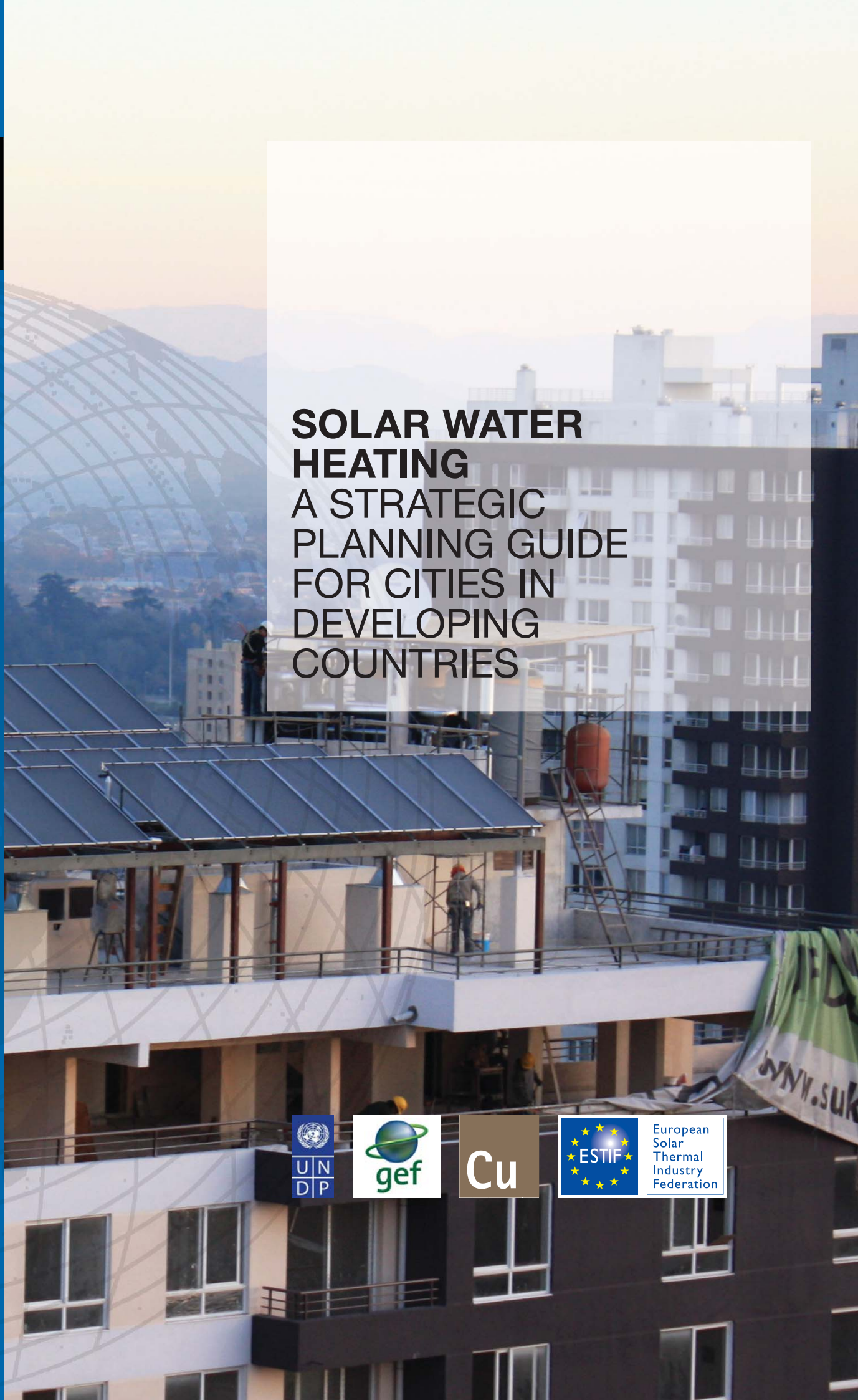
UNEP

SOLAR WATER HEATING
A STRATEGIC PLANNING GUIDE FOR CITIES IN DEVELOPING COUNTRIES



UNITED NATIONS ENVIRONMENT PROGRAMME

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The objective of the GSWH project is to develop, strengthen and accelerate the growth of the solar water heating (SWH) sector.

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EXECUTIVE SUMMARY

As the world's population continues to move into cities and urban energy demand increases, local officials – especially those in developing countries – are increasingly under pressure to address a range of energy, economic, and climate priorities. Cities, for example, produce approximately three quarters of the world's greenhouse gas emissions and account for a similar proportion of the world's energy demand.

At the same time, thermal energy consumption across the globe – including energy used for water heating – has been rising steadily since 2000 and is expected to continue to be a major proportion of total global energy demand in the future. Addressing these issues will require creative new energy, economic, and policy solutions.

Solar water heating (SWH) has significant potential to help local officials and urban planners address the needs and priorities of their jurisdictions. At the residential and commercial building level, SWH can provide a sustainable, reliable and cost-effective option for end-users. At the city level, SWH can improve energy access for city residents, improve the stability of energy costs and the reliability of the electrical grid, create opportunities for new jobs, and reduce a city's greenhouse gas footprint.

Despite these benefits though, there are number of persistent market barriers that impede SWH market development in cities (see Section 4.1). This includes high upfront costs, inadequate financing, and lack of skilled labor. In many jurisdictions, there is also a general lack of awareness of SWH market potential and/or the perception that SWH is too complicated.

Facing these challenges, how can city officials effectively align stakeholder interests, mitigate market barriers, and create successful policies and programs to drive SWH market development?

A SWH strategic plan is a key planning tool that can help urban leaders in developing countries across the globe jumpstart SWH market development. This document provides a detailed overview of the SWH strategic planning process (see Section 2), describing key steps in the process. This includes initial steps to build political support, like recruiting support from top city leadership, designating a SWH coordinator, and convening advisory committee members. It also describes how SWH coordinators can analyze the city's installation baseline, identify the most important market development barriers, and leverage SWH development opportunities.

Local officials and planners can then establish SWH market goals and the necessary enabling policies and programs to achieve them. Throughout this document, a range of SWH policies, programs, and case studies are described, which have helped jumpstart SWH market development in jurisdictions ranging from Kaohsiung City in Taiwan, to the Lebenese Republic in the Middle East, to the U.S. state of California.

Key SWH policies and programs include:

- **Incentive programs** that can increase SWH access by reducing high upfront cost and/or increasing SWH competitiveness compared with conventional (often subsidized) fossil fuels. This encompasses a range of different mechanisms, including upfront rebates, performance-based incentives (PBIs), and hybrid incentive structures (see Section 4.2).
- **Financing and innovative business models** that reduce high upfront costs, mitigate financial risk, and increase customer access to SWH. This includes low-interest lending programs, utility on-bill programs, and innovative contractor business models that provide "heat as a service" (see Section 4.3).
- **SWH mandates and regulations** that address landlord-tenant barriers and low customer awareness of SWH. A number of jurisdictions have implemented mandates or regulations that require the installation of SWH systems in new and existing buildings, at the time of building sale or lease, or at the time that existing heating systems are replaced. This section also includes an overview of utility mandates, which require utilities to derive a certain portion of their total energy load from renewable resources like SWH (see Section 4.4).
- **Permitting, training and quality control programs** that can address challenges related to the lack of skilled labor and/or poor quality of SWH installations in local jurisdictions. City leaders can work with industry to address these challenges – and improve the strength of the SWH market – by implementing streamlined SWH permitting processes as well as new training or certification programs (see Section 4.5).
- **Outreach and education programs** that can address SWH information, awareness and communication gaps. These include consumer advertising and awareness campaigns, group purchasing programs, and demonstration projects – all of which increase customer awareness of and confidence in SWH (see Section 4.6).

Ultimately, SWH represents an untapped renewable energy resource and market opportunity for many cities in developing countries. This guide provides a helpful starting place for planners, elected officials, and other city leaders to build a SWH market in their locale. While there are barriers to SWH, these obstacles can be overcome with a strategic planning process and the implementation of targeted and effective policies and programs.

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SECTION 1 **INTRODUCTION & PROJECT GOALS**

This report serves as a practical guide to assist local leaders develop actionable plans for solar water heating (SWH) deployment in developing countries. It includes an overview of solar thermal markets and describes solar thermal technologies, market barriers, international best practices, case studies, and potential policies and programs that can be implemented by urban leaders in developing countries.

Cities produce approximately three quarters of the world's greenhouse gas emissions and account for a similar proportion of the world's energy demand (UNEP-DTIE, n.d.). By 2050, it is anticipated that 66% of the world's population will live in urban areas (United Nations Department of Economic and Social Affairs, 2014). In an increasingly urbanized world, municipal energy policy will have a significant impact on the ability of global leaders to reduce greenhouse gas emissions and drive sustainable development. Policymaking at the city level – particularly for rapidly growing cities in developing countries – provides a major opportunity to drive economic development with lower environmental impact.

At the same time, global thermal energy consumption, including energy used for water heating, has been rising steadily since 2000 and is expected to continue to be a major proportion of total global energy demand in the future (Eisentraut & Brown, 2014). As the economies of developing countries continue to grow and consume greater amounts of energy, it will be important for municipal leaders to explore opportunities presented by SWH (and other renewable thermal energy technologies) in order to address climate, energy, and economic priorities.

Solar water heating provides a simple, cost-effective, and sustainable means of heating water for residential, commercial, and industrial applications. As described in Box 1 on the next page, SWH provides a number of important benefits for developing countries, including greenhouse gas emission reductions, increased energy access, improved quality of life, and new economic development opportunities. It can also mitigate burdens on local governments and infrastructure by reducing pressure on the national power system and diminishing pollution produced by conventional energy sources.

BOX 1

Benefits of SWHs in Developing Countries

Increased local deployment of solar water heaters (SWHs) in developing country cities provides numerous opportunities and benefits:

- **Energy security**. Developing nations are often subject to volatile fossil fuel energy imports, which are expensive and/or drain public resources due to government subsidies. This is especially problematic for many small island developing states (SIDS), which rely heavily on imported liquid fuels to provide domestic water heating and electricity generation (IEA-RETD et al., 2012). Fluctuations in fossil fuel prices can burden national and local governments and inhibit development. Large-scale deployment of cost-effective SWH can help to stabilize energy costs and reduce fuel import dependence and the burden on local and national governments (e.g. through reduction of energy subsidies).
- **Economic development opportunities**. Large-scale deployment of SWH facilitated by government programs can provide valuable local business and employment opportunities. In Tunisia, for example, the successful PROSOL SWH program created more than 3,500 direct jobs from 2002 to 2010. Over that time period, the number of qualified installers increased from 100 to 1,200 and the number of SWH companies selling SWHs increased from 8 to 50 (Touhami, 2011).
- **Improved energy access**. It is estimated that a significant proportion of SWH installations in developing countries are installed by households without existing water heating systems: in Mauritius, for example, approximately 47% of the 14,600 SWH systems installed under the first two phases of its grant program were installed in households that did not already have domestic hot water (Walters, 2013).
- **Grid stability and resilience**. Displacement of electric and gas water heaters through large scale deployment of SWH in cities can alleviate grid strain, reduce grid maintenance costs, and provide continued access to hot water during grid outages. In developing countries with mild and tropical climates, electricity is the primary fuel for domestic hot water. In these countries, the share of electricity consumption used for domestic hot water is high. In South Africa, for example, domestic electricity consumption accounts for approximately 35% of peak demand, 40% of which is used for water heating (Ijumba & Sebitosi, 2010). National electricity demand in developing countries is projected to continue to rise, further burdening already unreliable and overstrained urban electricity grids. Deploying SWH in these jurisdictions is one strategy to improve electric grid management and operation.
- **Greenhouse gas emission reductions**. As a mature renewable energy technology, SWH has the potential to reduce greenhouse gas emissions through avoided fossil fuel and electricity consumption (Haselip, Lutken, & Sharma, 2014). Overall, the international building sector is responsible for 30% of energy-related CO_2 emissions, and water heating makes up a large portion of that energy use. Water heating accounts for 24% of residential building energy use (up to 40% in some regions) and 12% of commercial building energy use worldwide.

1.1 OVERVIEW OF THE GLOBAL SOLAR THERMAL MARKET

The global solar heating market is well established. Internationally, there are over 406 gigawatts (GWth) of installed solar heating capacity, which produce approximately 341 terawatt-hours (TWhs) of energy per year (Franz Mauthner & Weiss, 2015). Among major renewable markets, solar heating is second only to wind power in terms of capacity installed and energy produced globally (see Figure 1 below).[1]

However, market growth is uneven across the world. Four of the five biggest markets for newly installed solar thermal heat capacity are located in developing countries. This includes (in order of market share) China, Turkey, Brazil, and India (see Figure 2) (REN21, 2015, p. 21). On the other hand, jurisdictions like Thailand and Taiwan have experienced little SWH market growth (F Mauthner & Weiss, 2013).

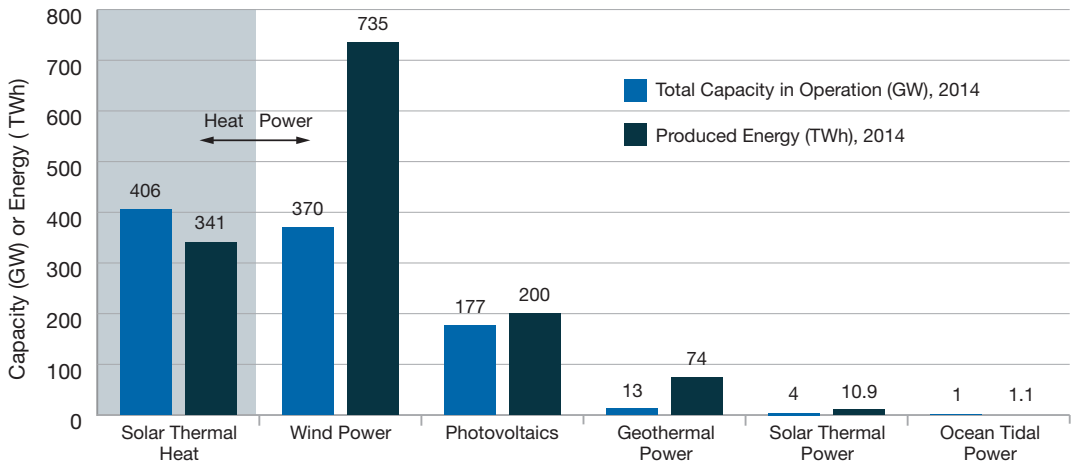

Figure 1. Worldwide solar heating and cooling capacity and production (Mauthner & Weiss, 2015)

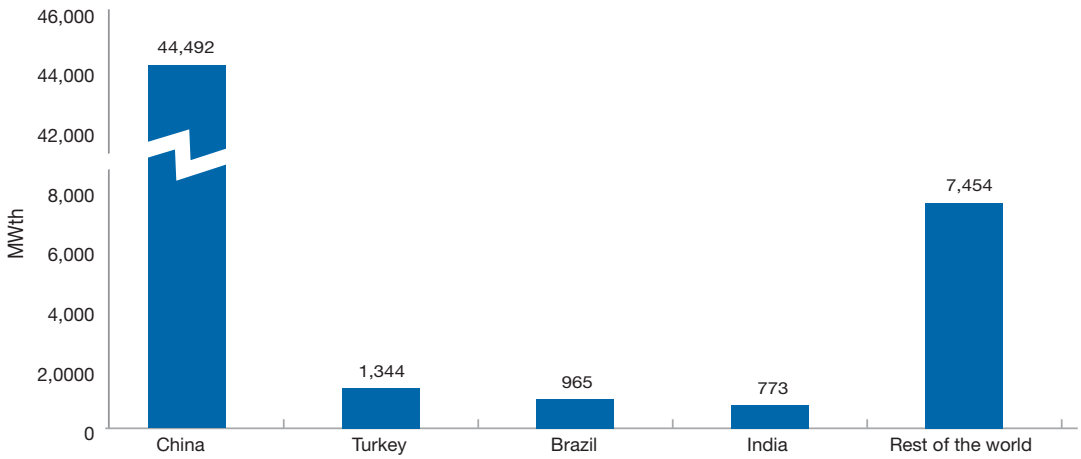

Figure 2. Share of newly installed capacity of SWHs at the end of 2013 in MWth (Franz Mauthner & Weiss, 2015)

1 This excludes some renewable resources like hydropower and biomass, which provide more power than wind or any other renewable energy resource.

This SWH strategic planning guide can assist local leaders in cities across developing country as they plan for deployment of SWH systems. The guide aims to (i) increase awareness of SWH heating technologies among urban planners and other local leaders, especially within developing countries, and (ii) provide them with a step-by-step handbook for developing a strategic plan to increase deployment of SWH technologies.

1.2 STRUCTURE OF THIS REPORT

In support of the goals described above, the guide provides the following information, tools, and resources to support urban planners, policymakers, and other leaders at the local level:

- **Section 2 provides a description of the SWH planning process for local jurisdictions.** This includes the basic structure of a strategic SWH plan, including a discussion of what stakeholders need to be involved in the process, how to fund and launch the strategic planning process, and approaches for conducting a technical assessment of SWH demand and growth potential within a local jurisdiction.
- **Section 3 provides an overview of SWH applications and technologies.** This includes an overview of the major types of applications (e.g. domestic hot water, process heat, etc.), solar collectors and other system components, and key system and building design parameters.
- **Section 4 provides a description of SWH barriers, policies and programs.** This focuses especially on policies and programs that can be implemented at the local level to address market barriers and support robust development. Each policy section includes a brief description of policy design options as well as case studies and examples of how jurisdictions have implemented them. It concludes with a summary of best practices and additional tools and resources that can help local policymakers implement policies in their jurisdictions.
- **Section 5 provides a brief conclusion**, summarizing next steps that elected officials and planners can take to realize the benefits of SWH market development within their communities.

SECTION 2
OVERVIEW OF THE SWH STRATEGIC PLANNING PROCESS FOR CITIES

Local governments are in a unique position to mitigate barriers, leverage opportunities, and drive widespread adoption of SWH. As described in Box 2, by developing a SWH strategic plan, local leaders can effectively align stakeholder interests, mitigate market barriers, and create successful policies and programs to drive SWH market development.

BOX 2

Benefits of SWH Strategic Planning for Local Governments

The SWH strategic planning process can provide a number of benefits to local governments:

Advance local energy, economic, and climate priorities. Local government leaders across the globe are under increasing pressure to take action to address a range of energy, economic, and climate priorities. This may include, for example, reducing the cost (and volatility) of their citizens' energy bills, mitigating greenhouse gas emissions, improving energy security, or driving local economic development activities. By implementing a SWH strategic planning process, local leaders can identify major barriers (or opportunities) to energy priorities (see Section 4). By working closely with a range of stakeholders, local leaders can gain deeper insight into key market issues, which will support development of a clear strategic direction for SWH. This could include the creation (or expansion) of projects or policies that simultaneously support energy, economic, and climate priorities.

- **Improve public communication and align stakeholder interests**. Stakeholder engagement and communication around energy and climate policies can be challenging for local officials. With regard to SWH, the technology is often viewed as complex, and local officials and other

stakeholders may lack awareness of how new policies or regulations will impact their constituencies (e.g. ratepayers, building owners, low-income groups, industry, investors, etc.). Such confusion could make policies controversial, especially if government officials try to introduce new policies without buy-in from key stakeholders in their city. The strategic planning process provides a unique opportunity for government officials to convene stakeholders and align interests. By creating a participatory process – built around a core strategic advisory group (see Section 2.2) – local leaders can foster a sense of ownership for the strategic plan and give stakeholders meaningful opportunities to shape policy. In some cases, a strategic planning process has been credited with significantly improving relationships between elected officials, administrative staff, and the constituents they serve (Poister & Streib, 1997).

- **Leverage public and private sector resources**. Local government leaders face significant resource constraints as they create and administer SWH policies and market development programs.. This may include, for example, lack of staff capacity, funding, or technical resources. These challenges are compounded in many developing countries, where SWH investment may be further constrained by tough macroeconomic conditions (e.g. high inflation, currency risk, poor credit ratings, etc.).

  Well-designed strategic planning processes may foster development of a common vision for SWH across stakeholders. In the best cases, SWH strategic plans identify opportunities to leverage resources from utilities, national governments, multilaterals, and the private sector. Strategic planning can ultimately increase the reach of market development programs and foster development of a sustainable SWH market over the long term.

- **Improve local policies, programs, and services**. Local governments are responsible for administering a wide range of services for constituents, requiring them to balance often competing objectives like consumer protection, safety, or economic development. Given the wide range of local government objectives – and the diffusion of local authority across departments in local governments – it can be challenging for leaders to provide streamlined policies, programs or services to support SWH market development.

  By fostering communication across government departments and industry leaders, the SWH strategic planning process can help government officials identify inefficiencies and improve local policies and services. For example, a number of jurisdictions have been able to streamline the SWH permitting process as a result of strategic plans, creating significant cost savings for both installers and permitting authorities (U.S. Department of Energy, 2011a).

Experience shows that the most challenging part of accelerating SWH market development is getting started. Local leaders should consider a range of market development issues, each of which may elicit a diversity of stakeholder concerns, needs, and perspectives. Taking the time to organize a strategic plan will help create the most effective policies and programs for each unique market context.

While there is no one right way to develop a SWH strategic plan, Figure 3 below illustrates five key steps that have been used with success in jurisdictions across the globe. Steps in the process include (i) establishment of the SHW market development initiative and designation of a local coordinator, (ii) creation of a SWH advisory committee or taskforce, (iii) identification of local barriers and opportunities for market development, (iv) evaluation of the installation baseline and creation of SWH development targets, and (v) development of local programs and policies.[2]

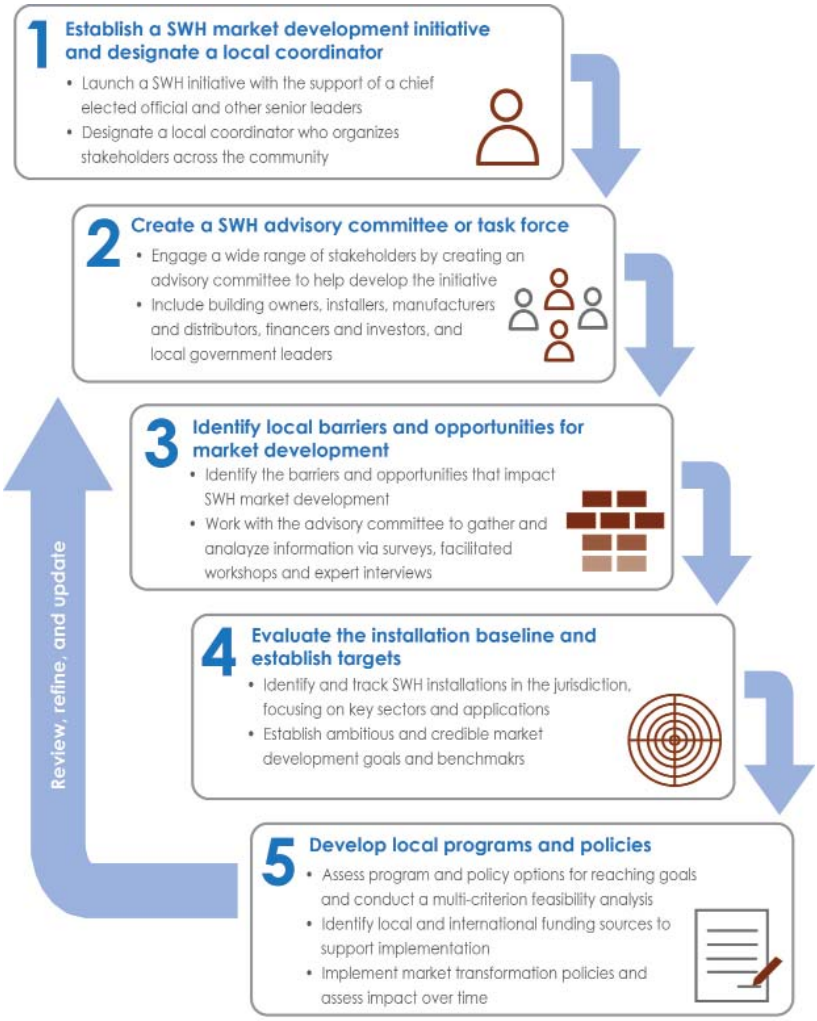

Figure 3: The SWH Strategic Planning Process for Cities (Meister Consultants Group, 2015).

2 This approach is based on a number of well-established planning methodologies. Interested readers may also consult best practices from Solar America Communities assessment (U.S. Department of Energy, 2011a), Fraunhofer Institute for Solar Energy Systems (ISE) Smart Energy Cities initiative (Stryi-Hipp, 2013), ESTIF's Guidelines for Policy and Framework Conditions (European Solar Thermal Industry Federation, 2012), and the UK Department for Communities and Local Government's Multi-criteria analysis: a manual (Great Britain & Department for Communities and Local Government, 2009).

The steps in this process are complementary, and it is generally recommended to implement the strategic planning process in an iterative and reflexive fashion, reviewing and refining throughout the process. For example, early in the process, local leaders may propose an initial market development target – and create pilot programs designed to achieve this target. This can be helpful for testing an approach and engaging and mobilizing stakeholders. As additional information becomes available – and understanding of market opportunities and barriers deepens – local leaders may refine programs, policies and development targets.

The following sections provide additional detail on steps in the SWH strategic planning process.

2.1 ESTABLISH A SWH MARKET DEVELOPMENT INITIATIVE AND DESIGNATE A LOCAL COORDINATOR

Effective market development strategies require strong leadership. It is imperative that an influential convener supports the SWH strategic planning process. This may be the chief elected official (e.g. the mayor) or another executive leader who has the authority to drive the process forward. A small group of influential leaders could also initiative the planning process.

Next, the convener should designate a local SWH coordinator to manage the day-to-day responsibilities of developing the SWH strategic plan. A strong coordinator will organize and move forward all aspects of the strategic planning process, as well as the resulting recommendations and next steps. This encompasses coordinating outreach and engagement of key stakeholders within a community's SWH initiative – including advisory committee members (see section 2.2), local government agencies, and other stakeholders – and tracking development and achievement of the community's SWH goals and objectives.

In many cases, the local government will hire the SWH coordinator, though successful coordinators could also be employees of local non-profits or universities. Importantly, the SWH coordinator should be placed in a clear leadership position and given authority to organize the planning process. This may include, for example, having the coordinator report directly to city mayor, town administrator, or another executive leader. A clear leadership designation is an effective means to raise the profile of the SWH strategic planning initiative and also helps facilitate coordination across government departments.

2.2 CREATE A SWH ADVISORY COMMITTEE OR TASK FORCE

Fostering development of strong local markets requires engagement and support from a wide range of stakeholders. Stakeholders include people who would be involved in or impacted by a SWH initiative, such as building owners (end-users), permitting authorities, plumbing contractors/installers, local manufacturers and distributors, finance and

investment leaders, municipal leaders, and advocacy groups, among others. By creating an advisory committee that includes representation from these different groups, local government leaders can gain insight into the perspectives of various market participants and better reach out to different constituencies. Guidance from the advisory group is essential to shape development of a robust SWH market and the local coordinator should strive to organize an advisory committee that reflects the diversity of groups and organizations who would be interested in or effected by a SWH initiative.

BOX 3

SWH Planning in Practice: New York City's SWH Advisory Committee (Veilleux & Rickerson, 2013)

In 2012, the City University of New York (CUNY) convened stakeholders from across the city to develop the New York City (NYC) Solar Water Heating Roadmap. The initiative was developed by the NYC Solar America City Partnership, a federally funded program to support large-scale solar energy market growth in New York. Led by CUNY, the partnership was comprised of senior officials from the New York City Economic Development Corporation and the Mayor's Office of Long-term Planning and Sustainability.

CUNY and its partners recognized that robust input from a wide range of stakeholders was crucial to create a strong strategic plan. As a result, they facilitated a series of stakeholder roundtables and interviews with industry, permitting, and government leaders in order to identify market barriers and develop recommendations to grow the SHW market.

Key stakeholders included:

- **Planners and city officials from** the Mayor's Office of Long-term Planning and Sustainability as well as the New York City Economic Development Corporation.
- **Permitting and inspection authorities** from the NYC Department of Buildings, who explored issues and options related to streamlined permitting and soft cost reductions for SWH.
- **State energy agency representatives** from the New York State Energy and Research Development Authority, (NYSERDA), who provided data to support local analysis on the number and types of installations in the city.
- **SWH industry leaders**, including manufacturers, suppliers, installers, and industry groups, who provided important insights on market barriers, opportunities, and project economics.
- **Building owners and consumer organizations** that provided insight on fuel price, volatility, and SWH performance concerns from the end-user perspective.
- **Community and environmental NGOs**, who explored how SWH could address local community, environmental, and climate concerns.
- **Utility representatives**, who discussed potential grid-related impacts and resources for SWH market development.
- **Investors**, who provided insights on investment needs and financing approaches to address market barriers.

2.3 IDENTIFY LOCAL BARRIERS AND OPPORTUNITIES FOR MARKET DEVELOPMENT

A number of barriers can slow market development. As discussed in Section 4, typical market development barriers include lack of supportive policy, financing and upfront costs, and a lack of awareness and customer trust.

SWH market barriers will typically play out in different ways depending upon the unique local market context in any given community. For that reason, the local coordinator and advisory committee should identify those barriers that have the biggest impact on market development in their city or region and address them first. In addition, special consideration should be given to what policies or programs could be deployed and what stakeholders (e.g. national or state policymakers, local building officials industry leaders, etc.) can best address them.

In assessing barriers, the local coordinator should consider gathering and analyzing information from both the advisory committee as well as a much broader network of stakeholders. Common approaches to gathering information include online or mailed surveys, facilitated workshops, and expert interviews. In addition, there are market analysis tools, such as the *Solar Water Heating TechScope Market Readiness Analysis Tool* that can be used to benchmark and evaluate SWH markets.

BOX 4

SWH Planning in Practice: Using the Solar Water Heating TechScope Market Readiness Analysis Tool

The SWH TechScope Market Readiness Analysis Tool aims to improve the understanding of opportunities and challenges related to development of vibrant SWH markets. Policymakers can use the TechScope to benchmark achievements within their jurisdiction against specific objectives or other jurisdictions, and set future SWH market and policy goals. The tool enables users to evaluate SWH markets against four key parameters. These include the:

- **National support framework**, which covers an assessment of government policies, regulations, and engagement programs.
- **National conditions**, such as solar insolation, market penetration, energy trends, and competitiveness of SWH compared to other heating fuels.
- **Financing conditions**, which takes into account macroeconomic conditions, as well as access to loans and the cost of financing.
- **Business climate**, such as a measure of the ease of doing business in the region, the existence of SWH quality standards, and certifications, among other factors.

The SWH Techscope was originally designed for application on the national level, but can be adapted for use at the city level (Rickerson et al., 2014).[3] An overview of the tool is available at www.solarthermalworld.org.

3 SWH Techscope has been deployed to assess a variety a national SWH markets, including Albania, Lebanon, India, Chile, Mexico, Mauritius, and Seychelles. UNEP is currently deploying the tool to analyze a wide range of other jurisdictions.

In 2015, TechScope Readiness Assessments were conducted for Mauritius and Seychelles, two small island developing states (SIDS) in the Indian Ocean at different stages of SWH market development and government policy. Mauritius had recently completed two phases of a SWH grant program. Leaders are interested in assessing the state of their SWH market in preparation to launch—and potentially redesign—the next phase of their SWH program. Seychelles, by contrast, had less enabling infrastructure for SWH in place and aimed to use the assessment to identify gaps in knowledge and the country's needs in fostering a stronger enabling environment and market for SWH.

Policymakers may find that the most difficult and time-consuming aspect of conducting a TechScope assessment is the data collection. Jurisdictions with small and undeveloped SWH markets often lack easily accessible data sources for many of the key indicators needed for the assessment (e.g. market penetration, share of fuels used for domestic water heating). Techschope can also identify in gaps in available data that would ultimately be needed to develop and manage a strong SWH strategic plan. It may be necessary to conduct the TechScope assessment alongside an installation baseline evaluation (Section 2.4) in order to secure the required data.

2.4 EVALUATE THE INSTALLATION BASELINE AND ESTABLISH TARGETS

A SWH installation baseline survey identifies all known existing SWH installations within the jurisdiction. In some jurisdictions, a comprehensive survey of all installations may not be feasible, and policymakers may opt to conduct a high level survey in order to get a representative sample of SWH installations. Establishing a baseline is an important part of the planning process, as it provides insight into a community's level of experience with SWH and enables coordinators and advisory committees to establish realistic market development goals.

Most installation baseline surveys include information about the type of SWH systems installed, their size, the sector (e.g., commercial, residential, industrial, or agricultural), as well as their application (DHW, space heating, process heat, etc). Coordinators should also use the survey to collect data about the conventional heating source that the SWH systems displace. Information about current installations may reside within databases managed by several organizations, including city energy or utility departments, renewable energy incentive programs, or permitting offices. Additionally, in some jurisdictions, state or provincial clean energy associations may be excellent sources for statistics on installed solar energy systems. Alternately, coordinators may wish to survey all known SWH installers active in the jurisdiction to gather information on installations. Jurisdictions on islands without domestic SWH manufacturing capacity may also be able to draw from import databases in order to quantify solar product imports.

The baseline survey and barriers and opportunities analysis (see section 2.3) provide evidence-based information that the coordinator and advisory committee can use to set

realist targets and goals for SWH market development. Specific goals for a citywide SWH initiative may vary considerably. They could include the number of installations across key sectors (e.g. 10,000 residential installations by 2020) or a capacity goal (e.g. 25 MWth by 2025). SWH development goals may be related back to greenhouse gas emission reduction targets (e.g. SWH will contribute 5% of city's overall GHG emission reduction goals), broader renewable energy (or energy efficiency) mandates for buildings (e.g. all new building must use SWH to meet 40% of hot water load), or citywide air emission quality goals (e.g. deploy SWH to reduce particulate matter or carbon monoxide emissions from oil heating).

BOX 5

SWH Planning in Practice: Conducting Surveys and Setting Targets

If up-to-date databases are not readily available, a robust surveying process will be crucial for an accurate assessment of a jurisdiction's installation baseline. The key aspects of a detailed installation baseline survey include:

- Identifying and mapping the target demographic
- Identifying key parameters
- Designing the surveying methodology and questionnaire
- Conducting the survey
- Analyzing the results

To effectively use surveys to establish realistic targets for SWH policies, coordinators should survey not only the installation baseline (e.g. current owners/users of SWH, SWH installers/manufacturers, databases, associations), but also potential end users' knowledge of and willingness to install SWH systems. More details on how to effectively conduct a market assessment for these purposes can be found in *Development of an area based energy service company (ESCO) model for solar water heating in India*, a report prepared for the Ministry of New and Renewable Energy of India, which also provides model questionnaires for various stakeholders (Mercados, 2010). These questionnaires have been summarized in Appendix I – Sample Survey Questions.

2.5 DEVELOP LOCAL PROGRAMS AND POLICIES

Once market and barrier assessments have been conducted and achievable targets have been identified, local leaders and policymakers should assess the most suitable program and policy options for achieving their SWH market development goals. A range of programs and policies can address local barriers to development (see Section 4), and local leaders should weigh the costs and benefits of each option, as well as their feasibility at the local level. Box 6 describes the utilization of one policy evaluation technique, multi-criterion analysis, in more detail.

Given the financial difficulties that many cities face, it is crucial for local leaders to leverage relationships with the private sector, utilities, and international development agencies to secure sources of funding beyond public money. Section 4.2 discusses funding and financing models in more detail.

Once programs and policies have been implemented, local leaders should assess their effectiveness. In addition to establishing the market baseline, metrics for measuring a program or policy's effectiveness should be determined prior to policy implementation. The SWH advisory committee or task force, as well as government officials administering the programs and policies, should meet on a regular basis (e.g. quarterly, annually) to evaluate the program or policy's performance and make adjustments as needed.

An effective SWH strategic plan extends beyond individual programs and policies, but represents a longer-term commitment to developing the SWH market. Policies and programs will need to be reviewed and refined over time—and discontinued if need be.

BOX 6.

SWH Planning in Practice: Using Multi-criterion Analysis to Develop Local Programs and Policies

In addition to high level market assessment tools like the TechScope, approaches to assess policy options and address barriers such as multi-criterion analysis (MCA)[4] can be valuable to local leaders. Local SWH markets are complex, and the costs and benefits of various opportunities are not always quantifiable and can be difficult to weigh against each other. Moreover, local stakeholders may be mistrustful of the decision-making process and lack of transparency from policymakers can lead to further dissatisfaction.

MCA is a process that aims to address these difficulties. MCA uses a weighted scoring method that allows for the evaluation of both quantitative and qualitative criteria, placing important emphasis on establishing objectives, selecting and determining the relative weight of each criterion, and providing a transparent process that can involve stakeholders.

Once key criteria for assessment are identified, a weighting system and performance matrix is utilized to compare options and the performance of each option against each criterion. In the context of SWH and local planning, various policy options being considered by policymakers might be included, with criteria including cost of implementation, projected growth in installations, technology types to be included, potential GHG emissions reductions, energy security benefits, accessibility across different income classes, etc. Policymakers could then weigh each criterion for its contribution to the final score (e.g. island jurisdictions reliant on fuel imports might place more weight on energy security than a jurisdiction with significant domestic fossil fuel production). With all criteria and score weighting made available, stakeholders in the advisory committee could provide input on additional criteria or modifications to scoring methodology.

4 Multi-criterion analysis is also sometimes referred to as multi-criteria analysis or multi-criteria decision analysis.

Guides to deploying MCA include “Multi-criteria analysis: a manual” by the UK Department for Communities and Local Government, which highlights key features of MCA, compares it to other monetary-based analytical techniques, walks through the process of conducting an analysis, and provides case studies that have successfully utilized MCA (Department for Communities and Local Government, 2009)

SECTION 3 **SOLAR WATER HEATING TECHNOLOGIES**

This section provides an overview of SWH technologies commonly deployed across cities in developing countries. It includes a basic description of SWH applications, an overview of how SWH systems work, and a description of major components and building design parameters for residential and commercial systems. It also includes an overview of key characteristics that make residential and commercial facilities good candidates for SWH.

3.1 SOLAR THERMAL APPLICATIONS

Solar thermal systems can provide a variety of heating and cooling applications. The majority of systems are designed to heat domestic hot water (Mauthner & Weiss, 2015). Other uses include process heat, space heating, swimming pool heating, and district heating and solar cooling among others. The following worldwide applications of solar heating and cooling can be used in cities across developing country:

- **Solar domestic hot water**. Heating for domestic hot water is the most common application for SWH. Globally, estimates show that domestic hot water applications accounted for 94% of the energy provided by solar heating systems worldwide in 2013 (Mauthner & Weiss, 2015). SWH can typically meet 40-80% of demand for domestic hot water, which is the most energy intensive use for households in developing nations (REN21, 2015). In countries with high solar insolation and low seasonal variation (e.g. in equatorial countries), SWH can supply up to 100% of domestic hot water demand (G. Stryi-Hipp, personal communication, August 13, 2015)
- **Solar space heating**. In addition to domestic hot water, SWH can also be designed to provide space heating for buildings. These so-called “combi-systems” can maximize the proportion of building energy provided by solar. However, market penetration for solar combi-systems is relatively small. It is estimated that solar-combi systems make up only about 2% of the solar thermal contribution to worldwide energy supply (Mauthner & Weiss, 2015).

- **Solar process heat**. Solar commercial and industrial process heating applications provide hot water for buildings and industries with process heating needs, such as hotels, hospitals, restaurants, car washes, textiles, food processing, water treatment, and desalination. SWH technologies are increasingly seen as a cost-effective means to provide process heat for commercial buildings and industrial processes. China and India, for example, have increased the deployment of solar based industrial process heating substantially in recent years (REN21, 2015), though many projects are still in the demonstration phase (Kempener, Ruud, 2015). In addition, growth in global demand for fresh water (especially in developing countries) is generating an increase in the need for desalination, a highly energy intensive process that traditionally relies upon oil as a fuel (Isaka, 2012). In nations with high insolation and rapid population growth (e.g. Saudi Arabia), concentrated solar thermal desalinatization can dramatically increase access to fresh water.
- **Swimming pools**. SWH can also provide hot water for swimming pools. Applications range from small summer pools, in which case the SWH system enables users to extend the swimming season, to large Olympic sized (indoor) pools that operate year round (RETScreen International, 2004). Globally, estimates show that SWH pool heating accounts for approximately 4% of solar heating's contribution to the energy supply (Mauthner & Weiss, 2015).
- **Solar cooling**. Solar cooling systems use solar collectors to capture heat from the sun, which drives a thermal cooling process (like absorption chillers or desiccant systems) to cool and/or de-humidify buildings (Beerepoot, 2012). The market for solar cooling is just emerging, though it is a promising application especially in countries with dry, sunny climates, high peak cooling loads, and expensive electricity prices (REN21, 2015). Over 75% of the solar cooling systems installed in 2014 were installed in Europe, though interest in solar cooling is growing in many cities, particularly in the Middle East (REN21, 2015, p. 21).
- **District heating systems**. Solar thermal technologies can also be integrated into district energy systems, which connect multiple buildings to central or satellite sources of energy, distributing heat to users through underground pipes in the form of hot water, steam, or chilled water. Integration of SWH into district heating is an increasingly common in some European countries like Denmark (Runager & Nielsen, 2007).

The following sections focus on the most common solar thermal uses – namely SWH for domestic hot water and commercial process heating applications.

3.2 HOW SOLAR WATER HEATERS WORK

A typical solar water system consists of solar collectors, water storage tanks, a controller, piping, insulation, valves, and gauges. Heat is generated from incoming direct and diffuse solar energy radiation, which is converted into useable energy for the building by the solar collector panel. Water or glycol (i.e. non-toxic antifreeze) is circulated through the panel, which transfers heat from the collector, through pipes, and to a storage tank – where hot

water is stored directly or transferred to the storage water indirectly via a heat exchanger (Veilleux, 2013).

The design, installation, and operation of solar thermal systems can vary significantly. For example, there are a number of different types of solar thermal panels, including flat plate collectors (glazed or unglazed), evacuated tube collectors, and concentrating collectors. Each of these has different operating characteristics, which influences its ability to fulfill various heating applications (see Section 3.2.1).

Panels may be mounted on rooftops, on the ground, or integrated directly into a building. Most solar thermal panels are installed on racking mounted on rooftops or on the ground. However, there is growing demand for integration of solar thermal systems directly into buildings (e.g. the façade or balustrade) (Nassab, 2013; Trenkner & Dias, 2014).

Solar thermal systems may also be designed as either active of passive systems (see Section 3.2.2). Active systems use pumps to move water or some other heat transfer fluid through the system. Passive systems rely on a thermosiphon design that uses natural convection based on differing densities to circulate heat throughout the system. Most solar thermal systems installed in the developing world are thermosiphon systems.

Finally, the operation and cost-effectiveness of a SWH system in urban developing country contexts will depend a number of building and technical characteristics (as described in Section 3.2.3). The cost or availability of alternative heating fuels, the need for a large (and consistent) hot water demand, as well as SWH friendly building characteristics are all important considerations to take into account.

Each of these issues is described in greater detail below.

3.2.1 SOLAR COLLECTORS

There are three main types of solar thermal panels, including flat-plate collectors (FPC), evacuated tube collectors (ETC), and concentrating collectors.

- **Flat plate collectors (FPC)**. Flat plate collectors may be either glazed or unglazed collectors (Figure 4). The simplest FPC is an unglazed collector made of plastic. Unglazed FPCs operate at low temperatures (75-95 degrees Fahrenheit) and are mainly used to heat swimming pools.

  Glazed FPCs (Figure 4) operate at low and medium temperatures (85-160 degrees Fahrenheit) and are typically used for domestic hot water and radiant floor space heating applications. They include a housing, typically consisting of a thin rectangular box with transparent glass covers, which provide insulation to trap heat. A network of tubes is distributed through the panel under an absorber plate, which heats a transfer fluid (i.e. water or glycol). The heated fluid is then transported to the storage tank for end-use. Glazed flat plate collectors account for 22.4% of worldwide capacity in operation (Franz Mauthner & Weiss, 2015).

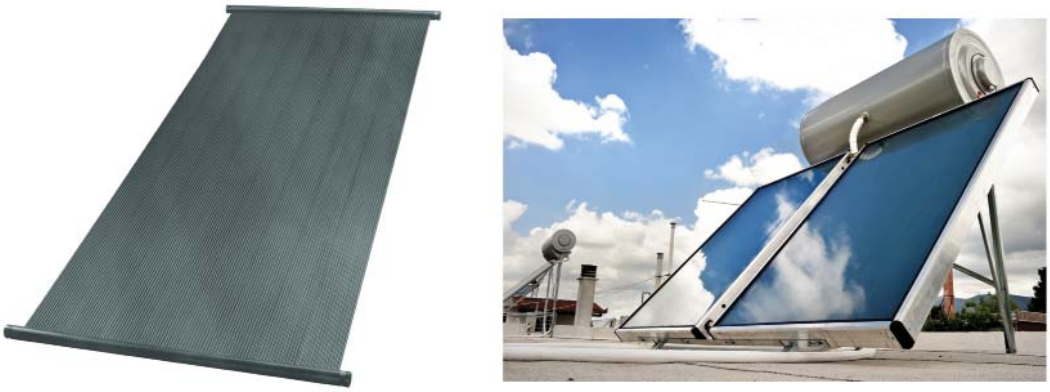

Figure 4. Unglazed (left) and glazed (right) flat-plate collectors (Image source: FPC Aqua Therm Industries and Fotolia)

- **Evacuated tube collectors**. Evacuated tube collectors are appropriate for low to medium-high temperature applications (up to 300 degrees Fahrenheit), including domestic hot water, process heating, or space heating. They absorb solar heat via parallel rows of vacuum sealed glass tubes (Figure 5).

  Evacuated tubes provide a high level of insulation, so that these collectors have very low heat losses to the outside environment. Compared to flat plate collectors, they function more efficiently in areas where ambient temperatures are low and in low irradiation conditions. This makes them a favored choice in many regions with overcast skies (Beerepoot, 2012). Worldwide, ETCs make up over 70% of the SWH market, in large part to their widespread adoption in China (Franz Mauthner & Weiss, 2015).

- **Concentrating collectors**. Concentrating solar technologies are used for medium to high temperature applications (up to 480 degrees Fahrenheit) such as large-scale process heating, industrial processes, boiler makeup water, or for producing steam for electricity generation. They use mirrors to focus sunlight from a large aperture onto a small area. The concentrated light is converted to heat, producing very high temperatures. Concentrated solar thermal collectors have seen limited deployment to date.

Figure 5. Evacuated tube collector (left) and concentrating solar collector (right) (Image source: Fotolia and sopogy.com)

3.2.2 THERMOSIPHON AND PUMPED SOLAR WATER HEATERS

Two main types of solar thermal designs exist for building applications: thermosiphon (natural circulation) and pumped solar thermal (forced circulation) systems (Figure 6).

Thermosiphon systems operate on natural convection, thus there is no requirement for pumps or other technologies to move the fluid. As hot water rises to the storage unit/building, it is replaced by cold water circulating from the bottom of storage unit as illustrated in Figure 6. Due to their design using natural convection, the storage unit must be stored on a higher level than the collector, which tends to limit their overall size. In addition, this type of system is best suited for frost-free climates. Thermosiphon systems comprise 77% of systems globally and accounted for 90% of newly installed systems in 2013, largely due to its prevalence in the Chinese market (Mauthner & Weiss, 2015).

Pumped solar thermal systems, by contrast, use of a pump and control system to circulate water or glycol from the collector through the storage tank. They permit the collector to be installed on the roof and the storage tank to be placed in the basement. These systems are suitable for climates that are prone to freezing and are mainly found in North America and Central and Northern Europe.

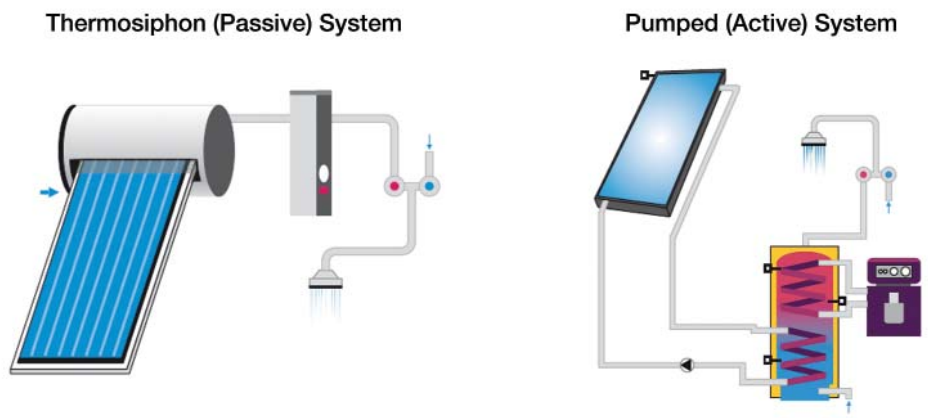

Figure 6. Example of a thermosiphon (passive) circulation system (left) and a pumped (active) circulation system (right) (Beerepoot, 2012)

3.2.3 BUILDING REQUIREMENTS FOR RESIDENTIAL AND COMMERCIAL BUILDINGS

The competitiveness of SWH depends upon a number of requirements, including current access to or cost of alternative heating fuels; large, consistent hot water demand; and SWH friendly building characteristics (Veilleux & Rickerson, 2013). Each of these factors is described below.

The availability or cost of alternative heating fuels heavily impacts SWH economics and market viability. In many developing country cities, there is not regular access to hot water. In such areas, SWH represents a cost effective means to increase access to hot water and improve quality of life for local residents.

In regions with convenient access to hot water, SWH is deployed as an energy saving measure. Here, SWH offsets the demand for hot water where gas, oil, propane, or electricity is used for heating. Countries with high cost heating fuels as well as SWH incentives will more likely have conditions favorable to SWH development. The SWH Techscope Market Readiness Assessment (Box 4, Section 2.3) provides a platform to evaluate the competitiveness of solar heating relative to conventional fuels, taking into account the payback of a typical SWH system (offsetting the predominant heating fuel) and the presence of energy subsidies (Rickerson et al., 2014).

Unlike solar PV, which can feed energy back into the electric grid, in most cases SWH can only be used for local, on-site applications. This means that heat production must be used to meet the immediate thermal load of the building or stored locally in tanks.[5] As a result, buildings with high, consistent demand for hot water tend to enjoy the best return on investment, as they can use more of the energy generated by the SWH system. Large systems also typically receive benefits from economies of scale. Building types with large, consistent hot water demand are commonly found in cities and include multi-family residences, hotels and motels, hospitals, fire stations, laundries, restaurants, car washes, food processing facilities, sewage treatment, and dairies, among others. Single-family homes with several residents are also good candidates (Veilleux & Rickerson, 2013).

Energy demand for hot water or process heating is often difficult to predict. Hot water demand is influenced by a number of variables including user habits, the number and efficiency of appliances, and the required water temperature (Trenkner & Dias, 2014). Compounding this, buildings rarely meter hot water usage, thus, it is challenging to find historical data on hot water usage. There are, however, some commonly applied “rules of thumb” based on utility bill analysis for total heating and hot water usage that can be used to estimate hot water requirements for buildings and hot water applications. Stakeholders may also utilize RETscreen or analogous software to quickly estimate the demand for hot water and determine the appropriate sizing for SWH systems. Alternately, stakeholders could temporarily meter hot water usage using a flow meter or similar device when considering SWH installation, especially for large, commercial systems.

A range of other project and building characteristics influence successful SWH projects. Projects with favorable economics often incorporate short piping runs (i.e. less copper), large and unhindered roof areas with accessible basement storage space, and unobstructed, south-facing roof space to position the panels. Developers and installers also note that commercial buildings from one to twelve stories are more desirable targets for SWH development than taller buildings. Taller buildings require longer piping runs and tend to lack the roof space needed to produce the requisite volumes of water to supply building demand (Veilleux & Rickerson, 2013). For finding appropriate rooftops in cities, the SWH coordinator and advisory committee can identify favorable sites as part of the baseline survey process (sections 2.3 and 2.4).

5 An exception is using SWH for a district heating network. In this case, it is possible to meter thermal energy generated by the SWH system back to the heating grid. A number of jurisdictions have recently piloted SWH applications on district heating networks with good results. Interested readers should consult Djebbar, McClenahan, Sibbitt, Thornton, & Wong, 2014 as well as Runager & Nielsen, 2007.

SECTION 4 **SWH BARRIERS, POLICIES AND PROGRAMS FOR CITIES**

4.1 SWH MARKET BARRIERS AND POLICIES

There are a number of persistent market barriers (Table 1) to increasing deployment of SWH across cities in developing country.[6] At a high-level, these barriers can be grouped into issue areas related to: (i) financing and the installation cost of SWH projects, (ii) lack of awareness at the end-user and municipal levels, and (iii) quality control for both equipment and service providers. In addition, municipal governments may face significant challenges related to jurisdictional authority and institutional capacity in implementing certain policies and programs (see Box 7).

Table 1. SWH barriers in developing countries

Barrier	Description
Financing and installation costs	• High upfront costs • Lack of accessible financing for SWHs • Import tariffs and other taxes on equipment • Subsidies on fossil fuels reduce favorability of SWH economics
Lack of awareness	• Lack of awareness of benefits of SWHs at end-user level • Few companies offering solar thermal systems, which are able to advise potential customers • Inadequate technical expertise within government ministries • Unfamiliarity with SWH in building departments that lead to permitting delays

6 Many of the barriers and challenges discussed here can be present in both developed and developing country cities. The impacts and magnitude of barriers will play out differently across regions, depending upon the unique national and local context. Some experts have pointed out, however, that financers' perception of investment risks resulting from of these (and other) challenges are greater in emerging economies, resulting in higher cost of capital for infrastructure investments like renewable energy projects (Deutsche Bank & Global Climate Partnership Fund, n.d.). This creates additional challenges for local governments that seek foreign investment to support SWH development strategies.

Barrier	Description
Customer trust in functionality / Quality control	• No standards for equipment • Few skilled installers • No installer and product certifications • Customers are not able to evaluate SWH system performance due to lack of simple, cheap and robust monitoring solutions

BOX 7

SWH barriers for municipal governments

In addition to the high-level barriers to SWH market deployment (see Table 1), municipal governments typically face challenges related to lack of intra-governmental coordination and lack of institutional capacity, which may restrict the types of policies and programs that can be effectively implemented in the municipality.

- **Lack of jurisdictional authority or intra-governmental coordination**. Municipal governments may face jurisdictional barriers resulting from policies at the national level that cannot be easily or solely addressed at the local level. For example, fuels used for domestic water heating (e.g. liquefied petroleum gas, electricity, etc.) are often subsidized by national governments in developing countries. The IMF estimates, for example, that the value of annual pre-tax subsidies[7] for electricity in developing countries is over $200 billion (Coady, et al. 2015). These subsidies are typically managed at the national level and reduce the cost-effectiveness of both SWH systems and the impact of any financial SWH incentives provided by local governments.

  Similarly, many developing countries have a single, state-owned monopoly utility regulated at the national level. While local governments may be able to develop policies with municipal or regional utilities, they may not be able to work as directly with national utilities in lieu of a collaborative effort with national level government.

  Building working collaborative relationships with other government agencies – including other municipal governments or regional/national governments – may be critical to address the most pervasive barriers to SWH. These collaborations may be beneficial not only by involving agencies that have the jurisdiction to implement policies at the national or regional level, but also by creating working networks policymakers can use to share best practices and communicate about progress in their jurisdictions.

- **Lack of institutional capacity**. Inadequate institutional capacity to manage SWH initiatives can result in poorly implemented programs that may ultimately have a detrimental effect on the SWH market. In addition to a lack of awareness among municipal officials regarding SWH technologies and policies, local

7 Pre-tax subsidies are defined in this context as subsidies that reduce the price of energy paid by consumers below the cost of supply.

governments frequently have insufficient staffing and financial resources to manage extensive SWH programs and policies.

City energy offices, particularly in small countries, may be underfunded, composed of only one or two individuals, or otherwise bundled in ministries with limited budgets that must address other priorities. They may also lack infrastructure and resources for maintaining regulations on product standards and installer certification. Frustration stemming from poor management of SWH policies and programs from both consumers and the SWH industry can hinder growth in the market and reduce the effectiveness of future government efforts.

It is thus important for local leaders to take into account the cost of administering the policies or programs of a SWH strategic plan. Ambitious policies should be tailored to the needs of the local context. Besides providing funding for SWH initiatives, international development agencies can also support the development or deployment of human capacity to support local or national energy ministries.

The development of strong local SWH markets in the developing world requires policymakers to address the barriers described above. Local planners and policymakers can mitigate barriers – and increase economic, environmental, and energy security benefits for constituents – by implementing a variety of SWH policies and programs. This section focuses on policies and programs that local governments can implement to address market barriers and drive robust SWH market development.

Table 2 below provides an overview of the SWH policies and programs explored in this section.

Table 2. SWH policies and programs

Policies & Programs	Description
Incentive programs	• SWH systems can offer significant energy access or savings to many homes and businesses; however, even in jurisdictions where SWH systems are competitive with conventional technologies, they have significant installation costs that may be prohibitive for many end-users, especially in developing countries. • Local policymakers can implement a range of incentive programs to increase SWH access by reducing installation costs or to compensate for lack of competitiveness (e.g. due to subsidization of fossil fuels used for water heating). • Potential options include capital incentives (like rebates or grants), performance-based incentives (like tradable credits or feed-in tariffs), or hybrid incentives that integrate features of both capacity and PBI incentive programs.

Policies & Programs	Description
Financing and business models	• Increasing access to innovative and low cost financing programs will be important to address barriers like high upfront costs for many solar thermal markets. • Local leaders can implement or encourage a range of innovative financing and business models that create value, reduce financial risk, and increase access to SWH for local residents and businesses. • These include options such as low-interest lending programs, utility on-bill programs, or innovative contractor business models that provide "heat as a service."
Mandates & regulations	• In many jurisdictions, stakeholders across the value chain – including architects, contractors, building owners, or tenants – are unfamiliar with SWH technologies. In many cases, landlords and tenants face barriers like split incentives[8] that prevent SWH deployment. • Mandates can be a powerful tool to drive deployment of SWH systems. For example, building mandates can be developed to address split incentive barriers by requiring the installation of SWH systems in new and existing buildings at the time of building sale or lease or at the time that existing heating systems are replaced. • Other options include utility mandates, which require utilities to derive a certain portion of their total energy load from renewable resources like SWH.
Permitting, training & quality control	• In many developing country markets, a lack of professionals with the expertise to design and install reliable, high-quality SWH systems can be a significant barrier to market growth. • Local leaders can influence quality control via the permitting process, training and certification programs. Such programs can increase the quality of installations, ensuring that high quality installations support the development of a sustainable market.
Outreach & education	• For many end-users, the value proposition of SWH may not be well understood. Lack of communication, information, and consumer education may prevent residents and businesses from installing SWH systems. • There are a wide variety of consumer education programs that local leaders can implement to support SWH market development. These include consumer advertising and awareness campaigns, group purchasing programs and demonstration projects.

Building on this overview, the following sections provides additional detail on:

- **SWH market development policies** that can be implemented and how they address key market barriers,
- **Case studies and examples** of jurisdictions[9] that have implemented policies or programs,
- **Implementation tips and options** that describe best practices,
- **Tools and additional resources** that can help local policymakers implement policies in their jurisdictions.

8 Split incentives are also referred to as landlord/tenant barriers. Split incentives occur when those who are responsible for paying the energy bill (e.g. the tenant) are not those who are responsible for making capital investment decisions (e.g. the landlord). In the case of SWH, the landlord is probably not inclined to make the necessary investment in SWH because the benefits associated with any savings will accrue to the tenant. Interested readers should consult ("Factsheet: Overcoming Split Incentives," 2013).

9 Note: Many of the case studies provided occur at the national or regional level. While the focus of this guide is on cities, many national level programs and policies (particularly those in small or island nations) can be implemented at the local level. In addition, several of the case study examples come from developed countries. Though developed countries have largely been more successful at large-scale deployment of SWHs (e.g. Cyprus, Israel, Austria), many of these policies and programs are still relevant for – and could be implemented in – developing countries.

4.2 INCENTIVE PROGRAMS

While solar hot water can offer significant savings to homes and businesses, upfront costs can be prohibitive and remain a persistent barrier to deployment in developing countries. The economics of SWH are especially challenging in jurisdictions with low or subsidized fossil fuel prices. Consumers in developing countries that lack domestic manufacturing for SWH may also face higher costs from import tariffs. These combined factors can push many residences and businesses that could benefit most from energy savings out of the market.

As a result, financial incentives are often necessary to help businesses and residents overcome upfront investment costs and achieve attractive economic returns. Innovative financing mechanisms (see Section 4.3) can also be helpful in addressing some of these barriers. There are three main types of incentive policies that can be deployed or leveraged by local jurisdictions. These include upfront capital incentives, performance-based incentives, and hybrid models based on expected performance.

- **Upfront capital incentives**. Upfront incentives, including rebates and grants, are the most widely implemented SWH incentives (REN21, 2015). These are usually structured as direct, one-time payments from the government to consumers at the time they purchase a SWH system. Capital incentives may be calculated based upon the total expenditure made for the system (e.g. 10% of the total system cost), the capacity of the system (e.g. $/m^2 of solar collector area), or a flat rate (e.g. $200 USD for residential SWH system) (Veilleux & Rickerson, 2015).

- **Performance-based incentives (PBIs)**. PBIs compensate SWH owners for the amount of generation or savings they produce (e.g. $/therm or $/kWhth) during a certain period of time (e.g. 10 years). They are usually structured as ongoing payments from the government or a third party to the owner of the system. While commonly used for solar photovoltaic (PV) technologies, PBIs are much less common for SWH or other renewable heating and cooling technologies, since it is challenge to measure the solar thermal energy generated and to justify if the generation is sufficient due to its dependency on on-site heating demand (Beerepoot & Marmion, 2012; Steinbach et al., 2013). However, a number of jurisdictions – including the United Kingdom, Australia, Italy, and several US states – have created PBI programs to incentivize SWH development (Veilleux & Rickerson, 2015).

- **Hybrid incentive structures**. Hybrid incentives integrate features of both capacity and PBI incentive programs. In these cases, consumers typically receive a direct, upfront payment based on the calculated performance of the SWH system. System performance is usually estimated based upon rated efficiency and production of the solar panels (e.g. via a third-party performance and efficiency rating of panels like the Solar Rating and Certification Corporation or Keymark) or via a system simulation program (e.g. RETScreen or T*SOL). This has been the approach of a number of U.S. state programs.

Incentive programs can be administered by tax authorities, utility administrators, government agencies, or via non-governmental partner organizations. The success of incentive programs will often depend upon the ability to identify a suitable funding mechanism (e.g. tax revenues or utility surcharges) and the appropriate authority to administer the program over the long-term. To the extent that incentive programs are entirely outside of local jurisdiction control (e.g. they are established and awarded by federal or state government) cities can drive outreach and education efforts in order to increase awareness and ensure local constituents get their "fair share" of available incentives.

4.2.1 CASE STUDIES AND EXAMPLES

Kaohsiung City, Taiwan (Local)

Program Type: Capital Incentive (Rebate)
Population: 2.77 million
Status: Completed (Sept. 2008-Dec. 2010)

In 2008, Kaohsiung City, the second largest city in Taiwan, implemented a SWH rebate matching an existing federal rebate program, collectively subsidizing approximately 50% of the cost of a residential SWH installation. City officials offered the SWH rebate on top of the Taiwanese Bureau of Energy's existing subsidy program that had been launched in 2000. The federal program provided NTD 1500 (approx. $46 USD) per m^2 of collector area to purchasers of glazed flat-plate and evacuated tube collectors and NTD 1000 (approx. $31 USD) per m^2 of collector area to purchasers of unglazed flat-plate collectors. The municipal government of Kaohsiung City then instituted an additional municipal rebate matching the value of the federal rebate.

The combined subsidies greatly strengthened the SWH market in Kaohsiung City, supporting over 18,000 new installations between 2009 and 2011.

Sources: *(Epp, 2012), (Chang, et al. 2011)*

United Kingdom (National)

Program Type: Performance-Based Incentive
Population: 64.1 million (2013)
Status: Ongoing (Commercial: 2011-present; Domestic: 2014-present)

The UK government passed the Energy Act of 2008, calling for the establishment of a payment system for heat generated from renewable energy sources. The Renewable Heat Incentive (RHI) introduced schemes for commercial and domestic systems in 2011 and 2014 respectively. Both schemes provide quarterly payments to SWH system owners and other renewable thermal technologies for each kWhth generated by the technology. Tariff rates are reevaluated every

quarter and payments may be reduced (by 5%, 10%, or 20%) based on a degression schedule, which is determined by whether tariff payments exceed trigger thresholds.

As of July 1, 2015, payments for commercial and domestic SWH systems were at 10.16p and 19.51p (GBP) per kWhth respectively. Commercial systems are eligible for payments for 20 years after installation while domestic systems are eligible for payments for seven years after installation. The proportion of system installation costs covered by the incentive is dependent on performance.

Source: *(Ofgem, 2015a), (Ofgem, 2015b)*

California, United States (State)

Program Type: Hybrid Incentive
Population: 38.8 million (2014)
Status: Ongoing (2010-present, only natural gas displacing systems still eligible)

In 2010, the California Public Utilities Commission established the California Solar Initiative (CSI) Thermal Program, which allocated $280.8 million USD to support the deployment of solar thermal technologies. The goal of the program is to support the replacement of the equivalent of approx. 200,000 natural gas and 100,000 electric water heaters.

The CSI-Thermal Program is a hybrid financial incentive: residential and commercial customers installing a SWH receive an upfront payment based on the quantity of fuel the system is expected to displace in the first year. The upfront payment received is determined either by the expected annual therms displaced (for natural gas systems) or by the expected kWh displaced (for electric/propane systems) with a maximum of $4,366 and $800,000 for residential and commercial natural gas-displacing systems respectively and $1,834 and $250,000 for residential and commercial electric/propane-displacing systems respectively. CSI-Thermal also supports the replacement of non-single family residential swimming pool heaters, as well as commercial solar thermal systems used for process heat, space heating, or absorption chilling. Incentive levels in each utility territory will drop as installation targets are reached. The incentive and its degression mechanism aims to support system installed cost reductions of at least 16%.

As of July 2015, certified annual energy savings for systems installed under CSI-Thermal are estimated at nearly 4 million therms and over 940,000 kWh. Applications for electric-replacing systems are no longer being accepted in most utility territories.

Source: *(California Public Utilities Commission, 2015) (Go Solar California, 2015)*

4.2.2 OPTIONS AND TIPS FOR IMPLEMENTATION

- **Identify means for funding an incentive program**. Cities frequently lack the budgets to support incentive programs that will bring down the cost of SWH systems to an affordable level for consumers. Cities that control their own tax collection and revenue may be able to create new taxes or tax credits to support incentives. Cities with their own energy or water utilities could raise program funding through ratepayer surcharges. International development agencies (e.g. UNEP, World Bank, GIZ) have supported SWH incentive schemes in the past and can be valuable sources of funding to developing cities and countries to advance SWH deployment. Cities should identify different options and weigh the tradeoffs between each.
- **Ensure continuity of incentives**. Erratic support for SWH incentive schemes can disrupt the market, causing consumers to be wary of purchasing a system and discouraging industry leaders from investing in infrastructure and training. Policymakers should be clear about the duration of any incentive programs and refrain from abruptly ending (and subsequently, restarting) a program in order to drive successful market development.
- **Coordinate incentive programs with financing options**. While incentive programs can reduce the capital costs of SWHs, consumers in low-income countries may still lack the upfront capital to purchase a solar water heater. Policymakers should strongly consider combining incentive programs with financing models (see Section 4.2).
- **Evaluate incentive design options**. As discussed above, there are a number of incentive programs that can be successfully implemented to reduce the capital costs of SWH. It is important for local governments to determine which type of incentive program is best suited for their jurisdiction, both for determining the most effective program to meet their SWH goals and for determining which programs can be most effectively managed by the local government. For example, capital incentive programs are typically the easiest for governments to implement and manage, but do not necessarily reflect the actual performance of the systems installed or their quality. PBIs and hybrid incentives can be tied more directly to performance, but can be difficult to manage in jurisdictions with inadequate metering or in jurisdictions that lack quality control mechanisms to ensure systems perform as intended. Though PBIs may provide more payments to system owners over the system lifetime, they also will not reduce the upfront costs for consumers as hybrid or capital incentives do.
- **Improve consumer awareness**. Any new incentive program should be combined with consumer education and outreach (see Section 4.4) to ensure that incentives are accessible to end-users. Incentive programs should be straightforward and easy for to consumers to navigate in order to maximize uptake.
- **Balance the need to jumpstart the market with the risk of persistent overpayment**. While strong government subsidies can be critical

for developing a nascent SWH market, incentives that do not adjust downward or sunset over time can distort market prices and lead to excess profits. Poorly designed incentive programs without degression mechanism can create a market bubble that will eventually bust, especially if/when policymakers are forced to suddenly eliminate incentives in order to manage policy costs.

4.2.3 TOOLS AND ADDITIONAL RESOURCES

- **SWH TechScope Market Readiness Assessment**. Prior to policy design, it can be valuable for policymakers to benchmark their jurisdiction against similar cities and countries around the world. The SWH TechScope uses four parameters and 18 indicators to perform a high level evaluation of a SWH market. In comparing their jurisdiction with others, policymakers can identify barriers gaps in local policy and barriers to address through policy, as well as programs and policies that have been successfully implemented in similar jurisdictions.
- **RETScreen**. RETScreen is a free energy management program that can be used to perform economic and environmental analysis for renewable energy technologies. Its SWH module allows users to evaluate projected energy production, savings, costs, emissions reduction, financial viability, and risk of SWHs. Policymakers can use RETScreen to model the impacts of various incentive programs on the financial viability of SWH systems, making RETScreen a valuable tool for determining where to set the incentive level.
- **T*SOL**. T*SOL is a simulation program aimed at designing and optimizing SWH systems. Drawing from a database of over 2,500 collector types, T*SOL can provide a dynamic annual simulation of a SWH system, calculating water temperatures and thermal energy generated with intervals as low as one minute. Policymakers can use T*SOL for a more in-depth modeling of SWH system performance in their jurisdiction, as well as using T*SOL's financial analysis module to evaluate the impacts of incentive programs and financing mechanisms on the financial viability of SWH systems.
- **Solarthermalworld.org**. The Global Solar Thermal Energy Council's (GSTEC) website aggregates global solar thermal news, policy developments, and best practices. Information contained in the platform is reported from around the world by GSTEC staff and partners. The site organizes content by solar thermal market sector, six pillars for market success (i.e. awareness raising, certification, finance and incentives, policy, standards, training & education), and by location. The web platform serves as a resource for policymakers, particularly for its database of solar thermal incentive programs.

4.3 FINANCING AND BUSINESS MODELS

Even with capital incentives from governments, upfront costs for SWHs may still be too high for many consumers. Access to residential and business financing is frequently lower in developing country cities, and high interest rates may deter many consumers from borrowing to finance a system where the option is available. Lenders in these markets are often hesitant to provide loans for unfamiliar technologies. In addition, SWH systems can seem complex – especially commercial installations – and many end-users will not want to deal with the hassle of managing the maintenance or operational issues that affect system performance.

Increasing access to SWH will in many cases require the development of low cost and innovative financing and business models to enable end-users to overcome high first costs. Local leaders can implement or encourage a range of financing and business models that create value, reduce risk, and increase access to SWH for residential and commercial customers. These include options such as low-interest lending programs, utility on-bill programs, as well as innovative contractor business models provided by energy service companies (ESCOs).

- **Low-interest lending programs**. SWH technologies are capital intensive, and typically represent a significant upfront investment for customers. Incentive programs can help improve the economics and reduce upfront costs (see Section 4.2); however, many customers will still lack access to the capital necessary to purchase and install a system.

  In such cases, government leaders can implement programs that increase customer access to low-cost financing for SWH investment. These may include (i) direct loan programs, where the government acts as the loan underwriter and servicer; (ii) matching loan programs, where the government provides a certain share of a loan (often at a below market interest rate) and a commercial lender provides the balance of the loan; or (iii) interest rate buy-downs, in which case a government agency subsidizes the interest rate offered by a private lender (Clean Energy States Alliance, 2009).

  The success of such programs will depend upon the government's ability to effectively market the program, evaluate the creditworthiness of borrowers and underwrite loan requests, quickly and efficiently review and close loan requests, monitor and support projects and loans, and make program modifications over time to address SWH priorities. In many cases, local or provincial government agencies will contract third parties to administer the program, providing funding from tax revenues, utility surcharges, or government bonds to implement it.

- **Utility on-bill programs**. The financial barriers to SWH can also be addressed by leveraging the unique relationship customers have with their gas or electric utility. On-bill utility programs provide customers with convenient access to financing for SWH or other energy efficiency investments. Customers are able to repay the cost of installation via a surcharge on their utility bill. In the best cases, the cost of repayment is equal to or less than the energy savings

afforded by the SWH system. Developing country cities with high consumer interest rates and low access to credit can particularly benefit from on-bill financing due to the typically higher creditworthiness of a regulated utility.

There are a variety of ways to implement on-bill financing programs. Utilities and governments across the globe have designed programs to utilize or address different capital sources, financing products, target markets, and overall implementation strategies. Typically, the utility or its financial partner will cover the cost associated with the purchase and installation of the SWH system. The utility recovers its cost by adding a charge to the consumer's utility bill until all costs are repaid. Funding for an on-bill financing program may be provided through a system-wide utility surcharge, use of utility's low-cost capital, or through a third-party lender. Grants, rebates, or other incentives can also complement on-bill financing programs (American Council for an Energy-Efficient Economy, 2015).

Local and state leaders can play an important role by encouraging utilities to implement on-bill financing programs. Utility participation often requires a mandate from the utility regulatory body, which may be a state or federal regulator in the case of investor owned utilities or a city board in the case of a municipal utility (ACEEE, 2015).

- **Innovative contractor business models**. In addition to the high upfront costs, SWH technologies, especially commercial-scale installations, have to compete against other corporate or institutional priorities for scarce internal investment dollars. Many businesses or institutions will resist making large capital investments in projects like SWH that are not related to core business activities. As a result, decision-makers will often determine that the opportunity costs associated with the time, energy, or capital required for investment in SWH is too great compared to potential returns (Veilleux & Rickerson, 2015).

Third-party ownership and other "heat as a service" or innovative SWH contractor business models mitigate the extra effort and cost associated with SWH by simplifying the design, development, operation, financing, and maintenance of systems. In this case, a separate entity, such as an energy service company (ESCO) or financial investor, assumes most of the operational risk for SWH and in some cases will also assume ownership of the system.[10] Thus, in regions with good SWH economics, commercial hosts can potentially integrate SWH into their building for little or no money down, reduce the risk and complexity related to system operation and maintenance, and achieve immediate cost-savings (e.g. cash flow positive in Year 1) (Cliburn, 2012; Veilleux & Rickerson, 2015).

Fostering a market for innovative contractor business models requires supportive policies. In markets where these models for SWH have been successfully implemented, programs have provided incentives or risk guarantees that create additional project revenue, offset development costs,

10 Some energy service companies (ESCO) have developed models wherein building owners finance and own the system, though they transfer all operational risk via a performance guarantee.

or reduce the cost of capital for developers. Local policymakers have an important role to play by fostering a supportive environment for innovative contractor business models.

4.3.1 CASE STUDIES AND EXAMPLES

Seychelles (National)

Program Type: Low-interest loan
Population: 89,173
Status: Ongoing (2014-2017)

In 2014, the Seychelles government launched a low-interest loan program for purchasing energy efficient and renewable energy equipment, including SWHs. The Sustainable Efficiency and Renewable Energy Program (SEEREP) provides loans of up to SCR 100,000 (approx. $7,700 USD) to households at a low interest rate of 5%. Avoided fuel costs from SEEREP are expected to save the Seychelles Public Utilities Corporation 30-40 million USD over the lifetime of projects funded.
Approximately $1.77 million USD has been provided for this project from the United Nations Development Programme and the World Bank's Global Environment Facility. The program is being implemented by the Seychelles government with support from the International Finance Corporation.

Source: *(Koo, et al. 2015), (Thande, 2014)*

Tunisia (National)

Program Type: On-bill financing; low-interest loan; incentive program; certification; public awareness campaign
Population: 10.9 million
Status: Ongoing (2005-present)

In 2005, the government of Tunisia, launched the Prosol Tunisia initiative to provide a capital incentive for SWH, an on-bill financing mechanism, SWH public awareness campaigns, and an installer certification scheme. Launched in partnership with UNEP, the Mediterranean Renewable Energy Program, and the Italian Ministry of the Environment for the Protection of Land and Sea (MATTM), the Prosol program is frequently highlighted as a standout enabling policy for SWH due to its successful record of installations, on-bill financing mechanism, and multi-pronged policy approach.

The Prosol program included a capital incentive for SWHs in order to level the technology with subsidies for liquefied petroleum gas (LPG), a series of outreach campaigns to both the general public and banks, and an accreditation scheme for suppliers and installers in order to maintain high quality installations. Prosol is most often noted for its financing mechanisms: Prosol created a subsidized low-interest loan for residential SWHs, and SWH suppliers initially were expected to indirectly

lend and guarantee the consumer loans. In 2007, the financing mechanism was streamlined, with the state utility (STEG) assuming all lending risks by providing loans directly to consumers. The loans were then repaid through the consumer's electricity bills, enabling STEG to handle defaulting customers by shutting off electricity service.

The successes of the Prosol program have been well-documented: 119,000 systems were installed between 2005-2010 (a five-fold increase over previous installation rates), and expected savings to the Tunisian government over the lifetime of the systems installed (through avoided LPG subsidies) are estimated at $101 million USD compared to an initial government investment of $21.8 million USD.

Source: *(Trabacchi, et al. 2012)*

Brazil (National)

Program Type: Guarantee for innovative contractor business model
Population: 200 million
Status: Ongoing (2011-present)

The Energy Efficiency Guarantee Mechanism (EEGM) is a $25 million de-risking mechanism that aims to facilitate energy service contracts between energy service companies, banks, and borrowers by providing partial-risk guarantees for both the performance risk of energy projects and the credit risk of the borrower. Established in Brazil by the Inter-American Development Bank (IDB) and Global Environment Facility (GEF), EEGM is designed to be accessed in conjunction with the signing of an energy service contract. Energy efficiency projects (which include SWH) that can demonstrate savings that exceed their incremental cost can receive a partial-risk guarantee of 83% of the value of the contract (or up to $800,00 USD) for up to 7 years. In addition to providing risk guarantees, the EEGM provides creditworthiness to the transaction through its AAA credit rating.

Source: *(Mazzei, 2013), (Inter-American Development Bank, n.d.)*

4.3.2 OPTIONS AND TIPS FOR IMPLEMENTATION

- **Identify means for supporting low-cost financing**. In order to make the cost of financing SWH more accessible to consumers, the government may need to underwrite consumer loans or provide subsidies for lower interest rates. International development agencies and development banks have supported SWH financing models in developing countries and can be valuable sources of funding, technical assistance, and expertise to developing cities and countries to advance SWH deployment. For example, in the aforementioned PROSOL Tunisia project, funding from UNEP was used to establish a $2 million USD loan fund to provide interest rate subsidies and capital incentives (United Nations Environment Programme, n.d.).
- **Form public-private partnerships prior to implementation**. Many of the models discussed in this section require cooperation from private sector entities such as banks, installers, and utilities. These private sector entities can aid in program implementation and will often assume some of the financial risk and burden from the program. It is crucial for local leaders to engage these private sector stakeholders early in the design – and throughout the program implementation process – in order to secure cooperation in implementation and ensure the viability of the program. Section 2.2 provides more tips on establishing an advisory committee and engaging stakeholders while developing a SWH initiative.
- **Build loan programs with energy savings in mind**. Policymakers should strongly consider designing programs so that loan installments do not exceed the energy savings from SWH (as in PROSOL Tunisia and in South Africa). A robust loan program that ensures the consumer bears minimal to no upfront costs and minimizes installment payments will be considerably more attractive to consumers. If loan programs are insufficient for achieving these goals, policymakers should consider combining incentive programs with them (see Section 4.1).
- **Improve consumer awareness**. Any new financing program should be combined with consumer education and outreach (see Section 4.4) to ensure that the incentive is understood and accessed by the community. Policymakers can leverage partnerships with the private sector to gain support in outreach efforts. For example, banks can advertise SWH loan programs to customers.

4.3.3 TOOLS AND ADDITIONAL RESOURCES

- **Caribbean Solar Technologies guide to fee-for-service programs**. A Guide to Fee-for-Service Solar Water Heating Programs for Caribbean Utilities was authored by Caribbean Solar Technologies to provide information for utilities to develop SWH fee-for-service programs. The guide evaluates different fee-for-service program options for utilities, and also provides additional information on SWH technologies, technical issues, and best practices for implementation. Though the guide is oriented towards utilities in Caribbean countries, local policymakers can consult this guide when designing third-party ownership programs for SWHs in coordination with utilities.

- **Report on SWH financing mechanisms in India**. Design and Implementation of New Financing Mechanisms and Instruments for Promotion of Solar Water Heating Systems in India was prepared for the Ministry of New and Renewable Energy in India. The report analyzes the Indian SWH market and evaluates SWH financing mechanisms at the national, regional, and local level. Though developed in the context of India, policymakers in other countries may find the report's analysis and recommendations to be valuable, particularly if similar market conditions exist in their jurisdictions.
- **RETScreen**. RETScreen software can be used to perform economic and environmental analysis for renewable energy technologies. Its SWH module allows users to evaluate the energy production, savings, costs, emissions reduction, financial viability, and risk of SWH. Policymakers can use RETScreen to model the impacts of various financing models on the financial viability of SWH systems, making RETScreen a valuable tool for determining targets for financing costs in policies and programs.

4.4 MANDATES AND REGULATIONS

Many developing countries lack trained professionals in the SWH value chain (e.g. architects, engineers, contractors) that are qualified to design and install SWH systems. In addition, landlords and tenants face barriers like split incentives, which discourage deployment of SWH in buildings. While education, outreach or training programs (see Sections 4.4 and 4.5) can help address these barriers, they can be difficult to sustain without clear signals that sustained market development will occur. As a result, it can be useful for policymakers to develop SWH mandates or obligations to send the proper signals that there is a long-term commitment to market development (Veilleux & Rickerson, 2015).

SWH mandates place an obligation on specific entities – like utilities, building owners, or building developers – to install SWH. They can be a powerful tool to drive development of SWH and have been implemented in jurisdictions across the globe (see Figure 7). Local policymakers can implement building mandates, for example, to address split incentive barriers, requiring the installation of SWH systems in new or existing buildings. Utility obligations for SWH can be coupled with incentive programs to encourage contractors and other stakeholders to increase installation of systems. The following provides an overview of utility obligations and building mandates.

- **Building mandates**. Solar building mandates (also known as solar ordinances) have been widely deployed to support SWH market development in new construction or building renovations. SWH mandates require building owners to source a minimum amount of their domestic hot water heating load from SWH systems. They are usually expressed as a percentage of the total hot water demand for a building sector and typically focus on new construction (e.g. SWH to provide 60% of hot water for all new residential construction).

  A handful of jurisdictions also require SWH or other renewable heating technologies to be integrated into existing buildings. When designed for existing buildings, it is necessary to establish a trigger for compliance. Triggers may include the sale or lease of a building, building renovation, replacement of the heating system, or energy commissioning or audits (Veilleux & Rickerson, 2015). Mandates also require cities or other implementing authorities to establish procedures for measuring and verifying compliance This may require the installation and use of meters to measure hot water heating load, or at a minimum, a standard procedure to estimate building hot water load and production from the SWH system. In addition, the design and enforcement for building mandates almost invariably requires active participation from local building inspectors to ensure compliance (ESTIF, 2007).

- **Utility obligations**. Utility obligations – such as Renewable Portfolio Standards (RPS) or Renewables Obligation (RO) schemes – have historically focused on renewable electricity technologies like solar PV, though there are several jurisdictions that have integrated SWH into utility obligations. In such cases, regulatory agencies require utilities to derive a certain portion of their total energy load from SWH.

Compliance by the utility is typically demonstrated through the creation and procurement of renewable energy certificates. Each energy certificate represents one megawatt-hour thermal (MWhth) of useful thermal output. Converting non-electric thermal output from SWH generators into a measure equivalent to MWh is done using a direct conversion factor of 3,412,000 British thermal units (BTUs) to 1 MWh.

Utilities procure a certain number of certificates from SWH or other renewable generators in order to meet their regulatory obligation. This can also be complemented by creation of an incentive program, wherein in utilities pay SWH owners for every renewable certificate procured. In cases where utilities fail to obtain the necessary certificates within a determined period, they are typically required to pay a fine – or alternative compliance payment – to regulatory authorities. This is a common approach taken to enforce compliance for utility RPS programs in the U.S. as well as the Renewables Obligation in the UK.

In most countries, utility obligations are set at the national level. Municipal governments in developing countries will likely be unable to affect utility policy in countries served by national monopoly utilities without working directly with the national government. As noted in the case studies below, however, local leaders in jurisdictions served by municipal utilities may be able to work with the utility to implement a local obligation.

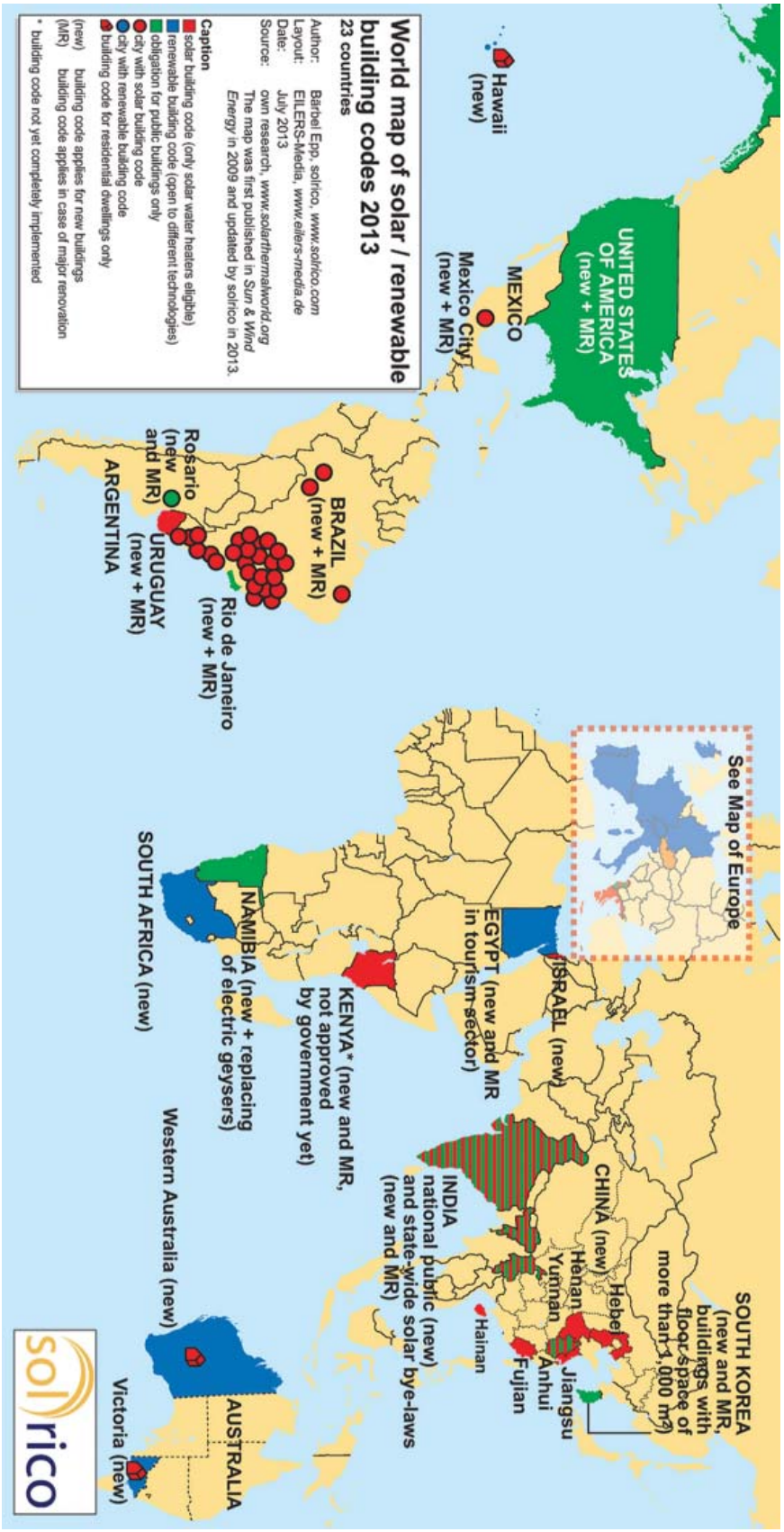

Figure 6. Examples of national and sub-national solar thermal mandates (Epp, 2013)

4.4.1 CASE STUDIES AND EXAMPLES

Rosario, Argentina

Policy Type: Building Mandate; Permitting; Installer Licensing and Certification
Population: 1,276,000 (2012)
Status: Ongoing (2013-present)

In 2011, the municipality of Rosario, Argentina approved an ordinance mandating that all new and renovated public buildings (including community centers and public housing) within the municipality derive at least 50% of hot water usage from SWH. This was the first SWH-related mandate in any jurisdiction within Argentina, a fossil fuel-producing country with adequate solar resource but lacking significant numbers of SWH installations or an enabling environment for SWHs (e.g. regulatory framework, financial incentives). While the ordinance was passed in 2011, it did not go into effect until 2013 when technical details were also passed (e.g. for SWH quality control, certification, and inspections).
To ensure compliance, all installation designs must be submitted to the Directorate General of Sustainable Development of the Ministry of Public Service and Environment of the Municipality of Rosario for approval. The Ministry also began offering trainings to SWH installers for appropriate system sizing and installation, as well as other public outreach and education actions.

Sources: *(Rosell, 2013), (Intendencia Municipal Rosario, 2012), (Concejo Municipal de Rosario, 2011)*

Columbia, Missouri, United States

Policy Type: Utility Mandate
Population: 115,000
Status: Ongoing (2004-present)

In 2004, voters in the city of Columbia, Missouri approved a local renewable portfolio standard for its municipal utility, Columbia Water & Light Department. This policy is distinct from the state-level renewable portfolio standard, which applies to the state's investor-owned utilities. The local standard mandates that the Columbia Water & Light Department generate or purchase 30% of its electricity from renewable energy sources by 2028, including SWH. In order to help achieve its mandate, the utility has instituted a rebate for customers installing SWHs, providing $400-800 for an installation in exchange for granting Columbia Water & Light the rights to claim the renewable energy attributes of the system.

The utility is expected to meet its annual requirements with maximum rate increases of 3%. Notably, the utility managed to exceed its requirement for 2013 at a rate impact of only 1.1%.

Source: *(DSIRE, 2015), (Columbia Water & Light Department, 2015)*

4.4.2 OPTIONS AND TIPS FOR IMPLEMENTATION

- **Ensure that infrastructure for SWH quality control is in place before enacting a building mandate**. Building mandates in developing countries with high rates of new construction can be very effective for increasing SWH deployment. However, unreliable components and poor installation quality will increase dissatisfaction among property owners as well as distrust of the effectiveness of SWHs as a technology. It is critical that basic product quality standards and an installer certification scheme (often referred to as "flanking measures") are in place prior to enacting any building mandates.
- **Determine the appropriate trigger for compliance**. When implementing a building mandate, policymakers need to determine the most appropriate "trigger" for compliance (i.e. when a building must be brought into compliance with the mandate). The majority of building mandates involving SWHs are triggered by new construction, but triggers for major building renovation or the sale or lease of a building can also be considered by local policymakers (Veilleux & Rickerson, 2015). Depending on the scope of the building mandate (e.g. only public buildings, all buildings, etc.), certain triggers may be more or less appropriate for the jurisdiction.
- **Establish measures for verification and compliance**. Upon enacting a building mandate, local governments should ensure that clear and enforced procedures for verifying compliance with the mandate are established. Regular random inspections by government personnel of properties covered by the mandate are important for ensuring building owners are in compliance. Verifying compliance with utility obligations can be more difficult, as both the building water heating demand and the SWH system's useful heat production typically must be measured (Veilleux & Rickerson, 2015). Installation of meters on buildings to measure water heating load and on SWH systems can allow for effective verification, but may also add to the cost of installation and compliance for a developing country. Estimates for expected SWH production from simulations can also be used, but measures should already be in place in the local jurisdiction to ensure that systems are properly installed. The risk of non-performing systems should also not be underestimated. In Mauritius, for example, approximately a third of SWH systems installed through the national grant program were either inactive or had system issues (e.g. non-functional evacuated tubes, water leakages) (Walters, 2013). It is important to ensure verification procedures are in place whenever a mandate is passed, but the costs and benefits of the various measures should be weighed by local leaders when designing a mandate.
- **Develop resources and outreach campaigns to assist builders and property owners in deploying SWH**. When developing a mandate, policymakers should consider the level of knowledge and ability of builders and property owners who are required to comply with it. Clear online resources to help property owners determine the steps they need to take to comply with a building mandate and find certified installers can help reduce soft costs associated with complying with a building mandate. Free workshops led by

local leaders that provide both basic knowledge on SWHs and best practices for SWH procurement can also provide valuable assistance to property owners.

4.4.3 TOOLS AND ADDITIONAL RESOURCES

- **ProSTO Project – STO Developers Toolbox**. The Solar Thermal Ordinance Developers Toolbox is designed to support policymakers in enacting ordinances primarily through local building codes at the municipal level. The toolbox provides background information on SWH ordinance, tools for analyzing the feasibility of an ordinance in the local context, model text components for drafting an ordinance, and other tools for supporting SWH ordinance implementation and monitoring its progress. While primarily targeted at European municipalities, developing country cities will still find value in consulting the tool as a baseline standard for effective ordinances for SWH.
- **Global Solar Water Heating Market Transformation and Strengthening Initiative – A Quick Guide for Architects and Builders**. This UNEP guide provides an overview of SWH technologies targeted at architects and builders from developing countries who would be affected by a SWH building mandate. From building integration to contracting and maintenance, the guide provides information specifically tailored to architects and builders with both beginner and intermediate levels of experience with SWHs.
- **Best Practice Regulations for Solar Thermal**. The European Solar Thermal Industry Federation (ESTIF) created this report to provide comprehensive analysis of the structure of solar obligations and develop best practice guidelines. It serves as a policymaking tool to support the design of effective regulations that promote the use of SWH and reduce administrative barriers.

4.5 PERMITTING, TRAINING, AND QUALITY CONTROL

In many developing country markets, a lack of professionals with the expertise to design, manufacture, and install reliable SWH systems can be a significant barrier to market growth. A recent survey by the International Renewable Energy Agency (IRENA) shows that poor system installation is the biggest factor that negatively affects development of SWH markets (International Renewable Energy Agency, 2014). Local leaders can influence quality of installations, provide consumer protections, and foster development of long-term markets by developing good SWH permitting and inspection process, establishing clear and reasonable licensing requirements, and creating SWH certification programs.

- **Quality permitting and inspection processes**. The effectiveness of building codes can vary significantly across developing country jurisdictions; however, when well-designed and implemented, they provide important protections to consumers by reducing building risks and increasing public safety (Moullier, 2014). For jurisdictions seeking to encourage SWH

development, trainings and clear processes that integrate SWH into the permitting and inspection process can provide consumer protections and increase the quality of SWH installations.

After a SWH installer signs a customer contract, the installer is typically required to get a building, plumbing and/or electrical permit from the local authority before beginning installation. Permits are required to ensure that the SWH installation will meet basic engineering and safety standards. After the installation is complete, a local inspector reviews the installation and verifies that it does in fact comply with the building code. With the approval of the inspector, SWH systems can begin operation (U.S. Department of Energy, 2011b).

It is worth noting that the effectiveness of SWH permitting processes can vary widely across jurisdictions. Especially in nascent markets, it is likely that permitting and inspection staff will have seen few – if any – SWH installations. Unfamiliarity with SWH technologies can lead to poor quality or overly cumbersome permitting processes. This may include, for example, multiple redundant inspections and unnecessary paperwork. Some installers have reported, for example, that SWH installations required up to five inspections when only one or two is generally needed (Veilleux & Rickerson, 2015).

To address these challenges, local leaders can implement code official trainings and create guidelines to expedite permitting. Code official trainings help permitting and inspection authorities get up to speed on the safe and proper practices for SWH installations. In addition, by publishing clearly defined installation and permitting requirements, local authorities can help both inspectors and installers streamline the inspection process. Clear guidelines will include model SWH design plans, engineering specifications, and loading requirements (Veilleux & Rickerson, 2015). Such best practices clarify permitting requirements and reduce unnecessary bureaucracy that can add significant costs to local governments, SWH contractors, and system owners.

- **SWH licensing and certifications**. When new or unfamiliar technologies are incorporated into the building stock, it is critical to ensure that manufacturing, design, and installation practices are based on tested and proven approaches. As a result, many jurisdictions will implement licensing, certification and workforce training programs as part of an overall quality control and consumer protection strategy.

  Licenses are granted by governments to individuals or companies that practice a specific trade or profession (e.g. for a plumber or electrician). The prevalence of licensing and other regulatory requirements vary across jurisdictions. This may include, for example, the requirement that a SWH installer have a plumbing license (as is common in the U.S) or a building contractor's license (U.S. Department of Energy, 2011b).

  A certification is a voluntary credential that is typically awarded by industry groups or associations. It indicates that the individual or company meets

standards established by the certifying body. A number of ISO (International Organization for Standardization) standards can help regulatory authorities or industry groups establish internationally recognized certifications for SWH products and system testing. These include, for example, test methods for solar thermal collectors (ISO 9806:2013 and ISO 9806-2:1995), SWH system performance characterization (ISO 9459-2:1995), as well as country reliability test labs for SWH components (ISO9806/ISO9459) (U.S. Department of Energy, 2011b). In some cases, certification can be linked to government licenses, incentive programs, or other regulatory requirements for SWH.

In addition to testing and product certifications, some countries and states have also established certifications for installers. In the U.S., for example, some states require (or strongly encourage) SWH installers to become North American Board of Certified Energy Practitioners (NABCEP) certified Solar Heating Installers in order to participate in incentive programs. NABCEP provides renewable energy and energy efficiency certifications, which are accredited to the ISO/IEC 17024 standard (the international standard for personnel certification programs). The Solar Heating certification covers fundamental principles of the application, design, installation and operation of SWH in North America (NABCEP, n.d.). Other jurisdictions have established more informal training requirements for incentive programs, such as installer workshops and inspections of a contractor's initial installations.

Ultimately, consumers, local governments, and industry benefit from high-quality installations and products. Licensing and certifications provide assurances that baseline standards are being met, which in turn leads to safer and higher performance installations and greater consumer confidence and satisfaction (U.S. Department of Energy, 2011b).

4.5.1 CASE STUDIES AND EXAMPLES

Cape Town, South Africa
Policy Type: Installer and product certification
Population: 3.75 million
Status: Ongoing (2013-present)

The City of Cape Town created an installer accreditation scheme as a prerequisite for recognition by the city as a reputable service provider. The goal of the program is to help residents to more easily identify qualified installers and products.

SWH installers in Cape Town can apply at no cost to become accredited service providers. Accredited installers must comply with national standards for solar installations, use only SABS-certified materials, provide a minimum 5-year warranty, and offer financing options that allow for payments in installments that are equal to or below the expected energy savings. Installers are also rigorously vetted for customer service and maintenance before becoming accredited and

listed on the City of Cape Town's energy-saving website as an accredited service providers. In addition to screening applicants, the city monitors performance, conducts inspections, and helps resolve disputes.

Sources: *(City of Cape Town, 2014), (City of Cape Town, 2013), (City of Cape Town, 2015)*

Uruguay (National)

Policy Type: Product and system design certification
Population: 3.4 million
Status: Ongoing (2014-present)

In 2014, the Uruguayan government approved the Especificaciones Técnicas Uruguayas (ETUS), a set of technical specifications for all SWHs in the country. Compliance with ETUS requirements is mandatory for installations on public buildings, homes, and private companies. The ETUS provides a range of SWH component requirements (e.g. mandated closed-loop systems for commercial installations, component materials, provided technical documentation and registration) and requires all installations to be designed and registered on a government website by a Responsible Registered Technician. ETUS considers installed SWH systems to be part of the building and must be maintained by the architect and builder for ten years. The regulations also call for the national regulator agency, URSEA, to conduct random inspections of completed installations.

Uruguay also SWH building mandates for some new and majorly-renovated public buildings, health care facilities, hotels, and sports clubs (SWH must meet 50% or more of hot water demand in buildings in these categories where 20% of total energy consumption is used on hot water).

Sources: *(Cabrera, 2014), (Parlamento de Uruguay, 2009)*

Mexico (National)

Policy Type: Certification
Population: 122.3 million
Status: Ongoing (2014-present)

In 2014, new installer certification standards came into effect in Mexico, which has a quickly growing SWH market (19% average annual growth from 2006-2011). The two standards provide accreditation for both thermosiphon and forced circulation systems. Requirements for certification include a three-day training course and an evaluation exam, which includes an on-site installation. Accreditation is offered through eight training centers around the country and cost approximately Mex $3,000 (approx. $185 USD), which must be paid for by the installation company if it works under the national low-interest SWH loan program.

Any SWH systems installed as part of federal programs must be installed by certified installers, though these national standards have not yet been strongly enforced at the local and state level. Nonetheless, the country's national renewable energy manufacturing industry association, FAMERAC, estimates that approximately 1,400 installers will be certified under the new standards by the end of 2015.

Sources: *(Rickerson, et al. 2014), (Rosell, 2015), (CONOCER, 2013), (CONOCER, 2014)*

4.5.2 OPTIONS AND TIPS FOR IMPLEMENTATION

- **Balance the need for SWH testing/certification infrastructure with program feasibility**. While it is important to use strong standards to ensure quality of SWH installations, many certification standards cannot be economically implemented. Similarly, developing countries often lack the necessary infrastructure (e.g. testing facilities) to create certifications. In such cases, it can be more beneficial to adopt less stringent standards for certification, though basic regulations should still be adopted for minimum quality assurance. For example, the government of Mauritius adopted EU standard EN 12976 (general requirements and test methods for factory-made SWH systems and components) for its own SWH standards in 2010. However, domestic suppliers objected to the strict standards: fewer than five out of the 40 registered domestic suppliers provided any models that met the standards at the time, and the suppliers argued that the added cost of conforming to strict EU standards would price SWH systems out of the reach of most homeowners. As a result, Mauritius abandoned the EU standard in favor of prescriptive minimum standards (i.e. requirements for safety, component materials, and warranties) when launching its incentive scheme (Koo et al., 2015).
- **Engage solar thermal installers and industry groups**. SWH installers and suppliers are key stakeholders in licensing and certification policy design. Members of the SWH industry can be some of the strongest advocates for tighter standards (Augsten, 2013), as mandatory standards and robust certification schemes help ensure quality installations and improve the reputation of the SWH industry. Any licensing and certification policies should be designed in coordination with local installers and suppliers to improve compliance and tailor standards to the local context.
- **Develop streamlined permitting processes**. Depending on the current permitting process for SWH systems, local leaders may consider streamlining the permitting process for SWH. This can reduce soft costs passed onto end users and administrative costs for the municipalities, clearly lay out the regulations to installers, and reduce regulatory issues that may prevent or delay installation. In some jurisdictions, SWH may not explicitly be mentioned, and a formal permitting process for SWH may need to be developed.

Municipalities can consider options for reducing the permitting burden on code officials, installers and building owners, that include as-of-right siting (i.e. removing the need for special permits or waivers beyond normal codes to proceed with project development); expedition of permitting and inspection time; reduction, capping, or elimination of permitting costs; provision of permitting checklists and tracking mechanisms to code officials to reduce errors and redundancies in the permitting and inspection process; and creation of online resources that provide clear guidance for installers and building owners and/or allow for permitting applications to be filed online.

Any streamlined or new permitting processes that results from municipal government programs should be accompanied by outreach efforts and workshops for local manufacturers, installers, and building owners in order to clearly establish any new or modified regulations.

4.5.3 TOOLS AND ADDITIONAL RESOURCES

- **ESTIF Guides**. The European Solar Thermal Industry Federation's *Guide on Standardisation and Quality Assurance for Solar Thermal* provides several best practices for product standards, certification, testing, and certification, including key factors for success for SWH mandates. ESTIF is notably an accredited partner of the Comité Européen de Normalisation (CEN, the European standardization body), the initiator of the Solar Keymark (international quality mark for solar thermal products based on EU standards), and contributes directly to the development of international SWH standards
- **Quality Certification: Solar Rating & Certification Corporation (US) and Solar Keymark (EU)**. The Solar Rating & Certification Corporation (SRCC) and Solar Keymark are voluntary third-party certification organizations for solar thermal systems and collectors in the US and EU respectively. In order to receive accreditation with either organization, systems must comply with all relevant standards and be tested by an independent laboratory that can be selected from an approved list in each region. Any system that has been certified by either organization will meet a high quality threshold, comply with all regional regulations (e.g. EU standards), and be eligible for subsidies in certain countries. The certification guidelines can provide guidance to policymakers in developing countries for establishing national standards for SWH technologies. Many of the models listed in each scheme may be too expensive for consumers in developing countries. However, mandating the use of SRCC- or Keymark-certified technologies in any government policies could reduce the need for testing infrastructure.
- **SWH Site Inspection Checklist**. The Florida Solar Energy Center produced a checklist identifying key factors for a successful SWH inspection. The checklist provides best practices for solar access, roof, water heater, electrical, and plumbing inspections. Policymakers in developing countries can consult this as a resource for establishing standards for system inspections in their jurisdiction.

- **NABCEP Solar Heating Installer Study and Resource Guide**. The North American Board of Certified Energy Practitioners (NABCEP) has authored a comprehensive guide aimed at individuals seeking a Solar Heating Installer Certification through its rigorous examination process. Though aimed at the North American market and installation needs in that context (i.e. codes, standards, and safety practices), the guide also provides an extensive overview of technical issues related to SWH technologies and components, site preparation and evaluation, and installation, commissioning, and servicing of SWH systems. This information may be valuable to local leaders aiming to create more rigorous certification processes or for local installers wanting to prepare for a certification exam.

4.6 OUTREACH AND EDUCATION

As with any new or unfamiliar technology, consumers need to understand what SWH is and how it works if they are to make an investment in it. In many developing country cities, there is a lack of information, and consumer education resources for SWH, as well as a lack of familiarity among municipal officials about how to approach and plan for SWH. As a result, many consumers are unfamiliar with the benefits that SWH can provide their home and business or where or how to install a system. At the municipal level, unfamiliarity among policymakers and code officials can lead to delays in permitting and approval processes, which can increase soft costs that are ultimately passed on to consumers.

There are a wide variety of consumer education programs that local leaders can implement to support SWH market development. These include consumer advertising and awareness campaigns, group purchasing programs, and demonstration projects. Ultimately, consumers who are educated about the benefits of SWH and understand financing and installation options are more likely to purchase and install a system (U.S. Department of Energy, 2011b).

- **Public advertising campaigns**. SWH public advertising campaigns help connect consumers with qualified installers and help contractors to better market the benefits of SWH to consumers. To be successful, community leaders should understand consumer perceptions about SWH and work to overcome any negative or inaccurate perceptions. They should also determine the value proposition and price points for SWH that are most appealing to local constituents, understand who consumers view as credible sources of product information, and determine how best to disseminate information to reach the target audience (U.S. Department of Energy, 2011b).

  Answers to these questions will help to inform the funding and outreach strategy deployed. For example, programs may be funded by government, economic development organizations, or industry groups. In some cases, campaigns have been successfully co-funded through public-private partnerships between state governments and industry groups. The public advertising campaigns may encompass a broad range of media and events, including workshops, pamphlets, online media, billboards, newspaper, radio, and TV. Lenanon, for

example, with support from United Nations Development Program (UNDP) implemented an amusing and successful SWH television advertising campaign, which targeted homeowners across the country.[11] By partnering with interested collaborators, local governments can help fund, design, and implement successful public advertising campaigns, increase public awareness, and drive market development to meet state energy goals.

- **Community-based group purchasing programs**. Group purchasing and discount programs use grassroots marketing and community-based outreach strategies in order to increase local demand for SWH.[12] In some cases, the group purchasing model uses a tiered pricing incentive, wherein the cost for an installation decreases as more customers sign-up over a set amount of time. These types of neighbor-to-neighbor programs have been used extensively to drive development of solar PV in the U.S., reducing the installed cost of solar PV by as much as 20-40%. A few jurisdictions have adopted this approach to increase community awareness and drive demand for SWH systems too. Typically, they are best suited for small commercial or residential customers, because installations and pricing can be standardized. In addition, the customer acquisition costs for residential and small commercial systems tend to be highest and the benefits of community outreach can drive down the installation costs for customers (Friedman et al., 2013).

  Local governments and non-profits are ideal to serve as a sponsor and administrator for community-based purchasing programs. A local coordinator can vet and select one or more contractors to install SWH systems, negotiate a fair price for a standard installation, and coordinate the community-based outreach and marketing campaign. In many programs, the local coordinator will recruit local community members to serve as SWH ambassadors to help drive outreach. Altogether, this provides many local constituents a sense of assurance, reducing the complexity and uncertainty they may associate with a relatively unknown technology like SWH.

- **Community demonstration projects**. SWH demonstrations projects help increase local awareness of the technology and its uses. Exploring SWH firsthand at a public facility enables constituents to get a solid understanding of the technology. While demonstration projects may be small or large, they should be in highly visible locations that are easily accessible to the community. This could include, for example, an installation on a local school, city hall, park, conference center, or community center.

  By their nature, community demonstration projects should be educational for the visitor. Educational strategies may include a kiosk at the SWH site, which describes how the SWH system works, its actual performance, as well as the expected savings and other benefits accruing to the host. Tours of the system by a knowledgeable guide can also help visitors gain a detailed understanding of the system's operation as well as the procurement and installation process (U.S. Department of Energy, 2011b).

11 A clip from Lebanon's SWH advertising campaign is available on YouTube: www.youtube.com/watch?v=Y0iLygXHVYQ

12 The group discount (i.e. "solarize") model has been effectively deployed by a number of jurisdictions in the United States. The first campaign started as a grassroots effort in Portland, Oregon. For more information, see: NREL. (2012). The Solarize guidebook: a community guide to collective purchasing of residential PV systems. U.S. DOE Sunshot Initiative. National Renewable Energy Laboratory. DOE/GO- 102012-3578.

In addition to consumer education programs, trainings for municipal policymakers and officials can be crucial to reducing staff time spent on overseeing SWH installations, including permitting, approving, and inspecting systems and processing incentives. Partnerships with local universities and industry groups/experts to deliver low-cost trainings to municipal officials can be a cost-effective way to reduce staff time and soft-costs that can increase the installed costs of SWH systems.

4.6.1 CASE STUDIES AND EXAMPLES

India (National)

Program Type: Public Advertising Campaign
Population: 1.25 billion
Status: Completed (February-June 2012)

The Ministry of New and Renewable Energy (MNRE) in India undertook an innovative public outreach campaign in 2012. With a now-expired 30% subsidy on SWHs and one of the largest populations of mobile phone users in the world, MNRE opted to target outreach through SMS text messages. Through weekly SMS blasts, MNRE ultimately reached half a million individuals, targeted for being more likely to purchase SWHs (i.e. higher income professions and building professionals).

The messages directed mobile users to call a toll-free hotline set up by MNRE to provide information on SWHs and how to access the government subsidy. The campaign drove hotline usage from a baseline of approximately 1,000 calls per month to nearly 25,000 calls between March and May.

Source: *(Malaviya, 2012)*

Southeast Tompkins County, New York, United States (County)

Program Type: Community based purchasing program
Population: 21,046
Status: Ongoing (2013-ongoing)

In 2013, the rural communities of Caroline, Danby, and Dryden, NY formed a "Solarize" partnership to support the expansion of SWH and solar PV systems within the three contiguous towns. The locally led volunteer campaign selected installers through a competitive bidding process and worked to educate local community members on the benefits of effective community-based group purchasing. The program, open to residents, farmers, businesses owners, municipalities, and institutions reduced the cost and complexity surrounding the solar procurement process by providing customers with bulk discounts and education.

The first Solarize Tompkins campaign resulted in 37 SWH installations and 108 solar PV installations.

Source: *("NY-Sun Brings Solar to Your Community," 2015) ("Solarize Tompkins SE," n.d.)*

Europe (Municipal Demonstration Projects)

In 2008, the European Commission launched the Covenant of Mayors in order to support national and regional sustainable energy policies at the local level. Joining the Covenant is voluntary, and signatories must commit to undertaking a Baseline Emission Inventory and submitting a Sustainable Energy Action Plan that outlines the key actions the municipality will undertake to achieve at least a 20% reduction in CO_2 emissions by 2020. Signatory municipalities across Europe have undertaken a wide range of demonstration projects, ranging from installation of solar thermal systems on public buildings to integration of solar thermal systems into district heating networks. Examples of such projects are discussed below:

- **Zagreb, Croatia**. The city of Zagreb has mandated that all health care-related buildings owned by the city install solar collectors by 2018. Total implementation costs are estimated at 569,500€ and will reduce annual emissions by 2077 tonnes of CO_2 equivalent (Covenant of Mayors, 2015).
- **Lerum, Sweden**. The locality of Lerum installed SWHs on the rooftop of a municipal swimming pool, as well as installing solar collectors that feed into the local district heating network while also serving as noise barriers for road and rail traffic. Costs are estimated at 288,000€ (Covenant of Mayors, 2014).
- **Loures, Portugal**. The city of Loures has mandated that all schools and athletic facilities with good sun exposure install SWHs by 2020. Costs are estimated at 700,000€ and will reduce annual emissions by 75.6 tonnes of CO_2 equivalent (Covenant of Mayors, 2011)

4.6.2 OPTIONS AND TIPS FOR IMPLEMENTATION

- **Leverage partnerships with community groups and private sector organizations**. Trusted local organizations and partners are crucial to the success of outreach campaigns and community-based purchasing programs. When financial support for a SWH outreach program comes from an international development agency (or any organization perceived as an “outsider”), leveraging these types of partnerships are often a requirement for funding.
- Ensure good-quality installations following an outreach campaign. Outreach campaigns promoting SWH programs and technologies that result in poor quality installations will foster negative attitudes towards the technology that will be difficult to overcome in future initiatives. Addressing barriers to uptake can be challenging in communities where the technology is unknown, and the challenge will be compounded if poor quality pilot installations cause negative views of the technology. In communities where SWHs are unknown or government incentives have not been previously available, it is important to “get it right” the first time.

4.6.3 TOOLS AND ADDITIONAL RESOURCES

- **ESTIF Guides**. The European Solar Thermal Industry Federation's *Guide for Awareness-Raising Campaigns* provide best practices for designing and implementing public outreach campaigns and leveraging online platforms and social media, as well as additional examples of successful awareness campaigns.
- **The Solarize Guidebook**. The Solarize Guidebook provides a framework for communities interested in designing and implementing a "Solarize"-style community-based group purchasing program. While examples are limited to the United States, best practices and lessons learned from the large number of campaigns that have been conducted throughout the country can be similarly applied to developing communities.

SECTION 5
CONCLUSION

As the world's population continues to move towards cities and urban energy demands increase, city leaders should strongly consider developing SWH markets in their jurisdictions. At the residential and commercial building level, SWH can provide a sustainable, reliable and cost-effective option for tenants. At the city level, SWH can improve energy access for city residents, improve the stability of energy costs and the reliability of the electrical grid, create opportunities for new jobs, and reduce a city's greenhouse gas footprint. Cities wishing to build a SWH market, however, face several barriers. At the building level, these can include the upfront costs of installing a system and securing financing. Consumers may be unfamiliar with SWH and may have trouble finding companies that can provide equipment and install a system. At the city level, the government may lack technical expertise and awareness about SWH, and may not have developed standards for equipment or SWH permitting.

To confront these barriers and build a successful SWH market, city leaders should engage in a robust strategic planning process. The chief elected officials can designate a local coordinator and advisory committee to bring together stakeholders to participate in and inform the process. These stakeholders identify opportunities and barriers unique to their context, establish a baseline and targets, and then work with planners and elected officials to implement policies and programs to promote SWH in their city. Policy interventions can range from incentive programs to mandates, and offer opportunities for financing projects or accrediting installers. To be successful, policies and programs need to increase awareness about SWH and break down the barriers that keep residents from accessing SWH.

SWH systems represent an untapped renewable energy resource and market opportunity for many developing country cities. This guide provides a helpful starting place for planners, elected officials, and other city leaders for building a SWH market in their locale. While there are barriers to SWH, these obstacles can be overcome with a strategic planning process and the implementation of targeted and effective policies and programs.

APPENDIX I
SAMPLE SURVEY QUESTIONS

This appendix provides sample questions that policymakers can use to survey end users and building owners in their jurisdictions. Many topic areas provide multiple questions for should be tailored to the demographic being surveyed. They are in part drawn from *Development of an area based energy service company (ESCO) model for solar water heating in India*, a report prepared for the Ministry of New and Renewable Energy of India.

Building Profile

- How many occupants/units/rooms are in the building?

Water Source

- What is the current water source of in the building? (e.g. piped, well, other)

Usage

- (For domestic consumers) What is hot water used for (e.g. bathing, cooking, cleaning)?
- (For commercial/industrial consumers) What level of heat is required? What % of hot water use falls into each category? (e.g. warm, boiling, steam)
- How much hot water is consumed? (e.g. liters/month)

Current Hot Water System

- Is there currently hot water in the building?
- What fuel(s) is used for water heating? (e.g. LPG, electricity, kerosene, gas)
- What is the average monthly fuel consumption? (e.g. average monthly electricity/gas bill, number of LPG cylinders)
- How satisfied are you with your current hot water system?

Solar Water Heating – Willingness to Pay

- Would you be willing to switch to SWH?
- How much would you be willing to pay for SWH? (e.g. in terms of cost for installation or cost per month)
- If a government incentive/low interest loan program became available to reduce the price of SWH, would you purchase a SWH?

Solar Water Heating – Motivation and Awareness

- If you are interested in installing SWH, what would be the most important motivating factor? (e.g. economics, convenience, reliability, environment)
- If you are not interested in SWH, why not?
- How well do you feel you understand SWH?
- Do you have any previous experience with SWH? (e.g. as a system owner, building manager, housing organization)

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This "Solar Water Heating – A strategic planning guide for cities in developing countries" serves as a practical guide to assist local leaders develop actionable plans for solar water heating deployment in developing countries. It includes an overview of solar thermal markets and describes solar thermal technologies, market barriers, international best practices, case studies, and potential policies and programs that can be implemented by urban leaders in developing countries.

This UNEP Guide was developed as part of the Global Solar Water Heating (GSWH) Market Transformation and Strengthening Initiative.