perspective considering energy and non-energy benefits).

Policies supporting the use of on-site renewable energy systems to reduce the energy burden of low-income households can expect to achieve similar non-energy benefits as that of WAP. Various aspects of program implementation, such as labor requirements, local purchasing requirements, reductions in the use of grid energy, and lower utility bills, etc., suggest that the non-energy benefits of WAP might be useful complementary indicators for expectations surrounding renewable energy assistance programs.

Although LIHEAP and WAP differ in how they address energy affordability, these programs also complement each another. A study conducted by the Environment Sciences Division of the Oak Ridge National Laboratory examined this relationship. It was hypothesized that WAP would decrease the aggregate financial need for LIHEAP assistance when recipients received help from both programs (Tonn et al, 2002). The study looked at a random sample of households in Boston receiving both LIHEAP and WAP assistance, compared it to a sample of households receiving only LIHEAP over several years, and the results showed that the need for LIHEAP assistance was diminished in weatherized homes, but not eliminated altogether (Tonn et al, 2002).

Similarly, a 2006 report (Kulkarni et al, 2006), examining conditions in Delaware, assessed the impacts of the Delaware WAP initiative on energy consumption and related energy costs. The study found that, for low-income homes, weatherization saved both energy and money for participants. Specifically, the cost of conserved energy was estimated as $0.05/kWh-$0.06/kWh, versus $0.10/kWh, the retail electricity price paid by low-income households utilizing electricity. For natural gas-reliant low-income households, the cost of conserved energy fell between $0.77/CCF-$0.90/CCF compared to the $1.50/CCF retail price for natural gas. With these types of gains, the report determined that weatherization assistance for low-income households yielded higher benefits than mere financial assistance to cover energy bills (Kulkarni et al, 2006).

These findings offer a clear indication that inclusion of a renewable energy assistance program within the policy mix will at least diminish, if not completely eliminate, the need for utility bill payment assistance to low-income households.

3.2 State Energy Assistance Programs

States may be better positioned than the federal government to pursue energy assistance programs specific to renewable energy technologies. Historically, jurisdiction over many activities related to energy and climate change have been delegated or devolved to state jurisdiction. These activities include ownership and/or regulation of electricity and natural gas companies, land use planning, job creation, public health, and disaster management (Byrne et al, 2007). Recently, this relationship has been evidenced by the redistribution of federal stimulus funds to state and local governments for energy efficiency and public transportation projects through the American Recovery and Reinvestment Act of 2009 (Recovery Accountability and Transparency Board, 2009).

Byrne et al write that, "the rise of state and local policy interest in the U.S. in climate-sensitive energy policy may point to important pathways for policy innovation whose political durability could equal or exceed conventional 'top-down' national energy policymaking" (2007: 4556). Such "bottom-up" approaches to energy planning, including policies for low-income assistance, can overcome the "institutional gridlock" experienced in the national government (Byrne et al, 2007). Citizens, through direct democracy, ballot initiatives, and constituent activism, have better opportunities to participate in state and local policymaking.

This distinctiveness of state and local government could, in theory, foster the development of exemplary energy assistance programs. The types of assistance programs administered at the state and local levels of government include loans, rebates, tax credits, tax exemptions, grants, public benefit charges and other utility-based programs.

Loans with a low interest rate are available to assist applicants within their jurisdictions to implement a range of qualifying energy efficiency and renewable energy projects. Repayment of the loans usually does not begin until after construction is completed.

Rebates are offered for the installation of renewable energy measures by residents within their particular jurisdiction amounting to a proportion of the initial cost of eligible improvements, up to a maximum rebate per application. Applicants are initially required to have an energy audit performed by a certified contractor to determine whether the home is sufficiently weatherized.

Tax credits are provided with regard to both corporate taxes and personal income taxes. This incentive can apply to both owners and tenants of eligible buildings that install renewable energy systems.

Tax exemptions are provided in the form of property tax exemptions for renewable energy installations or sales tax exemption for the initial purchase of renewable energy technology.

Grants are provided to eligible applicants as compensation for a portion of, or total initial costs associated with, renewable energy systems or energy efficiency measures. Applicants must contact an approved contactor or consultant for a comprehensive assessment report to determine what measures are needed.

Public benefit charges are utility-based programs collected via a surcharge levied on consumers' utility bills, with funds used to support energy efficiency and renewable energy programs. This program may also be administered by utilities without government intervention.

Other utility-based programs that can be implemented include using customer or shareholder profits and/or profits from the sale of emissions credits by the utilities to provide rate assistance to customers through discounts, waivers, and arrearage forgiveness. In 2006, energy utilities provided $1.8 billion in assistance to low-income households through discounts, fee waivers, efficiency/weatherization programs, and arrearage forgiveness. This assistance was funded by customers and stockholders without government financing (American Gas Association, 2007).

3.3 Energy Assistance Programs in Delaware

Many of the energy assistance programs described above are available to low-income residents in Delaware. The federal assistance programs, LIHEAP and WAP, are both administered by Delaware's Division of State Service Centers (DSSC). For FY 2009, Delaware received a $17 million block grant for LIHEAP and an additional $1.36 million in emergency contingency funds (LIHEAP Clearinghouse, 2008). The Delaware WAP received $1.18 million in DOE funding in FY 2009. Due to the passage of the American Recovery and Reinvestment Act of 2009, Delaware's WAP budget has ballooned with the additional stimulus funding award of $13.73 million, which will be spent over the next 36 months (Weatherization Assistance Program Technical Assistance Center (2009).

Delaware Health and Social Services (DHSS) contracts Catholic Charities to identify clients for both programs. Weatherization services are contracted out to the Neighborhood House for clients in New Castle County and First State Community Action Agency in Kent and Sussex Counties. These agencies then subcontract to energy service companies to provide the actual weatherization services (U.S. Department of Health and Human Services, 2008).

Delaware has also established additional state-funded programs to alleviate the energy burden on residents. In October 1999, the Electric Utility Restructuring Act of 1999 (House Bill No. 10 and amendments) created an environmental incentive fund – administered by the Delaware Economic Development Office – to support conservation and energy efficiency programs in the Delmarva Power service territory. The Act designated $0.000095 per kWh from each rate class, or $800,000 annually, to support WAP and complement LIHEAP as administered by the DSSC.

In April 2006, the Act to Provide Supplemental Funds for the Delaware Energy Assistance Program (Senate Bill 280) appropriated $2 million from the General Fund to the Department of Health and Social Services (DHSS) for the Delaware Energy Assistance Program (DEAP). The Act also required the Secretary of the DHSS to report to the Director of the Office of Management and Budget and the Controller General with a projection of the long-term needs of the DEAP through FY 2010.

Additionally, several private entities have established residential energy assistance programs targeted to low-income and vulnerable segments of Delaware's population. The Chesapeake Utilities Sharing Program uses customer donations and shareholder contributions to assist fixed income, elderly, or disabled households with their heating costs (LIHEAP Clearinghouse, 2008). Delmarva Power (Conectiv) has a similar program, the Good Neighbor Fuel Fund, which matches customer contributions and donates these funds to LIHEAP-eligible households (LIHEAP Clearinghouse, 2008). Both the Chesapeake Utilities and Delmarva Power programs are administered by Catholic Charities and the Salvation Army at the county level.

4.0 RENEWABLE ENERGY ASSISTANCE PROGRAMS

As this report indicates, the LIHEAP and WAP programs form the basis of low-income energy assistance in the U.S. and are augmented by state and local level programs. Despite their achievements, limitations in their reach or effectiveness have led to a continuing high energy burden for many households. An expansion of energy assistance tools – including the use of renewable energy technologies, and more specifically an integration of solar energy technologies – would resolve many of these deficiencies by providing permanent energy reduction measures or replacing conventional energy needs with cleaner, price-stable energy sources.

Renewable energy from wind, water, the earth, and the sun provides a cleaner alternative to conventional fossil fuels, thus decreasing human contributions to global climate change. Investments in renewable energy create local jobs in fields such as engineering, manufacturing, construction, and maintenance, which can help to stimulate the local economy. The price and efficiency of renewable energy technologies varies widely, but in most cases, due to certain economies of scale that have yet to be realized with regard to the investments being made, customer-sided renewables are often prohibitively expensive for low-income households. Therefore, the benefits of using this technology have not been fully realized by this portion of the population.

In an effort to provide opportunities for low-income residents to use renewable energy and thus achieve greater energy justice, policy can be used to support assistance programs that aim to supplement or cover the costs of purchasing, installing, and/or maintaining renewable energy systems. Assistance with these costs can help to alleviate the energy burden on low-income households by providing a price-stable energy supply that is clean and dependable.

4.1 Benefits of Solar Technologies

State renewable energy assistance programs have been developed to support a range of technologies. For example, in 2003, the State of Washington received federal funding to allow low-income households access to local wind energy (State of Washington Department of Community, Trade and Economic Development, 2003). However, the majority of state renewable energy assistance programs have focused on solar energy technologies.

Three types of solar energy technologies are typically identified in solar energy assistance programs based on the parameters of market readiness, efficiency, and cost: photovoltaics (PV), solar water heaters, and passive solar systems. Detailed descriptions of these technologies are listed in the appendices of this report. Many benefits of solar make this energy source a superior option for electricity and heating for low-income households compared to conventional sources. These benefits, described in greater detail below, include cleaner air, avoided environmental degradation, climate change mitigation, reliable and abundant energy, price stability, a contribution to renewable portfolio standards, and job creation.

4.1.1 Cleaner Air and Avoided Environmental Degradation

The use of solar energy improves local air quality by reducing dependence on pollution-emitting technologies, such as those associated with fossil fuel-based energy. Organic compounds and metals found in fossil fuels, which make their way into the air when these fuels are combusted, can penetrate the human lung and cause health damage. Solar technologies do not emit greenhouse gases or air pollutants during operation. Solar technologies also operate silently, thus reducing local noise pollution. In addition, solar energy – for its fuel source – does not require mining or any form of extraction because sunlight is available everywhere (though not necessarily in an economically-feasible intensity) and is only limited by the life of the sun (Goodstein, 2004).

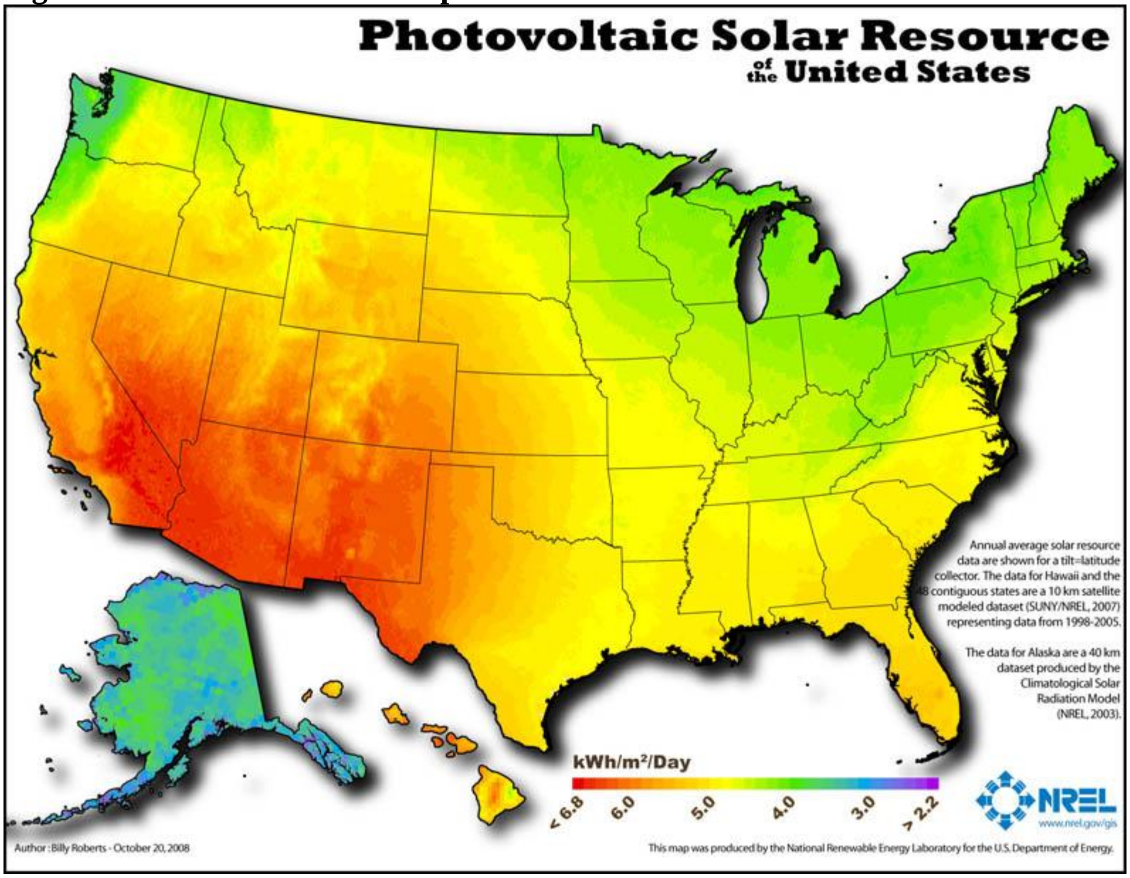
4.1.2 Climate Change Mitigation

On a broader scale, solar energy technology helps to mitigate climate change by lowering household CO_2 footprints. As witnessed in disasters such as Hurricane Katrina, low-income populations are often the most vulnerable to, and highly affected by, extreme weather events. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007), the acceleration of climate change due to fossil fuel use is very likely to result in the more frequent occurrence of extreme weather events. Low-income populations should be made aware of these threats, and likewise be encouraged – through assistance policy – to utilize clean technologies such as PV, solar hot water heating, and passive solar in order to mitigate their contribution to climate change.

4.1.3 A Reliable and Abundant Energy Source

Solar energy is a renewable, reliable source of power. Although the sun is an intermittent source of light, and the amount received by a PV system will fluctuate between and within days and seasons, as long as these variations are accounted for and expected, the sun can be considered a reliable source of energy. Figure 5 offers a map of solar PV resources in the U.S. when using a flat, south-facing surface at a tilt equal to latitude.

Figure 5. Solar PV resource map



Source: National Renewable Energy Laboratory, 2009

The above map indicates available solar resources, but the efficiency of solar energy will vary by the harvesting technology. Current efficiencies for commercial crystalline silicon cells equal about 15-20 percent. Efficiencies for PV modules are 10-15 percent for commercial crystalline silicon modules and 5-10 percent for commercially available thin-film PV modules (Denholm et al, 2007). These efficiencies are expected to improve slightly in the future. It is also important to note that, because these solar technologies are customer-sited, efficiency losses from transmission and distribution are avoided.

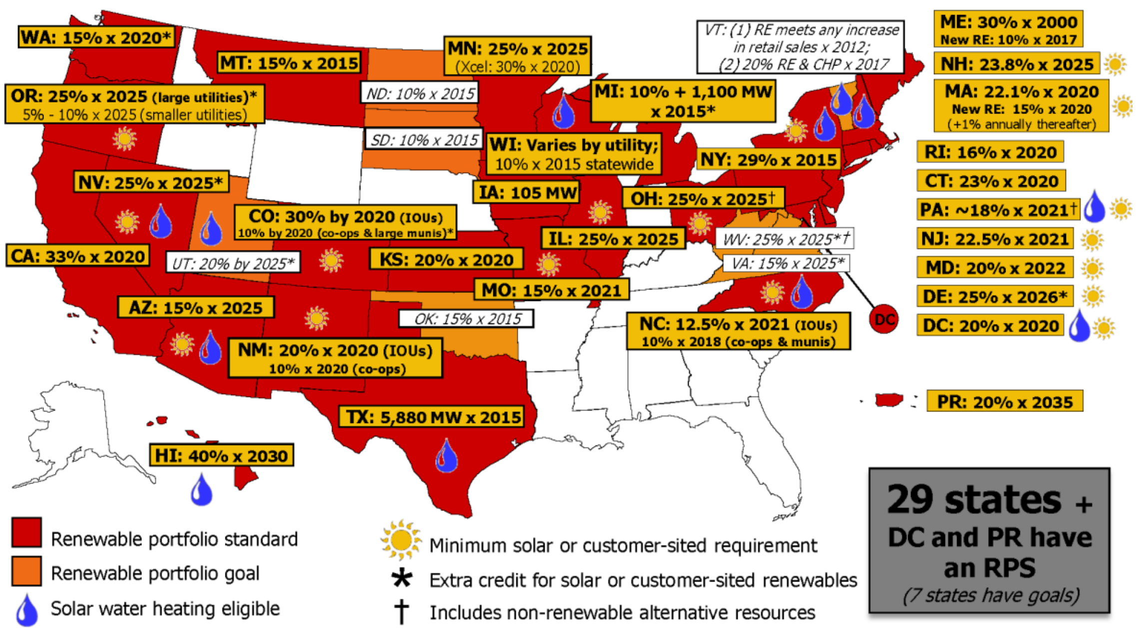
4.1.4 Price Stability

Solar technology is not subject to fuel price volatility or future fossil fuel price increases. The price of using solar energy remains constant during operation, even during peak hours. When used in addition to utility-purchased electricity, solar technologies can help offset total electricity costs through net metering policy. Similarly, PV and solar hot water technology have very low operation and maintenance costs compared to other technologies. In most cases, passive solar technology does not have any operation costs at all.

4.1.5 Contributions to Renewable Portfolio Standards

In recent years, state governments have increasingly adopted renewable portfolio standards. These obligate utilities to obtain a certain percentage of retail electricity sales or a certain amount of generating capacity from renewable sources, including solar energy, within a specific time period. This required amount could gradually increase over several years until the desired target or goal is achieved. As of December 2010, 29 states plus the District of Columbia and Puerto Rico have mandated renewable energy targets, and seven states have established a non-binding renewable energy goal (DSIRE, 2010), as shown in Figure 6. Each state has varying requirements, including timeframes, percentages, and eligible energy sources.

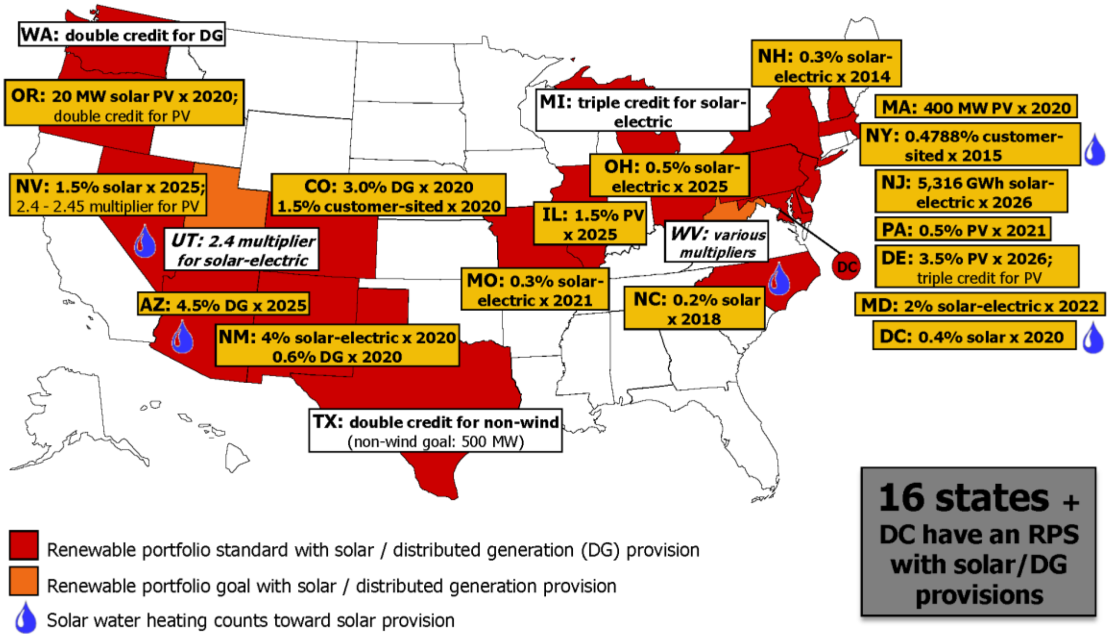
Figure 6. State renewable portfolio standards



Source: DSIRE, 2010

Many states have solar carve-outs within the goals of their RPS initiatives. At present, 16 states and the District of Columbia have adopted a solar carve-out or distributed generation requirement (DSIRE, 2010), as depicted in Figure 7.

Figure 7. Renewable portfolio standards with Solar/DG provisions



Source: DSIRE, 2010

Demand for solar technology is fostered by the Renewable Energy Credit (REC) and Solar Renewable Energy Credit (SREC) markets created by RPS policies. Such RECs and SRECs represent one unit of electricity (MWh) generated by qualifying renewable sources (Chupka, 2003). When sold in the open market, RECs and SRECs "create a supplemental stream of revenues for renewable generators and allow retail entities to demonstrate compliance with the mandated percentage requirement by purchasing RECs in lieu of direct procurement of renewable generation" (Chupka, 2003). The market essentially guides investment in renewable energy technologies by encouraging such investments to attain the goals of the state RPS. Investments in solar technology for low-income households would further help the RPS goal while generating sellable SRECs.

4.1.6 Creating Green Jobs

In this report, the terminology "green jobs" is used to refer to all jobs – direct, indirect, and incidental – that are a result of investment in renewable energy systems. A study conducted by Kammen, Kapadia and Fripp (Kammen et al, 2004) concluded that the renewable energy sector generates more jobs per MW installed, more jobs per dollar invested, and more jobs per unit of energy generated, when compared with the fossil fuel-based energy sector.

It has been shown that the green jobs potential of the solar PV sector, starting from system integrators (to put the system together) and sheet metal workers to roofers and service crews, etc., per million dollars invested over 10 years is 5.65 person-years. This is a much higher figure compared to the employment generated by the coal industry at 3.96 person-years per million dollars invested (Kammen et al, 2004).

For the purpose of this report, only the green jobs generation potential of solar PV investments is considered. Investments in solar PV projects can create local, permanent jobs, entailing highly-skilled positions in research and development, manufacturing, sales and installation. Examples of positions associated with opportunities in this field include electrical engineers, electricians, industrial machinery mechanics, welders, metal fabricators, electrical equipment assemblers, construction equipment operators, installation assistants, construction managers, and laborers (Pollin et al, 2008). Also boosted are indirectly-created jobs in the manufacturing and service sector for intermediate needs related to the retrofitting of buildings or the "greening" of existing infrastructure. Finally, the induced effects of solar investments include retail and wholesale jobs for the sale of technology parts or products.

To estimate the green jobs labor potential of PV, studies conducted by Singh et al (2001) and Bezdek (2007) relied on surveys with related industries based on labor requirements in the manufacturing of finished parts, the delivery of goods to power plants, alongside construction, installation and project management, and operation and maintenance schedules of 10 years. With its rapidly decreasing costs, increasing efficiencies, and high labor intensity, solar PV offers up to four times more jobs per dollar invested compared to coal-based power generation and is identified as clean, commercially available, and well-suited for distributed generation of power (Singh et al, 2001; Bezdek, 2007).

The typical investment required to establish a 1 MW solar power system in the U.S. is approximately $5 million (Lazard, 2009). The Bezdek study showed that solar PV projects can generate 15.70 permanent jobs per million dollars invested (Bezdek, 2007). Thus, a 1 MW solar PV project costing $5 million will generate 78.5 permanent new jobs. It is important to note that this number reflects the concentration of manufacturing and installation jobs, and that the operation and maintenance activities typically spread over the duration of the project are modest.

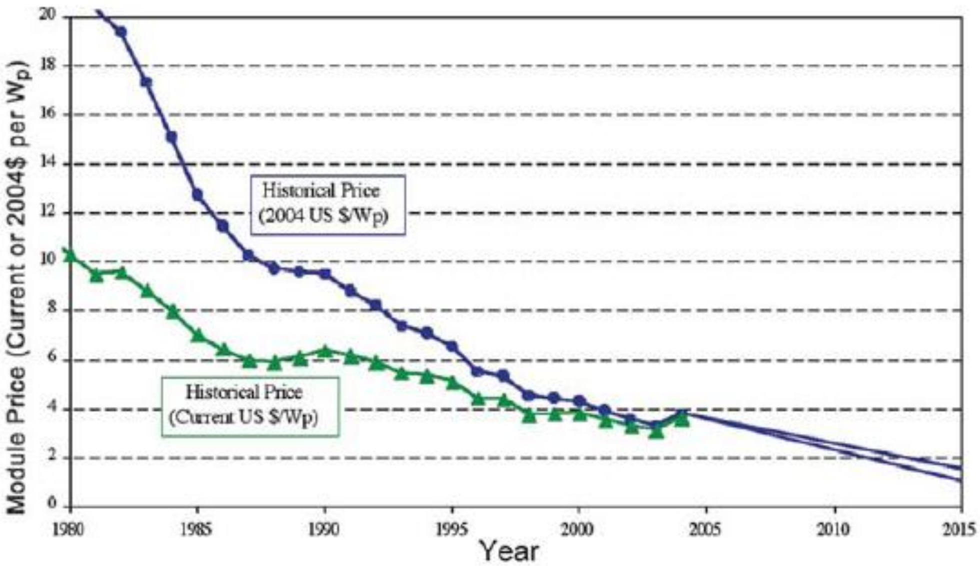
4.2 Limitations of Solar Technologies

As with any energy source, certain limitations to solar energy must be addressed. These limitations include cost, issues of intermittency, inefficiency, limited storage capacity, and inaccessibility in terms of location, education, and affordability.

As stated previously, efficiencies for PV modules are 10-15 percent for commercial crystalline silicon modules, and 5-10 percent for commercially available thin-film PV modules (Denholm et al, 2007). This level of efficiency reflects fundamental cell properties caused by losses associated with occurrences such as resistance and incomplete light absorption. Additionally, external factors such as temperature and solar irradiance influence the output of the cell (Markvart, 2000). Low levels of efficiency require more modules, and consequently, more surface area and higher installation costs. Continued efforts that support investment in increasing PV efficiency will help to boost the viability of solar PV as an option for low-income consumers.

Compared to conventional, large-scale technologies, solar power technologies at the current stages of development are expensive relative to output. Issues such as limited silicon processing capacity, high upfront costs, and low production levels make solar technology prohibitively expensive for low-income groups. However, Figure 8 indicates that the cost of PV modules have decreased rapidly since 1980, and is expected to decrease continually through 2015.

Figure 8. Historic PV module price and current price targets



Source: Denholm et al, 2007

Research focusing on increasing the affordability of solar power through advancing technologies such as thin-film PV is currently underway. Continued public financial support of such initiatives should be considered part of a comprehensive approach to lessening the low-income energy burden.

Due to the source of its power, PV generated electricity will not supply a constant flow of energy. Daily and seasonal variations in sunlight will lead to potentially dramatic fluctuations in output from a PV system. For this reason, low-income families depending upon on-site PV installations to stabilize and lower energy costs must be trained in intermittency issues, so that fluctuations are expected and corresponding variations in cost savings and utility bill payments are managed accordingly.

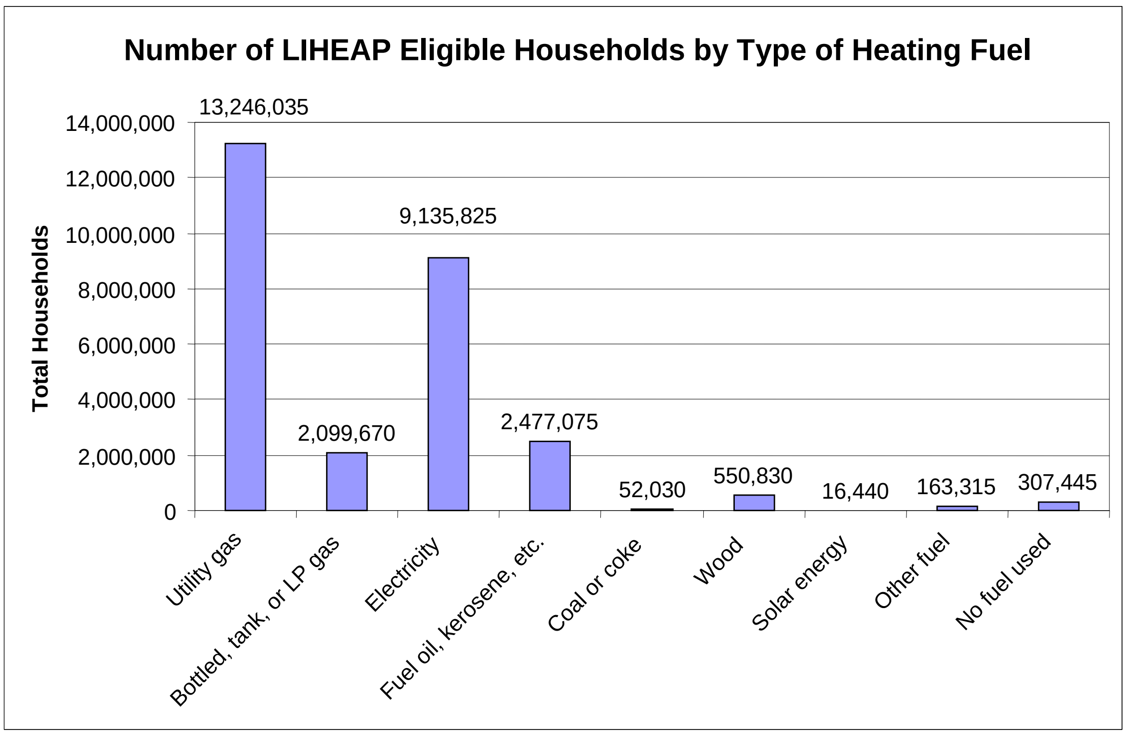
Finally, several characteristics of solar technologies make accessibility difficult for low-income families. Price is the most obvious limitation for households that cannot afford the initial upfront capital investment in this technology. Energy assistance programs that offer loans, grants, rebates, or other funding mechanisms can help overcome this barrier. Another, more fundamental accessibility problem concerns information barriers, as low-income households and communities may not be aware of opportunities to receive assistance, or may lack knowledge of the many benefits of solar energy relative to conventional energy. Policies to reduce the low-income energy burden should include outreach and educational initiatives to help lessen this barrier.

5.0 STATE SOLAR ENERGY ASSISTANCE PROGRAMS

Currently, the federal energy assistance programs – LIHEAP and WAP – are not used to promote the use of renewable energy technologies for low-income households. LIHEAP supports the use of renewables, but does not actively seek to promote these technologies in recipient households. Although funding can be provided for a variety of fuel sources, no effort has been made to encourage recipients to purchase fuel from renewable resources.

Figure 9 indicates that solar energy is a type of heating "fuel" currently underutilized by low-income households. However, an opportunity exists to improve energy assistance programs by encouraging and supporting a switch from conventional fuels to solar technologies.

Figure 9. LIHEAP eligible households by type of heating fuel



Source: U.S. Department of Health and Human Services, 2009

Similarly, WAP does not discriminate between fuel sources used in a home that is eligible for weatherization assistance. Therefore, WAP does not promote the use of renewable energy technology. An opportunity may exist to link weatherization to the installation of renewable energy technologies, since this type of home improvement would improve the efficiency of the new system.

As previously noted, state governments are better positioned than the federal government to implement assistance programs for the use of renewable energy. Recently, several state weatherization agencies developed pilot programs and projects to include solar energy technologies as part of energy savings measures. While many of these pilot programs were considered successful, the lack of permanent funding sources became a common barrier to wider progress, and many projects were not renewed once initial funding was exhausted.

Solar PV and solar hot water installation programs were implemented in several states including Florida and Wisconsin. Florida was the first state to install this energy technology – Solar Hot Water Program – on weatherized, low-income homes. The Solar Weatherization Assistance Program (SWAP) was a joint effort between the U.S. Department of Energy (U.S. DOE), the Florida Department of Community Affairs (DCA) and the Florida Solar Energy Center (FSEC, 2007), installing approximately 800 solar hot water systems in eligible low-income homes. Program summaries indicated that the project, on average, lowered household energy bills by $120-$250 annually, depending on household size and water consumption levels. As a result of the energy savings, the report viewed this application as a viable weatherization tool. However, findings also suggested that the cost of the solar hot water systems was higher and less cost effective than other weatherization measures achieving similar energy savings. A final report by the FSEC found that the systems were only cost effective above a certain level of water consumption. The SWAP program ended after an initial round of funding, followed a few years later by a new solar hot water installation program initiated through a partnership with Governor Jeb Bush's Front Porch Florida program, which targeted the revitalization of low-income neighborhoods.

The Wisconsin Energy Bureau and Wisconsin Energy Center developed an innovative pilot program entitled Simple Solar in the 1990s. This program integrated the benefits of renewable energy technology into the state's WAP through installation of passive solar technologies – such as solar warm air collectors – into low-income households to supplement heating (U.S. DOE, 2001). The project was funded with grants from the Wisconsin Energy Bureau and the Energy Center of Wisconsin, matched by WAP and LIHEAP funds. (LIHEAP Clearinghouse, 2005).

While failing to inspire a change in low-income energy assistance, these pilot programs demonstrated the potential for renewable energy applications to assist low-income communities. With a renewed sense of urgency, an improved program structure, and funding opportunities, the development of strong renewable energy assistance programs for low-income households are becoming a reality.

5.1 Case Studies

The federal government has recognized the need for improved energy services in the American Recovery and Reinvestment Act of 2009, allocating more than $8 billion to weatherization, energy efficiency, and renewable energy programs for states (Recovery Accountability and Transparency Board, 2009). Additionally, many states are bolstering policy commitments to renewable energy and energy efficiency investments through financial incentives such as tax credits and grants, the creation of utility and third-party incentive programs, as well as an expansion of existing low-income energy assistance programs. Weatherization techniques, energy efficiency measures, and customer-sited renewable energy systems can reduce home energy costs to nearly zero.

Opportunities to implement low-income renewable energy programs continue to increase. Many states and municipalities are adopting innovative programs to take advantage of policy and funding opportunities, and dedicating these resources to ensure that individuals realizing the highest energy burden are first to receive the benefits of solar energy technologies. By doing so, program participants become partners in building a more sustainable, affordable, and reliable energy system.

The following sections highlight exemplary state-initiated programs for low-income, solar-based renewable energy applications. These best practice policies were determined from a state-by-state survey of solar renewable energy funding incentives using the Database of State Incentives for Renewables & Efficiency (DSIRE), as well as a review of state low-income energy assistance programs. While many states offer financial incentives for solar energy applications, few dedicate specific incentives for low-income segments of the population.

5.1.1 California

The State of California has been a leader in advancing energy efficiency and renewable energy policy. The strategies and regulations set by the California Energy Commission (CEC) and California Public Utilities Commission (CPUC) have designated energy efficiency a top priority, and maintained California's per capita energy use flat since the 1970s -- the lowest in the country. In addition to excellent solar and wind resources, California is striving to have 33 percent of its electricity generated from renewable sources – such as wind and solar – by 2020 (DSIRE, 2009a).

Energy Burden

According to the U.S. Census Bureau, 13 percent of individuals and 9.7 percent of families in California fall below the poverty line, nearly comparable to the national average (U.S. Census Bureau, 2009). However, California's high cost of living is not adequately reflected in official poverty data, which uses national standards for determining the poverty threshold. For example, the median value of owner-occupied homes is $211,500 compared to $119,600 nationally – some 76 percent higher than the national average – while the median household income of $53,025 is only 5 percent higher than the national average. A 2006 study prepared for the CPUC indicated that 33 percent of California residents qualified for state energy assistance programs based on their income levels (KEMA, 2007).

Solar Energy Assistance Programs

Since 1998, the California Energy Commission has offered rebates for small renewable energy systems in residential buildings through the Emerging Renewable Program, with eligible affordable housing projects qualifying for 25 percent above the standard rebate (Fitzgerald et al, 2004). When Governor Schwarzenegger unveiled the Million Solar Roofs Initiative in 2004, solar energy system incentives were first moved to the Million Solar Roofs Program, then to the California Solar Initiative in 2006 (Go Solar California, 2009). The California Solar Initiative (CSI) is a 10-year commitment for solar incentives, with goals of installing 3,000 MW of solar electricity in addition to building a self-sustaining solar industry in the state, without ratepayer subsidies after 2016 (CPUC, 2007).

As part of the California Solar Initiative (Table 2), $216.7 million – 10 percent of the total program budget – was allocated to low-income incentive programs for PV system installations. These incentives are divided into programs for existing homes under the Single Family Low-Income Incentive Program, Multi-family Affordable Solar Housing, and new homes under the New Solar Homes Partnership.

Table 2. CPUC California Solar Initiative Budget, 2007-2016

Program Category	Budget ($ Million)
General Market Program Subtotal	$1,897
• *Direct Incentives to Consumers for PV and non-PV technologies*	*$1,707*
• *Program Administration, Marketing & Outreach, Evaluation (10%)*	*$190*
Low-Income Programs (10%)	$217
Research, Development, Deployment and Demonstration (RD&D)	$50
Solar Hot Water Pilot (Administered in San Diego by CCSE)	$2.6
Total California Solar Initiative Budget	$2,167

Source: California Public Utilities Commission (CPUC), 2008

The Single Family Low-Income Incentive Program is the first statewide low-income solar program of its size, utilizing $108 million for the installation of PV systems on low-income residences. The program is available to single family, owner-occupied homes whose applicants are enrolled in the Low-Income Energy Efficiency program (LIEE) and have undergone energy efficiency and/or weatherization measures.

Grid Alternatives, a nonprofit solar installer in California, is program manager under a contract with the CPUC finalized in December 2008. Grid Alternatives recently completed a program implementation plan where low-income system incentives range from $4.74 to $7 per watt, compared to the general CSI subsidies that begin at $2.50 per watt. The subsidy incentives will cover roughly 50-75 percent of the PV system, and will be available for approximately 5,000 qualifying homeowners (CPUC, 2007). In addition, the program will also provide a fully subsidized 1kW PV system for approximately 1,800 qualifying households. Eligible homeowners are those who financed their homes through local, state and federal housing assistance programs, and whose household income is at or below 50 percent of the area median income (CPUC, 2008).

The remaining portion of this program budget will go toward multifamily residences under the Multifamily Affordable Solar Housing (MASH) program managed by Pacific

Gas & Electric, Southern California Edison, and the California Center for Sustainable Energy for the San Diego Gas & Electric territory (CPUC, 2008). Per the CPUC website, the program goals are to: 1.) stimulate the adoption of solar power in the affordable housing sector; 2.) improve energy utilization and overall quality of affordable housing through the application of solar and energy efficiency technologies; 3.) decrease electricity use and costs without increasing monthly household expenses for affordable housing building occupants; and 4.) increase awareness and appreciation of the benefits of solar among affordable housing occupants and developers (CPUC, 2008).

Two incentive types are offered under the program, noted as Track 1 and Track 2. Track 1 provides typical capacity-based incentives for PV systems that offset loads for common areas and for tenants at rates of $3.30 and $4.00 per watt, respectively. Track 2 offers higher incentives for installations that have quantifiable direct benefits for tenants, such as shared savings from the system's output (CPUC, 2008).

The California Solar Initiative also includes a 10-year, $400 million program to encourage solar in new home construction, known as the New Solar Homes Partnership (NSHP). This program, managed by the California Energy Commission (CEC), offers a variety of incentives to incorporate energy efficiency and solar systems in the construction of single family, low-income, and multi-family housing (Go Solar California, 2009). The CEC works with developers and builders to construct "solar homes," which are homes that incorporate a high level of energy efficiency and high performance solar electric systems. The NSHP program offers a range of financial incentives based on a system's expected performance, while also providing technical and market support for participating builders.

The Solar Hot Water Heating Efficiency Act of 2007 authorized a $250 million solar hot water incentive program to be administered by the CPUC and funded by natural gas ratepayers. Pending the outcome of a pilot program currently underway in San Diego, this program will cover the entire state. The legislation – AB 1470 – carved out a minimum of 10 percent of the total funds for low-income homes and affordable housing, although no incentive rates have been set at this stage. In addition, low-income ratepayers enrolled in the California Alternative Rates for Energy (CARE) or Family Electric Rate Discount (FERA) programs are exempt from paying the surcharge that funds the program.

Lessons Learned

California faces a challenging energy burden due to its size and population. For this reason, its energy assistance programs must be well-funded to reach a large number of residents. Residential electricity consumption in California is about 89.8 billion kWh (EIA, 2009). Approximately one-third of its residents are low income, and an estimated half of these residents are eligible for state energy assistance, meaning that the low-income electricity consumption that could be met by a solar energy assistance program is 14.4 billion kWh. Calculations completed for this report indicate that the California Solar Initiative, if fully funded, can only meet 0.96 percent of low-income electricity consumption in the state. This figure is based on market penetration scenarios, PV potential for this region, residential system size, and the average cost of a PV system now and as predicted for the future. This calculation is included in Table 3.

Table 3. Low Income Consumption Met by CSI

	(billion kWh)
CA Residential Electricity Consumption	89.8
Low-Income Electricity Consumption (About Half of the Households Eligible for State Energy Assistance)	14.4
Predicted Solar Installation Capacity Based on Funding	0.14
% of Low-Income Consumption Met by CSI	0.96%

Sources: EIA, 2009d; Go Solar California, 2009; CPUC, 2008; Paidipati et al, 2008

California is a leader in energy assistance programs, but as indicated in Table 3, the energy burden on low-income residents is far greater than the available state funds. Compared to other states, California has pursued an exemplary energy assistance program. However, even as PV technologies become more efficient and cheaper to purchase, the CSI will barely cover a small portion of energy needs in the state. Additional funding will be needed either from another source: private funding, for example, or the federal government. Due to the project timeframe, it is unclear whether the demand for funding from this program has exceeded the funding allocated, regardless of need in the state. Increased educational and outreach programs could increase demand for PV from low-income residents, but this may strain available program funds.

5.1.2 Massachusetts

Energy Burden

Massachusetts has experienced increasing energy prices in the past decade. From 1999 to 2004, electricity rates have increased 102 percent, leaving the state with the fourth highest electricity rates in the nation as of 2005 (Burke et al, 2008). During that same period, natural gas prices grew 45 percent and water rates increased 38 percent. Although heating oil prices decreased in 2007, this decline followed a 23 percent increase during the winter of 2005-06.

Solar Energy Assistance Programs

Established in 1998, the Massachusetts Technology Collaborative (MTC) is a quasi-state agency formed to develop clean renewable energy applications and renewable energy technology industries in the State of Massachusetts. The agency also administers the Massachusetts Renewable Energy Trust and the John Adams Innovation Institute. Since 2004, when it launched its first targeted incentives program through the Renewables &

Low Income Collaborative, the MTC has promoted the use of renewable energy in low-income homes. The Collaborative initially targeted the development and implementation of a four-year, $10.3 million Joint Energy Efficiency and Renewable Energy Low-Income Housing Initiative through a strategic partnership with the Low-Income Energy Affordability Network (LEAN), created in 1997 to coordinate all low-income energy services in the state. With this partnership in place, the MTC aimed to provide immediate and direct benefits to low-income households through on-site housing improvements coupled with the state's electric utility conservation and energy efficiency programs and federal weatherization and fuel assistance programs. Additionally, the MTC provided funding for off-site, grid-connected renewable energy installations, with a portion of associated revenue streams going to low-income communities (Fitzgerald et al, 2004).

Through the MTC and the Clean Energy Choice program, customers of participating electricity utilities may elect to support renewable energy projects through a monthly premium of $5-12 on their electric bill. Up to 80 percent of the collected premiums are matched to support grants for community and low-income renewable energy projects (Massachusetts Technology Collaborative, 2009). One million dollars has been raised in low-income matching grants to date, with several PV installation projects in the cities of New Bedford, Haverhill and Chelsea helping to lower energy costs for elderly citizens, public library and middle school facilities.

The MTC also established a Green Affordable Housing Initiative to provide financial support to developers to utilize renewable energy and green building features in new affordable housing projects throughout Massachusetts. Under the Initiative, $24.5 million was bid by public and private sector organizations to finance the integration of renewable electricity into affordable housing. The Initiative was funded through proceeds from the state's system benefits charge, a 0.5 mill/kWh charge on retail electricity sold within the state. Many of the renewable energy grants funded by the system benefits charge require a form of matching grant or funds (Burke et al, 2008).

Boston's innovative Green Affordable Housing Program (GAHP) leverages a $2 million grant awarded by the MTC Initiative for renewable energy projects, integrated into affordable housing loans to finance housing projects using energy efficiency, renewable energy, and green and healthy building design. Overseen by the Department of Neighborhood Development, the GAHP also offers outreach, training, and project management. The city plans to gain long-term savings from reduced energy and water use and seeks to improve living conditions for residents (United States Conference of Mayors, 2009). As of 2007, its zoning laws require all new affordable housing developments to be certified LEED[2] Silver and meet Energy Star standards (City of Boston, 2008).

The Department of Neighborhood Development set four primary goals for the GAHP: 1.) disburse funds to directly support 130-160kW solar energy systems on 200 housing

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[2] The LEED acronym stands for the U.S. Green Building Council's Leadership in Energy and Environmental Design Green Building Rating System™.

units; 2.) establish education and training programs toward green building for the development community; 3.) coordinate funding between the Department of Neighborhood Development, utilities, foundations, and other partner organizations involved in the MTC Green Affordable Housing Initiative; and 4.) establish new baseline green building standards for affordable housing that will qualify for the initiative (Burke et al, 2008: 14). Unfortunately, funds for the GAH Initiative are expended, and it is unclear whether the MTC will renew the program.

Lessons Learned

Massachusetts relies on a unique multi-sectored collaborative to address the state's energy burden. The state government works with nonprofits, utilities, and local governments to administer programs promoting the use of renewable energy in low-income households, ensuring that these programs reach a wider pool of recipients, and improve implementation and efficient use of funds. The MTC has also sought to comprehensively address the energy burden in terms of renewable energy technology and green building initiatives. Unfortunately the MTC is experiencing a lack of funding. Therefore, the full potential of this collaborative has not been realized to date.

5.1.3 New York

Energy Burden

Home energy costs are a crippling financial burden for low-income New York households, but particularly for those with income below 50 percent of the federal poverty level. In the winter of 2005-06, a study indicated that 526,477 households faced an energy burden of 55 percent (Home Energy Affordability Gap, 2007). Low-income households (235,503) with income between 50-74 percent of the federal poverty level faced an energy burden of 22.5 percent. And 280,436 low-income households (75-99 percent of the federal poverty level) faced an energy burden of 16.1 percent (Home Energy Affordability Gap, 2007). Even with a "mild" winter, energy costs can be an overwhelming burden on low-income families.

Solar Energy Assistance Programs

In New York State, two programs assisting low-income households address the issue of energy burden: the Assisted Home Performance Program and the Energy $mart Loan program. The Assisted Home Performance Program provides grants to low-income homeowners for up to 50 percent of the cost for solar hot water and PV applications. The household income eligibility cut-off is set at 80 percent of the median state income, or 80 percent of the median area income (by county), whichever is higher. Single-family homeowners meeting the income eligibility guidelines qualify for grants up to $5,000 (DSIRE, 2009b). An income-qualified owner occupying a unit in a two- or four-unit building can receive a subsidy of $5,000 for the entire building without verification of tenant income. A higher subsidy of $10,000 per building may be available if tenants are income eligible (DSIRE, 2009b). The remaining costs of installation and purchase could be covered by either the NYSERDA Home Performance with Energy Star® or the Energy $mart Loan Fund. The qualified homeowner must contact a contractor or a community organization, whereby a Comprehensive Home Assessment (CPA) will be performed to determine what measures are needed. The assisted home performance work scope must reflect a savings-to-investment ratio of at least 1:1 for the recommended package of improvements in the CPA (DSIRE, 2009b). Eligible applicants are the customers of New York's six investor-owned utilities who pay the System Benefits Charge (SBC).

Funding for New York's low-income assistance programs come from a System Benefits Fund (SBC). The SBC, established in 1996 by the New York Department of Public Service (DPS), supports energy efficiency, research and development, and low-income energy assistance. To support this program, the state's six investor-owned electric utilities collect funds from customers through a surcharge on their bills. Each year, utilities must collect and remit to the NYSERDA, a sum equal to 1.42 percent of the utility's 2004 revenue (DSIRE, 2009c). The SBC program, administered by NYSERDA, funds the New York Energy $mart Program.

In December 2005, the DPS extended the SBC for an additional five years – through June 30, 2011 – and increased annual funding from $150 million to $175 million (DSIRE, 2009c). This means that from 2006-2011, approximately $875 million will be collected. Of that total, $190 million will be allocated to low-income energy assistance. This funding distribution is shown in Table 4 (NYSERDA, 2009).

Table 4. Funding Distribution of New York Energy $mart Program (Until 09/30/2008, $ Million)

	Total 13-Year Budget [1]	Funds Spent			
		SBC I & SBC II [2]	SBC III [3]	Total Spent	% of Budget Spent
Commercial/Industrial	634.0	247.1	93.3	340.4	53.7%
Residential	312.8	165.4	66.0	231.5	74.0%
Low-Income	318.6	86.6	81.5	168.1	52.8%
Research and Development	388.3	105.9	55.3	161.2	41.5%
General Awareness[4] (Marketing)	31.0	15.9	4.7	20.5	66.1%
Program Areas Total	**$1,684.6**	**$620.9**	**$300.8**	**$921.7**	**54.7%**

Source: NYSERDA, 2009

Lessons Learned

According to the Public Service Commission's quarterly report on the New York Energy $mart Program, home performance assisted programs have helped New York's low-income families save energy and money (NYSERDA, 2009). Tables 5 and 6 show the electricity and fuel savings, and indicate that through September 30, 2008, statewide residential and low-income programs achieved a total electricity savings of 773.9 GWh, and fuel savings of 2,172,023 MMBtu.

Table 5. Residential and Low-Income Program Cumulative Annual Electricity Savings

Programs	Energy Savings (GWh)				
	Saving achieved through			Five-year goal through June 30, 2011	Progress toward five-year goal (% achieved)
	June 30, 2006	Sept. 30, 2008	June 30, 2006 through Sept. 30, 2008		
Single-Family Existing Homes	13.5	18.9	5.4	26.1	21%
Single-Family New Homes	7.3	18.7	11.4	8.9	128%
Multi-Family Existing Homes	31	46.1	15.1	225.5	7%
Multi-Family New Homes	0	0	0	24	0%
Other Support Programs	559.2	690.2	131.1	251.1	52%
Statewide Residential and Low-Income Total	610.9	773.9	163.0	535.6	30%

Source: NYSERDA, 2009

Table 6. Residential and Low-Income Program Cumulative Annual Fuel Savings

Programs	Fuel Savings (MMBtu)				
	Saving achieved through			Five-year goal through June 30, 2011	Progress toward five-year goal (% achieved)
	June 30, 2006	Sept. 30, 2008	June 30, 2006 through Sept. 30, 2008		
Single-Family Existing Homes	454,958	824,110	369,152	1,119,000	31%
Single-Family New Homes	376,103	664,630	288,527	518,500	56%
Multi-Family Existing Homes	43,932	286,666	242,734	6,014,500	4%
Multi-Family New Homes	0	0	0	649,000	0%
Other Support Programs	280,139	396,618	116,469	N/A	N/A
Statewide Residential and Low-Income Total	1,155,142	2,172,023	1,016,882	N/A	N/A

Source: NYSERDA, 2009

The average cost of residential electricity was $014.3/kWh in New York in 2008 (EIA, 2009a). Therefore, the total electricity savings through September 30, 2008, in New York was almost $111 million. In addition, since the average household used 936 kWh per month in 2007, the electricity savings are about equal to an entire year of electricity consumption for a total of 68,900 households (EIA, 2009a).

5.1.4 Connecticut

Energy Burden

In Connecticut, energy affordability is a significant issue due to a combination of climate factors and increased demand. The energy affordability gap has doubled in the past two years, exceeding $510 million, leading to speculation that this may be partially attributable to the rise in unemployment throughout the nation (Kuhn, 2009). All of these variables contribute to an increasing energy burden in the state, thereby over-burdening both private and public energy assistance agencies in Connecticut (Colton, 2008). Renewable energy can lead to lasting energy demand reductions and reduced dependency on social services.

Solar Energy Assistance Programs

Since its creation in 2000 by the state legislature, Connecticut's Clean Energy Fund (CCEF) has provided over $100 million to fund clean energy projects. Money is collected for this fund through a surcharge paid by residential and commercial electricity customers. The primary mission of the fund is to support and promote the development and use of renewable energy.

Affordable Housing Initiative

One program being supported through the fund is the Affordable Housing Initiative. In addition to promoting the goals of the CCEF, this initiative is aimed toward benefiting both owners and tenants of these projects by lowering electricity costs and freeing up capital for property improvements and rent stabilization (CCEF, 2009).

Under this initiative, developers of small and large affordable housing units are eligible to receive rebates for integrating solar PV systems into housing design. Owners and management of existing affordable housing projects and third-party energy service providers are also eligible for the financial incentive. For small-sized, one-to-four family projects, the capacity of the solar PV installation can be up to 10 kilowatts, and rebates for up to $60,000 of the cost are available. For large projects, the generation capacity of the solar PV system cannot exceed the amount of electricity being used on-site, and costs up to $850,000 are eligible for reimbursement (CCEF, 2009).

Connecticut Solar Lease

Affordable options are also available for homeowners earning less than 200 percent of their area's median income and who wish to install solar PV systems at their homes. Under the Connecticut Solar Lease program, qualifying homeowners are eligible for an arrangement requiring no money down and payments less than $120 per month for a typical kilowatt system (Connecticut Solar Lease, 2009).

Participants can lease their solar system from Connecticut Solar Lease for up to 15 years at a fixed monthly payment. As the costs of on-grid electricity are anticipated to rise while the monthly fee under the Connecticut Solar Lease program remains constant, enrollee electricity savings will increase over the life of the agreement.

This program also retains an optional feature to assist recipients with maintenance costs – the Solar Dividends Program. Solar energy generated by each installation can be counted as part of a renewable energy credit (REC). Proceeds from these RECs are then placed into an account, which can later be drawn upon to cover future maintenance costs (Connecticut Solar Lease, 2009).

Lessons Learned

Connecticut has two unique programs aimed at achieving energy justice. The Affordable Housing Initiative addresses energy issue with the housing issues often faced by low-income residents. By supporting the installation of solar technologies in affordable housing units, the program can help to lower electricity costs, which frees up capital for property improvements such as weatherization of building structures and rent stabilization. This type of initiative has great potential to bring awareness to landlords and owners of low-income housing regarding the savings that could be achieved with the use of cleaner, price stable energy.

The Connecticut Solar Lease program helps low- and middle-income residents purchase solar technology. The program not only assists residents with the initial purchase, but also creates a sense of ownership due to the terms of the lease. This encourages leasing residents to maintain their systems and realize continued benefits.

5.1.5 Hawaii

Energy Burden
High energy prices in Hawaii make its affordability difficult for low- and moderate-income segments of the population. Low-income households pay 79.8 percent of their annual income toward home energy bills. In the aggregate, actual low-income residents of Hawaii have energy bills exceeding the affordable level by $263 million (Fisher et al, 2009). Given the wealth of solar resources in Hawaii, substituting utility bill assistance with renewable energy programs focusing on solar energy would provide an opportunity to lessen the energy burden.

Solar Energy Assistance Programs
Solar Water Heating Systems in Low-Income Housing in Hawaii
Several conditions in Hawaii have resulted in its leadership in solar energy policy. The state's climate, with 278 sunny days per year, makes Hawaii a favorable environment for the utilization of solar technologies. Also, due to Hawaii's remote location, the cost of importing energy makes electricity rates in the state among the highest in the country. For example, in September 2008, residential electricity prices were $0.37/kWh, more than double the U.S. average of $0.12/kWh (EIA, 2009b). Moreover, energy demand in Hawaii is relatively low, as temperatures are moderate for much of the year, and most homes do not have furnaces. It has been estimated that up to 90 percent of home hot water energy costs can be saved over the life of the equipment (Hawaii Energy, 2009).

The benefits of using solar energy in Hawaii, given the state's climate and current electricity prices, are so great that the state has enacted several policies to boost renewable energy usage. In the spring of 2008, Hawaii passed a law requiring new homes built in and after 2010 to be equipped with solar water heaters. Prior to the passage of this legislation, state and local administrations in Hawaii enacted programs encouraging the use of solar hot water heaters, some of which have targeted or been made more attractive for low- and moderate-income segments of the population. Descriptions of these programs follow.

City of Honolulu and Hawaiian Electric Company's Solar Roofs Initiative Loan Program
Under this program, low- and moderate-income households and landlords renting to this group are eligible for a $1000 rebate, the state's 35 percent tax credit, as well as a loan for solar water heater purchase and installation. Low-income residents can get zero-interest loans, and moderate-income residents are eligible for 2 percent interest rates. For

purposes of this program, low-income recipients are defined as those who make less than 60 percent of Oahu's median income. Median income households are defined as those between 60-80 percent of the island's median income (HECO, 2009). Program applicants do not need to provide any cash down payments in order to obtain solar hot water heaters, and the money saved on the electric bill is used for loan repayment for a term of up to 12 years (HECO, 2009).

Lessons Learned

The State of Hawaii has recognized that, due to its unique climate, solar hot water heating is an efficient way to save money while helping to mitigate global climate change. This is evident in policy that requires all new homes to be equipped with solar water heaters beginning in 2010. While many solar assistance programs in the state are private or local government-based, the state actively supports these programs with funding and renewable energy policies.

One example of success is the Ke Aka Hoona Housing Project in Waianae, Hawaii. Ke Aka Hoona is a collection of duplex units built for 75 low-income families, which has ground mounted solar water heater storage tanks installed in a collection of the units. Families were also able to take advantage of the Hawaiian state's tax credits for solar water heating installations, and were able to reduce the prices of the homes by $1,000 by taking advantage of the Hawaiian Electric Company's rebate (George, 2000).

6.0 POLICY RECOMMENDATIONS: SOLAR ENERGY ASSISTANCE IN DELAWARE

The case studies in this report show that solar energy assistance programs have the potential to alleviate energy burden on low-income residents, if adequate funding can be provided. As described in Chapter 2, Delaware faces a significant energy burden. Delaware households with an income below 50 percent of the federal poverty level spend 72.5 percent of their annual income on energy-related expenses (Fisher, Sheehan & Colton, 2007). Delaware should therefore consider implementing a solar energy assistance program similar to those in California, Massachusetts, Connecticut, New York, and Hawaii. Fortunately, Delaware currently has several unique energy policies in place that could be used as a starting point for an assistance program. These policies include the Sustainable Energy Utility, the Energy Efficiency Resources Standards, and the Renewable Portfolio Standards.

6.1 The Sustainable Energy Utility

In June 2007, the Delaware Sustainable Energy Utility (SEU) was formally established, and Delaware became the first state to establish a nonprofit utility whose primary mission is to promote efficiency and renewable energy. The SEU is a public/private partnership that combines public funding sources and consumer savings with private sector funds and management skills to provide energy users with assistance for all of their energy efficiency and renewable energy needs. Every three to five years, the Delaware Energy Office will select a private sector energy consulting firm to be the SEU Contract Administrator (CA). Together, local government, energy service companies, community service organizations, utilities, and other providers of education and outreach will implement target programs selected by the CA. For example, target programs may include electricity end-use, natural gas end-use, clean vehicles, green buildings, or affordable energy services.

One of the Early Launch programs developed by the SEU is a pilot energy efficiency shared savings program for a low-income community in Wilmington – the Urban Health and Environmental Learning Project (UHELP). This program not only offers weatherization and heating assistance, but also includes an educational component where participants learn more about energy sources, use and costs, and acquire tools to lower their energy expenditures. With additional funding, the SEU program could expand this or a similar program statewide. Such a program would help to distribute information about potential solar energy financing options and subsidy programs.

The SEU also has the authority to administer the Delaware Solar Lifeline program. According to Delaware state code, this program "shall provide, by December 31, 2015, each low-income household with a life-sustaining supply of at least 200 kilowatt-hours per month of low-cost electricity not to exceed $.05 per kWh in real 2007 dollars from in-state solar electric resources, the electricity generated thereof dedicated entirely for use by low-income households in the Solar Lifeline program" (State of Delaware, 2009). If implemented, this program has the potential to serve as the type of solar energy assistance effort that can achieve both the economic and environmental goals advocated for in this report. However, considering the previous experiences of other states examined for purposes of this study, adequate funding will likely be vital to the success of this initiative.

6.2 Energy Efficiency Resources Standards

In June 2009, the Delaware State Assembly passed the Energy Efficiency Resources Standards (EERS), which requires electric and natural gas utilities in the state to achieve a two percent electricity consumption savings and a two percent peak demand per capita reduction by 2011, increasing to 15 percent by 2015. This legislation established a "loading order" for new energy supplies that requires energy efficiency to be considered before new supply-side resources are obtained (cost-effective renewables before traditional fossil fuels). The EERS also recognizes that energy efficiency will lower consumer spending on energy, improve regional and local air quality, improve public health, increase electric supply diversity, increase protection against price volatility and supply disruption, improve transmission and distribution performance, and create new economic development opportunities.

One of the ways that utilities can reduce energy consumption is to provide direct weatherization and energy efficiency services. Weatherization may include reducing leaks from electrical outlets, switch plates, window frames, baseboards, doors, fireplaces, attics, wall- or window-mounted air conditioners, improper or insufficient insulation, and sealing ductwork. The potential energy savings from reducing drafts in a home may range from 5-30 percent per year (U.S. DOE, 2009). As described in a previous section, the federal Weatherization Assistance Program (WAP), administered by the state, offers aid for weatherizing low-income homes. However, implementation of the EERS must reach an even greater number of low-income residents in order for policy targets to be achieved. There will be many opportunities to incorporate the SEU and the EERS to ensure that residents have weatherized their homes before installing renewable energy systems.

6.3 Green Jobs in Delaware: Jobs Created by the Renewable Portfolio Standard

The Delaware Renewable Portfolio Standard (RPS) was enacted in 2008. With new provisions (Senate Bill 1 for Senate Bill 119) signed into law by Gov. Jack Markell in July 2010, the minimum RPS target for 2025 is 25 percent, out of which 3.5 percent must come from solar PV. According to the Energy Information Administration (EIA), the electricity sector of Delaware alone consumed about 65 trillion BTUs in the year 2006 (EIA, 2009c). This is equal to 1.237*10^8 Btu/min, or 2175 MW. Assuming no escalation in power consumption rates in Delaware by 2025, then, under the RPS, utilities must acquire 3.5 percent of 2175 MW from solar PV installations, or 76 MW.

As shown earlier in this report, the green job potential of solar PV is 15.70 persons per million dollars of investment. For the requirements under the RPS, an investment of $380 million to install 76 MW of PV would result in 5,966 new jobs.

The impact of the RPS on solar PV installations, and the consequent green job creation, stands to be substantial – some 5,966 new positions. These are jobs that could be supported by a workforce development program through Delaware Technical and Community College, the University of Delaware, and other educational institutions in the state. Educating the green job workforce within state boundaries ensures that these jobs remain local and contribute to the state's economy.

7.0 CONCLUSION

The need for energy assistance programs is apparent on a number of levels. Unfortunately, existing programs, even in the most exemplary states, are inadequate for reducing the energy burden. Additional funding for WAP, LIHEAP, and state programs is needed to increase the number of eligible households that receive assistance. In addition, expanding the number and types of programs and services offered for weatherization in the state could contribute to better weatherization practices. For example, Delaware could institute a local chapter of Home Performance with ENERGY STAR, a national program from the U.S. EPA and U.S. DOE, which offers a comprehensive, whole-house approach to improving energy efficiency. As in New York, this program could offer stronger rebates for low- and moderate-income homes, for both energy efficiency measures and solar energy technologies.

Due to the many benefits of solar energy, additional federal and state solar energy assistance programs should be established. By providing loans and grants for solar energy purchases and installation, the cost limitations of these technologies may be overcome. As noted in the state case studies, many programs are structured to remove the large upfront costs of solar energy that are often economic and psychological barriers to investment. Programs such as Connecticut's Solar Lease help remove these barriers by offering financial incentives along with a customer-friendly loan repayment design.

In addition to developing greater solar energy funding opportunities, educational and job training programs should be established for the development, installation and maintenance of solar technology. To illustrate the success of such programs, the City of Oakland, California, has established the Oakland Green Jobs Corp. The program trains low-income adults in the community for careers in green industries such as energy efficiency, green construction, and solar energy (Ella Baker Center, 2009). Similar to the Oakland Corps, Solar Richmond and Grid Alternatives are nonprofit organizations that work with local and state governments, foundations, and the private sector to provide community-based green-collar job training for low-income youth, starting with the installation of PV systems in Richmond and other surrounding low-income communities. Both these programs utilize funding from CSI incentives.

Solar energy assistance could be greatly improved and provide many economic and social benefits to families, communities and the state as a whole, by developing greater opportunities to provide weatherization, solar energy, and other sustainable energy options that reduce high energy bills and the energy burden, while also providing high paying local jobs.

In conclusion, solar technology can provide a clean, price stable and reliable source of energy. However, federal and state energy assistance programs are needed to supplement the high initial costs of this emerging technology for low-income households. Several states, including California, Connecticut, New York, and Massachusetts, have implemented successful solar energy assistance programs that could be models for the rest of the country. Through such assistance programs, the energy burden on low-income households could be mitigated, with positive movement toward achieving energy justice.

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APPENDIX I[3]

Photovoltaic (PV) technology produces direct current (DC) electrical energy via semiconductors based on illumination by photons, from sunshine. The basic PV unit is the solar cell (Figure 10). Typically, cells are joined together electronically to create PV modules, also known as solar panels (Figure 11). In general, PV cells may be categorized as crystalline silicon (cut from ingots, grown ribbons or castings) or thin film (placed in narrow layers on a low-cost backing). Most PV cells are of the silicon variety.

Figure 10: Solar cell

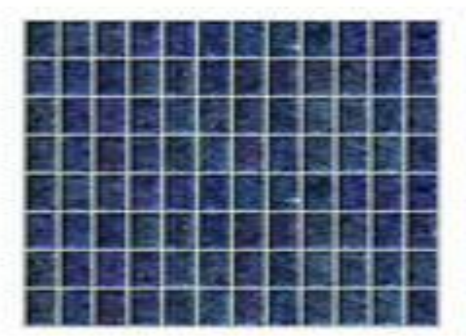


Figure 11: Solar panel

Approximately 90 percent of PV modules support grid-connected electricity generation, where an inverter is needed to convert DC to AC. They may be ground-mounted (Figure 12), or built into roofs or walls, known as Building Integrated Photovoltaics (BIPV), shown in Figure 13. Other markets allow for the use of off-grid power. In these markets, solar powered, storage battery-based applications offer the only source of electricity.

Figure 12: Ground-mounted PV

Figure 13: BIPV

[3] Source material for this appendix is A. Luque and S. Hegedus, 2005, *Handbook of photovoltaic science and engineering*, published by Wiley online at: http://www3.interscience.wiley.com/cgi-bin/bookhome/109867790?CRETRY=1&SRETRY=0

Net metering and financial incentives have encouraged PV installations in many countries throughout the globe, including the U.S. As the fastest-growing type of energy technology, PV production is also gaining momentum.

APPENDIX II

Solar hot water technology relies on sunshine to heat water for applications such as cleaning or showering. A solar water heating (SWH) system (Figures 14 and 15) is usually comprised of solar thermal collectors, alongside a fluid system to transport heat from the collector to its particular location for usage, a storage basin for the hot water, a system of controls, and perhaps pumping technology.

Figure 14: Solar water heat system

Figure 15: Solar water heater

An SWH system can be classified as passive or active (Figures 16 and 17). With a passive system, the water moves upward after being heated. On entering the tank (placed above the solar panel), the warm water displaces cold water from inside, allowing heat transfer to occur without pumps. An active system locates the storage tank inside the building, and a controller assesses water temperatures to gauge when the water in the panels is hotter than in the tank. The system utilizes a pump for moving the fluid.

Figure 16: Passive solar water heater

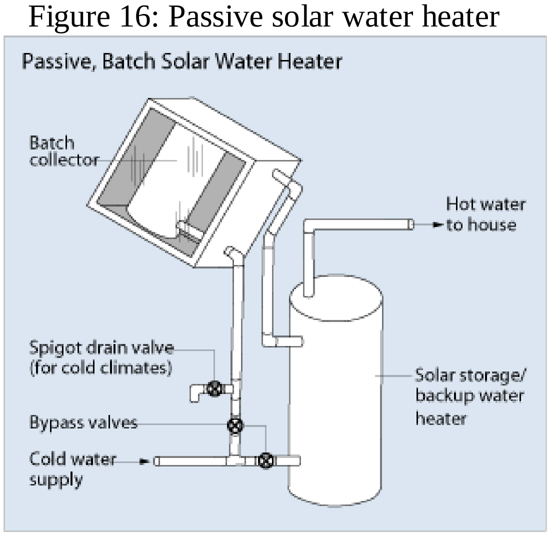
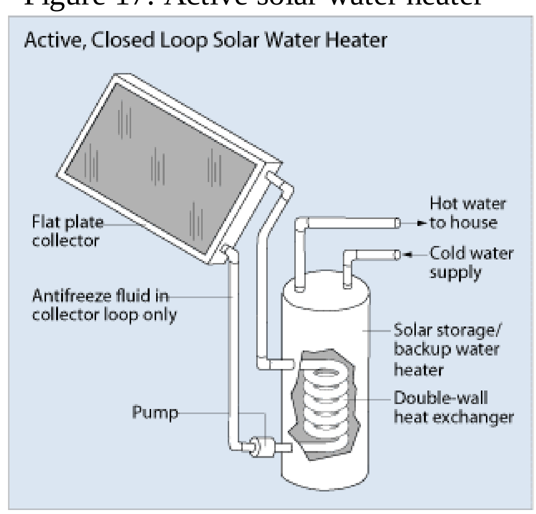


Figure 17: Active solar water heater



Source: U.S. Department of Energy. (2009). Solar water heaters: How they work. Available at: http://www.energysavers.gov/your_home/water_heating/index.cfm/
The following section reviews the potential of SWH to meet needs in the residential sector.

Hot Water Consumption

The typical adult consumes some 20 gallons of hot water daily (Renewable Energy Resource Center, 2009), but this changes by variables in the household such as the number of residents, usage habits and water conservation efforts. Tables 7 and 8 estimate hot water use by household application and size.

Table 7. Hot Water Consumption by Different Use

Use	Average Gallons of Hot Water per Use
Shower	20
Bath	20
Shaving	2
Hands and Face Washing	4
Hair Shampoo	4
Hand Dishwashing	4
Automatic Dishwasher	14
Food Preparation	5
Clothes Washer	30

Source: Renewable Energy Resource Center, 2009

Table 8. Hot Water Consumption by Household (gallons)

	Number of Household Members				
	1	2	3	4	5
Daily Household Hot Water Consumption	30-40	40-50	55-65	65-75	75+

Source: Renewable Energy Resource Center, 2009

Water heating accounts for approximately 17 percent of residential energy in the U.S., making it the third largest source of energy consumption in homes, after heating/cooling and energy used to operate kitchen appliances.[4] As discovered by the National Renewable Energy Laboratory, the fuels utilized for water heating are as follows: natural gas, 49 percent; electricity, 44 percent; and oil and liquefied petroleum gas (LPG), seven percent.[5] Table 9 shows the energy consumption by fuel source that supports a four-person family hot water demand.

[4] U.S. Department of Energy. (2008). U.S. Department of Energy implements criteria for ENERGY STAR® water heaters. Retrieved August 23, 2009 from <http://www.energy.gov/news/6134.htm>.

[5] Denholm, P., et al. (2007).

Table 9. Average Hot Water Fuel Use

Average Annual Water Heating Fuel Use for a Family Of Four	
Type of Fuel	**Energy Used**
Electricity	5106 kWh
Natural gas	258 therms
Liquefied Petroleum Gas (LPG)	252 gallons
Oil	187 gallons

Source: Scheckel, 2005

Benefits of Solar Water Heating Systems

Table 10 offers a brief comparison between SWH and conventional water heating.

Table 10. Comparison of Solar to Conventional Water Heaters

SOLAR WATER HEATER	STANDARD WATER HEATER
FREE energy from the Sun	COSTLY gas or electric
Annual operating cost: $50	Annual operating cost: $500+
Storage Capacity: 80-120 gal	Storage Capacity: 40-50 gal
Life expectancy: 15-30 years	Life expectancy: 8-12 years
Lifetime operating cost: $1,000	Lifetime operating cost: $10,000
Does NOT pollute environment	Depletes fossil fuels
Increases equity in your home	No added value to your home
25% return on your investment	No return on utility payments
Protection from future increases	At mercy of utilities/government
Hot water during blackouts!	No hot water during blackouts

Source: Solar Direct, 2008

As indicated in Table 10, solar water heating (SWH) retains economic, environmental, and energy sustainability benefits for consumers. In particular, by installing SWH systems, an average household can meet 50-80 percent of its hot water needs. In southern climates, a SWH unit can provide nearly 100 percent of a household's hot water demand. In most cases, water heating costs should decrease by 50-80 percent.[6] Additionally, as most conventional water heating applications rely on fossil fuels which generate pollution and greenhouse gas emissions, the energy conserved by SWH avoids the harmful byproducts that would typically result in poor air quality and climate change.

Today, in the U.S., technical potential for SWH is estimated at approximately one quad of primary energy savings annually, or a yearly CO_2 emissions potential decrease of 50-75 million metric tons. For end users, this savings represents $8 billion in yearly retail energy costs, and may also serve to dampen fuel price escalation.[7]

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[6] U.S. Department of Energy (U.S. DOE). (2009). The economics of a solar water heater. Retrieved Aug. 23, 2009 from http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12860

[7] Denholm, P., et al. (2007). Potential Carbon Emissions Reductions from Solar Photovoltaics by 2030. In Charles F. Kutscher (Ed.), *Tackling Climate Change in the U.S.: Potential Carbon Emissions Reductions from Energy Efficiency and Renewable Energy by 2030*. Boulder, CO: ASES, 79-99.

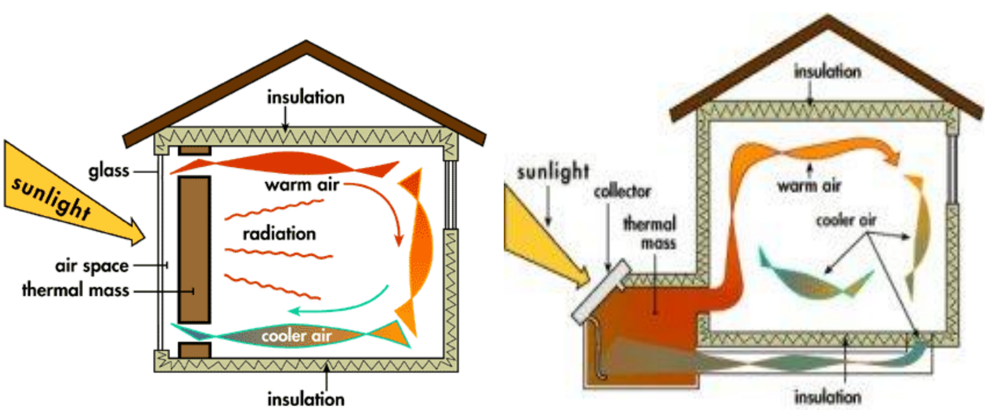
APPENDIX III

Passive solar systems allow solar energy to flow via natural means, to include radiation, construction, and natural convection. Passive solar technologies include passive heating systems,[8] passive cooling systems,[9] and day-lighting[10] design. The technology converts sunlight (radiant energy) into heat (air, water, thermal mass), and forces air movement for ventilating, space heating and cooling. Minimal use of additional energy sources is required. Certain passive systems require a modest amount of conventional energy to run dampers, night insulation, shutters, and miscellaneous devices that boost solar energy collection, use or storage, or decrease unwanted heat transfer.

Passive solar systems rely on fundamental choices in the architectural design of buildings (Figure 18), such as elongation on an east-west axis, overhangs or other shading devices that protect any south-facing glazing against the summer sun, and windows on the west and east walls (with no windows on the northern-facing walls). Recommendations suggest the inclusion of passive solar heating as part of the original building design, during the initial stages.

With passive solar technology, any absorbed heat can be moved to thermal storage through natural means, or may be used directly to warm a structure. Passive cooling systems rely on natural energy flows to shift heat to environmental sinks, such as the ground, air and sky (Figure 19). The use of natural illumination for the interior of a building is called day-lighting. This design may use solar beam radiation (sunlight) and the diffuse radiation scattered by the atmosphere (skylight) as sources for interior lighting (Figure 20).

Figure 18: Passive solar heating system designs

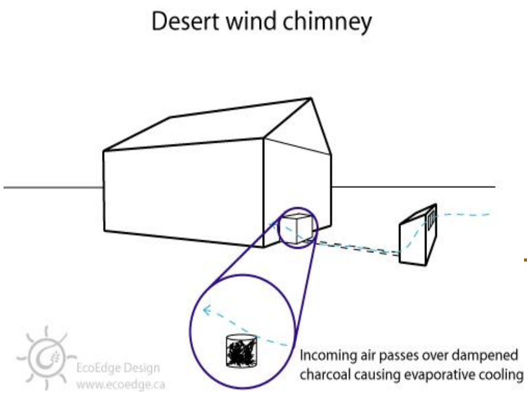


[8] Please see J. Fosdick, 2008, "Passive solar heating," retrieved April 7, 2009 from http://www.wbdg.org/resources/psheating.php

[9] Please see D.J.E. Barnes and S.A. Meister, 2006, "Passive cooling," retrieved April 7, 2009 from http://www.energybulletin.net/node/22792

[10] Please see J.H. Morehouse, 1997, "Passive solar heating, cooling and daylighting," in F. Kreith and R.E. West (Eds.), *CRC handbook of energy efficiency*, Boca Raton, Florida: CRC Press, 851-902.

Figure 19: Passive solar cooling system designs



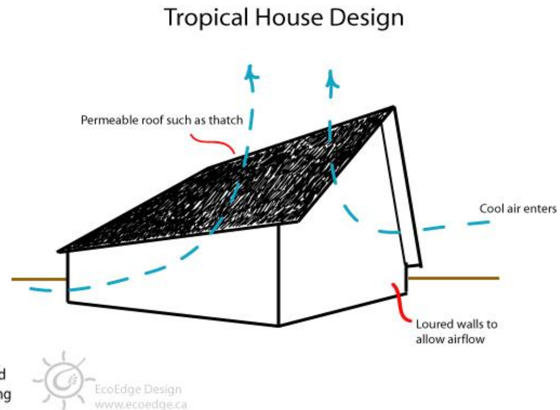
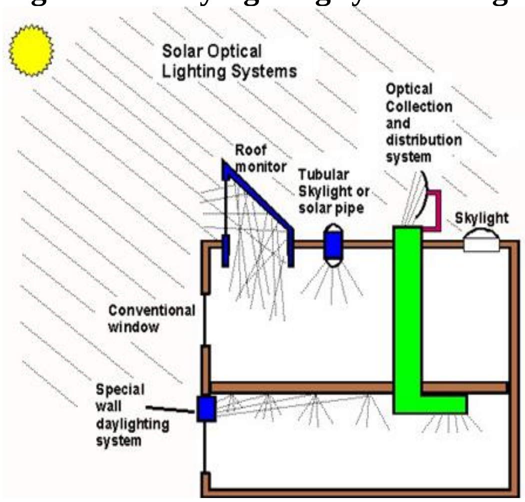
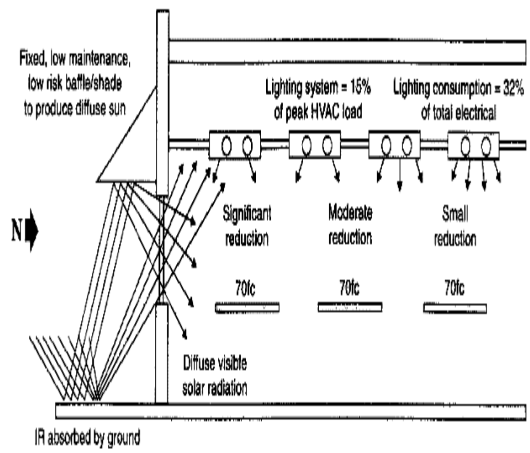


Figure 20: Day-lighting system designs





Passive solar systems retain low operating and maintenance costs, and do not generate any greenhouse gases during operation. The systems do, however, require optimization for best performance and economics, but their use lessens the required size of active renewable or conventional energy systems, assuming that well-designed energy efficiency changes are likewise prioritized.