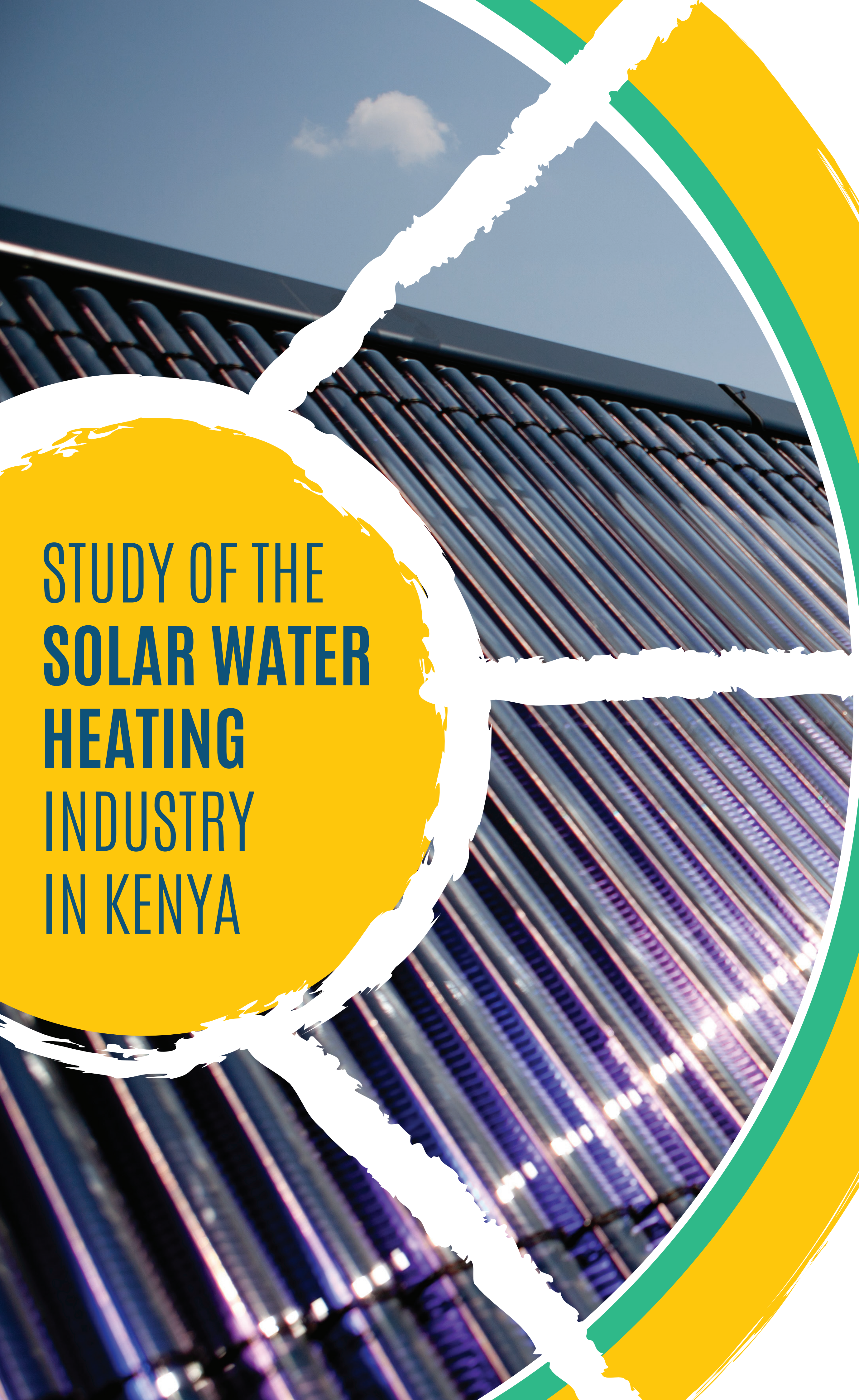

STUDY OF THE **SOLAR WATER HEATING** INDUSTRY IN KENYA

ACKNOWLEDGEMENT

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AC -------------------Alternating Current
CAPI -----------------Computer Aided Personal Interview
ERC ------------------Energy Regulatory Commission (Also referred to as the Commission)
ETC ------------------Evacuated Tube Collector
FPC ------------------Flat Plate Collector
GHG -----------------Greenhouse gas
GIZ ------------------Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GPS -----------------Global Positioning System
GW_{th} ----------------Thermal Gigawatt
IEA ------------------- International Energy Agency
KES ------------------Kenyan Shilling
KRA -----------------Kenya Revenue Authority
KII -------------------Key Informant Interview
KPLC ----------------Kenya Power and Lighting Company
KRA -----------------Kenya Revenue Authority
LPD ------------------Litres per day
MENA ---------------Middle East and North Africa
MWth ---------------Thermal Megawatt
NGO -----------------Non-Governmental Organization
ODK -----------------Open Data Kit
PAYG ----------------Pay As You Go
PV -------------------Solar Photovoltaic
PV-T------------------Solar PV Thermal Systems
SWH -----------------Solar Water Heating Solution
ToR ------------------Terms of Reference
UNDP----------------United Nations Development Program

Executive Summary

Introduction

The solar water heating systems (SWH) industry in Kenya operates under several laws and policies. Published on the 25th May 2012 through legal notice No. 43, the Energy (Solar Water Heating) Regulations 2012, is the central regulatory instrument. These regulations make it mandatory for all premises (within the jurisdiction of a local authority) with hot water requirements exceeding one hundred litres per day to install and use solar water heating systems. Premises are defined as "existing, new or alterations and extensions to existing residential or commercial buildings or structures" and include domestic, institutional, commercial and industrial buildings.

The expected outcome of this regulation was an enhanced national energy security achieved through: "the diversification of the energy supply mix and reduction in over reliance on petroleum imports; reduced demand at peak times; reduced greenhouse gas emissions through offsetting the use of fossil fuel fired peaking power plants; and increased employment and income generation opportunities". However, five years after its enactment and despite the seemingly enormous potential, the uptake of SWH has been low. The Energy Regulatory Commission (ERC) has commissioned this study to identify and document the factors which may explain and contribute to the low uptake of SWH as a first step towards improving the business and regulatory environment. This study (i) documents the state of SWH within the global context; (ii) reviews the current policy, legal and institution framework; (iii) identifies barriers hindering the uptake of SWH; and (iv) provides recommendations on appropriate actions to address the barriers.

State of play – SWH in Kenya within the global context

Based on the International Energy Agency (IEA) SWH average growth rates for Sub Saharan Africa, and SWH importation data collected from the Kenya Revenue Authority, this study estimates that there are about 77,000 SWH (equivalent to 457,076 m^2 of collector area or 0.3 GW_{th}) in the Kenyan market as of April 2017. This is significantly less than the commonly cited figure of 140,000 units. The market currently supports an estimated 960 direct and indirect jobs. The untapped market including domestic, commercial, institutional and industrial is conservatively estimated to be 2 million units (without distinguishing those that are within and outside a 'local authority'). Using the UNFCCC CDM methodology AMS-I.J (Solar Water Heating systems version 1), this study estimates that the current installed SWH systems in Kenya offset about 40,000 tCO_2e per year. The average levelized cost of a SWH in Kenya is KES 13/kWh (11 €-ct/kWh) compared to global average lows of KES 2.4 – 5.9/kWh (2-5 €-ct/kWh) in Brazil, India, Israel and Turkey, and average highs of KES 8.3 – 14.3 (7-12 €-ct/kWh) in Australia, China and South Africa. Total costs of domestic SWH with a capacity of between 100 – 300 litres range between KES 70,000 (€ 576) to KES 300,000 (€ 2,470). Depending on the type of system and type of premise, SWH increases the final cost of residential property by between 0.6 and 2.1%. Flat plate systems are the most common systems in Kenya.

The ability to deflect demand, especially during peak hours, makes the deployment of SWH a potentially effective demand-side management tool for utilities. However, the real-time monitoring carried out under this study reveals that although there are clear energy cost savings to be made (i.e. through reduced energy consumption), there is no significant difference in the peak demand between comparable houses that have and those that do not have SWH. The main reasons for this are that many of the SWH have heating boosters, some of the users have backup options like instant showers units and a considerable number have electronic devices such as microwaves, electric kettles and irons with relatively high-power ratings, and these are commonly switched on during peak hours.

The industry is serviced and supplied by several players. The ERC registry dated the 29th May 2017, had 147 technicians and 58 contractor firms licensed. Within the span of just four months (February to May 2017), 13 additional technicians and 7 contractor firms were added to the registry – this is perhaps in response to ERC notice to enforce the regulation. Most of these companies have their head office location in Nairobi. Only 3 licensed and interviewed companies began operations before 2000 and includes Davis and Shirtliff, Allied Utilities and Steelstone Limited. Most companies (44%) mentioned China as the main source of their imported products. Other supplier countries frequently mentioned include Greece (22%) and Turkey (28%). Nairobi and Mombasa are the main markets for SWH products. Other notable towns include Kisumu, Nakuru and Thika.

Structure of the legal, policy and institutional frameworks

The Solar Water Heating regulations were enacted by the Cabinet Secretary for Energy under the powers conferred by the Energy Act in force (No.12 of 2006), and are in line with the current national energy policy - Sessional Paper No. 4 of 2004. However as currently structured, the regulation (i) suffers from definitional ambiguities of key terms including “local authority” (section 3), “technical limitations” (section 4) and “special circumstances” (section 4); (ii) is unclear on the definition of the party/parties culpable although it is implied to be the owner of the premises (section 6) - the developers, promoters of the construction, architects or engineers engaged in the design and construction, and occupant are also mentioned; (iii) has wide definitional boundaries of who should comply, given that the regulations groups residential, industrial and commercial consumers together and sets a fixed use of 100 litres of hot water per day as a differentiator without consideration of other parameters such as floor space; and (iv) distributes the responsibility of enforcement across different institutes including the Commission, Kenya Power, National Construction Authority, Kenya National Bureau of Standards, County Governments and others but the ultimate responsibility of enforcement has not been explicitly specified in the regulations. Some of the institutions are unaware of the operational procedures and/or lack the capacity to review applications. Others such as Kenya Power, struggle with conflicts of interest, since their mandate and measure of success is determined by the number of new connections to the grid. Another problem is the prevalent lack of water supply. This leaves users suffering from water shortages confounded as to why the government would seek to penalize them for non-compliance yet having the SWH presupposes that the users have adequate water supply in the first place. On the positive side, there exist fiscal incentives for solar water heating under Kenya’s tax laws. The Value-Added Tax (VAT) (Amendment) Act 2014 expanded the list of goods and services that are exempt from VAT as set out under the First Schedule to the VAT Act, 2013. The expanded list includes VAT exemption for, “specialized solar equipment and accessories, including solar water heaters and deep cycle-sealed batteries which exclusively use or store solar power”. As such, the sale of solar water heating systems is currently VAT exempt.

Analysis of the main barriers

This study uses the problem tree analysis to cluster and illustrate the main barriers hindering the uptake of SWH in Kenya. These barriers have been clustered into technical, financial, policy and regulatory, and others. This study identifies 12 core barriers to SWH system uptake: inadequate technical skills, high upfront cost, lack of innovative business models, limited financing options, limited awareness/interest and demand, unclear policy requirements, lack of water, disjointed institutional mandates, inadequate technical standards, limited enforcement capacities among mandated institutions, low quality products and services, and the owner-occupier mismatch. A few of these are further illustrated by the examples below.

The upfront cost of a SWH is prohibitive. A basic 250 litres evacuated tube domestic system from China would cost KES 70,000 (€ 576) at a minimum. This is more expensive than most of the common appliances and fittings found in an average household including fridges and washing machines. Although the systems are expected to operate for over 10 years, most of the warranties given are valid for 1 year or less. This creates limited confidence in a market already impacted by a prevalence of substandard products and services. There is also a widespread lack of awareness. Of those interviewed, many of the non-users (79%) of those required to comply do not know about the regulation and only 14% (out of the 21%) of those that say they do, have sufficient details of the requirements. Additionally, the culpable parties are not clearly defined. It is implied that the owner of the premises is culpable but section 6 of the regulations list other parties. It is therefore unclear, in certain circumstances, whether one or all the parties are liable.

Conclusions and Recommendations

The barriers hindering the uptake of SWH are closely interrelated and it is important to address them simultaneously. Training professions only to install substandard products will not work, and addressing the high upfront cost without raising the level of awareness will not result in the desired outcomes. The final delivery should be a SWH market transformation initiative as opposed to measures that will only address some of the barriers. However, in view of the Commission's mandate, the immediate output of this process should be the replacement of the existing regulation to provide a more supportive policy and regulatory environment that will anchor the necessary research and development, market expansion and capacity development. This study presents 8 recommendations summarized as follows.

Replace the current SWH regulation: This current regulation - the Energy (Solar Water Heating) Regulations 2012, should be repealed and replaced with a dedicated SWH policy that seeks to provide incentives that will grow the market rather than enforce compliance. The new policy should at a minimum provide or result in financial incentives for end-users, support capacity development efforts across practitioners, strengthen the licensing procedures for practitioners, raise awareness among end-users through light-handed industry-led standards and certification processes. This policy should support the other recommendations provided below.

Update the current standards and revise the training curriculum: This can be done through an industry led approach (like World Bank's Lighting Africa program where leading sector players align their products and services to peer approved standards) or through KeBS. The first approach, which is industry-led and light-handed is preferred. Merits and demerits of developing labels should also be considered. The draft curriculum should, among other thing, distinguish between domestic and commercial-institutional systems. Critical reviews to the content and structure are needed but also consideration should be given to the method of deployment. This study proposes partnering with learning and training institutions like the Strathmore Energy Centre, National Industrial Training Authority, Nairobi Technical Training Institute and Jomo Kenyatta University of Agriculture and Technology – who are currently offering various training courses on energy systems.

Develop a highly discounted time of use tariff for water heating: This recommendation is best anchored and delivered through a policy and will bring together the Commission, SWH distributors, financial institutions, Kenya Power and SWH end-users. It leverages Kenya Power's payment platform that has over 5.5 million customers. The Commission will recommend a highly discounted tariff for water heating done between 3am and 5.30am, for example, as an incentive extended to all who purchase SWH systems. Prequalified SWH distributors and products will be eligible to supply the end-users under clearly defined terms including longer warranty periods while financial institutions provide the necessary financing (where applicable). SWH distributors will deploy the systems through(i) direct sales where monthly repayments will be collected as a pass-through cost on the users' electricity bills, (ii) a lease model where users pay a standard monthly fee for a specified period and (iii) a lease to own model where an upfront fee (deposit) is charged and the rest of the payment done through an extended period. A management or facilitation fee should be extended to Kenya Power as an incentive.

Develop a Nationally Appropriate Mitigation Action (NAMA): Although a reduction of 40,000 tCO_2e per year is relatively small incentive for implementing a climate finance project, there is an opportunity to develop a NAMA that will support mandated institutions to monitor the impact of a SWH policy or regulation. This would also contribute towards Kenya's Nationally Determined Contribution (NDC) that requires the monitoring and reporting on mitigation and aligns with the recently enacted Climate Change Act (2016). The expected increased uptake of SWH systems will also increase the amount of emissions avoided making this initiative even more viable.

1 Introduction

1.1 Purpose of the study

The current national installed electricity generation capacity has expanded to 2,341 MW and over 5 million customers are now connected to the national grid[1]. If a modest 5% of these customers regularly use electric water heaters with an average capacity of 2 kW per heater, the total demand attributed to solar water heating would stand at 480 MW or over 20% of the total installed capacity. This illustration demonstrates the significant potential that solar water heating could play in demand side management.

The Energy Regulatory Commission (ERC) of Kenya developed the Energy (Solar Water Heating) Regulations 2012 which were gazetted on 25th May 2012 through legal notice No. 43 as a subsidiary legislation under The Energy Act No. 12 of 2006. The objective of this regulation was to promote the uptake of solar water heating solutions (SWH) in industrial, commercial and residential buildings. The expected benefits of this regulation were, (i) enhanced national energy security through diversification, (ii) reduced demand during peaking hours which results in avoiding expensive fossil fuel powered plants, (iii) increased environmental protection through reduction of greenhouse gases (GHG) and (iv) increased employment, technical capacity and income from an expanded SWH industry. Five years after its enactment and despite the seemingly enormous potential, the uptake of SWH has been low. ERC has commissioned this study to identify and document factors that contribute to this low uptake of SWH as a first step towards improving the business and regulatory environment. This study will (i) document the state of SWH in Kenya within the global context, (ii) review the current policy, legal and institution framework, (iii) identify measures to stimulate SWH uptake and (iv) provide recommendations on suitable actions to address the barriers.

1.2 Approach and methodology

Data and information presented in this report was collected through a three-step approach to meet the requirements of the Terms of Reference (TOR). i) Desk review, ii) Primary data collection and iii) Synthesis.

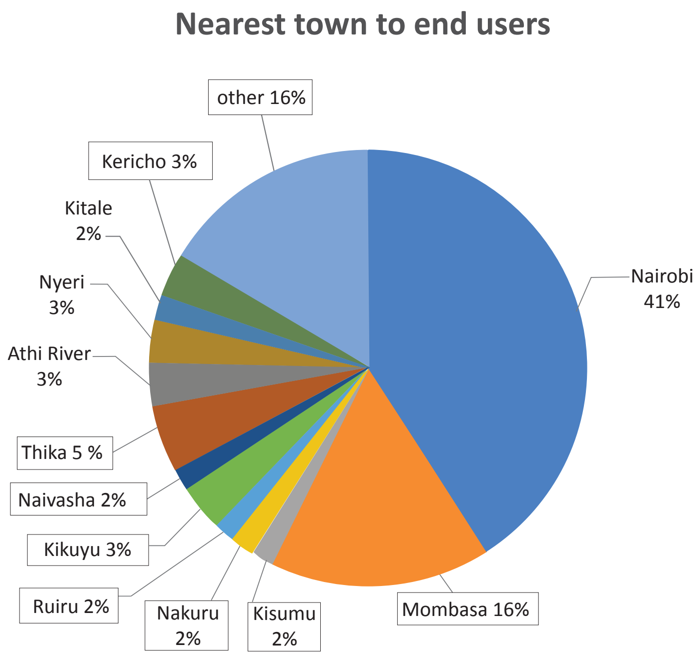
Considerable amount of high-level generic literature exists on SWH technologies. The desk review was done to understand the past, present and future trends in SWH technologies including aspects of design, cost, penetration, business models, economics, supplier profiles among others. This covered an extensive review of the uptake of solar water heating technology, its benefits and the investment climate surrounding it through the review of related case studies, for example, the South Africa Eskom rebate program to part-finance the uptake of SWH technologies in low-income households in various townships, development of Brazil's solar water heater markets, and the role of government in promoting the uptake of SWH systems (China, Australia and Israel). The review was divided into four main aspects: i) the technological, ii) the business and financing, (iii) policy and regulatory, and iv) social-cultural and design.

Primary data was collected through interviews and comparative continuous real-time energy monitoring comparing users of SWH and electric water heaters. Interviews were done with i) suppliers of the systems, ii) licensed installers, iii) developers of industrial, commercial and residential buildings and apartments, iv) financing institutions, (v) development agencies and (vi) end-users. For group (i), (ii), (iii), (iv) and (v), the Key Informant Interview (KII) approach based on a semi-structured questionnaire was used. For end-users (group vi) we used a tablet based survey platform Open Data Kit (ODK) for CAPI (Computer Aided Personal Interviews). CAPI allows for interview inputs to be saved on an electronic device's memory or uploaded directly to a local server where

[1]Kenya Power (2016) Annual Report and Financial Statements, Kenya Power, Nairobi

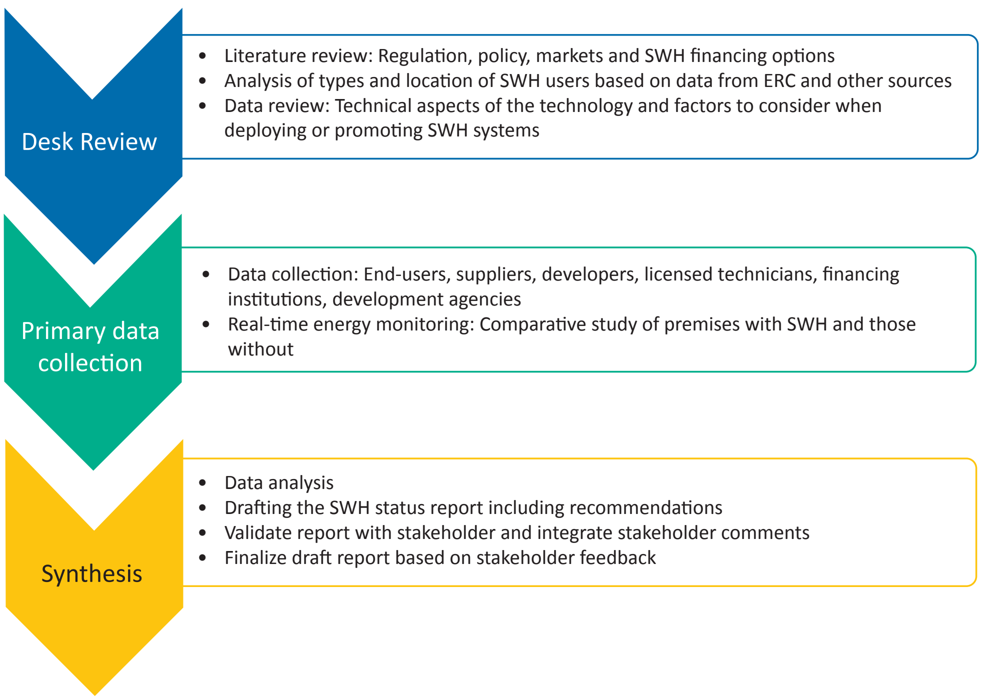
data cleaning and analysis is done. Comparative continuous real-time energy monitoring was done using power analyzers (loggers) to measure the load on the selected premises. These recorded the daily peak demand graphs across the different users to test the veracity of promoting SWH as a practical demand-side management instrument. 27 SWH suppliers and contractors, 18 ERC licensed technicians, 10 Key Informants, 60 SWH end users and 28 non-users were interviewed. Real-time energy monitoring was done at 6 premises.

Figure 1: Distribution of end-users interviewed



Finally, outputs from the desk review and primary data was synthesized to create a coherent discussion on the state, opportunity and challenges of SWH in Kenya. The conclusions and recommendation were drawn from this process.

Figure 2: Summary of the approach and methodology

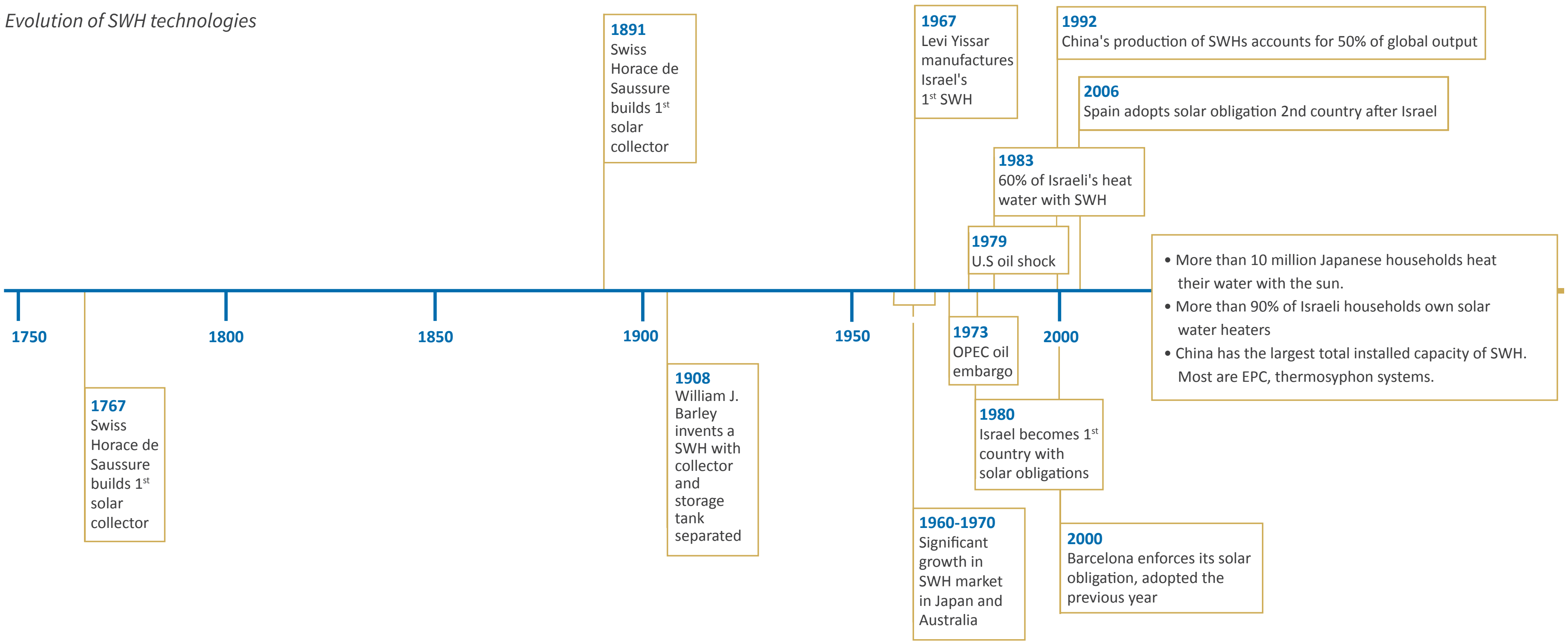


2 Technology Options

2.1 Evolution of SWH

The development of SWH and markets can be traced to periods as early as the 16th century with the discovery of the ‘hot box’ phenomenon. This formed the foundation of solar thermal energy and has since evolved into the current market as shown in Figure 3 below [2,3,4,5]. Solar water heating is the earliest and most common application of solar energy.

Figure 3: Evolution of SWH technologies



[2] John Perlin (2013), The history of Solar Energy, http://www.australiansunenergy.com.au/uploads/67672/ufiles/The_History_of_Solar_Energy.pdf
[3] US Department of Energy, The history of Solar, https://www1.eere.energy.gov/solar/pdfs/solar_timeline.pdf
[4] European Solar Thermal Industry Federation (2007), Best practice regulation for solar thermal, ESTIF, Brussels.
[5] REN21 (2009), Background Paper: Chinese Renewables Status Report October 2009 and Observatoire Méditerranéen de l’Energie (2012), solar thermal in the Mediterranean region: Solar thermal action plan, http://www.solarthermalworld.org/sites/gstec/files/news/file/2013-04-26/solar_thermal_action_plan_ome-mediterranean.pdf

2.2 Types of SWH

SWH are broadly classified based on i) solar collector type, ii) heat transfer fluid and mechanism and/or iii) the fluid circulation system. Below is a summary description of these classes.

2.2.1 Classification by solar collector type

Table 1: Solar collector type

TYPE	FLAT PLATE COLLECTOR (FPC)	EVACUATED TUBE COLLECTOR (ETC)
Key components and working principle	A rectangular frame with a transparent, glass/ plastic front cover that allows solar energy to pass through to a dark solar absorber which has a row of pipes filled with water or a heat transfer fluid flowing through. The frame has an insulated casing. Common in Europe and Africa.	Multiple evacuated glass tubes connected by a manifold. Each tube has a pipe with the heating fluid running through it and an absorber coating. The coating absorbs solar radiation and convert it to heat energy transferred to the fluid. The vacuum space between the outer and inner tube reduces heat loss. Common in China and the Asia region
Advantages	• Cheaper than ETC • Can be exposed to solar radiation even without water in tubes therefore less prone to damages • Lasts for 15 years or more without major maintenance	• More efficient therefore have higher water output temperatures • Tubes are sealed therefore dirt from atmosphere cannot get into collector • Adaptable to areas that experience winter, extreme cold.
Disadvantages	• Less efficient because of inferior insulation capacity relative to ETC • No anti-freezing capacity unless used with heat exchanger • Limited maximum temperature of water output • Scale formation in pipes due to bad quality water	• More expensive compared relative to FPC • Cannot be exposed to solar radiation when there is no water in tubes • Risk of overheating to dangerously high levels • Glass tubes sensitive to breakage • Lasts for 3-5yrs without major maintenance

Flat plate collectors can be glazed or unglazed. Unglazed collectors have a heavy-duty rubber or plastic covering instead of a glass (glazed) one. They are cheaper and can be used in applications that do not require high water temperatures such as swimming pool heating. Evacuated tube collectors can be configured as i) single wall tubes or double walled tubes and ii) direct flow pipes (U pipes) or heat pipes as shown in Figure 3 below.

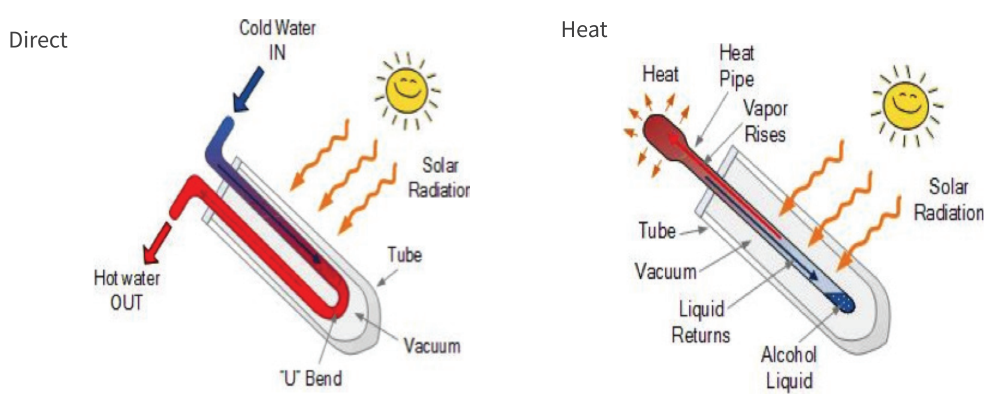
Batch collectors are another type of system less common compared to flat plate or evacuated tube collectors. They are also referred to as integrated collector storage systems and as their name suggests, their distinct feature is the collector and storage tank are housed in the same unit. Their main advantage is, they do not require circulation pumps or electronic controls therefore they have a simple design, easy installation and are relatively cheaper. Their heavy weight and system inefficiency due to higher rates of heat loss compared to other collectors are the main drawbacks of these systems. They are suitable for use in warm climates where hot water requirements are during the day or early evening.

2.2.2 Classification by heat transfer fluid and mechanism

Table 2: Heat transfer fluid and mechanism

TYPE	DIRECT (OPEN) SYSTEM	INDIRECT (CLOSED LOOP) SYSTEM
Key components and working principle	Water to be used is heated directly by solar radiation in the collector. It then flows through the collector to the outlet or via the storage tank.	Water to be used is heated indirectly by a heat transfer fluid. This fluid is heated by solar radiation in the collector and then transfers its heat to the water in the storage through a heat exchanger. The collector loop and water storage loop are separate.
Advantages	• Function well in temperate climates • Most direct systems are passive therefore simpler in design and relatively cheaper	• Most indirect systems are active therefore relatively more expensive • Can be less efficient than direct systems due to heat loss through the heat exchanger • Heat transfer fluid needs to be checked and replaced after several years.
Disadvantages	• Cannot function well in areas that experience temperatures below 4^{0}C without freeze protection. Water prone to freezing • Water can be overheated • Unsuitable for areas with Poor quality water as water deposit can build up and block passages	• More expensive compared relative to FPC • Cannot be exposed to solar radiation when there is no water in tubes • Risk of overheating to dangerously high levels • Glass tubes sensitive to breakage • Lasts for 3-5yrs without major maintenance

Figure 4: Illustration of direct versus indirect system



Source: Alternative Energy Tutorials, http://www.alternative-energy-tutorials.com/solar-hot-water/evacuated-tube-collector.html

2.2.3 Classification by fluid circulation system

Table 3: Fluid circulation systems

TYPE	DIRECT (OPEN) SYSTEM	INDIRECT (CLOSED LOOP) SYSTEM
Key components and working principle	Portable water or the heat transfer fluid moves from the collector to storage by natural convention due to density differences of cold and hot water (thermo-siphon effect) .	Have a pump and a controller to drive portable water or a heat transfer fluid through the system
Advantages	• Do not rely on pumps or electrical controls therefore do not need electrical supply to operate • Simpler design therefore relatively cheaper • Easier to maintain and have a longer lifespan	• Typically, indirect system therefore heat transfer fluid is freeze resistant. Ideal for areas with cold climates. • Greater flexibility in location of system components due to circulation pumps
Disadvantages	• Comparatively tall and heavy units that require larger and stronger mounting roof space. • Collector must be located a lower level from the storage tank therefore system layout is rigid • Normally a direct system therefore hard water can cause scale deposits to clog passages	• Additional components such as pumps and controllers make the system more expensive • Need electricity supply to operate

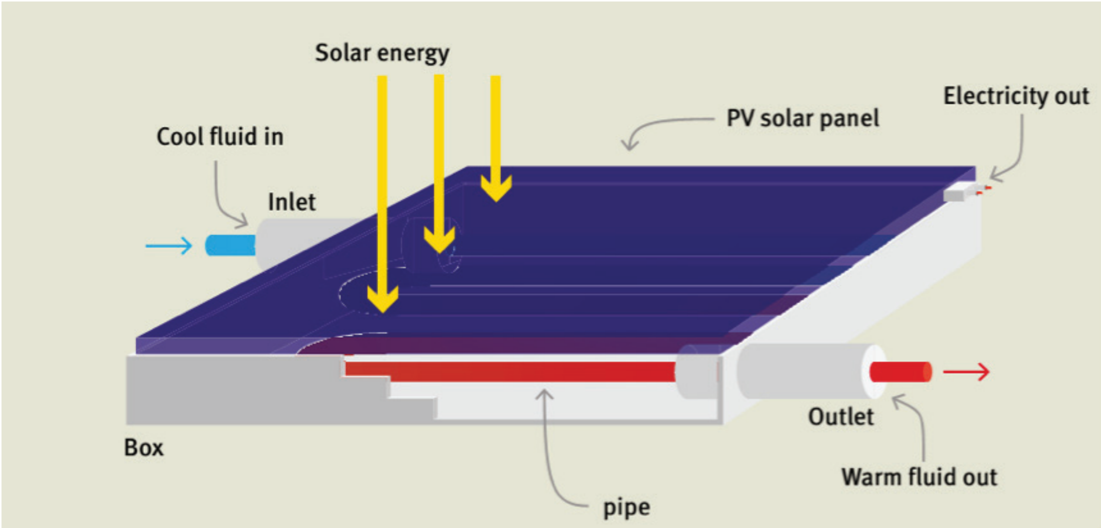
2.3 Innovations in SWH

The growing global market introduces layers of technological and business efficiencies along the value chain as the economies of scale expand. Most of the technological changes are designed around tried and tested technological models mentioned above. There are some initiatives that are exploring ways of radically transforming the design of these systems. One of this is the solar PV-thermal (PV-T) hybrid systems.

Conventional PV panels convert between 4-17% [6] of incident solar radiation to electricity with the remainder being received as heat which leads to a high working temperature of the panel of up to 80^{0}C during hot days. High temperatures negatively impact the electrical output of the silicon in solar PV panels, with efficiency dropping by 0.4%/^{0}C [7] for temperatures above 25^{0}C and cells being structurally damaged by sustained high temperature operation. In a bid to enhance the efficiency and build on the synergies of both solar PV and thermal technologies, PV-T collectors which combine both technologies, have been designed and tested. They can produce up to 40% [8] more energy than individual PV and solar-thermal systems installed side by side over the same roof area. Even with these benefits, only a small number of manufacturers produce these systems as market demand is low limited by the price of the systems which is roughly double the price of a comparable PV system. With the price of solar PV components projected to further decline in the near future, these systems are expected to be increasingly attractive to users who need both electrical and thermal energy in places with limited roof space such as urban environments. The systems are also of particular interest where the low (<100^{0}C) thermal load is in close proximity to the panel such as in domestic use, as the generated electricity can be used to power the booster heater during cold months.

[6] T.T. Chow (2010), *A Review of Photovoltaic/Thermal Hybrid Solar Technology, Applied energy*
[7] Jeffery L. Gray (2011), *The Physics of the Solar Cell, Handbook of Photovoltaic Science and Engineering*, John Wiley & Sons, Ltd. 82-129
[8] Ramos et al (2017), Solar-Thermal and Hybrid Photovoltaic-Thermal Systems for Renewable Heating, Imperial College, London

Figure 5: Schematic of a solar PV-thermal system



Source: Ramos et al (2017), Solar-Thermal and Hybrid Photovoltaic-Thermal Systems for Renewable Heating, Imperial College, London

In anticipation of future regulation mandating PV panels in Kenya, the characteristics of the PV-T system make it suitable for Kenya's tropical climate where it's operation would complement existing SWH regulation and enhance the workings of SWH systems during cold months as well as providing electricity generation capacity for users.

2.4 Size of the global SWH market by technology

Total global installed capacity is estimated to be 410.2 GWth, equivalent to 586 million square meter of collector area 71% of which was in China alone. These estimates are based on a 2016 International Energy Agency (IEA) study which assessed 61 countries that represent about 95% of the worldwide market[9]. The number of jobs created by the sector's value chain from production to installation to maintenance stood at 730,000 in 2014. The prices of small domestic thermosiphon systems (comparable to those in Kenya) vary greatly from KES 2.4 – 5.9/kWh (2-5 €-ct/kWh) in Brazil, India, Israel and Turkey to KES 8.3 – 14.3 (7-12 €-ct/kWh) in Australia, China and South Africa[10].

Evacuated tube collectors constitute the largest share of the cumulative capacity of SWH systems in operation at 71%. In terms of fluid circulation, 75% of installed systems worldwide are thermosyphon systems compared to active/pumped systems. This is a growing trend as sales figures illustrate that these two types are increasingly popular. In 2014, 78% of the new installed systems were evacuated tubes and 90% thermosyphon systems. China has heavily influenced this technological trend as it remains by far the largest at 289,520 MWth and fastest growing market for SWH as shown in Figure 5 below. Suppliers in China are specializing in thermosyphon, evacuated tube systems. However, the capacity of SWH systems installed per 1,000 inhabitants remains higher in countries such as Austria, Cyprus and Israel. The same year (2014), China also led in terms of additional installed capacity at 36.7 GWth followed by Europe (3.4 GWth). The two regions had a combined market share of 85.9% of the capacity installed that year[11]. By 2015 China alone had 77% of installed capacity of installed SWH systems[12]. It also has over 2800 SWH manufacturers across the country to provide supply[13].

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[9]IEA (2016), Solar Heat Worldwide, Markets and Contribution to the Energy Supply 2014, International Energy Agency, Paris

[10]Conversion rate of € 1 = KES 118.8

[11]Solar Heating and Cooling Programme, *Solar Heating Worldwide Markets and contributions to Energy supply 2014, 2016*

[12]Renewable Energy Policy Network for 21st Century, (2016) *Renewable 2016 Global Status Report, 2016*

[13]Li, W., Song, G., Beresford, M., Ma, B. (2011) *China's transition to green energy systems: The economics of home solar water heaters and their popularization in Dezhou City.*

The growth of the SWH market has been varied from country to country as growth was experienced in Denmark, Israel, Mexico, Poland and Turkey however, despite China having the largest market share its market has slowed due to decreasing housing construction. For African countries, statistics from South Africa, Lesotho, Zimbabwe, Mauritius, Mozambique show installed capacity of 0.1 GWth and of the SWH market 63% accounts for domestic hot water use in single family households and 28% for large domestic households and institutions such as schools, hospitals and hotels. Climate and cost of systems are two of the main factors that affect the choice of SWH used in the world. The SWH sector in the North American market for example due to climatic factors is dominated by pumped systems because they are better suited for freezing control. Most systems in regions with warm climates such as Africa, MENA and Asia are thermosyphon systems due to their relatively cheaper cost.

Figure 6: Type of SWH collectors installed in the top 10 counties (Data source: IEA, 2016)

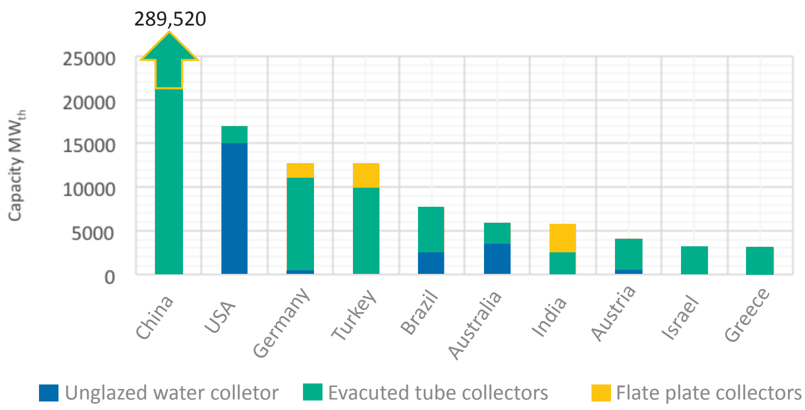


Figure 7: Type of SWH collector installed by region (Data source: IEA, 2016)

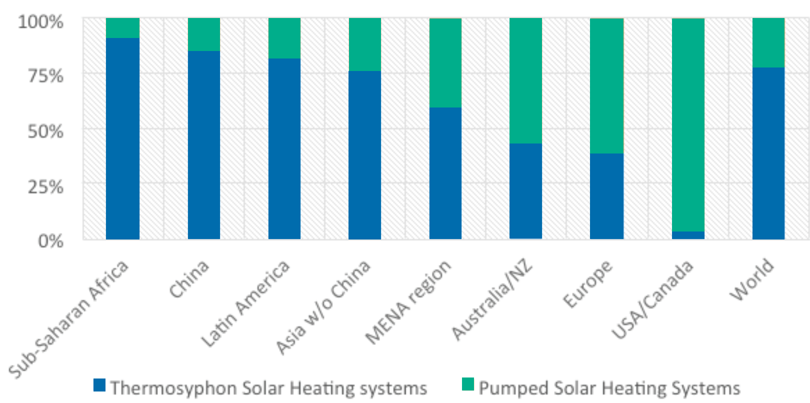
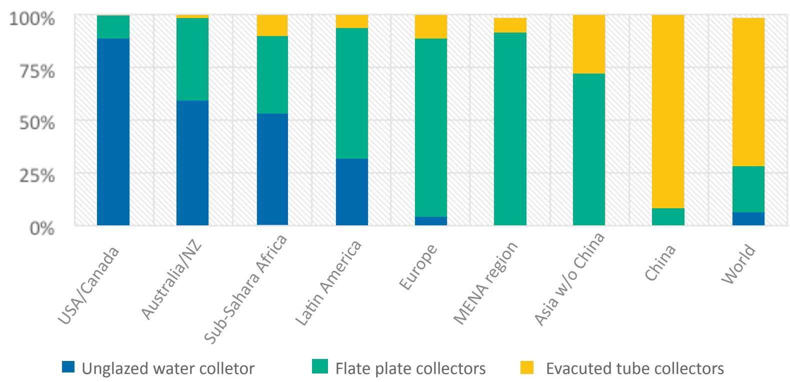


Figure 8: Type of SWH circulation installed by region (Data source: IEA, 2016)



3 Structure of Kenya's SWH Market

3.1 Background and size of Kenya's SWH market

A 1987 World Bank report[14] notes that "dissemination of information on SWH technologies to potential consumers and producers in Kenya is needed to increase public awareness of the merits of this new technology and facilitate its replication." The report recommends among other things improved coordination, product certification, loan disbursement and capacity building. Thirty years later the SWH market in Kenya still contends with the very same challenges that have hindered the growth of the market for decades.

This report estimated that the potential market size for domestic systems in Kenya at the time was 140,000m^2 in collector area. Other market size estimates include a 2005 paper by AFREPREN[15] which stated 50,000 units installed (equivalent to a collector area of 140,000m^2) and the 2011 Ministry of Energy SREP Investment Plan which put the figure at 140,000 units installed[16]. This could have been the same 140,000 from the 1987 World Bank report but a misreporting of units – instead of collector area, total units installed was used. To update this important statistic, this study collected SWH importation data from the Kenya Revenue Authority (KRA) across 7 years (January 2010 to April 2017). Based on this information and the average growth rate of installed SWH capacity in select Sub Saharan Africa countries from the International Energy Agency's[17], this study estimates that the current number of installed and operational SWH units in Kenya stands at 77,000 units.

According to the KRA data collected, 25,193 systems were imported between 2010 and 2015 (this excludes the 1,362 systems imported in 2016 and the beginning of 2017). The average growth rate in Sub Saharan Africa according to the IEA stood at 11% per year from 2011 to 2016. If Kenya's SWH market follows a comparable long-range growth rate, the average annual SWH imports of 4,200 based on the KRA data would be comparable to an 11% growth rate. The initial installed capacity as at ending 2009 would therefore be 38,181 operational systems and the country's estimated capacity as of April 2017 would be 64,739 systems (sum of 38,181, 25,193 and 1,362), extrapolated to 65,789 as at June 2017. To cater for the few units that are manufactured locally (only Steelstone Limited reported local manufacturing) and some that may have entered the market outside the scope of the KRA data, this study applied a 10% top-up to the basic number (70,000 units, which was rounded off from 65,789) to arrive at 77,000. Using Sub-Saharan Africa estimates from the IEA report, about 84.5% of the systems installed in Kenya are expected to be domestic translating to a collector area of about 2.9m^2 and the remaining 15.5% systems covering about 22.5m^2. This adds up to a total installed capacity of 415,524 m^2 corresponding to about 0.3 GWth of installed capacity. As at the end of 2015 the estimated installed capacity in a select number of sub-Saharan Africa countries[18] was 1.4 GWth[19].

Most systems installed in Kenya are domestic water systems with tank capacities ranging from 150L to 300L. Many commercial organizations, such as hotels, with SWH systems also use modular domestic systems to meet their demand. The gross collective area of thermosyphon domestic system ranges from 2.0 – 4.0m^2. Table 4 breaks down the total collector area, number of systems and consequently average square meter per system for select countries in sub – Saharan Africa.

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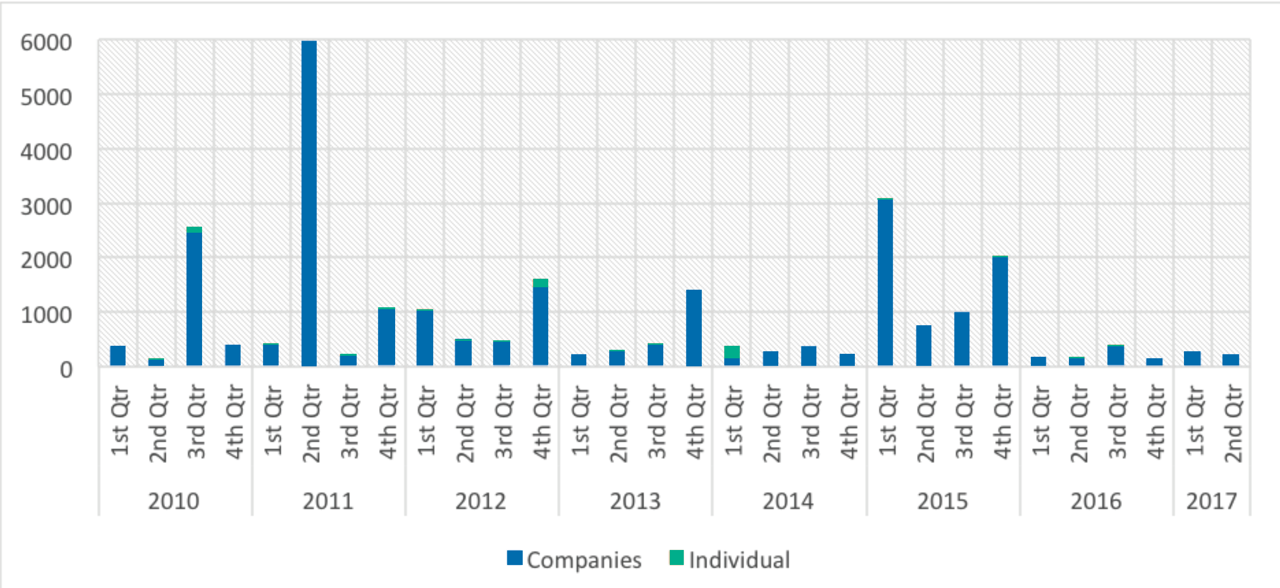
[14]World Bank (1987), Kenya Solar Water Heating Study, Joint UNDP/World Bank Energy Sector Management Assistance Program, Washington DC.
[15]Karekezi, S, et al (2005), *The potential contribution of non-electrical renewable energy technologies (RETs) to poverty reduction in East Africa, AFREPREN, Nairobi*
[16]CIF (2011), SREP Investment Plan, Kenya, Scaling-up Renewable Energy Plans for Low Income Counties, Climate Investment Funds, Nairobi
[17]IEA (2017), Solar Hear Worldwide, 2017 Edition http://www.iea-shc.org/data/sites/1/publications/Solar-Heat-Worldwide-2017.pdf
[18]South Africa, Botswana, Burkina Faso, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal and Zimbabwe.
[19]IEA (2017), Solar Hear Worldwide, 2017 Edition http://www.iea-shc.org/data/sites/1/publications/Solar-Heat-Worldwide-2017.pdf

Table 4: Total collector area and total number of systems installed in specific countries in Sub- Saharan Africa

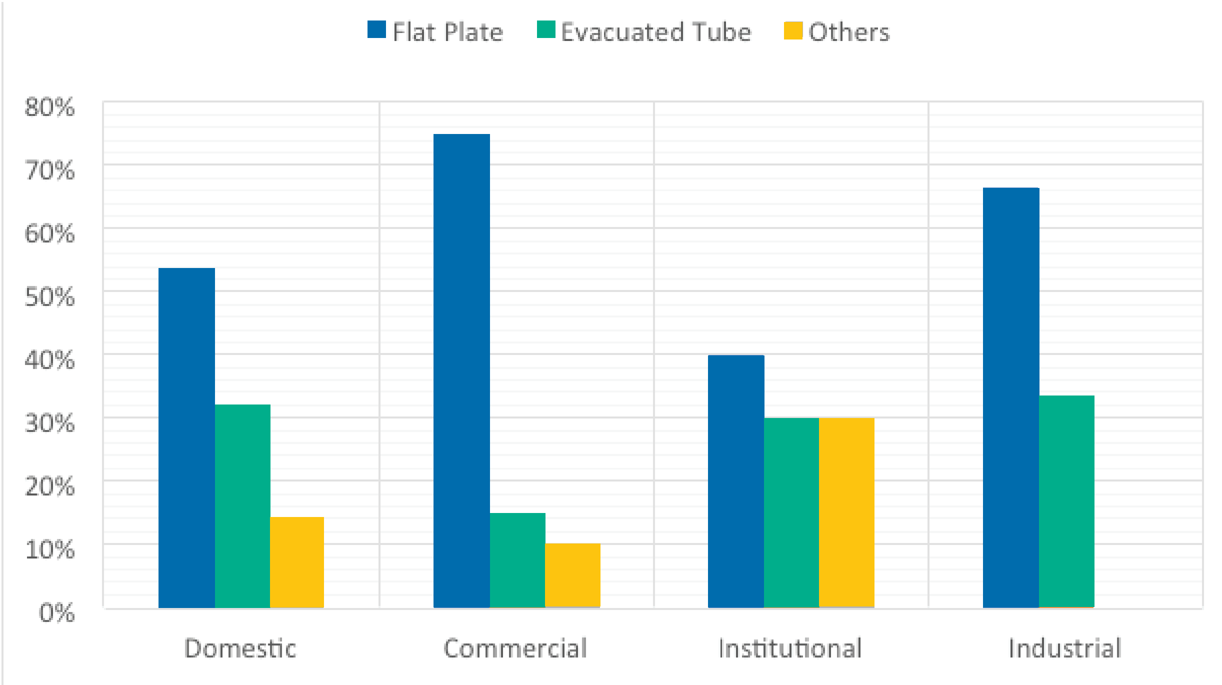
COUNTRY	DOMESTIC SYSTEMS			MULTIPLE HOUSES/HOTEL SYSTEMS			% of domestic systems against total systems
	Total collector area (m^2)	Total number of systems	Average m^2 per system	Total collector area (m^2)	Total number of systems	Average m^2 per system	
Botswana	4,200	1,050	4.0	2,800	93	30.0	91.9%
Lesotho	359	179	2.0	1,288	43	30.0	80.6%
Mauritius	132,793	88,529	1.5	0	0	0.0	100.0%
Mozambique	1,359	340	4.0	0	0	0.0	100.0%
Namibia	14,273	3,568	4.0	17,445	349	50.0	91.1%
Senegal	1,601	800	2.0	50	11	4.5	98.6%
South Africa	725,696	483,797	1.5	14,619	3,655	4.0	99.3%
Zimbabwe	28,074	7,019	4.0	0	0	0.0	100.0%
Average			**2.9**			**22.5**	**84.5%**

Figure 9: Number of SWH units imported into the country between QTR1 2010 and QTR2 2017 (Source: KRA)



Flat plate collectors are the most common systems in Kenya. Although there appears to be widespread market spoilage, evacuated tube systems in particular are perceived to be of ‘substandard’ quality. This could be because evacuated tube systems are typically more difficult to install than flat plate collectors and the tubes are fragile and prone to breakage or overheating. Also, these systems do not work well in areas with ‘hard’ or saline water including some borehole supply or in areas along the coastline and they require regular maintenance. These factors contribute to their negative reputation in the Kenyan context. Due to their affordability, however the market for evacuated tube systems is growing in Kenya especially among end-users. From the end user interviews done, there is a clear preference of flat plate collector systems compared to evacuated tube systems. This is most pronounced among commercial users.

Figure 10: Distribution of SWH technologies among end-users interviewed[20]



The estimated annual emission reductions from SWHs use was determined using the formula below:

Emission Reduction = Energy saved × Emission Factor of electricity/fuel displaced[21]

Electric energy saved was determined from the energy production in kWh of the installed systems used as shown below:

Annual production of solar thermal energy = 0.29 × H0 × Aa[22]

Where H0: Annual global solar irradiation on horizontal the given location in kWh/m^2

Aa: Collector aperture area in m^2

Kenya's solar irradiance on a horizontal plane is 4.5 kWh/m^2 [23] per day translating to an annual figure of 1642.50kWh/m^2. Using a conservative national grid emission factor of 0.18tCO_2e/MWh, and the calculated annual solar energy generated from imported SWH of 194,592 MWh, the estimated emission reductions per year is 35,027 tCO_2e. As above, assuming a 10% increase to cater for locally manufactured systems and those imported outside the KRA network, the annual emissions avoided is 38,530 tCO_2e rounded off to 40,000 tCO_2e.

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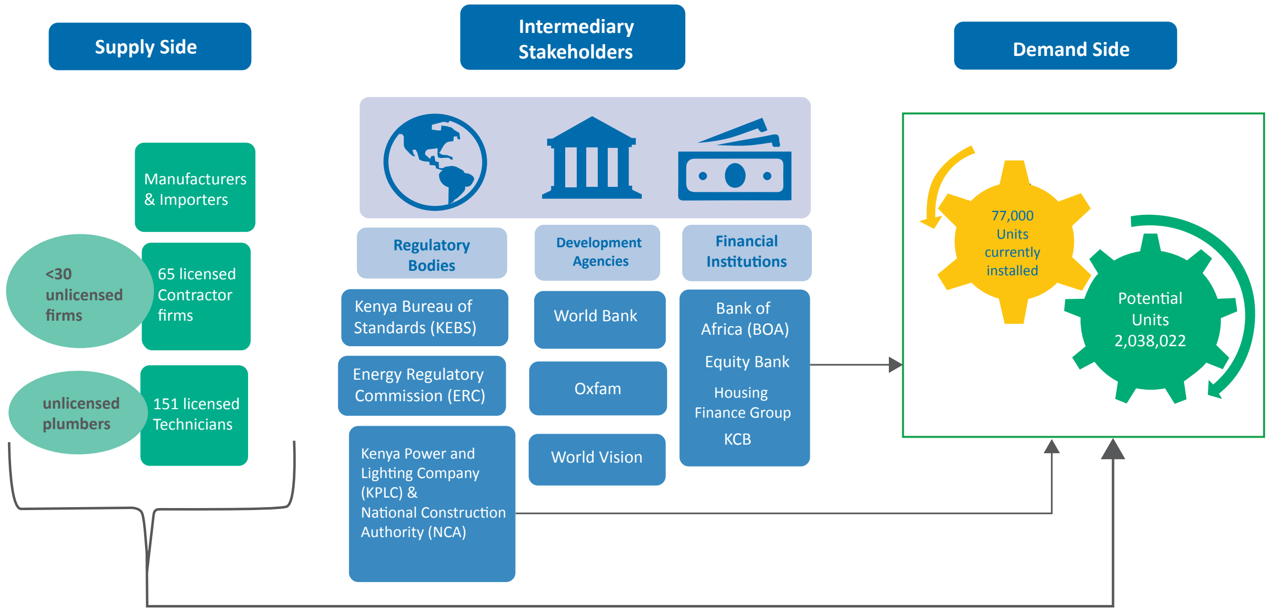
[20] 'Others' include installations that are a combination of ETC and FPC or installations that the end-user did not know the type of collector in their system.

[21] UNFCCC CDM Methodologies,2011, *AMS-I.J Solar Water Heating systems version 1*, https://cdm.unfccc.int/filestorage/C/D/M/CDM_AMSW6UZGA5S50I7V3N2F5WOFHCRFEOMND/EB60_repan17_AMS-I.J%20_ver01.pdf?t=WG18b3RhZTRqfDCX5YmKKHRlppfuw45A4Uev>

[22] International Energy Agency, C*onverting Installed Solar Collector Area & Power Capacity into Estimated Annual Solar Collector Energy Output*, https://www.iea-shc.org/Data/Sites/1/documents/statistics/Calculation_Method.pdf>

[23] The Solar and Wind Energy Resource Assessment Project 2008, Solar and Wind Energy Resource Assessment http://kerea.org/wp-content/uploads/2012/12/Kenya-Solar-Wind-Energy-Resource%20Assessment.pdf

3.2 Key actors



In 2012, The Ministry of Public Works published a registry of building contractors. In the list, 10 plumbing companies were identified as providing solar water heating systems services. In line with the 2012 solar water heating regulation that requires SWH technicians and contractor firms to be registered under ERC, the Commission received its first applicants in 2013. Of the 3 contractor firms that applied, none were licensed and of the 7 technicians that applied only 1 was licensed[24]. Since then, this group of licensed technicians and contractors has grown significantly. The most recent registry as at 10th July 2017 has 151 technicians and 64 contractor firms. In 2017 alone, 17 additional technicians and 13 contractor firms have been added to the ERC registry within a span of 6 months (February to July).

Using the contacts from the February 2017 registry all contractor firms and 25 randomly selected technicians were contacted to be interviewed. Based on their willingness to participate and availability, interviews were carried out with 27 contractor firms and 18 registered technicians. Only 3 of the technicians interviewed do not carry out their services as part of an organization/company. Most of these companies have their head office location in Nairobi except for 3 based in Nairobi's environs; Kikuyu, Syokimau and Thika. Only 3 companies began operations before 2000 including Davis and Shirtliff, Allied Utilities and Steelstone Limited with a majority having started from 2010. Most companies are small to medium size with only 4 having more than 100 employees. 45% of the companies interviewed carry out operations internationally while majority operate only in Kenya. However only 17% source products locally with the majority importing all or most of the components. 44% of the companies interviewed mentioned China as the main source of their imports. Other countries mentioned as the main source of imports include Greece (22%) and Turkey (28%). Nairobi and Mombasa are the major markets for products. Other towns mentioned include Kisumu, Nakuru and Thika. Most companies, 86%, supply both SWH systems and provide technical services such as installation of systems.

Although limited in scope and terms, there are programs that provide credit for SWH systems. There are partnerships between financial institutions and SWH distributors such as KCB Bank and Chloride Exide, Equity Bank and Orb Energy, and Bank of Africa with Energood Limited. For example, Chloride Exide and KCB Bank provide loans with a tenure of 3 to 4 years. Bank of Africa and Energood provide 100% financing with loans ranging from KES. 50,000-2,000,000. However, the current Central Bank interest rate regulation that came into force in 2016 capped commercial interest rates

[24] ERC (2013), Annual Report and Financial Statements 2012-2013, Nairobi

at 14% have negatively impacted these initiatives. Interest rates prior to this were between 15 and 25%. The reduced rate makes unconventional lending unattractive for financial institutions.

Other potentially interesting financing structures include pay-as-you-go options now widely used for solar PV systems and selling energy through energy delivery contracts, more practical for larger commercial or institutional users. In Europe, SWH manufacturers are delivering services through heat supply contracts based on the Energy Service Company contracts (ESCO) to increase uptake[25]. Kenya has had at least one ESCO established in 2001 and supported by the Global Environment Facility and the Kenya Association of Manufacturers, however there is no data on the number of projects undertaken[26]. A key challenge for ESCO's is securing long term financing brought about by the novelty of the idea and lack of experience among financial institutions[27]. There are no long-range robust examples that can assist with pricing the risk and evaluating applications for credit. Carbon finance can also provide some financial support although the compliance and voluntary carbon markets are experiencing an unprecedented decline in carbon prices. Development institutions such as the World Bank and the French Development Agency has offered support to the sector as well. World Bank also supported a study on the barriers and potential of the SWH sector in 1987 with an aim to stimulate uptake. More recently, the French Development Agency through Kenya Association of Manufactures and select financial institutions including Cooperative Bank have been offering financing for renewable energy projects under the SUNREF (Sustainable Use of Natural Resources and Energy Finance) initiative.

KeBS mandate is to provide standardization and conformity assessment services across industries including the solar water heater sector. KeBS has developed two SWH specific standards i) standards/specification of thermal components including collectors and storage tanks (several documents), ii) KS 1860:2009 Solar heating systems for domestic hot water - design, installation, repair and maintenance - Code of practice. The code of practice document was developed in 2009. It has however not been reviewed since. Standards are due for review after a 5-year period. In its current form, the standard only covers solar heating systems having collectors with liquid heat transfer media for heating water for domestic purposes in single family or two-family dwellings. According to an interview with a KeBS official, KeBS has a limited capacity to test the components of the SWH systems that come into the country and so they depend on the certificate of conformity (COC) from the country of origin as a measure of quality.

3.3 Growth and potential unreached market

Non-users interviewed belong to households with three bedrooms or more. The number of people per household ranges from 1 – 7. As a representative of the potential market for SWH systems, they were interviewed to highlight hindrances to the adoption of SWH systems among potential users. Non-users were asked a series of questions to better understand their attitudes and perception on household's electricity use especially regarding hot water applications, and on solar water heating systems and the sector at large. Their feedback is represented in Figure 11 below. It was clear that very few potential users are aware of the regulations and the few that do, do not have the details. About half of the potential users perceive hot water heating consuming more than half of their recurrent electricity costs.

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[25] Renewable Energy Policy Network for 21st Century (2016), *Renewable 2016 Global Status Report*

[26] IISD (2010), *Energy Service Companies in Developing countries*

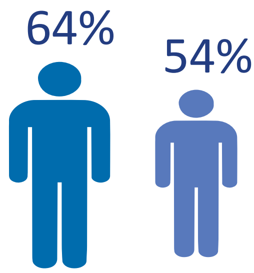
[27] UNEP (2014), *Solar Water Heating Techscope Market Readiness Awareness*

Figure 11: Feedback from non-end users of SWH (domestic)

3 - (i) Perception & Attitudes of control group

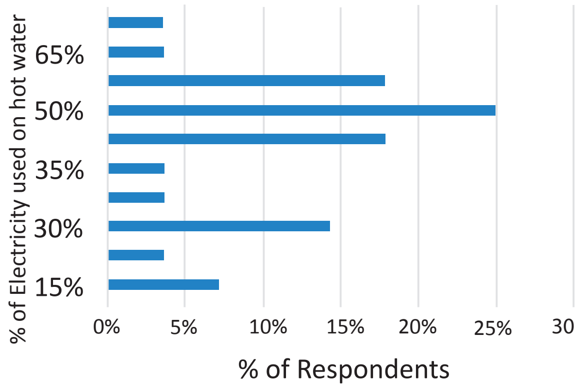
Attitudes on Household electricity use

64% agree that the amount of electricity their household uses is high,
54% agree than the amount of electricity they use for heating water is high



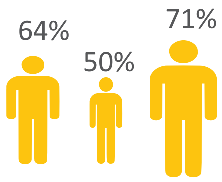
Perceived proportion (%) of electricity used for hot water applications by households e.g. 25% perceive to use 50% of their electricity on hot water applications

% of Electricity used on hot water



3 - (j) Perception & Attitudes of control group

64% agree that SWH systems are expensive,
50% have no opinion on whether they work well or not
71% believe systems can be retrofitted on already built and occupied houses



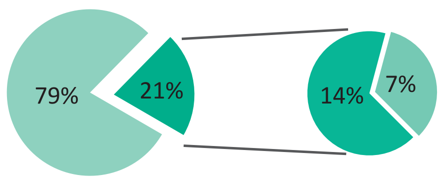
Opinions on SWH systems & the sector

50% believe there are few good technicians that can install SWH systems well. 42% have no opinion on the matter
50% believe it's difficult to get credit or financial assistance to buy a SWH system. 36% have no opinion on the matter

Awareness of the SWH sector &

64% know where to buy a SWH system
32% know where to get a good technician to install it

21% only arc aware of the existence of the 2012 SWH regulation
14% know the details of the regulation



It is evident that though most individuals believe that the proportion of electricity they use on hot water applications is high, they lack information on SWH systems as a possible alternative.

3.3.1 Potential market

Despite the development of the regulation and the accompanying five-year grace-period for premises which previously had no SWH, there has been slow uptake of SWH and little enforcement. This means that there is still a large untapped market. The potential market has been broadly categorized into three; residential buildings, commercial buildings and institutions encompassing educational institutions, health institutions, hotels and restaurants and laundries as set out in the SWH Regulations. Industrial institutions have been incorporated as they represent a likely market segment.

Potential Residential Market

The potential residential market can further be broken down into two categories, upcoming residential houses and established residential premises which have yet to be fitted with SWHs. The 2017 Kenyan Economic Update drafted by the World Bank indicates that the number of dwelling units being developed annually in Kenya stands at an estimated 50,000 units. The 2012 SWH regulations stipulate that the average water demand per person in a domestic residential house is 30L per day and the number of persons occupying a premise shall be equal to the number of bedrooms multiplied by a factor of 1.5. The regulations further highlight that SWH should be installed for premises with hot water requirements exceeding a capacity of 100L per day. This means that residentials homes with three bedrooms or more are the target dwelling units for SWH systems. Of the 50,000 units developed it is assumed that about 45% are three bedroomed houses based on that 1999 Kenya National Demographic Census indicator of homes larger than 3 bedrooms. Using this percentage, it is assumed that only 22,500 units will be 3 bedroomed or more representing the potential untapped market for SWH. There are two scenarios that can be developed for established residential premises without SWHs.

a) Scenario One

This scenario assumes rigorous enforcement of the regulations for all households that have yet to comply. The 2012/2013 Kenya National Housing Survey Basic Report places the number of households as 9,180,716 in 2013. This figure can be further disaggregated into the different types of dwelling units which include bungalows, flats, maisonettes, Swahili houses, shanties and manyattas/traditional Houses. Shanties and Manyattas conventionally do not have SWH units installed and have thus been eliminated from the subsequent calculations. Bungalows, maisonettes, flats and Swahili Houses make up 76.6% of the total household figure equivalent to 7,032,428 households[28]. If 50,000 units have been developed annually since 2013, then the current number of Bungalows, Maisonettes, Flats and Swahili house units in Kenya can be estimated to be 7,232,428. As at 1999, the percentage of houses with 3 bedrooms and more was 45%[29]. Using the same percentage, the current household units with three bedrooms and above will stand at 3,254,593 some of which have already been fitted with a SWH. Of the 77,000 SWH units in Kenya an estimated 84.5%[30] have been fitted in domestic residential houses. This means that the actual untapped potential of established residential premises stands at 3,189,528 units. The combined figure for potential residential market under scenario 1 stands at 3,212,028 units.

b) Scenario Two

This scenario assumes enforcement among residential houses occupied by home owners as opposed to rented premises. The field survey revealed that most households with SWH systems own the premises, thus it becomes important to look at the at the potential market from a land tenure perspective. According to the 2012/2013 Kenya National Survey Housing report 64% of the households in Kenya are owned while 36% households are rented. If the percentage tenure remains constant then the current number of Bungalows, Maisonettes, Flats and Swahili Houses that are owned in 2017 can be estimated to be 4,628,754 households out of a total 7,232,428. Applying 45% for houses with 3 bedrooms or more puts the number of households at 2,082,939. The potential market from established residential premises in scenario two then stands at 2,017,874 units after deducting the SWH units that have already been installed. The figure for established residential premises in scenario two with the figure for upcoming residences you get a potential residential market of 2,040,374 units.

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[28] This does not disaggregate those under a "local authority" as this remains ambiguous

[29] Analytical Report on Housing Conditions and Social Amenities Volume X

[30] IEA (2017), Solar Hear Worldwide, 2017 Edition http://www.ieashc.org/data/sites/1/publications/Solar-Heat-Worldwide-2017.pdf

Potential Market from Institutions and Commercial Buildings

The approach adopted for determining the potential market from institutions and commercial buildings involved calculating the average daily hot water requirements in litres for a sub-sector, selecting the appropriate system size based on the litre requirement then determining the number of SWH units required. The institutions captured in the study include Health Facilities and Educational Centres while the commercial buildings are Hotels, Hostels Camps and other similar premises providing accommodation.

a) Health Institutions

The number of beds per 1000 people in Kenya is reported to be 1.4[31], thus the total number of hospital beds in Kenya amount to 67,910 beds. The SWH regulations estimate that each bed has a daily hot water requirement of 50L. Thus, the total requirement comes to 3,339,524L. If SWH systems of 20m^2/1000L[32] are installed across the medical facilities. Then an average of 3,396 units will be installed with a total collector area of 67,920m^2.

b) Educational Institutions

All boarding schools at primary and secondary level are considered as well as public universities, Technical and Vocational Education and Training (TVET) Centres and teacher training colleges. The number of students enrolled was multiplied by the 5L hot water requirement outlined in the SWH regulations to determine the litre requirements at the educational institutions. The numbers are outlined in the table below.

Table 5: Educational Institutions and hot water requirements

#	Educational Institution	Number	Enrolment	Litres of Hot Water
1	TVET	1,300[33]	202,556	1,012,780
2	Public and Private Universities	58[34]	564,507	2,822,535
3	Teacher Training Colleges	430[35]	41,707	208,535
4	Private and Public Secondary Boarding schools	6812[36]	1,818,804	9,094,020
5	Private and Public Primary Boarding Schools	3,035[37]	1,025,830	5,129,150
6.	**Total**			**18,267,020**

If SWH systems of 20m^2/1000L[38] are installed in educational institutions. Then an average of 18,267 units will be installed with a total collector area of 372,540m^2.

c) Hotels, Hostels and Accommodation Premises

According to the Kenya Hospitality Sector Report by Cytonn Real Estate, the number of hotel beds in Kenya at the end of 2015 stood at 58,000. The SWH regulations give an average daily amount of 40L per bed. Assuming full bed occupancy, the hot water requirement across Kenya in would be 2,320,000L. Adopting the use of SWH systems of 20m^2/1000L will result in 2,320 units for hotels Kenya with a total collector area of 46,400m^2. Cumulatively the total number of SWH units required for institutions and selected commercial buildings comes to 23,983 units. Of the 77,000 SWH units in the Kenyan market an estimated 15.5% have been installed in commercial building and institutions. Thus, the potential untapped market for installation of SWH units in this sub-sector becomes 12,048 units.

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[31] World Health Organization (WHO) http://data.worldbank.org/indicator/SH.MED.BEDS.ZS?locations=KE
[32] Solar Water Heat 2017
[33] World Bank (2017), The Kenya Economic Update, April 2017
[34] World Bank (2017), The Kenya Economic Update, April 2017
[35] World Bank (2017), The Kenya Economic Update, April 2017
[36] 2014 Basic Educational Statistical Booklet; UNICEF and GOK
[37] 2014 Basic Educational Statistical Booklet; UNICEF and GOK
[38] IEA (2017), Solar Hear Worldwide, 2017 Edition http://www.ieashc.org/data/sites/1/publications/Solar-Heat-Worldwide-2017.pdf

Overall Potential SWH Market.

The overall potential market for SWH units in Kenya in scenario one is **3,224,076** units while in scenario two it is **2,052,422** units with the caveat that there is 100% market penetration in both scenarios. With the current population growth rate and housing deficit of 2 million units[39]. These figures are likely to increase. It is also important to note that due to the lack of credible data on restaurants and eateries as well as laundry facilities in Kenya, the potential market could be marginally larger. The untapped market can be harnessed through awareness creation on the 2012 Energy (Solar Water Heating) Regulations as well as providing a variety of financing mechanisms to promote uptake of the SWH systems. This should go hand in hand with rigorous enforcement of the regulations.

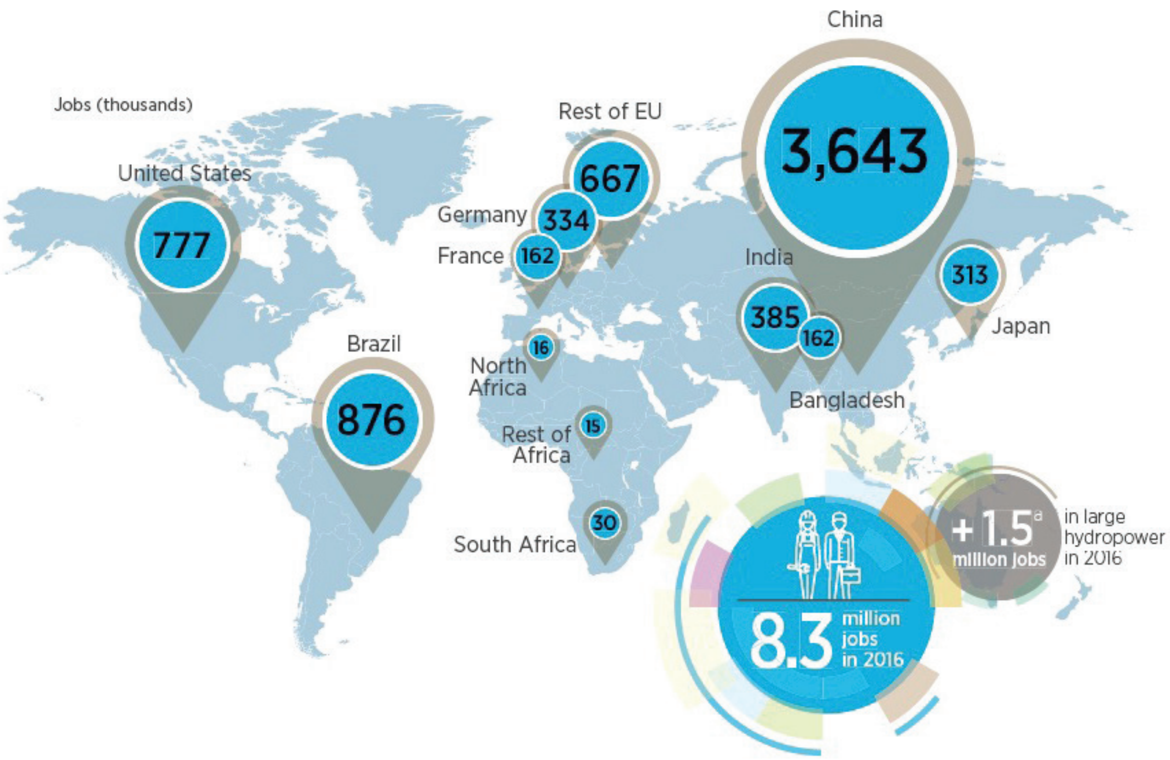
3.3.2 Job creation in the SWH sector

Current Jobs from SWH

IRENA's 2017 annual review on renewable energy and jobs estimates that the renewable energy sector employed 9.8 million people, directly or indirectly, around the world in 2016. Of these 828,000 jobs were developed in the solar water heating and cooling value chain. Analysis reveals that the percentage proportion of renewable energy jobs created by Solar heating/cooling is 9.97%.[40] Renewable energy-related job creation remains low across the continent of Africa where it is estimated that only 45,000 renewable energy jobs were created in Sub-Saharan Africa in 2016 as illustrated in **Figure 12** below.

Using the percentage proportion of jobs created globally, this study estimates that about 4,500 are supported by the SWH industry in Sub Saharan Africa. According to the 2017 Solar Heat Worldwide report, the total installed capacity of solar water heater units in Sub Saharan Africa is estimated to be 1.4 GWth compared to 0. 3GWth in Kenya. If the same employment creations variables are in play, this study estimates that about 960 direct and indirect jobs are supported by the sector.

Figure 12: Number of renewable energy jobs per continent in 2016



Source: IRENA Renewable Energy and Jobs 2017 Annual Review

[39]World Bank Kenya Economic Update 2017

[40]IEA (2017), Solar Hear Worldwide, 2017 Edition http://www.ieashc.org/data/sites/1/publications/Solar-Heat-Worldwide-2017.pdf

Potential Jobs

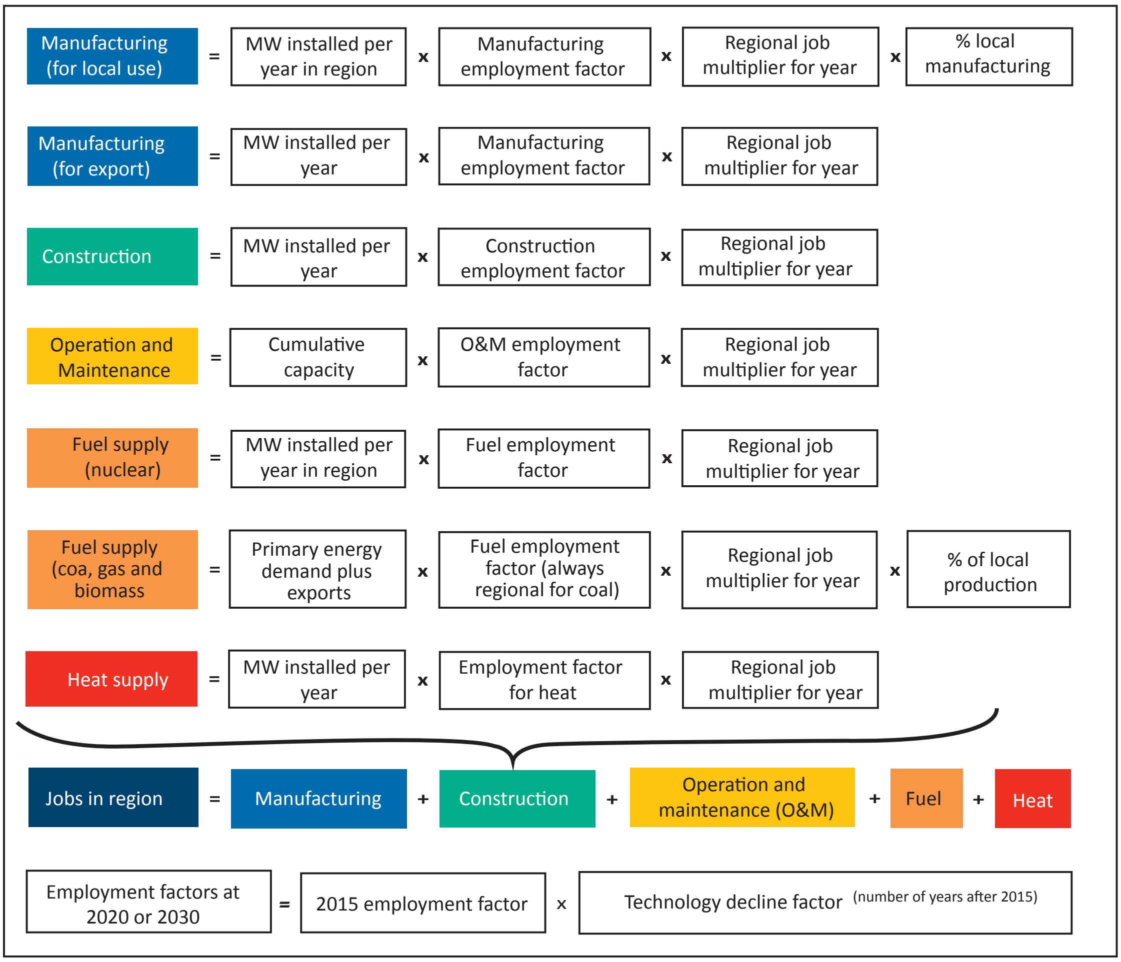
Two scenarios can be developed for calculating potential jobs created through the proliferation of SWH technologies. Scenario one involves using the current estimated growth rate for SWH technologies of 11.9% and projecting the growth until 2030. Scenario two involves using figures for the potential market for SWH uptake. Jobs in both scenarios will be computed using the employment factor method described below. Indirect and induced jobs have not been factored in.

Direct jobs are those in the primary industry sector and include jobs in fuel production, manufacturing, construction, and operations and maintenance. Indirect jobs generally include jobs in secondary industries which supply the primary industry sector, for example, catering and accommodation, while induced jobs are those resulting from spending wages earned in the primary industries. Indirect and induced jobs are usually calculated using input-output modelling. The inclusion of indirect jobs would typically increase job numbers by 50 – 100%, while the inclusion of both indirect and induced jobs could increase job numbers by 100 – 350%.[41]

Employment Factor Method

The employment factor method is one of the ways of determining the potential number of jobs. Employment factors indicate the number of full-time equivalent (FTE) jobs created per physical unit of choice. This can be a unit of installed peak capacity or produced energy, expressed in megawatts or megawatt- hours for electricity-generating technologies (MW or MWhel) or heat-producing RETs (MWth or MWhth)[42] .

Figure 13: Employment factor calculations



Source: Institute for Sustainable Future's report 2015

[41]Institute for Sustainable Futures; Calculating Global Energy Sector Jobs 2015: Methodology Update
[42]IRENA (2013), Renewable Energy and Jobs Report

Figure 13 indicates the mode of calculating employment for Solar Water Heating using the employment factor method. The table 6 below gives the employment factors and the other relevant multipliers to be used in subsequent computation.

Table 6: Job calculation multipliers

Multiplier Name	Figure
World Average Employment Factor in 2015 for Solar Thermal Heat (Construction and Manufacturing)	8.4
Overall Technology Decline Factor form 2015-2030	6.0%
Annual Technology Decline Factor	0.004%
Regional Job Multipliers	5.4 up to 2020 and 4.5 up to 2030

The Employment factor of 8.4 is an overall estimate for jobs per MW_{th} in construction and manufacturing in the Solar Thermal Heating sector. Kenya currently only has one company manufacturing solar water heating units so the job figures below could be lower.

Table 7: Number of Jobs Using Annual SWH growth rate

Year	Number of SWH(Units)	Cumulative Installed Capacity MW_{th}	Annual additional Installed Capacity(MW_{th})	Number of Direct Jobs	Employment Factor	Regional Adjustment Factor
2017	77000	300.00	35.70	**1606**	8.33	5.40
2018	86163	335.70	39.95	**1790**	8.30	5.40
2019	96416	375.65	44.70	**1995**	8.27	5.40
2020	107890	420.35	50.02	**2224**	8.23	5.40
2021	120729	470.37	55.97	**2066**	8.20	4.50
2022	135096	526.35	62.64	**2302**	8.17	4.50
2023	151172	588.98	70.09	**2566**	8.13	4.50
2024	169161	659.07	78.43	**2860**	8.10	4.50
2025	189292	737.50	87.76	**3187**	8.07	4.50
2026	211817	825.26	98.21	**3552**	8.04	4.50
2027	237024	923.47	109.89	**3959**	8.01	4.50
2028	265229	1033.36	122.97	**4412**	8.0	4.50
2029	296792	1156.33	137.60	**4918**	7.9	4.50
2030	332110	1293.93	153.98	**5481**	7.9	4.50

3.4 Market delivery approaches

From the stakeholder and end user interviews, three market delivery approaches were identified, that is i) full payment upon installation of the system, ii) credit through bank loans and iii) credit from the system supplier. In the first and most common option, the contractor gives a quotation of the cost of acquiring the system to the end user or developer. This cost is often inclusive of other labour costs such as installation and the cost of the SWH system. There is then agreement on the mode and terms of payment. It is common place for an initial deposit to be paid and the balance paid upon installation and commissioning of the system. The second market delivery approach is bank loans. It includes a third stakeholder, financial institutions. As discussed earlier in this report, local banks have formed partnerships with SWH suppliers to provide their products on loan to end users. End users who are account holders in these banks can access loans at preferential terms to enable them to acquire the SWH systems from the partner suppliers. Equity Bank for example has such an arrangement with Orb Energy Limited where it provides loan packages to end users for Orb energy products including their SWH systems. The partnership between KCB with Chloride Exide Ltd alternatively targets mortgage customers accessing financing from the bank and enables them to acquire SWH systems from Chloride Exide at discounted rates and free installation. In the third market delivery option large suppliers such as Davis and Shirtliff extend credit terms to specific end users. Often these end users are developers purchasing systems in bulk, commercial or industrial users acquiring large systems or repeat customers such as smaller suppliers. More than 80% of the respondents indicated they acquired their systems through the first market delivery mode indicating that the other two may not be very established in the sector.

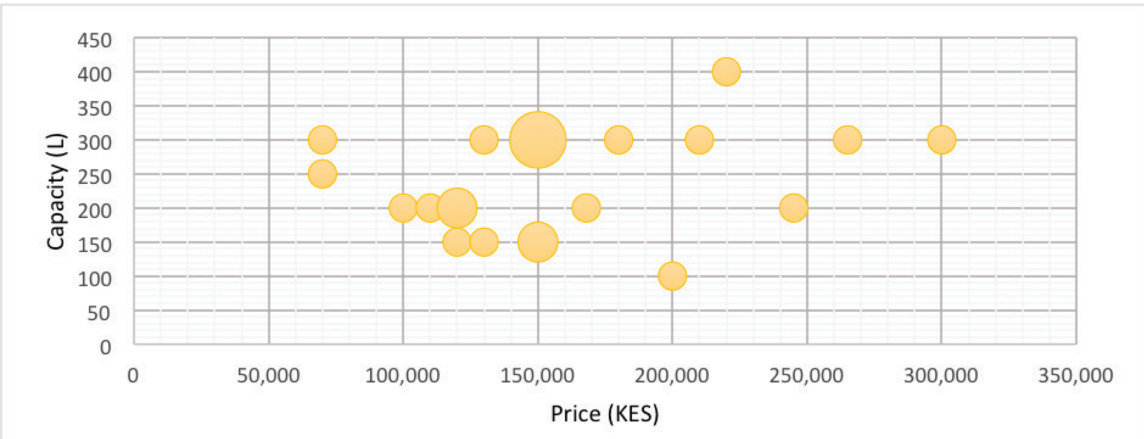
One of the main barriers to the adoption of SWH systems is the high initial cost. Market delivery approaches that extend forms of credit or financing to end users need to be further developed to spur growth of the sector. As the market stands, SWH system financing schemes have been developed by financial institutions and suppliers based on their own initiative. There may be value in roping in other relevant stakeholders such as the utility Kenya Power to explore innovative SWH financing schemes that can be integrated into their operations as a company. KPLC for example can bear the upfront cost of the purchase and installation of SWH, retaining ownership of the systems while charging end users for the hot water used from the system. This charge could be a fixed monthly one lower than the cost incurred if a traditional hot water device was used so the household can still realize savings with the system or can be based on consumption by employing a hot water meter. Based on how the financing scheme is set up, the end user could end up acquiring ownership of the system after KPLC has recouped its investment.

3.5 Economics of SWH

3.5.1 Cost of systems

From the end user interviews, domestic systems with a capacity of between 100 – 300L have a price range of KES 70,000 to KES 300,000. Figure 14 below presents self-reported capacities and costs of domestic systems and as can be seen, the largest proportion of systems are 300L units sold at KES 150,000. One of the cheapest systems encountered during this study was a 200L evacuated tube system retailing at KES 49,000 on an online portal, demonstrating how varied the current market prices are. Evacuated tube systems are, however, generally observed to be cheaper relative to the flat plate collector systems.

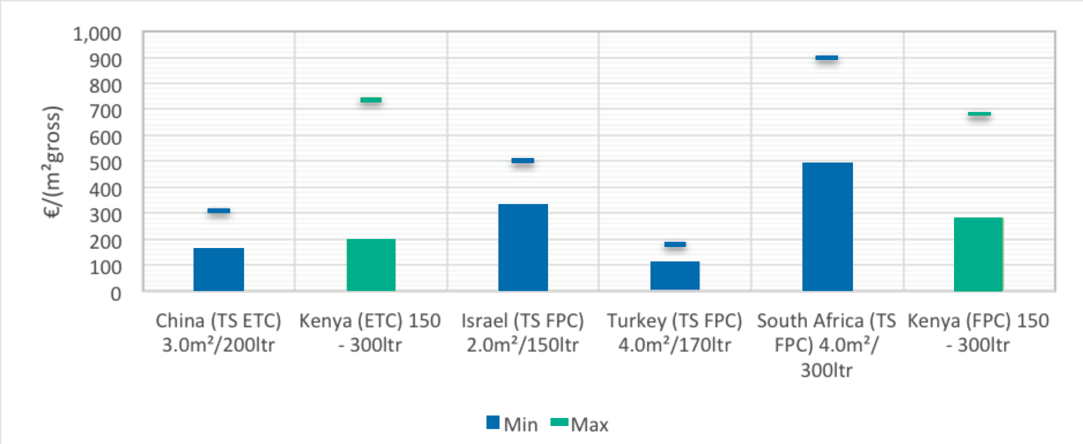
Figure 14: Price points of <400L end user SWH systems



Larger systems (>1000L) are understood to have a greater price variance. The most expensive system recorded was a 10,000L system that cost approximately KES 30 million and the cheapest was a 1,000L system for KES 1.2 million. Comparing this to costs of similar systems in other countries, SWH systems seem to be relatively expensive in Kenya. For instance, the cost for a thermosyphon (TS), evacuated tube, 200L system in China ranges from 160 - 310 €/(m²gross) (19,171 – 37,144 KES/ m²gross).[43] A similar evacuated tube system in Kenya, assuming similar collector area and capacity, has a cost range of 194.7 – 737.3 €/m²gross (23,333 -88,333 KES/ m²gross) based on end-user interviews. This trend is consistent for flat plate collector systems observed.

[43]IEA (2017), Solar Heat Worldwide 2017 edition

Figure 15: Cost of SWH systems in Kenya compared to other countries



3.5.2 Impact on the cost of premises

As shown above, the cost of SWH varies greatly and depends on the type, size, source and business delivery model. Other factors that influence the final cost include economies of scale (for large commercial developments as opposed to a standalone premise) and place of purchase (local or direct import). Apartment complexes with several housing units for example, would gain from the two benefits as the system's infrastructure is shared across units and the developer may opt to import the systems directly rather than purchase them from a local retailer. The choice of system is also user dependent and the factors that inform the decision vary as much as the end-users. Therefore, the estimated impact on the final cost of property should be treated as indicative and not definitive.

As earlier highlighted, the final cost of domestic systems with a capacity of between 100 – 300L range between KES 70,000 and KES 300,000. These are suitable for residential houses of 1 to 6 bedrooms. In calculating hot water demand, the regulations put across some assumptions: a person in a residential building is assumed to consume 30 litres of hot water per day and each bedroom is assumed to accommodate 1.5 persons. This means that a 1 bedroom, 2 bedrooms and 3 bedrooms houses are expected to each consume 45, 90 and 135 litres per day respectively. According to the Quarter 1 2017 Hassconsult Property Index[44], an average 1-3 bedroom and 4-6-bedroom house costs 14.1 and 47.3 million respectively. This means at the high end of the impact spectrum– comparing the highest cost system with the smallest housing units – the property price increases by 2.1%, while on the low end – comparing the least cost system with the largest housing units – the property price increases by 0.6%.

3.5.3 Payback period

Simple payback is the calculation of the time taken (in years) for annual savings to recoup the initial cost of the system.

$$\text{Payback Period (yrs)} = \frac{\text{(Capital Cost)}}{\text{(Annual Savings)}}$$

The capital cost of SWH systems includes cost of technology, installation labour and other costs incurred in the setup of the system including taxes. Annual savings is determined by factoring in the alternative energy cost and energy produced by the system to meet demand annually.

$$\text{Annual Savings pa} = 365 \text{ days} \times \left(\frac{P_{solar}}{day} \times CF\right)$$

Where:

- pa is per annum
- Psolar is the energy produced by the SWH system
  CF is the cost of the alternative heating energy (e.g. electricity) per kWh

Using data on monthly averaged insolation incident on a horizontal surface (kWh/m²/day) for Nairobi[45] (SI), daily energy produced by the system(P_{solar}) can be determined as a function of collector area (CA) and efficiency (µ).

$$\frac{(P_{solar}}{day} = SI \times CA \times \mu)$$

The lowest recorded SI for Nairobi is 5.65 kWh/m²/day, average CA for domestic systems ranges from 2-4 m² and the efficiency of ETC and FPC assumed to be 46.2% and 50.7% respectively[46].

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[44]Hassconsult (2017) The Hass Property Index – Quarter 1, 2017, Hass Consult, Nairobi

[45]NASA surface meteorology and Solar Energy available tables for Nairobi. Lat 1.292 and Lon 36.822 over a 22year average

[46]Assumption based on estimated efficiencies for ETC units from China and FPC units from Turkey used in IEA 2017 Solar Heat Worldwide report.

Table 8: Payback of domestic SWH systems in Kenya

HH No.	Collector type	Psolar/day (kWh)	CF- Cost of elec in Kenya (KES/kWh)	Annual savings p.a.	Capital cost (KES)	Payback period (years)
1	ETC	5.198	20	37,945.4	70,000	**1.8**
2	FPC	5.763	20	42,069.9	100,000	**2.4**
3	ETC	10.396	20	75,890.8	265,000	**3.5**
4	FPC	11.526	20	84,139.8	300,000	**3.6**

As can be seen in Table 8, the payback period based on energy produced by the system ranges from approximately 2yrs – 4yrs. This can be estimated as

$$\frac{Q_{Load}}{day} = \text{Use}\left(\frac{\text{ltr}}{day}\right) \times \rho_{water} \times C_{water} \times \Delta T$$

Ideally, when the system is sized well, Q_{load} is equal to PSolsr. However, this is not often the case. Assuming each person in the house consumes 30 Ltrs of hot water per day, the daily Q_{load} per person is 1.566 kWh; if HH No. 1 and 2 in Table 8 had 3 people each, Q_{load} would be 4.698 kWh and the payback would increase to 2yrs and 2.9yrs respectively.

3.6 Technical performance of SWH

32% of the end users interviewed have had to repair or replace their SWH systems at some point. Most of the problems faced were related to piping. Some specific issues included clogged pipes, leaking pipes, pipes that had burst due to high pressure and airlocks. End users also faced problems related to the electrical heating elements of the systems.

Though only 20% of end users stated that they were dissatisfied with the performance of their system, 45% had faced one or more challenges with their procurement, installation or operation. Some of procurement and installation challenges mentioned include:

- difficulty in finding a good supplier;
- poorly mounted frame that is now slanting on the roof;
- additional work needed for pipe network and roofing to accommodate the system which was expensive;
- little information given by technicians of functionality of system,
- most fixtures required during installation were not available locally.

Most of the challenges faced were operational. Some of these include

- Clogged pipes,
- Lack of sufficient hot water during cold season
- Leakages
- Poor quality systems that often broke down

3.6.1 Domestic energy monitoring

To better analyze savings made by end users of solar water heating systems compared to non-end users, electric load measurements were carried out on 6 households, 4 with SWH systems and 2 without, for a period of 24 to 72hrs. A power analyzer was used to log variations in household electricity use per second interval[47].

It was observed that households with SWH had less power spikes and lower peak demands than those without SWH systems. However, there was a small peak power difference between SWH and non-SWH system households where other electrical water heating devices were used as backup including instant showers and electric boilers. This was observed in SWH end user 1, 2 and 3. Energy monitoring was done during the cold season therefore the backup use of electric water heating elements or devices was observed in all but one of the end users monitored. 18% of SWH end users interviewed stated they used either an instant shower or electric boiler as backup source of hot water as well. Electric kettles are used in 54% of the interviewed domestic households.

3.6.2 Industrial and commercial energy monitoring

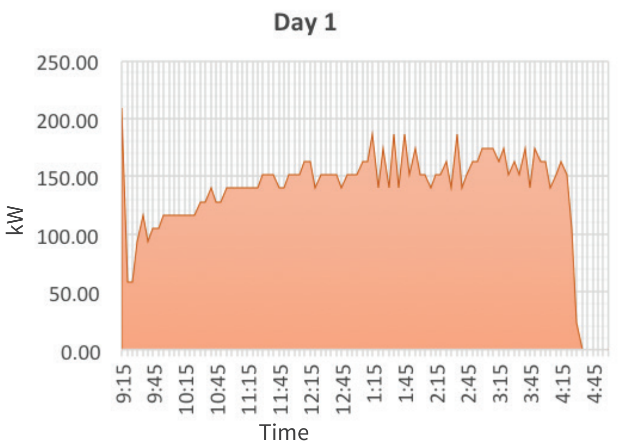
It was noticed that many commercial (especially hotels and lodges) and industrial end users use hot water devices that are

[47]Load profile curves in ANNEX 1

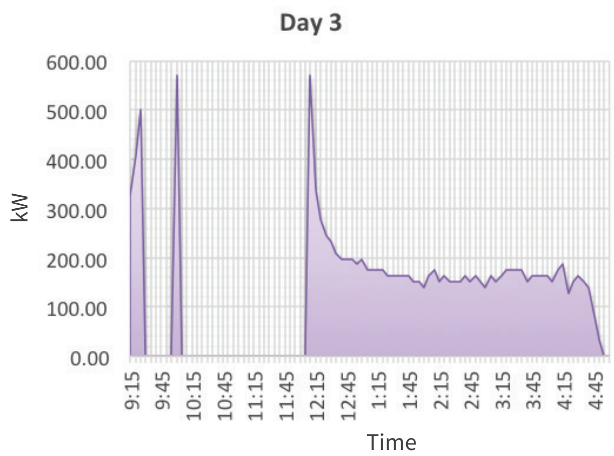
not electrical, namely fuel and wood boilers. Furthermore, in cases where these end uses get solar water heating systems, they still retain their original boilers as backup systems. Energy savings are therefore based on the reduction in fuel (diesel and HFO) and firewood needed for the organizations operations.

Case study – Large FMCG manufacturer based in Industrial Area

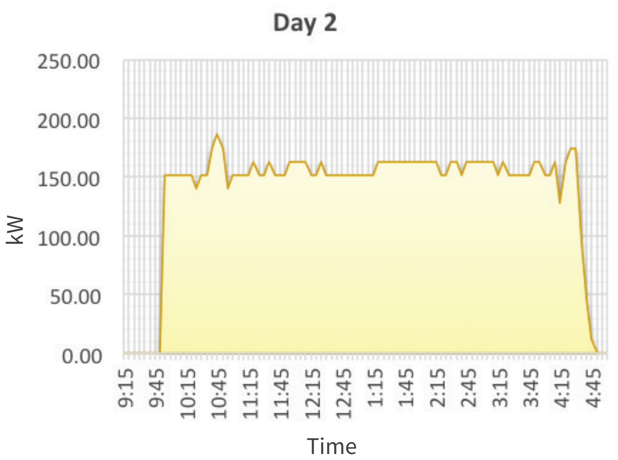
In February 2017, the company set up the largest SWH system in the country. It is a 10,000L capacity system with 171 flat plate panels. The system was set up to displace the use of a HFO boiler system during the day. To evaluate the energy saving made by the company, data was collected on the energy produced by the installed SWH system based on temperature difference monitoring between the collector and tank of the system. Below is a representation of 4 days of energy monitoring data.



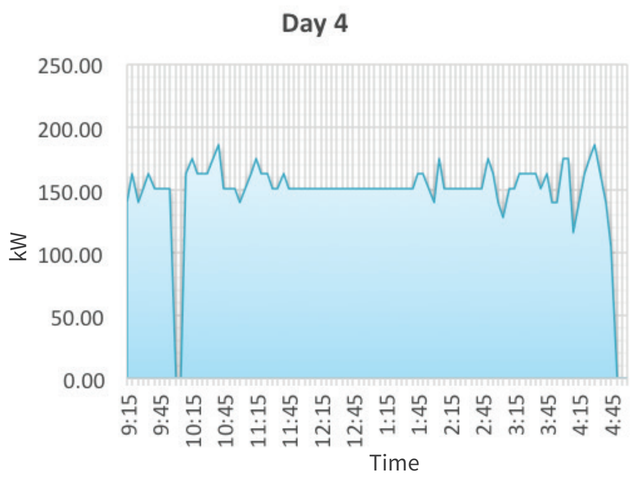
Total energy produced by SWH = **1,041 kWh**



Total energy produced by SWH = **1,054 kWh**



Total energy produced by SWH = **967 kWh**



Total energy produced by SWH = **1,134 kWh**

Case study – Large Beach and Spa Resort, Mombasa

In November 2011, the hotel set up a Heliodyne SWH system in their hotel in Mombasa. The system has 64 flat plate collector panels and a collective capacity of 20,000L. Previously, the hotel used a diesel boiler to meet its hot water demands. Now this system is used as a backup. Table 9 presents their self-reported numbers.

Table 9: Recorded fuel use saved

YEAR	TOTAL DIESEL USED (L)	SAVINGS (L) (DIFFERENCE)
2011 (Solar Installed in Nov)	96,900	
2012	67,800	29,100
2013	80,400	16,500
2014	70,700	26,200
2015	66,200	30,700
2016	71,700	25,200
Average (2012- 2016)	**71,360**	**25,540**

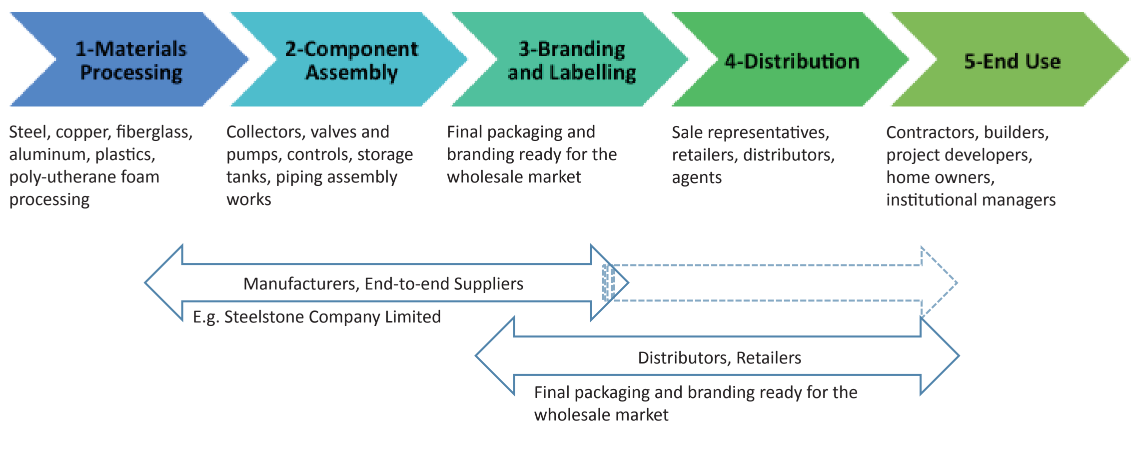
Based on the average diesel consumption of the hotel, the SWH system has resulted in about 25% in savings of fuel needed for operations per annum.

3.7 Skills Requirements

3.7.1 Skills Matrix and Gaps

The SWH sector in Kenya is estimated to support about 960 direct and indirect jobs. The sector's value chain starts from material processing to end-use (as shown in Figure 16) with all steps requiring various sets of skills. Although many of the materials required for manufacturing are available in Kenya, the process typically starts at step 3. The focus has been on the configuration of the SWH system with little attention given to plumbing and civil works, both of which are crucial to the optimal functionality of the system. Apart from Steelstone Company Limited, none of the distributors interviewed stated that they carry out local manufacturing. However, assembly of systems is not uncommon in the market

Figure 16: Generic SWH value chain schematic



**Adapted with modifications from the China Solar Energy Fact Book*

The challenges with manufacturing SWH in Kenya are similar to those faced in the manufacturing sector in general. These primarily raise the cost of production making products manufactured locally less competitive to those manufactured abroad, for example in China. Limited skills and experience are a secondary factor limiting manufacturing. However, it was evident from the interviews that there are major skills gaps in the market – especially in plumbing and civil works associated with SWH. Other seemingly peripheral skills, for example, system sizing, orientation considerations, water quality testing, material selection (for plumbing especially), are important but are not commonly featured in the training and capacity development narrative. Also, it is important to distinguish the skills required for large commercial-institutional systems relative to domestic systems. The skill sets required per step according to the value chain schematic (Figure 16) are summarized in the Table 10 below. The specific skill will vary by technology type, scale and business model.

Table 10: Summary of generic skills required per step on the value chain

#	STEP	SKILLS/EXPERIENCE
1	Manufacturing	Specialized skills in: • System design, research and testing • Shearing/cutting of metallic or alloy sheets • Welding, riveting, soldering, gluing and other joinery techniques • Bending of various materials • Insulation materials
2	Assembly	Detailed understanding of: • Types of systems and solar collectors (FPC/ETC) • System sizing and configuration • Local market needs and resources • Water storage, valves, auxiliary heaters, controllers and insulation • Costs, efficiency, system specifications, functioning principles
3	Branding	• Product marketing • Leveraging distribution systems • Market penetration and sales strategy
4	Distribution	General understanding of: • Types of systems and solar collectors (FPC/ETC) • Demand driven system sizing • Water storage, valves, auxiliary heaters, controllers and insulation • Costs, efficiency, system specifications, functioning principles
5	End Use*	Installation • Mounting posts, roof attachments, anchors • Collector mounting structure and corrosion protection • Weather proofing and measures to avoid seepage • Performance test on collectors to detect leakages • Testing for air interlocking • Testing fluid circulation and pipe leakages • Testing the SWH system (and auxiliary heater, where applicable) • Health and safety considerations • Policy and regulations (e.g. building codes) Maintenance • Periodic maintenance of collectors and mounting structures • Cleaning of water storage facilities • Air vents and pressure valves maintenance • Cleaning of fluid circulation pumps and pipes

**Adapted from Skills Development Corporation Guidelines (2015), New Delhi, India*

The specific skill will vary by technology type, scale and business model.

3.7.2 Training Curriculum Review

Format and Content

The content scope to be covered in the curriculum needs to be broken down in clear detail. The section under system design, for example should include different chapters for domestic and commercial systems, which require a different design dynamic (energy output per m^2, flow rate, power and temperature profile to manage the backup system as contrasted with a simple requirement in litres per day for domestic systems) and added lessons in aspects like pump and pipe sizing among others.

Relevance and Suitability

The draft curriculum does not address the following aspects that characterize the specific needs of the local industry.

i. Energy and power output – the technician should have a good thermodynamic understanding of the energy and power output of a square meter of collector surface area. A sizing methodology based on litres of demand per day is only useful for domestic systems and is inadequate for large commercial and industrial systems design.

ii. Quality of systems –the curriculum should adequately cover the technological aspects that give a solar heater its practical quality, durability and cost. Factors that may compromise the quality of a system such as corrosion and blockage by hard water needs to be covered in greater detail including contingencies and alternatives available.

iii. Collector type – evacuated tube collectors (ETCs) and flat plate collectors have specific advantages and disadvantages in different situations. However, both systems have satisfactory operation and performance. The operations and application of these two collector types needs to be clearly taught.

iv. System type – the foundation and reasoning for direct and indirect system applications needs to be covered more extensively. The curricular could include issues such as what measure or threshold of hard water necessitates an indirect system and selection of heat transfer fluids for indirect systems. For instance, in Kenya, distilled water, which has a higher heat capacity than glycol, may be ideal with a little anti-corrosion additive if parts of the system are made of mild steel. This makes the overall closed system cheaper and easier to maintain.

v. Pipework, fixtures and accessories – suitable material and accessories related to different types of systems needs to be covered in the curriculum. For instance, in selection of tank material, though aluminum withstands the effects of corrosion better than mild steel, the ultra-light tanks made of 0.7mm thin aluminum can fail in less than a year due to the structural stresses of expansion and contraction. Some may not withstand water pressure when connected to domestic pumps increasing the risk of bursts. The pipework and system of water supply in the household should also be included in the curriculum as these are a common point of system failure.

vi. Water supply – Most parts of Kenya's urban areas do not have a reliable supply of water. Most homeowners have storage tanks and water pumps are an integral part of their water supply. The dynamics of how to install solar water heaters in this set-up need to be covered in the curriculum. Content covered should be broader than the sizing and installation for gravity-fed, domestic solar heating systems.

4 Policy, Legal and Institutional Frameworks

4.1 Introduction

The solar water heating industry in Kenya operates under several laws and policies. The central regulatory instrument enabling the development of the industry is the Energy (Solar Water Heating) Regulations, 2012 (the "regulations"). The regulations make it mandatory for the installation and use of solar water heating systems in all premises within the jurisdiction of a local authority with hot water requirements exceeding one hundred litres per day, and define premises as existing, new or alterations and extensions to existing residential or commercial buildings or structures[48]. These include small domestic houses, domestic dwellings or residential houses, commercial buildings including hotels, laundries and similar premises, health institutions and educational institutions. The aim is to ensure that all premises have a minimum annual solar contribution of sixty percent to the premises' hot water demand[49].

The solar water heating system installation work is to be undertaken by a person who is licensed as a technician or contractor[50].

The regulations place responsibility for installation of solar water heating systems on developers of a housing estate, promoters of the construction, owners of the premises, and architects or engineers engaged in the design and construction, although it is not clear which of these persons is ultimately liable. Responsibility for operational maintenance and repairs of the system is placed on the owner or occupier of the premises that has a solar water heating system, whilst, electric power distributors or suppliers are prohibited from supplying to premises where a solar water heating system has not been installed. The systems must comply with the Kenya Standard, and the regulations grant the Commission or its agent powers of inspection to check compliance, and sets out a penalty for failure to comply with requirement to install and use solar water heating systems[51], and penalty for failure to comply with a compliance notice issued by the Commission or its agent[52].

The Solar Water Heating regulations were enacted by the Cabinet Secretary for Energy under the powers conferred by the Energy Act in force (No.12 of 2006), and are in line with the current national energy policy, Sessional Paper No. 4 of 2004, which aims to both promote energy efficiency and conservation and encourage the wider adoption and use of renewable energy technologies, and national development priorities as set out in Vision 2030, which aims for Kenya to increase efficiency in energy consumption in its path towards a middle income industrialized country[53]. The regulations are a good initiative to increase the use of solar water heaters in Kenya. However, as currently structured, the regulations bear the following shortcomings:

a) The lack of sufficient financial incentives to cater for the barrier that is the high upfront cost of solar water heating systems compared to electric water heaters that are currently in use. The regulations provide the option for premises to use the clean development mechanism (CDM) and other carbon finance mechanisms as a means

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[48] Regulation 2. Local authorities are the bodies (Boards) controlling local governance in urban areas in Kenya and are subject to the Urban Areas and Cities Act of 2011 which sets out three classes of local authorities: City, Municipality, and Town.

[49] Regulation 5 (1).

[50] Regulation 11 (1).

[51] A person who fails to in his responsibility for compliance under Rule 6 commits an offence and shall be liable upon conviction to a fine not exceeding one million shillings or imprisonment for a term not exceeding one year, or to both. See Regulation 6 (6).

[52] A person who does not comply with a compliance notice within the specified period commits an offence and shall, on conviction, be liable to a fine not exceeding ten thousand shillings for residential premises and thirty thousand shillings for all other premises for each day or part thereof that the contravention continues. See Regulation 7 (5).

[53] Republic of Kenya, *Kenya Vision 2030: The Popular Version, (GoK, 2007)*

of funding the implementation of a solar water heating project.[54] They do not provide further elaboration on these schemes nor set out a requirement for a national carbon programme to be instituted.[55] The regulations also fail to make provision for other non-carbon-related types of financial incentives.

b) The lack of specific penalties in the regulations for unlicensed persons who carry out SWH system installation work. The only penalty stipulated under licensing is for solar water heating system technicians and contractors registered by the Commission, who fail to maintain records of solar water heating systems installed, specifying the location, capacity and type.[56] This is insufficient to act as a deterrent and protect consumers from unscrupulous firms/persons.

c) The failure to include that a person shall not undertake solar water heating system repair and maintenance work unless the person is licensed by the Commission as a solar water heating system technician or contractor. Whereas installation has to be carried out by a licensed person under the regulations, repair and maintenance of solar water heating systems is left open and this may lead to repair and maintenance work being carried out by unqualified workers with a likelihood of damage to systems and disappointment to users.[57]

d) The lack of a sufficient monitoring and verification regime for large systems. The regulations provide for spot-check inspections, however in addition to this, current best-practice indicates that monitoring devices and procedures, as well as regular maintenance must be considered as an integral part of the investment in the solar system.

e) The wide definitional boundaries of who should comply with the regulations, given that the regulations group residential, industrial and commercial consumers together and sets a fixed use of 100 litres as a differentiator without consideration of relevant parameters such as floor space. The use of the term "local authority" also introduces a level of ambiguity as this is not mentioned in paragraph (interpretation). The expansive scope of those that need to comply creates an enforcement challenge to the Commission.

f) The powers of inspection granted to the Commission or its agents focus on contraventions of law by an owner or occupier. However, installation technicians and contractors should also be included under this section, and where after inspection, significant underperformance is observed due to installation errors, the installing technician or contractor should be issued with a compliance notice and obliged to repair or improve the system at their own cost.

g) The regulations place an administrative burden on investors as the provision exempting certain categories of premises from the ambit of the regulations requires them to undertake the task of applying for an exemption for premises that clearly do not fall within the letter or intent of the regulations.

h) The exemption provided create ambiguities as premises could demonstrate their "technical limitations" or "special circumstances" in several ways. Also a reading of this suggests that existing premises that fall under the ambit of the exemption need not apply for an exemption, as the provision only applies to new buildings and alterations to new buildings which have to seek building plan approvals. However, if the intention of the provision is to include existing premises in the obligation to seek an exemption, there is need for clarity on when this exemption is to be sought.

4.2 The surrounding regulatory framework

In addition to the regulations, there are other laws and policies with a bearing on the solar water heating industry in Kenya. These include those related to other facets of energy generally, as well as those on tax, climate change, standards and certifications, building codes and construction. These laws are discussed in greater detail hereunder:

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[54] Regulation 6 (5)

[55] This may be strategic as studies have shown that discussing or even announcing a future Incentive scheme for solar water heaters results in a decline in sales while the market delays investment until the programme is in place. See Jones, e. and Mowris, R. *California's Solar Water Heating Programme: Scaling Up to Install 200,000 Systems by* 2020 (ACEEE, 2010)

[56] See Regulation 11 (6). On conviction, one is liable to a fine not exceeding one million shillings, or to a term of imprisonment of one year, or to both

[571] Regulation 11 (1)

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4.2.1 Energy

Kenya's energy sector is currently in a state of flux as steps are taken to align the regulatory framework with the Constitution. In line with this, there is in place a draft National Energy and Petroleum Policy which recognizes that the operationalization of the Energy (Solar Water Heating) Regulations will spur demand for solar water heating (SWH), projecting that use will grow to more than 800,000 SWH units by 2020, with demand mainly be from domestic, institutional and small commercial consumers. Enforcement of these regulations is highlighted as a key strategy in the short, medium and long-term.[58] There is also in place a draft Energy Bill which does not mention solar water heating explicitly, but makes wide provision for the promotion of renewable energy specifically mentioning solar, and energy efficiency.[59] This draft regulatory framework however falls short of setting out legally binding solar water heating targets that would provide greater investment certainty.

The Least Cost Power Development Plan discusses the characteristics of solar thermal technology,[60] and though it does not explicitly refer to solar water heating, the Plan calls for the promotion of all renewable energy technologies by giving duty and tax incentives, as well as the promotion of energy conservation.[61] Lastly, the Government also has in place an ongoing national electricity connection programme (Last Mile Connectivity Programme) that is aimed at facilitating the objective of affordably connecting Kenyan households to the national network grid.[62] There is lack of clarity between Kenya Power's mandate to connect all households under the national connectivity programme, and Kenya Power's obligation as an electric power distributor and supplier to withhold connections to Premises without solar water heating systems, as set out in the regulations [63] .

4.2.2 Tax

There exist fiscal incentives for solar water heating under Kenya's tax laws. The Value-added Tax (VAT) (Amendment) Act 2014 expanded the list of goods and services that are exempt from VAT as set out under the First Schedule to the VAT Act, 2013. The expanded list includes VAT exemption for, "specialized solar equipment and accessories, including solar water heaters and deep cycle-sealed batteries which exclusively use or store solar power". As such, the import of solar water heating systems is currently VAT exempt. Whereas removing the 16% VAT on solar products such as solar water heating systems reduces the cost to consumers and aids access to solar products, there is a risk of harm to the domestic PV manufacturing sector.

An influx of imports may also have a negative effect on consumers of solar water heating systems who may lose out on the benefits of locally manufactured systems such as the advantage of offering after sales and warranty services due to proximity. There is however now in force (as at 1st July 2016), a duty remission on inputs or raw materials for the manufacture of solar equipment incentivizing local manufacturing with a view towards export.[64] Further, specialized equipment for development and generation of solar energy, including accessories and deep cycle batteries which use and/or store solar power, are customs exempt.[65]

4.2.3 Climate Change

Kenya has developed a National Climate Change Response Strategy, a Climate Change Action Plan and a Climate Change Act, 2016 to govern the country's transition to a low carbon climate resilient development pathway. This policy and regulatory framework for climate change promotes the adoption of renewable energy technologies and energy efficiency.

Specifically, with regards to solar water heating, the Climate Change Action Plan recognizes solar water heating as a low carbon activity.[66] The Climate Change Action Plan Mitigation Report goes further and considers the greenhouse gas abatement potential and costs of solar thermal water heating

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[58] Section 3.7, The Government of Kenya, Draft National Energy and Petroleum Policy, 2015

[59] Part IX, Draft Energy Bill, 2015

[60] See Section 5.2.5 Republic of Kenya, Updated Least Cost Power Development Plan-Study Period: 2011-2031 (March 2011).

[61] Section 3.2.1 Updated Least Cost Power Development Plan-Study Period: 2011-2031 (March 2011).

[62] This is geared towards achieving a national connectivity rate of 70% by 2017 as part of the government's goal of universal access to electricity by 2020.

[63] Regulation 6 (4)

[64] Legal Notice No. EAC/33/2016, East African Community Customs Management (Duty Remission) Regulations, 2008, Paragraph 11

[65] East African Community Customs Management, Sixth Schedule, paragraph 26, as amended by Legal Notice No. EAC/39/2016, paragraph 2

[66] Republic of Kenya, the National Climate Change Action Plan 2013 -2017, (GOK, 2013) at 34; and at 70.

and concludes that though solar water heaters have numerous developmental benefits and a mitigation potential in the order of 115 ktCO_2/year in 2030, the high upfront investment costs and access requirements to rooftops to place the heat collector and water reservoir (for passive systems), are barriers that mean that the use of solar water heaters is not feasible in apartments or businesses established in shared buildings, and households or businesses that do not own the property.[67] The study estimates a 20 percent total penetration of solar water heaters by 2030 and notes that although a regulation is in place mandating solar thermal water heaters in all new buildings of a certain size, significant additional support is needed to achieve this penetration by 2030.[68]

The Climate Change Act does not specifically mention solar water heating. However the Act is likely to have an impact on the solar water heating industry as it provides for the imposition of climate change obligations on private entities and these obligations may entail the taking of mitigation action, stimulating further adoption of solar water heaters.[69] Further, the Act is likely to further stimulate the uptake of solar water heating technologies, as it provides that financial and fiscal incentives shall be given to persons who put in place measures for promotion of renewable energy and mitigation of climate change.[70]

Finally, under its Nationally Determined Contribution (NDC), Kenya seeks to abate its GHG emissions by 30% by 2030 relative to the BAU scenario of 143 MtCO_2eq. To achieve this target, the focus is on mitigation activities which include expansion in *inter alia* solar energy production and enhancement of energy and resource efficiency across the different sectors. Though not mentioned explicitly in the NDC, expansion in the use of solar water heating would fall within the mitigation activities necessary for Kenya to meet her NDC. As Kenya's NDC is to be funded by domestic and international support, a national solar water heating programme may be instituted to benefit from international climate finance such as under the Green Climate Fund or be packaged as a Nationally Appropriate Mitigation Action (NAMA) to benefit from NAMA funding.[71] Grants and loans from the national Climate Change Fund once established as stipulated under the Climate Change Act are another potential source of funding for a solar water heating programme.[72]

4.2.4 Building and Construction

Kenya's Housing Policy and Building Code do not refer to the use of renewables generally and solar water heating in particular.[73] The antiquated Building Code however grants local authorities powers to approve or reject building plans. According to the Code, grounds for disapproval of a Plan include that the Plans disclose a contravention of the By-laws or of any other written law.[74] Thus though this Building Code does not specifically refer to solar water heating requirements, local authorities may rely on this provision on disapproval to object to a plan that does not comply with solar water heating regulations. Though not specifically referring to solar water heaters, the Code further makes provision that ensures that such systems do not exceed roof load, lead to improper wiring or unlawful tampering with water supplies.[75]

The draft Planning and Building Regulations, 2009 [KS Code (2009) (English): Building Code of the Republic of Kenya (2009 Edition)], more specifically discuss solar water heating. These planning regulations prescribe that all new housing developments or alterations and extensions to existing buildings should have solar hot water heating installations for bathroom use, and no new housing development should be allowed to use the national grid electricity for hot water heating in bathrooms. Further, new developments should consider generating electricity from stand-alone photovoltaic installations (comprising of wall cladding and roofing) and from wind power in suitable locations.[76] The regulations also deal with approval of building plans, and stipulate that a Plan

[67] Raouf Saidi et al, Republic of Kenya, National Climate Change Action Plan –Mitigation: Chapter 6 Energy Demand, (CDKN 2012) at 27
[68] Raouf Saidi et al, Republic of Kenya, National Climate Change Action Plan –Mitigation: Chapter 6 Energy Demand, (CDKN 2012) at 13.
[69] Section 16 (1) Climate Change Act, 2016.
[70] Section 26 Climate Change Act, 2016
[71] James Arthur Haselip et al, Guidebook for the Development of a Nationally Appropriate Mitigation Action for Solar Water Heaters (DTU, 2014).
[72] See section 25 (1); Section 25 (8) (c), Climate Change Act 2016
[73] Republic of Kenya, Sessional Paper No.3 on Housing Policy for Kenya; Building Code (Adoptive by- laws) Building Order, 1968
[74] Regulation 10
[75] Building Code (Adoptive by- laws) Building Order, 1968
[76] Regulation NN 31.5, KS Planning and Building Regulations 2009

will not be approved if it discloses a contravention of the code or any written law.[77] Based on these provisions, the lack of a solar water heating system in a submitted plan from a Premise that is required to have one is grounds for the local authority to refuse to grant the requested approval. The provision that "no new housing development should be allowed to use the national grid electricity for hot water heating in bathrooms" may however be problematic as it is inconsistent with the solar water heating regulations which allow at a maximum, 40% of a premises' hot water demand to be provided by means other than solar, and allow a conventional back-up water heating system to be used when necessary to ensure there is an adequate supply of hot water at all times.[78]

The Physical Planning Act empowers the local authorities to prohibit or control the use and development of land and buildings in the interests of proper and orderly development of an area and to control or prohibit the subdivision of land or existing plots.[79] Under the County Governments Act the above function of granting approvals will be undertaken by the county governments.[80] The Physical Planning Bill, 2015 seeks to repeal and replace the Physical Planning Act. Further, the [draft] Planning and Building Regulations, 2009 discussed above are anchored on the Bill. Thus, delay in passing the Bill into law leads to a failure to harmonize physical planning and building works and make explicit provision for solar water heating in the building and construction sector. To ensure that only skilled professionals are engaged in the building and construction sector, various laws have been enacted to govern the registration and governance of contractors, engineers, architects and quantity surveyors.[81] These laws prohibit an unqualified person from carrying on the business of such professionals and this oversight has a bearing on the solar water heating industry as qualified architects and engineers are best placed to effectively incorporate solar water heating systems in the design, construction, extension or alteration of Premises as required under the regulations.

4.2.5 Standards and Certification

The design, installation, repair and maintenance of a Solar Water Heating System shall be in accordance with the Code of Practice- Solar Water Heating for Domestic Hot Water Kenya (Standard KS 1860:2008). Though the regulations lack penalties for suppliers and technicians who fail to meet the minimum standards set out for SWH systems/apparatus, the Standards Act makes provision for enforcement of standards and sets out that goods manufactured or sold without meeting this code of practice will be destroyed.[82] Further, a penalty for general offences under the Act including imprisonment and/or a fine is set out. This is necessary to curb proliferation of sub-standard solar water heaters and acts as a deterrent, protecting consumers against dumping of sub-standard equipment

The standard provides recommendations for solar heating systems having collectors with liquid heat transfer media for heating water for domestic purposes in single- or two-family dwellings to help ensure adequate operation and safety. Design considerations, manufacture, handling, installation, operation and maintenance are included.[83] These standards are recognized and accepted nationally and are beneficial as they provide consumer confidence. Industry and consumers also benefit from standards that are appropriate to the geographic location of use. However as international trade in solar products increases, adoption of internationally recognized standards is suitable as they reduce non-tariff barriers to trade and reduce unnecessary costs of duplicate product testing for different jurisdictions.[84] Kenya should therefore also consider relevant, available international standards.

4.3 Solar water heating under a devolved system of government

Under the Constitution, power is devolved to each of the forty-seven counties of Kenya with a set-out distribution of

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[77] Regulation BB10.7 (b) Planning and Building Regulations 2009
Act No.6 of 1996

[78] Chapter XI, The County Governments Act 2012

[79] National Construction Authority Act, Act No. 41 of 2011; Engineers Act, Act No. 43 of 2011; Architects and Quantity Surveyors Act Cap 525 Laws of Kenya

[80] Part IV Standards Act, Cap 496; Section 14(A)

[81] World Trade Organization, Committee on Technical Barriers to Trade: Kenya Notification, G/TBT/N/KEN/159 (1 October 2009). At http://policy.mofcom.gov.cn/GlobalLaw/blank/enspstbt!fetch.action?libcode=TBT&id=5C7DEA1D-6656-453A-937E-237F84E50B22.

[82] Ken Guthrie et al, "International standards for solar heating collectors and systems", Energy Procedia 30 (2012) 1304 – 1310

[83] See Chapter 11 and the Fourth Schedule of the Constitution of Kenya, Revised Edition 2010, Government Printers, Nairobi (hereinafter Constitution of Kenya 2010)

[84] Ken Guthrie et al, "International standards for solar heating collectors and systems", *Energy Procedia* 30 (2012) 1304 – 1310

functions between the national government and the county governments.[85] The Energy Bill 2015 further clarifies these roles and responsibilities. Though neither the Constitution nor the Energy Bill refer explicitly to solar water heating, various provisions in the Bill have a bearing on it, placing different and in some cases overlapping responsibilities on the two levels of government as set out hereunder:

Table 11: SWH under a devolved system

FUNCTION	NATIONAL GOVERNMENT	COUNTY GOVERNMENT
Planning for solar water heating	Formulation of the National Energy Policy. [Sixth Sch. Part A. Sec. 1 (a)] Preparation of Integrated National Energy Plan, incorporating a renewable energy master plan. [Sixth Sch. Part A. Sec. 1 (b)]	County energy planning including physical planning relating to energy resource areas such as solar. [Sixth Sch. Part B Sec 1 (b)]
Enactment of solar water heating rules, regulations and standards	Preparation and enforcement of regulations and standards. [Sixth Sch. Part A. Sec. 2 (f)] Formulation of National codes for energy efficiency and conservation in buildings [Sixth Sch. Part A. Sec. 2 (g)]	Customizing National codes for energy efficiency and conservation in buildings to local conditions (with approval of the Energy Regulatory Authority). [Sixth Sch. Part B Sect 2 (h)]; Sec 220 (a) By notification in the Gazette, make rules not inconsistent with the rules and regulations, if any, made by the National Government on inter alia, energy efficiency and conservation building codes [Sec 226 (2) (a)]
Creating knowledge and awareness/capacity building on solar water heating regulations	Establishment of Energy and Petroleum Institute to create awareness and disseminate information on the efficient use of energy and its conservation (Sec 55 (2) (ff) National Government to provide technical and other capacity building support to County Governments. [Sixth Sch. Part A. Sec. 3 (h)] Energy Regulatory Authority to promote and facilitate the implementation of energy efficiency and energy conservation policy measures, by organizing seminars, workshops and courses in energy efficiency, demand management or conservation. [Sec 227 (2) (b)] Energy Regulatory Authority to educate and provide information to the public regarding energy demand management and conservation. [Sec 227 (2) (c)]	Establishment of energy centres for promotion of renewable energy technologies, energy efficiency and conservation. (Sixth Sch. Part B Section 3 (g) Take all measures necessary to create awareness and disseminate information for efficient use of energy and its conservation [Sec 220 (d)] Train personnel and specialists in the techniques for efficient use of energy and its conservation [Sec 220 (e]

[85] See Chapter 11 and the Fourth Schedule of the Constitution of Kenya, Revised Edition 2010, Government Printers, Nairobi (hereinafter Constitution of Kenya 2010)

FUNCTION	NATIONAL GOVERNMENT	COUNTY GOVERNMENT
Certification of solar technicians	Certification of solar system installation technicians and contractors [Sixth Sch. Part A Sec. 2 (l)].	n/a
Enforcing implementation of the solar water heating regulations	Prosecution of offences created under the Energy Act. [Sixth Sch. Part A Sec. 2 (k)] Resolution of complaints and disputes between parties over any matter in the energy and petroleum sector. [Sixth Sch. Part A Sec. 2 (j)] Protection of consumer, investor and other stakeholder interests. [Sixth Sch. Part A Sec. 2 (e)]	Appoint as many inspecting officers as may be necessary for the purpose of ensuring compliance with minimum energy efficiency performance standards [Sec 222(1] Direct every owner or occupier of a building or building complex being a designated consumer to comply with the provisions of the energy efficiency and conservation building codes [Sec 220 (b)] Direct, if considered necessary for efficient use of energy and its conservation, any designated consumer to get energy audit conducted by an accredited energy auditor in such manner and at such intervals of time as may be specified by regulations [Sec 220 (c) Direct, any designated consumer to furnish to the Energy Regulatory Authority, in such form and manner and within such period as may be specified by rules made by it, information with regard to the energy consumed by such consumer [Sec 220 (g)]
Financing solar water heating programs	Administration and management of the Consolidated Energy Fund and the National Energy Conservation Fund. [Sixth Sch. Part A Sec. 3 (i)] The Consolidated Energy Fund is set up to finance inter alia, the promotion of renewable energy initiatives and energy efficiency and conservation [Sec 243 (1) (e) and (h)]	Establishment of a Fund for the purposes of promotion of efficient use of energy and its conservation within the County, credited with grants and loans that may be made by the County Government, National Government or any other organization or individual. [Sec 221 (1) and (2)] The Fund shall be applied for meeting the expenses incurred in implementing provisions of the Act. [Sec 221 (3)]
Set up of fiscal and other incentives to support solar water heating industry	Issuance of energy saving certificates to enhance energy efficiency and conservation [Sixth Sch. Part A Sec. 2 (h)]; (Sec 218)	Take steps to encourage preferential treatment for use of energy efficient equipment or appliances [Sec 220 (f)]

From the table on page 40-41, it is clear that the County Government and the National Government have key roles to play in creating a thriving solar water heating market. There are also some overlapping functions between the National Government and the County Government when it comes to implementation of the solar water heating regulations and development of the solar water heating industry. However, the Bill does provide some clarity on how the roles are to be carried out to avoid conflict. For example, though both have a role to play in the enactment of energy rules and regulations, for a County to customize a building code to fit local conditions it requires the approval of the Energy Regulatory Authority to provide checks and balances. To make rules, the County must ensure that they are not inconsistent with National Government rules and regulations.

The Constitution also clarifies issues, such as what fiscal incentives are in the domain of the National Government and which ones are in the domain of the County Government. This is by providing clarity on powers of taxation with regards to VAT, excise and customs duty, and the imposition of various fees and levies, all which have an impact on the solar water heating industry especially in clarifying what steps either government can take to encourage preferential treatment for use of solar water heating appliances.[86]

The challenge for the growth of the solar water heating industry under Kenya's devolved system of government is the lack of clarity on how the governance of the energy sector at county and national governments will be managed in practice, as the Energy Bill for actualizing devolution in the energy sector has not yet been enacted. This is for example with regards to the working of county energy centres to be set up under the Bill vis-a vis Ministry energy centres in counties, and co-operation between the National Energy Regulatory Authority and the County Governments generally.[87]

4.4 Creating an Enabling Environment: Lessons from Other Countries

Government policies, regulations, and engagement programs have played an important role in scaling up many of the world's leading solar heating markets.[88] Whereas it is difficult to define universal "best practices," since what is best will vary from country to country based on national policy objectives and national conditions,[89] studies show that the most effective way to shift the market towards more energy efficient equipment is achieved when a combination of various instruments is used resulting in a permanent market transformation.[90] This includes the use of incentives, to complement mandatory rules and regulations.[91] Specifically with regards to solar water heating, the measures that have been identified as key in promoting the diffusion of solar panels for heating water have been categorized in three as, economic incentives- to lighten the investment barrier and improve cost effectiveness (for example, direct subsidies, low-interest loans, tax exemptions and third-party financing,); regulations- requiring new or renovated apartment buildings to be equipped with solar energy systems; and strategies- to improve the quality of equipment and installations through the use of technical standards and quality labels.[92] When properly combined these measures create synergy between instruments and an environment that effectively supports the diffusion of solar heaters and the attendant benefits of this technology.

A review of these measures is carried out below, with an analysis of how different countries have used the different instruments and the resultant impact on the countries' solar water heating industry.

4.4.1 The Economic Incentives Approach

Measures to support the development of solar water heating technology are based principally on economic instruments (for

[86] Article 209, Constitution of Kenya, 2010. Only the national government may impose --income tax; value-added tax; customs duties and other duties on import and export goods; and excise tax. A county may impose--
property rates; entertainment taxes; and any other tax that it is authorized to impose by an Act of Parliament.

[87] Oliver Johnson et al, *County Energy Planning in Kenya: Local Participation and Local Solutions in Migori County*, Stockholm Environment Institute, Working Paper 2016-01 at 12.

[88] Wilson Rickerson et al, The SWH TechScope Market Readiness Assessment (UNEP, 2014) at 12.

[89] Ibid at 1991

[90] Stephen Wiel and James E. McMahon, Energy efficiency labels and standards: A Guidebook for Appliances, Equipment and Lighting (CLASP, 2005)

[91] Stephane de la Rue du Can et al, "Design of Incentive Programs for Accelerating Penetration of Energy-Efficient Appliances", Energy Policy 72 (2014) 56-66

[92] Philippe Menanteau, Policy Measures to Support Solar Water Heating: Information, Incentives and Regulations, (World Energy Council , 2007)

example subsidies, low interest loans and tax relief), because in most countries the diffusion of solar water heaters is still severely limited by economic constraints. There are however a few countries such as Greece which have succeeded in making solar water heating a standard technology that now competes with conventional water heating systems sufficiently well for economic incentives to be no longer needed.[93] For countries such as Kenya requiring economic incentives, the following are a good example of viable options for consideration:

(i) Subsidies are intended to reduce the capital cost at the time of purchase and shorten the payback time, which are the principle barriers to growth of the solar water heating market. Economic incentives should be designed on the basis of the maturity of the target markets. For example, subsidies though generally effective, become counterproductive if they are introduced too late. Further, if discontinued prematurely, the possibility for a significant drop in sales in a market that is not sufficiently mature as was experienced Tunisia, is quite high.[94] However, once the critical mass has been reached economic incentives such as subsidies can be reduced and even stopped as experienced in Greece, without slowing down diffusion of solar water heaters in the market.[95]

(ii) Low - interest loans/3rd party financing provide access to credit, lowering the initial cost barrier of solar water heaters, as long as the interest rates are lower than those generally applicable to consumer loans. Loan facilities are often set up as a complement to direct subsidies to help cover the remaining cost that has to be paid by the investor. In Spain, the possibility of obtaining low interest loans (6-8 % instead of 14-18%) has greatly facilitated implementation of legislation on solar installations.[96] The Barcelona Solar Ordinance which applies to the city of Barcelona provides that all new buildings and buildings undergoing major refurbishment are obligated to use solar energy to supply 60% of their running hot water requirements. Swimming pool heating must be 100% from solar. The extra investment incurred by the Ordinance is estimated to be 0.5%-1% in building work and materials and may be financed by interest-free credit arrangements backing up to 70% of the total investment.[97]

(iii) Rebates are another economic incentive which has been used to stimulate the development of solar water heating markets. However, In South Africa, the rebate succeeded in stimulating the supply side of the solar water heating industry, but it failed to stimulate the demand. Only 11% of the original target for hot water heating systems was met, and due to this failure to meet its objectives, the rebate programme was suspended in 2015.[98] Lessons from the South African experience on structuring rebates include that a rebate must offer a net decrease in the price of the solar water heater; it should not be arbitrarily increased and decreased; the programme must have committed funding for a pre-specified period of time; and the rebate programme needs a robust M&V and feedback programme to confirm actual savings and provide information for the project team.[99] On the converse, the California Solar Initiative exemplifies a rebate that has succeeded in providing longevity, certainty and scale through a financial incentive structure- the CSI-Thermal Program that offers cash rebates to residential and commercial consumers.[101]

(iv) Tax incentives include tax reductions (lower VAT for example) applicable to equipment or installation costs, reduced tax rates on imported equipment where applicable. Kenya has in place such tax incentives.

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[93] European Solar Thermal Industry Federation, Best practice regulations for solar thermal (ESTIF, 2007) at 14

[94] In 1996 the Tunisian National Energy Management Agency implemented a project with support from the World Bank to subsidize 35 percent of the capital cost of solar water heaters to commercial (public and private) institutions and later to the residential sector the project successfully stimulated market growth and resulted in the installation of 50,000 square meters of new solar thermal panels. However, when international support ended in 2002, the solar water heater market collapsed from 17,000 square meters installed in 2001 to 7,500 square meters in 2004. This was attributed to a project design that did not consider the long-term sustainability of the initiative, and other barriers, including the commercial immaturity of the solar water heater market, fossil fuel subsidies, lack of financing availability, and lack of consumer confidence in domestically manufactured systems. See Clifford Polycarp et al, Mobilizing Climate Investment Annex 3 - Solar Water Heaters in Tunisia (WRI, 2014) at 2.

[95] Philippe Menanteau, Policy Measures to Support Solar Water Heating: Information, Incentives and Regulations, (World Energy Council, 2007)

[96] Philippe Menanteau, Policy Measures to Support Solar Water Heating: Information, Incentives and Regulations, (World Energy Council, 2007)

[97] Dominic Goncalves, The South African Solar Water Heater Industry, Renewable Energy Africa Conference July 28, 2011.

[98] Karin Kritzinger and Theo Covary, Review of South Africa's Solar Water Heating Rebate Programme. At https://www.researchgate.net/publication/308168429_Review_of_South_Africa's_Solar_Water_Heating_Rebate_Programme [accessed Jun 7, 2017].

[99] Ibid

[100] Pierre Bull, California's Landmark Solar Deployment Program - the CA Solar Initiative - has Successfully Lifted the State's Distributed Solar Industry into Orbit, NRDC blog post, June 20, 2014.

However, it has been observed that policies that remove taxes imposed on solar heating systems by government (e.g. sales tax, excise tax, import duties, property tax, etc.) can be useful complementary measures, but typically do not have a significant impact on market development on their own.[101] Tax incentives like all other incentives need to be consistent and long-term to provide industry with confidence to make business investments. In Chile, the domestic industry went through a severe crisis because Chile's new tax credit scheme for the housing industry, originally expected to be approved in early 2015, did not come into effect until February 2016. As a result, several manufacturers and system suppliers were forced to temporarily suspend their solar thermal activities.[102]

(v) Carbon finance has been a viable source of financing for low carbon projects such as solar water heating programmes. Examples of projects that have sought carbon credits for solar water heating programmes include, the Standard Bank Low Pressure Solar Water Heater Programme for South Africa and the Solar Water Heater Programme in Tunisia.[103] However, from the experiences of these countries, the CDM was complimentary to the use of other instruments. This is because the CDM is not a viable funding mechanism to finance a solar water heating system in its entirety, especially currently, due to the low price of Certified Emission Reductions (CERs) vis-a vis the high cost of a solar water heater.[104] The restriction under the European Union Emissions Trading Scheme (EU-ETS) of carbon credits from non-LDCs also limits the markets for Kenyan carbon credits.[105] Further, the workings of the carbon markets under the Paris Agreement are unclear and still under consideration in the Paris Rulebook under construction.

(vi) Renewable Energy Certificates (REC) have been used in countries such as Australia to stimulate the growth of the solar water heating industry through the Small Scale Renewable Energy Scheme. These are certificates that are created for eligible installations of solar water heaters. In the case of solar water heaters, they are referred to as small-scale technology certificates (STCs). One STC is generally equivalent to 1 MWh of electricity deemed to be displaced by the installation of solar water heaters. They have to be created within 12 months of the installation of an eligible system in the REC Registry, before they can be bought, sold, traded or surrendered. They create a financial incentive for individuals and businesses to install solar water heaters, as STCs can be sold to recoup a portion of the cost of purchasing and installing the system. The STCs are bought by Renewable Energy Target liable entities such as energy retailers, who have a legal obligation to buy and surrender to the Clean Energy Regulator on a quarterly basis. [106]

4.4.2 The Regulatory Approach

Measures to support the development of solar water heating technology are based principally on economic instruments, and regulatory approaches started to make their appearance in recent years, in many cases making the use of solar energy compulsory in situations where economic incentives have not been sufficient to overcome existing barriers.[107] Regulation has now become one of the most well-known policy measures to assist the solar water heating market. These are building mandates that compel all buildings meeting certain specifications to install solar water heaters. Countries that have followed the regulatory approach have demonstrated firstly, that the wording of the regulations is of fundamental importance in ensuring the law achieves its purpose. For example, Israel, which was in 1980 the first country in the

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[101] Wilson Rickerson et al, The SWH TechScope Market Readiness Assessment (UNEP, 2014) at 20

[102] REN21, Renewables Global Status Report 2016, (REN21 2016) at 73

[103] See https://cdm.unfccc.int/ProgrammeOfActivities/poa_db/IAC8FW3TU7SZKRE2P9OVY6HB0LQNM1/view; http://cdm.unfccc.int/ProgrammeOfActivities/poa_db/7KX218NCPREWQ4YSB90MUI5T6FHZJA/view

[104] Chrisna Du Plessis and Thomas Arnoldus Petrus du Plessis, Funding the implementation of solar water heating in low-income housing in South Africa through the clean development mechanism (University of Pretoria, 2013).

[105] European Commission, Use of International Credits, https://ec.europa.eu/clima/policies/ets/credits_en

[106] Governing laws and regulations include Renewable Energy (Electricity) Act 2000 Renewable Energy (Electricity) Regulations, the Renewable Energy (Method for Solar Water Heaters) Determination 2016

[107] Philippe Menanteau, Policy Measures to Support Solar Water Heating: Information, Incentives and Regulations, (World Energy Council, 2007) at 7.

world to introduce mandates at the national level, enacted a solar obligation that was a success, reaching the critical mass of market size necessary to create self-sustained growth without any subsidy.[108] However, in recent years and with the advent of high rise buildings, the law had a loophole through which many builders of high-rise condos could legally not include solar water heaters in their construction. The original law stipulated the installation of a solar water heating system for new residential buildings up to a height of 27 m, which is about 8 to 9 floors. This law was extended in September 2012 and now also applies to buildings above 27 m, stipulating the installation of solar water heaters for the first seven floors under the roof to plug the loophole and increase penetration of solar water heating technologies.[109]

Secondly, consensus with all the stakeholders involved in the construction sector is essential to the success of the regulation. This is regulatory buy-in, whereby property developers, construction companies, architectural colleges and engineering schools and installation contractors are all closely associated to the construction and implementation of the regulation. In the case of the Barcelona Solar Ordinance covering the city of Barcelona (Spain), several stakeholders and associations (architects, energy associations, municipal representatives, associations of renewable energies) were involved in its design.[110] Between its approval in 1999 and its coming into force in the year 2000, a moratorium was placed to both counteract existing skepticism and refusal by certain stakeholders regarding the integration and maintenance of solar water heaters, and due to the expectation of rising prices of construction projects.[111] During the one year moratorium a guidebook was developed to explain the Ordinance, and an information campaign was launched.[112] The ordinance, which has since been revised, prescribed that all new buildings and buildings undergoing major refurbishment using more than 0.8 MW per day for hot water production were obligated to use solar energy to supply 60% of their running hot water requirements, whilst swimming pool heating must be heated 100% from solar, achieved an approximately 2000% increase in solar water heater market penetration in just over five years from the date of coming into force.[113]

Thirdly, Implementation of the regulations is critical. In November 2011, South Africa's building regulations (SANS 10400-XA) were modified to specify 'that not more than 50% of the annual volume of domestic hot water may be heated using electricity', to make the installation of solar water heaters, heat pumps, gas or similar mandatory on all newly built and renovated buildings. However once in force, this building mandate did not contribute materially to solar water heating sales because in South Africa building plans are approved by local authorities, most of whom did not fully understand the new regulations.[114] Further, even when the training of building control officers improved, plans were approved on the understanding that solar water heaters will be installed, though this was not often the case and a lack of site inspections has resulted in poor compliance with the regulation.[115] Effective implementation by public authorities can be done at different points in time. This includes at an early stage of the planning of the building (or of the renovation), comparing the proposed installation with the legal requirements, before the building is commissioned, comparing what has been effectively installed with the legal requirement and after one or two years of operation, inspecting a sample of systems to see if they perform according to the requirements.[116] For example, in Barcelona, the revised Ordinance includes a model declaration to be signed by the installation company after the works are completed. This declaration includes the data needed for the public authority to determine if the installed solar system complies with the requirements.[117]

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[108] European Solar Thermal Industry Federation, Best practice regulations for solar thermal (ESTIF, 2007) at 35.
[109] See http://www.solarthermalworld.org/content/israel-front-runner-solar-building-code-strong-impact-market
[110] Philippe Menanteau, Policy Measures to Support Solar Water Heating: Information, Incentives and Regulations, Country Studies: Spain (World Energy Council, 2007)
[111] CTRAN, Building Sector Policies and Regulation for Promotion of Solar Water Heating System (CTRAN, 2010) at 8
[112] CTRAN, Building Sector Policies and Regulation for Promotion of Solar Water Heating System (CTRAN, 2010) at 8
[113] Christoph Peters, Solar thermal legislation on municipal, regional and national level in Spain Success and remaining barriers, at http://www.solarthermalworld.org/sites/gstec/files/legislation%20spain.pdf.
[114] Karin Kritzinger and Theo Covary, Review of South Africa's Solar Water Heating Rebate Programme, Conference Paper June 2016. At https://www.researchgate.net/publication/308168429_Review_of_South_Africa's_Solar_Water_Heating_Rebate_Programme
[115] Karin Kritzinger and Theo Covary, Review of South Africa's Solar Water Heating Rebate Programme, Conference Paper June 2016.
[116] European Solar Thermal Industry Federation, Best practice regulations for solar thermal, (ESIF, 2007) at 30
[117] European Solar Thermal Industry Federation, Best practice regulations for solar thermal, (ESIF, 2007) at 30

4.4.3 The Strategy Approach

Regulatory measures encourage diffusion of solar water heaters. However, minimum quality levels must be imposed to prevent the solar energy obligation from encouraging the use of inexpensive and inefficient equipment. Standards and quality labels can ensure that such minimum requirements are met. An effective way to achieve this is for economic incentives such as subsidies and low interest loans to be granted only for equipment that has an approved quality label. This has been observed in France for instance, where the government has set up a system of tax credits that are applicable to solar water heating equipment provided the solar collectors concerned have been awarded CSTBat or Solar Keymark certification. Similarly, in India, only solar collectors certified by the Bureau of Indian Standards are eligible for low-interest loans.[118] In Tunisia, the solar water heating market collapsed when subsidies were withdrawn because of insufficient quality control and a negative perception of the quality of solar equipment among consumers.[119] This shows that it is not enough to set up schemes to finance investment in solar water heating, without accompanying effective measures to improve quality. With regards to labelling, the labelling of water, space and combi heaters under the Ecodesign Directive (2005/32/EC) became mandatory in all 28 EU Member States in September 2015, though there is some skepticism as to whether this energy labelling will increase demand for solar thermal system.[120]

Standards are however not a magic bullet and may lead to unintended consequences where they are improperly structured. Under the South African solar water heating programme, adherence to a national standard was a requirement. However, the standards were local (formulated by industry) raising questions regarding vested interests. Further, international standards were largely ignored. The availability of standards did increase consumer confidence, but as they were largely inappropriate, they created new barriers such as increased production and administration costs.[121] In the case of Barcelona, the existing national procedure to certify the quality of solar thermal equipment – a compulsory requirement to receive public subsidies for installing a solar thermal system – does not facilitate either the introduction of foreign companies into the Spanish market or the commercialization of new national product developments.[122] One of the ways of ensuring standards set are effective is to benchmark national standards against international/regional ones. For example, the European Union Keymark label was one of the basic references used by the Chinese government to develop its own national technical standards for solar thermal equipment, helping China gain easier access to the European market for its solar products as well as increase consumer confidence by limiting the presence of poor quality equipment domestically. It has however been pointed out that there are still some problems of product quality in China, though these are related to a lack of enforcement of the standards as opposed to an absence of effective standards.[123]

In addition to standards, special contractual approaches have also been developed aimed at guaranteeing or improving the quality of solar water heating systems. For example, the Guaranteed Solar Results (GSR) quality approach has been implemented successfully in Austria, France, Germany and Greece, and experience transferred to Bulgaria, Poland, Romania, Slovakia and Slovenia.[126] Performance guarantees as in this case are applicable to large installations and aim to check that the real performance of a system corresponds to the advertised performance, as well as compensate users if this is not the case. Thus, the risk related to poor performance is no longer borne by the user but by manufacturers and installation contractors, who are therefore more likely to supply high quality equipment.[125] Further, economic

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[118] Philippe Menanteau, Policy Measures to Support Solar Water Heating: Information, Incentives and Regulations, (World Energy Council, 2007) at 12

[119] Philippe Menanteau, Policy Measures to Support Solar Water Heating: Information, Incentives and Regulations, (World Energy Council, 2007) at 12

[120] REN21, Renewables Global Status Report 2016, (REN21 2016) at 74.

[121] Karin Kritzinger and Theo Covary, Review of South Africa's Solar Water Heating Rebate Programme. Available https://www.researchgate.net/publication/308168429_Review_of_South_Africa's_Solar_Water_Heating_Rebate_Programme [accessed Jun 7, 2017].
Christoph Peters, Solar thermal legislation on municipal, regional and national level in Spain Success and remaining barriers, at http://www.solarthermalworld.org/sites/gstec/files/legislation%20spain.pdf.

[122] Philippe Menanteau, Policy Measures to Support Solar Water Heating: Information, Incentives and Regulations, (World Energy Council , 2007) at 11

[123] Philippe Menanteau, Policy Measures to Support Solar Water Heating: Information, Incentives and Regulations, (World Energy Council , 2007) at 11

[124] European Commission, Solar thermal applications in Eastern Europe with Guaranteed Solar Results (EAST-GSR), at https://ec.europa.eu/energy/intelligent/projects/en/projects/east-gsr

[125] Philippe Menanteau, Policy Measures to Support Solar Water Heating: Information, Incentives and Regulations, (World Energy Council, 2007) at 11.

incentives such as subsidies can be granted to encourage the use not only of high quality products but also of qualified installation contractors and high-performance installations if they are awarded based on minimum performance levels. For instance, in the Netherlands, the amount of the subsidy is determined by the performance of the installation.[126] In Barcelona, the revised ordinance requires installers to issue a certification of the quality of the installation work and a maintenance contract.[127]

Finally, public information and awareness campaigns are critical to the success of a solar water heating programme. Such government-led or government-supported campaigns are intended to stimulate public interest in solar water heating and ensure that all stakeholders are aware of any solar water heating regulations in place including the availability of any economic incentive schemes. In Austria, which is amongst the world's top 12 countries in their solar water heating collectors' global capacity,[128] numerous activities are carried out to in order to raise awareness about solar water heating technologies.

These include free answers to questions about renewable energy and energy efficiency (energy hotline), free advice and auditing for private households, public institutions and companies and distribution of publications and information tools (videos, interactive CD-ROMs).[129] India, which is among the top 5 countries globally for new installations as at 2015, [130] has an active outreach campaign that includes a SWH website and electronic newsletter, a toll free help line, advertisements in public places and in print media, and awareness raising workshops.[131] Other countries such as Lebanon, which has support from the Global Environment Facility (GEF), offers a similar broad-based SWH outreach campaign with innovative national media and advertising campaigns that rely on both traditional and social media Including a bi-annual newsletter, a weekly email, public informational seminars, TV and radio appearances, and print articles and advertising. [132] Conversely, lack of consumer awareness and marketing, have been found to be among the biggest weakness the South Africa's solar water heating programme.[133]

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[126] Philippe Menanteau, Policy Measures to Support Solar Water Heating: Information, Incentives and Regulations, (World Energy Council, 2007) at 11.

[127] European Solar Thermal Industry Federation, Best practice regulations for solar thermal (ESTIF, 2007) at 40.

[128] REN21, Renewables Global Status Report 2016, (REN21 2016) at 71

[129] Philippe Menanteau, Policy Measures to Support Solar Water Heating: Information, Incentives and Regulations, Country Study: Austria (World Energy Council , 2007)

[130] REN21, Renewables Global Status Report 2016, (REN21 2016) at 70.

[131] Wilson Rickerson et al, The SWH TechScope Market Readiness Assessment (UNEP, 2014) at

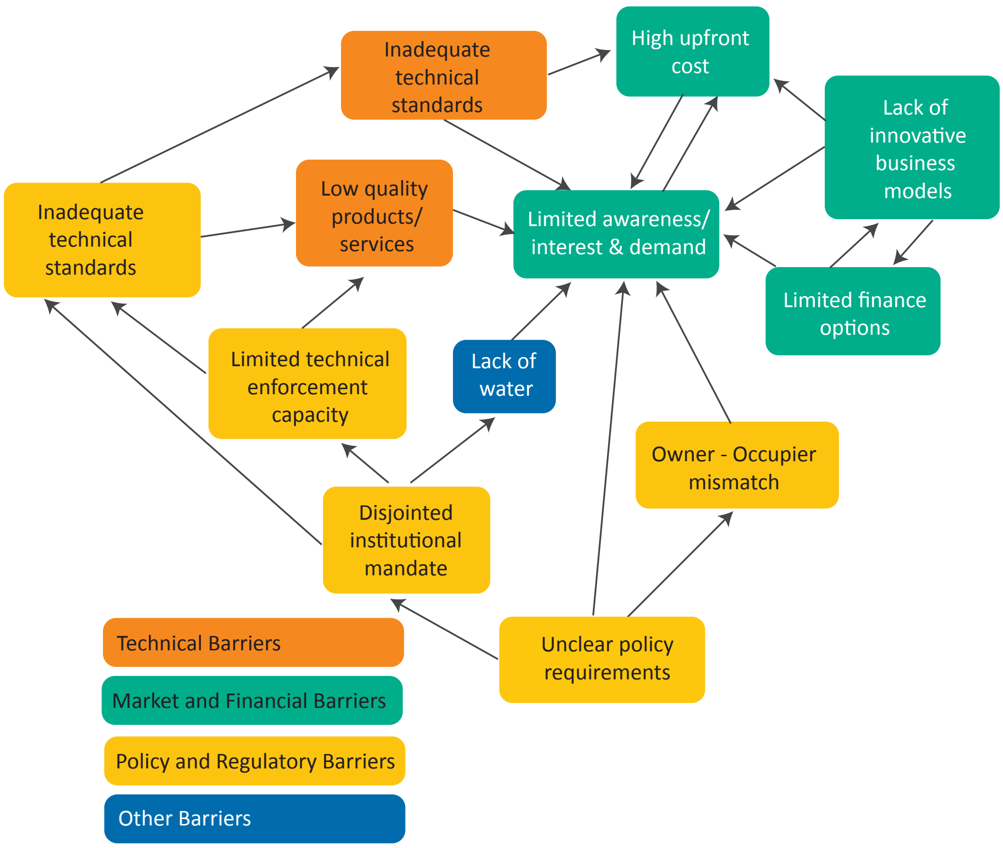
[132] Wilson Rickerson et al, The SWH TechScope Market Readiness Assessment (UNEP, 2014) at

[133] Karin Kritzinger and Theo Covary, Review of South Africa's Solar Water Heating Rebate Programme. Available https://www.researchgate.net/publication/308168429_Review_of_South_Africa's_Solar_Water_Heating_Rebate_Programme

5 Analysis of Market Barriers

This chapter outlines and clusters the main barriers hindering the uptake of SWH in Kenya using the problem tree analysis. The analysis below provides a visualization of the cause-effect hierarchy between the barriers. These barriers can be grouped into technical, financial, policy and regulatory, and others.

Figure 17: Summary of leading barriers



5.1 Technical Barriers

There are two main categories of technical barriers. The first is related to the products in the market and the second to the services associated with successfully deploying these products.

Table 12: Summary of technical barriers

NO.	BARRIER	DESCRIPTION
1	**Low quality product**	Post regulation many of the installations are done driven by the need to comply and therefore users or developers go for the lowest cost option which are often low quality. The quality of the systems is wanting in terms of the collector, piping system, storage and integration with the water supply units of the premises. Evacuated tube collectors are perceived to be of the lower quality but this is largely because they are harder to install and maintain. They also do not work well in areas with saline water including most borehole sources and areas along the coast.
2	**Inadequate technical skill and experience**	Technical knowledge of the SWH system and plumbing works are both crucial for the installationof proper functioning systems. The current setup focuses on training on the former without proper attention being given to the latter. The problem is compounded further in instances where the plumbing works are already in place and may be old or poorly installed. In residential apartment blocks, it is not uncommon to find integrated systems that serve multiple houses which reducing the efficiency of these systems. A lot of water is wasted in an effort to drain out the cold water in the pipe, for example. There is also limited assessment of the user needs and circumstances before recommending a system. Issues like hot water use patterns and needs, quality of the water available, storage, weather aspects all need to be considered while selecting a system.

5.2 Market and Financial Barriers

Table 13: Summary of financial barriers

NO.	BARRIER	DESCRIPTION
1	**High upfront cost of system**	A basic 250 litres evacuated tube system from China would cost KES 70,000 at a minimum. This is more expensive than most of the common electrical appliances found in an average household. Complicating this further is the fact that many of the occupants of these houses are not the owners and therefore do not have the incentive to invest in these systems.
2	**Lack of innovative business models**	Most of the SWH on the market are purchased in cash and this limits the number of potential clients. Lessons from the solar PV market demonstrate that innovative business models, for example, leveraging pay-as-you-go platforms, can expand the market size. SWH are sold based on a very rigid model. Although the SWH are expected to function for over 10 years, most of the warranties given are one year or less.
3	**Limited finance options**	A few SWH distributors have partnered with financial institutions to finance SWH systems. These include KCB and Chloride Exide; Equity and Orb Energy; and Bank of Africa and Energood. Before the Central Bank directive capping interest rates, these loans would be given at rates between 15-25% per annum. This directive has affected the disbursement and reach of this form of support.
4	**Limited awareness/ interest and demand**	Most of the barriers identified contribute to this barrier, which then reinforces other barriers in a feedback loop. Due to limited demand, the market is yet to realize the benefits that come with sufficient economies of scale. Of those interviewed, many of the non-users (79%) required to comply do not know about the regulation and only 14% have sufficient details of requirement.

5.3 Policy and Regulatory barriers

Many of the policy, institutional and regulatory barriers are discussed above in section 4. Below is a summary of the key types of barriers.

Table 14: Summary of policy and regulatory barriers

NO.	BARRIER	DESCRIPTION
1	**Unclear policy requirements**	There are definitional ambiguities including use of the term "local authority" and other terms under section 4 (exemptions). These include the application of the term "technical limitations" and "special circumstances." It is also unclear whether premises that exist and qualify for such exemptions need to apply for these exemptions or applications is only for new premises seeking approval. A bigger problem is the identification of the culpable party or parties. It is implied that the owner of the premises is culpable but section 6 of the regulations list other parties. It is therefore unclear, in certain circumstances, whether one or all the parties are liable. This makes enforcement particularly difficult.
2	**Disjointed institutional mandates**	Several institutions have a role in the enforcement of these regulations. These include the Commission, Kenya Power, subnational agencies, National Construction Authority, among others. Many of these institutions do not have the capacity to adequately follow through on the regulation requirements, and a few are not even aware of their mandate – especially those at the subnational level. Conflict of interest may arise in certain cases, for example, with Kenya Power who are mandated to rapidly expand connections.
3	**Limited technical/ enforcement capacity**	There are challenges with system selection, user needs assessment, sizing and configuration. Expertise lacking go beyond the understanding of the thermal components and but includes piping and storage considerations. There are instances where high quality systems are installed in an improper manner leading to failure or suboptimal performance.
4	**Inadequate technical standards**	KeBS has developed two main SWH standards (standards on thermal components and solar heating systems for domestic systems) which both apply to domestic systems excluding commercial and industrial systems. They also have not been updated since 2009 (but require updating every 5 years). KeBS also does not have the capacity to test imported SWH systems and depend on the certificate of conformity (COC) from the country of origin to ascertain the quality of the systems.
5	**Owner – Occupier mismatch**	Although the responsibility is generally perceived to fall on the owner, section 6 of the regulation repeatedly uses the phrase "owner or occupier". This could mean that either is culpable under different circumstances (that are not defined) or both are culpable all the time.

5.4 Other Barriers

Table 15: Summary of informational barriers

NO.	BARRIER	DESCRIPTION
1	**Lack of water**	Although unrelated, the widespread lack of consistent water supply in many urban areas bring to question the appropriateness of the regulation. Some section of Nairobi's South C area have not had consistent water supply for the last 5 years. Respondents in such areas question the validity of this regulation as the requirement of having a SWH presupposes that the person has household water. Many of the respondents see the source of this regulation and the responsible party for ensuring consistent water supply as being one, the government.

6 Conclusions and Recommendations

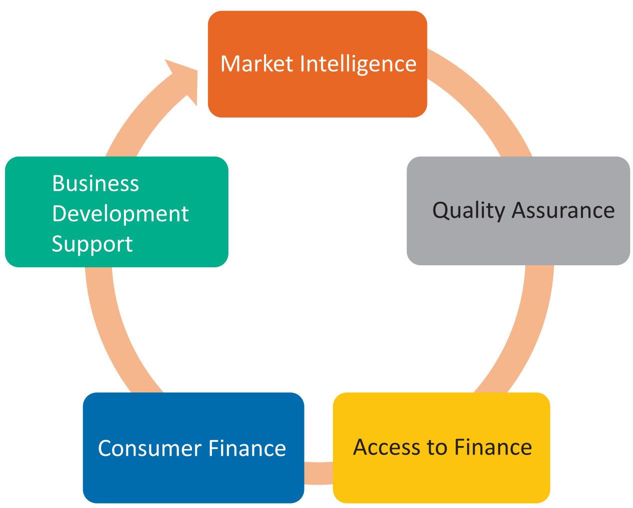
6.1 Conclusion

The intention to regulate with the desire to promote the SWH sector in Kenya is noble. Other countries have demonstrated that the uptake of SWH could result in a net positive socio-economic outcome. As currently structured, the regulatory framework for SWH in Kenya encompasses a wide variety of laws with the key piece of legislation being the regulations enacted under the Energy Act. The regulations are a good indication from the policy makers on the important role SWH can play. However, the regulations and surrounding laws contain various shortcomings and inconsistencies that require resolving to realize their intended purposes. The regulations also take a punitive approach and do not offer any incentives to the market players. They are also very difficult and costly to enforce. Even with the punitive measures, the regulations have failed to create an increase in demand for SWH. Data from KRA do not show any significant changes before and after the regulations. Although the uptake has remained unchanged, the current capacity in Kenya is higher than most of the countries in the East Africa region.

The barrier groups are closely interrelated and it is important to address them simultaneously. Only training professionals only to not install substandard products will not work, and addressing the high upfront cost without raising the level of awareness will not result in the desired outcomes. The final delivery should be a SWH market transformation initiative as opposed to piecemeal measures that will address only some of the barriers (see Figure 16). In developing such an initiative, the focus should be on the potential socio-economic benefits which include the creation of employment opportunities, energy cost reduction among end-users, improved demand side management by the utility and a reduction in GHG emissions. However, in view of the Commission's mandate, the immediate output of this process should be the revision of the existing regulation to provide a more supportive policy and regulatory environment that will anchor the necessary research and development, market expansion and capacity development. The policy should also be accompanied by clear targets that will act as strong indicators of the regulator's intentions, a monitoring system and periodic evaluation (like this study) that will track progress or lack thereof in the SWH sector.

Kenya's market has demonstrated its ability to incubate, nurture and prove new and appropriate energy technologies as demonstrated by the successes realized under the Kenya Ceramic Jiko promotion of the 1980s, the first solar PV revolution of the 1990s (dissemination of SHS) and the second solar PV revolution (dissemination of PAYG systems) of the 2010s. These successes were realized in a largely unregulated environment at its infancy. Many of the respondents interviewed, including sector experts, distributors and end-users, see the promotion of SWH as a priority but do not view the current regulation as being the catalyst to achieve this. The current regulations place a focus on residential markets yet the greater potential lies in the institutional, commercial and industrial sectors. This does not mean that priority should be on any one, but that all should be considered within the context of their unique characteristics.

Figure 18: Lighting Africa's approach to market transformation



6.2 Recommendations

6.2.1 Technical Recommendations

- There is a need to develop sector standards to address the widespread market spoilage. This can be achieved through industry-led and managed approaches like the World Bank Lighting Africa program where sector players align their products and services to peer approved standards. Alternatively, these can be done through a formally recognized regulatory agency like KeBS. Existing standards could be updated in close cooperation with the sector representatives including the Kenya Renewable Energy Association, Kenya Private Sector Alliance and the Alliance of Energy Practitioners of East Africa (AEPEA)and should be based on international standards. This initiative should also consider the merits and demerits of developing a labelling system. This report places a preference on the first light-handed approach as a start. It is important for the regulators and the market to gather critical momentum before formal standards are adopted.

- The Commission should improve the draft training curriculum based on the broad recommendations provided in this report. Beyond this, the curriculum should be finalized in close collaboration with learning and research institutions such as the Strathmore Energy Centre, Jomo Kenyatta University of Agriculture and Technology, National Industrial Training Authority, National Technical Training Institute and the Kenya Industrial Research and Development Institute whose core competency is capacity development. Consultation should be done in association with Kenya Renewable Energy Association, Kenya Private Sector Alliance and the Alliance of Energy Practitioners of East Africa (AEPEA) to avoid duplication. The curriculum should also clearly distinguish between required training for domestic systems and commercial-industrial ones. It should be clear on peripheral issues such system sizing, orientation considerations, water quality testing, material selection (for plumbing and piping especially) which are critical to the good functionality.

6.2.2 Policy and Regulatory Recommendations

- This current regulation - the Energy (Solar Water Heating) Regulations 2012, should be repealed and replaced with a dedicated SWH policy that seeks to provide incentives that will grow the market rather than enforce compliance. The new policy should at a minimum provide or result in financial incentives for end-users, strengthen the licensing procedures for practitioners, support capacity development efforts across practitioners, raise awareness among end-users through light-handed industry-led standards and certification processes. This policy should support the other recommendations provided here. If the revised regulations/policy require approvals, these should be administered only by one entity (preferably the Commission) in collaboration with others, especially county governments. Many of the mandated agencies do not have the capacity to adequately evaluate the applications. However, the Commission does not have the presence across counties and therefore any approval process should be one can that be done remotely, for example, using online tools/platforms.

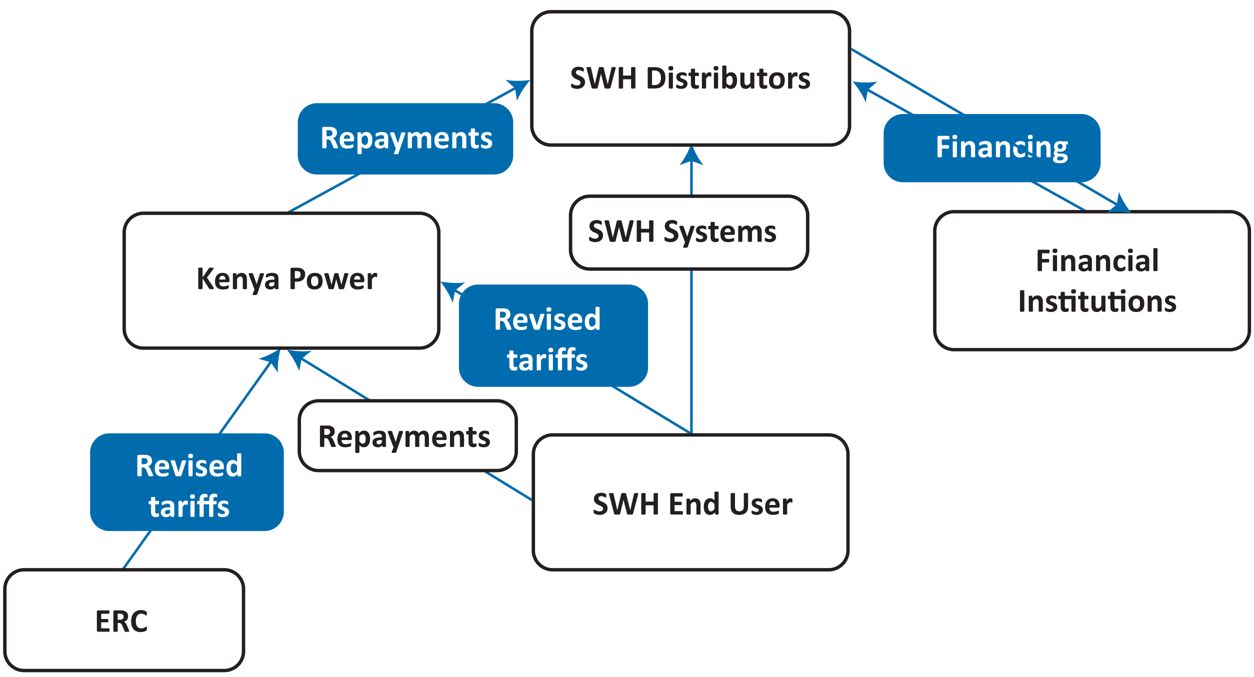
- Although not required by law (apart from notices in the Kenya Gazette), any policy/regulatory revision should be promoted through various channels including sector associations like Kenya Renewable Energy Association, Kenya Private Sector Alliance and the Alliance of Energy Practitioners of East Africa (AEPEA). These entities can be encouraged to draft simplified versions of the regulations to be disseminated to wider audiences.

6.2.3 Market and Financial Recommendations

- The Commission should develop a policy NAMA to support the recommended market transformation efforts. Funds from the NAMA could be used to support quality monitoring of installed systems and electricity consumption towards energy efficiency. For this ERC will be required to have records of all installations. Data such as the system type installed and the supplier company can be sent electronically to an ERC database system with details of the electricity meter used in the household. In conjunction with Kenya Power, data on electricity consumption from the provided meters can be monitored and analyzed to calculate the energy savings and emission reductions of households. This could also have broader benefits like identifying systems that are of poor or high quality in terms of performance. This system should be automated to minimize the need for extra human resource at the Commission.

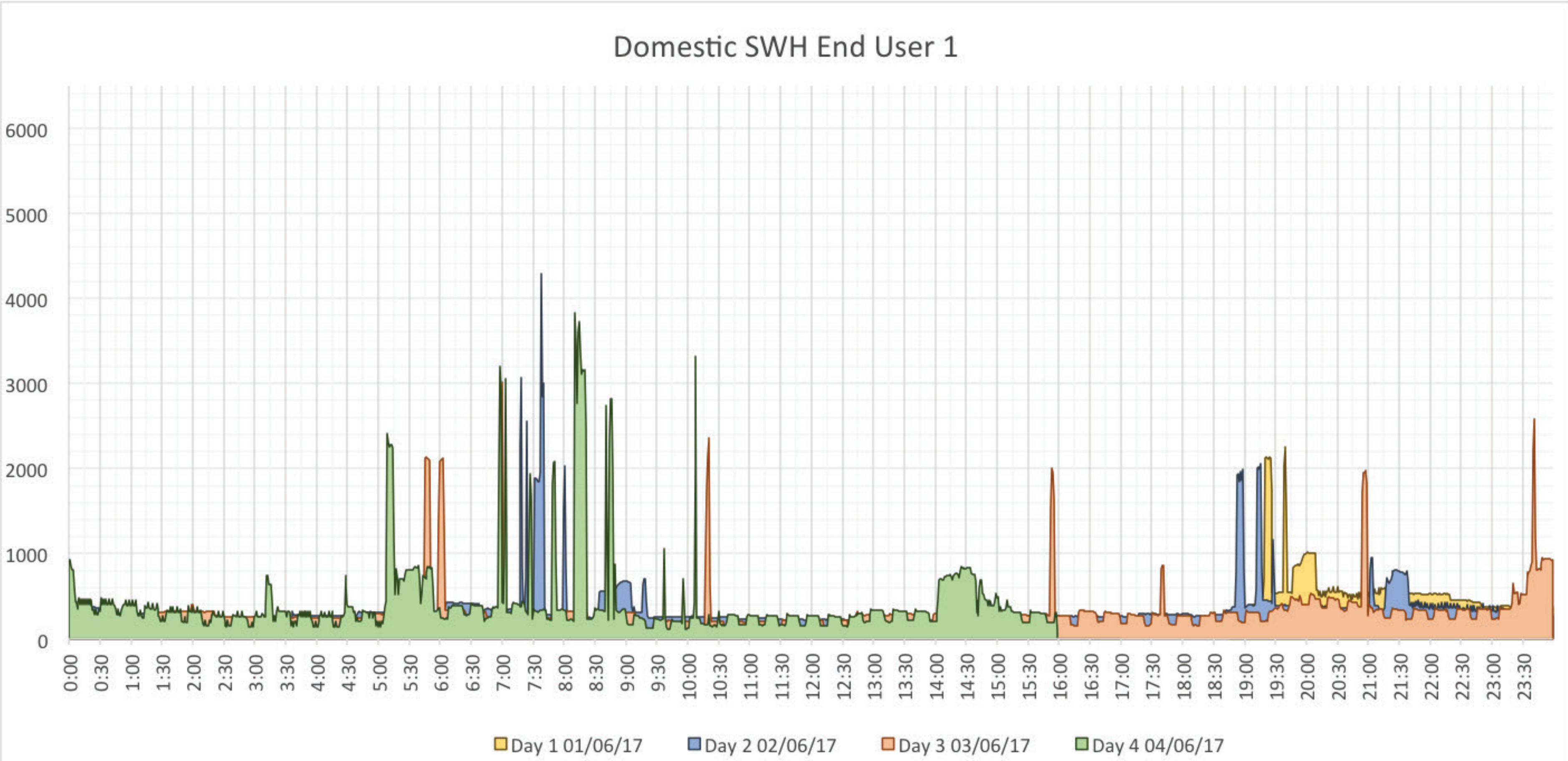
- Develop a highly discounted time-of-use water heating tariff and SWH repayment system for SWH users in collaboration with Kenya Power and anchored in policy. This recommendation brings together the Commission, SWH distributors, financial institutions, Kenya Power and SWH end-users as shown in Figure 19 . The Commission will recommend a highly discounted tariff for water heating done between 3am and 5.30am, for example as an incentive for users of hot water to purchase SWH systems. These times are deemed to experience the lowest demand. Prequalified SWH distributors deploying preapproved products will be eligible to supply the end-users under clearly defined terms and conditions including longer warranty periods while financial institutions provide the necessary support (where applicable). SWH distributors will deploy the preapproved systems through (i) direct sales where monthly repayments will be collected as a pass-through charge on the users' electricity bills, (ii) a lease model where users pay a standard monthly fee for a specified period and (iii) a lease to own model where an upfront fee (deposit) is charged and the rest of the payment collected through a pass-through charge over an extended period. A processing fee should be paid to Kenya Power as an incentive. End users benefit from preferential warranty terms, easier payment terms and lower water heating charges for the morning peak. This recommendation has multiple benefits including offsetting of peak demand (morning peak), promotion of higher quality products and services as the distributors will now have a longer-term engagement with the end-users that does not end at the point of sale or a few months after, optimizing the power demand curve (during off-peak and average demand hours), integrating the payment for SWH with Kenya Power's collection system, reducing GHG emissions using renewable baseload power (hydro and geothermal as opposed to fossil fuel fired peaking plants) and employment creation due to the scale up of SWH sector.

Figure 19: Structure of the time-of-use tariff and repayment collection system

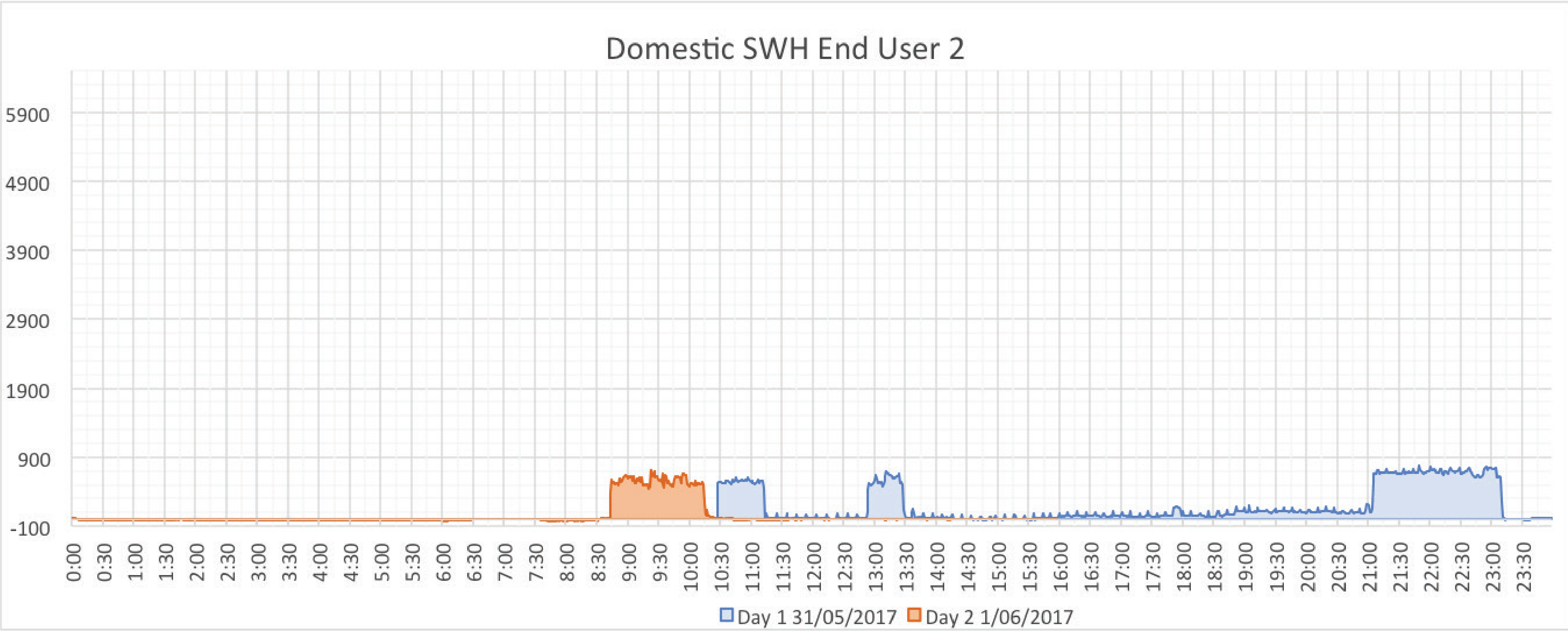


ANNEX 1: END USER LOAD CURVES

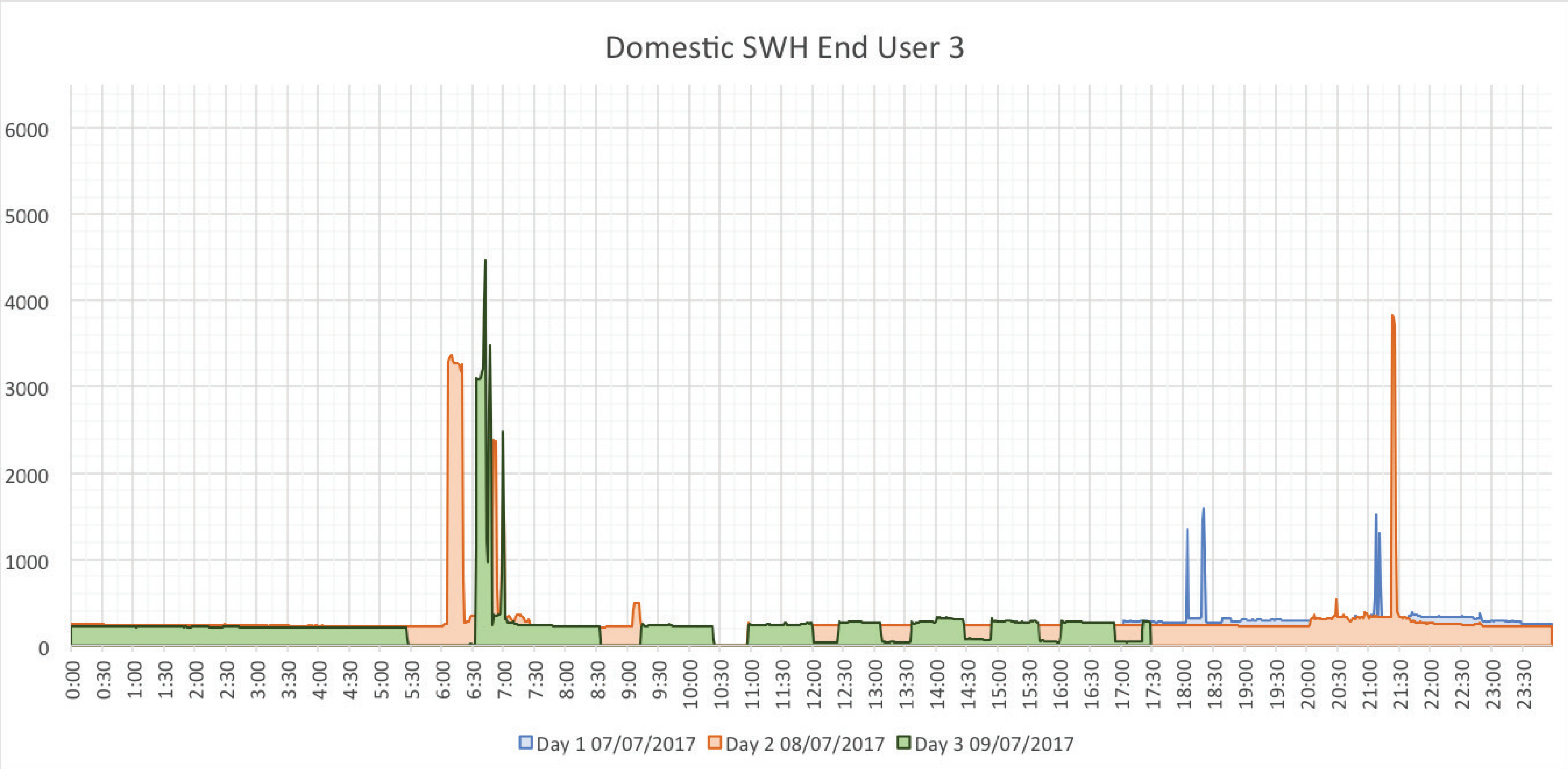
1. Domestic SWH End User 1



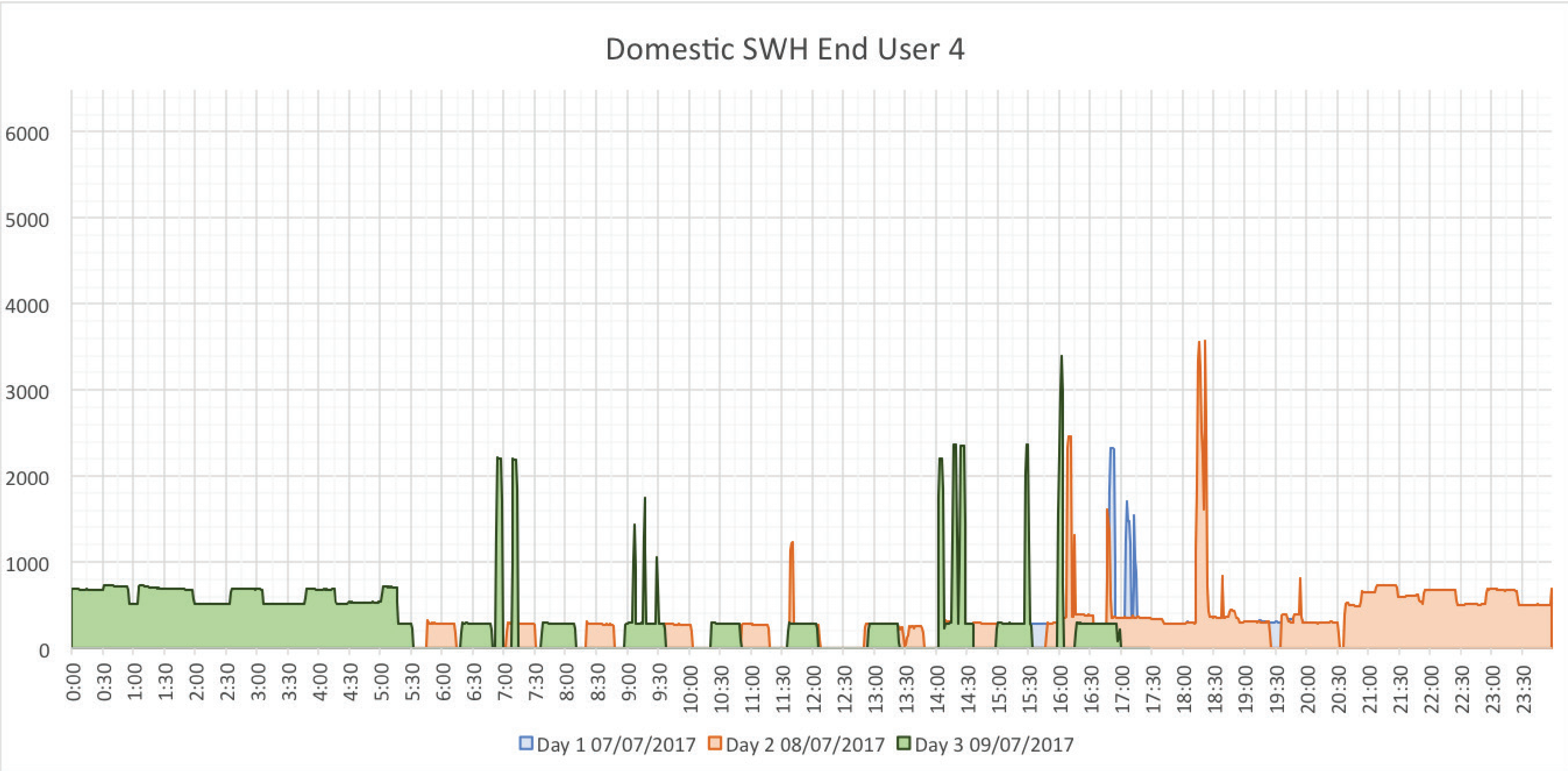
2. Domestic SWH End User 2



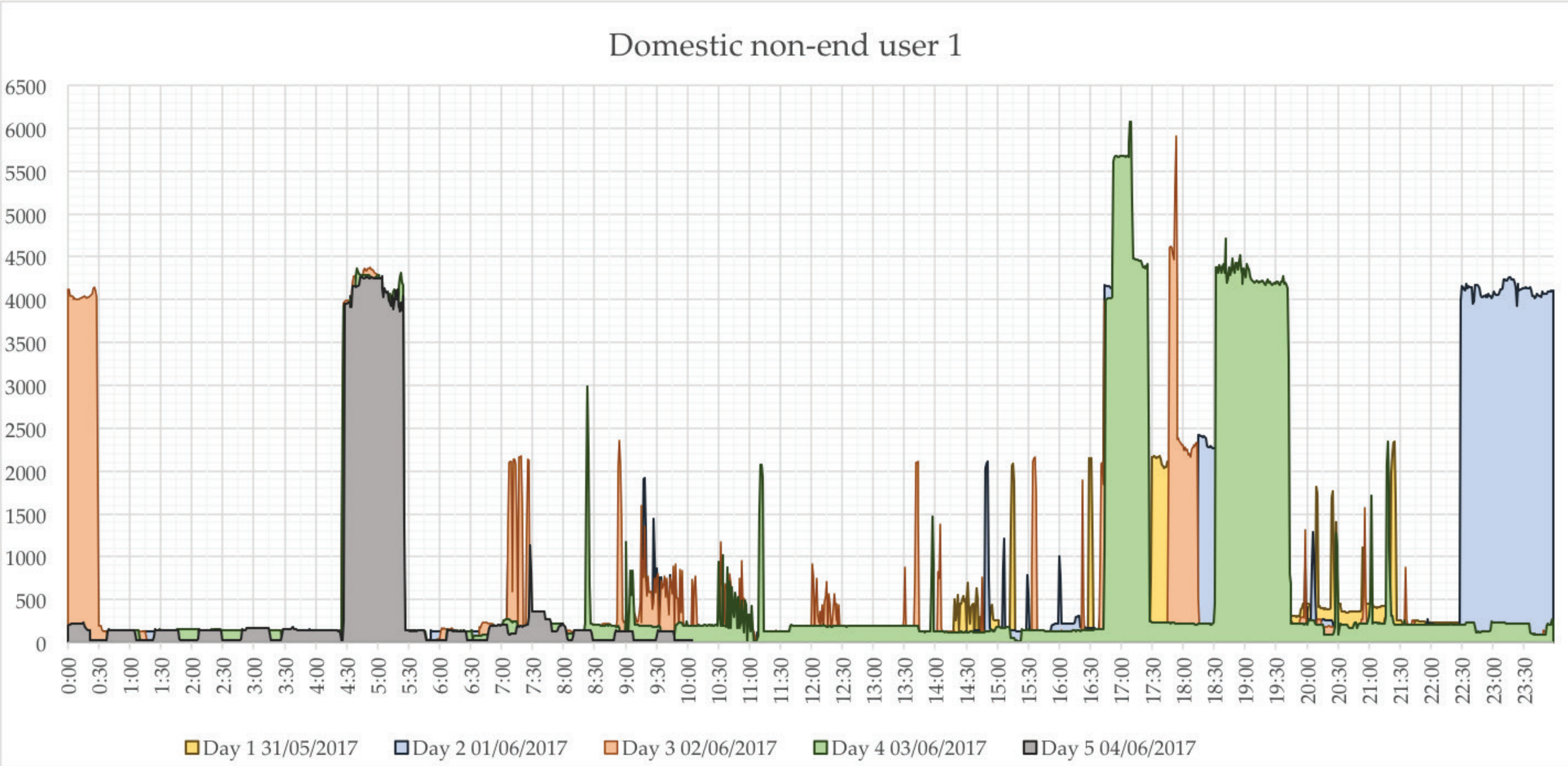
3. Domestic SWH End User 3



4. Domestic SWH End User 4



5. Domestic Non SWH End User 1



6. Domestic Non SWH End User 2