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Solar Water Heating Supply Chain Market Analysis

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Prepared for:
The City of Milwaukee & the National Renewable Energy Laboratory

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Introduction

Solar Water Heating Systems

Solar water heating (SWH) systems use solar energy that is absorbed by a thermal collector to heat water. SWH systems are available in many configurations and are used in multiple applications; they provide water heating solutions to residential, commercial, and industrial customers, as shown in Figure 1.

Residential		A portion or all of the water heating requirement for homes can be provided by solar thermal systems/SWH systems. SWH generally provides 50 – 70% with the remainder of the residence's water heating needs met by an auxiliary heating system.
Commercial		Commercial buildings that have a large demand for water heating are the best candidates for SWH systems. The most common applications are in apartment buildings, nursing homes, hotels, hospitals and restaurants.
Industrial		SWH can be integrated into some industrial processes. Some examples are meat processing, canned foods, and large-scale laundry.

Figure 1. Applications for Solar Hot Water Heating

SWH systems can be up to ten to fifteen times more efficient than photovoltaic (PV) systems that generate electricity. Most SWH systems in the U.S. today are used for residential and pool applications and are typically installed by local installers. However, larger commercial and industrial systems for customers who use large amounts of water such as water parks, hotels, and laundromats are a growing segment of the market. With more customers realizing the potential savings and larger installers, such as energy services companies (ESCOs), expected to enter the market and offer SWH as part of their comprehensive solution offering, the commercial segment of the market is also expected to grow.

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Solar Hot Water Temperature Categories

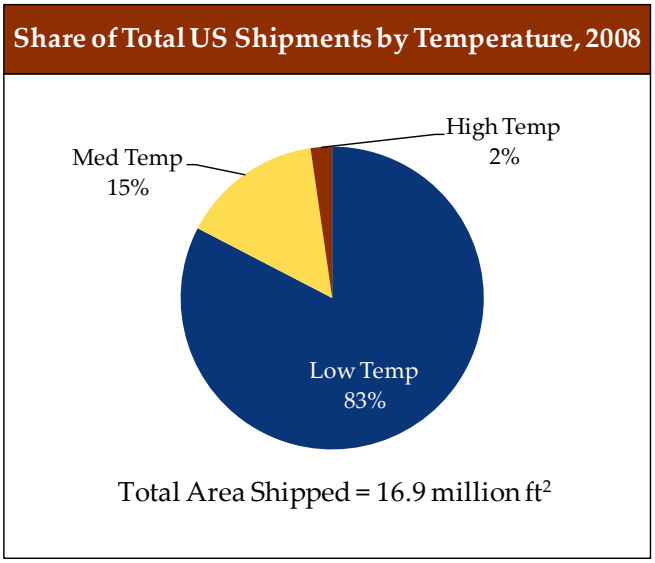
Solar thermal systems are generally divided into categories of low, medium, and high temperatures, as shown in Figure 2. Systems designed for SWH applications are generally either low- or medium-temperature systems, with high-temperature systems used for electricity generation through the production of steam.

Low Temperature (70 to 110° F)		Low temperature solar thermal collectors include an absorber material which is not covered by glass. A glass covering would prevent some heat loss and heat gains, but adds cost and rigidity. These "unglazed solar collectors" are most often associated with solar pool heating systems because of their low cost and the application's modest temperature requirements.
Medium Temperature (110 to 180° F)		To obtain higher temperatures the absorber material is covered by glass to reduce heat losses. These "glazed collectors" are most commonly used to heat domestic water heating systems. Also included in this category are evacuated tube collectors and concentrating (focusing) collectors.
High Temperature (> 180° F)		High temperature solar thermal electric technologies concentrate large amounts of sunlight onto a smaller area to achieve high temperatures, which are then converted to electricity by various means, including conventional steam-cycle technology. Parabolic dish and trough collectors are the main type of high temperature collector.

Note: High temperature CSP systems are used in area that receive direct sunlight radiation such as deserts. Attractive areas are in the U.S include AZ, NV, and southern CA. This technology will not work in the Wisconsin due to low direct sunlight conditions.

Figure 2. Temperature Categories of SWH

At least 80 percent of the U.S. market is dominated by low-temperature systems, as shown in Figure 3. These systems are mainly used in pool heating applications. The low-temperature market leads with respect to area shipped due to the size of solar water heating systems needed in pool heating, the simplicity of the system, low cost, and ease of installation.

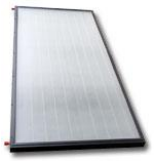


Source: Energy Information Administration (EIA)

Figure 3. Share of Total U.S. Shipments by Collector Temperature

Collector Types

There are three main types of collectors used in SWH applications: flat-plate, evacuated-tube, and concentrating collectors, as shown in Figure 4.

Flat Plate Collector (70 to 110° F)		A **flat-plate collector** contains a dark absorber inside an insulated, weatherproofed box, under a transparent or translucent cover. The cover, or glazing, is used to minimize the amount of heat escaping, while still allowing sufficient sunlight to pass through and reach the absorber. This is the most prevalent type of solar thermal collector for water heating systems in the U.S.
Evacuated Tube Collector (110 to 180° F)		An **evacuated-tube collector** is made up of rows of parallel, transparent glass tubes. There are many different configurations used in ET design, but generally each tube consists of a glass outer tube with an absorber inside of the tube. Some models have a second, inner glass tube. A vacuum within, or between, the tubes inhibits heat loss, making this type of solar thermal collector less-restricted by ambient temperatures
Concentrating Collector (> 180° F)		A **concentrating collector** for residential applications utilizes a mirrored parabolic surface to concentrate the sun's energy on an absorber tube (called a receiver) containing a heat transfer fluid.

Source: Homepower, NREL

Figure 4. Types of SWH Systems

The collector is the primary component in a SWH system and accounts for almost half of the cost of all system components (not including labor). Flat-plate collectors are most used due to their lower cost and high efficiency at lower temperatures.

Solar Water Heating Benefits

There are three key benefits that SWH systems provide: reduced traditional energy consumption, reduced emissions, and life-cycle cost savings:

- **Reduced traditional energy consumption:** The energy used by conventional water heating methods—electric, natural gas, or oil heat—is reduced by using a solar thermal system. For appropriately sized solar thermal collectors, a residential homeowner or business owner can expect to reduce their water- heating-related energy consumption by as much as two-thirds.
- **Reduced emissions**: The conversion of solar energy to thermal energy does not produce emissions. By installing a SWH system, a customer avoids emitting carbon dioxide, nitrogen oxides, sulfur dioxide, and other air pollutants that are generated by traditional sources of energy.
- **Life-cycle cost savings:** Over the life of the SWH system, the customer will see cost savings compared to conventional water heating systems because the fuel is free. In addition, solar energy can be used as a hedge against traditional sources of energy, which are subject to price fluctuations.

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SECTION

2

Milwaukee Area SWH Opportunities Analysis

The purpose of the Milwaukee area SWH opportunities analysis is to determine whether Milwaukee area advantages and its current industrial base provide a good location for manufacturing of components for the SWH industry. Three basic criteria were looked at when assessing the SWH manufacturing opportunity. First, the region was evaluated based on what it has to offer for manufacturing and support of a manufacturing industry. Next, common SWH components were identified and their potential value was determined. Finally, the Navigant team conducted a survey to understand the interests and capabilities of existing manufacturers in the area.

After researching the greater Milwaukee area, many advantages were identified and it was determined to have a solid foundation for manufacturing. Some of Milwaukee's strengths include a strong manufacturing base, solid transportation infrastructure, strong state incentives for manufacturing and solar installations, local interest in entering the solar industry, and opportunities to attract existing or new manufacturing to expand or relocate to Milwaukee. A summary of Milwaukee strengths is presented in Table 1.

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Milwaukee Area Strengths

Table 1. Milwaukee Strengths

Milwaukee's Area Strengths	
Existing manufacturing and engineering base	Milwaukee's manufacturing employs 16% of areas workforce, the third highest percent of manufacturing employees in the country.
Skilled manufacturing workforce	Milwaukee is a leader in the production of medical electronics, mining machinery, power trains, forgings, and internal combustion engines.
University engineering programs	Marquette University, Milwaukee School of Engineering ,and University of Wisconsin Milwaukee are just three of the engineering schools in the Milwaukee area.
Abundant high-quality water supply	Located on the coast of Lake Michigan, Milwaukee has access to an abundance of usable water.
Competitive electrical rates	Wisconsin's electrical rates for industrial and commercial sectors are below the national average.
Good transportation/distribution channels and facilities	Lake Michigan provides water transport in addition to the railways and highway infrastructure to supports Milwaukee's distribution.
Public/private enthusiasm and support for creating solar product	Many stakeholders within the state support solar development.
Milwaukee-area companies already involved in solar product supply chain	Examples include: A.O.Smith, Caleffi, Helios USA, Hot Water Products, and Johnson Controls
We Energies committed to developing solar generation	We Energies supports the development of renewable energy and supports their manufacturers. Workforce, development and incentive programs are available to the SHW industry.
Federal, state and city incentives	Wisconsin offers property tax exemption on SWH systems. Focus on Energy offers utility incentives for SWH property to eligible customers, Federal incentives include tax credits, depreciation and loan programs.

Milwaukee's strong manufacturing base is one of the more important strengths related to this study. Having an existing base is advantageous as manufacturing facilities require a significant amount of start-up capital for machinery and tools. The local manufacturers also have a high pool of skilled labor they can draw on, with more than 16 percent of the total workforce employed in the manufacturing industry. Local employees are highly proficient, with diverse skill sets that can be leveraged for SWH component manufacturing.

In addition to a strong manufacturing base, the Milwaukee area is also home to several engineering schools. These technical schools help provide the manufacturing industry with engineers and skilled labor as well as keep the industrial base up to date with new manufacturing methods and tools. In addition, the schools provide a great resource in terms of research and development. Many of the schools have technology transfer programs to promote the commercialization of new technologies. Such transfer programs are highly beneficial to the local manufactures and provide them with opportunities to manufacture products using state-of-the art technology.

Milwaukee's manufacturing base is also supported by its robust infrastructure. Lake Michigan provides access to an abundance of usable water. In addition, the Great Lakes provide a route for shipping supplies and products in and out of the city. For faster shipping methods, there

are two large interstates that intersect the region as well as several large commercial railroads. Finally, for fast shipping and personnel transportation needs, there is General Mitchell International Airport. Due to high- quality shipping solutions—local manufacturers can compete in markets throughout the U.S. and globally—location is less of a factor when choosing a new market.

The region's commercial electricity rates are on par with the rest of the country. The electricity rates provide a solid and affordable energy base for manufacturers. We Energies also shows support for the SWH industry by providing a percentage match of Focus on Energy's incentive for installing SWH systems. Such programs are instrumental in helping to grow the SWH market locally.

In addition to We Energies, *Milwaukee Shines* provides support for the local SWH industry. The *Milwaukee Shines* program and We Energies partially funded this study in addition to previous studies to help identify new revenue streams for manufacturers within the SWH industry.

Several Milwaukee-based companies are highly active in various segments of the SWH value chain, as shown in Figure 5.

- Large manufacturers such as A.O. Smith, who makes water heating tanks, also provide complete SWH system solutions. Caleffi is another leading company that offers solutions for the SWH industry and has its North American headquarters located in Milwaukee.
- Johnson Controls, a global ESCO, is trying to offer more customers SWH as part of a comprehensive solution offering. As system sizes increase, ESCOs and other large installers will drive the industry forward.
- First Supply and Hot Water Products are local distributers of SWH systems that have been highly involved in the industry for many years. Local installers benefit from these distribution channels as product is easier to obtain.

In addition, there are many local installers and several smaller component manufacturers in Milwaukee and in other parts of the state that serve the SWH industry exclusively. Manufactures of SWH components could benefit from local distribution channels and local demand. There are high quality education and training program, such as the Midwest Renewable Energy Association, that train and support the installer and site assessor base.

Solar Hot Water Value Chain

Financing (1. I Banks, 2. Pension Funds, 3. Financial Advisory/Placement); R&D

Selected Local Businesses	Component Manufacturer	System Integrator/ MFG	Distributor/ Wholesaler	Contractor
Bubbling Springs (Collector)	■			
IMC Instruments (Controller)	■			
A.O. Smith	■	■		
Caleffi	■	■		
First Supply			■	
Hot Water Products			■	
Johnson Controls		■		
Access Solar American Renewable Power, LLC Castleman & Sons Plumbing, Inc Heiden Plumbing Company, Inc J M Brennan, Inc Mared Mechanical Milwaukee Solar				■

Figure 5. Milwaukee Area Solar Hot Water Value Chain

Beyond the manufacturing base and infrastructure, there are also various incentives available for manufacturers of SWH components. These incentives come in the forms of cash back rewards, grants, tax credits, and loans. The incentives are provided by a wide range of sources such as the State of Wisconsin, City of Milwaukee, the federal government, utilities such as We Energies. Table 2 and Table 3 summarize these incentives.

Table 2. Milwaukee Area Incentives for SWH

Summary of Key Incentives and Policies for Solar Hot Water						
County or Agency	Program	Program Features				Description Or Other Notes
		Customer Class	Incentive Type	Max Incentive	Budget	
State	Industry Recruitment Loan	C, I	Loan	25% of project costs		Loans at 2% interest rate for 5-10 years (equipment) or 5-7 years (working capital) - **EXPIRED**
State	Energy Independence Fund Program	C, I	Loan/ Grant	Unspecified	$150 M (over 10 years)	Grants: 50% cost-share required; Loans: 4% interest rate for up to 15 years, maximum of 25% of project cost
Utility	Focus on Energy Incentives	Served by participating utility	Rebate	25% of costs	$8.2 MM (2010, all RE)	Performance-based incentive
We Energies	RE Cash-Back Rewards (CBR)	All	Rebate	30 - 100% Match of FOE CBR	% Rebate Depending on Customer Class	Match of Focus on Energy (FOE) Programs for NFP or 7.5% bonus for R, C, I customers.

Source: DSIRE Database: September 2010

R – Residential, C – Commercial, I – Industrial, NP – Non-Profit, A – Agricultural, MF – Multi-Family, G – Government, S - Schools

Table 3. Wisconsin Business Incentives

Summary of Key State Business Incentives				
Program	Program Features			Description Or Other Notes
	Incentive Type	Max Incentive	Budget	
Community Development Block Grant	Loan	N/A	$ 50+ M	The average local RLF loan is about $75,000; "tailor-made" loans, which may include deferred payments and interest rates.
Industrial Revenue Bond (IRB) program	Bonds	$ 10 M	$200 M	Interest rates may be 1.5-2.5% below corporate bond rates & payment term is negotiable.
Early Planning Grant (EPG) program	Grant	$3,000	N/A	The program typically provides grants for 75% of eligible project costs up to $3,000, there are limited funds available.
Economic Development Tax Credit	Tax Credit	N/A	N/A	Tax credits vary for businesses with the following eligible activities: job creation, capital investment, employee training, & corporate HQ location.

Milwaukee Area – Opportunities Analysis

The next step of the analysis of the Milwaukee area SWH opportunities required understanding the components that make up a SWH system, the manufacturing that goes into each component, and the potential value in each component, as shown in Figure 6. On the Milwaukee side, it was necessary to determine the capabilities of local manufacturers and their respective interest in manufacturing components for the SWH industry. In order to incorporate all of these criteria, a screening process was created to narrow down the list of SWH components to a few attractive components.

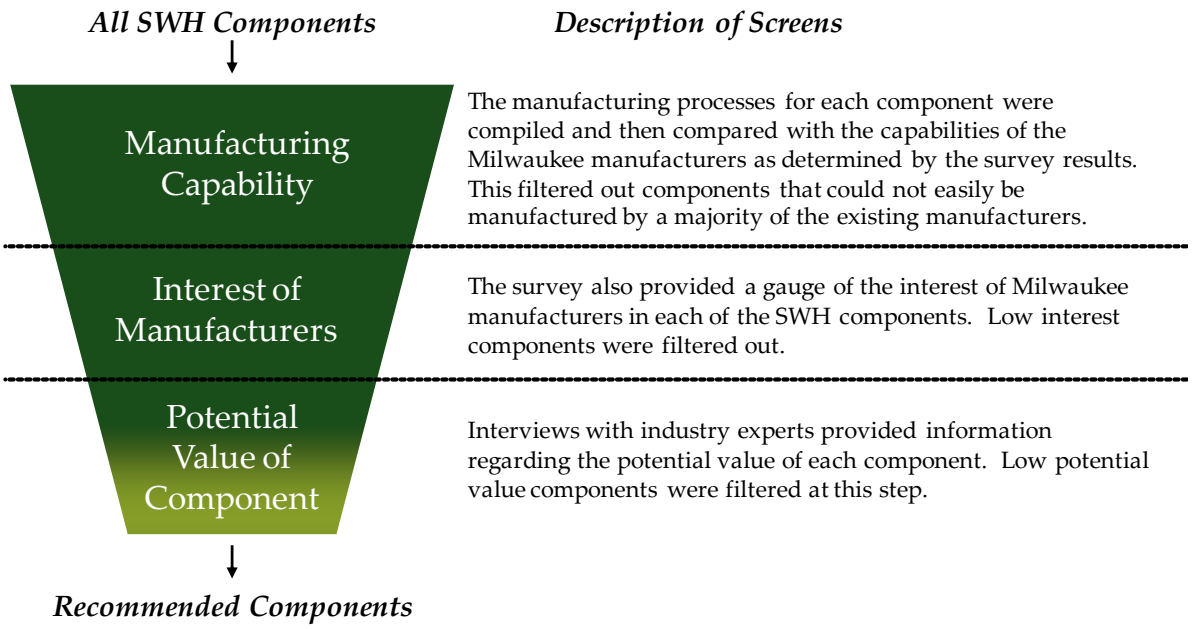


Figure 6. SWH Component Attractiveness Screening Process

The first step in determining the most attractive SWH components for Milwaukee was determining the required manufacturing processes used to make each component. Industry experts provided the necessary information to create the matrix shown in Table 4. A list of the most common SWH components is in the first column and common manufacturing capabilities are listed across the top. An "X" denotes whether a particular manufacturing process is needed for each component. However, due to the variety of types, some components may require all the processes that are noted by the Xs. For example, a heat exchanger can simply be a coil of pipes or a series of parallel plates. These two different types of heat exchangers

require very different manufacturing processes—pipe bending versus stamping and rolling, as shown in Table 4.

Table 4. SWH Component Manufacturing Matrix

SWH Component	Machining	Stamping	Rolling	Turret Punch	Welding (TIG & MIG)	Laser Cutting	Casting	Pipe Bending	Sandblasting	Painting	Coating	Molding	Enamel Coating
SWH Water Storage Tank		X	X	X	X	X	X	X	X	X	X	X	X
Heat Exchanger for potable water		X	X					X					
Electronic Controls												X	
Fractional Horsepower Pumps	X						X						
Pump Motor Flanges	X	X					X						
Hydronic Valves	X						X						
Expansion Tank		X											
Air Elimination Valve	X						X						
Piping			X										
Pipe Fittings		X											
Assembly – Pump Stations													
Temperature Gauges	X	X					X						
Pressure Gauges	X	X					X						
Drain back Tank		X	X	X	X	X	X	X	X	X	X	X	X
Pipe Insulation													
Dirt and Air Separators	X	X					X						
Thermal Mixing Valves	X	X					X						
Solar Thermal Collector					X			X		X	X	X	

The matrix helps show that storage and drain-back tanks require the largest variety of manufacturing processes due to the number of different parts and complexity of the process. In addition, it shows that the most commonly used manufacturing processes for the SWH industry are machining, stamping, and casting.

Following the identification of each part's manufacturing processes, Navigant matched these processes to capabilities of local manufacturers. A survey of the local manufacturing base was conducted to obtain this information. The survey was sent to a large number of manufacturers in the greater Milwaukee area. Recipients were asked to identify their current manufacturing capabilities as they relate to the SWH industry and if they plan to develop these capabilities over the next one to three years. According to the survey, the most common capabilities are machining, stamping, turret punching, and welding. Machining and stamping match up with the more common processes needed for SWH component manufacturing, putting Milwaukee in a good position to manufacture components for the SWH industry. Milwaukee-area manufacturers have a wide variety of capabilities; however, despite the variety, there is a limited amount of casting and enamel coating, which limits the possibility of manufacturing

some SWH components, as shown in Figure 7. Enamel coating for example is used mainly by tank manufacturers, other manufacturers will not have this capability.

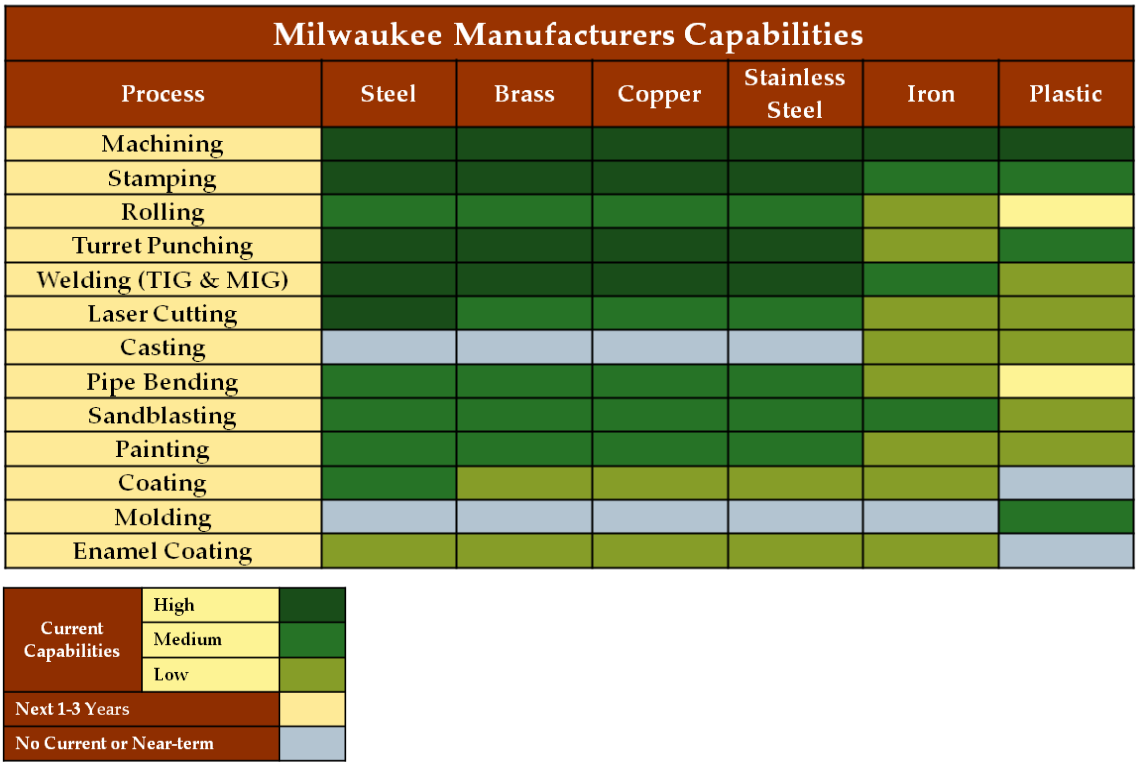


Figure 7. Milwaukee Manufacturers Capabilities

The components that could feasibly be made in the Milwaukee area without extensive retooling were determined by combining the manufacturing processes needed for the components and the Milwaukee-area manufacturing capabilities. The results are shown in Table 5.

Table 5. Components that Can be Manufactured in Milwaukee

SWH Component	Machining	Stamping	Rolling	Turret Punch	Welding (TIG & MIG)	Laser Cutting	Casting	Pipe Bending	Sandblasting	Painting	Coating	Molding	Enamel Coating
SWH Water Storage Tank		X	X	X	X	X	X	X	X	X	X	X	X
Heat Exchanger for potable water		X	X					X					
Electronic Controls												X	
Fractional Horsepower Pumps	X						X						
Pump Motor Flanges	X	X					X						
Hydronic Valves	X						X						
Expansion Tank		X											
Air Elimination Valve	X						X						
Piping			X										
Pipe Fittings		X											
Assembly – Pump Stations													
Temperature Gauges	X	X					X						
Pressure Gauges	X	X					X						
Drain back Tank		X	X	X	X	X	X	X	X	X	X	X	X
Pipe Insulation													
Dirt and Air Separators	X	X					X						
Thermal Mixing Valves	X	X					X						
Solar Thermal Collector					X			X		X	X	X	
Solar Thermal Collector - Frame	X	X			X						X		
Collector Mounting system	X	X			X						X		

Current Capabilities	
High	
Medium	
Low	

X:
Manufacturing process or assembly needed for component

Components that have Xs in high- and medium-capability columns in Table 5 are currently the most feasible to manufacture in the Milwaukee area. Components such as water pumps, valves, gauges, and pipe insulation were considered less feasible than other components and were filtered out. Although these components remained in the list as comparison in the following filters, they were not considered for the final group of attractive components for the Milwaukee area. Some of the more attractive components include the collector frame, mounting system, and expansion tank.

The three screening criteria are summarized in Figure 8, leading to seven components that were selected based on scoring in all three screens. Components with a low score were not considered. However, they may be applicable for certain manufacturers on a case-by-case basis. Collectors did not receive any low scores; however, they were not considered an attractive component due to the relatively high amount of Intellectual Property (IP) required for manufacture. In 2008, about 70% of the collector area used in U.S. installations was produced domestically with the majority of imports coming from Israel and Europe. However, as the U.S. market grows, more European companies are expected to enter the market presenting an opportunity for the Milwaukee area. Milwaukee could leverage local high quality manufacturing to attract international companies.

SWH Component	Capability	Interest	Value-Add
SWH Water Storage Tank	Medium	High	Medium
Heat Exchanger for Potable Water	High	High	Medium
Electronic Controls	Low	Low	High
Fractional Horsepower Pumps	Low	Low	Low
Pump Motor Flanges	Medium	Low	Low
Hydronic Valves	Low	Low	Low
Expansion Tank	High	Medium	Medium
Air Elimination Valve	Medium	Medium	Low
Piping	Medium	Low	Low
Pipe Fittings	Medium	Low	Low
Assembly – Pump Station	Medium	Medium	High
Temperature Gauges	Low	Low	Low
Pressure Gauges	Medium	Low	Low
Drain back Tank	Medium	High	Medium
Pipe Insulation	Low	Low	Low
Dirt and Air Separators	Medium	Low	Low
Thermal Mixing Valves	Medium	Low	Low
Solar Thermal Collector	Medium	High	Medium
Solar Thermal Collector Frame	High	High	High
Collector Mounting/Racking System	High	High	High

The recommendations above are for the entire manufacturing base.
Specific company recommendations will vary depending on interests and capabilities.

SWH Components
Assembly – Pump Station
Collector Mounting/ Racking System
Solar Thermal Collector Frame
Expansion Tank
Heat Exchanger for Potable Water
Drain back Tank
SWH Water Storage Tank

Figure 8. Component Selection Summary

Potential Opportunities for Milwaukee Manufacturers

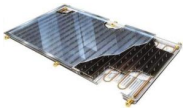
The prioritized components for Milwaukee manufacturers include the pump station, collector mounting system, collector frame, drain-back and storage tanks, expansion tank, and heat exchanger.

First-Tier Components:

The first components are components with a lower barrier to entry, as shown in Table 6.

- The pump station is a high-value component, as it is made from purchased parts and requires the molding of a case, pipe brazing, and assembly. The pump stations are crucial in the advancement of the SWH industry, as they have potential to reduce the system installation cost. Installation costs represent roughly half of the total system costs. With limited or no foreseeable decrease in labor costs, the pump station provides a way to cut down on labor time and cost. The pump station also helps promote system standardization and reliability. Currently, many installers use a mix of various system components, leading to a variety of system components and designs. Consequently, this has led to many poorly engineered systems that tend to break or underperform, giving the industry a poor reputation. Pump stations are reassembled and will help reduce nonstandard systems and increase reliability.
- The collector mounting/racking system and the collector frame were chosen as attractive components due to their manufacturing compatibility with the current capabilities of the Milwaukee manufacturing base. These components are generally made by stamping and machining sheet metal, a very common manufacturing process in the Milwaukee area. Also, similar to the pump station, universal mounting systems will help to standardize the industry, lowering costs and increasing reliability.
- Expansion tanks are currently manufactured for the general plumbing industry. However, with the increased use of glycol SWH systems, more robust expansion tanks are required. The glycol in the SWH systems can break down the material used for the air bladder in current expansion tanks. Thus, unique tanks can be made for the SWH industry with higher grade bladders to resist the glycol.

Table 6. Milwaukee Component Recommendations – Tier 1

	Component	Picture	Comments
Teir 1	**Assembly – Pump Station**		Pump stations are high value add components, as they reduce the installation costs of SWH systems which constitute nearly half of the total cost. The pump station is made up of manufactured parts and requires assembly, pipe brazing and a molded plastic case.
	Collector Mounting/ Racking System		Collector racks are currently made by the collector manufacturer. A metal fabricating shop could easily produce collector racks using metal stamping and machining.
	Solar Thermal Collector Frame		The collector frame is typically aluminum and serves to encase the absorbing pipes, glass and insulation. The frame could be made using sheet metal stamping.
	Expansion Tank		Expansion tanks are another product that is currently made for the general water heating market, however with the growing use of glycol, expansion tanks for the SWH industry must be manufactured with tougher inner bladders to resist deterioration due to the glycol. The tanks can be manufactured by stamping and assembly.

Second-Tier Components:

The second-tier components, as shown in Table 7, are more complex to manufacture, and local manufacturers may not have all the capabilities to make the entire product. However, there are attractive opportunities for local manufacturers to act as subcomponent suppliers to manufacturers.

- The drain-back and storage tanks are fairly similar in manufacturing needs and value added. Drain-back tanks and certain types of storage tanks are unique to the SWH industry. Storage tanks for SWH require a second heat exchanger to transfer the heat from the collectors to the potable water. There are few storage tanks currently sold in the U.S. market that have a heat exchanger for the collectors and a second heat exchanger or a heating element for the backup heater.
- Finally, heat exchangers match up with the manufacturing capabilities in the area and there is an interest for manufacturing them. They provide an adequate value add and are an integral component for SWH systems.

Table 7. Milwaukee Component Recommendations – Tier 2

	Component	Picture	Comments
Teir 2	**Specialty SWH Water Storage Tanks**		Although hot water storage tanks are currently made for the general water heating industry, some applications for the SWH industry may require tanks with two heat exchangers, one for the back up heater and one for the solar collectors. The major requirements for manufacturing are stamping, rolling, painting and assembly. However, coating techniques are a substantial barrier for entry
	Drain-back Tank		Drain-back tanks are used to drain the fluid out of the solar collectors when there is not enough sun to prevent freezing in cold weather. The tanks are specific to the SWH market. The major manufacturing requirements are stamping, rolling, machining, and painting.
	Heat Exchanger for Potable Water		Heat exchangers are an important part of the SWH market and are required to be made out of stainless steel with the growing use of glycol. The plate exchangers can be manufactured using machining, stamping, rolling and welding but are mostly used in double walled tanks that are mandated by building code in certain areas.

The Navigant Team's Assessment of SWH Opportunities for Milwaukee Manufacturers

The Navigant team believes the SWH market could be an attractive opportunity for Milwaukee manufacturers:

- Milwaukee manufacturers have the capabilities to manufacture high-quality components for the SWH industry.
- The size and highly fragmented nature of this emerging market present opportunities for new players, but also risks.
- The Navigant team recommends Milwaukee manufacturers concentrate on producing high-value components that customers are willing to pay a premium for such as components that are currently imported from Europe.
- In the past, Milwaukee manufacturers have focused on one customer. However, to be successful in the SWH market, the Navigant team recommends targeting multiple customers.
  - The SWH industry is more fragmented, with smaller customers that could quickly exit and leave manufacturers with stranded assets.
- Local manufacturers could potentially capture about 2–5% of the total U.S. market share ($10–20 million) in the short term.
- With increased market adoption and industry recognition, local manufacturers could potentially gain higher market shares of 5–10% in the medium to long term.

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SECTION

3

Milwaukee Area Case Study

Scope and Approach for Case Study

The Navigant team conducted a case study on Res Manufacturing, a local manufacturer that has successfully retooled in the past and is considering retooling for the SWH industry. The scope and approach to the case study are detailed in Figure 9.

Scope	Approach
• Identify a local or regional company, if one exists, that has overcome barriers and successfully entered the SWH industry. • Discuss the decision making process, steps to re-tool/reinvest and market success. • Present best-practices and lessons learned for other companies considering a similar investment decision.	• Navigant worked with the City of Milwaukee to identify a local/regional company that fits the scope's definition; however, no such company could be identified. • Per the City's request, Navigant selected a local company that is currently evaluating such a decision to re-tool, but has not fully committed yet. • Navigant interviewed the candidate company, RES Manufacturing, and documented the key questions and answers the company is currently facing.

Figure 9. Case Study Scope and Approach

Res Manufacturing was chosen as the subject of the case study due to its location in the Milwaukee area and its current status of evaluating the SWH market. Res's situation enabled

the company to provide relevant information regarding the steps taken to evaluate a new market.

Background

Res Manufacturing is a metal-stamping manufacturer in the process of determining whether or not to enter the SWH component space. The company is more than 100 years old and has manufactured for a variety of industries over the years. Res's largest industry 15 years ago was commercial cookware and has since transitioned to having most of its business based in the automotive industry. Res does not focus on a single industry and continues to make products for the commercial cookware industry as well as the automotive industry. More information on Res's background and current situation can be found in Figure 10.

RES Manufacturing Company Background

- Metal stamping manufacturer founded in 1907
- Privately held organization owned by DLSM, Inc.
- Currently have about 75 employees
- Specializing in:
  - Progressive die stamping
  - Design assistance
  - Tool build
  - Prototypes
  - Heat treating, welding, tapping & machining, finished coating
  - Automated assembly

Current Situation

- Res has performed well in the past few years despite the recession.
- Currently, >80% of its business is based on automotive work; **Res wants to move towards a higher non-automotive mix.**
- Res is in the process of determining if the SWH market offers a strategic fit for their company.

Figure 10. Res – Company Background and Current Situation

Manufacturing Capabilities

Res's current capability and near-term interest in new capabilities is concentrated on stamping, welding, and machining processes. Table 8 shows the company's current manufacturing processes and their planned future capabilities.

Table 8. Res Manufacturing Capabilities

Process	Steel	Brass	Copper	Stainless Steel	Iron	Plastic
Machining						
Stamping						
Rolling						
Turret Punching						
Welding (TIG & MIG)						
Laser Cutting						
Casting						
Pipe Bending						
Sandblasting						
Painting						
Coating						
Molding						
Enamel Coating						

Current Capabilities	
Near-term Interest	
No Capability/Interest	

Component Match

Based on Res's process capabilities alone, the Navigant team identified five SWH components that represent current or near-term opportunities. Table 9 shows how the following components could be produced by Res currently or in the near future.

Current or near-term opportunities for Res:

- Heat exchanger for potable water
- Expansion tank
- Pipe fittings
- Solar thermal collector – frame
- Collector mounting system/rack

The additions of rolling, turret punching, and welding will greatly expand their capabilities, allowing them to produce more of the SWH components.

Table 9. Manufacturing Requirements of SWH Components Compared to Res Capabilities

SWH Component	Machining	Stamping	Rolling	Turret Punch	Welding (TIG & MIG)	Laser Cutting	Casting	Pipe Bending	Sandblasting	Painting	Coating	Molding	Enamel Coating
SWH Water Storage Tank		X	X	X	X	X	X	X	X	X	X	X	X
Heat Exchanger for potable water		X	X					X					
Electronic Controls												X	
Fractional Horsepower Pumps	X						X						
Pump Motor Flanges	X	X					X						
Hydronic Valves	X						X						
Expansion Tank		X											
Air Elimination Valve	X						X						
Piping			X										
Pipe Fittings		X											
Assembly – Pump Stations													
Temperature Gauges	X	X					X						
Pressure Gauges	X	X					X						
Drain back Tank		X	X	X	X	X	X	X	X	X	X	X	X
Pipe Insulation													
Dirt and Air Separators	X	X					X						
Thermal Mixing Valves	X	X					X						
Solar Thermal Collector					X			X		X	X	X	
Solar Thermal Collector - Frame	X	X			X						X		
Collector Mounting system/rack	X	X			X						X		

Current Opportunities | Current Capabilities | Near-term Interest | No Capability/Interest | X = required process for component

Component Priorities for RES

Given Res's process capabilities and interests, attractive SWH components include collector frames, mounts, and expansion tanks. Res expressed specific interest in the manufacturing of collector frames and mounts. There are few companies that currently produce universal mounting systems for the solar thermal industry. A universal mounting system would help to reduce the high installation costs involved with SWH systems and would also improve reliability. The mounting system and collector frame require manufacturing processes that are held by Res, making them a good candidate for new revenue stream.

Expansion tanks were also included in the recommendation as they can be made with Res's current capabilities and offer a high value add product. Although expansion tanks are currently made for the general hot water market, they require more durable inner bladders to resist deterioration when used with glycol in SWH systems. This would enable Res to manufacture a unique product for the SWH industry at a higher value.

Pipe fitting and heat exchangers were not chosen as attractive components for Res because of their low value add and Res's lack of interest, respectively.

Porter's 5 Forces

Res is currently evaluating the collector mount as a potential manufacturing opportunity and has used the Porter's 5 Forces analysis to evaluate the market, as shown in Figure 11. Porter's 5 Force is a tool that companies across the country use to evaluate new strategic directions.

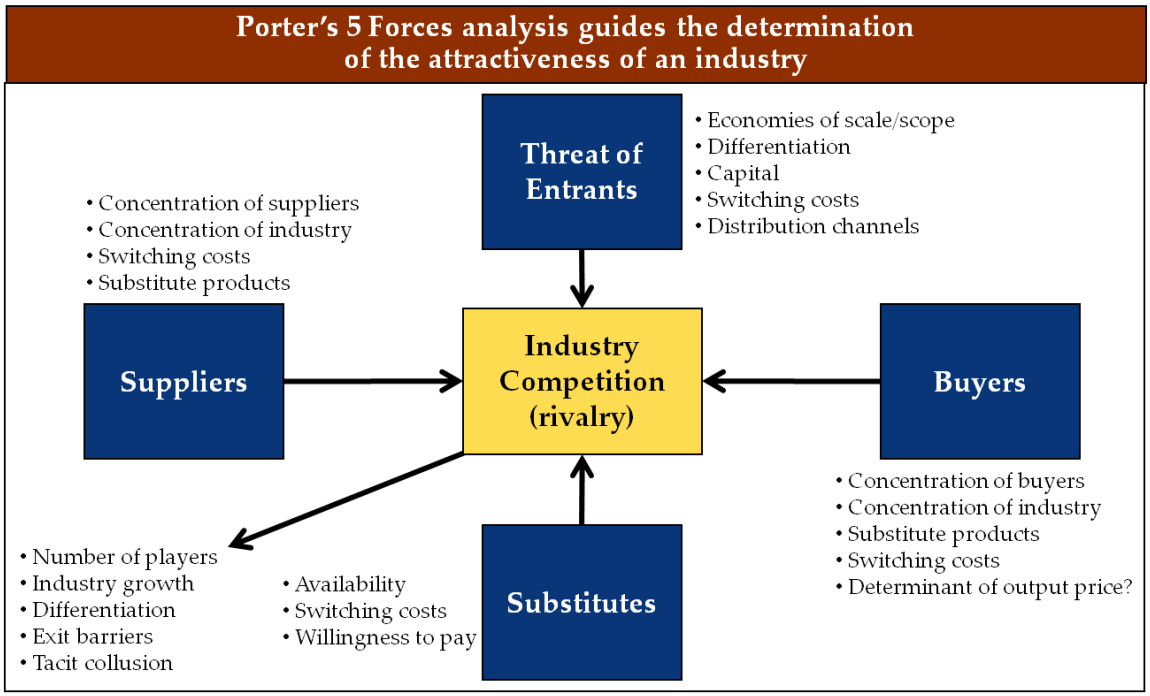

Figure 11. Porter's 5 Forces – Analysis of Res

- Suppliers: It is important to Res to look into the material and retooling costs for manufacturing new components for the SWH industry. A component that's cost is mostly made up of material costs, such as a pipe, would not be an attractive product for Res to manufacture. Additionally, re-tooling costs must be low, especially for a small potential market, in order to minimize risk.
- Threat of New Entrants: Res chooses products to manufacture based on whether or not it will have a unique advantage, or there is a differentiating factor. One of Res's differentiating factors is its design services to reduce production cost and time. Res's design for manufacture service sets them apart and allows them to differentiate themselves in the market. In order to enter a new market, Res would have to offer this service to a new

client in addition to finding other competitive advantages in order to minimize the potential for competitors to enter their space.

- Buyers: The number of potential buyers is a very important aspect to any company looking to enter a new market. The number of buyers or the requested production volume of a single buyer must be able to sustain a reasonable internal rate of return (IRR) and pay off the re-tooling costs.
- Substitutes: Due to the switching costs involved with entering a new market, it is important that a competitor does not sell a substitute product in the near term. The ease of creating substitutes is thus a very important aspect. Res would not want to enter a market where a product has already become a commodity.
- Competition: Res plans to enter a market where it can differentiate itself from competitors, allowing them to avoid a price war. Barriers to entry are also important as they will help to prolong the time before competitors enter the market.
-

SWOT Analysis

Res is currently in the process of understanding whether manufacturing collector mounts for the SWH industry fits within their core competencies. To evaluate this, a SWOT (strength, weakness, opportunities, and threats) analysis was performed, as shown in Figure 12.

	Strengths	Weaknesses
Internal to Company	• U.S.-based manufacturing company (supports re-shoring trend in U.S.) • Experience with lean manufacturing and efficient cost structures leveraged from success in the auto industry • Highly adaptable manufacturing capabilities • In house manufacturing design capabilities • Ability to attract highly qualified employees.	• Company is not located near major SWH markets (CA, HI, & FL). • No experience with channels to market in the industry. • Company is highly risk averse. While the technical aspects of the product are low risk market risk exists.
	Opportunities	**Threats**
External to Company	• Wisconsin has a commitment to supporting the SWH industry with incentives and other programs. • Strong Wisconsin-based manufacturing culture could provide partnership opportunities along SWH value chain. • High quality US based products are sought after in the SWH industry	• SWH is small and fragmented. • Potentially no room for standardized product • SWH systems lack standardization leading to a mix of products. • Midwest market primarily uses cheap natural gas to heat water, creating less attractive SWH economics

Figure 12. SWOT Analysis – Res

One of Res's greatest strengths is their in-house design for the manufacturing team. Although the team does not do any original design, it provides design advice for more efficient and cost-effective manufacturing. Simple changes in the design of the component have saved clients a significant amount of money.

Res does have a weakness in the sense that it is a highly risk-adverse company. This poses a problem with a relatively new industry that has not yet been tested for its sustainability, such as the SWH market.

The SWH market offers some opportunities for a manufacturer looking to enter the SWH market. State, federal, and private incentives exist for manufacturers in the SWH industry. The incentives are in place to boost the consumer market in addition to providing direct incentives for the manufacture of SWH components. Additionally, Res is located in a dense manufacturing region that offers a variety of capabilities. Thus, Res could partner with other facilities to harness the necessary manufacturing process for nearly all of the SWH components.

Although the SWH industry is growing, there are threats that exist to manufacturing companies such as Res. There is a lack of standards for the industry, which makes it difficult to manufacture universal components such as a mounting system. The market is currently volatile and dynamic. As the market takes shape in coming years, manufacturers like Res should diversify their exposure to a single customer.

Investment Perspective

In addition to the Res's SWOT analysis, the Navigant team notes the company's investment perspective, which is a conservative plan to ensure a sustainable IRR for the owners. This plan makes investments in unproven, new industries relatively unattractive. The company also expects short payback periods on investments.

Conclusions

The case study helped identify the important criteria that manufacturers consider when evaluating a new market. When evaluating a new market, Res weighs the potential IRR and payback period heavily. Thus, if other manufacturers use similar evaluation methods as Res, few of them will retool and risk a low IRR or long payback period if there is not a stable industry.

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In addition, other criteria such as value add potential, differentiation, and competitive advantage impact the decision to manufacture parts for a new industry. Value add is important to the SWH industry as many of the components used in the industry are also used in the general water heating industry, and thus are produced in large quantities with relatively small margins. Res would not manufacture something for the general water heating market with a profit margin that had already been minimized. Products such as pipes and fittings fall into this low value add component area. Unique products to the SWH industry that require a large amount of manufacturing would be more attractive to a company such as Res. See Figure 13 for key takeaways that apply more broadly to Milwaukee-area manufacturers.

Key Takeaways from *Res Manufacturing*

- Res is using a systematic approach to evaluating a new market, including:
  - understanding its own unique capabilities,
  - selecting a potential product for investment, and
  - evaluating the attractiveness of the industry.
- Payback and IRR threshold requirements are of utmost importance in determining the attractiveness of the investment.
- Investment in undifferentiated, low value-add products will not result in a sustained competitive advantage in a new market.

Figure 13. Key Takeaways from Res Manufacturing Case Study

SECTION

4

The Solar Water Heating Industry

U.S. Market

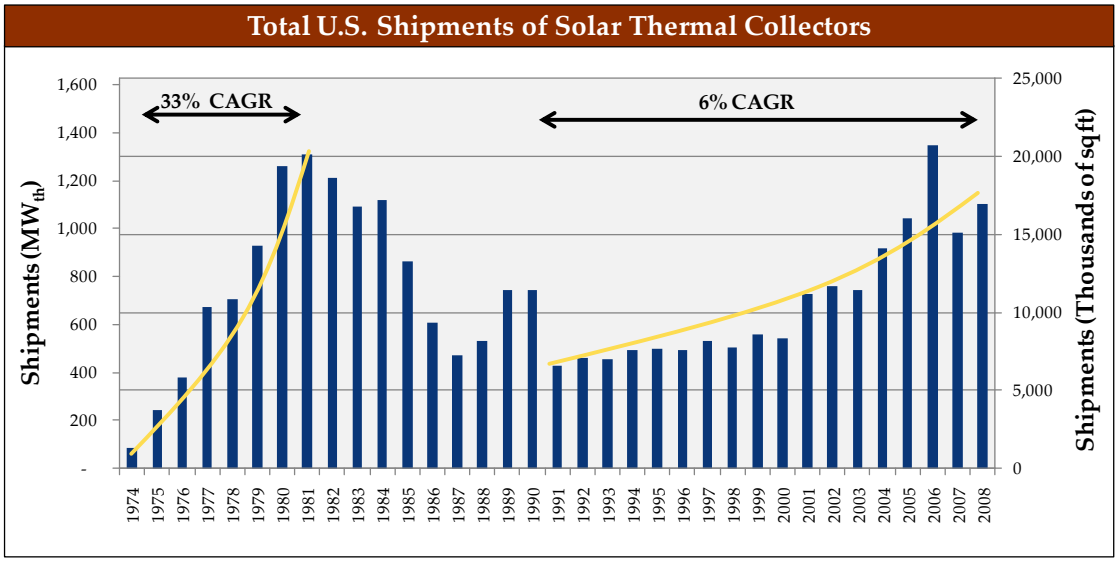
The first U.S. installations were deployed to provide water heating in areas inaccessible to other energy supplies or to complement them, especially prior to World War II. After World War II, consumers began to expect higher quality water heating (i.e., water of consistently high temperature that would be available at any time) and as a result, the U.S. solar water heating market declined.

With the energy crises of the 1970s, the SWH market rebounded and several hundred companies entered the industry. The Solar Heating and Cooling (SHAC) program provided a 40 percent federal tax credit and state-level incentives were available and helped jump-start the industry. Unfortunately, the policy did not support long-term, sustainable development. When the incentives were discontinued in 1986, the U.S. market quickly collapsed.

The Energy Policy Act of 2005 provided a 30 percent federal tax credit up to $2,000 for residential SWH systems (no cap for commercial systems) that were certified by the Solar Rating and Certification Corporation (SRCC), through 2008. This was extended through 2016 by the Energy Improvement and Extension Act of 2008 and the $2,000 cap on residential systems was lifted. In parallel with the recent federal tax credits, several utilities and states have introduced SWH programs (either incentive or building code based) that have driven renewed interest in the industry.

Figure 14 illustrates some of the policy and economic impacts on annual solar thermal collector shipments in the U.S. during the past 30-plus years. During the 1970s when incentives were high, the U.S. market experienced a strong growth period. However, when incentives expired, the strong growth disappeared as well. The market is only now returning to similar annual shipment levels that were present in the early 1980s. The SWH market growth is rising, while

the pool segment of the market is continuing to grow around 6 percent annually. The hot water segment of the market is growing much faster, around 30 percent annually.

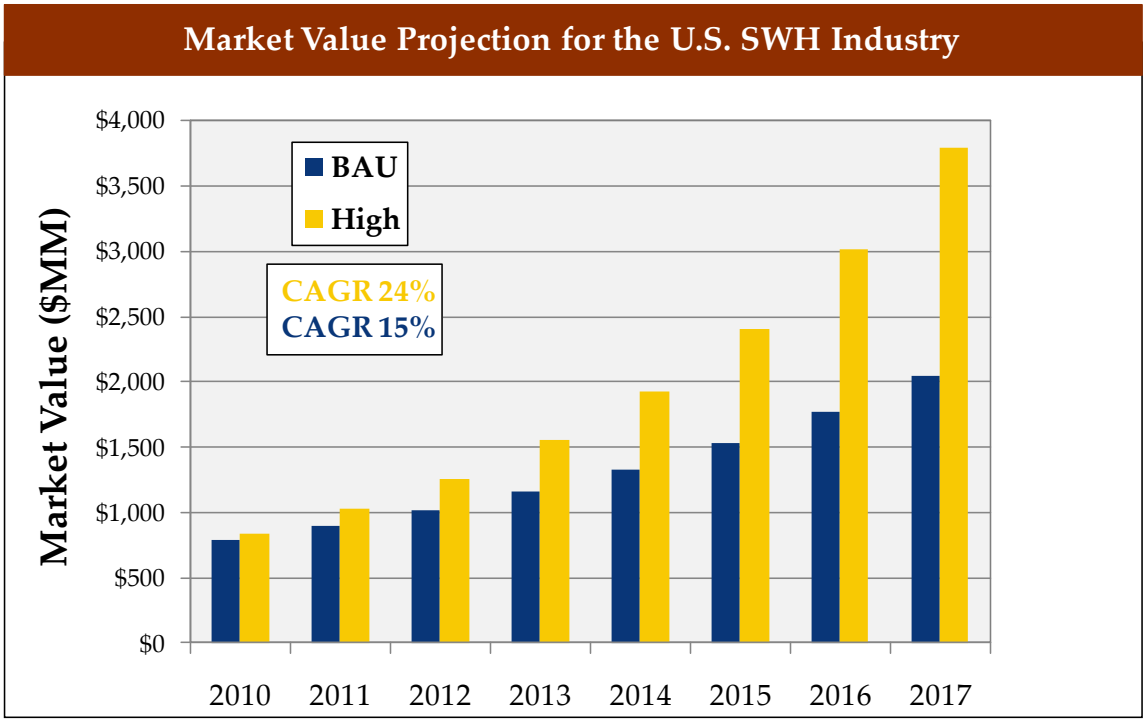


*Data reported in 1000's of sq.ft. MWth is calculated based upon an internationally agreed upon conversion factor of 0.7 kW_{th}/m^2.
Source: International Energy Agency's Solar Cooling and Heating Program, Solar Heating Worldwide 2008 Edition, Industry Interviews, Navigant Consulting, Inc. based on data from Energy Information Administration, Solar Thermal Collector Manufacturing Activities 2008 & Renewable Energy Annual. Annual installations domestic production and imports of low, medium and high temperature collectors.
CAGR: Compound Annual Growth Rate

Figure 14. Total U.S. Shipments of Solar Thermal Collectors

During the past 30-plus years the U.S. market has been highly susceptible to growth and contraction periods. These periods are highly correlated with incentive programs. As they are introduced (for example, in the 1970s), we see high growth, and as they expire or are withdrawn (for example, in the early 1980s), the market contracts. The SWH market is currently experiencing a growth period due to attractive federal and state incentives. While the pool segment of the market is continuing to grow modestly due to the slowing in the housing market, the hot water segment of the market is growing much faster, at around 30 percent annually.

Even with strong U.S. market growth, the total value of the market remains modest. The total U.S. market value in 2010 was around $800MM (millions). The Navigant team considered two growth scenarios—Business as Usual (BAU) and High Growth Rate (High) between 2010 and 2017, as shown in Figure 15. In both scenarios the compound annual growth rates (CAGRs) of the pool segment and SWH segment were varied separately. In 2017 the market is likely to be valued between $2-4B, which is still small compared to other related industries such as solar PV.

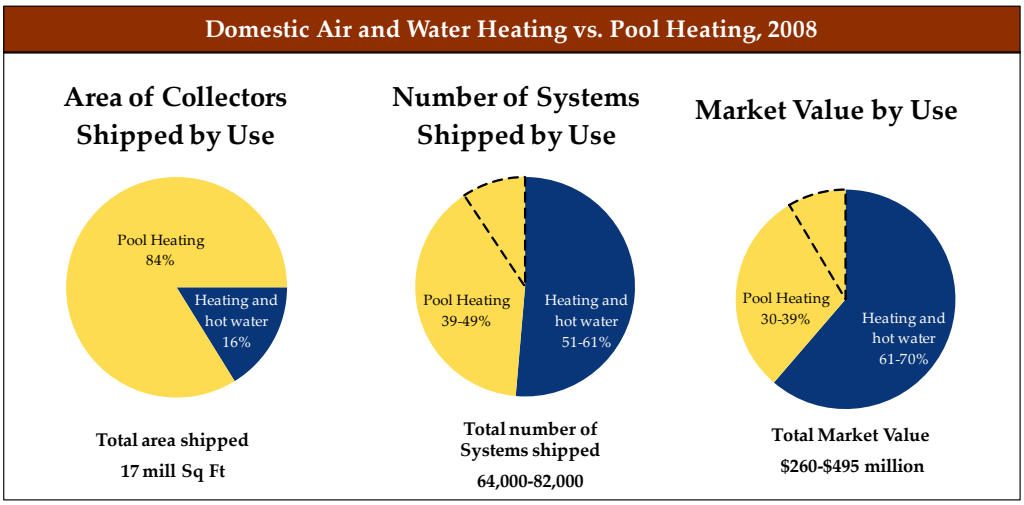


Source: NCI Analysis.
System Size: domestic SWH system 40sqft; Pool system 400sqft;
BAU – Business As Usual; CAGR – Compound Annual Growth Rate

Market Growth Assumptions
BAU: Pool CAGR 5%; other SWH CAGR 21%
High: Pool CAGR 8%; other SWH CAGR 32%

Figure 15. Market Value Projection for the U.S. SWH Industry

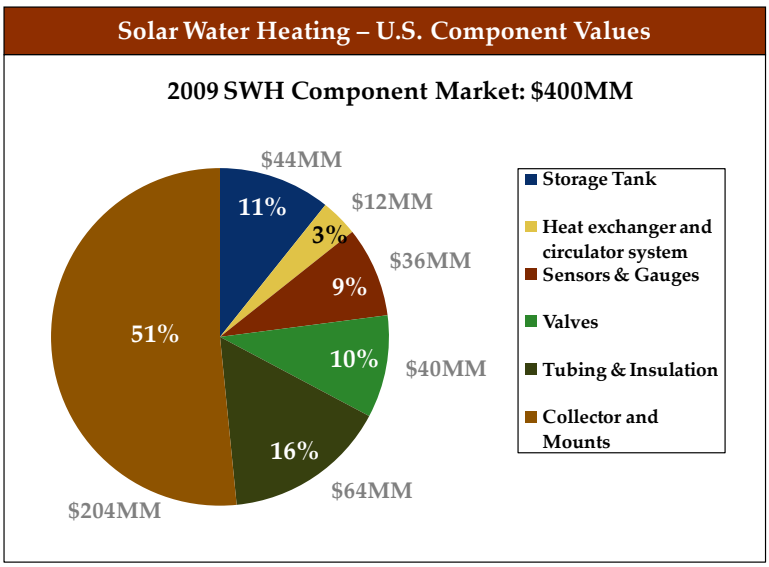
Although the pool heating segment of the market dominates the total collector area shipped in the U.S. market, the domestic water heating market represents most of the market value. When we convert the data from total area shipped to the number of systems shipped, we see that about half the systems are pool heating and half are used for heating and hot water applications. Upon further correction to account for the value of each system, we determine that heating and hot water applications represent up to 70 percent of the market value, but only 16 percent of the area of collectors shipped, as shown in Figure 16 . The higher capital cost of a domestic versus pool heating system is due to the collector type used and specific system configuration.



Source: Navigant Consulting, Inc. based on data from Energy Information Administration, Solar Thermal and Photovoltaic Collector Manufacturing Activities 2008 and Renewable Energy Annual.
Note: Pool Heating System size was assumed to be 350-400sqft; Non-pool heating systems were assumed to be 50-64sqft. The dashed line represents the level of uncertainty in the calculations and should be considered as a range.

Figure 16. Domestic Air and Water Heating vs. Pool Heating, 2008

The U.S. SWH market value was about $800 million in 2009. Roughly half of the total market value is labor costs and the rest is attributed to system component costs, which is dominated by collector-related costs. Figure 17 shows a breakdown of the total market value by the value of each component.



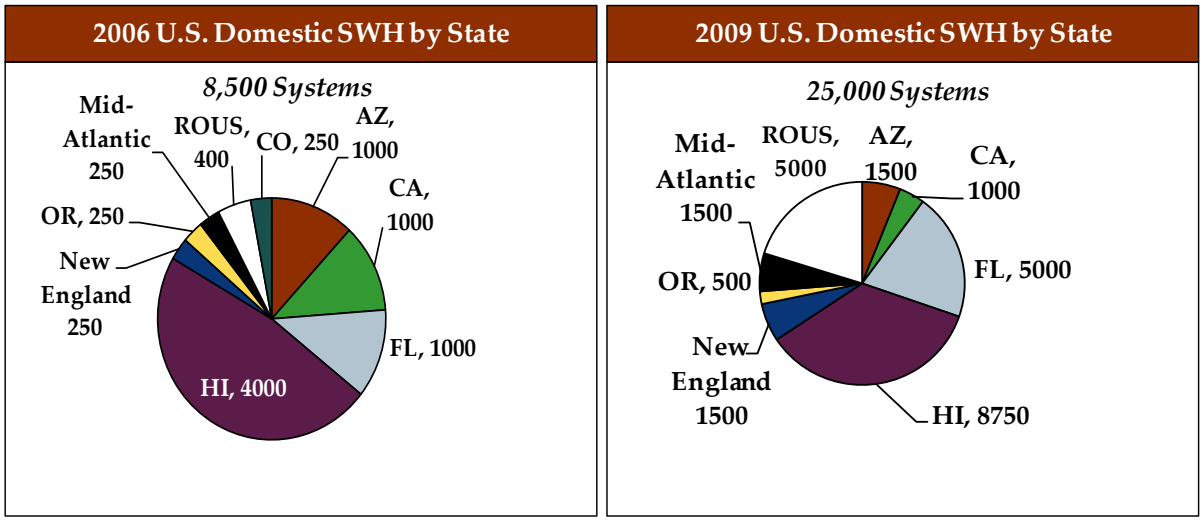
Source: RS Means, Navigant Consulting, Inc. based on data from Energy Information Administration, Solar Thermal and Photovoltaic Collector Manufacturing Activities 2008 and Renewable Energy Annual and Industry Interviews.

Figure 17. SWH – U.S. Component Values

The U.S. market is dominated by a small number of states. Between 2006 and 2009, Hawaii and Florida remained the top U.S. markets. The rest-of-the-U.S. (ROUS) market segment illustrated the most obvious jump in terms of U.S. SWH market share.

Figure 18 illustrates the following:

- On the order of 35% of all new U.S. solar domestic water heating systems are installed in Hawaii.
- Six states continue to account for almost 70% of all domestic SWH systems.
- On the order of ~8,500 SWH systems were sold in the U.S. in 2006, and ~25,000 in 2009.



Source: Navigant Consulting, Inc. based on interview with Les Nelson, SRCC, State Incentive Programs (CA, HI, FL)

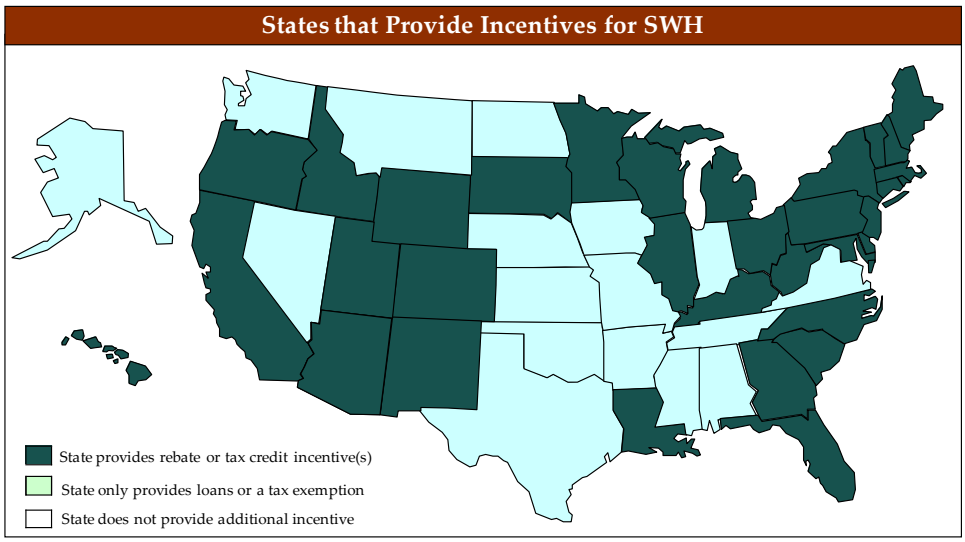
Figure 18. 2006 and 2009 U.S. Domestic SWH by State

U.S. Policy

Although the U.S. SWH market has grown during the past 30 years, is has been subject to typical policy/incentive expirations. However, the past few years have shown signs of promise. From 2006 to 2009, U.S. shipments grew about 40 percent each year. Market share erosion indicates an increase in supplier competition, which should drive system price declines.

The U.S. market is experiencing near-term growth because of the emergence of new incentives at the state and federal levels. A U.S. federal tax credit is available for SWH systems installed through December 31, 2016. Consumers can claim a tax credit equal to 30 percent of the costs, with no cap for commercial or residential systems. The SWH systems must: be used exclusively for purposes other than heating swimming pools and hot tubs, utilize panels that are certified by the SRCC, and produce 50 percent or more of the water heating needed by the residence. In addition, 30 states have one or more incentives for SWH, as shown in Figure 19. The types of incentives include: (number of states)

- Income tax credits (11)
- Rebates (21) or production incentives (2)
- Sales tax exemptions (7). Sales taxes range from 4–7% of the system cost.
- Grant programs (4)
- Loan options (11)
- Other programs include building requirements (1) and leasing program (1)



Source: http://www.dsireusa.org database of RE incentives, Jan. 2009

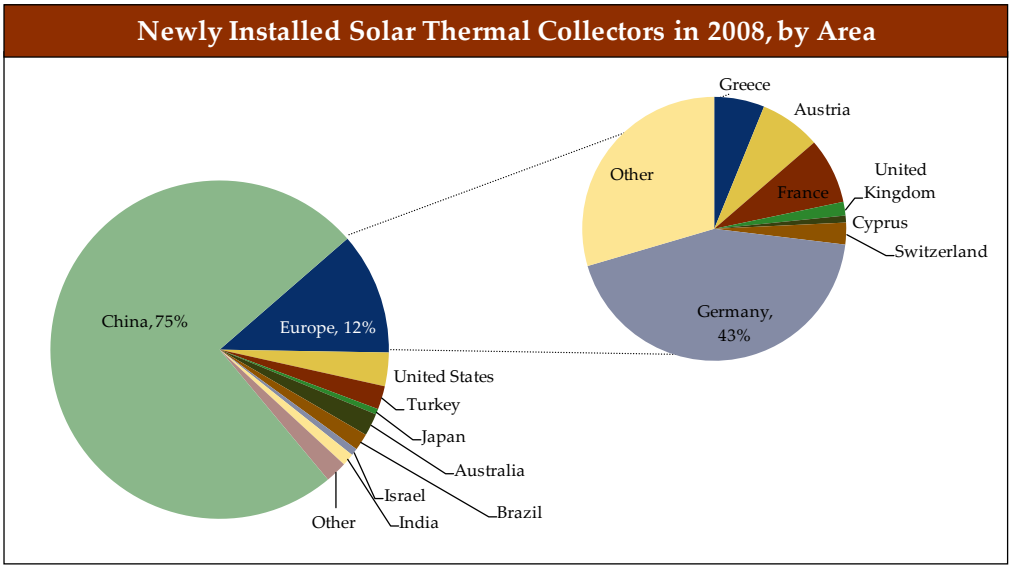
Figure 19. U.S. States that Provide Incentives for SWH

Global Market

China and Europe lead the global demand for SWH systems for different reasons.
In Europe, many countries have successfully implemented SWH incentive programs. The main factors for successful programs are:

1. **Continued long-term support of SWH incentives.** This helps industry plan long term, reducing the risk that the incentive program will disappear.
2. **Education campaigns**. Awareness of SWH systems is lacking in most markets. Campaigns targeted at raising awareness and pointing out the benefits of SWH systems create more demand from customers.
3. **Performance-based incentives.** This encourages proper system design and sizing and puts the needs of the customer first.
4. **Policy.** Some municipalities are requiring SWH systems to be installed in local building codes.

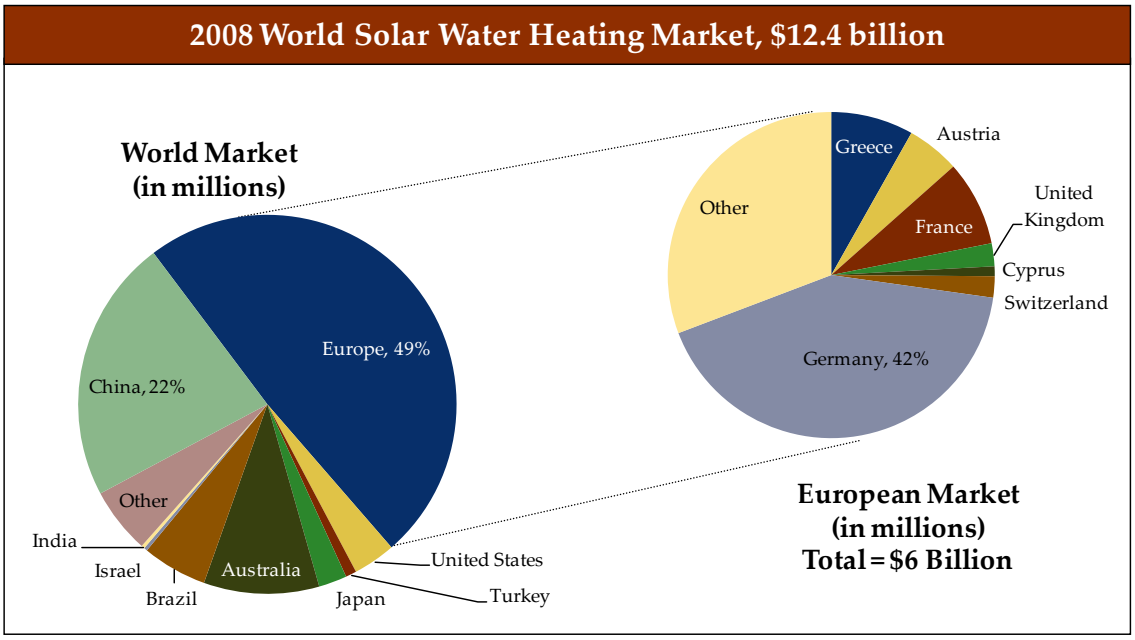
In China, however, SWH adoption has grown with limited intervention by the government. Low-cost systems and limited availability of electricity and natural gas around the country have driven industry growth. In contrast to most other markets around the world, the Chinese government does not offer incentives for manufacturers or end users. Industry growth in countries that have limited incentive programs usually occurs in mild climates where the solar resource is good and there is no need for freeze protection. Most global markets have seen recent growth, with the Chinese leading the global market with respect to collector area shipped, as shown in Figure 20.



Source: International Energy Agency Solar Heating and Cooling Programme, *Solar Heat Worldwide – Market and Contributions to the Energy Supply 2008, Edition 2010.* May, 2010.

Figure 20. Newly Installed Solar Thermal Collectors in 2008, by Area

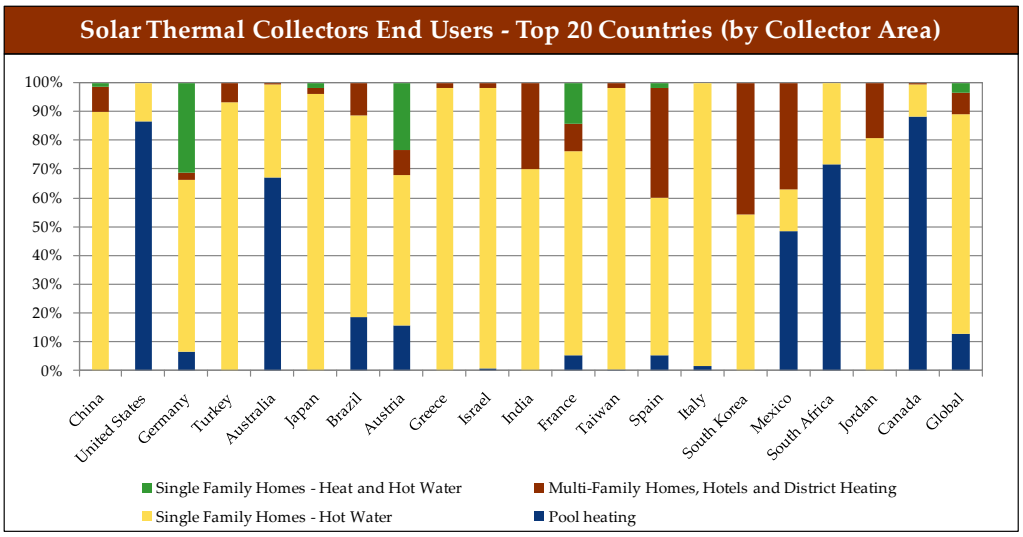
However, cheap systems dominate the Chinese market and market value is on a par with that of Germany, the second largest market. Europe is the largest SWH market with nearly half ($6 billion) of the global SWH market value. The impact of the cheaper systems in China can be seen in Figure 21.



Source:
1. International Energy Agency Solar Heating and Cooling Programme, *Solar Heat Worldwide – Market and Contributions to the Energy Supply 2008, Edition 2010*. May, 2010.
2. Sensors Report, 2008. http://www.mdpi.org/sensors/papers/s8021252.pdf
3. NCI analysis

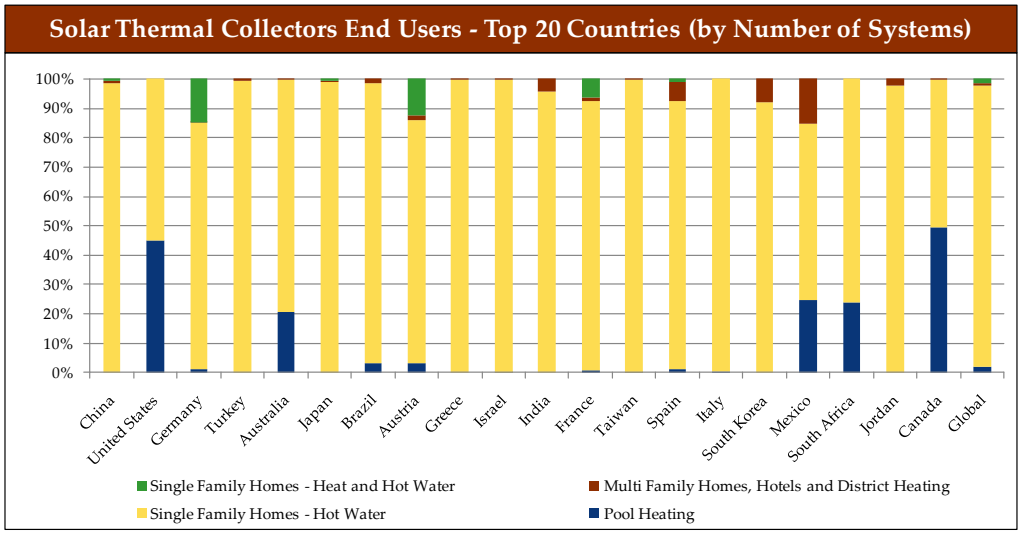
Figure 21. 2008 World Solar Water Heating Market, $12.4 Billion

The majority of solar thermal collector area is used for single-family houses. As discussed previously, the U.S. market is dominated by pool systems. However, when we calculate the total number of systems in each country, we find that most installed systems are single-family home SHW systems, which dominate the global market. The value of domestic SWH systems is larger than pool systems due to higher end collectors because of the high temperature requirements and more complex system design as shown in Figure 22 and Figure 23.



Source: International Energy Agency Solar Heating and Cooling Programme, *Solar Heat Worldwide – Market and Contributions to the Energy Supply 2008, Edition 2010*. May, 2010.

Figure 22. Solar Thermal Collectors End Users – Top 20 Countries (by Collector Area)



Source: International Energy Agency Solar Heating and Cooling Programme, *Solar Heat Worldwide – Market and Contributions to the Energy Supply 2008, Edition 2010*. May, 2010.
Notes: This assumed that the Average sizes of the systems were: 150 sqft for SFH – Heat and Hot Water; 500 sqft for Multi Family Homes, Hotels and District Heating; 50 sqfr for SFH – Hot Water; and 400 for Pool Heating

Figure 23. Solar Thermal Collectors End Users – Top 20 Countries (by Number of Systems)

Drivers/Barriers

A variety of drivers influence the solar water heating market.

- **Incentives:** To counter high paybacks in some areas, governments have established capacity-based (i.e., $/kWth) or performance-based (i.e., $/kWhth or $/MMBtu) incentives to encourage adoption.
- **Regulation:** Several jurisdictions (e.g., Hawaii, Israel, and Spain) have created SWH regulation. Regulation typically takes the form of building code requirements that SWH be included in a certain percentage of new construction.
- **Marketing:** To counter lack of consumer awareness, governments or national trade groups have conducted large marketing campaigns.
- **Infrastructure:** Rural areas in some countries have no access to electricity or natural gas for water heating, so SWH systems are the only option for domestic hot water (beyond boiling over a fireplace).

However, key barriers continue to prohibit strong growth in the U.S.

- **Consumer Awareness:** Most consumers are not aware that SWH is an option for their home or business – they mostly associate "solar energy" with photovoltaics.
- **Labor Supply:** SWH installation requires skills of both plumbers and roofers, but many contractors are not trained in both. As a result, installers have trouble finding the right talent in order to expand their workforce.
- **Economics:** Water heaters are typically replaced when one breaks and is an unexpected expense. Because the building owner is not expecting this expense, they opt for the regular water heater with a lower up-front cost (~$1,000 vs. ~$6,000). Many potential customers focus solely on payback (as opposed to return on investment [ROI] or IRR) and paybacks are greater than seven years in most of the U.S.
- **Regulations:** Many incentive programs require system-level SRCC OG-300 certification. The certification is for a fixed set of components, so an installer would have to get certification for every variation in component choice. The certification process currently takes 12 to 18 months.

In the past, improving economics drove market uptake. Domestic water heating has been successful in states with high incentives, high electricity or natural gas prices, and high solar insolation. Payback is most attractive in states where water is heated using electricity, as electric water heating is less efficient and more expensive than natural gas.

Pool heating economics are more favorable than for domestic water heating systems. Recirculation pumps are included in most pools, so one simply has to pay for a few unshaded collectors (1/2 – 1 times the pool area) to obtain three- to four-year simple paybacks. However,

solar collectors are ten times more expensive than electric heaters. This high up-front cost limits market penetration. Additional market trends are listed in Table 10.

Table 10. SWH Expected Market Trends

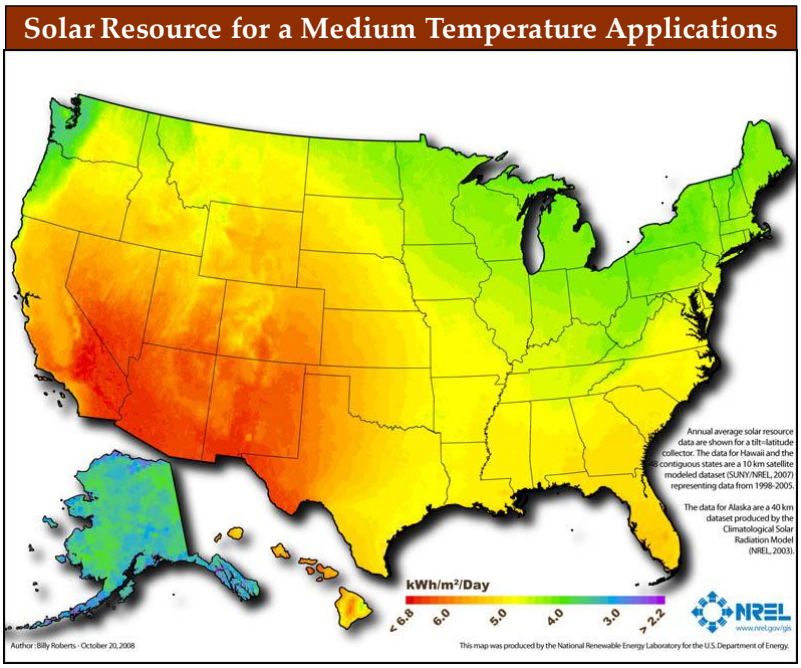
Increased Number of Commercial Projects	• Larger commercial projects are expected to increase over the coming years. • Funding from the American Recovery and Reinvestment Act (ARRA) is being used to finance many energy efficiency and alternative energy generation projects. While these projects are typically larger government or public facilities, ARRA funds are likely to impact the industry only in the short term until funds are depleted. • As system prices decrease and the SWH industry matures, project economics will become more attractive. • The market will depend on available financing for projects
Reduced Natural Gas Prices	• Natural gas (NG) prices drive electricity prices. Current forecasts are not as high as several years ago as a result of shale gas. Lower NG prices may not increase electricity prices as much as once expected. • Carbon tax or cap and trade could lead to an increase in electricity prices.
Reduced System Prices	• As the industry matures and manufacturing volume grows, prices are likely to decline. • Streamlining installation cost and time is expected as installers gain more experience. Innovative components and preassembly will also reduce cost.
Stricter Incentive Reporting Requirements	• More states may adopt strict incentive reporting requirements, similar to HI and CA, which may hinder market adoption by installers. But, this will result in higher quality and better design installations.

Economics:

Most consumers evaluate SWH purchase decisions on payback period, and four variables dominate the payback period calculation: solar insolation levels, federal and local incentives, energy prices, and installed system costs

Solar Insolation

In terms of insolation, the southwestern U.S. has the best solar resources for SWH systems, as shown in Figure 24.

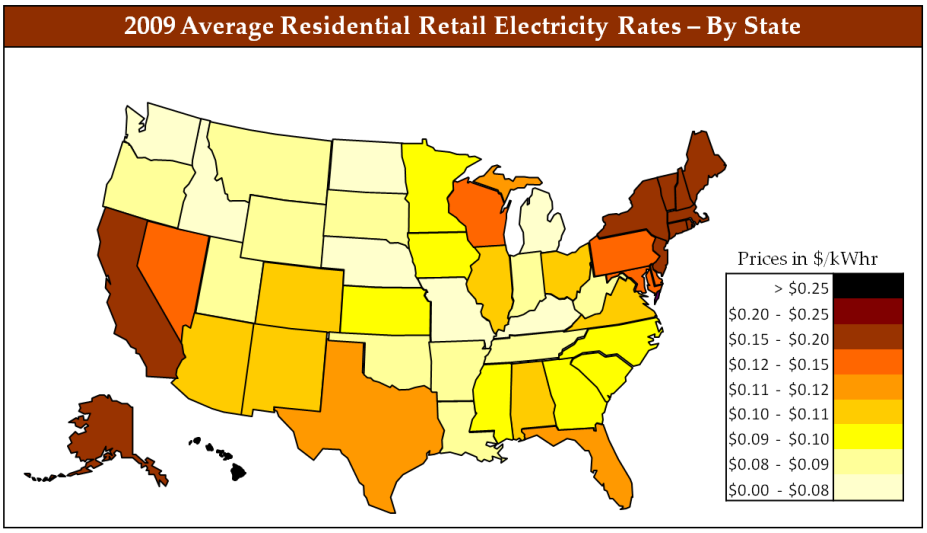


Source: National Renewable Energy Laboratory

Figure 24. Solar Resource for a Flat-Plate Collector

Energy Prices

Hawaii has the highest residential electricity price in the U.S.; New England, California, Texas, Nevada, and Alaska follow, as shown in Figure 25.

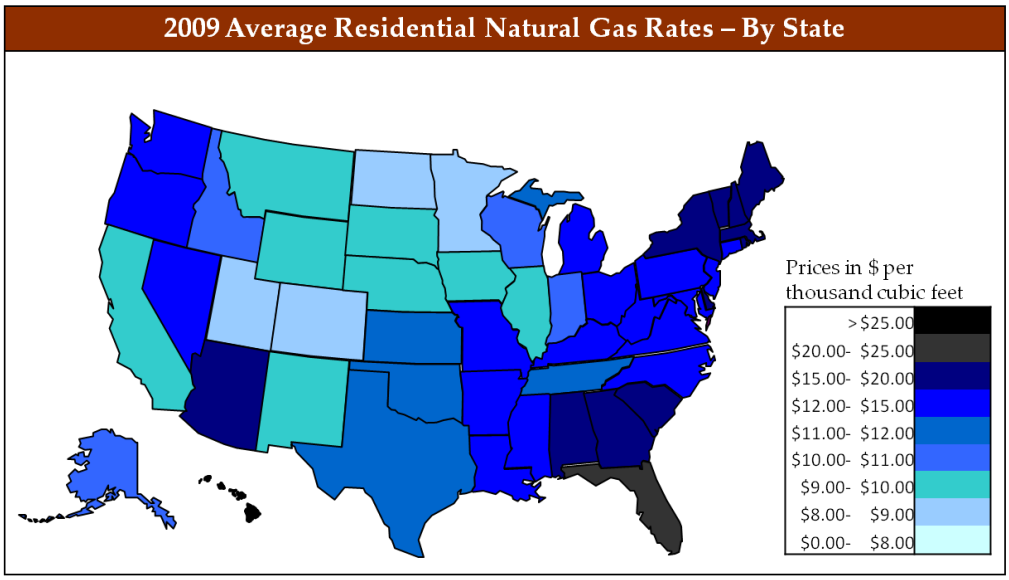


*Rate averages are year-to-date as of May 2010.
Source: EIA http://www.eia.doe.gov/cneaf/electricity/epm/table5_3.html

Note: NCI used residential electricity prices as a proxy for commercial natural gas prices as well.

Figure 25. 2009 Average Residential Electricity Rates – by State

Hawaii also has the highest residential natural gas prices in the U.S.; Florida, Alabama, Georgia, Arizona, and the northeastern states follow, as shown in Figure 26.



*Source: Reflects most recently available EIA data by state. Where 2009 data was not available (DE, FL, KY, NH and OH), 2008 data was used. http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_a_EPG0_PRS_DMcf_a.htm

Note: NCI used residential gas prices as a proxy for commercial natural gas prices as well.

Figure 26. 2009 Average Residential Natural Gas Rates – by State

Installed System Cost

About half of the total system costs are associated with labor and the other half are material costs. The majority of the material costs are in the collector and the installation of the tubing and insulation. Assembling and joining tubing and insulation account for the majority of the labor installation costs, as shown in Figure 27.

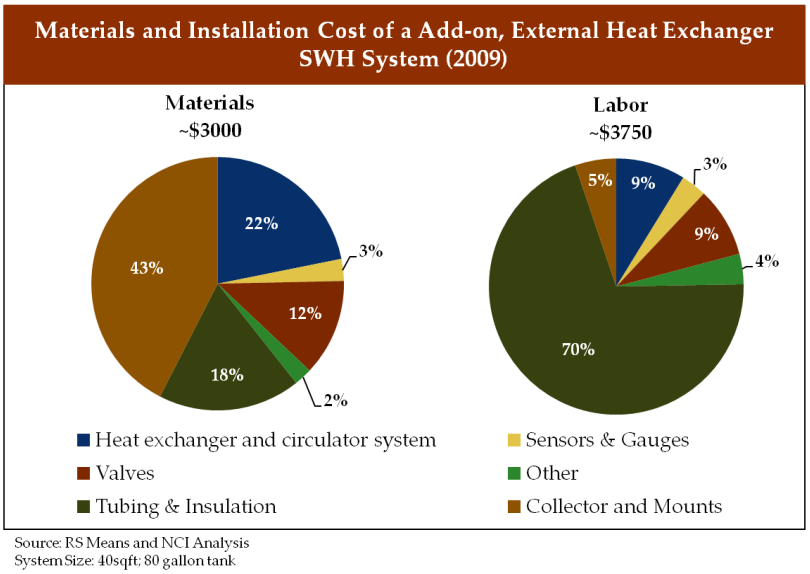
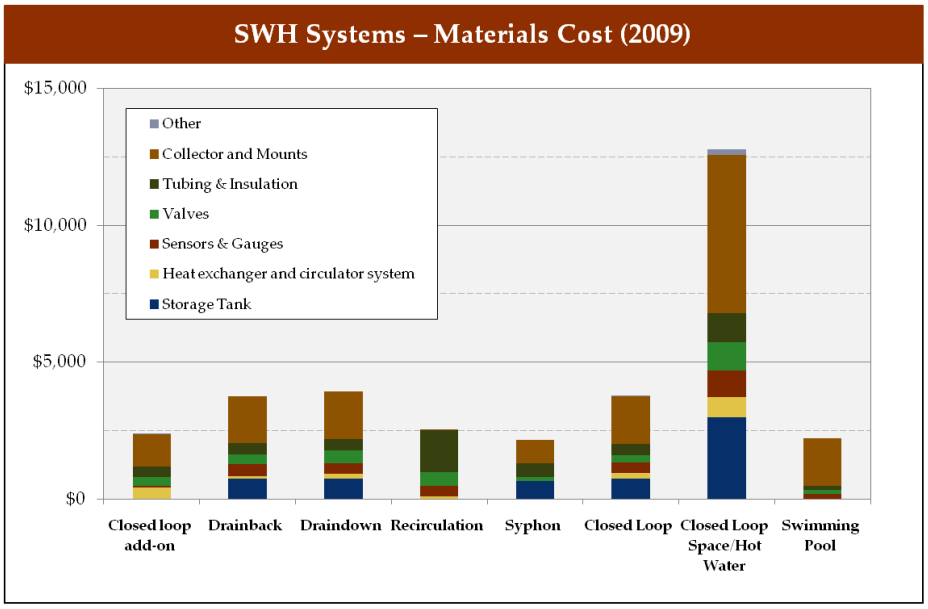


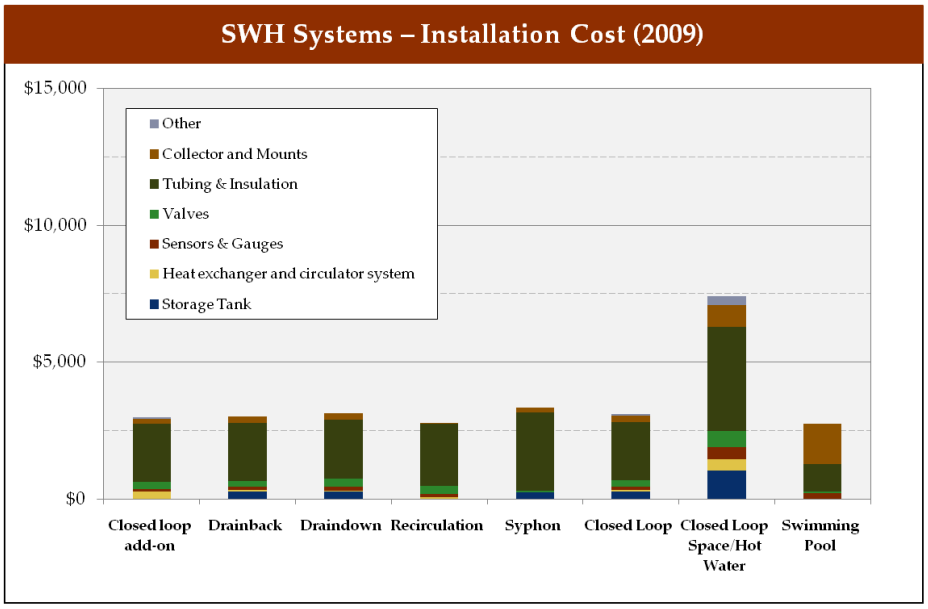
Figure 27. Materials and Installation Cost of an Add-on External Heat Exchanger SWH System (2009)

The various costs of installing a SWH system also vary by system type. Material and labor costs for the various system types are presented in Figure 28 and Figure 29. There are many factors that impact system price such as system size and higher cost for systems installed in colder climates that are not represented in these figures. The figures represent typical average installed system pricing.



Source: RS Means, CSI database, NCI Analysis

Figure 28. SWH Systems – Material Costs (2009)



Source: RS Means, CSI database, NCI Analysis

Figure 29. SWH Systems – Installation Costs (2009)

Reducing the labor required for installing a SWH system will potentially reduce cost significantly. Labor-reducing methods provide much value to the industry, as they are one of the largest drivers for overall system cost reduction.

The top methods for labor reduction include:

Prepackaged systems

- In order to reduce the cost of installation, companies have begun creating prepackaged pump and control systems or "pump stations." This reduces the installation time as well as insuring quality construction. Currently, these types of systems are only available for antifreeze applications.
- Pool heating is such a large market in the U.S. because it is cheap and because it consists of simple packaged systems that are easy to specify and install.

Solder-less pipe fittings

- With pipe installation as a significant portion of the total cost, it is an obvious target for cost reduction. Pipe manufacturers have created fittings that have a gasket that is compressed onto the pipes to form a seal. The seal is compressed using commercially available power tools. The fittings are expenses so they are mainly used on larger pipe applications.

Flex piping

- Flex piping typically consists of two flexible stainless-steel tubes insulated and connected together with a sensor wire sandwiched in between. Flex pipe reduces the need for brazing rigid pipes, making it easier to run piping through confined areas. This greatly reduces the installation costs of systems, especially in retrofit applications.

Payback

A simple comparative of payback analysis for different U.S. states illustrates the impact of the factors discussed above (insolation levels, electricity/gas prices and incentives, and system prices) have on project payback (see Figure 30). The analysis reveals that payback is more favorable when compared against electricity rates rather than natural gas.

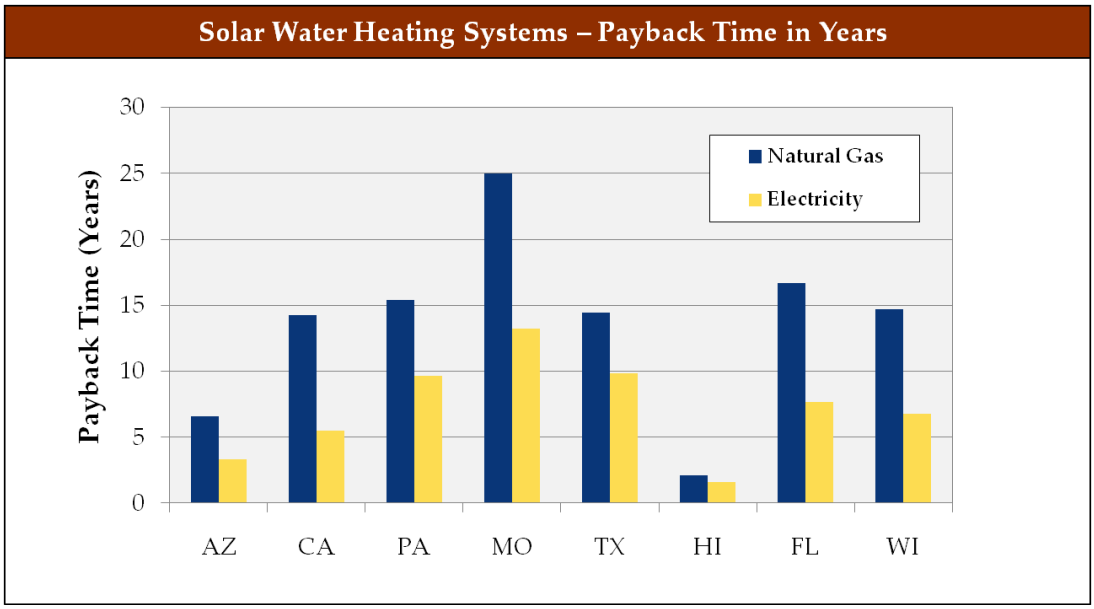
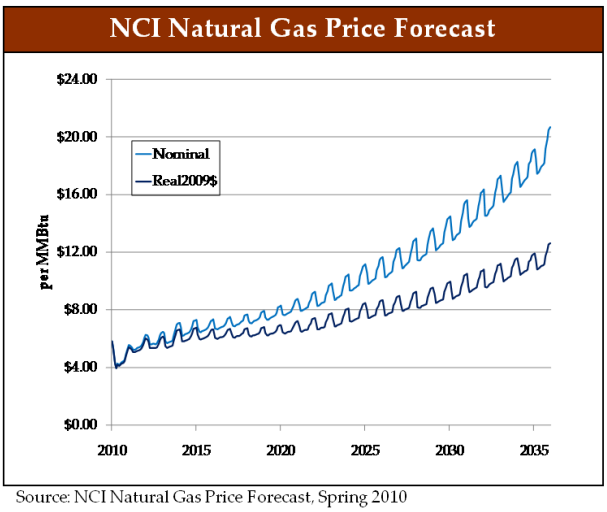


Figure 30. Solar Water Heating Systems – Payback Time in Years

Going forward, the Navigant team predicts NG prices are not likely to increase significantly during the coming years, as shown in Figure 31. Consequently, unless system costs decline more significantly or greater incentives are offered, states with low levels of solar insolation and electricity rates will not have a great economic incentive to install a SWH system.

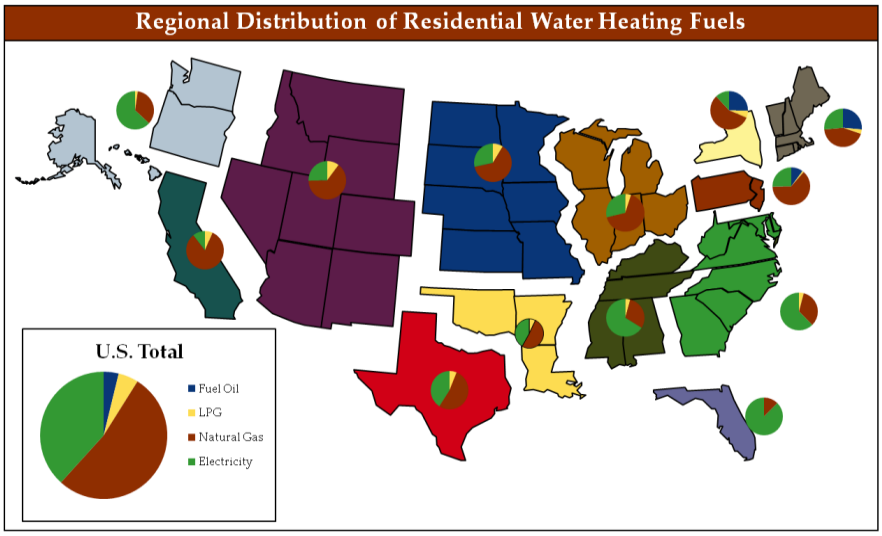


Source: NCI Natural Gas Price Forecast, Spring 2010

Avg. Henry Hub Price Forecast		
	Real 2009$/MMBtu	Nom $/MMBtu
2010 Q2	4.09	4.14
2010 Q3	4.28	4.37
2010 Q4	4.81	4.93
2010	4.57	4.65
2015	6.26	6.80
2020	6.66	8.01
2025	7.93	10.54
2030	9.44	13.87
2035	11.53	18.72

Figure 31. Navigant Natural Gas Forecast

Buildings with electric water heating will be more likely to adopt solar water heating going forward. The Pacific Northwest, Southeast, New England and Mid-Atlantic States are examples of states that have high proportions of electric water heating, as shown in Figure 32 .



Source: EIA's 2005 Residential Energy Consumption Survey
* While New England does not have majority if residences with electric water heating, it has a high number of residences that use fuel oil and fuel oil is much more expensive than natural gas.

Figure 32. Regional Distribution of Residential Water Heating Fuels

Solar insolation, system pricing, prevailing energy prices, and conventional water heating fuel used, illustrate why states such as Florida, California, and Hawaii are the biggest U.S. markets. Wisconsin and other similar states need more attractive incentives to stimulate a competitive market that will realize system cost reduction as current economic attractiveness of SWH systems is relatively low.

Solar Water Heating System Types

A solar water heating system is comprised of three main components: a solar collector, a storage tank, and a control system (pump and electrical controls).

Collector Types

The solar collectors are the basis for the system; they absorb the solar thermal energy and use it to heat water directly or through additional indirect steps. Collectors have three common forms: unglazed, glazed, and evacuated tube, as shown in Figure 33.

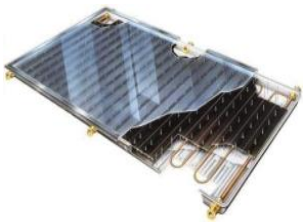
Collectors		
Unglazed	Glazed	Evacuated Tube
		

Figure 33. SWH Collector Types

- Unglazed collectors are the cheapest and consist of a series of parallel tubes, usually coated in a black solar-absorbing material. The tubes are generally rubber for flexibility and are connected by manifolds at the top and bottom. Unglazed collectors are relatively inefficient due to increased heat loss. Their low efficiency and low peak temperature does not get high enough for domestic water heating applications. However, they are the lowest cost option and are used mainly in pool heating applications, as shown in Figure 34.
- Glazed flat-plate collectors are similar to the unglazed collectors, with the exception that the absorption tubes are housed in an insulated box with a glass or transparent covering. The transparent covering allows sunlight and solar energy in while minimizing the heat loss due to convection to the outside air. Glazed collectors are much more efficient than the

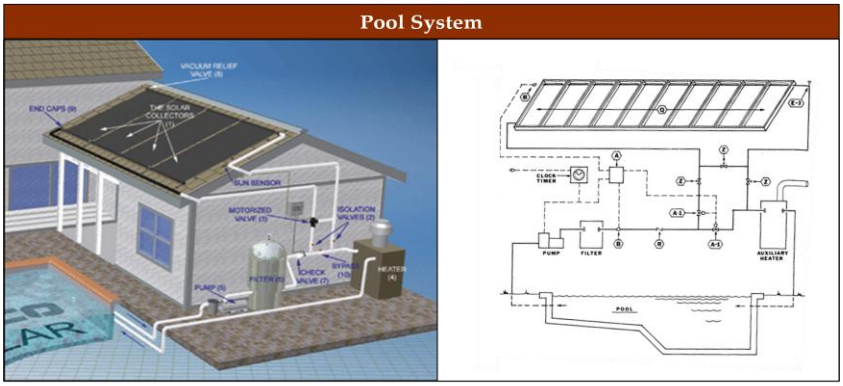
unglazed collectors and are capable of reaching the necessary temperatures for domestic water heating applications.

- Evacuated-tube collectors are the most efficient of the three collector types and are also the most expensive. These collectors consist of a series of evacuated glass cylinders with absorption tubes located inside. The evacuated space in between the absorption tube and the glass cylinder helps to prevent heat loss due to convection and thus increases efficiency. These collectors are expensive and fragile; however, single tubes can be replaced if broken and the whole collector does not have to be replaced.

The various collectors can be used with almost any type of system. The storage tank, control system, and overall architecture are what define the different systems. There are six basic types of SWH systems. The systems differ in cost, technology, complexity, efficiency, and applicable geographic locations. The range of systems types is another reason for the fragmented market in the U.S., as there is no set standard for system type or design. This lack of standard design is partially due to requirements of systems in different climate regions. For example, cold-weather climates require more complex systems that will prevent freezing and damage to the system; however, this comes at an increased price tag.

Pool Systems

One of the less complicated systems is the solar pool heating system. These systems do not require complex and expensive collectors because of a pool's generally constant demand for low-temperature (70 to 110^{0}F) water. Instead, solar pool heating systems utilize unglazed collectors consisting of a large number of small black rubber tubes that collect the solar energy and transfer it to the water. A typical pool system usually has a collector area equivalent to the area of the pool. In addition, because pools are usually not in use in the winter or are located in warm climates, there is little need for freeze protection, which helps to keep the cost down. See Figure 34.

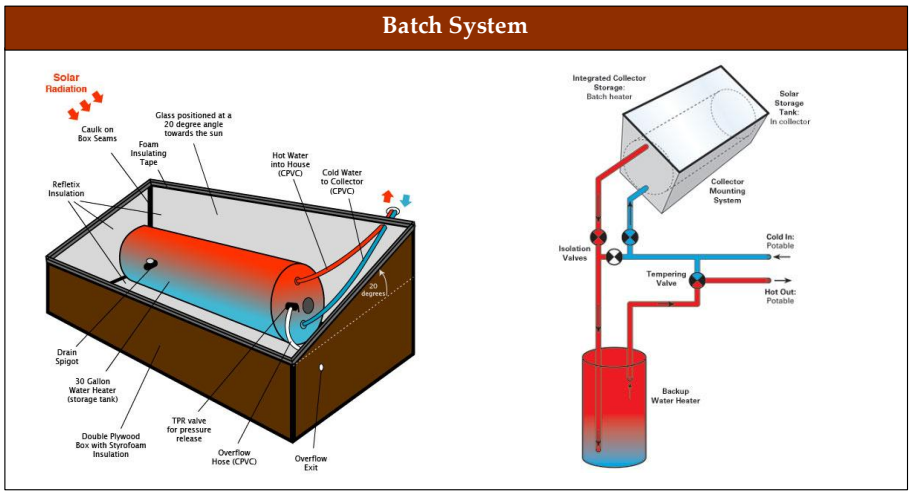


Source: Northern Lights Solar Solutions and RS Means

Figure 34. Pool System

Batch System

The simplest system used for domestic hot water heating is the batch system. The batch system combines the collector and the storage tank into one unit, as shown in Figure 35. A large tank coated in a solar- absorbent material and enclosed in a box with a transparent cover serves as the collector and the storage tank. The stored water is then drained from the tank when needed. This type of system, although very simple and cheap, is not as efficient as some other systems and does not offer simple freeze protection. These systems are typically used in rural areas where other heating sources are not available and homeowners cannot afford more efficient systems.

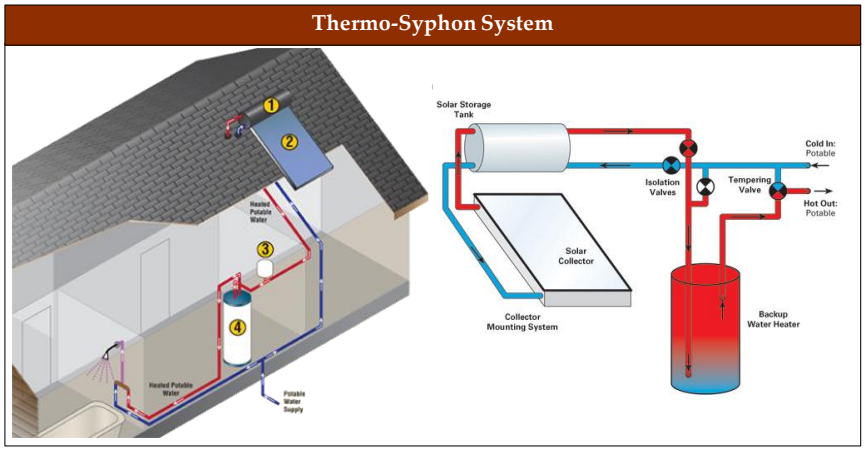


Source: Homepower, June/July 2005; www.homepower.com

Figure 35. Batch System

Thermo-Syphon System

The thermo-syphon system is similar to the batch system in that it is simple and cheap, although it is slightly more efficient. The system consists of an evacuated-tube collector fitted with a storage tank at the top of the collector. The water is stored in the tank and drained when it is needed. Although the evacuated tubes are efficient because the storage tank is not located inside the home, it loses a large amount of heat when it is in cold surroundings. The thermo-syphon systems lack adequate freeze protection; therefore, they are mainly used in warm climates for small, single-family applications, as shown in Figure 36.

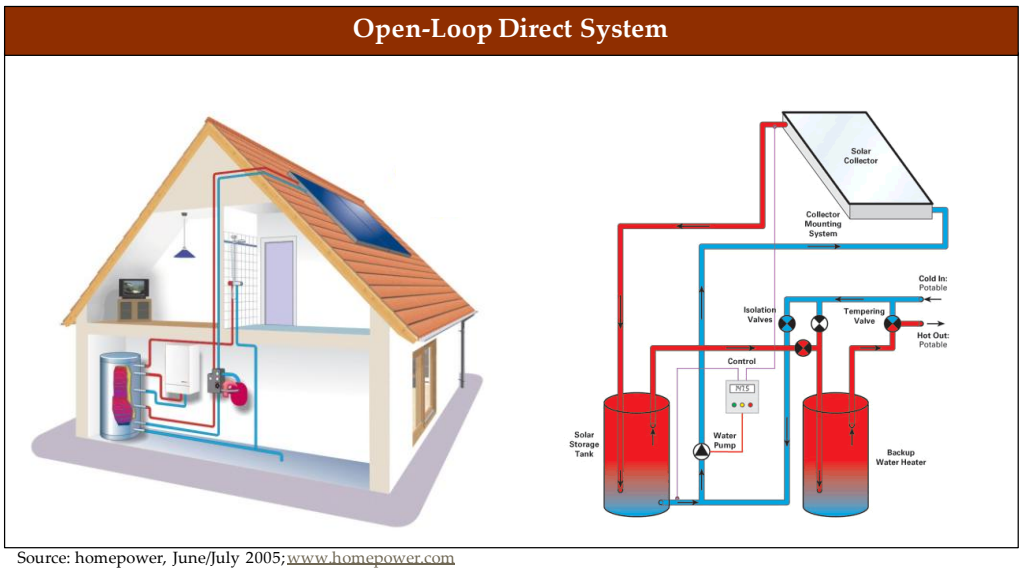


Source: Homepower, June/July 2005; www.homepower.com

Figure 36. Thermo-Syphon System

Open-Loop Direct System

Open-loop direct systems are more complex than the batch and thermo-syphon systems, although they are the simplest systems that utilize an indoor storage tank. A collector is mounted outside, usually on the roof, and water is pumped up to the collector where it is heated. The heated water is then piped back into the house where it is either used or stored in a hot water storage tank. The storage tank generally has a backup heating element for when there is not enough sun energy. These systems are simple; however, having an open loop with water can cause severe corrosion and wear on the pipes, as shown in Figure 37.

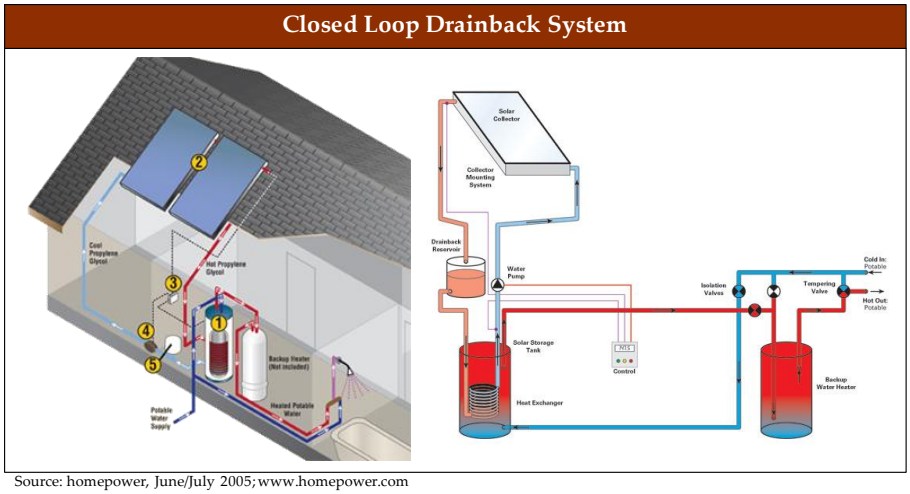


Source: homepower, June/July 2005; www.homepower.com

Figure 37. Open-Loop Direct System

Closed-Loop Drain-Back System

A closed-loop drain-back system is similar to the open loop system in that it utilizes a roof-mounted collector and a backup water heater/storage tank. However, in the closed-loop system, the water that flows through the collector is not used for domestic use. Instead, the water circulated through the collector is sent through a heat exchanger to transfer the heat to the potable water. This system also has a drain-back tank so that if the temperature were to drop below freezing, the water can drain out of the collector into a tank inside the house, where it will be sheltered from the freezing temperatures, as shown in Figure 38.



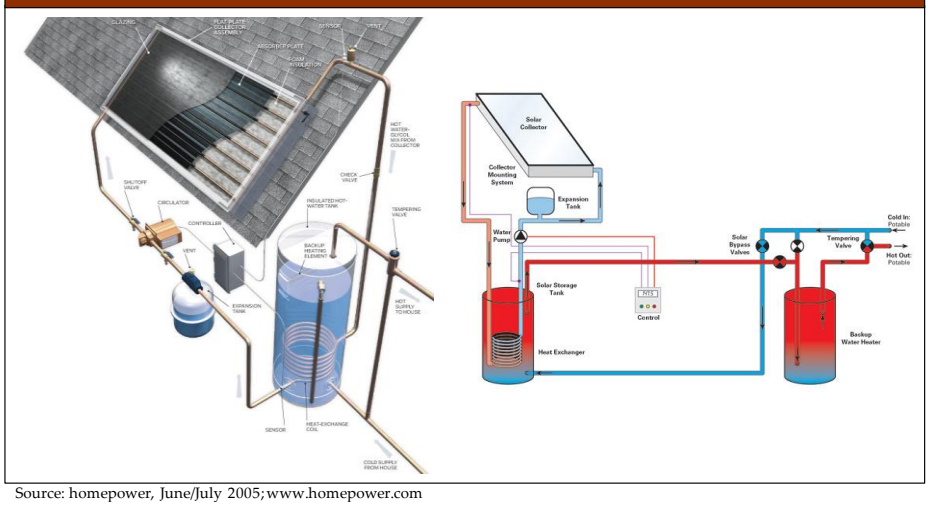
Source: homepower, June/July 2005; www.homepower.com

Figure 38. Closed-Loop Drain-Back System

Pressurized Glycol System

Finally, there is the pressurized glycol system. These systems utilize a closed loop of a glycol and water mix to transfer the heat from the roof-mounted collector to a heat exchanger located in the hot water storage tank. The glycol-water mix prevents freezing and the heat exchanger allows the heat to be transferred without contaminating the potable water with glycol. This system is generally safe from freezing; however, it is not safe from overheating. If temperatures in the collector get too hot due to stagnation (loss of flow through the collector), the heat can break down the glycol, which can cause damage to the entire system. System controls usually account for this to ensure that when the temperature is high there is always a constant flow through the collector. These systems are not as efficient as a similar system utilizing water; however, they are popular due to their effective freeze protection, as shown in Figure 39.

Pressurized Glycol System



Source: homepower, June/July 2005; www.homepower.com

Figure 39. Pressurized Glycol System

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6

Solar Water Heating Components and Supply Chain

SWH Components

SWH systems have many components, some of which are designed specifically for SHW applications and others that are more general and are in use in other plumbing applications and systems. Most SWH system architectures use a consistent set of components.

Many of these system components are shared with ones used in the plumbing industry for water heating and storage applications. However, system components are also shared across the various SWH system configurations, as shown in Table 11.

Table 11. System Components for Various SWH Systems

Components	Types	Pool	Batch	Thermo-syphon	OL Direct	Press. Glycol	CL Drain-back
Solar Collector	Flat plate Evacuated tube ICS	X	X	X	X	X	X
Collector Mounting System	Roof Ground Awning	X	X	X	X	X	X
Solar Storage Tank	Insulated	Pool	X	X	X	X	X
Water Pump	AC DC (solar)	X			X	X	X
Heat Exchanger	Coil Pipe in pipe					X	X
Expansion Tank	Air bladder					X	
Controls	Thermostat	X			X	X	X
Isolation Valve	3-/2-port 3- bi-valves	X	X	X	X	X	X
Backup Water Heater	Tank Tankless	X	X	X	X	X	X
Tempering Valve	Mixing		X	X	X	X	X

However, the highest value components in a SWH system are usually components that are specifically made for use in SWH systems and not ones that are shared with the general plumbing industry.

The SHW industry is highly fragmented and many systems lack standardization. Installers tend to use multiple component combinations and system designs when building systems.

Supply Chain

The SWH industry is highly fragmented and immature. In the U.S. certain areas and states have varying degrees of market maturity. These largely depend on the incentive levels and market adoption in specific areas. Therefore, the supply chain is also variable.

The solar photovoltaic market supply chain, for example, is global and well defined. Product flows from the manufacturer through a distributer to a system installer. In some cases, large system integrators who sell in large volumes may buy directly from the manufacturers.

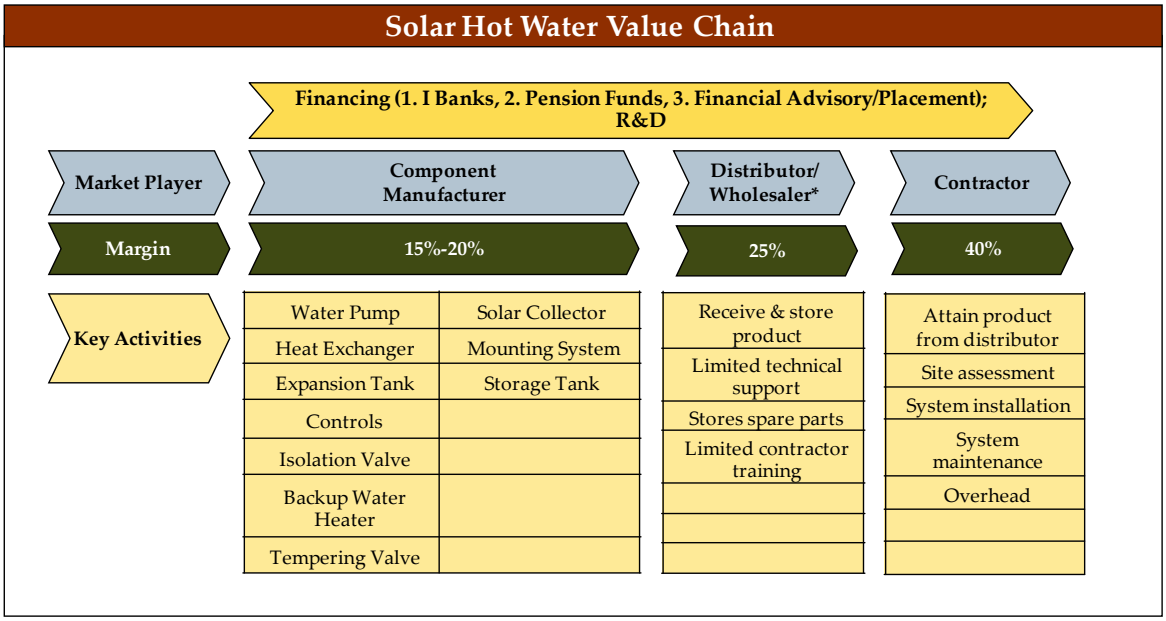

Figure 40. SWH Industry Value Chain

The SWH market, however, is much smaller and localized. The industry is not large enough for dedicated distributers. In most cases, component manufacturers take the roll of a wholesaler or distributer and sell product directly to the system installers, as shown in Figure 40. These sales

are based on personal relationships and the contractor's familiarity with a specific product(s). Such procurement methods are not unusual for maturing markets. However, they lead to many different component combinations in the installed systems as each installer uses their own combination; this is especially true in the residential market. Such variability in system components and lack of standardization can lead to lower quality systems and increased system breakdowns. In some states such as Hawaii where the market is more mature, some solar and plumbing distributers do stock SWH components.

Large system integrators do not really exist in the SWH industry in the U.S. with the exception of large ESCOs. The commercial market of larger SWH systems is growing but is currently a small segment of the overall U.S. market. Larger installers such as ESCOs who design and install more sophisticated systems will act as distributers in many cases, as shown in Figure 41. However, with unpredictable project demand, larger installers also do not want to stock inventory. They buy product on an as-needed, project-by-project basis and use standard off-the- shelf components or contract their own component designs directly from part manufacturers.

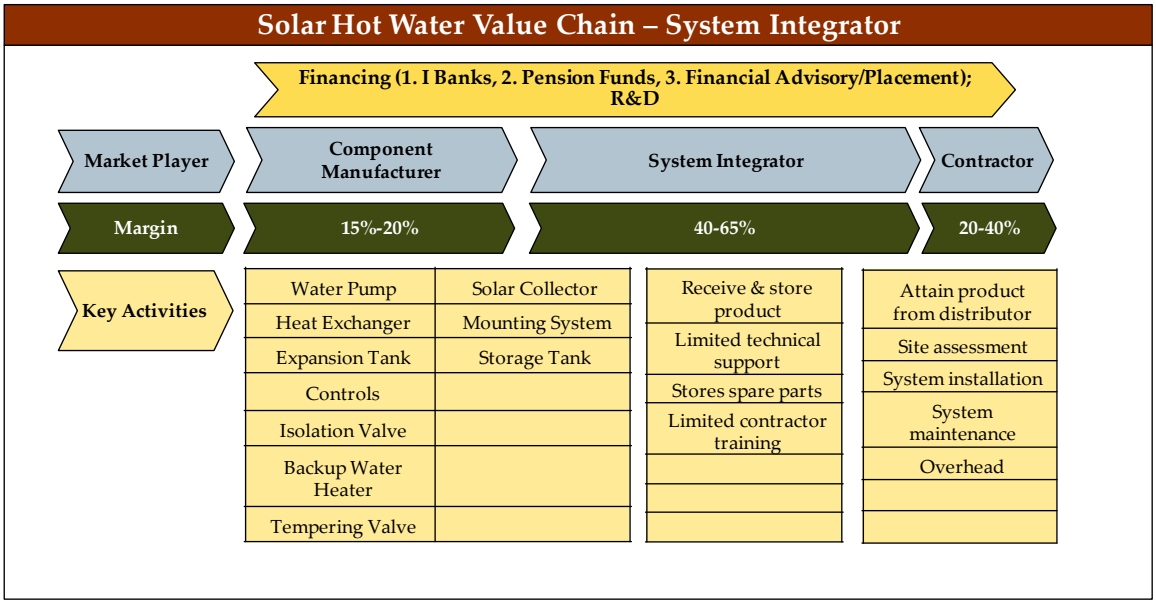

Figure 41. SWH Industry Value Chain – System Integrators

Margins vary throughout the supply chain. Manufacturers typically have margins between 10 and 20 percent. Many components in a SWH system are shared by the plumbing industry and are considered to be commodity components with lower margins (e.g., pipes andvalves). Other higher value components include solar collectors that are specific to the SWH industry or water pumps that are used in the general plumbing industry that will make higher margins. As

products do not always pass through a distributer, the contractor, manufacturer, or system integrator may absorb this additional margin. Installers or contractors typically make similar margins to those of the plumbing industry (about 40 percent). Additional supply chain decision drivers are listed in Table 12.

Table 12. SWH Supply Chain – Decision Drivers

SWH Supply Chain – Decision Drivers	
Suppliers	Installers usually work with a limited number of suppliers, usually ones they have long-standing relationships with and are comfortable using their products.
Decision Makers	The SWH market is still very fragmented, purchasing decisions are usually made based on existing relationships with manufacturer's representative.
Key Drivers and Competitive Advantages	Overall system cost reduction is very important moving forward. • Pump stations and preassembled systems will reduce installation cost. • Larger system will benefit from economics of scale and capitalize on cost reduction. However, additional engineering/permitting costs are usually needed. • Many SWH system components are shared with the general water heating and plumbing industry. Increasing volumes in the SWH industry are not likely to have large impact on prices of these components.

International Exports

In the U.S., SWH market components are usually manufactured and/or assembled locally. In some cases cheaper components are imported from overseas with final assembly done locally. For example, some U.S. collector manufacturers may import low-cost components from China and assemble them locally. This is a way to rebrand low-cost products and present them as higher quality as well as made in the USA. Chinese systems have a reputation for being low quality and U.S. as well as European customers are reluctant to purchase them.

The exceptions to the locally manufactured trend are high-quality products that may be imported from overseas, usually from Europe. The European market has the highest value market globally. Similar to the U.S. market, they use high-quality systems that have an expected lifetime of 25 years. However, the SWH industry in Europe is more mature than that of the U.S., and European companies have been able to leverage their high-quality products together with higher volume manufacturing and successfully export outside their respective markets, even with the higher shipping costs.

The U.S. exports very little now, and when it does, it is usually to markets in the Pacific Rim, the Caribbean, and South America. Selling into the European market has been difficult for U.S. companies. Strict certification processes and higher shipping costs make it difficult for U.S. products to be competitive. To date, no U.S. manufacturer has obtained the Solar Keymark certification, the standard in Europe, as shown in Table 13.

Table 13. SWH Component Exports

SWH Component Exports		
U.S.	**Exports**	• Some US manufacturers sell into international markets such as South America, the Caribbean, and the Pacific Rim.
U.S.	**Exporting to Europe**	• Selling into the high value European market is more difficult, mainly due to regulatory issues and shipping costs. • The accepted certification in Europe is the **Solar Keymark** certification. To date no US manufacturer has gained this certification. • The certification process and shipping costs and do not allow for US products to be price competitive with local manufacturers.
EU	**Exporting**	• European companies have established themselves as exporters outside their domestic market. • Successful products are high quality with advanced product design such as tanks, controllers, and pumps. • European products have established SRCC OG300 certification for their products to be sold in the US. • Companies also assemble and manufacture locally in the US.
China	**Exporting**	• Chinese products are mostly used in the local Chinese market. • Due to Chinese reputation for low quality products exports to EU and US markets include many sub-components that are later repackaged and rebranded by local companies.

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