INTEGRATING SOLAR ENERGY AND LOCAL GOVERNMENT RESILIENCE PLANNING

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ABSTRACT

Integrating Solar Energy and Local Government Resilience Planning

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Resilience and *solar energy* are separately growing in popularity for urban planners and similar professionals. This project links the two discrete terms together and examines the extent to which solar energy can improve local government resilience efforts. It includes a detailed literature review of both topics, as well as the methodology and findings related to a survey and interviews of local government officials and key stakeholders across the country related to hazard mitigation and energy assurance planning.

This research finds that integrating the use of solar energy can improve local government resilience efforts related to mitigation, preparedness, response and recovery activities in the following ways: by being incorporated into hazard mitigation strategies as a means to maintain critical operations, thereby reducing loss of life and property; by being utilized in comprehensive planning efforts to increase capacity and decrease reliance and stress upon the grid, thereby reducing the likelihood of blackout events; by being used in tandem with backup storage systems as an integral part of energy assurance planning, which can help ensure critical functions continue in times of grid outage; by being used to provide power for response activities such as water purification, medicine storage and device charging; and by being used as an integral part of rebuilding communities in a more environmentally-conscious manner.

The result of the research is a document entitled *Solar Energy & Resilience Planning: a practical guide for local governments,* a guidebook for local government officials wishing to have more information about incorporating solar energy into current resilience initiatives; it is included at the end of the report as Appendix C.

Keywords: solar, energy, resilience, climate change, climate action, climate adaptation, solar PV, global warming, renewable energy, emergency management, disaster reduction, hazard mitigation

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LIST OF ACRONYMS

ARRA: American Recovery & Reinvestment Act

CEC: California Energy Commission

DOE: United States Department of Energy

EAP: energy assurance plan(ning)

FEMA: Federal Emergency Management Agency

HMP: hazard mitigation plan(ning)

NREL: National Renewable Energy Laboratory

PTI: Public Technologies Institute

INTRODUCTION

First used by Roman orator Cicero (Alexander, 2013), the term *resilience* is gaining popularity in both academia and personal interest. Since 1990, usage of the term in American English academic literature has grown five-fold (Books.google.com, 2014); since 2004, Google searches for the word have increased three-fold (Google.com, 2014). This rise has coincided with an increase in attention at the national and international governmental level. In February 2014, the White House announced a Climate Resilience Fund to “do more to help communities across the country become more resilient to the effects of climate change" (Neuhauser, 2014). The World Health Organization (2013a, 2013b), United Nations (Habitat, 2011; UNISDR, 2013, 2011) and World Bank (2013), among others, have all enacted policies to increase resilience. Yet the word remains somewhat vacuous, akin to such planning buzzwords as *sustainability* and *vibrancy*, as evidenced by scholarly work on the subject that does not even bother to define it. The recent Presidential Climate Action Plan, released by the White House in June 2013, uses the word 29 times and fails to even attempt to define it in any context (Executive Office of the President, 2013). When definitions are provided, most are so broad as to render them meaningless (Rose, 2007). [The definition of resilience in this project is defined in Chapter One].

At the same time, global and domestic solar energy capacity has grown rapidly over the past several decades, from invention of the photovoltaic panel in 1954 (Seia.org, 2013) to over 100 gigawatts of installed capacity sixty years later (Renewable Energy Policy Network for the 21st Century, 2013). The growth is due largely to declining prices

for both manufacturing and installation. With the launch of the SunShot Initiative in 2011, the United States Department of Energy aims to further reduce the cost of solar installations thereby making solar energy use more widespread. The White House is joining the effort by honoring "Solar Champions of Change;" the American Planning Association (APA), the preeminent professional organization in the United States for planners, is also involved and recently published various materials related to planning for solar energy in communities (APA, 2013; Morley & Anthony et al, 2014).

Though enjoying a recent surge in both popularity and significance, these two topics are segregated in theory and practice. The findings of an extensive literature review (included in Chapter Three) show that while copious research has been done on each topic separately, only a small amount of work has been done that involves the interplay of the two terms. The dearth of information linking solar (and other carbon-free) energy sources with resilience planning is inherently incompatible with the shift in the American energy portfolio. In 2013, solar energy ranked second only to natural gas in terms of newly installed capacity and nearly doubled the amount of new coal capacity (Brown, 2014). It is also incompatible with the fundamentals of sustainability, which advocate the use of fuels that are both renewable and clean. Failing to use such sources contributes to increasing amounts of carbon dioxide in the atmosphere, thereby contributing to global climate change and its associated issues. In effect, combatting the issue of climate change by utilizing fossil fuels accelerates the very issue itself.

This project synthesizes disparate information from various sources in order to determine the extent to which the use of various solar energy technologies can improve contemporary resilience efforts at the local government level. Chapter One outlines in more detail the problem and relevance, and why action at the local level is important. Chapter Two provides detailed information resulting from a literature review of both *resilience* and *solar energy*. Chapter Three details the methods used in the project, including a survey, interviews and a literature review. Chapter Four outlines the findings from the survey and interview processes and includes a discussion of the significance. Chapter Five provides a conclusion to the research, including limitations and implications for future research and policy-making. Appendix A includes materials used in the methodology, such as the survey instrument and data. The report concludes (Appendix C) with *Solar Energy & Resilience Planning: A practical guide for local governments*, a guidebook for local government officials seeking information about how to incorporate solar energy into ongoing resilience planning efforts.

1 PROBLEM AND RELEVANCE

1.1 RESEARCH PROBLEM

This project seeks to determine the extent to which the use of various solar energy technologies can improve contemporary resilience efforts at the local government level. *Improve* is defined in this context as complementing or restructuring efforts in order to further reduce risk to human life and property and decrease the environmental impact of operations associated with such efforts. Drawing upon Cowell (2013), Rose (2007), the National Renewable Energy Laboratory (2012) and Federal Emergency Management Agency (2013b), *resilience* is defined here as the ability of a community to adapt to ever-changing conditions by organizing efforts around four phases: mitigation, preparedness, response and recovery. The primary focus of the project and associated guidebook (Appendix C) is solar photovoltaic energy technology; however, the use of other technologies is included. The focus on local governments, defined here as cities and counties, is chosen because it is the scale at which action is urgently required and is likely to have the greatest impact (World Bank, 2013; United Nations Office for Disaster Risk Reduction, 2013).

1.2 RELEVANCE

In November 2013, President Barack Obama put forth an executive order calling for action "to deal with the impacts of climate change and [direct] federal agencies to revise programs and policies that might serve as barriers to climate adaptation" (Sheppard, 2013). The order included a directive to establish the Task Force on Climate Preparedness

and Resilience comprising state, local and tribal leaders from across the country that advised the President on matters regarding climate change preparedness, adaptation and resilience. This order follows the Administration's development of the Presidential Climate Action Plan in June 2013 aimed at reducing the government's greenhouse gas emissions and predicated upon a "moral obligation to future generations to leave...a planet that is not polluted and damaged" (Executive Office of the President, 2013, p. 4). It also follows the United States Department of Defense's *Climate Change Adaptation Roadmap* which states that the department "will need to adjust to the impacts of climate change on its facilities, infrastructure, training and testing activities" (2012, p. 1). With these actions, the federal government of the United States of America has joined the ranks of governments and organizations around the world acknowledging global climate change as an important issue of our time that necessitates immediate and swift action.

The evidence backing these decisions is increasingly hard to deny. The Intergovernmental Panel on Climate Change, a scientific body of the United Nations, stated that "scientific evidence for warming of the climate system is unequivocal" (2007) and that “in recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans” (2014). They go on to say with “very high confidence” that recent extreme events “reveal significant vulnerability and exposure of some ecosystems and many human systems” and that those in poverty face increased likelihood of negative outcomes from such events (2014). The United Nations' *Global Report on Human Settlements* considers climate change to be one of the most dangerous issues facing humanity in the 21st century (2011). Further, the World Health Organization estimates that the annual costs globally from healthcare alone related to

climate change will reach US$2-4 billion by 2030 (2013a) and has therefore initiated the "first global project on public health adaptation to climate change" (2013b). Estimates from the Climate Vulnerable Forum show that five million deaths occur each year as a result of climate change impacts and that the figure will likely increase to six million a year by 2030 if current patterns continue (Chestney, 2012). Perhaps the most staggering statistics are the economic figures—in 2001 alone, approximately $36 billion in economic losses and $11.5 billion in insured losses resulted from global climate change (Godschalk, 2003). As each subsequent year produces more severe weather events, this number will likely increase.

In *Causal Stories and the Formation of Policy Agendas*, Deborah Stone (1989, p. 281) says that "difficult conditions become problems only when people come to see them as amenable to human action." The human action necessary to combat the difficult condition that is climate change is increasingly considered to be *resilience*, which refers broadly to the ability of communities to cope with external disturbances that result from social, political and environmental change. Rather than considering the increase in global disaster events as natural acts ("acts of God") that are not amenable to human intervention and are forgotten once urgency has subsided and normalcy has returned, the progression from focusing solely on greenhouse gas reduction toward increasing the resiliency to climate change impacts aims to slow down and reverse the "tendency towards increasing risks" (Ihdp.unu.edu, 2013) that result in the aforementioned losses. The most recent report from the IPCC (2014) states that in North America, governments are beginning to engage in such activities, primarily at the municipal level, and that “resilience…can accelerate successful climate-change adaptation.”

1.3 LOCAL GOVERNMENT ROLE

Although the majority of attention on climate change action has been focused on international-scale groups and agreements (e.g. IPCC, Kyoto Protocol), local government action is both necessary and ongoing. The National Climate Assessment states that most action thus far in the US has been at the local and regional level (Melillo, Richmond & Yohe, 2014). And according to the United Nation's Office for Disaster Risk Reduction (2013), climate change will have the greatest impacts at the local level. This sobering fact has a silver lining. In the United States alone, there are nearly 100,000 units of local government that regularly create detailed plans such as Hazard Mitigation Plans to indentify and mitigate risks (FEMA, 2013a). Local actions such as these offer a way to break down the increasingly "complex and fragmented" global agenda for how to approach climate change action into a manageable scope (Otto-Zimmermann, 2011). Local action has been swift in comparison to larger-scale action, as well. Less than a year after the United Nations Framework Convention on Climate Change in Rio de Janeiro (1992), local governments sprung to action with the Cities for Climate Protection campaign. In contrast, the United Nations' reaction, the Kyoto Protocol, came 13 years later and has not resulted in any significant changes to unified, global action. It was also never adopted by the United States.

Local governments are both well-equipped and responsible for tackling challenges related to climate change. Abraham Lincoln said that the legitimate goal of government is to do for people what they need to have done, but cannot do, for themselves as individuals. Through comprehensive planning, policy-making and the ability to regulate and incentivize, local governments can prepare communities for climate change and other

issues that individuals cannot address alone (Icleiusa.org, 2014). Local governments have been called the "Silicon Valley garages" (Fischer, 2014) that lead to innovations in climate policy because they are the scale at which risks can be taken and then promulgated to higher levels once novel practices are honed. Property Assessed Clean Energy (PACE), a mechanism by which local governments facilitate the installation of solar PV systems by allowing them to be paid for over time via property taxes, began in Berkeley, California, and has seen widespread adoption across the country. Innovations like this are at the core of local government climate action and are necessary functions to increase resilience.

2 LITERATURE REVIEW

Given its long history and current popularity, in the urban planning and disaster management fields among others, literature regarding resilience abounds. Likewise, solar energy is thoroughly covered in scholarly articles, government documents, websites and the like. To a much less degree, however, the overlap between resilience and solar energy is covered—mainly by a number of organizations like Meister Consultants Group and Florida Solar Energy Center. What follows is an overview of past and present literature related to defining resilience in its various forms, outlining current methods of resilience planning, understanding solar technologies and financing mechanisms, and linking the two somewhat disparate topics together in practice.

2.1 DEFINING RESILIENCE

Generally

The term resilience in common parlance refers generally to the ability to recover from or adjust to a hardship. By some accounts, usage of the term dates as far back as famed Roman orator Cicero's utilization of *risilire* (Latin for *to rebound)* and spans through Ovid and Pliny the Elder to Thomas Blount who first defined the term in *Glossographia* or *A Dictionary of the Hard Words of Whatsoever Language* in 1661 (Alexander, 2013). Currently, resilience is most often associated with psychology, as in the resilience of an individual, and ecology, as in the resilience of a system (Anderies and Martin-Breen, 2013). In ecology, it can be more specifically defined as the capacity of an ecosystem to

tolerate disturbance without transforming into a functionally different state (Resilientcity.org, 2013; Ihdp.unu.edu 2013).

W. Neil Adger and C.S. Holling were among the first scholars in the environmental realm to define the term (Rose, 2007), with the latter referring to it as "the ability of systems to absorb changes and still persist" (Holling, 1973). In the last few decades the term has evolved to account for human-environment relations and can in that sense be defined as "the ability of groups or communities to cope with external stresses and disturbances as a result of...environmental change" (Ihdp.unu.edu, 2013). The nuance between adjustment and recovery is important to understanding the complexity of the term. In *Economic resilience to natural and man-made disasters,* Rose (2007) argues for two types of resilience—static and dynamic—based upon that subtle difference. Static resilience refers adjusting to a change by making the best of the resources currently available, while dynamic resilience focuses on the ability to recover in a timely manner.

The literature about resiliency also implies that it can refer to an improvement of condition after recovery, meaning that a truly resilient organism (in the context of this research, city or community) may undergo changes and re-emerge in an improved state (Rose, 2007; Handmer and Dovers, 1996). When viewed from this standpoint, resiliency simultaneously refers to solving problems and increasing opportunities. New York City's *Vision 2020* (Department of City Planning, City of New York, 2011) for example, outlines plans to build more livable land area in the city's waterfront by ensuring that the development will be resilient to the effects of climate change. Therefore resiliency is acting as an opportunity in addition to a solution to a problem. As the plan says, "building

resilience can be an impetus for transforming...in ways that can make the city not only more climate-resilient, but also more healthy, prosperous, and livable." Likewise, the City Resilience Simulator as part of the *Coastal Cities at Risk* study is focusing on predicting the impacts of a hazard event and monitoring the performance of certain critical functions (emergency response, hospital access) to see how hazard events can cause short term impacts but potentially result in improved long-term overall system performance (Peck, 2014).

With an increased and varied usage, resilience has become akin to such vacuous buzzwords as "sustainability" and "vibrancy" as evidenced by the fact that some scholarly work on the concept does not even bother to define it. For example, the President's Climate Action Plan, released by the White House in June 2013, uses the word 29 times and fails to even attempt to define it in any context. When definitions are provided, most are so broad as to render them meaningless (Rose, 2007). In *Deconstructing Resilience: Lessons from Planning Practice*, O'Hare and White (2013, p. 276) state that the prolificacy of the term is unmatched in terms of disregard for its definition and disagreement in policy and practice. They further say that planners and similar professionals have adopted the term to catalyze action against "almost any threat." Echoing these thoughts is Jabareen (2012, p. 220), who says in *Planning the resilient city: Concepts and strategies for coping with climate change and environmental risk,* that most studies on resilience use "general, vague, and confusing terminology" and fail to approach the concept in a systematic way.

Specifically

Resilience is not merely an abstract, academic concept. Several organizations have working definitions of the term which guide their practice. ICLEI-Local Governments for Sustainability (2013), an international member organization focused on local environmental initiatives, states that "a resilient city is [defined by] low risk to natural and man-made disasters. It reduces its vulnerability by building on its capacity to respond to climate change challenges, disasters and economic shocks." Their campaign, Resilient Communities for America, was launched in June 2013 and considers resiliency to result in "...more prepared communities that can bounce back from extreme weather, energy, and economic challenges." These definitions point to disasters, energy, and economy being the focal point of their concept of resilience. The United Nations Office of Disaster Risk Reduction (UNISDR) is tasked with implementing the UN's disaster reduction strategy and considers resilience to be "the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate to, and recover from the effects of a hazard in a timely and efficient manner" (2011). According to the World Bank in its report *Building Urban Resilience: Principles, Tools, and Practice* (2013), resilience refers to the capacity of a community to absorb and adapt to changes associated with various challenges to its stasis. A resilient community in this sense is one that can respond adequately to such changes and maintain essential functions. The World Bank notes that any attempt to instill resiliency must focus on the social aspect which can be achieved by reducing both risk to poverty and disaster (Pasteur, 2011).

Several branches of the United States government formally define the term as well. The Department of Defense (2012) considers resilience to be "the ability to adapt to changing conditions and prepare for, withstand, and rapidly recover from disruption." The Federal Emergency Management Agency (2013), a major actor in resilience efforts in the US, defines resilience as a process that seeks to minimize risk to all hazards and strengthen the ability to withstand and recover from future disasters. The Department of Energy uses the term in the context of energy, but nevertheless defines it as the ability to recover quickly from damage to essential or external systems. They note that resiliency does not prevent damage but allows systems to continue operating despite damage and promotes a rapid return to normal operations. Ernest Moniz (2013), US Secretary of Energy, says that the department is taking action to increase resilience by creating an integrated resilience program. The recent National Climate Assessment from the US Global Change Research Program (Melillo, Richmond & Yohe, 2014) defines resilience as the "capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment."

Compiling the words used in the definitions from the previous discussion shows how important *ability*, *recover* and *challenge* are to the prevailing concept of resilience overall.

Figure 1. Most common words used to define resilience from the literature

2.2 CURRENT METHODS OF RESILIENCE PLANNING

Hazard mitigation planning

The Federal Emergency Management Agency (FEMA) is the federal government's official disaster reduction and preparedness arm. Its mission is "to support...citizens and first responders to ensure that as a nation we work together to build, sustain, and improve our capability to prepare for, protect against, respond to, recover from, and mitigate all hazards" (2013b). Under provisions of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), FEMA provides the impetus for state, local and tribal governments to create Hazard Mitigation Plans (HMP) in the US. An HMP must be submitted and approved by FEMA in order for a jurisdiction to receive federal funding for disaster relief. As of 2008, there were more than 14,000 local hazard mitigation plans in the United States (Berke & Lyles et al., 2012). The plans are required to outline processes for identifying natural hazards, risks, and vulnerabilities relevant to the jurisdiction (Robert T. Stafford Disaster Relief and Emergency Assistance Act, 2013). According to FEMA (2013a), hazard mitigation is sustained action taken to reduce or eliminate the long-term

risk to human life and property from hazards. Hazard mitigation planning is therefore the "cornerstone of the approach taken by [the agency]... to reduce the nation's vulnerability to disasters from natural hazards" (Godschalk, 2003, p. 136). FEMA (2013c) provides the following guidelines for developing a hazard mitigation plan:

1. Focus on the resources needed for a successful mitigation planning process; identify and organize interested members of the community as well as the technical expertise required during the planning process.
2. Identify the characteristics and potential consequences of hazards.
3. Determine priorities and look at possible ways to avoid or minimize the undesired effects.
4. Implement specific mitigation projects; conduct periodic evaluations and make revisions as needed.

Energy assurance planning

According to the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability (Energy.gov, 2013), the goal of energy assurance planning is to "[improve] the ability of energy sector stakeholders to prevent, prepare for, and respond to threats, hazards, natural disasters, and other supply disruptions." The first large-scale Federal funding mechanism for energy assurance planning available to local governments came in 2010 via the American Recovery and Reinvestment Act, which allocated approximately $8 million to 43 cities. This came after a 2009 investment of $38 million by the DOE to states to prepare energy assurance plans, and was followed in 2012 by a grant for 50 California cities to prepare energy assurance plans. The California grant was for $3 million (Public Technology Institute, 2011b).

On behalf of the Department of Energy, the Public Technology Institute (PTI) has developed various resources for local governments seeking to address energy assurance issues. In its *Local Energy Assurance Guidelines*, PTI (2011b) recommends that plans address all hazards that have potential to affect energy assurance in a locality, giving attention to unexpected events. PTI goes on to state that local energy assurance planning (LEAP) involves preparing for and responding effectively to energy emergencies and should include close collaboration with various partners including utility companies and state and federal-level offices. They also note that EAPs must complement pre-existing plans such as Emergency Response and Continuity of Operations Plans. Related to this, the guidelines offer a ten-step process for planners (PTI, 2011b):

1. Build an energy assurance response and planning team
2. Know the emergency authority framework
3. Understand response roles and responsibilities
4. Know the local government energy profile
5. Identify energy suppliers
6. Know the primary contacts and related partners
7. Identify key assets within the jurisdiction
8. Develop an energy assurance crisis communications protocol
9. Develop additional local, state, regional and federal partnerships for energy assurance
10. Update the plan on a consistent basis

The guidelines also include various issues to be considered by local governments, such as the importance of relationships and the complexity of grid interdependencies (PTI, 2011b).

There are two approaches given for incorporating renewables into energy assurance planning: long-term and tactical. A long-term approach is meant to diversify an energy portfolio with renewables over an extended period of time, complemented by energy efficiency measures; a tactical approach is short-term and meant to respond to particular events, such as emergency situations (Public Technology Institute, 2012a). PTI notes that the long-term approach increases the resiliency of an energy supply by reducing vulnerability to disruptions associated with relying on one power source only (Public Technology Institute, 2012a).

2.3 SOLAR ENERGY OVERVIEW

Various technologies

Solar Photovoltaic

The most common type of solar energy technology deployed in the United States is solar photovoltaic (PV), garnering about 96 percent of global investment in 2012 (Renewable Energy Policy Network for the 21st Century, 2013). First developed in 1954 by Bell Labs (Seia.org, 2013), this technology uses semiconductors to produce electricity. This is achieved through the use of cells, which contain diodes made up of positively- and negatively-charged semiconductors that allow for electrons to flow and generate a current. When sunlight hits the positively-charged semiconductor of the diode, the force of the impact causes electrons to separate from their atoms and travel to the negatively charged part of the diode. The electrons cannot bond with the negatively charged portion and therefore are transferred to a metal conductor strip that channels them into an electrical current. Multiple cells are typically combined to form a panel, which can be joined to form an array (Icleiusa.org, 2013).

Concentrated Solar Power

Another way of harnessing solar energy is referred to as concentrated solar power (CSP). This technology works by using parabolic mirrors and/or lenses to focus reflected sunlight on a turbine that produces heat, which is in turn harnessed to drive a mechanical engine, which subsequently drives an electric generator. The mirrors or lenses track the sun throughout the day to maximize solar intake. CSP installations, in contrast to solar PV, are generally only done on a large scale, as to be cost-effective. They have an advantage over PV installations because the thermal energy collected can be stored for extended periods of time, allowing it to generate electricity when the sun is setting (Icleiusa.org, 2013).

Solar Thermal

Solar thermal systems harness thermal energy from the sun to heat water, which in turn can provide heating and cooling needs for residential, commercial, or industrial facilities. Solar thermal systems are often mounted on the roof of the facility and are one of the lowest-cost and most effective ways to capture solar energy (Icleiusa.org, 2013; Morley, Anthony et al, 2014).

Current status

In mid-2013, the United States surpassed 10 gigawatts (GW) of capacity from solar PV installations, becoming the fourth nation in the world to reach such a level (after Germany, Italy, China). This figure is expected to reach 17 GW by the end of 2014 (Montgomery, 2013). This continues the trend of tremendous growth; from 2011 to 2012,

national capacity rose from 3.9 GW to 7.2 GW (Renewable Energy Policy Network for the 21st Century, 2013). Solar thermal capacity is projected to reach about 1.3 GW overall by 2014, boosted by large utility-scale projects in the western US (Eia.gov, 2013a). Combined solar energy capacity in the US accounted for just 0.11 percent of total energy generation in 2011 (Eia.gov, 2013b).

Photovoltaic installations grew 41 percent between 2012 and 2013, making solar generation second only to natural gas in amount of new capacity added in that year (29 percent). In fact, more solar capacity has been added since the beginning of 2013 than in the previous 30 years combined in America. Overall, residential solar capacity grew 60 percent, utility 58 percent and non-residential only four percent. The price of installations across all sectors fell 15 percent between 2012 and 2013, reaching a low of $2.59/watt (Solar Energy Industries Association, 2014).

Put in perspective, global PV capacity reached 100 GW in 2012, up from 71 GW in 2011, with the US accounting for just over seven percent of that; the US now accounts for about 10 percent of global solar energy (Renewable Energy Policy Network for the 21st Century, 2013).

Recent domestic growth in solar capacity is largely attributed to innovative state incentive programs (Renewable Energy Policy Network for the 21st Century, 2013), increase in demand from consumers, and price declines (Montgomery, 2013). Research from Navigant states that solar PV could reach grid parity without subsidies by 2020 (2013).

Future outlook & emerging trends

New technologies

The majority of electricity in the United States is generated in central coal or natural gas plants which then distribute power across their designated regions. The distribution process results in power loss through inefficient infrastructure. Though inefficiencies exist in any type of power generation, centralized production is typically less efficient than distributed production (nrel.gov, 2012). The antithesis to this system is known as distributed grid, which generates and uses power on-site or near the place of production, eliminating such losses and increasing efficiency. Distributed generation has an added advantage of off-grid capability, allowing for a contribution to energy assurance planning at the local level (PTI, 2011b). Numerous sources imply that distributed grid technology may be the future of the American electricity grid. The trade association Edison Electric Institute, in their January 2013 report *Disruptive Challenges: Financial Implications and Strategic Responses to a Changing Retail Electric Business,* states that falling prices of solar PV, among other things, is "expected to challenge and transform the electric utility industry" (p. 1) and that distributed solar presents the "ultimate risk" to traditional grid viability (p. 3). The process has been likened (p. 14) to the way in which mobile phones have surpassed home phone lines, an idea once thought unimaginable. David Crane of NRG Energy similarly sees distributed solar as the inevitable successor to the traditional, concentrated grid and research from the Bloomberg New Energy Finance group shows that distributed solar is expected to continue growth through 2020 resulting in 4.5 GW of capacity in distributed rooftop PV (Kind, 2013). Further, recent research from investment firm Morgan Stanley suggest that growth of the distributed grid could result in a "tipping point" that pushes utility consumers to shift *en masse* to off-grid solar power. They

estimated that the US could reach 240 gW of distributed solar installations by 2020 (Parkinson, 2014).

"Smart grid" technology is also expected to change the status quo in energy delivery infrastructure. The concept can be thought of as the internet for energy that intends to modernize the electricity delivery system by automatically optimizing it through intelligent computer systems. As envisioned thus far, the smart grid will allow greater integration of renewables and distributed generation energy resources. Future operators of the smart grid will have the ability to switch energy sources and reroute energy supply to meet demand in advance of an energy emergency instead of only after the emergency (PTI, 2011b).

Storage technology is a vital component to maximizing the utility of solar energy, as it allows systems to power facilities in times of little or no sunlight. In 2010, solar company SolarCity joined with Tesla Motors and the University of California, Berkeley, in a $1.7 million research and development effort related to energy storage, funded by the California Public Utilities Commission (CPUC). The goal of the R&D effort was to help advance battery storage technology for use in tandem with solar PV electric systems by working with Tesla's existing car battery systems. According to the SolarCity's website, "the battery storage will collect excess PV power production so that during peak periods, the utility can pull from battery storage rather than power plants which have greater emissions" (Solarcity.com, 2010). According to an article from GreenTech Media in early 2014, the combination of SolarCity and Tesla may be utilities' "worst nightmare" because the storage systems will challenge the very foundation of the electric utility business

model. The CPUC has been hesitant to permit such systems for fear that they can "store grid electricity and feed it back [to the utility via net-metering] under the guise of green, solar-generated power," which Tesla CEO Elon Musk has called a "crazy" notion (St. John, 2014). As of March 2014, SolarCity has sold and installed about 100 of the systems in California. After hearing that some customers have waited months to receive a decision on a connection application for the systems from the utilities in California, SolarCity CEO Lyndon Rive accused the utilities of trying to slow the process (Baker, 2014). The situation is ongoing.

Regulatory and Legal Concerns

Regulation can be both an enabler and barrier to solar energy development. Beginning with Iowa in the 1980s, states have enacted so-called Renewable Portfolio Standards (RPS) as a way of mandating increases in renewable energy capacity. As of 2013, 29 states have an RPS, and some have specific "solar carve outs" which specify how much of the renewable generation must come from solar installations (Griffin, 2014; nrdc.org, 2013). These standards are legally binding once adopted, and therefore controversial. In recent years, many RPSs have come under legal attack because of potential violations to the Commerce Clause, by virtue of granting "clean" facilities special privileges (Griffin, 2014). In 2013, 26 bills were introduced around the country to repeal or roll back RPSs and none were successful; seven states increased their RPSs in the same year. Figure Two shows an overview of RPS legislation by state in 2013 (Center for the New Energy Economy, 2013).

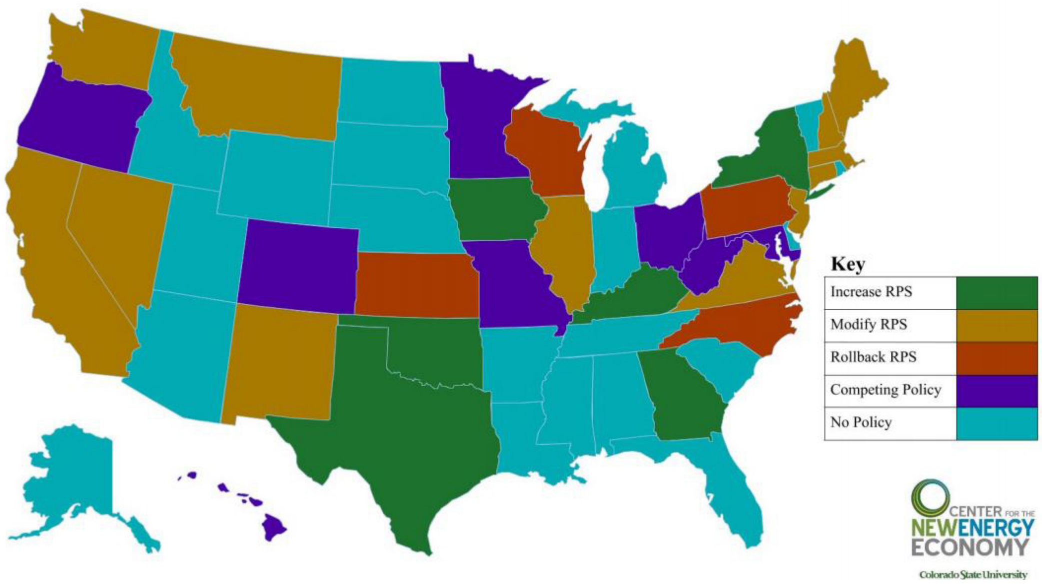


Figure 2. Map showing RPS legislative actions by state in 2013 (Center for the New Energy Economy, 2013)

Net-metering is another popular mechanism for increasing solar capacity, making installations more affordable by allowing utility customers with solar electric systems to sell back excess power at retail rates. Like RPSs, net-metering is coming increasingly under attack. The May/June 2014 issue of *Sierra* magazine outlines the various state-level battles over net metering rates and legal status across the country (there were 22 states at the time of the article). The main argument of utilities against paying retail rates for the excess energy they are required to buy back is that increased solar capacity is causing a "cost shift" and actually costing the utilities money because the solar customers are "free riding" and being subsidized by traditional grid customers that have to pay more to maintain and expand the grid. Utilities in some states (Utah, Arizona, among others) are currently trying to impose fees on solar customers to make up for lost revenue (Humes, 2014). The rulings are pending for many of these cases and the future is unclear.

Regulation from the Federal Energy Regulatory Commission (FERC) has played a part in facilitating increased amounts of storage systems tied to solar electric systems. FERC Order 792 was introduced in November 2013 to make solar electric systems with backup capacity eligible for interconnection with the grid (Casey, 2014). Combined with FERC Order 784 from July 2013, these rulings have "open[ed] the floodgates for the increasing importance of energy storage as part of the electric grid" (Haleakalasolar.com, 2013) Prior to these Orders, FERC and other regulators did not specify guidelines for energy storage, which had made the option a large risk for consumer, utilities and investors alike (Haleakalasolar.com, 2013).

Regulations acting as a potential barrier to solar energy development include those like Rule 21 in California, which can significantly add to the time and cost of incorporating storage in solar electric systems. (In California, the interconnection process for such systems can take up to eight months and add between $1,400 and $3,700 in extra fees.) These rules are predicated upon safety issues, as well as net-metering concerns. California utilities have cited a concern that customers with storage systems could store power from the grid and sell it back to the utility as if it were generated from their solar panels. To combat this, utilities in the state have until now been slow to connect such systems, and charged upwards of $1,000 for special meters to guard against unwanted uses; SolarCity CEO Peter Rives has said that such meters cost from $75-100 (Wesoff & St. John, 2014; Hales, 2014).

In May 2014, driven largely by pushback from companies like Tesla and SolarCity, the California Public Utilities Commission amended the rule which makes it easier to add storage to grid-connected systems (Wesoff & St. John, 2014), but similar rules exist in other states.

Myths

Prevailing myths are an obstacle to solar development. Lack of understanding about the technology was cited as one of the top five obstacles preventing the installation of solar electric systems by the International City/County Management Association (ICMA) annual member survey (2012).

A common myth is that solar is too costly. A report from NREL, *2010 Solar Market Technologies Report,* shows that solar prices have fallen an average of seven percent a year since 1980, dispelling the "too expensive" myth (2011) cited by ICMA as the number one barrier preventing its members from installing solar (2012). Announcements like the recent DOE promise of $19 million in funding to reduce both hard and soft costs related to solar show American commitment to continue the precipitous price decreases (Energy.gov, 2013b). That being said, there is still a large gap in federal spending that likely contributes to the price disparity between traditional fuels and solar. While the oil and gas industry receives a combined average of $4.86 billion in subsidies annually from the federal government, solar receives about only about $37 million. And such investment is relatively recent compared to that of petroleum—1994 compared to 1918, respectively (APA, 2013).

One of the most persistent myths is that much of the United States suffers a climate too cloudy for solar to be effective. This is dispelled by the fact that Germany on average has about as much solar resource as Alaska, and far less than the US average, but leads the world in total solar capacity and "dominates the PV market" worldwide (NREL, 2011). The American Planning Association (2013) notes that at times, solar energy offsets about 50 percent of total energy usage in Germany. False reporting from Fox News has played a large part in spreading this myth (Oremus, 2013). In fact solar collectors still produce energy in cloudy or overcast conditions, with the panels actually working more efficiently in the cooler temperatures according to an NREL tool PVWatts (APA, 2013).

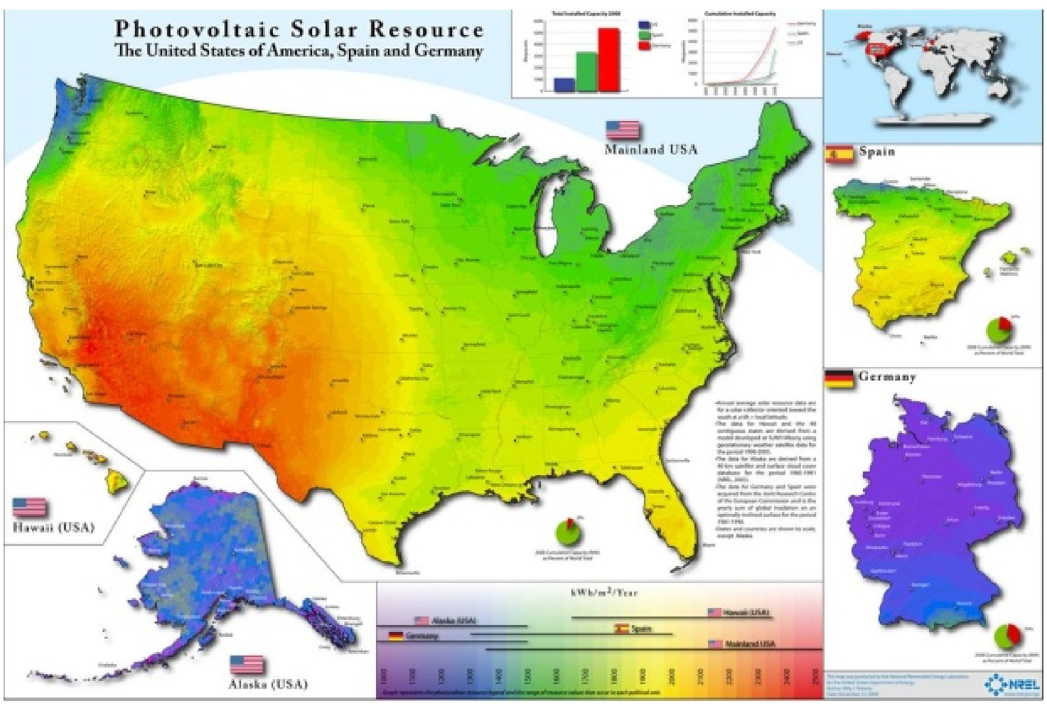


Figure 3. Map showing amount of sun received for selected countries (NREL, 2012)

Another common myth is that solar systems require timely and costly maintenance. The fact that solar systems have no moving parts and often come with lengthy warranties (Flicker and Kaplar et al., 2012) means that in reality, maintenance costs are very low. Estimates show that on average, maintenance costs $17 annually per kW generated (Electric Power Research Institute, 2010). Additionally, solar energy is often characterized as unreliable compared to traditional sources of energy. According to NREL (2003), solar electric systems are "some of the most reliable products" on the market and have been rigorously tested by multiple organizations. In the context of this research, the *reliability* of solar energy refers to its complementary and supplementary nature to other forms of energy, rather than on its own accord.

2.4 EXAMPLES OF SOLAR IN RESILIENCE PLANNING

Though limited, examples exist in the literature where solar energy has been linked directly to resilience planning. Meister Consultants Group (Boston) and the Florida Solar Energy Center have produced the bulk of the research that is drawn upon in this project. There are four typical phases cited in resilience planning; examples of the use of solar energy can be found in all phases. There is considerable overlap between the phases and many examples have benefits in more than one phases—the phases are meant to provide an overall organizational hierarchy rather than a defined category. [Not all examples here result directly from local government action.]

Mitigation

The City of Baltimore's Disaster Preparedness and Planning Project (DP3) is an innovative combination of hazard mitigation, climate adaptation and floodplain mapping.

The project links research, outreach and strategies to create a comprehensive action plan. Some of the City's strategies directly utilize solar energy in implementation, under the Energy Systems & Buildings section. The report notes the importance of backup storage systems and distributed generation in mitigating and reducing vulnerability to gird outages. According to a source at the City, the implementation of projects in the plan are being funded by the Abell Foundation, a philanthropic organization in Maryland (City of Baltimore Department of Planning, 2013).

Preparedness

The majority of examples are related to the use of solar energy in preparedness/planning. KBET Radio in Santa Clarita, California, installed a 10 kW solar PV system on its facility that can become an emergency power source for an AM transmitter in the case of power outage. This is important because the radio station is designated as an Emergency Operations Center communications facility that provides communications between police, fire, and other disaster response contacts in time of emergency (PTI, 2011b).

The Florida Department of Transportation operates solar-powered signage in times of emergency (Lee et al, 2013) and the fire department in Shawnee, Kansas has a solar array on a fire truck to power small personal electronic devices (Lee et al, 2013).

The Santa Rita Jail in Alameda County, California installed a 1.2 mW solar pv system on its roof in 2001; in 2011, the jail added a two megawatt energy storage system and in 2012, a microgrid was installed. These features allow the jail to switch on and off

the main utility grid which increases the energy resiliency in an emergency while contributing clean energy to the main grid on a routine basis. Funding for the project came from a variety of sources including utilities, state funding and the DOE (Otto, 2013).

Solar electric systems with backup batteries were installed on fire stations throughout Montana to serve as community centers and first-responder hubs in the event of widespread power loss. Between 2003 and 2007, the National Center for Appropriate Technology collaborated with utility NorthWestern Energy to install the systems on 20 stations, each capable of generating 2-3 kW. In 2008, a fire station in City of Billings with such a system installed maintained power after record snowfalls left many in the city without power. The fire station was able to respond to emergency calls thanks to the backup solar power. Funding for the project came from a public benefit fund established by the state and dispersed through the utilities (Schmidt, 2013a).

In Boston, a solar evacuation route pilot program was launched with the support of the US Department of Energy, as part of American Recovery & Reinvestment Act (ARRA) funding. The program seeks to facilitate safe and efficient evacuation by utilizing solar powered lighting, fueling station and signage that can continue operation in isolation from the grid (United States Department of Energy, 2011a; Chow, 2013).

In 2009, the SunSmart E-Shelter program in Florida provided solar panels and backup storage batteries to more than one hundred schools which were identified as emergency shelters. The program was coordinated by the Florida Solar Energy Center and was funded through the American Recovery Act, with additional funding provided by public

and private utilities. Each school received a 10 kW system. The unique aspect of backup battery storage capacity increased the resiliency of the communities by allowing critical operations such as medical care and communications to continue when the larger grid is down. The project was financed largely from ARRA funds (Mirzazad, 2013).

Santa Clara University in California has developed a micro-grid that can operate completely independent of the larger grid network, allowing facilities to maintain power in an outage event. The micro-grid is powered partly by solar on university land and renewable energy purchased from Silicon Valley Power, a local utility. Universities in general have been early proponents of microgrids (Schiller, 2014).

Largely a reaction to Hurricane Sandy, *PlaNYC: A Stronger, More Resilient New York* (2013) incorporates the use of solar energy in a variety of ways. Initiative 14 in the Buildings section calls for the amendment of building and construction codes to facilitate installation of solar and other renewables to allow for "rapid restoration of electricity...during utility outages." (p. 86) A strategy in the Utility chapter states that the City should "diversify customer options in case of utility outage" (p. 129) and notes solar generation "can provide electricity for individual customers and their local communities" (p. 129) in such cases. Additionally, in the Water & Wastewater chapter, the plan states that "solar energy...would improve the ability of wastewater treatment plants to operate reliably during disruptions to the electrical grid while also enabling significant reductions in...greenhouse gas emissions" (p. 216).

Response

In the aftermath of Hurricane Katrina, Waveland, Mississippi had a solar-powered water purifying system donated by WorldWater & Solar Technologoies, Inc. that provided 350,000 gallons of clean water for 8 months (Lee et al, 2013).

After Hurricane Sandy ravaged much of New York City, AT&T developed the Street Charge program to install free solar mobile charging stations in parks and other outdoor spaces across all five boroughs of the City, where the public could charge their phones, tablets and other devices. The project was funded by AT&T (Marano, 2013).

The City of Houston, Texas, is one of the most at-risk American cities for hurricane damages. After such devastating events as Hurricane Ike in 2008 left many areas without power for several days, the City purchased 17 *Solar Powered Adaptive Containers for Everyone* (SPACE) units in 2011 to supply emergency energy in times of need. The units have been placed as schools, community centers and fire stations in preparation for a future event. Each unit cost approximately $60,000 and was financed via ARRA funding of over $1.3 million. The units are equipped with solar panels to generate about 4 kW of power, and battery storage to save the power for use when necessary (Lee, 2013).

Recovery / rebuilding

In 2010, with financial support from the FEMA Public Assistance program, the Verendryne Electric Cooperative in North Dakota used solar photovoltaic energy to replace traditional power lines that were downed by the Good Friday Storm. The remote location of lines made traditional repairs difficult and costly. Combined with the low power

requirements, the utility decided to restore power to some area infrastructure with solar PV panels. This experience was the first time that VEC utilized solar power to respond to a natural disaster (Ayhow, 2013).

New York City released the *Hurricane Sandy After Action Report* which outlines potential for solar powered street lights that will maintain power in an outage (Fermino, 2013).

2.5 ASSORTED FINANCING METHODS FOR SOLAR DEVELOPMENT

Various methods of financing for solar energy projects exist. Some of the most common are profiled below:

Property assessed clean energy

Property-Assessed Clean Energy (PACE) financing was pioneered in 2007 in Berkeley, California and allows property owners to finance various energy efficiency and renewable energy projects by adding the cost as an assessment to the property tax bill, therefore eliminating upfront costs and allowing repayment to be made over a longer timeframe, typically from five to 20 years. The assessment is typically placed as a senior lien on the property and stays with that property, not the applicant (Schmidt, 2013b). Energy Financing Districts (EFDs) enable local governments to raise money through the issuance of bonds to fund these clean energy projects (though bonds are not the only possible source of funds). The financing is repaid over a set number of years through a “special tax” or “assessment” on the property tax bill of only those property owners who choose to participate in the program. The financing is secured with a lien on the property,

and, like other taxes, is paid before other claims against the property in the case of foreclosure. There is little or no up-front cost to the property owner, and if the property is sold before the end of the repayment period, the new owner inherits both the repayment obligation and the financed improvements (United States Department of Energy, 2011b).

Shared / community solar

In A *Guide to Community Shared Solar: Utility, Private, and Nonprofit Project Development*, community solar is defined as any solar electric system that benefits multiple community members. The idea is to allow members with non-optimal solar resources (renters, those with shaded roofs) to still be able to take advantages of the benefits of clean energy and lower utility bills (Coughlin and Grove et al., 2012). Community solar projects are typically funded in one of three sponsorship categories: non-profit, utility, or special enterprise funded.

In a traditional non-profit funding model, the systems are owned and hosted by the non-profit organization and financed by various donations and/or member contributions. Utility projects are typically owned, hosted and financed by the utility or a chosen third-party, and the power is provided to utility ratepayers. Special enterprise projects are typically owned by the enterprise, financed by members and hosted by a third-party. The following chart is adapted from Coughlin and Grove et al., 2012, and provides an overview of all models.

Group purchasing / Solarize campaigns

Grove et al. (2011) describes a "solarize" campaign as a community collective purchase of PV solar installations. In a report for NREL, they outline the first such program, in Portland, in a guide created to help local governments mimic the successful initiative. They condense the program into three essential elements: a competitive contractor selection process, community-led outreach and education, and limited time availability for participation. Over the course of six months, a successful program should lead consumers from "awareness to installation," (p. 8) eliminating barriers along the way. In the report, the authors note successful programs in Portland, Seattle and San Diego among others that were initiated by local government officials.

Power Purchase Agreements

Power purchase agreements (PPA) are a particularly beneficial financial mechanism for municipalities because they allow the entity to take advantage of financial benefits typically not available to them due to their tax-exempt status. The incentives are achieved by working with private sector solar developers who pass along the savings to the municipality via a lower electricity rate. The municipality further benefits by reducing upfront installation costs which are often cost-prohibitive (Kreycik, 2011).

According to research on municipal PPAs in Massachusetts, the most common issue cited as a challenge to the process was fear that the solar developer would leave in breach of the contract. The authors recommend that municipalities draw up clear contracts with clauses that protect them in that case, since budgets can hinge significantly upon the

projected savings from a PPA. They also suggest seeking legal counsel considering the complex nature of the contracts (Kreycik, 2011).

FEMA funding

While not explicitly for solar energy projects, FEMA offers grant funding programs that can be used for resilience projects that may include a solar energy component. The Pre-Disaster Mitigation program provides annual funding for hazard mitigation-related projects at the state and local level and aims to "reduce overall risk to people and structures." The funding for fiscal year 2014 has been increased from $23 million to $63 million nationwide (fema.gov, 2014b).

The Hazard Mitigation Grant Program also provides grants to state and local governments in order to implement long-term hazard mitigation measures once a disaster has occurred and the locality has been officially declared as a disaster area. The funds may be used for projects that reduce or eliminate the losses from future disasters and take a long-term approach: the "elevation of a home to reduce the risk of flood damages as opposed to buying sandbags and pumps to fight the flood." The projects must also have potential savings greater than the overall project cost. Local governments must contact the relevant State Hazard Mitigation Office to apply, as the grants are funneled through states (fema.gov, 2013a).

The Public Assistance grant program provides assistance to state and local governments to respond to and recover from disasters or emergencies declared by the President of the US. Under the program, FEMA provides financial assistance for activities

such as debris removal, emergency protective measures, and the repair, replacement, or restoration of damaged publicly facilities. FEMA covers a share "not less than 75% of the eligible cost for emergency measures and permanent restoration" (fema.gov, 2013b).

3 METHODOLOGY

The project seeks to determine the extent to which solar energy applications can improve resilience efforts at the local government level in the US. The methods employed are three-fold: a survey of local government officials related to hazard mitigation planning; interviews of key stakeholders and local government officials related to energy assurance planning; and a review of the literature, including secondary and tertiary information sources such as scholarly articles and case studies. Each component is detailed subsequently.

3.1 SURVEY

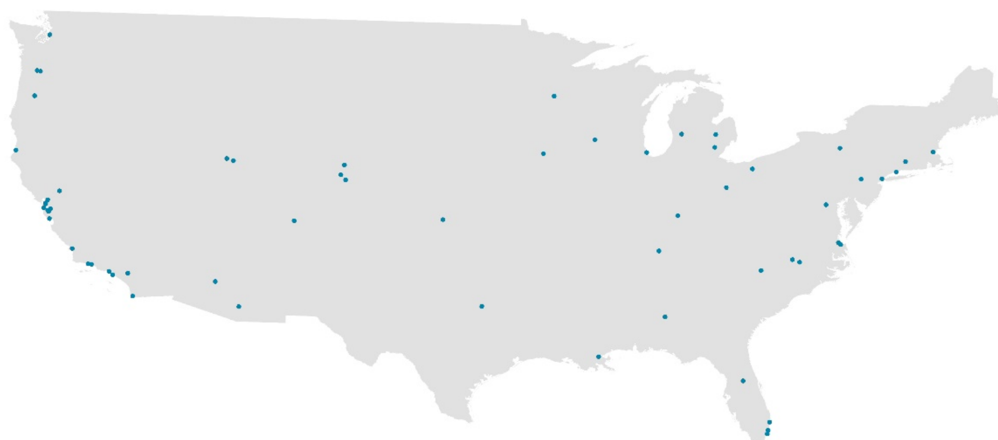
A prior review of existing hazard mitigation plans at the state and local level showed that the vast majority do not include the use of solar energy applications as a mitigation strategy. This is despite evidence that exists in the literature, specifically from Meister Consultants Group (Lee, Laurent et al, 2013) and the Florida Solar Energy Center (Young, 2008, 2005, 1996), showing that it may be useful to do so. Therefore a survey was created to determine why solar energy is not being included, or at least considered, in formally adopted hazard mitigation plans. Questions were meant to elicit information not generally available to the public, such as “backroom conversations” and internal debates. The survey also aimed to identify barriers to local government officials related specifically to incorporating solar energy into ongoing efforts.

The sample set for the survey was determined to be communities that signed onto the ICLEI-USA Resilient Communities for America (RC4A) campaign, which aims to

"champion the leadership of hundreds of local elected officials who commit to creating more prepared communities that can bounce back from extreme weather, energy, and economic challenges" (Resilientamerica.org, 2014). This sample set was chosen because it represents communities that have a demonstrated interest in pursuing resilience at the local level. These communities are the target audience for the accompanying guidebook (Appendix C). The actual number of signatories at the time of the survey was 113 (see Figure 4). As the campaign is ongoing, the sample only takes into account the signatories as of January 2014 (the time of data-gathering commencement).

Figure 4.Location of all communities signed onto ICLEI Resilient Communities for America campaign as of January 2014

As the RC4A website only displays the name of the official that signed onto campaign (e.g. Mayor, County Supervisor), the officials working on the community's hazard mitigation plan had to be identified via additional research. It was assumed that each community would have a FEMA-approved hazard mitigation plan, as it is the requisite document for disaster relief and recovery funding. After searching for the plans online and following up with the communities by phone and email, 53 individual email addresses were collected. Therefore the final survey sample comprises 53 local government officials that have worked or are currently working on hazard mitigation planning or related tasks in communities that have signed onto ICLEI-USA's *Resilient Communities for America* (RC4A) campaign. Figure 5 shows the communities included in the sample.



Akron, OH
Anapolis, MD
Ann Arbor, MI
Beaverton, OR
Benicia, CA
Boulder, CO
Bridgeport, CT
Burlingame, CA
Cambridge, MA
Carpinteria, CA
Carson, CA
Chapel Hill, NC
Charlotte, NC
Chicago, IL
Clarkstown, NY
Columbus, OH
Des Moines, IA
Dubuque, IA
Duncanville, TX
Easton, PA
Eugene, OR
Fremont, CA
Ft. Collins, CO
Gaithersburg, MD
Grand Rapids, MI
Greensburg, KS
Hallandale Beach, FL
Hartford, CT
Hillsboro, OR
Hoboken, NJ
Ithaca, NY
Louisville, KY
Miami-Dade, FL
Montgomery, AL
Mountain View, CA
Nashville, TN
New Orleans, LA
Newport News, VA
Norfolk, VA
Oakland, CA
Oakland Park, FL
Palo Alto, CA
Park City, UT
Raleigh, NC
Santa Barbara, CA
Santa Barbara, CA
Santa Cruz, CA
Santa Monica, CA
Seattle, WA
St. Paul, MN
Surprise, AZ
Riverside, CA
Sacramento, CA

BOLD designates County

Figure 5.Location of all communities in survey sample

The survey was administered via Google Forms, an online platform allowing for survey dissemination and data collection. This medium was chosen over similar services such as SurveyMonkey because of its familiarity to the researcher, ease of use and affordability; downloading survey data as a Microsoft Excel file (.xls) is free in Google Forms, while it is a paid service in SurveyMonkey. Prior to dissemination, the survey was reviewed, edited and pre-tested by colleagues and others familiar with the project to ensure it was clear, concise and free of errors.

The survey included 16 questions. It also allowed for optional input of contact information upon completion. A copy of the actual survey as a Google Form can also be found in Appendix A. For reference, the questions also appear below:

1. Please provide your job title, at the time of your role in the plan development.
2. Please state briefly your role in the development of your community's hazard mitigation or similar plan.
3. Please elaborate on how you think the hazard mitigation planning process could be improved, if at all.
4. In your opinion, do you face any of the following barriers to hazard mitigation planning in your community? [Check all the apply: Political will, financial constraints, staffing capacity]
5. Does your community's most recently adopted hazard mitigation (or similar) plan include the use of solar energy as a strategy to reduce the risk of and vulnerability to natural and/or man-made disasters?
6. If you answered *Yes* above, please elaborate on how it was incorporated into the plan.
7. If solar energy was not included in the plan, was it considered as a potential strategy?

8. If solar energy was considered, please explain why it was eventually not selected.
9. If solar energy was not considered, please elaborate on the rationale.
10. Is solar energy being used or considered in the implementation phase of your community's hazard mitigation or similar plan? [Yes, No, Not applicable]
11. Which of the following hazards are you concerned about for your community? [Earthquake, Wildfire, Extreme Temperature, Flooding, Drought, Other]
12. Of the previously selected hazards, do you think that increased use of solar energy could potentially help mitigate the negative effects?
13. Do any of your jurisdiction's facilities have solar electric systems installed? [Yes, No, Unsure]
14. If you selected *Yes* above, please provide more information.
15. If the information is available, please provide an estimate of how much installed solar energy capacity these facilities currently have.
16. Please provide any additional feedback you have related to the topics covered in the survey.

The initial round of survey invitations was sent on March 3, 2014 via email. The emails included a brief overview of the purpose of the survey, a statement on anonymity (per university guidelines) and a link to the online survey tool. Recipients were asked to respond by March 13, 2014. On March 11, 2014, a follow-up email was sent to all of the sample. The recipients were asked to respond by March 17, 2014 as a final deadline.

By the deadline of March 20, 2014, the survey had received 13 responses, or about a 25 percent return rate. The low rate and raw number is attributed by the author to the high proportion of generic departmental email addresses obtained, as opposed to direct email addresses. The response rate and total number of responses is not statistically significant. The nature of the sample made it inherently difficult to achieve

statistical significance because it is a very small population: about 100 communities compared to over 89,000 units of local government nationwide (Census.gov, 2014), and 25,000 nationwide that have completed FEMA-approved hazard mitigation plans (2013a). Therefore, no claims can be or are made on behalf of the entire community of local government officials nationwide; rather, the subsequent findings in the project refer specifically to the sample group (i.e. those working on hazard planning in ICLEI RC4A communities). Though a low total number of responses were collected, those that did respond are considered to be at the forefront of hazard planning in the US based on their demonstrated efforts to increase resilience by signing the RC4A agreement. The willingness to respond to the survey as requested further demonstrates their commitment to advancing resilience planning by participating in novel research. Therefore, the findings are considered to represent the essence of the intended audience for this research. [A detailed overview of findings, as well as a discussion of their significance, follows in Chapter Four.]

3.2 INTERVIEWS

The interview process was divided into two parts: a sample of local government officials working on energy assurance efforts and key stakeholders in the energy assurance and hazard mitigation planning processes. Each part is described below.

Energy assurance planners

Between 2010 and 2012, the US Department of Energy's Office of Electricity Delivery and Energy Reliability (n.d.) awarded grant funding to 93 cities and counties to "identify and assess energy disruption events, train personnel on energy infrastructure

systems, and increase their knowledge of regional energy interdependencies." An interview process was conducted primarily to provide insights into the DOE grant process for energy assurance planning, and how (if at all) solar energy usage was explicitly included in the planning process.

After cross-referencing the list of 93 communities with the RC4A campaign signee list, 15 in-common cities and counties emerged. These communities were selected (excluding San Luis Obispo County, California, for conflict of interest reasons) as the pool for in-depth interviews related to the energy assurance planning process on the basis that they are actively engaged in both primary aspects of resilience planning, as defined in the context of this project. See Figure 6 for a map of communities in the interview sample.

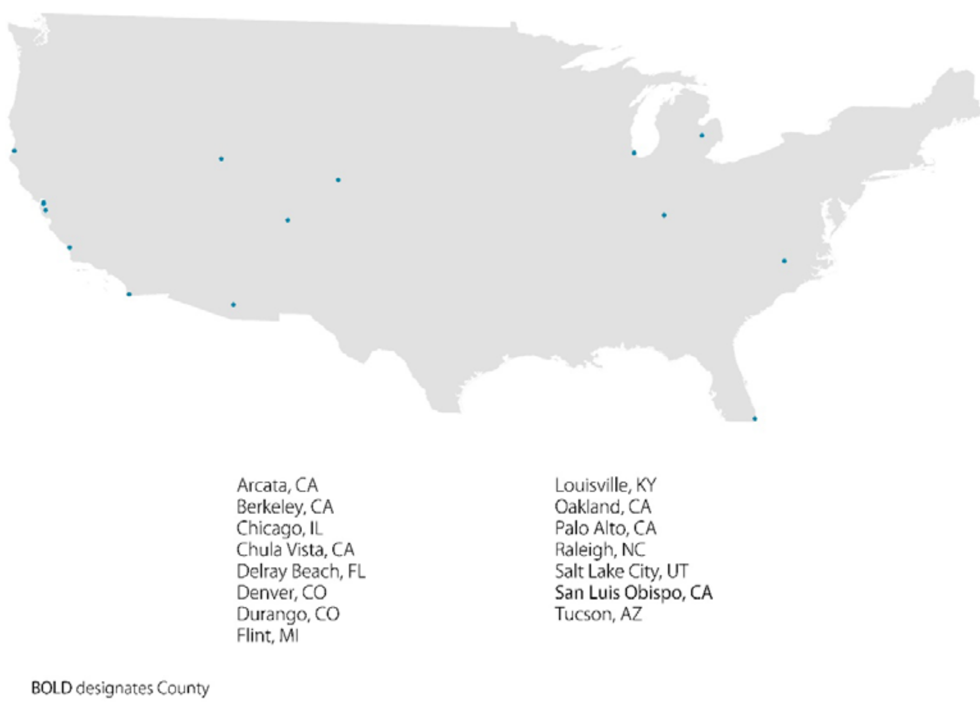


Figure 6. Communities that both signed the RC4A campaign and received energy assurance funding from US Department of Energy

Email contact information was gathered through formal websites of the DOE, internet research and phone calls. Of the original sample of 15, one community was eliminated for conflict-of-interest purposes and two were eliminated as email addresses were unable to be located. After locating all possible contact information for local government officials involved in the planning process in each community, five interviews were conducted. Though the interviews tended to be free-flowing discussions aimed at providing an overview of the energy assurance planning process in each community, the following questions were addressed:

1. How was the community selected for the Department of Energy grant for energy assurance planning?
2. If there was an application process, did a certain event compel the community to apply?
3. What progress has been made in regards to energy assurance planning since the grant was awarded?
4. Was the project treated as a priority?
5. Do you feel that energy assurance planning has the capability of increasing your community's resilience to disasters; economic recession; energy emergencies?
6. Have you collaborated with the hazard mitigation planning staff regarding the development of an energy assurance plan?
7. What role, if any, has solar energy played in the development of your energy assurance plan?
8. What obstacles have you faced in plan development?

The initial invitations were sent via email directly to the identified official in each community on March 12, 2014; follow-up emails were sent a week later. Both emails included an overview of the purpose, as well as information regarding anonymity, per

university research protocol. Twelve invitations were sent in total, with five responses, resulting in ~42 percent response rate. The interview process was undertaken in an exploratory fashion and was not intended to produce results that could be generalized to all communities nationwide. The results show an in-depth look at the planning process and allowed the author to uncover information not available online.

Key stakeholders

Key stakeholders were identified through the literature as those organizations that play a direct role in the development of hazard mitigation and energy assurance plans. The Federal Emergency Management Agency sets the requirements for hazard mitigation planning through its formal guidance and therefore has the power to alter the planning process for over 14,000 HMPs created and updated throughout the US (Berke, Lyles & Smith, 2012). Information from FEMA online was utilized in the literature review and no mention of utilizing solar energy exists in their guidance for HMP. Therefore several attempts were made to discuss the internal planning process and determine whether or not solar energy has been considered in the HMP process but left out for any particular reason. No communication was possible and therefore any reference to FEMA hereafter refers only to available publications and information found online.

A senior-level staff person at Public Technologies Institute was interviewed regarding the energy assurance planning process in order to solicit more information about how the DOE grant process played out in the participating cities. Also, an employee of the California Energy Commission (CEC) familiar with the DOE process for California cities was interviewed to provide more information on that specific portion of the DOE grant

funding for energy assurance planning. These interviewed were undertaken due to the lack of available background information about the DOE energy assurance planning grant online. [Findings from the interview process follow in Chapter Four.]

3.3 LITERATURE REVIEW

A literature review is a summary and synthesis of the gamut of published material on a particular topic that is meant to provide a convenient overview of the current and historical academic work on said subject (The Writing Center, 2014). Chapter Two of this report includes the literature review comprising both resilience and solar energy *writ large* in order to allow the author and audience to understand the complexities of the general terms *resilience* and *solar energy*. Over 150 sources, ranging from formal plans and government resources to popular magazines and websites, were reviewed.

4 FINDINGS AND DISCUSSION

This section includes information on the findings of each of the three methods employed in the project. Interspersed throughout the findings is a discussion of the significance and relevance to the overall research question: *to what extent can the use of various solar energy technologies improve contemporary resilience efforts at the local government level?*

4.1 SURVEY

The survey response rate was 24.5 percent (13 of 53). The results are not meant to be generalized to communities as whole but rather only to the conditions of the responding communities from the sample. As was the original intention of the survey, the responses provided insight into the state of solar energy integration in hazard mitigation planning as well as barriers faced by local government officials. The respondents to the survey reported a diverse range of roles in their community's hazard mitigation plan. The most common role cited was that of manager or project lead (including primary author). The sample also included officials that focused on specific tasks, such as implementation or grant-writing.

The responses showed that among the sample communities, about 15 percent of the hazard mitigation plans included solar energy applications as a hazard mitigation strategy; of the remaining 85 percent, only one plan considered solar energy as a *potential* mitigation strategy. This corroborates the literature review which showed a lack of connection between formal resilience planning and explicit solar energy usage. This also is

in direct contrast to the finding that nearly two-thirds of respondents stated a belief that solar energy could "potentially help mitigate the negative effects" associated with the hazards that their community faces. The lack of incorporation of a technology that is seen as useful confirms that the sample communities face barriers to solar energy development in this context. Barriers cited by respondents included an existing heavy dependence on fossil fuels in the community; the widespread belief that solar is expensive, especially with backup capacity; the uncertainty about solar as a risk reducer; and the general resistance to change by the public. While insightful, the data is anecdotal and insufficient to make any universal claims about the barriers to solar energy's explicit use in hazard mitigation planning. More responses to this question could provide further insights regarding barriers.

Among the responding communities, the most common barriers to developing solar in general were, from greatest to least: staffing capacity (~62 percent), financial constraints (~46 percent), political will (~23 percent), and time constraints (~8 percent). This is in line with a more extensive survey completed by ICMA (2011) regarding solar energy in general. Though not explicitly addressed through the survey, an additional barrier was uncovered from the responses: a lack of connection between the benefits of solar energy usage and how those translate into an increase in resiliency.

In the plans from the sample that do incorporate solar energy, its use was identified by the respondents as a means to reduce stress on the electricity grid and thereby reduce vulnerability to power outages. Some respondents also noted that special attention was paid to mitigating impacts on critical facilities.

The officials that worked on plans that do not utilize solar energy as a mitigation strategy noted that the use of solar energy is generally seen as a way to reduce carbon emissions, but not specifically as a means for improving resilience to hazards. This further exemplifies the failure to link the benefits of solar energy to the hazard mitigation planning process, and demonstrates the need for the guidebook included as Appendix C.

The survey also showed that while the communities for the most part had not included solar energy usage in their HMP, they do have solar installed on municipal facilities. More than 60 percent of respondents indicated that their communities utilize solar electric systems of various technologies and scales on their municipal facilities. This shows that even when barriers to solar development in general are overcome, there is not necessarily an integration between existing solar energy installations and resilience planning efforts—such a link is often "not on the radar," as some respondents put it.

When prompted to provide general thoughts on how the hazard mitigation planning process could be improved, officials in the sample reported a desire to see hazard mitigation planning linked to existing community efforts toward sustainability and climate change. Some interviewees posited that because HMPs are a requirement for communities to receive money from the federal government, plans exist solely for that purpose. It was indicated that plans can have more value if they are not formalities or afterthoughts, but rather comprehensive plans that account for a changing climate and the related need for sustainable practices (including energy usage). No respondents specifically noted a desire to include solar energy or other sources to enhance the hazard mitigation process; the question was asked to determine whether or not such a response

would occur. This once again indicates a disconnect between the hazard mitigation planning process and solar energy usage.

4.2 INTERVIEWS

Energy assurance planning

Five interviews were conducted following twelve requests, resulting in a response rate of ~42 percent. As with the survey. The interviews provided more information about how the DOE grant process for energy assurance planning played out in each community, as a proxy for the process in general. The grant process was divided into two phases: a nationwide round of funding for 43 cities in 2010, and a California-specific group of 50 cities in 2012.

Nationwide

The 43 cities in the first round of funding applied directly to the Department of Energy (DOE). The interviews did not reveal any specific event or concern that led the cities to apply for the grant. Consultants were assigned to the cities by DOE to help with plan development and typically played a larger role than local government officials in the plan development process.

California

In 2012, 50 cities were awarded DOE funding for energy assurance under the California Local Energy Assurance Planning (CaLEAP) initiative. These cities were approached directly by the California Energy Commission to participate in the program; therefore, no specific events that led to application could be identified. Local governments

from the CaLEAP cities were more engaged in the planning process as compared with the cities in the nationwide round of funding, and consultants played a smaller role in plan development.

Overall

None of the cities in the interview sample formally completed and adopted energy assurance plans; rather, the grants served to complete the initial phase of identifying issues and envisioning potential solutions related to the energy sector of each community. This could potentially be the result of the projects not being considered a priority once the funding source was removed, or because the plans are a relatively new concept and formal mechanisms for adoption are not yet in place.

In contrast to the hazard mitigation planning process, the role of solar energy in energy assurance planning appears well-known and understood by practitioners in the interview sample. The idea that solar energy can offset demand on the grid was mentioned several times as its greatest asset to energy assurance. Likewise, the use of solar energy as a backup supply source for critical facilities was also mentioned often. This mimics the survey findings. However, the interviewees stated that the planning processes did not explicitly note advantages of solar energy over any other energy source, but rather mentioned it as one factor in diversifying the large energy portfolio. Collaboration between hazard mitigation and energy assurance plan development was only noted in one community. The majority of the planning efforts focused solely on energy distribution issues and had no overlap with other plans.

Barriers to using solar energy in assurance planning, as noted by the interviewees, included regulatory issues that may prevent off-grid capability, and the perceived high cost of battery storage necessary to maximize the utility of solar energy systems. Regulations such as "Rule 21" in California can prevent solar customers from adding storage capacity to their systems for worker safety and grid reliability concerns (Cpuc.ca.gov, 2014; Humes, 2014). The State of California Public Utilities Commission is currently considering amendments to the rule; similar regulations exist in other states.

The DOE energy assurance grant program did not result in any adopted plans in the sample communities. This is likely because, according to the interviewees, funding was not available to complete the entire process. Instead, the consultants worked with the communities to develop the initial stages of the plans, such as identifying critical facilities, with the hope that the cities could complete the planning process when further time and funding became available. Future research may yield more results related to plan progress.

Key stakeholders

As stated earlier, attempts to reach FEMA representatives for an interview were unsuccessful. Based upon available materials online, the organization does not explicitly promote solar or any renewable energy usage in its formal HMP guidance (2013a, 2013b, 2013c, 2011, 2003).

Staff from Public Technologies Institute (PTI) and California Energy Commission (CEC) reiterated many of the findings from the interviews with city staff. Staff at PTI stated

a hope that the EAP grant process will help keep energy concerns in the minds of officials rather than having it come to the forefront only in time of dire circumstances. It was noted that many local government planners in the US understand how important energy issues are for their communities and that the connection between these planning officials and those in emergency management or similar departments is a crucial issue that needs to be addressed through the EAP process. Therefore, integration with the HMP processes is very important; as such, FEMA was identified as a key player in the process but did not participate in the program.

PTI staff cited critical facilities as an integral part of energy assurance planning. An issue identified was reaching an agreement on the prioritization of facilities in each community, which has proven to be difficult throughout the process. For example, one city in the grant process had over 900 critical facilities identified. Assessing the needs of each facility in time of emergency was also cited as a difficult but necessary because solar energy systems must be the appropriate size to contribute to the redundancy of facilities. Solar energy can play an important role in adding redundancy to critical facilities but barriers were cited, such as financing and storage technology/capability.

According to staff at CEC, the process for the California cities emphasized working directly with local governments to mainstream the process and "change the culture," rather than allow consultants to do the majority of the work and leave with the knowledge gained via the EAP process. The CEC lead the effort and developed a methodology for energy assurance planning that blends traditional planning principles with emergency response practices.

The use of solar is viewed as an important part of the EAP process, but faces barriers. A major benefit is that it offers communities additional energy choices, thereby reducing dependency on one source or another. It was noted that dependence on liquid fuels in particular is dangerous because they can often be scarce or unavailable in the event of a disaster or other event causing a power outage. Solar energy systems with off-grid capability were also noted as a nascent method of increasing resilience, but facing regulatory and technological barriers. Legislative amendments and more advanced inverter technology are expected to resolve some of the existing barriers. A further benefit of solar energy cited was its ability to be complementary with other sources such as liquid fuel generators. Staff noted the importance of solar energy contribution to sustainability—its clean and renewable nature—and therefore resilience. A general barrier cited was the fact that energy portfolios are slow to evolve and require significant time and capital resources.

Future research related to the results from the different approaches taken in the grant funding rounds is needed to determine whether or not the idea of energy assurance has been "mainstreamed" and if either grant program is replicable for additional communities.

4.3 LITERATURE REVIEW

The literature review included over 150 sources, ranging from current websites to scholarly journals. The examination of case studies and planning documents in particular revealed several examples of how solar energy use has already proven to improve

resiliency efforts at the local government level. Notable projects are outlined in more detail in Chapter Two. Common characteristics emerged and are as follows:

Mitigation

Examples of solar energy usage in mitigation activity point to its ability to lower emissions overall, and thereby reduce grid stress and outages. The only example is from the City of Baltimore (2013) and the results, therefore, are anecdotal.

Preparedness

Examples showed that solar energy used as a preparedness measure can be beneficial to resilience efforts overall by incorporating the usage of battery backup storage which can reduce outages in important municipal and private infrastructure. Additionally, the usage of solar energy to power microgrids has proven to increase the resilience of both universities and correctional facilities in times of grid outage. Overall, the role of preparedness is closely linked to that of mitigation—in a sense, preparedness is the planning stage of increasing mitigation.

Response

Overwhelmingly, hurricane response has proven to be the most prominent use for solar energy in response applications. From Texas (Lee, 2013) to New York (Marano, 2013), solar energy has been used for water purification, personal communication and general provisions in the aftermath of events such as Katrina and Sandy. The role of solar energy in response efforts is less important for its contribution to total energy demand and more important for the services that it enables.

Recovery

While not many examples were identified in the literature, solar energy in recovery efforts can be used to "start over" with cleaner energy options. In North Dakota, solar energy was used in lieu of traditional grid power after a storm caused outages (Ayhow, 2013); in Greensburg, Kansas, a devastating tornado came with a silver lining: the community went from having no solar capacity to having a comprehensive renewable energy plan developed by NREL which facilitated the development of a 4.6 kW solar electric system on the County Commons building (Billman, 2009).

5 CONCLUSION

This project sought to determine the extent to which the use of various solar energy technologies can improve contemporary resilience efforts at the local government level. Three methods were utilized: a survey of hazard mitigation planners, interviews with energy assurance planners and key stakeholders, and an extensive literature review. In the project context, resilience efforts are defined as attempts to adapt to ever-changing conditions by mitigating, preparing for, responding to and recovering from disruptive events. These attempts often come by way of formal planning, policy and regulation.

5.1 OVERVIEW OF FINDINGS

Survey

The survey was used to identify the ways in which solar energy is being utilized in hazard mitigation planning and uncover the reasons why it is not. It also included questions about general barriers faced and issues with the HMP process in general. Responses showed that 85 percent of hazard mitigation plans in responding communities do not explicitly include the use of solar energy applications in the planning or implementation phase. Conversely, nearly two-thirds of respondents stated a belief that using solar energy could improve the resilience of the community. Additionally, the survey found that about 60 percent of the sample communities have solar electric systems installed on municipal facilities, but do not explicitly utilize the systems in a mitigation capacity. Considering that respondents in general state a belief that solar energy can improve resilience, yet do not include it as a measure in formal plans, it is assumed that specific barriers exist that prevent the incorporation of solar energy into resilience planning

efforts. Further, considering that some respondents both believe using solar energy can improve resilience and currently have solar installations on municipal facilities, but still do not use solar energy as a strategy in their community HMP, it is assumed that there is a disconnect between the attitudes expressed by the survey respondents and the subsequent actions taken by the respective communities. This is likely explained by the fact that the HMP process involves many actors, one official's stated belief about solar energy cannot be extrapolated to the entire planning team.

The findings indicate that among those respondents who do believe that the use of solar energy can improve the hazard mitigation planning process in sample communities, there are two primary reasons: (1) by reducing the need for fossil fuels, thereby reducing stress on the grid, the potential for power outages at times of peak demand, and GHG emissions overall; and (2) by adding redundancy to critical facilities, thereby mitigating the impacts associated with outages that impede vital community functions.

Interviews

The interview process provided insights into the energy assurance planning process generally, and the role of solar energy therein. Discussions with local government officials responsible for working on energy assurance initiatives revealed that solar energy is seen primarily as a complement to other sources and can serve two distinct functions: assuring the continuity of critical facilities in grid outage events, and diversifying overall energy sources in a community to ease grid stress. The DOE grant program for energy assurance did not result in formally adopted plans in the interview communities, and the idea of energy assurance is still relatively novel among local governments in the US.

The findings from the interview process closely mirror those from the survey, and indicate a belief by respondents that the use of solar energy can improve energy assurance planning in sample communities by (1) reducing the need for fossil fuels, thereby reducing stress on the grid, the potential for power outages at times of peak demand, and GHG emissions overall; (2) by adding redundancy to critical facilities, thereby mitigating the impacts associated with outages that impede vital community functions; and (3) by incorporating backup systems in tandem with solar electric systems to allow off-grid use, thereby allowing for continuous operation despite grid outages.

The findings from the survey of HMP officials and interviews with EAP officials reveal an overlap for the use of solar energy in both planning processes; the difference is that formal HMP policy from FEMA does not mention solar energy at all, whereas formal EAP policy from CEC and PTI specifically discusses the integration of solar energy—and other renewables—into the planning process. This is likely because solar energy usage is well-known to have a role in diversifying the energy portfolio but not in increasing resiliency in the emergency planning/management field. As was stated by a PTI staff member, cooperation between all fields involved is necessary to achieve maximum utility from solar energy capacity.

Literature Review

The literature review was undertaken to achieve an in-depth understanding of both solar energy and resilience in general. The review revealed two major findings which influenced the content of the final guidebook:

1. Despite persisting myths such as solar is cost-prohibitive and that most of the US does not receive enough sunlight to have a significant amount of solar energy capacity, an argument emerged for solar energy rather than traditional energy sources typically used in resilience efforts. The tenets of the argument are summarized as: clean, cheap, abundant, domestic ("ours"), safe, versatile and reliable. The argument is outlined in depth in Chapter Four of the guidebook (Appendix C).
2. Several successful examples of current and previous uses of solar energy technologies in local government resilience efforts already exist, though without much publicity. The examples, and information about the underlying financing, are incorporated in Chapter Six of the guidebook in Appendix C; many examples are also provided in Chapter Two of this report.

5.2 FURTHER RESEARCH

All of the above findings have implications for future research. The lack of existing information on the topic combined with the wealth of information uncovered in this research implies a need for further study. This research was limited in its reach, in terms of survey and interview respondents, and can be best used as a base for further research that seeks to elicit information about the barriers that exist in integrating resilience planning and solar energy. A more thorough review of hazard mitigation plans in the US, as well as the inclusion of climate action and sustainability plans, could enhance the study as well.

With more time and resources, email addresses for the rest of the sample could be identified and the survey could potentially receive sufficient responses to be statistically significant and thus extrapolated to all ICLEI RC4A communities. The survey findings related particularly to why solar energy is not utilized in HMP would also be better understood with more data. Interviews would also be more productive if energy assurance plans were mainstreamed and adopted. Upon the completion of a large sample of energy assurance plans, analysis could be done to see what specific role solar energy has in the plans. It would also be valuable to follow-up in the California communities in particular to determine if the CEC's goal of mainstreaming energy assurance awareness has been achieved,

5.3 POLICY IMPLICATIONS

The findings have specific policy implications. The promising nature of solar energy's usage in hazard mitigation planning and the lack of its consideration in formal guidance reveals a potential for changes in federal-level policy (i.e. the Stafford Act) to promote a more holistic approach to hazard mitigation. At the least, this research provides merit for future study by FEMA of how solar can improve resilience guidance in the US. Other types of plans could also be required to evaluate the role that solar energy could play in the process. These include Comprehensive or General Plans required for jurisdictions in certain states, as well as voluntary Climate Action or Sustainability plans.

Legislative and regulatory changes related to solar energy in general are currently pending in many states. Specific issues regarding net-metering arrangements and solar storage system interconnection are of particular importance to the future of solar energy in the resilience context.

The interviews revealed an additional finding that has implications on resilience planning, though not necessarily solar energy specifically: staff at PTI stated that the definition of "critical facilities" is somewhat fluid and not widely agreed upon, which illustrates a demand for a codified and universal definition that would facilitate the energy assurance planning process overall.

The guidebook in Appendix C provides specific recommendations for policy and legislation action by local governments. The recommendations are organized by the four phases of resilience planning—mitigation, preparedness, response and recovery—though there is considerable overlap therein. Briefly summarized, the recommendations are as follows:

Mitigation

The research shows that solar energy can be integrated with hazard mitigation strategies in order to implement plan goals. The City of Baltimore has already done so, and cities across the country could benefit from a more comprehensive hazard planning approach that considers climate change projections as well as solar energy. Examples from the literature show that incorporating solar-powered infrastructure on evacuation

routes and critical facilities can help prevent loss of life and property, which are tenets of hazard mitigation planning.

Preparedness

Solar energy has its greatest benefit to resilience in the preparedness phase. The research suggests that incorporating solar energy into all aspects of formal planning is the most effective way to ensuring a solar-friendly policy and regulatory environment in communities. Energy assurance and comprehensive plans are the ideal medium for such integration.

Response

Solar energy has a proven record of improving response actions after major storm events, especially hurricanes. Local governments are encouraged to improve their resilience to such events but obtaining mobile solar units such as the SPACE units in Houston (see Chapter 2.4 for more information on the project). Other solar powered devices can help as well.

Recovery

The role for solar energy in recovery efforts is best exemplified by Greensburg, Kansas. After a tornado devastated most of the small, rural town, the city leadership (with support from NREL) decided to rebuild in a more energy-conscious way. Before the tornado in 2008, the town had no solar energy capacity; after the tornado, the city has a comprehensive plan in place to remove barriers and set facilitate solar growth. The new

County Commons building in Greensburg has a 4.6 kW solar electric system (Billman, 2009).

5.4 CLOSING

While solar energy presents a novel and exciting resilience opportunity, it alone is insufficient to address global climate change and foster resilience in communities across the US. However, this research suggests that solar energy can have a role in improving resilience at the local government level in a variety of ways, in all phases of resilience as defined in this research. Given that a unanimous scientific consensus suggests that weather will become more severe, and extreme events will become more frequent, any means of improving current resilience practices is beneficial to both the field and society at large. Energy specifically is expected to become increasingly vulnerable due to global climate change, evidenced in the most recent National Climate Assessment (Melillo, Richmond & Yohe, 2014) which states that "energy supply...will be increasingly compromised by interrelated climate change impacts."

Actions taken to increase resilience are inherently predicated upon assumptions of climate change, and any action taken against a force that is not certain comes with risks. Solutions such as increased solar energy capacity hedge against this risk because they come with "no regrets" and co-benefits and often contribute to existing community goals. Solar energy is emissions-free; it is becoming cheaper every year; it is the most abundant source of energy on Earth; it does not need to be imported from foreign lands; it is safe and has no danger of fallout events as seen in Chernobyl and Fukushima; and it can be used in open spaces and in the most densely populated urban centers in the world. The

most recent National Climate Assessment (Melillo, Richmond & Yohe, 2014) states that "the nation's economy, security and culture all depend on resilience." This report and accompanying guidebook demonstrate that the integration of solar energy and local government resilience planning can improve the resilience of the nation's communities.

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APPENDIX A - SURVEY INSTRUMENT

Solar Energy & Hazard Mitigation Planning

Edit this form

This survey is part of a research project being completed by Stephan Schmidt, a graduate student in the Department of City & Regional Planning at Cal Poly, San Luis Obispo, under the supervision of Dr. Michael Boswell. The purpose of the study is to identify the barriers to the integration of solar energy usage in formal resilience planning, i.e. hazard mitigation and energy assurance plans. As such, it asks questions about the hazard mitigation planning process in general, as well as how it related to solar energy as a strategy to reduce risk and vulnerability to natural and human-caused hazards.

Your responses will be provided anonymously to protect your privacy unless you so choose to provide your contact information, in which case your details will be visible solely to the principal researcher for the purpose of further communication in the future. Potential benefits associated with the study include contributing to a novel research topic which can help improve the resilience planning process at the local government level across the United States. There are no direct incentives provided for, nor any risks anticipated with, your participation.

If you have questions regarding this study or would like to be informed of the results when the study is completed, please feel free to contact Stephan Schmidt (614) 208-2477 or swschmid@calpoly.edu. If you have concerns regarding the manner in which the study is conducted, you may contact Dr. Steve Davis, Chair of the Cal Poly Human Subjects Committee, at (805) 756-2754, sdavis@calpoly.edu, or Dr. Dean Wendt, Interim Dean of Research, at (805) 756-1508, dwendt@calpoly.edu.

Thank you for your participation.

1. Please provide your job title, at the time of your role in the plan development.

2. Please state briefly your role in the development of your community's hazard mitigation or similar plan.

3. Please elaborate on how you think the hazard mitigation planning process could be improved, if at all.

Please provide an answer below.

4. In your opinion, do you face any of the following barriers to hazard mititgation planning in your community?

Please select all that apply.

- [ ] Political will
- [ ] Financial constraints
- [ ] Staffing capacity
- [ ] Other: ______

5. Does your community's most recently adopted hazard mitigation (or similar) plan include the use of solar energy as a strategy to reduce the risk of and vulnerability to natural and/or man-made disasters?

Please select the most appropriate answer.

- ○ Yes
- ○ No

6. If you answered Yes above, please elaborate on how it was incorporated into the plan.

Please provide an answer below, if applicable.

7. If solar energy was not included in the plan, was it considered as a potential strategy?

Please select the most appropriate answer.

- ○ Yes
- ○ No

8. If solar energy was considered, please explain why it was eventually not selected.

Please provide an answer below.

9. If solar energy was not considered, please elaborate on the rationale.

Please provide an answer below, if applicable.

10. Is solar energy being used or considered in the implementation phase of your community's hazard mitigation or similar plan?

Please select the most appropriate answer.

- ○ Yes
- ○ No
- ○ Not applicable

11. Which of the following hazards are you concerned about for your community?

Please select all that apply.

- ☐ Earthquakes
- ☐ Wildfires
- ☐ Extreme temperatures
- ☐ Flooding
- ☐ Drought
- ☐ Other: ______

12. Of the previously selected hazards, do you think that increased use of solar energy could potentially help mitigate the negative effects?

Please provide an answer below.

13. Do any of your jurisdiction's facilities have solar electric systems installed?

Please select the most appropriate answer.

- ○ Yes
- ○ No
- ○ Unsure

14. If you selected Yes above, please provide more information.

15. If the information is available, please provide an estimate of how much installed solar energy capacity these facilities currently have.

Provide an answer if possible.

16. Please provide any additional feedback you have related to the topics covered in the survey.

OPTIONAL: If you wish to be included in future research on this topic, please provide contact information below.

Submit

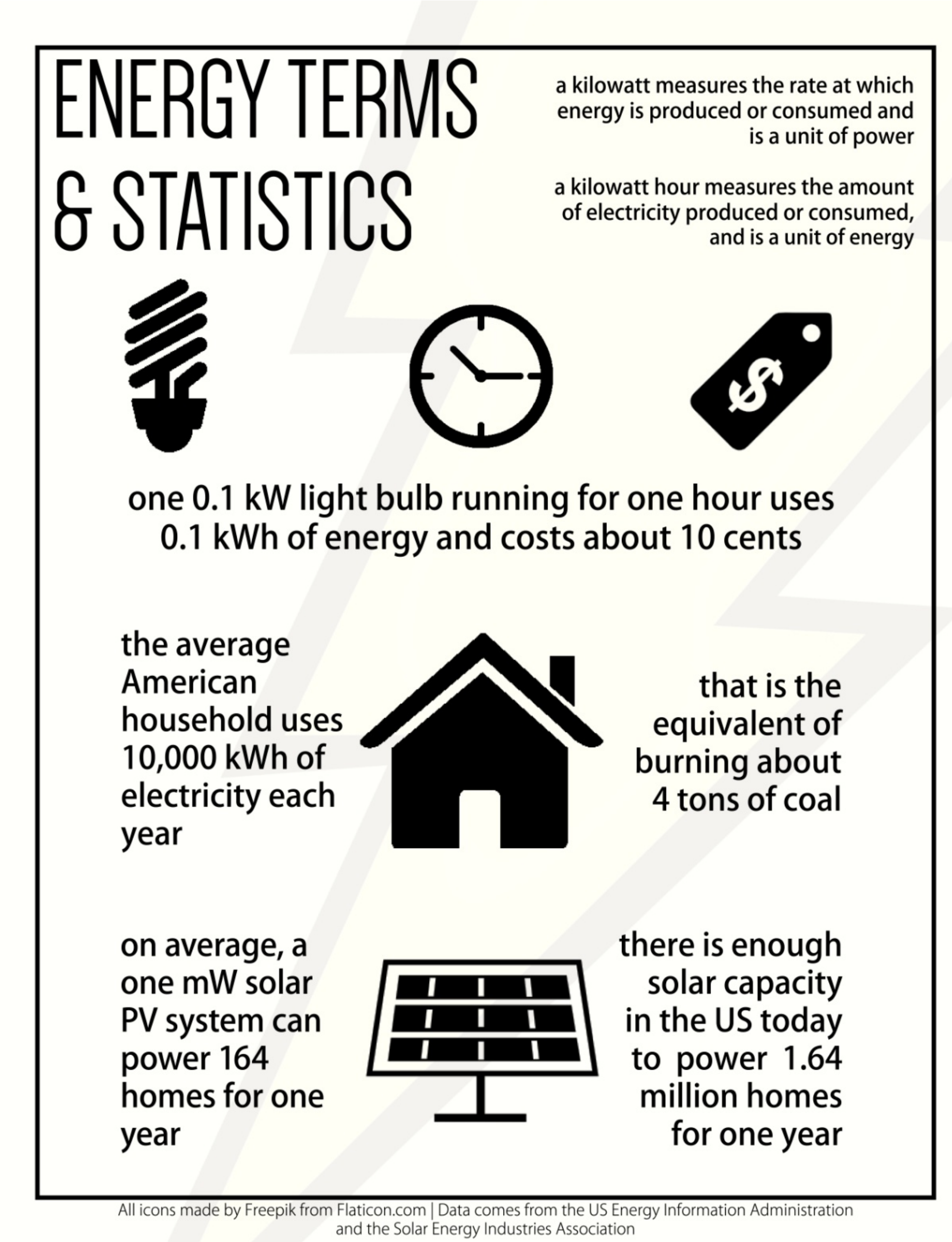
Never submit passwords through Google Forms.

APPENDIX B - ENERGY OVERVIEW

This document uses many terms to describe both energy and power that may not be commonly understood. This appendix defines some of the key terms as well as provides statistics to place the numbers used throughout the document in context.

A kilowatt (kW) / megawatt (mW) is the rate at which energy is produced or consumed; they are units of power. A kilowatt hour (kWh) / megawatt hour (mWh) is the amount of electricity produced or consumed, and is a unit of energy. It is calculated by multiplying kilowatts by hours-—for example, a 100 watt light bulb (0.1 kilowatts) uses 0.1 kilowatt hours of energy in one hour.

According to the US Energy Information Administration, the average American household uses about 10,000 kWh of energy annually, which amounts to about four tons of coal. The US is among the highest users in the world; Chinese households use about 1,349 kWh annually and the global average was 3,471 in 2010. The average cost per kWh across all sectors (residential, commercial, industrial, transportation) in the US as of February 2014 is $0.1035, up from $0.0979 in February 2013. Accounting for factors such as solar insolation and peak demand, an average 1 mW solar PV installation can power about 164 homes for an entire year. As of the end of 2013, there is enough solar energy capacity in the US to power over 1.6 million homes per year.


ENERGY TERMS & STATISTICS
a kilowatt measures the rate at which energy is produced or consumed and is a unit of power
a kilowatt hour measures the amount of electricity produced or consumed, and is a unit of energy
one 0.1 kW light bulb running for one hour uses 0.1 kWh of energy and costs about 10 cents
the average American household uses 10,000 kWh of electricity each year
that is the equivalent of burning about 4 tons of coal
on average, a one mW solar PV system can power 164 homes for one year
there is enough solar capacity in the US today to power 1.64 million homes for one year
All icons made by Freepik from Flaticon.com | Data comes from the US Energy Information Administration and the Solar Energy Industries Association

APPENDIX C - WORK PRODUCT

The following document is the work product for the client, titled *Integrating Solar Energy and Local Government Resilience Planning.*

SOLAR ENERGY & RESILIENCE PLANNING

a practical guide for local governments

CRP

ICLEI USA
LOCAL GOVERNMENTS FOR SUSTAINABILITY

CAL POLY
SAN LUIS OBISPO

RESILIENT COMMUNITIES FOR AMERICA

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ICLEI-USA

ICLEI-Local Governments for Sustainability is the leading network of local governments committed to sustainability, clean energy, and climate action, with more than 1,000 cities, towns, and counties around the globe. ICLEI provides leading resources and technical guidance to help local governments reach their goals, and connects leaders to share solutions and accelerate progress. Learn more at www.icleiusa.org.

RESILIENT COMMUNITIES FOR AMERICA

The Resilient Communities for America Agreement is a national campaign that is mobilizing hundreds of U.S. local elected officials—mayors, county executives, city council members, etc.—who pledge to create more resilient cities, towns, and counties, built to overcome our nation's extreme weather, energy, and economic challenges. The campaign is a partnership between ICLEI, WWF, National League of Cities, US Green Building Council, and other leading organizations.

CALIFORNIA POLYTECHNIC STATE UNIVERSITY

Founded in 1901, California Polytechnic State University comprises six distinct colleges and offers 147 Bachelor's degrees, 49 Master's degrees, and 7 teaching credentials. The university is one among a small group of polytechnic universities in the US which is primarily devoted to the instruction of technical arts and applied sciences. Cal Poly is known for its "learn by doing" educational philosophy that encourages students to solve real-world problems by combining classroom theory with experiential laboratory exercise.

CAL POLY DEPARTMENT OF CITY & REGIONAL PLANNING

City & Regional Planning at Cal Poly is an integral part of the nationally recognized College of Architecture and Environmental Design. The program began in 1968 and has nearly 1,000 graduates (Bachelors and Masters level). The program evolved in the College where the planning laboratory (studio) has been the core of the curriculum.

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Stephan Schmidt

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CONTENTS

LIST OF ACRONYMS

ARRA: American Recovery & Reinvestment Act

DOE: United States Department of Energy

EAP: energy assurance plan(ning)

FEMA: Federal Emergency Management Agency

HMP: hazard mitigation plan(ning)

kW(h): kilowatt (hour)

mW(h): megawatt (hour)

NREL: National Renewable Energy Laboratory

PTI: Public Technologies Institute

PV: Photovoltaic

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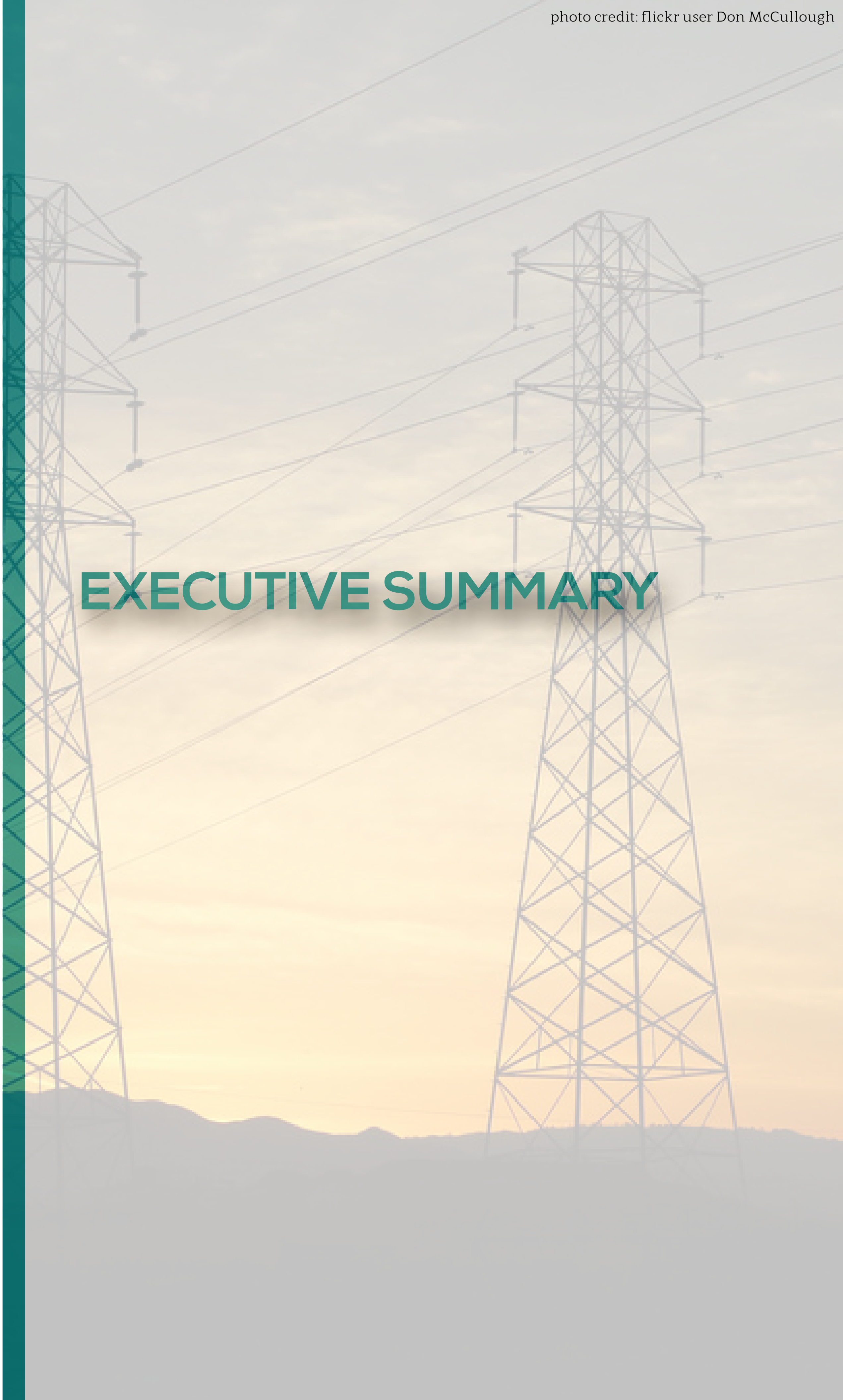
photo credit: flickr user Don McCullough



EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Solar Energy & Resilience Planning: A Practical Guide for Local Governments is a guide for local government officials in the United States who wish to expand and/or improve ongoing efforts to foster resilience in their communities by incorporating the use of solar energy in various contexts. This document is the result of a research project in the Department of City & Regional Planning at California Polytechnic State University, San Luis Obispo, and is a reaction to the growing need to both mitigate and adapt to the impacts on natural and human systems caused by global climate change.

This guidebook is organized into seven chapters that together provide a comprehensive overview of resilience, solar energy and the current and potential integration of the two by local governments across America. It begins with an introduction to the underlying problem of global climate change and calls on local governments to act accordingly.

Chapter One, "Defining Resilience," introduces the idea of resilience as a way for local governments to combat climate change. The chapter defines the term in its various contexts and outlines how it is used specifically in the guidebook.

Chapter Two, "The Current State of Resilience Planning," provides a brief overview of contemporary efforts in the US to foster resilience, which are divided into four phases that are discussed throughout the remainder of the document: mitigation, preparedness, response and recovery. These phases are adapted from the National Renewable Energy Laboratory and Federal Emergency Management Agency and are meant to represent a continuum rather than rigidly-defined categories.

Chapter Three, "The Current State of Solar Energy," describes some of the most common technologies used to harness the power of the sun, and examines the potential future of solar

energy in the US with specific information regarding emerging technologies and pending legal and regulatory issues.

Chapter Four, "Solar & Resilience," introduces the concept of utilizing solar energy in ongoing resilience efforts and is the focal point of the guidebook. The chapter outlines the advantages of solar energy over traditional energy sources used in resilience planning and includes examples of past and present projects that integrate resilience planning and solar energy in communities across the US.

Chapter Five, "Recommendations for Local Government Action," provides recommendations for local governments wishing to utilize solar energy in resilience planning efforts and is based upon leading-edge examples found in an extensive literature review. The recommendations are organized by the four aforementioned phases, though there is considerable overlap therein.

Chapter Six, "Project Financing," addresses potential financing mechanisms for solar energy projects. It provides detailed information about how specific projects were funded in US cities and counties, to serve as inspiration and information for local government officials.

Chapter Seven, "Conclusion and Additional Resources," provides lessons learned from the research, as `well as additional resources for local government officials seeking more information on the topic.

A BRIEF PRIMER ON ENERGY & POWER

This document uses many terms to describe both energy and power that may not be commonly understood. This section defines some of the key terms as well as provides statistics to place the numbers used throughout the document in context.

Key Terms

A kilowatt (kW) / megawatt (mW) is the rate at which energy is produced or consumed; they are units of power.

A kilowatt hour (kWh) / megawatt hour (mWh) is the amount of electricity produced or consumed, and is a unit of energy. It is calculated by multiplying kilowatts by hours—for example, a 100 watt light bulb (0.1 kilowatts) uses 0.1 kilowatt hours of energy in one hour.

Statistics

According to the US Energy Information Administration, the average American household uses about 10,000 kWh of energy annually, which amounts to about four tons of coal.[1] The US is among the highest users in the world; Chinese households use about 1,349 kWh annually and the global average was 3,471 kWh in 2010.[2]

The average cost per kWh across all sectors (residential, commercial, industrial, transportation) in the US as of February 2014 is $0.1035, up from $0.0979 in February 2013.[3]

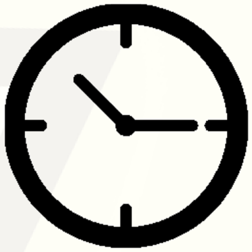
Accounting for factors such as solar insolation and peak demand, an average 1 mW solar PV installation can power about 164 homes for an entire year.[4] As of the end of 2013, there is enough solar energy capacity in the US to power over 1.6 million homes per year.

1 Kenword, 2011
2 Shrink that Footprint website
3 eia.gov, 2014b
4 seia.org, n.d.,b

ENERGY TERMS & STATISTICS

a kilowatt measures the rate at which energy is produced or consumed and is a unit of power

a kilowatt hour measures the amount of electricity produced or consumed, and is a unit of energy



one 0.1 kW light bulb running for one hour uses 0.1 kWh of energy and costs about 10 cents

the average American household uses 10,000 kWh of electricity each year

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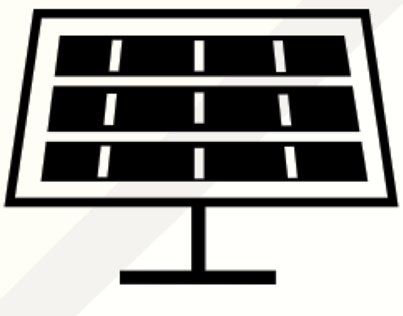

there is enough solar capacity in the US today to power 1.64 million homes for one year

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photo credit: flickr user Alex Lang

INTRODUCTION

INTRODUCTION

In November 2013, President Barack Obama put forth an executive order calling for action "to deal with the impacts of climate change and [direct] federal agencies to revise programs and policies that might serve as barriers to climate adaptation."[1] The order included a directive to establish the Task Force on Climate Preparedness and Resilience comprising state, local and tribal leaders from across the country to advise the President on matters regarding climate change preparedness, adaptation and resilience. This order follows the Administration's development of the Presidential Climate Action Plan in June 2013 aimed at reducing American greenhouse gas emissions, and predicated upon a "moral obligation to future generations to leave...a planet that is not polluted and damaged."[2] It also follows the United States Department of Defense's Climate Change Adaptation Roadmap which states that the department "will need to adjust to the impacts of climate change on its facilities, infrastructure, training and testing activities."[3] With these actions, the federal government of the United States of America has joined the ranks of governments and organizations around the world acknowledging global climate change as a preeminent challenge of the 21st century that necessitates immediate and swift action.

"We're going to need to get prepared [for climate change]...states and cities across the country are already taking it upon themselves to get ready. And we'll partner with communities seeking help to prepare for droughts and floods, reduce the risk of wildfires, protect the dunes and wetlands that pull double duty as green space and as natural storm barriers."
- President Barack Obama, 2013

The evidence backing these decisions is increasingly hard to deny. The Intergovernmental Panel on Climate Change (IPCC), a scientific body of the United Nations, stated that "scientific evidence for warming of the climate system is unequivocal"[4] and that "in recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans."[5] The IPCC also finds with "very high confidence" that recent extreme events "reveal significant

1 Sheppard, 2013
2 Executive Office of the President, 2013, p. 4
3 United States Department of Defense, 2012, p. 1
4 IPCC, 2007
5 IPCC, 2014

vulnerability and exposure of some ecosystems and many human systems" and that those in poverty face increased likelihood of negative outcomes from such events.[6] The United Nations' Global Report on Human Settlements considers climate change to be one of the most pressing issues facing humanity in the 21st century.[7] Further, the World Health Organization estimates that the annual costs globally from healthcare alone related to climate change will reach US$2-4 billion by 2030[8] and has therefore initiated the "first global project on public health adaptation to climate change."[9] Estimates from the Climate Vulnerable Forum show that five million deaths occur each year as a result of climate change impacts and that the figure will likely increase to six million a year by 2030 if current patterns continue.[10] Perhaps the most staggering statistics are the economic figures—in 2001 alone, approximately $36 billion in economic losses and $11.5 billion in insured losses resulted from global climate change.[11] As each subsequent year produces more severe weather events, this number will likely increase.

"We must do more to help communities across the country become more resilient to the effects of climate change."
-Obama Administration, 2014

In 'Causal Stories and the Formation of Policy Agendas,' Deborah Stone says that "difficult conditions become problems only when people come to see them as amenable to human action."[12] The human action necessary to combat the difficult condition that is climate change is increasingly considered to be resilience, which refers broadly to the ability of communities to cope with external disturbances that result from social, political and environmental change. Rather than considering the increase in global disaster events as natural acts that are not amenable to human intervention—and are forgotten once urgency has subsided and normalcy has returned—resilience

The human action necessary to combat the difficult condition that is climate change is increasingly considered to be resilience, which refers broadly to the ability of communities to cope with external disturbances that result from social, political and environmental change.

6 IPCC, 2014
7 United Nations-Habitat, 2011
8 Who.int, 2013a
9 Who.int, 2013b
10 Chestney, 2012
11 Godschalk, 2003
12 Stone, 1989, p. 281

aims to slow down and reverse the "tendency towards increasing risks" by combining mitigation and adaptation to combat global climate change[13] that results in the aforementioned losses. The most recent report from the IPCC states that in North America, governments are beginning to engage in such activities, primarily at the municipal level, and that "resilience... can accelerate successful climate change adaptation."[14]

THINK GLOBAL, ACT LOCAL

Although the majority of attention on climate change action has been focused on international-scale groups and agreements (e.g. IPCC, Kyoto Protocol), local government action is both necessary and ongoing. According to the United Nation's Office for Disaster Risk Reduction, climate change will have the greatest impacts at the local level.[15] This sobering fact has a silver lining—in the United States alone, there are nearly 90,000 units of local government that regularly create detailed plans such as hazard mitigation and climate action plans to identify and mitigate risks.[16] Local actions such as these offer a way to break down the increasingly "complex and fragmented" global agenda for how to approach climate change action into a manageable scope.[17]

Local action has been swift in comparison to larger-scale action, as well. Less than a year after the United Nations Framework Convention on Climate Change in Rio de Janeiro,[18] local governments sprung to action with the Cities for Climate Protection campaign. In contrast, the United Nations' reaction, the Kyoto Protocol, came 13 years later and has not resulted in any significant changes to unified, global action. It was also never adopted by the United States.

13 Ihdp.unu.edu, 2013
14 IPCC, 2014
15 UNISDR, 2013
16 FEMA, 2013a
17 Otto-Zimmermann, 2011
18 1992

Local governments are both well-equipped and responsible for tackling challenges related to climate change. Abraham Lincoln once said that the legitimate goal of government is to do for people what they need to have done, but cannot do, for themselves as individuals. Through comprehensive planning, policy-making and the ability to regulate and incentivize, local governments can prepare communities for climate change and other issues that individuals cannot address alone.[19] Local governments have been called the "Silicon Valley garages"[20] that lead to innovations in climate policy because they are the scale at which risks can be taken and solutions can be promulgated once novel practices are honed. Property Assessed Clean Energy (PACE), a mechanism by which local governments facilitate the installation of solar PV systems by allowing them to be paid for over time via property taxes, began in Berkeley, California, and has seen widespread adoption across the country. Innovations like this are at the core of local government climate action and are necessary functions to increase resilience.

19 Icleiusa.org, 2014
20 Fischer, 2014

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photo credit: greenlivingideas.com

DEFINING RESILIENCE

DEFINING RESILIENCE

OVERVIEW OF THE LITERATURE

The term resilience in common parlance refers generally to the ability to recover from or adjust to a hardship. By some accounts, usage of the term dates as far back as Roman orator and philosopher Cicero's use of risilire—Latin for 'to rebound'—and spans through Ovid and Pliny the Elder to Thomas Blount who first defined the term in "Glossographia, or A Dictionary of the Hard Words of Whatsoever Language" in 1661.[1] Adger and Holling were among the first scholars in the environmental realm to define the term, with the latter referring to it as "the ability of systems to absorb changes and still persist."[2] In the last few decades the term has evolved to account for human-environment relations and can in that sense be defined as "the ability of groups or communities to cope with external stresses and disturbances as a result of...environmental change."[3]

New York City's Vision 2020 is a comprehensive plan for the city's waterfront. One of the goals is to "identify and pursue strategies to increase the city's resilience to climate change and sea level rise." An important aspect of the plan is the idea that resilience can create opportunities for New York City to become "more healthy, prosperous and livable." The plan won the 2012 Daniel Burnham Award, the highest honor from the American Planning Association for a comprehensive plan.

The literature about resiliency also implies that it can refer to improving the condition after recovery, meaning that a truly resilient organism may undergo changes and re-emerge in an improved state.[4] When viewed from this standpoint, resiliency simultaneously refers to solving problems and increasing opportunities. New York City's Vision 2020[5] for example, outlines plans to build more livable land area in the city's waterfront by ensuring that the development will be resilient to the effects of climate change. As the plan says, "building resilience can be an impetus for transforming...in ways that can make the city not only more climate-resilient, but also more healthy, prosperous, and livable." Likewise, the City Resilience Simulator, as part of the Coastal Cities at Risk study, is focusing on predicting the impacts of a hazard event and monitoring the performance of certain critical functions (e.g. emergency response, hospital access) to see how hazard events can cause short term impacts

1 Alexander, 2013
2 Holling, 1973
3 Ihdp.unu.edu, 2013
4 Rose, 2007; Handmer and Dovers, 1996
5 Department of City Planning, City of New York, 2011

but potentially result in improved long-term overall system performance.[6]

With increased and varied usage, however, resilience has become akin to such vacuous buzzwords as ‘sustainability’ and ‘vibrancy’ as evidenced by the fact that some scholarly work on the concept does not even bother to define it. For example, the Presidential Climate Action Plan, released by the White House in June 2013, uses the word 29 times and fails to even attempt to define it in any context. When definitions are provided, most are so broad as to render them meaningless.[7] In ‘Deconstructing Resilience: Lessons from Planning Practice,’ O’Hare and White[8] state that the prolificacy of the term is unmatched in terms of disregard for its definition and disagreement in policy and practice. They further say that planners and similar professionals have adopted the term to catalyze action against “almost any threat.” Echoing these thoughts is Jabareen,[9] who states in ‘Planning the Resilient City: Concepts and Strategies for Coping with Climate Change and Environmental Risk,’ that most studies on resilience use “general, vague, and confusing terminology” and fail approach the concept in a systematic way.

KEY ORGANIZATIONS

Resilience is not merely an abstract, academic concept. Several organizations have working definitions of the term which guide their practice. The United Nations Office of Disaster Risk Reduction (UNISDR)[10] is tasked with implementing the UN’s disaster reduction strategy and considers resilience to be “the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate to, and recover from the effects of a hazard in a timely and efficient manner.”

6 Peck, 2014
7 Rose, 2007
8 2013, p. 276
9 2012, p. 220
10 2011

According to the World Bank in its report 'Building Urban Resilience: Principles, Tools, and Practice,'[11] resilience refers to the capacity of a community to absorb and adapt to changes associated with various challenges to its stasis. A resilient community in this sense is one that can respond adequately to such changes—meaning it maintains essential functions.[12]

Released in May 2014, the National Climate Assessment integrates scientific information and consistent methods to inform the public and governmental decision-makers related to climate change in America. The NCA defines resilience as the "capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment."

Several branches of the United States government formally define the term as well. The Department of Defense[13] considers resilience to be "the ability to adapt to changing conditions and prepare for, withstand, and rapidly recover from disruption." The Federal Emergency Management Agency,[14] a major actor in resilience efforts in the US, defines resilience as a process that seeks to minimize risk to all hazards and strengthen the ability to withstand and recover from future disasters. The Department of Energy (DOE) defines it as the ability to recover quickly from damage to essential or external systems. They note that resiliency does not prevent damage but allows systems to continue operating despite damage and promotes a rapid return to normal operations. Ernest Moniz, US Secretary of Energy, says that the DOE is taking action by creating an integrated resilience program. The recent National Climate Assessment from the US Global Change Research Program [15] defines resilience as the "capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment." Compiling the words used in the definitions from the previous discussion shows how important ability, recover and challenge are to the prevailing concept of resilience overall, as defined by the previously-mentioned groups.

11 2013
12 Pasteur, 2011
13 2012
14 2013
15 Melillo, Richmond & Yohe, 2014

ICLEI-Local Governments for Sustainability, an international member organization focused on local environmental initiatives, states that "a resilient city is [defined by] low risk to natural and man-made disasters. It reduces its vulnerability by building on its capacity to respond to climate change challenges, disasters and economic shocks."[16] Their campaign, Resilient Communities for America, launched in June 2013 and considers resiliency to result in "...more prepared communities that can bounce back from extreme weather, energy, and economic challenges." These definitions point to disasters, energy, and economy being the focal point of their concept of resilience.

IN THIS GUIDEBOOK

In this guidebook, the term resilience refers broadly to the ability of a community to adapt to ever-changing conditions by preparing for, responding to and recovering from disruptive events. The primary components of resilience planning in the US are mitigation, preparedness, response and recovery. These four components are adapted from publications by the National Renewable Energy Laboratory[17] (NREL) and Federal Emergency Management Agency[18] (FEMA); the integration of solar energy planning into these efforts is the focus of this guidebook.

16 2013
17 2012
18 2013b

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photo credit: flickr user deylumes

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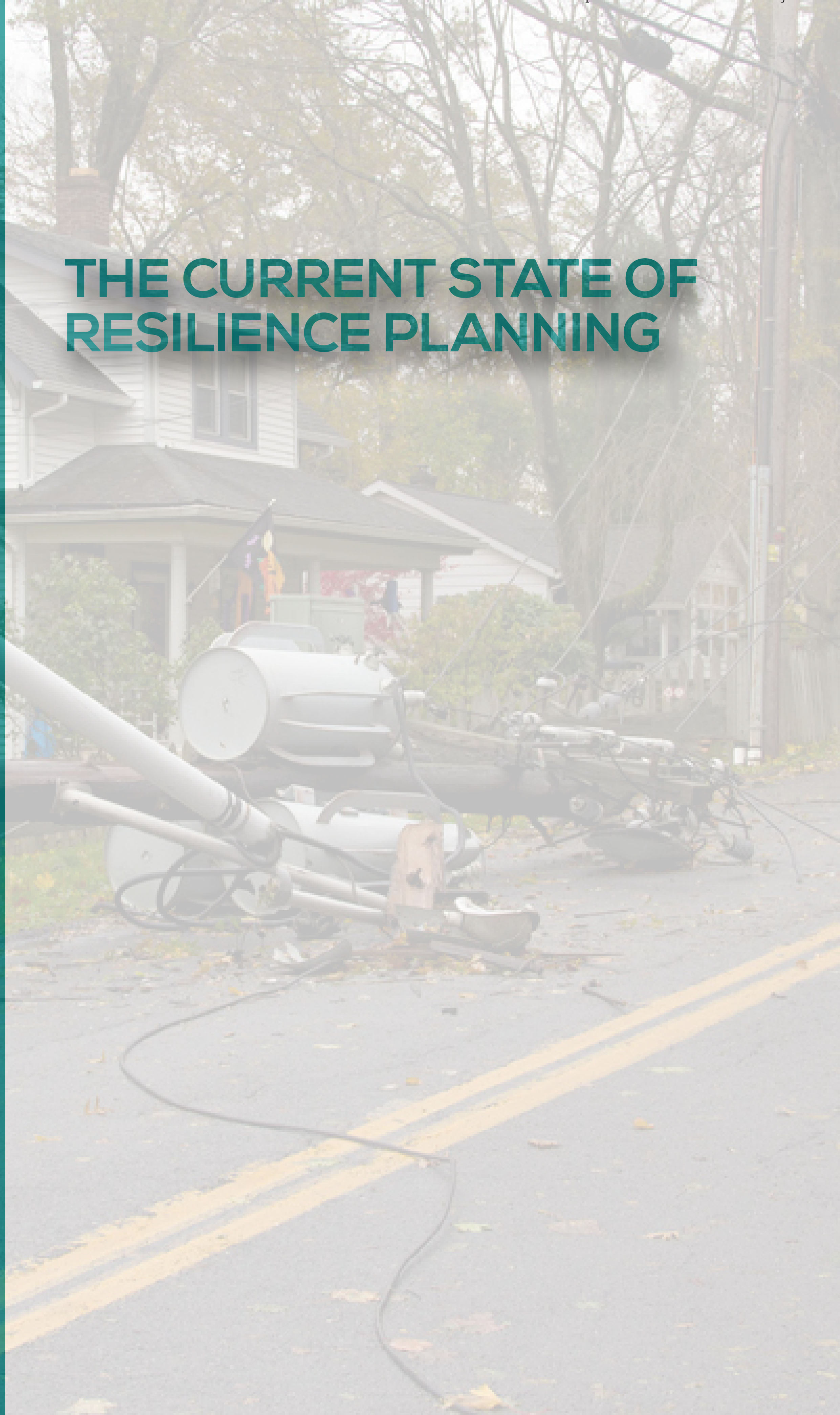
THE CURRENT STATE OF RESILIENCE PLANNING



THE CURRENT STATE OF RESILIENCE PLANNING

There are a variety of ways in which local governments are currently seeking to foster resilience in communities across the United States. Specific action plans such as Climate Action Plans and Sustainability Plans, and comprehensive plans, such as General Plans and Community Master Plans, all address resilience through mandatory and voluntary actions such as land use regulations and building standards. This section provides a brief overview of the current state of resilience planning in America in order to contrast it later with the recommendations for future actions [see Chapter Five].

A combination of the National Renewable Energy Laboratory[1] and Federal Emergency Management Agency[2] phases cited in emergency management and disaster resilience is used as a proxy for resilience in this report. The phases, mitigation, preparedness, response and recovery, are each discussed in terms of the contemporary efforts and organizations involved therein. The phases are used as an organizing principle and are therefore meant to represent a continuum rather than rigidly defined categories. [An overview of how solar energy is used in each phase is included in Chapter Four].

MITIGATION

Mitigation in general refers to efforts to lessen the impact from specific events.[3] It is used in this context as mitigation to climate change impacts. According to the IPCC,[4] it encompasses efforts to both reduce greenhouse gas emissions and increase processes that capture those gases from the atmosphere. While it is mostly connected to carbon dioxide emissions, other forms of particulate matter are of concern. For many decades, the focus of all climate change action has been on mitigation. Even as

1 2012
2 2013b
3 fema.gov, 2013c
4 2014

the focus shifts toward a more holistic approach that includes adaptation, mitigation remains important because adaptation efforts will be “more difficult, more costly, and less likely to succeed if significant mitigation actions are not taken” as a precursor.[5]

Hazard mitigation planning

With more than 14,000 plans in existence in the US, the most prominent example of mitigation planning in the country is the hazard mitigation plan.[6] The Federal Emergency Management Agency (FEMA) is the federal government’s official disaster reduction and preparedness arm. Its mission is “to support… citizens and first responders to ensure that as a nation we work together to build, sustain, and improve our capability to prepare for, protect against, respond to, recover from, and mitigate all hazards.”[7] According to FEMA (2013a), hazard mitigation is sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards. Hazard mitigation planning is therefore the “cornerstone of the approach taken by [the agency]… to reduce the nation’s vulnerability to disasters from natural hazards.”[8]

Under the provisions of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), FEMA provides the impetus for state, local and tribal governments to create local Hazard Mitigation Plans (HMP) in the US. An HMP must be submitted and approved by FEMA in order for a government to receive funding for hazard mitigation measures. The plans are required to outline processes for identifying natural hazards, risks, and vulnerabilities relevant to the jurisdiction.[9]

FEMA provides the following guidelines for developing a hazard mitigation plan:

1. Focus on the resources needed for a successful mitigation planning process; identify and organize interested members of the community as well as the technical expertise required during the planning process.

2. Identify the characteristics and potential consequences of hazards.

3. Determine priorities and look at possible ways to avoid or minimize the undesired effects.

4. Implement specific mitigation projects; conduct periodic evaluations and make revisions as needed.

Adapted from FEMA, 2013c

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5 Melillo, Richmond & Yohe, 2014
6 Berke, Lyles & Smith, 2012
7 2013b
8 Godschalk, 2003, p. 136
9 Robert T. Stafford Disaster Relief and Emergency Assistance Act, 2013

PREPAREDNESS

ICLEI considers preparedness as the process by which communities prepare for the impacts associated with a changing climate and more severe and extreme weather events.[10] Several ICLEI members are part of the recently formed Presidential Task Force on Climate Preparedness and Resilience which was borne out of an Executive Order in 2013 that called on the Federal government to "establish an integrated strategy towards sustainability...to make reduction of greenhouse gas emissions a priority for [all] Federal agencies."[11]

Preparedness in the resilience context usually comes from a variety of different formal planning processes. Plans such as New York City's PlaNYC: A Stronger, More Resilient New York[12] demonstrate the comprehensive approach to resilience planning by examining the City's buildings, green spaces, infrastructure and other components and identifying vulnerabilities therein. The plan resulted from the aftermath of Hurricane Sandy in 2012 and, as the name suggests, devises a way to prepare the City for the next major storm event.

Energy assurance planning

According to the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability[13], the goal of energy assurance planning is to "[improve] the ability of energy sector stakeholders to prevent, prepare for, and respond to threats, hazards, natural disasters, and other supply disruptions." The first large-scale Federal funding mechanism for energy assurance planning available to local governments came in 2010 via the American Recovery & Reinvestment Act, which allocated approximately $8 million to 43 cities across the US to prepare local energy

10 Icleiusa.org, 2014b
11 Fedcenter.gov, n.d.
12 2013
13 Energy.gov, 2013

assurance plans that aimed to "improve electricity reliability and energy security;"[14] in 2012, 50 California cities were funded by DOE for the same purpose. These grants came after a 2009 investment of $38 million by the DOE to states to prepare state-level energy assurance plans.[15]

On behalf of the Department of Energy, the Public Technology Institute (PTI) has developed various resources for local governments seeking to address energy assurance issues. In its Local Energy Assurance Guidelines, PTI[16] recommends that plans address all hazards that have potential to affect energy assurance in a locality, giving attention to unexpected events. PTI goes on to state that local energy assurance planning (LEAP) involves preparing for and responding effectively to energy emergencies and should include close collaboration with various partners including utility companies and state and federal-level offices. They also note that LEAP must complement pre-existing plans such as Emergency Response and Continuity of Operations Plans.

The Public Technology Institute notes that the long-term approach increases the resiliency of an energy supply by reducing vulnerability to disruptions associated with relying on one power source only.[17]

Public Technologies Institute guidelines offer a ten-step process for planners to create an EAP:

1. Build an Energy Assurance Response and Planning Team
2. Know the Emergency Authority Framework
3. Understand Response Roles and Responsibilities
4. Know the Local Government Energy Profile
5. Identify Energy Suppliers
6. Know the Primary Contacts and Related Partners
7. Identify Key Assets within the Jurisdiction
8. Develop an Energy Assurance Crisis Communications Protocol
9. Develop Additional Local, State, Regional and Federal Partnerships for Energy Assurance
10. Update the Plan on a Consistent Basis

from PTI, 2011b

14 Office of Electricity Delivery and Energy Reliability, n.d.
15 Public Technology Institute, 2011b
16 Ibid
17 Public Technology Institute, 2012a

RESPONSE

FEMA, in addition to being a leader in hazard mitigation, is also the country's greatest disaster response resource. The agency offers a variety of ways to help communities respond to emergency events such as the Community Emergency Response Team, which "educates people about disaster preparedness for hazards that may impact their area and trains them in basic disaster response skills, such as fire safety, light search and rescue, team organization, and disaster medical operations."[18] FEMA also promotes the continuity of operations planning, which seeks to ensure that all critical functions of a community are able to continue to be performed during emergencies caused by a number of different factors.[19]

RECOVERY

FEMA's National Disaster Recovery Framework outlines the formal process for disaster recovery in the US. It aims to "ensure coordination and recovery planning at all levels of government…and defines how [the agency] will work together, following a disaster, to best meet the needs of states, local and tribal governments and communities and individuals in their recoveries." There are six key functions that are set up to assist governments in the recovery process: Community Planning and Capacity Building; Economic; Health and Social Services; Housing; Infrastructure Systems; and Natural and Cultural Resources.[20]

18 fema.gov, n.d.
19 fema.gov, n.d.,b
20 fema.gov, n.d.,c

ISSUES

While FEMA plays the largest role in fostering resilience in American communities, their protocols and actions are not without criticism and controversy. Hurricane Katrina devastated parts of the southern United States and caused billions of dollars in damages, but also "laid bare huge gaps in the nation's ability to respond to disasters,"[21] evidenced by a response effort that left thousands without food and water for weeks. Beyond ineffective actions lie inept planning and policy. Several studies of local hazard mitigation planning, the foundation of FEMA's mitigation efforts at the local level, have found that plan quality overall is "moderate to weak overall" and have "considerable room for improvement."[22] The planning process suffers mostly from a lack of coordination with existing community planning initiatives, and poor implementation and monitoring processes.[23] A review of state-level plans by Columbia University produced similar results and noted that many weaknesses resulted from a lack of a comprehensive approach, exemplified by a failure to account for climate change predictions in nearly 80 percent of state plans.[24]

With over 14,000 local hazard mitigation plans in the US[25] it is important that such plans be an effective method for creating and increasing resilience in communities across the country. This document outlines the potential for solar energy to improve the HMP process and various other resilience-building mechanisms.

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21 usatoday.com, 2007
22 Berke, Lyles & Smith, 2012
23 Ibid
24 Babock, 2013
25 Berke, Lyles & Smith, 2012

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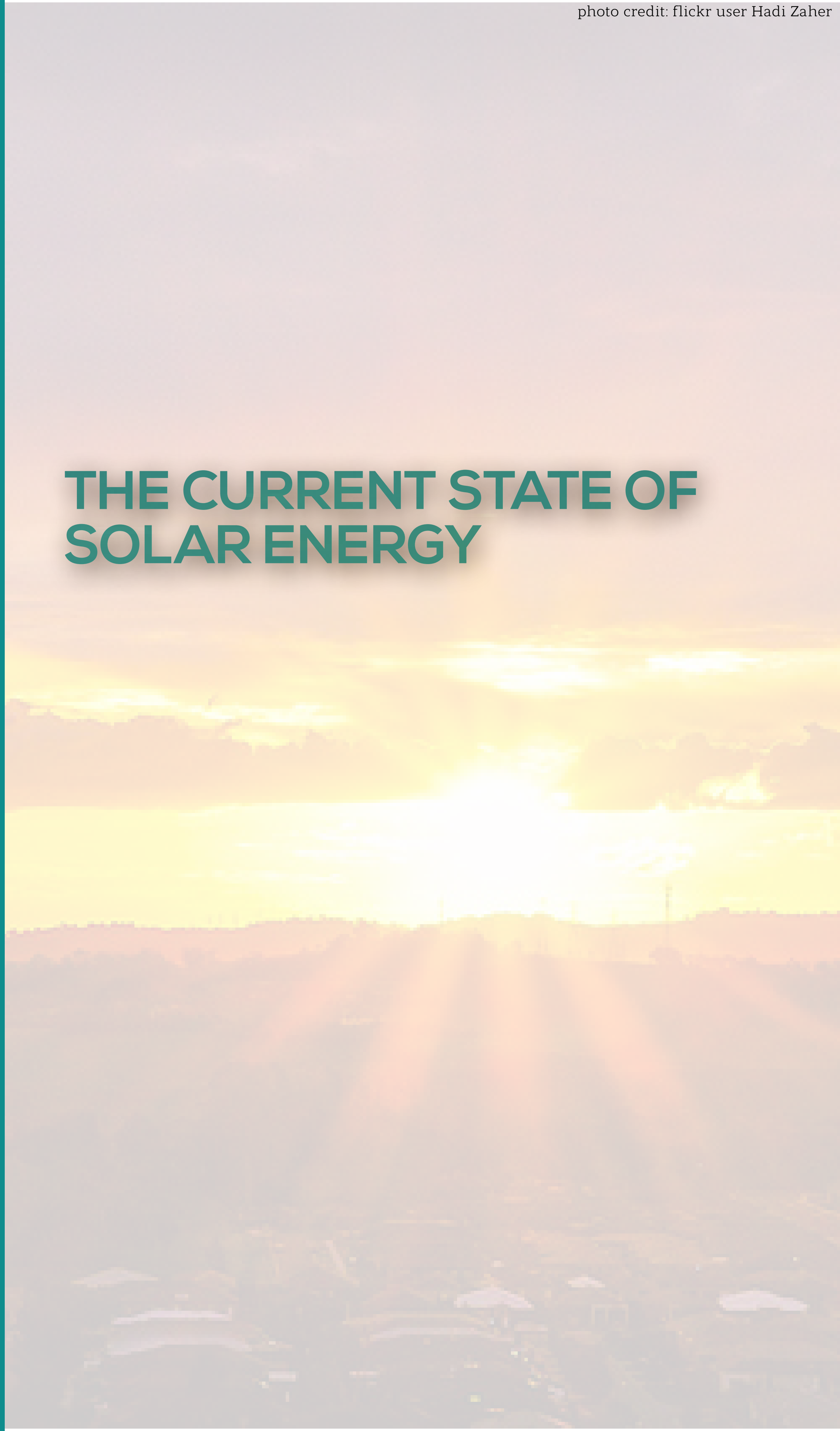
photo credit: flickr user Hadi Zaher



1 2 3 4 5 6 7

3 THE CURRENT STATE OF SOLAR ENERGY

THE CURRENT STATE OF SOLAR ENERGY

VARIOUS TECHNOLOGIES

Solar energy is growing rapidly in the American energy, in both popularity and total installed capacity. This chapter provides a brief overview of the current state of solar energy in the US by discussing different technologies and scales; and the outlook for the future, including emerging trends and legal/regulatory issues.

Solar Photovoltaic

The most common type of solar energy technology deployed in the United States is solar photovoltaic (PV).[1] First developed in 1954 by Bell Labs,[2] this technology uses semiconductors to produce electricity. This is achieved through the use of cells, which contain diodes made up of positively- and negatively-charged semiconductors that allow for electrons to flow and generate a current. When sunlight hits the positively-charged semiconductor of the diode, the force of the impact causes electrons to separate from their atoms and travel to the negatively charged part of the diode. The electrons cannot bond with the negatively charged portion and therefore are transferred to a metal conductor strip that channels them into an electrical current. Multiple cells are typically combined to form a panel, which can be joined to form an array.[3]

Photo courtesy of flickr user Pacific Southwest Region.

The Ivanpah Solar Electric Generating System is located in the Mojave Desert in southern California. Sitting on approximately 3,500 acres and generating nearly 400mW of power, it is the largest solar array in the world.[1]

1. BrightSource Energy | Ivanpah Project Factsheet

Concentrated Solar Power

Another way of harnessing solar energy is referred to as concentrated solar power (CSP). This technology works by using parabolic mirrors and/or lenses to focus reflected sunlight on a turbine that produces heat, which is in turn harnessed to drive a mechanical engine, which subsequently drives an electric generator. The mirrors or lenses track the sun throughout the day to maximize solar intake. CSP installations, in contrast to

1 Renewable Energy Policy Network for the 21st Century, 2013
2 Seia.org, 2013
3 Icleiusa.org, 2013

solar PV, are generally only done on a large scale, as to be cost-effective. They have an advantage over PV installations because the thermal energy collected can be stored for extended periods of time, allowing it to generate electricity when the sun is setting.[4]

Solar Thermal

Solar thermal systems harness thermal energy from the sun to heat water, which in turn can provide heating and cooling needs for residential, commercial, or industrial facilities. Solar thermal systems are often mounted on the roof of the facility and are one of the lowest-cost and most effective ways to capture solar energy.[5]

SCALE

Solar energy can be harnessed at various scales, from a single rooftop to the 400mW Ivanpah plant in the Mojave Desert. As such, solar energy systems can be the primary or accessory land use for a particular piece of land.[6] Large plants like Ivanpah are commonly referred to as "utility-scale," and can consist of various technologies (PV, CSP). Utility-scale solar is different from distributed generation, like that from rooftop PV, in project size and end use. Generation from utility-scale systems is wholesale and generally sold to electric utilities, whereas distributed generation can go directly to the end-user. Utility-scale solar plants can often provide fixed-priced electricity.[7]

4 Ibid
5 Icleiusa.org, 2013; Morley, Anthony et al, 2014
6 Morley, Anthony et al, 2014
7 Seia.org, n.d.

CURRENT STATUS

In mid-2013, the United States surpassed 10 gigawatts (gW) of capacity from solar PV installations, becoming the fourth nation in the world to reach such a level (after Germany, Italy, China). This figure is expected to reach 17gW by the end of 2014.[8] This continues the trend of tremendous growth; from 2011 to 2012, national capacity rose from 3.9gW to 7.2gW.[9] Solar thermal capacity is projected to reach about 1.3gW overall by 2014, boosted by large utility-scale projects in the western US.[10] Combined solar energy capacity in the US accounted for just 0.11 percent of total energy generation in 2011.[11]

Photovoltaic installations grew 41 percent between 2012 and 2013, making solar generation second only to natural gas in amount of new capacity added in that year (29 percent). In fact, more solar capacity has been added since the beginning of 2013 than in the previous 30 years combined in America. Overall, residential solar capacity grew 60 percent, utility 58 percent and non-residential only four percent. The price of installations across all sectors fell 15 percent between 2012 and 2013, reaching a low of $2.59/watt.[12]

Put in perspective, global PV capacity reached 100 GW in 2012, up from 71gW in 2011, with the US accounting for just over seven percent of that; the US now accounts for about 10 percent of global solar energy.[13]

Recent domestic growth in solar capacity is largely attributed to innovative state incentive programs,[14] increase in demand from consumers and price declines.[15] Research from Navigant[16]

8 Montgomery, 2013
9 Renewable Energy Policy Network for the 21st Century, 2013
10 Eia.gov, 2013a
11 Eia.gov, 2013b
12 Solar Energy Industries Association, 2014
13 Renewable Energy Policy Network for the 21st Century, 2013
14 Ibid
15 Montgomery, 2013
16 2013

states that solar PV could reach grid parity without subsidies by 2020.

OUTLOOK

Emerging technologies

The majority of electricity in the United States is generated in central coal or natural gas plants which then distribute the power across their respective region. The process can result in power loss through inefficient infrastructure. The antithesis to this system is known as distributed grid, which generates and uses power on-site or near the place of production, eliminating such losses and increasing efficiency. Distributed generation has an added advantage of off-grid capability, allowing for a contribution to energy assurance planning at the local level.[17] Numerous sources imply that distributed grid technology may be the future of the American electricity grid. The trade association Edison Electric Institute, in their January 2013 report Disruptive Challenges: Financial Implications and Strategic Responses to a Changing Retail Electric Business, states that falling prices of solar PV, among other things, is "expected to challenge and transform the electric utility industry"[18] and that distributed solar presents the "ultimate risk"[19] to traditional grid viability. The process has been likened[20] to the way in which mobile phones have surpassed home phone lines, an idea once thought unimaginable. Mark Coughlin of PricewaterhouseCoopers has said that in "the next five years, consumers will exert unprecedented control over energy supply, usage, service standards and costs."[21] David Crane of NRG Energy similarly sees distributed solar as the inevitable successor to the traditional, concentrated grid and research from the Bloomberg New Energy Finance group shows that distributed solar is expected to continue growth through 2020 resulting in 4.5 GW

17 PTI, 2011b
18 p. 1
19 p. 3
20 p.14
21 Parkinson, 2014b

of capacity in distributed rooftop PV.[22] Further, recent research from investment firm Morgan Stanley suggests that growth of the distributed grid could result in a “tipping point” that pushes utility consumers to shift en masse to off-grid solar power. They estimated that the US could reach 240gW of distributed solar installations by 2020.[23]

“Smart grid” technology is also expected to change the status quo in energy delivery infrastructure. The concept can be thought of as the internet for energy that intends to modernize the electricity delivery system by automatically optimizing it through intelligent computer systems. As envisioned thus far, the smart grid will allow greater integration of renewables and distributed generation energy resources. Future operators of the smart grid will have the ability to switch energy sources and reroute energy supply to meet demand in advance of an energy emergency instead of only after the emergency.[24]

Storage technology is integral to maximizing the utility of solar energy, as it allows systems to power facilities in times of little or no sunlight. In 2010, solar company SolarCity joined with Tesla Motors and the University of California, Berkeley, in a $1.7 million research and development effort related to energy storage, funded by the California Public Utilities Commission (CPUC). The goal of the R&D effort was to help advance battery storage technology for use in tandem with solar PV electric systems by working with Tesla’s existing car battery systems. According to the SolarCity’s website, “the battery storage will collect excess PV power production so that during peak periods, the utility can pull from battery storage rather than power plants which have greater emissions.”[25] According to an article from GreenTech Media in early 2014, the combination of

22 Kind, 2013
23 Parkinson, 2014a
24 PTI, 2011b
25 Solarcity.com, 2010

SolarCity and Tesla may be utilities' "worst nightmare" because the storage systems will challenge the very foundation of the electric utility business model. The CPUC has been hesitant to permit such systems for fear that they can "store grid electricity and feed it back [to the utility via net-metering] under the guise of green, solar-generated power," which Tesla CEO Elon Musk has called a "crazy" notion.[26] As of March 2014, SolarCity has sold and installed about 100 of the systems in California. After hearing that some customers have waited months to receive a decision on a connection application for the systems from the utilities in California, SolarCity CEO Lyndon Rive accused the utilities of trying to slow the process.[27] The situation is ongoing.

A necessary technology for the storage systems and solar electric systems to operate effectively is known as a "smart inverter." These advanced inverters help manage the increasing amount of intermittent generation from renewables rather than automatically shut down when intake changes suddenly, as is the norm now.[28] The "smart" comes from the inverters' ability to "send and receive messages quickly, as well as share granular data with the owner, utility and other stakeholders." This also helps technicians diagnose and monitor problems remotely, as well as install updates when needed. The smarter inverters may also alleviate some of the pending regulatory and legal issues related to distributed solar technology by allowing for greater grid stability.[29] Hawaii is already seeing an influx of the inverters and along with California is likely to be a testing center in the future.

Tesla Motors' GigaFactory, a $5 billion project in cooperation with Panasonic and other companies, is set to begin construction in the southwestern United States in mid-2014. The factory will build batteries for Tesla Motor's vehicles as well as for SolarCity's backup solar electric systems. Tesla hopes the increase in production scale will drive down the costs of batteries by at least 30 percent, which in turn to make solar backup systems more affordable in the consumer market. A rendering for the future site is included below.

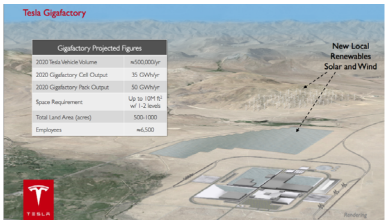


photo credit: cleantechnica.com

26 St. John, 2014
27 Baker, 2014
28 Barney, 2014
29 Beler, 2014

ARIZONA
is the first state to impose a net-metering fee on customers. Utility Arizona Public Services sought a $50 monthly average fee per net-metered customer; the state utility commission settled on $5.

CALIFORNIA
decided to continue its net metering program through at least 2016 after much deliberation in 2014.

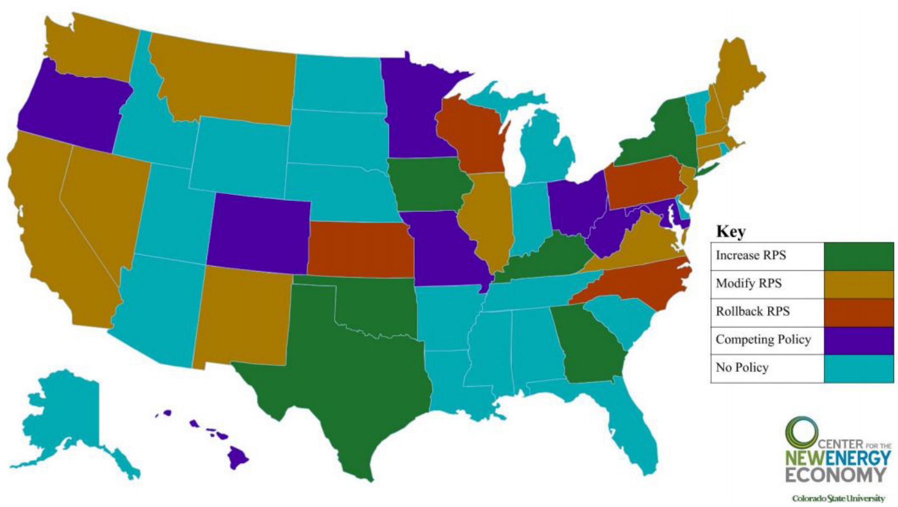
FLORIDA
has one of the nation's most generous net metering programs: Any customer using a renewable energy electric system up to 2 mW receives credit at the retail rate until their electric bill becomes zero.

MINNESOTA
regulators are considering various ways to replace net metering with a "value of solar tariff." Utilities in the state are currently opposing the recent decision to build a large distributed solar project, instead of gas-fueled power plants, to meet the state's future electricity needs.

All above information adapted from: Humes, E. (2014). Throwing Shade. Sierra, (99.3).

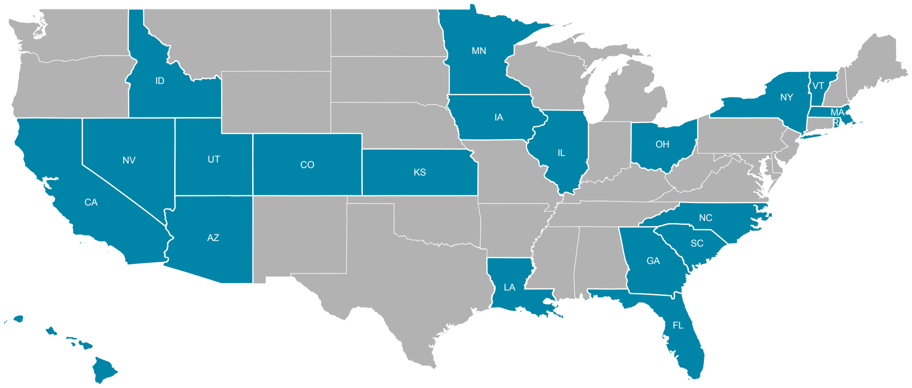
Regulatory and Legal Concerns

Regulation can be both an enabler and barrier to solar energy development. Since the 1980s in Iowa, states have enacted so-called Renewable Portfolio Standards (RPS) as a way of regulating mandates to increase in renewable energy capacity. As of 2013, 29 states have an RPS, and some have specific "solar carve outs" which specify how much of the renewable generation must come from solar installations.[30] These standards are legally binding once adopted, and therefore controversial. In recent years, many RPSs have come under legal attack because of potential violations to the Commerce Clause, by virtue of granting "clean" facilities special privileges.[31] In 2013, 26 bills were introduced around the country to repeal or roll back RPSs and none were successful; seven states increased their RPSs in the same year. The following map[32] shows an overview of RPS legislation by state in 2013.[33]



30 Griffin, 2014; nrdc.org, 2013
31 Griffin, 2014
32 Center for the New Energy Economy, 2013
33 Ibid

Net-metering, a popular mechanism for making solar more affordable by allowing utility customers with solar electric systems to sell back excess power at retail rates, is coming increasingly under attack. The May/June 2014 issue of Sierra magazine[34] outlines the various state-level battles over net metering rates and legal status across the country (there were 22 states at the time of the article). The main argument of utilities against paying retail rates for the excess energy they are required to buy back is that increased solar capacity is causing a "cost shift" and actually costing the utilities money because the solar customers are "free riding" and being subsidized by traditional grid customers that have to pay more to maintain and expand the grid. Utilities in some states (Utah, Arizona, among others) are currently trying to impose fees on solar customers to make up for lost revenue.[35] The rulings are pending for many of these cases and the future is unclear. This map illustrates the states currently considering changes to their net metering agreements.[36]



34 Humes, 2014
35 Ibid
36 As of May, 2014

Regulation from the Federal Energy Regulatory Commission (FERC) has played a part in facilitating increased amounts of storage systems tied to solar electric systems. FERC Order 792 was introduced in November 2013 to make solar electric systems with backup capacity eligible for interconnection with the grid.[37] Combined with FERC Order 784 from July 2013, these rulings have "open[ed] the floodgates for the increasing importance of energy storage as part of the electric grid."[38] Prior to these Orders, FERC and other regulators did not specify guidelines for energy storage, which had made the option a large risk for consumer, utilities and investors alike.[39]

Regulations acting as a potential barrier to solar energy development include those like Rule 21 in California, which can significantly add to the time and cost of incorporating storage in solar electric systems. (In California, the interconnection process for such systems can take up to eight months and add between $1,400 and $3,700 in extra fees.) These rules are predicated upon safety issues, as well as net-metering concerns. California utilities have cited a concern that customers with storage systems could store power from the grid and sell it back to the utility as if it were generated from their solar panels. To combat this, utilities in the state have until now been slow to connect such systems, and charged upwards of $1,000 for special meters to guard against unwanted uses; SolarCity CEO Peter Rives has said that such meters cost from $75-100.[40]

In May, 2014, driven largely by pushback from companies like Tesla and SolarCity, the California Public Utilities Commission amended the rule which makes it easier to add storage to grid-connected systems,[41] but similar rules exist in other states.

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37 Casey, 2014
38 Haleakalasolar.com, 2013
39 Ibid
40 Wesoff & St. John, 2014; Hales, 2014
41 Wesoff & St. John, 2014

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SOLAR & RESILIENCE

photo credit: author

SOLAR & RESILIENCE

Myths about solar energy persist and are an obstacle to solar development. Lack of understanding about the technology was cited as one of the top five obstacles preventing the installation of solar electric systems by the International City/County Management Association (ICMA) annual member survey.[1] This chapter aims to dispel these myths and provide accurate information about solar energy in order to facilitate its incorporation into resilience planning efforts. This chapter concludes with examples of past and current uses of solar energy as resilience measures, across the country.

Upon the boom in natural gas due to hydraulic fracturing in 2011, T. Boone Pickens said that the growth of that fuel source was good for America because it is "clean, cheap, abundant and ours."[2] But according to a detailed literature review, solar energy can be considered superior to natural gas and other energy sources in all of those terms, as well as in safety, versatility and reliability [in this context, solar energy is considered "reliable" insofar as it diversifies the overall energy portfolio and complements existing uses, rather than taken on its own].w

Clean

Substituting solar energy for traditional fuels such as diesel or gasoline (or at least supplementing their use with solar) can have many benefits. The first is that energy derived from the sun, rather than carbon-based matter, is clean and emission-free. While there are up-front emissions associated with creating the infrastructure and installing the technology (lifecycle emissions), the power generated from the sun does not create further greenhouse gas emissions. A study by the National Renewable Energy Laboratory[3] found that over the course of a lifetime, each kilowatt hour derived from a solar

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1 2012
2 Hamilton, 2011
3 2012b

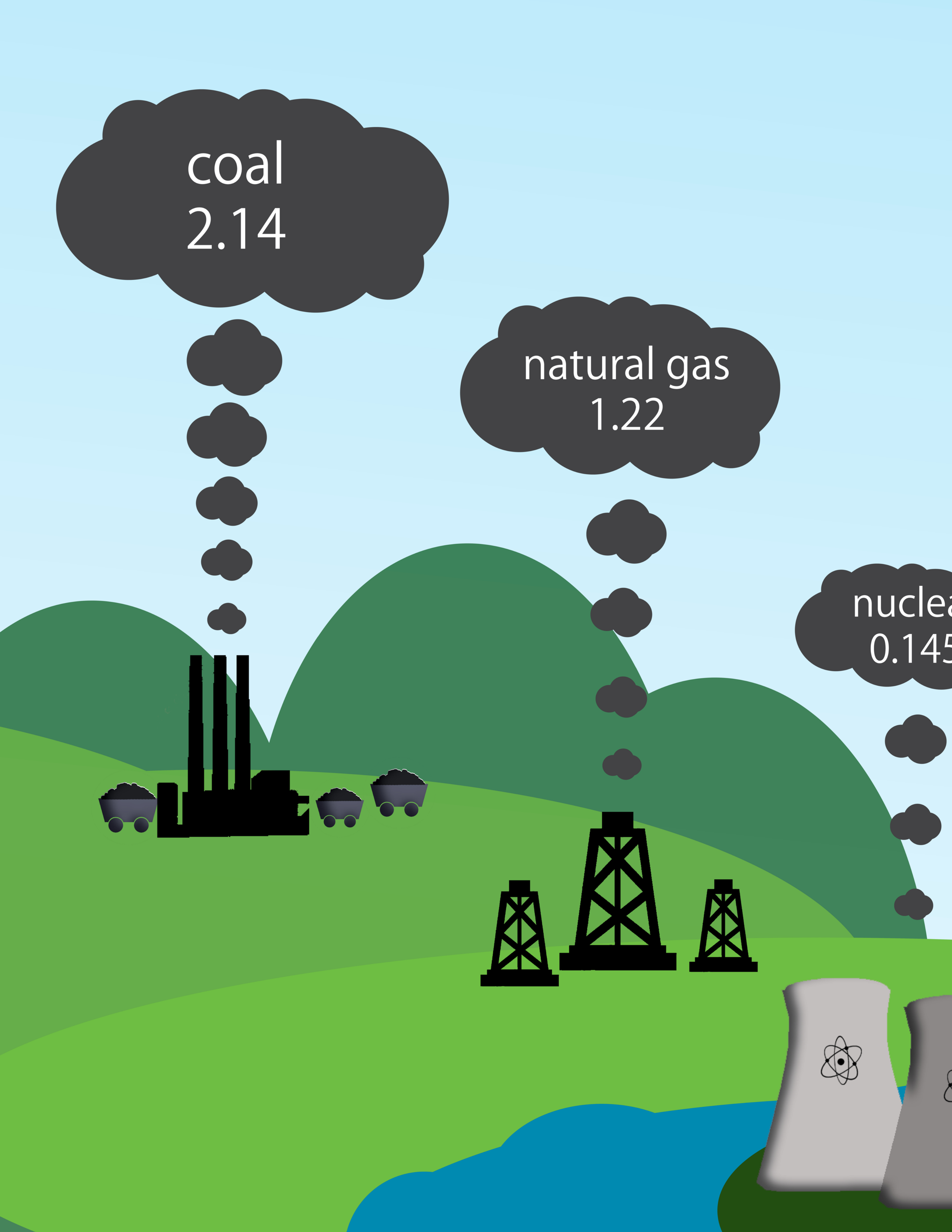
photovoltaic electric system creates about 40 grams of carbon dioxide equivalent, compared to about 1,000 for the same at a coal burning facility.

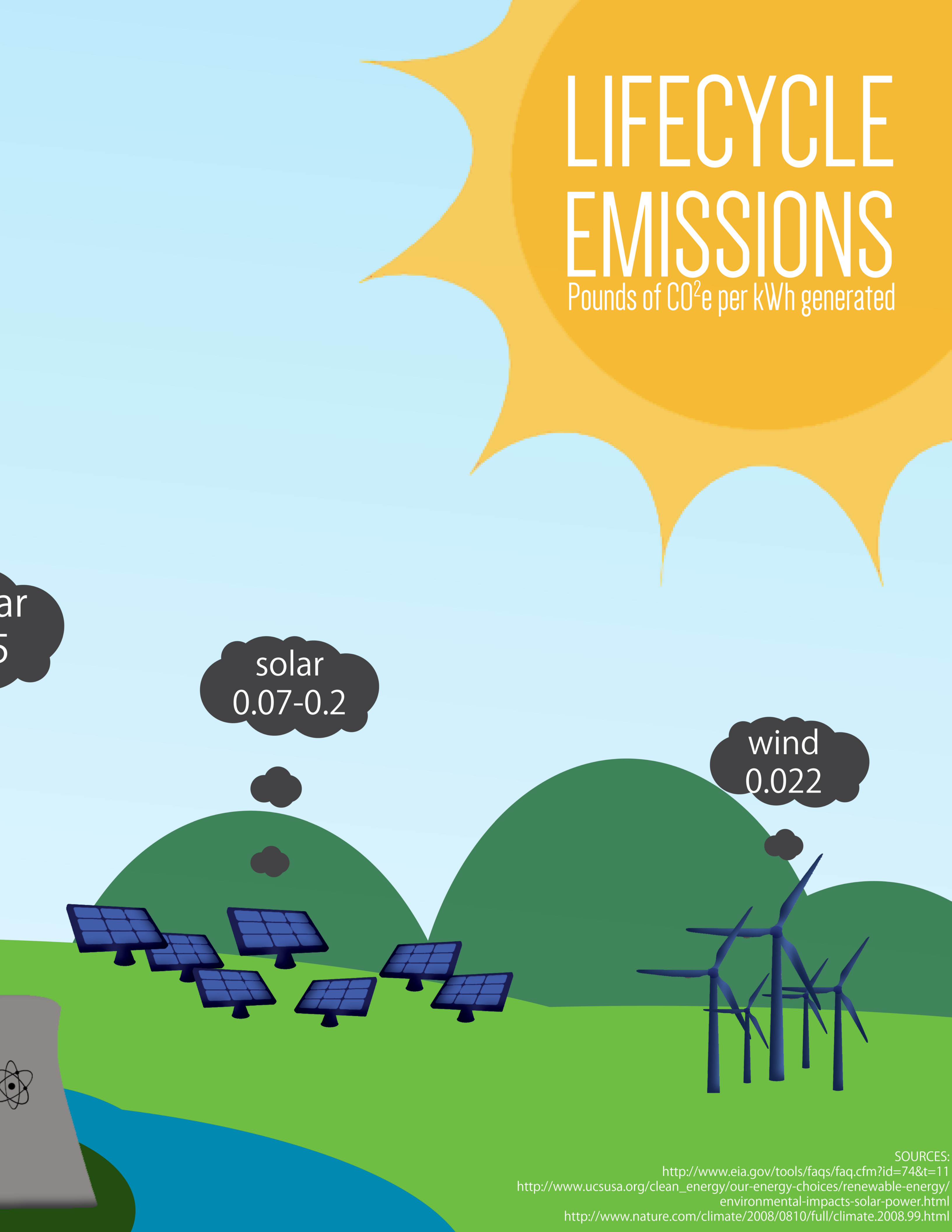
According to the US Energy Information Administration,[4] burning one gallon of diesel produces a little more than 22 pounds carbon dioxide (CO2) and burning one gallon of gasoline produces about 19 pounds of CO2. These fuels are often used to power generators in the case of an electrical outage. The demand for such equipment is high--valued at about $11.5 billion in 2010, according to the Brookings Institute.[5] Diesel fuel in particular accounts for the majority of the capacity in the widespread use of generators across the country. The same Brookings study estimated that in 2007, nearly 12 million generators were installed in the US with a total capacity of more than 200 gigawatts. About 79 percent of that capacity was used for emergency backup purposes.[6] With so many generators being used in the US to provide backup power, it is important to weigh alternatives. While generators are relatively cheap (excluding fuel cost), have a long life expectancy and can match demand load well, they are also very dirty and inefficient.[7]

With about 9 million of those 12 backup generators in 2007 being used for emergency backup,[8] the total emissions add up. EPA regulations[9] allow backup diesel generators to be used for 100 hours annually. Assuming all 9 million systems all ran the allotted time annually, 14,369,806 metric tons of CO2 would be emitted into the atmosphere. That is equivalent to nearly 3 million miles traveled in a standard vehicle, or the result of

In Seaside Heights, New Jersey in the aftermath of Hurricane Sandy, three 2 megawatt diesel generators operated for three weeks to provide power for emergency response and other critical activities (Fema.gov, 2014). Assuming the generators operated at capacity for 16 hours per day, they would have produced 84,420 kilowatt hours of power. That is equivalent 45,628 pounds of carbon dioxide, or roughly seven tons of landfill waste, according to the EPA (Epa.gov, 2014a). For a community of just 3,000 people, this is a substantial amount of emissions.

4 2014
5 Banks and Carl et al., 2011
6 Ibid
7 Ibid
8 Pentland, 2013
9 2014


coal
2.14
natural gas
1.22
nuclea
0.145


LIFECYCLE EMISSIONS
Pounds of CO^2e per kWh generated
solar
0.07-0.2
wind
0.022
SOURCES:
http://www.eia.gov/tools/faqs/faq.cfm?id=74&t=11
http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/environmental-impacts-solar-power.html
http://www.nature.com/climate/2008/0810/full/climate.2008.99.html

powering 717, 773 homes for a year.[10] By substituting solar, these emissions would disappear.

Cheap

In mid 2014, Austin Energy, a municipal utility in Texas, signed a 20 year Power Purchasing Agreement with Recurrent Energy to purchase 150 megawatts of power from two new large installations for less than five cents per kilowatt, the lowest recorded price to date for such an arrangement. The estimated price per kilowatt in the area is about seven cents for natural gas, 10 cents for coal and 13 cents for nuclear. More information is provided in Chapter Six.

Wesoff, 2014

Another common myth is that solar is too costly. A 2011 survey by ICMA cited cost as the number one obstacle to its member in installing solar.[11] A 2012 survey by Sunrun[12] of over 2,000 Americans also showed that 97 percent overestimated the cost of installing solar electric systems. While the price per kilowatt hour is indeed generally cheaper for coal than solar, this raw number belies many hidden factors that result in a very different view on the true cost of power sources. Announcements like the recent DOE promise of $19 million in funding to reduce both hard and soft costs related to solar show American commitment to continue the precipitous price decreases.[13] That being said, there is still a large gap in federal spending that likely contributes to the price disparity between traditional fuels and solar. Annually, subsidies in the United States for the oil and gas industry amount to $4.86 billion, according to an American Planning Association[14] report. In stark contrast, Federal subsidies for clean energy are about 13 times less, totaling $37 million annually. And such investment is relatively recent compared to that of petroleum—1994 compared to 1918, respectively.[15] Data suggests that over a five-year period, each American taxpayer contributes $521.73 to the oil and gas industry, while just $7.24 to solar energy development. This lack of subsidies explains why despite having almost 4,000 percent more sun cover than Germany, the US had about 6,000 percent less solar capacity in 2010.[16] Still, Duetsche Bank predicts that by

10 Epa.gov, 2014a; Epa.gov, 2014b; Dieselserviceandsupply.com, 2014
11 2012
12 2014
13 Energy.gov, 2013b
14 2013
15 Ibid
16 Llorens, 2010

the end of 2014, solar energy will likely be cost-competitive with all other sources, even without subsidies.[17] And the price of installing solar has dropped by about seven percent annually in the US since 1980, including about 30 percent between 2011 to 2013.[18] In 2010, 14 percent of consumers could already purchase solar for cheaper than standard grid power; it is estimated that it would be 100% if Federal subsidies were equal, according to One Block Off the Grid (Llorens, 2010). Former US Secretary of Energy Steven Chu has also predicted that within ten years, solar energy will compete in price with all other forms of energy in America (Francescato, 2013).

Another hidden cost of fossil fuel usage are the externalities —the costs of doing business that are incurred by those not choosing to participate in the transaction. The New York Times[19] reported that $120 billion in health costs associated with fossil fuel usage occurs annually, mostly from the thousands of premature deaths caused. This high figure does not account for climate change that is likely being caused by continued combustion of fossil fuels.

Abundant

It is a common misconception that much of the United States has a climate too cloudy for solar panels to be effective. The facts reveal a different story. Germany leads the world in total solar capacity and "dominates the PV market" worldwide despite having, on average, about as much solar resource as Alaska, and far less than the US average.[20] The American Planning Association[21] notes that at times, solar energy offsets about 50 percent of total energy usage in Germany. Even in parts of

"Solar energy is the most abundant form of energy in the world: the solar energy striking the Earth's surface in one hour is equivalent to the total global energy consumption for all human activities in one year."

(Banks and Carl et al., 2011)

17 Beetz. 2014
18 Solar Energy Industries Association, 2014
19 2009
20 NREL, 2010
21 2013

the country that do not have significant solar resources, solar collectors are able to produce energy in cloudy or overcast conditions, with the panels actually working more efficiently in the cooler temperatures according to an NREL tool PVWatts.[22]

Gallons of water used on-site to produce one mWh, by energy source

0
Solar PV

78
Dry-cooling solar CSP

760
Wet-cooling solar CSP

364
Coal (traditional steam)

1,438
Coal with carbon capture

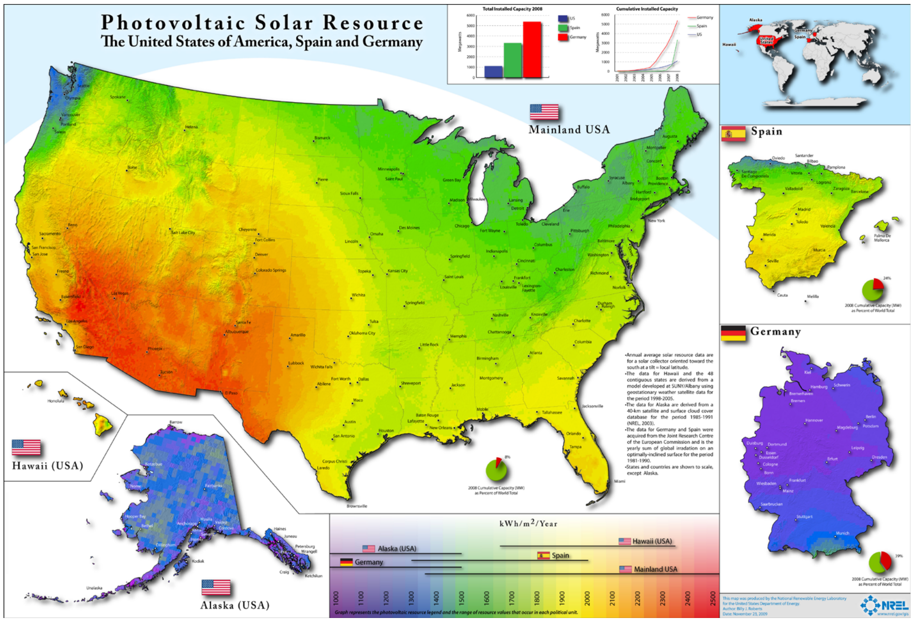
583
Natural Gas

609
Nuclear

all data from Western Resource Advocates, 2008

While solar energy is abundant and renewable, water is not. Many energy sources require extensive amounts of water to produce usable energy. Solar electric systems are much less water intensive. The National Climate Assessment[23] states that future water shortages related to climate change will constrain many energy sources and that "water shortages are already interrupting energy supply and impacts are expected to increase in the future." Western Resource Advocates[24] calculated the water consumption per mWh generated by energy source. The research found that solar PV systems use, on average, no water; dry-cooling concentrated solar power (CSP) systems used 78 gallons; wet-cooling CSP systems used 760 gallons. This is compared to coal generation which varies from 364 (traditional steam) to 1,438 gallons (with carbon-capture technology); natural gas, 583 gallons; and nuclear, 609 gallons. This illustrates that on average, solar energy generation uses far less of a scarce resource to produce power. It also shows a wide range in water use between solar technologies—CSP systems, like coal and nuclear plants, harness power from turning water to steam and therefore use more water than solar PV panels which use no water at all. [The previous data only consider on-site use; therefore, it does not include a full life-cycle analysis of water used in mining, transportation or other activities related to energy generation. An assessment like this would change the above estimates.]

22 APA, 2013
23 Melillo, Richmond & Yohe, 2014)
24 2008



Ours

When Pickens talked about natural gas being ours, he was really talking about the concept of energy independence. According to the US Energy Information Administration,[25] the United States imported 40 percent of its petroleum needs in 2012, which is down from the peak in 2005. In the same year, the US had a net import of 16 percent of total energy consumption. This is also down from its peak in the mid-2000s, largely due to an increase in production and exportation of natural gas in the country.[26] Even though the country is becoming less dependent on foreign energy sources, the global nature of the market means that the US is still impacted by its volatile price fluctuations. Declining

25 2013c
26 2013d

dependence may also mean less military intervention in the future.[27]

Increasing the capacity of solar power in the US, no matter which method is employed, can contribute to even less dependence on foreign markets and can liberate the American energy portfolio from volatile price vicissitudes and geopolitics. And since solar power is cleaner and becoming increasingly more affordable, it is an attractive alternative to natural gas extraction.

Increasing solar energy in the US also has economic benefit. The industry saw twenty percent growth from 2012 to 2013, and now has approximately 143,000 nationwide employees. Growth was ten times greater than the average industry and outpaced projections.[28]

Safe

FEMA states that the emissions from gasoline generators are one 100 times more toxic than vehicle exhaust, and can kill--739 people died from 1999 to 2012, the majority from using a generator in their home after a power outage due to weather event.

from FEMA 2014, esfi.org, 2014

A 2012 article in Forbes outlines the idea of the "deathprint" of an energy source--how many lives that are lost per kilowatt hour of energy production. The numbers include direct deaths, such as those from accidents, and those related to the externalities of the fuel source. Globally, 170,000 death per year result from every trillion kWh produced by coal; 36,000 from oil; 4,000 from natural gas; and 440 for rooftop solar.[29] In general, renewables like solar and wind don't pose the same level of safety risks associated with fossil fuel combustion and storage. The plants that produce renewable energy also don't suffer from high profile accidents like the one at the Fukushima-Daiichi nuclear plant following a tsunami in Japan.[30]

Versatile

27 Krauss, 2012
28 The Solar Foundation, 2014
29 Conca, 2012
30 Wisland, 2012

Solar technologies are generally more versatile than traditional energy sources because of four key characteristics: modularity,

island-capability, diverse applicability, a complementary nature.

Like other renewables, solar electric systems are modular, meaning that even if one particular section of a system is damaged, the entire system will not necessarily collapse. Large, centralized coal and natural gas are much more prone to cascading failures when part of a system is damaged.[31] It can be helpful to think of solar panels as a string of Christmas tree lights--if one panel is damaged, the rest of the array can continue operation.[32]

photo credit: flickr user J

Solar panels are appropriate for both urban and rural settings.

photo credit: wikipedia

Solar electric systems are likewise versatile because they can operate both on- or off-grid depending on need and inverter technology used. When the systems operate within the confines of the grid, they provide clean energy and can potentially save consumers money under net-metering arrangements. When off-grid, solar electric systems can be arranged to supply consistent power to a facility in the event of a blackout. As storage technologies continue to grow, this arrangement will likely become more common and financially-feasible.

One of the great advantages of solar energy generation is that it is appropriate for a diversity of contexts, both urban and rural. Large-scale utility solar farms can be sited in open space or agricultural areas, while rooftop PV installations can be distributed throughout the largest and most dense cities in the world.[33] This is possible because of its clean and quiet nature, compared to large power plants using other sources. When

31 Ibid
32 Wood, 2012

solar electric systems are used to provide power directly to the facility on which they are cited, there is no need for distribution infrastructure such as substations and power lines.

It is not necessary for solar electric systems to power an entire facility in order to realize the benefits of clean energy. Critical facilities such as hospitals or community centers can offset some of their peak load usage with solar panels in order to provide their own energy and save money when grid electricity pricing is highest; they can also install backup storage systems to maintain critical loads in the event of a power outage.

Reliable

In the immediate aftermath of Hurricane Sandy, nearly 1,000 patients in hospitals across New York City had to be evacuated and transferred to nearby medical facilities due to lack of power caused by inundated infrastructure and failing backup supplies.[34] The City's PlaNYC: A Stronger, More Resilient New York[35] was created in the aftermath of Sandy and incorporates the use of solar energy as a means to improve reliability and prevent such events in the future. One of its strategies for improving the resilience of the city's water and wastewater infrastructure is to incorporate solar energy on the facilities as a means of improving their ability to operate reliably during disruptions to the grid; in the Utilities chapter, a strategy to improve reliability is to promote the use of renewables, namely solar PV installations. Likewise, the City of Baltimore incorporates solar energy and backup storage as a way to ensure that critical operations such as evacuation infrastructure maintains operation despite outages. These examples point to the reliability of solar energy as a complementary and/or supplementary use, offsetting the use of other energy sources and thereby diversifying the overall energy portfolio and

34 Heiman, 2012; Ornstein, 2012
35 2013

providing additional backup capacity as needed. The use of solar energy in and of itself is not necessarily any more or less reliable than other energy sources.

EXAMPLES IN PRACTICE

There is little publicity for the use of solar energy in resilience efforts, though many examples are found in communities across the country. The following examples are categorized by the phase of resilience in which they occur. More information about some of these projects, including detailed financing information, can be found in Chapter Six.

Mitigation

Examples of solar energy usage in mitigation activity point to its ability to lower emissions overall, and thereby reduce grid stress and outages. As the only example discovered was from the City of Baltimore[36] the results are anecdotal.

The City of Baltimore's Disaster Preparedness and Planning Project (DP3)[37] is an innovative combination of hazard mitigation, climate adaptation and floodplain planning. The project combines research, outreach and strategies to create a comprehensive action plan. Some of the City's strategies directly utilize solar energy in implementation, under the Energy Systems & Buildings section. The report notes the importance of backup storage systems and distributed generation in mitigating and reducing vulnerability to grid outages.[38] According to a source at the City, the implementation of projects in the plan is being funded largely by the contributions of the Abell Foundation, a philanthropic organization in Maryland.

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36 2013
37 Ibid
38 Ibid

Preparedness

Examples showed that solar energy used as a preparedness measure can be beneficial to resilience efforts overall by incorporating the usage of battery backup storage which can reduce outages in important municipal and private infrastructure. Additionally, the usage of solar energy to power microgrids has proven to increase the resilience of both universities and correctional facilities in times of grid outage.

KBET Radio in Santa Clarita, California, has a 10 kilowatt solar PV system installed on its facility that can become an emergency power source for an AM radio transmitter in the case of power outage. This is important because the radio station is designated as an Emergency Operations Center communications facility that provides communications between police, fire, and other disaster response contacts in time of emergency.[39]

The Santa Rita Jail in Alameda County, California installed a 1.2 megawatt solar PV system on its roof in 2001; in 2011, the jail added a two megawatt energy storage system; and in 2012, a microgrid was installed. These features allow the jail to switch on and off the main utility grid which increases the energy resiliency in an emergency while contributing clean energy to the main grid on a routine basis. Funding for the project came from a variety of sources including utilities, state funding and the DOE.[40] Likewise, Santa Clara University in northern California has developed a microgrid that can operate completely independent of the larger grid network, allowing

39 PTI, 2011b
40 Otto, 2013

facilities to maintain power in an outage event. The microgrid is powered partly by solar on university land and renewable energy purchased from Silicon Valley Power, a local utility.[41]
Solar electric systems with backup batteries were installed on fire stations throughout Montana to serve as community centers and first-responder hubs in the event of widespread power loss. Between 2003 to 2007, the National Center for Appropriate Technology collaborated with utility NorthWestern Energy to install the systems on 20 stations throughout the state, each capable of generating 2-3 kilowatts. In 2008, a fire station in City of Billings with such a system installed maintained power after record snowfalls left many in the city without power. The fire station was able to respond to emergency calls thanks to the backup solar power. Funding for the project came from a public benefit fund established by the state and dispersed through the utilities.[42] This project is outlined in further detail in Chapter Six.

In Boston, a solar evacuation route pilot program was launched with the support of the DOE's Solar America Initiative, as part of American Recovery & Reinvestment Act funding. The program seeks to facilitate safe and efficient evacuation by utilizing solar powered lighting, fueling stations, signage and other infrastructure that can continue operation in isolation from the grid.[43] This project is outlined in further detail in Chapter Six.

In 2009, the SunSmart E-Shelter program in Florida provided solar panels and backup storage batteries to more than 100 schools which were identified as emergency shelters. The program was coordinated by the Florida Solar Energy Center and was funded through the American Recovery & Reinvestment Act (ARRA), with additional funding provided by public and

41 Schiller, 2014
42 Schmidt, 2013a
43 United States Department of Energy, 2011a; Chow, 2013

private utilities. Each school received a 10 kilowatt system. The unique aspect of backup battery storage capacity increased the resiliency of the communities by allowing critical operations such as medical care and communications to continue when the grid is down.[44]

PlaNYC: A Stronger, More Resilient New York[45] is a plan that is largely a response to Hurricane Sandy, and involved the use of solar energy in a variety of ways. Initiative 14 in the Buildings section calls for the amendment of building and construction codes to facilitate installation of solar and other renewables to allow for "rapid restoration of electricity…during utility outages."[46] A strategy in the Utility chapter states that the City should "diversify customer options in case of utility outage"[47] and notes solar generation "can provide electricity for individual customers and their local communities"[48] in such cases. Additionally, in the Water & Wastewater chapter, the plan states that "solar energy…would improve the ability of wastewater treatment plants to operate reliably during disruptions to the electrical grid while also enabling significant reductions in… greenhouse gas emissions."[49]

Response

Overwhelmingly, hurricane response has proven to be the most prominent use for solar energy in response applications. From Texas[50] to New York,[51] solar energy has been used for water purification, personal communication and general provisions in the aftermath of events such as Katrina and Sandy.

44 Mirzazad, 2013
45 City of New York, 2013
46 p. 86
47 p. 129
48 Ibid
49 p. 216
50 Lee, 2013
51 Marano, 2013

In the aftermath of Hurricane Katrina, WorldWater & Solar Technologoies, Inc. donated a solar-powered water purifying system to Waveland, Mississippi that provided 350,000 gallons of clean water for 8 months.[52]

After Hurricane Sandy ravaged much of New York City, AT&T developed the Street Charge program to install free solar mobile charging stations in parks and other outdoor spaces across all five boroughs of the City, where the public could charge their phones, tablets and other device. The project was funded by AT&T.[53]

The City of Houston, Texas is one of the most at-risk American cities for hurricane damages. After such devastating events as Hurricane Ike in 2008 which left many areas without power for several days, the City purchased 17 Solar Powered Adaptive Containers for Everyone (SPACE) units in 2011 to supply emergency energy in times of need. The units have been placed as schools, community centers and fire stations in preparation for a future event. Each unit cost approximately $60,000 and was financed via ARRA funding of over $1.3 million. The units are equipped with solar panels to generate about 4 kW of power and battery storage to save the power for use when necessary.[54]

Recovery

While not many examples resulted from the literature, the usage of solar energy in recovery efforts can be used to “start over” with cleaner energy options. In Vermont, solar energy was used in lieu of traditional grid power after a storm caused outages;[55] in Greensburg, Kansas, a devastating tornado came with a silver lining: the community went from having no solar

52 Lee et al, 2013
53 Marano, 2013
54 Lee, 2013
55 Ayhow, 2013

capacity to having a comprehensive renewable energy plan developed by NREL which facilitated the development of a 4.6 kW solar electric system on the County Commons building.[56]

In 2010, with financial support from the FEMA Public Assistance program, the Verendryne Electric Cooperative in North Dakota used solar photovoltaic energy to replace traditional power lines that were downed by the Good Friday Storm. The remote location of lines made traditional repairs difficult and costly. In this context, also considering the low power requirements, the utility decided to restore power to these pumps with solar PV panels. This experience was the first time that VEC turned to solar power to respond to a natural disaster.[57]

56 Billman, 2009
57 Ayhow, 2013

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photo credit: flickr user PLACE Built Environment Centre

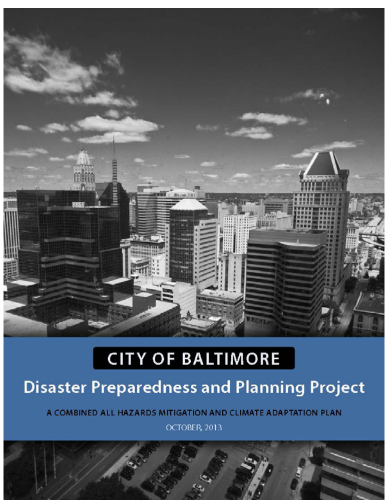
5 RECOMMENDATIONS FOR LOCAL GOVERNMENT ACTION

RECOMMENDATIONS FOR LOCAL GOVERNMENT ACTION

Based upon a review of the past and current uses of solar energy in resilience planning, and a survey of local government officials in ICLEI Resilient Communities for America communities, best practices emerged for its incorporation by local government officials. The following are recommendations for action:

Incorporate solar energy into hazard mitigation plan strategies

The primary way local governments mitigate against the impacts of climate change is the local hazard mitigation plan. [Information on the planning process is found in Chapter Two]. A review of existing plans, as well as a survey of local government officials working in the field, revealed that the integration of solar energy into hazard mitigation planning is infrequent--about 15 percent of officials surveyed noted any usage of solar energy in their community's plan.



The Baltimore Disaster Preparedness & Planning Project combines hazard mitigation and climate adaptation efforts into a comprehensive resilience strategy.

Traditionally, hazard planning has not incorporated climate change, even though it "is affecting and will continue to affect the frequency and severity of natural hazard events."[1] The lack of attention is likely because states and local governments are not required by FEMA to consider climate change in their HMPs. Despite the lack of requirement, FEMA convened the Strategic Foresight Initiative that concluded the following impacts will require additional action and attention now and into the future: rising temperatures, increased storm intensity and frequency, rising sea levels, changing drought and fire risk, and shifting human health and disease patterns.[2]

1 Babock, 2013
2 Ibid

In a review of SHMPs, Babock[3] found that only 11 states[4] included a "thorough discussion of climate change impacts on hazards," as of 2011. Similarly, the local HMP process has been characterized as weak overall, and lacking the incorporation of climate change[5] and therefore efforts to improve the process are necessary. A notable plan that addresses hazard mitigation comprehensively is the City of Baltimore's Disaster Preparedness and Planning Project (DP3). The plan, adopted in 2013, blends hazard mitigation and climate adaptation strategies in order to address climate change impacts in a holistic way. In the Transportation section, DP3 includes an implementation strategy that "requires that backup solar powered street lights and signals be integrated along evacuation routes and high traffic areas." This is done because "hazard events may disrupt power supply to street light and signal systems" which need to remain operational in evacuation situations."[6] This strategy could be expanded to include other infrastructure, as it has been in Boston (see Chapter Six for more information on the Boston Solar Evacuation Pilot Project).

The 2013 California State Hazard Mitigation Plan[7] and the City of Boston's 2013 Hazard Mitigation Plan[8] exemplify hazard mitigation plans that could be improved by the inclusion of strategies that utilize solar energy, as Baltimore's DP3 does. Goals and objectives from these plans are outlined in table below.

"We must remember that climate change is going to happen over the foreseeable future and that development lasts for decades...For decades to come, [Baltimore] may continue to experience risks associated with elevated [greenhouse gas] emissions. While these changes cannot be prevented, Baltimore can prepare by incorporating the anticipated risks associated with climate change into hazard mitigation planning efforts. Integrating hazard mitigation planning, which focuses on past events, with climate adaptation planning, which focuses on what will likely happen in the future, offers a positive, win-win solution for Baltimore City."

Above information from the City of Baltimore's Disaster Preparedness & Planning Project (2013)

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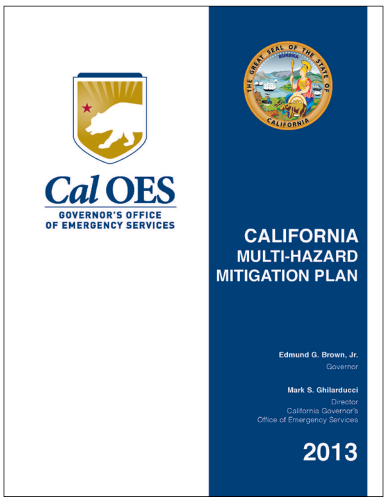
3 Ibid
4 AK, CA, CO, CT, HI, MD, MA, NH, NY, VT, WA
5 Berke, Lyles & Smith, 2012
6 City of Baltimore, 2013
7 California Governor's Office of Emergency Services, 2013
8 Boston Hazard Mitigation Executive Steering Committee, 2013

PLAN JURISDICTION	GOAL	OBJECTIVE
State of California	Protect the environment	Promote and implement hazard mitigation plans and projects that are consistent with state, regional and local climate action and adaptation goals, policies, and programs.
		Encourage all state, regional and local hazard mitigation planning programs to protect the environment and promote implementation of sustainable mitigation actions.
	Minimize damage to structures and property, as well as minimizing interruption of essential services and activities	Support the protection of vital records, and strengthening or replacement of buildings, infrastructure, and lifelines to minimize post-disaster disruption and facilitate short-term and long-term recovery.



The California State Hazard Mitigation Plan was updated in 2013 and is one of the few state-level plans to incorporate climate change projections into hazard planning.

PLAN JURISDICTION	GOAL	OBJECTIVE
City of Boston	Protect the health and safety of the public	Ensure that services related to public health can function during and after a hazard, e.g., sanitation, water, debris removal, hospitals and emergency services.
		Minimize secondary impacts from hazards, such as the release of pollutants. e.g., by covering salt piles.
		Ensure that evacuation can happen in an organized and efficient manner.
	Protect existing properties and structures	Ensure that critical facilities are protected from hazards
		Educate the public on measures they can take to protect their property

The California State Hazard Mitigation Plan (SHMP) contains a goal of protecting the environment, and thus promotes policies and projects that are sustainable and consistent with other state-level plans related to climate action and adaptation. Solar energy integration would accomplish plan objectives by virtue of being clean and renewable--and thus sustainable--and also because it already plays a large part in state climate actions to reduce GHG emissions overall. The plan has an additional goal of "minimiz[ing] damage to structures and property, as well as minimizing interruption of essential services and activities."[9] One objective of that goal is to "support the protection of vital records, and strengthening or replacement of buildings, infrastructure, and lifelines to minimize post-disaster disruption and facilitate short-term and long-term recovery."[10] Solar energy in tandem with backup storage capacity can play a role in ensuring continuity of services during a disaster event and can provide a quick way to restore power service in the event of outages.

Though the State of California is aggressively developing its solar industry, and the plan notes that "stronger national and local policies and financial incentives are needed to support the development and production of alternative energy sources, such as solar,"[11] it does not specifically mention how solar energy is connected to hazard mitigation. Explicitly stating this link in California's SHMP, as well as in any hazard mitigation plan, can not only improve current processes but also work toward other community goals.

The City of Boston's HMP stresses the importance of protecting people, property and critical infrastructure. Objectives related to the plan goals include ensuring that services and evacuation can occur during and after a hazard event; minimizing

9 California Governor's Office of Emergency Services, 2013
10 Ibid
11 Ibid

secondary impacts such as air pollution and emissions; and educating citizens of the city to protect their own property. Boston's HMP makes no mention whatsoever about the role of solar energy as a mitigation measure. However, the goals of the plan could be achieved in part by incorporating solar energy. By developing solar powered- or backed up- infrastructure on critical facilities, the City could ensure that services are maintained during and after hazard events. [Interestingly, while the City does incorporate solar infrastructure in its evacuation routes, the project is not noted in the HMP].

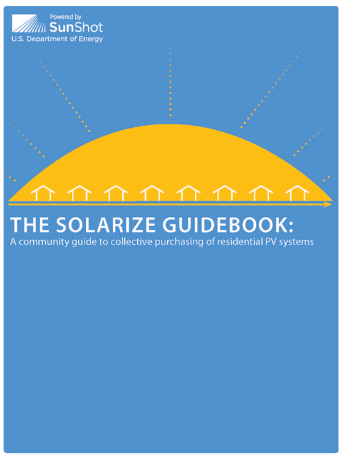
The City could further achieve its hazard mitigation goals by utilizing solar energy instead of generators with traditional fuels, thus reducing both emissions and air pollutants. And by promoting the development of solar electric systems with backup capacity on residential and commercial property, the City could facilitate individuals in mitigating their own personal losses related to hazard events.

Create an energy assurance plan

The best way for a local government to ensure energy reliability despite uncertainties (from outages to short supplies) is to create an energy assurance plan. The energy assurance planning process is outlined in Chapter Two of this guidebook. In the guidelines from Public Technologies Institute, there are two approaches given for incorporating renewables into energy assurance planning: long-term and tactical. A long-term approach is meant to diversify an energy portfolio with renewables over an extended period of time, complemented by energy efficiency measures; a tactical approach is short-term and mean to respond to particular events, such as emergency situations.[12]

12 Public Technology Institute, 2012a

The Solarize Guidebook, produced by the National Renewable Energy Laboratory and sponsored by the City of Portland Bureau of Planning and Sustainability, is an important resource for local governments interested in initiating a "solarize" campaign.



One of the most important aspects of an EAP is the evaluation and protection of critical facilities. Solar energy specifically can be incorporated into energy assurance plans in this capacity by providing backup capacity to support the continuity of critical loads at designated facilities.

While the role of solar energy is more discussed in energy assurance than hazard mitigation, EAPs are relatively new and there are very few formally adopted plans nationwide. Sample plans and strategies are therefore not available, but PTI provides general guidance on creating a plan and incorporating the use of renewable energy sources. [See Chapter Seven for more information].

Create a community solar or "solarize" program

Solarize programs are often set up in communities to pool together those who wish to install solar electric systems, in order to achieve cost savings from bulk purchasing. The first American campaign was launched in Portland and programs has since been launched across the country. The basic process of starting a campaign has eight steps: develop partnerships and initiate planning; build a database and customer interface; recruit volunteers; RFP process; outreach and education; customer enrollment; site assessment; and installation (Grove, Irvine & Sawyer, 2011). The process is outlined in detail in The Solarize Guidebook: A Community Guide to Collective Purchasing of Residential PV Systems; see Chapter Seven of this guidebook for additional resources.

Consider solar energy in all aspects of planning

Comprehensive plans (sometimes called General or Master plans) are among the most important policy tools available to local governments because they establish a long-term vision for communities. All states either require or allow the creation of plans, which are binding once adopted.[13] Comprehensive plans are an ideal method by which local governments can foster a solar-friendly policy and regulatory environment. By allowing, incentivizing or requiring the use of solar in the comprehensive plan of a community, officials can make sure that barriers to solar development do not impede the process; conversely, failing to address solar energy in formal planning and regulation creates unnecessary barriers to its development.[14]

This can be achieved by integrating solar throughout the entirety of the plan, or by creating a specific element to address it. For example, Lawrence Township, New Jersey, added a "Green Buildings and Environmental Sustainability Element" to their Master Plan which includes an Energy Conservation and Renewable Energy Production chapter which discusses. More information can be found on Lawrence Township's plan in Chapter Seven of this guidebook.

Local governments can remove barriers to solar energy development by crafting "right-to-solar" ordinances or solar access laws, which ensure that those wishing to install solar electricity will not have their systems impeded by Homeowners Association regulations, landscaping or other physical obstacles. Local governments can also classify solar electric systems as a "by-right" accessory uses, meaning that their approval is pre-approved in certain zoning designations.[15] A good starting point

The City of San Luis Obispo, California, requires the creation of solar easements when approving subdivision projects; the easements must be recorded on subdivisions maps.

Adapted from San Francisco Department of Environment, Permitting Solar Access, 2012

13 APA, 2013
14 Morley, Anthony et al, 2014
15 APA, 2013

of local government officials is to examine current zoning, building and subdivision codes and regulations to determine if, how and to what extent solar energy is addressed and what barriers exist. The City of Seattle, for example, conducted a gap analysis of codes and policies to identify existing barriers and provides a good example for local governments. [More information on the project can be found in Chapter Seven].

Solar energy can be incentivized through local government planning in myriad ways. For example, the permitting and review process can be streamlined and fees can be reduced or removed to facilitate solar installations. Accounting for potential solar installations via zoning and setback regulations can spur development.[16] The Greater Tucson Solar Development Plan (Tucson, Arizona) provides a good example of strategies to incentivize solar development in a community [see Chapter Seven for more information].

Create a municipal utility

In May 2014, the City of Boulder, Colorado, voted to create its own power and light utility. The City was previously served by Xcel Energy and was unhappy with its slow progress toward renewable energy generation and the "status quo" that "wreck[s] the natural systems." A City Council member said that Boulder needed to "usher in a new era in the relationship with the natural world" and that their work is "a high calling."[17] This move transcends Boulder: according to a 2013 article in the New York Times, cities across the US are showing an interest in transitioning from privately held, for-profit utilities to publically held ones. They are primarily driven by three factors: climate change, power outages and fuel mix. According to an American Public Power Association (APPA) staff member, "the biggest

16 Morley, Anthony et al, 2014
17 Meltzer, 2014

benefit about public power is the local control."[18] Currently, about 75 percent of all electricity produced in the US comes from investor-owned utilities.[19] These IOU's are beholden to shareholders and seek monetary profit, which causes concerns. On the other hand, government-owned utilities answer to citizens.[20] Some of the other benefits to municipal utilities include:

- cheaper rates: one study says that rates for IOUs are on average 14 percent higher than rates for municipal customers;[21] the New York Times[22] cites EIA statistics showing that rates are cheaper for municipal utility customers than IOU customers in 32 of the 48 states where both types exist

- quicker response to outages: in some of the most impacted areas of Massachusetts after Hurricane Irene (2011), municipal utilities restored power in a few days, while IOUs took roughly a week to restore power to customers;[23] in Denton, Texas, municipal utility Denton Municipal Electric restored its customers in about an hour, compared with outages of several days in much of the Dallas-Fort Worth metroplex.[24] This could be because municipal utilities average more line workers per customer than IOUs.[25]

- Access to tax-exempt financing, and no federal income taxes: this allows the companies to keep rates low[26]

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18 Cardwell, 2013
19 The Regulatory Assistance Project, 2011
20 Cardwell, 2013
21 American Public Power Association, 2013
22 Cardwell, 2013
23 Ibid
24 Guevara-Stone, 2014
25 Cardwell, 2013
26 Ibid

Utilize solar-powered generators and devices

After the Northridge (California) Earthquake in 1994, two workers were required to monitor generators for six hours a day to ensure fuel levels were sufficient. Solar powered generators require no fuel and allow workers to focus on life-saving activities.

from NREL, 1999

In the immediate response to hazard events that cause power outages, first responders require electricity to do almost all tasks—from pumping gas for vehicles, to utilizing communications devices. The traditional way the electricity is procured is through diesel and/or gasoline generators. However, these use fossil fuels which are noisy and polluting.[27] There are also fuel routing challenges in the aftermath of disaster events because power is required to pump diesel and gasoline. Even when they can be obtained, they are often scarce.[28] The DOE has recommended solar powered sources as a quiet, safe, clean and reliable alternative to liquid fuel generators. In practice, the Department of Defense has used solar powered backup generators since the late 1990s, and cities in the US Gulf have also utilized these systems for hurricane relief for decades.[29]

Houston's SPACE units are capable of generating 4kW of clean energy to power communications devices, keep medicine cool and purify drinking water. They are also mobile and can be located around the city as needed.

The City of Houston, Texas, provides an example for how local governments can utilize solar powered backup generators to improve resilience. The city procured 17 mobile solar units (Solar Power Adaptive Container for Everyone, or SPACE) in 2011 utilizing ARRA funds. Each unit costs approximately $60,000 and is capable of generating 4 kW of power; the units are also equipped with a storage system to ensure power supply despite low levels of sunlight. The units were designed and built by architecture students at the University of Houston, from recycled shipping containers, and are about 160 square feet. Each unit is also air-conditioned inside. Staff at the university said that the units can charge "hundreds of computers and cellphones" each, from their 18 solar PV panels.[30][31] See Chapter Seven for more information on this project.

27 NREL, 1999
28 PTI, 2011b
29 NREL, 1999
30 Siegle, 2011
31 Lee, 2013

Incorporate solar energy into recovery efforts

An oft-overlooked aspect of resilience is opportunity. As such, a tragedy can be turned into an improvement by deciding to forge a new path in recovery efforts.[32] Greensburg, Kansas, offers an exemplary case for local government wishing to recover from a disaster and improve conditions in the process. A tornado in 2007 devastated the small town and damaged electrical distribution infrastructure so badly that some areas of the town did not regain full access to power for nearly a year. Coincidentally, the city's agreement with its utility provider expired in 2007 and political leaders decided after its expiration and the tornado to negotiate with then-provider Sunflower Electric to assess potential for integrating renewables into the power mix. Officials eventually entered into a contract with Kansas Power Pool, which develops renewable energy in the area.

A FEMA Long-Term Community Recovery Plan was used in Greensburg to "promote [a] successful long-term recover[y] for communities suffering extraordinary damages."[33] NREL was an active partner in the entire process and lead efforts to rebuild Greensburg as a national leader in energy efficiency and LEED-certified facilities.[34] A major focus was facilitating the development of renewable electric systems in the community. As such, the town went from having no installed solar capacity before the tornado to having a formally adopted Solar and Wind Ordinance, a Net Metering Agreement, and an Interconnection Agreement, as well as a new County Commons building powered partly by rooftop solar PV.[35] [see Chapter Seven for more information].

The Kiowa County Commons building was constructed to replace the old facility destroyed after a 2007 tornado in Greensburg, Kansas. The new building contains a rooftop solar array with 33 solar PV panels, capable of generating 4.6kW of power.

photo credit: Compton Construction

32 NREL, 2009
33 Gordon, 2013
34 NREL, 2009
35 Gordon, 2013

Fukushima, Japan, provides perhaps an even more comprehensive example of using solar energy in recovery efforts, with translatable actions for US local governments. After the highly-publicized and catastrophic earthquake in 2011 spurred the Fukushima Prefecture to wean off its nuclear sources, the local government had made investments in renewables, specifically solar, to supply lost power and provide a safer and more resilient alternative to nuclear. By 2040, the Prefecture has a goal of being 100 percent powered by renewables, with an interim goal for the end of March 2016 at 805mW (about half of that from solar). The area has thus far installed a 1.2mW PV project at its airport, all $4 million USD of which was funded locally. The project was implemented after the local government formed its own municipal utility. To further its efforts, the government also started the Fukushima Renewable Energy Research and Development Center to advance renewable technologies and create jobs in the budding green sector.[36]

Other governments throughout the region have utilized solar as well. Nearby Iwaki City has also develop solar installations by creating a municipal utility ad plans to use some of the revenue from purchase agreements to fund recovery efforts in the city. Nishishirakawa developed a two megawatt solar installation on a former golf course site and plans to add more capacity in the future. Sukagawa is planning a 26.2mW installations at another former course site.[37] While the solar energy is in most cases more expensive than the previous power derived from nuclear sources, "most consumers think that sacrifice is worthwhile" because of the hidden cleanup and other costs of nuclear that emerge only after an accident such as the Fukushima earthquake and subsequent tsunami.[38]

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36 Movellan, 2014
37 Ibid
38 Harlan, 2013

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photo credit: flickr user Maryland GovPics

6 PROJECT FINANCING

PROJECT FINANCING

This chapter provides examples of how solar energy is being used in resilience efforts at the local government level across the US. There is a specific focus on the financing aspects of the projects, and examples are categorized by the source of funding: federal government; state government; local government; utilities; and public/private partnerships are all discussed.

FEDERAL FUNDING

Perhaps the most high-profile federal involvement in solar energy to date is the Solar America Cities initiative in 2007 and 2008, which provided a combined $4.9 million to 25 US cities to "build... sustainable solar infrastructure, streamline city-level regulations, and promote the adoption of mainstream solar technology among residents and businesses."[1] One of the cities, Boston, Massachusetts, received $1.343 million to develop a pilot project for solar-powered infrastructure on designated evacuation routes. Early in the process, city officials recognized that solar power "can provide a useful backup to critical applications in the event of widespread blackout" and thus used the Solar America Initiative funding to work with a diversity of stakeholders to determine the best way that they could utilize solar in this capacity. Among the public-sector collaborators were the Transportation Department, Police Department, Fire Department, Emergency Medical Services, Public Health Commission and Office of Emergency Preparedness. Such widespread involvement was unique. After examining solar-powered shelters and other potential applications, the working group chose to work with the more than two dozen existing designated evacuation routes because they provided a nexus between energy and emergency services, which was at the heart of Boston's initiative. The city also expressed concerns due to potential terrorism events, blackouts and severe weather throughout the region.

According to the Federal Highway Administration, more than 400 emergency evacuations occur each year in the United States and the majority of these are caused by natural disasters. Boston's Solar Evacuation Pilot program provides a way to ensure that these critical actions remain possible in the event of widespread power outage by equipping infrastructure with solar electric systems.

from Glass, 2014

1 NREL, 2008

The routes had an existing infrastructure consisting of signage, fueling stations, and lighting that could be switched to solar-powered to provide reliability, cost savings and reduce emissions. The original pilot called for a prime route on Washington Avenue to receive installations of five variable message boards, 21 solar-powered intersection lights, 50 kW of backup capacity on fueling stations, 27 LED-solar street lights and 10 solar radio repeaters. The infrastructure was designed to be able to operate both on- and off-grid, to provide benefits in time of emergency and normal conditions.[2]

While not explicitly for solar energy projects, FEMA offers two additional grant funding programs that can be used for resilience projects that may include a solar energy component. The Pre-Disaster Mitigation program provides annual funding for hazard mitigation-related projects at the state and local level and aims to "reduce overall risk to people and structures." The funding for fiscal year 2014 has been increased from $23 million to $63 million nationwide.[3]

The Hazard Mitigation Grant Program also provides grants to state and local governments in order to implement long-term hazard mitigation measures once a disaster has occurred and the locality has been officially declared as a disaster area. The funds may be used for projects that reduce or eliminate the losses from future disasters and take a long-term approach: the "elevation of a home to reduce the risk of flood damages as opposed to buying sandbags and pumps to fight the flood." The projects must also have potential savings greater than the overall project cost. Local governments must contact the relevant State Hazard Mitigation Office to apply, as the grants are funneled through states.[4]

2 Chow, 2013; US DOE 2011a; Belden, nd
3 fema.gov, 2014b
4 fema.gov, 2013a

Between 2007 and 2008, the United States Department of Energy selected 25 cities for its Solar America Cities grant program. The cities received a combined $4.9 million in financial assistance as well as technical and policy assistance provided by DOE and NREL among other organizations. Cities were selected that demonstrated a comprehensive approach to solar planning to expand capacity and remove market barriers, as well a high level of commitment to promote solar power throughout the city.

adapted from NREL, 2008

The Public Assistance grant program provides assistance to state and local governments to respond to and recover from disasters or emergencies declared by the President of the US. Under the program, FEMA provides financial assistance for activities such as debris removal, emergency protective measures, and the repair, replacement, or restoration of damaged publicly facilities. FEMA covers a share "not less than 75% of the eligible cost for emergency measures and permanent restoration."[5]

STATE FUNDING

An important source of funding for renewable energy projects for local governments comes directly from states. The funds are commonly referred to as a Public Benefit Fund or Public Systems Benefit, and come from a fee imposed on all electricity sold by the utilities in the state. Generally, state utilities commissions or similar organizations impose the fee which utilities collect and allocate for renewable energy or energy efficient projects by applicants. As of 2010, 30 states plus the District of Columbia have such systems in place.[6]

In 1997, the State of Montana introduced the Universal System Benefits (USB) program. Utilities were tasked with collecting fees and allocating money to projects that follow general guidelines provided by the Montana Public Service Commission. The largest electricity utility in the state, NorthWestern Energy, annually collects about $9 million, of which around $1.2 million is earmarked for renewables development. In 2003, the National Center for Appropriate Technology (NCAT), a Montana-based nonprofit dedicated to sustainability issues, applied for funding to install solar photovoltaic backup systems at fire stations across the state. Following the applications from NCAT, NorthWestern Energy dedicated specific funding for such projects. Twenty systems were installed between 2003 and 2005 with a combined capacity of approximately 50 kilowatts. Though no new systems have been installed since then, the program has shown success,

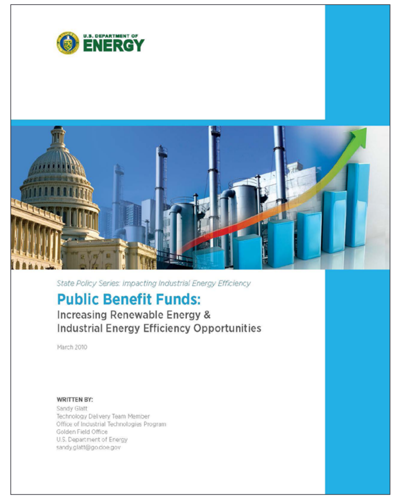
5 fema.gov, 2013b
6 Glatt, 2010

most notably in Billings where a fire station maintained power after record snowfalls and subsequent grid outage. Emergency response continued uninterrupted during the storm thanks to a backup system that operates independent of the grid in the event of an outage.

The Fire Station Solar Electric Demonstration Project installed close to 50 kilowatts on 20 fire stations throughout the state. Each station was equipped with two to three kilowatts, either on the roof or on fixed poles nearby. Each station can supply from 25 to 35 kilowatt hours of electricity when needed. The total installation from the project amounts to about five percent of the state's fire stations and represents almost eight percent of total PV capacity in Montana.

The total cost of installation for each of the station's PV-backup systems ranges from $11.00 to $12.00 a watt, which is more than the previously mentioned average for the state. This is notably more expensive because of the battery storage systems, a necessary component of the backup systems.

Though few in number, the systems that have been installed have been a success. Benefits include quicker response times during power failures and reduced tax expenditures related to fire department utility bills. The performance has been excellent with installers reporting that no significant problems have been reported thus far aside from minor preventative maintenance issues. Most importantly, the systems have kept fire stations operational during blackouts. In October 2005, heavy snowfall caused power outages in southeastern Montana. Billings, the largest city in the state, was impacted. Billings Firehouse #6, one of the stations with solar backup capacity, maintained continuous operations. But the benefits of the systems transcend emergency power and can serve as vital educational tools for the community. According to a Montana



As part of its State Policy Series, the DOE produced 'Public Benefit Funds: Increasing Renewable Energy & Industrial Energy Efficiency Opportunities' in 2010. This guide outlines the status of public benefit and similar funds in states across the county.

Fire Chief, they can "provide great benefits for both public safety and public relations," and "[increase] energy awareness and energy efficiency concern." (adapted from Schmidt, 2013a)

Local governments did not play a direct role in this project; all installations were driven by applications by NCAT. However, 30 states and the District of Columbia have similar funds in place which could be utilized by local governments in the same vein. Many municipalities can take finance projects via issuing municipal bonds. These bonds help communities finance public-benefit projects with high up-front costs, and come in a variety of types. Some, like the General Obligation bond, allow cities to provide no capital assets come with "the full faith and credit" of the municipality, meaning it can use various means to repay to debt. Others have specific provisions regarding how they will be repaid, including new or increased taxes. These are often known as limited or special tax bonds.[7]

LOCAL FUNDING

In 2007, Salt Lake County proposed a $192 million bond initiative to raise money primarily for a new Public Safety Building (PSB), which combined the Police and Fire Departments, as well as the dispatch center and the Emergency Operations Center. The basis of the need was that repairs to the existing facility would not guarantee that the old facility "would be functional in the event of a serious natural or man-made disaster." The original space was also overcrowded: it was built to accommodate 123 people, but had around 500 at time of bond proposal.[8] The bond failed by 263 votes.[9] In 2009, voters in Salt Lake County passed a general obligation bond initiative in 2009 known as Proposition 1: Public Facilities Bond with about 66 percent approval.[10] The 2007 version of the bond measure would have cost the owner of a $250,000 home (about the average for the

7 finance.yahoo.com, 2014
8 Salt Lake City Council, 2009
9 Jensen, 2009
10 Ballotpedia.org, 2014

area) $147.33; the 2009 version cut that by more than half and lowered the property tax impact to $71.82.[11]

Replacing the previous building built in 1957, the new LEED-Silver building was completed in downtown Salt Lake City in 2013 and includes many features to make it earthquake resistant.[12] The PSB has a rooftop solar canopy with over 1,000 panels[13] and according to city staff has a capacity of 3.2 mWh. Additionally, the facility is equipped with 1.38 mWh of emergency backup power. The bond measure also provided $3 million in funding for an off-site solar farm on a former landfill that will generate power for the PSB, further offsetting its use of fossil fuels.[14] The farm will have 4,000 panels generating a combined one megawatt and upon its completion will allow the PSB to be a net-zero facility (it will generate as much power as it uses). The solar farm will be paid in full in ten years.[15]

The PSB facility is increasing the resilience of Salt Lake City in many ways. By combining departments involved in the emergency response/management of the city in a facility that is both earthquake-resistant and of adequate size, the PSB allows for more effective safety operations. Solar energy plays a key role in the resilience, as well. By generating solar energy to partly power the facility, there is less reliance and stress on the grid overall; by incorporating emergency backup capacity from solar energy, the PSB can ensure critical functions will persist despite external weather events and power outages. Given the critical nature of the PSB operations (police and fire, emergency command) this is of upmost importance. And by using energy as efficiently as possible, the facility will annually produce only about 524 metric tons of carbon dioxide per year, compared to

The Public Safety Building in Salt Lake City, Utah, was completed in 2013 with funding from a County bond levy. It is perhaps the largest net-zero facility in the US, meaning that it generates nearly as much energy as it uses in operations. The building features a solar canopy capable of generating 3.2mWh and has 1.38mWh of emergency backup capacity.

photo credit: Salt Lake City government website

11 Salt Lake City Council, 2009
12 Slcgov.com, 2014
13 Rascon, 2013
14 Cunningham, 2013
15 Rascon, 2013

about 2,670 MTCO2e for an average facility of its size, thereby contributing less to global climate change.[16]

UTILITY FUNDING

In April 2014, the US DOE announced $15 million in funding for communities to increase solar energy capacity by developing more community solar programs.[17] In A Guide to Community Shared Solar: Utility, Private, and Nonprofit Project Development, community solar is defined as any solar electric system that benefits multiple community members. The financing mechanism allows members with non-optimal solar resources (renters, those with shaded roofs) to still be able to take advantages of the benefits of clean energy and lower utility bills.[18] Community solar projects are typically funded in one of three sponsorship categories: non-profit, utility, or special enterprise funded.

In a traditional non-profit funding model, the systems are owned and hosted by the non-profit organization and financed by various donations and/or member contributions. Utility projects are typically owned, hosted and financed by the utility or a chosen third-party, and the power is provided to utility ratepayers. Special enterprise projects are typically owned by the enterprise, financed by members and hosted by a third-party.

The Sacrament Municipal Utilities District (SMUD) is a publically-owned utility in Sacramento, California and the ninth largest of its kind in the US in terms of annual revenue.[19] In 2008, SMUD initiated the SolarShares program, a community solar program that allows the utility's consumers than cannot or choose not to install a personal soar electric system to still reap the benefits of solar energy. This is done by offering consumers "shares"

16 O'Donoghue, 2013
17 Energy.gov, 2014
18 Coughlin and Grove et al., 2012
19 American Public Power Association, 2009

of solar power in increments from one to four kilowatts, for up to half of their annual consumption. Participants sign 12 month agreements and SMUD owns and operates all of the infrastructure involved in the process and charges users a monthly fee. The electricity purchased from the program costs about five cents more per kilowatt hours compared to the standard electricity mix pricing (18.7 versus 13.5 cents/kWh). As of early 2014, the program has approximately 600 participants and is at maximum capacity.

The SMUD SolarShares allows customers to predict how many shares they need by entering previous usage information into their online estimate tool. This allows their users to purchase an appropriate amount of shares and maximize savings.

The solar energy is sourced from a one megawatt solar farm located in Wilton, a community in Sacramento County. All of the electricity comes from that source and no panels are located on customer's property. This allows participants to keep their shares in the event of a move, provided they remain in SMUD territory. The solar farm was developed after a bid process with a third-party (enXco) who owns the installation and sells the energy directly to SMUD at a fixed rate over a 20 year period. There are plans to expand the program with two future additions: a 1.4 megawatt installation for commercial and residents participants, and a five megawatt system for State facilitates. The expansion will likely reduce the price per kWh.[20]

SolarShares is increasing resiliency in the Sacramento area by increasing overall solar capacity and therefore decreasing reliance on the grid and greenhouse gas emissions. This is achieved by making it easier for customers that are unable to install their own solar electric systems (due to poor location or financial constraints) to nonetheless invest in solar energy. The SolarShares program generates 1,736,402 kWh of generation annually which if offset from fossil fuels, which equates roughly to planting 307 acres of trees.[21] Due to the nature of the program, however, power is still generated at centralized facilities and distributed across the region rather than locally. This lessens its

20 smud.org, 2014; McCabe & Sarver, 2014; Coughlin and Grove et al., 2012

21 smud.org, 2014

resilience because in the event of a grid disturbance, consumers would be without power.

PUBLIC/PRIVATE PARTNERSHIPS

A public/private partnership is a cooperative effort between a public entity and one or more private entities. They are often used to finance public benefit projects. In the context of solar energy, a common form of this partnership is known as a power purchase agreement (PPA). Since 2003, major cities like Denver and St. Paul and small municipalities have utilized PPAs to work with private developers to invest in solar projects. PPAs are currently the financial mechanism driving most commercial solar installations.[22]

A power purchase agreement is a financial mechanism in which a third-party developer owns, operates, and maintains a solar photovoltaic system on land owned or leased by a host costumer (in this context, a municipality). The host agrees to terms by which they buy power produced by the system for a set time and price. These arrangements allow the host to avoid the traditional barriers to solar installation, such as upfront cost, as well as often receive a stable and lower rate on electricity than a utility would typically be able to provide. PPAs also ensure that the producer has a stable source of income.[23]

PPAs are particularly beneficial for municipalities because they allow the entity to take advantage of financial benefits typically not available to them due to their tax-exempt status. The incentives are achieved by working with private sector solar developers who pass along the savings to the municipality via a lower electricity rate. The municipality further benefits by reducing upfront costs to installation which are often cost-prohibitive.[24]

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22 Sustainable City Network, 2014
23 epa.gov, n.d; Sustainable City Network, 2014
24 Ibid

A unique opportunity available to municipalities comes via the Morris Model--so called for the location of first use in Morris County, New Jersey. The process for this model is different than for a traditional PPA in that it involves the creation and sale of bonds, but follows generally the same principles. The basic premise is that a public entity issues a government bond at a low interest rate and transfers that low-cost capital to a developer in exchange for a lower PPA price (source?).

According to research on municipal PPAs in Massachusetts, the most common issue cited as a challenge to the process was fear that the solar developer would leave in breach of the contract. The authors recommend that municipalities clearly draw up contracts with clauses that protect them in that case, since budgets can hinge significantly upon the projected savings from a PPA. They also suggest seeking legal counsel considering the complex nature of the contracts.[25]

In early 2014, Austin Energy, a municipal utility in Texas, signed a 20 year PPA with Recurrent Energy to purchase 150 megawatts of power from two new large installations for less than five cents per kilowatt, the lowest recorded price to date for such an arrangement. The estimated price per kilowatt in the area is about $0.07 for natural gas, $0.10 for coal and $0.13 for nuclear.[26]

Austin Energy has a 35 percent renewable energy resource goal by 2016 and an overall solar goal of 200 megawatts by 2020. The utility is currently at about 25 percent renewable, much of it made up by its 850 megawatts of wind.

25 Kelly, Mendelson, Suzuki & Szekely, 2012
26 Wesoff, 2014

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photo credit: flickr user William Cho

7 CONCLUSION & ADDITIONAL RESOURCES

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CONCLUSION

While solar energy presents a novel and exciting resilience opportunity, it alone is insufficient to address global climate change and foster resilience in communities across the US. However, research suggests that solar energy can have a role in improving resilience at the local government level in a variety of ways, in all phases of resilience. Given that a unanimous scientific consensus suggests that weather will become more severe, and extreme events will become more frequent, any means of improving current resilience practice is beneficial to both the field and society at large. Energy specifically is expected to become increasingly vulnerable due to global climate change, evidenced in the most recent National Climate Assessment[1] which states that "energy supply...will be increasingly compromised by interrelated climate change impacts."

Actions taken to increase resilience are inherently predicated upon assumptions of climate change, and any action taken against a force that is not certain comes with risks. Solutions such as increased solar energy capacity hedge against this risk because they come with "no regrets" and co-benefits and often contribute to existing community goals. Solar energy is emissions-free; it is becoming cheaper every year; it is the most abundant source of energy on Earth; it does not need to be imported from foreign lands; it is safe and has no danger of fallout events as seen in Chernobyl and Fukushima; and it can be used in open spaces and in the most densely populated urban centers in the world. The most recent National Climate Assessment[2] states that "the nation's economy, security and culture all depend on resilience." This guidebook demonstrates that the integration of solar energy and local government resilience planning can improve the resilience of the nation's communities.

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1 Melillo, Richmond & Yohe, 2014
2 Ibid

ADDITIONAL RESOURCES

The following documents and websites are great sources for more information on topics listed throughout this guidebook:

Baltimore Disaster Planning & Preparedness Project, the city's combined hazard mitigation and climate adaptation plan, provides an excellent example for local governments interested in taking a holistic approach to energy and climate issues. It is available at http://www.baltimoresustainability.org/disaster-preparedness-and-planning-project

The Solarize Guidebook: A Community Guide to Collective Purchasing of Residential PV Systems, provides a wealth of information about how to start a community solarize campaign, and is available at http://www.nrel.gov/docs/fy12osti/54738.pdf

The Green Buildings and Environmental Sustainability Element of the Master Plan for Lawrence Township, New Jersey, is an example of how local governments can incorporate solar energy into comprehensive planning efforts. It is available at http://www.lawrencetwp.com/documents/planning/Lawrence%20Sustainability%20Element.pdf

The Local Government Energy Assurance Guidelines, from Public Technologies Institute, provide an in-depth overview of the energy assurance planning process, and are available at http://www.pti.org/index.php/t1/more/82

Solar Briefing Papers, from the American Planning Association, contain six separate reports about the nexus of solar energy and planning. They are available at http://www.planning.org/research/solar/briefingpapers/

Planning for Solar Energy, from the American Planning Association, is a comprehensive look at how local government officials can effectively plan for solar energy. It is available at http://www.planning.org/store/product/?ProductCode=BOOK_P575[3]

Rebuilding Greensburg, Kansas, as a Model Green Community: A Case Study, outlines the process of rebuilding a community in an environmentally-conscious way after a disaster. It is available at http://www.nrel.gov/docs/fy10osti/45135-1.pdf; Also see Rebuilding It Better—Greensburg, Kansas: High Performance Buildings Meeting Energy Savings Goals, available at http://www.nrel.gov/buildings/pdfs/53539.pdf

Public Benefit Funds: Increasing Renewable Energy & Industrial Energy Efficiency Opportunities, provides information about state-level public benefits funds and how they can fund various projects at the local level. It is `available at http://www1.eere.energy.gov/manufacturing/states/pdfs/publicbenefitfunds.pdf

3 Free for APA members; available for purchase for non-members

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