SOLAR THERMAL IN THE MEDITERRANEAN REGION: SOLAR THERMAL ACTION PLAN

OME report for GSWH-UNEP-UNDP

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Acronyms

ADEREE	National Agency for Renewable Energy and Energy Efficiency
AMISOLE	Moroccan Association of Solar and Wind Industries
ANME	Tunisian National Agency for Energy Efficiency
CDER (Al)	Centre de Développement des Energies Renouvelables
CREDEG	Centre de Recherche et de Développement de l'Electricité et du Gaz
CSNER	Chambre Syndicale Nationale des Energies Renouvelables
CSP	Concentrated Solar Power
DNI	Direct Normal Irradiance
DSWH	Domestic Solar Water Heater
FNME	Fond National de la Maîtrise de l'Energie
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHI	Global Horizontal Irradiance
IAEREE	Institut Algérien des Energies Renouvelables et de l'Efficacité Energétique
IEA	International Energy Agency
IRI	Lebanon Industrial Research Institute
LCEC	Lebanese Center for Energy Conservation
LIBNOR	Lebanese Institute for Norms and Standards
LPG	Liquefied Petroleum Gas
LSES	Lebanese Solar Energy Society
NERC	National Energy Research Center (Jordan)
NERC	National Energy Research Center (Syria)
NREA	New and Renewable Energy Authority
OME	Observatoire Méditerranéen de l'Energie
PEA	Palestinian Energy Authority
PROMASAOL	Moroccan Program for promoting Solar Water Heater
PROSOL	Tunisian Program for promoting Solar Water Heater
PV	Photovoltaic
RCREEE	Regional Center for Renewable Energies and Energy Efficiency
RE	Renewable Energy
REAOL	Renewable Energy Authority of Libya
RES	Renewable Energy Sources
RET	Renewable Energy Technology
RSS	Royal Society
SEMCs	South East Mediterranean Countries
SWMCs	South West Mediterranean Countries
NEUMCs	Non-EU Mediterranean Countries
NEUNMCs	Non-EU North Mediterranean Countries
SHIP	Solar Heat for Industrial Process
ST	Solar Thermal
STEG	Société Tunisienne de l'Electricité et du Gaz
SWH	Solar Water Heater
TFC	Total Final Consumption
TPES	Total Primary Energy Supply
UNDP	United Nations Development Programme
UNEP	United Nation Environment Programme

Units

%/y	percent per year
tCO2	tonne of Carbon Dioxide
GW	Gigawatt = 10^9 watt
kWh	kilowatt-hour
kWh/m²/y	kilowatt-hour per square meter per year
Mtoe	Million tonne of oil equivalent
MW	Megawatt = 10^6 watt
MWp	Megawatt peak
PPP	Purchasing Power Parity
Toe/cap.	Tonne oil equivalent per capita
TWh	terawatt-hour
USD	United States Dollar
USD/cap.	United States Dollar per capita

1. Introduction

Energy security, avoiding greenhouse gas (GHG) emissions and generating positive socio-economic impact are among the main reasons behind promoting development and deployment of renewable energy technologies worldwide.

Resource availability, technological maturity and, economic feasibility are some of the prerequisites for a large scale deployment of renewable energy, in general, and solar thermal technologies, in particular. The Mediterranean region is endowed with significant, yet largely untapped solar resources. Solar water heating (SWH) systems are already commercially viable and, in some cases, already cost competitive. In particular, domestic solar water heating applications are the most well known and widespread. A great potential is still to be tapped in other niches. Thus, promising future applications include process heat, district heating, cooling and desalination.

Nevertheless, several barriers such as relatively high up-front investment cost, competition with subsidized fossil fuels-based technologies, mistrust vis-à-vis the technology and lack of policy support mechanisms, etc. constitute real challenges for the large scale penetration in the South and East Mediterranean countries (SEMCs)[1].

Overcoming such barriers would more likely result in a wide penetration of solar thermal applications, thereby reducing electricity and fossil fuels consumption, and ultimately energy savings and costs savings for both governments and end-users. A number of critical factors are, thus, necessary for such wide scale deployment.

The present “Action Plan for Investment Promotion” comes under the framework of the Global Environment Facility’s funded programme titled “Global Solar Water Heating (GSWH) Market Transformation and Strengthening Initiative,” executed jointly by the United Nations Development Programme (UNDP) and the United National Environment Programme (UNEP). The objective is to create the enabling conditions for the SWH systems market uptake at the global level, in general, and in the Mediterranean region, in particular. The programme consists of two main components:

1. Global Knowledge Management and Networking: Effective initiation and co-ordination of the country specific support needs and improved access of national experts to state of the art information, technical backstopping, training, sharing of international experiences and lessons learnt.

2. UNDP Country Programs: The basic conditions for the development of a SWH market on both the supply and demand side are established, thus leading to the overall, global market transformation goals of the project. Currently, country programmes are ongoing in Albania, Algeria, Chile, Lebanon, India and Mexico, but it is expected that other countries will join as an ultimate outcome of the current initiative.

Within this framework, the Observatoire Méditerranéen de l'Energie (OME) has been selected as a regional partner to coordinate the implementation of the Knowledge Management and Networking components in the Mediterranean area.

The main activities carried out by OME within the project so far include: i) review of the state of the art and prospects of solar thermal technologies in the Mediterranean region, ii) identification of main needs, barriers and priorities for action, iii) collection of relevant information and dissemination through the project website, conferences and other events, and iv) organisation of a regional workshop gathering public and private sector experts and v) the Market Assessment report.

The action plan – covers the South and South East Mediterranean Countries - gives an overview of the status of solar heating and cooling (SHC) technology and its applications, potential benefits, critical factors for a wide market penetration, and recommendations to policy makers to take concrete steps to put in place and or realize national plans for investments in SWH systems.

[1] SEMCs are Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syria, Tunisia and Turkey.

2. Overview of global technologies and market trend

2.1. Solar resources

The potential for solar thermal applications at a global level is high. Regions which belong to the so-called Sunbelt are among the most suitable for solar thermal deployment, given the favourable irradiation rates (Figure 1). Nevertheless, some solar thermal technologies can operate almost everywhere, even in cloudy regions, mainly due to the fact that non-concentrating solar thermal collectors (flat-plate and evacuated tube collectors) can use both direct and diffuse solar radiation to produce heat. On the contrary, concentrating solar collectors, which use direct radiation to operate, have to be installed in locations with limited clouds (e.g. deserts).

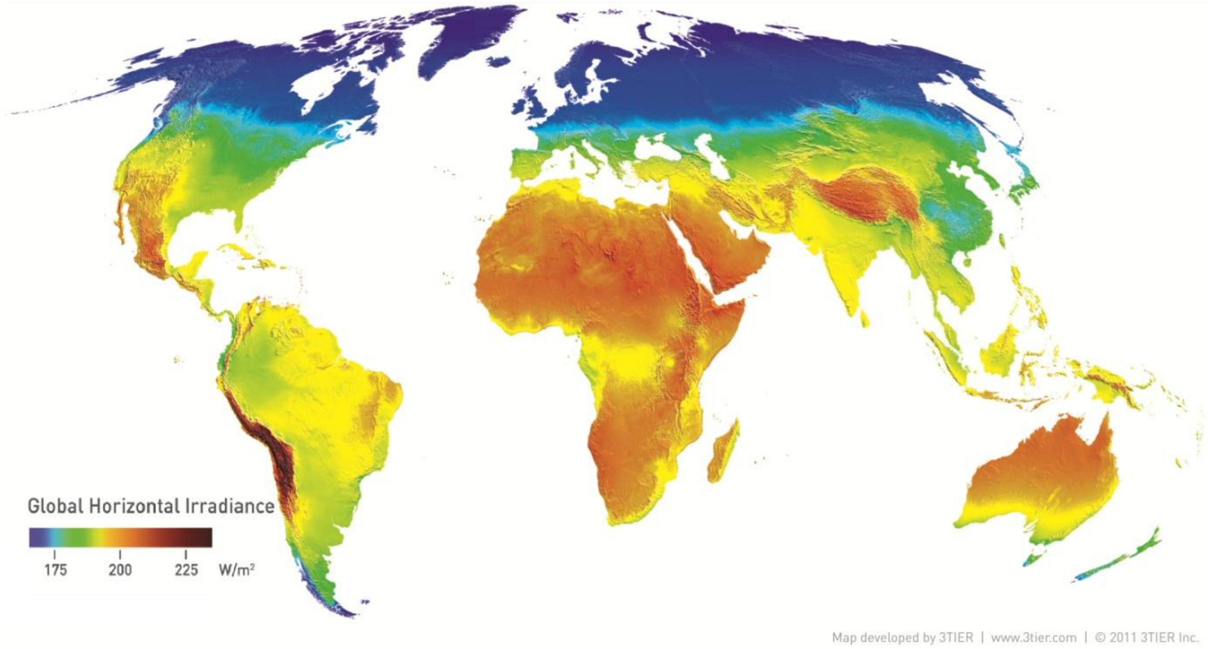


Figure 1: Global horizontal Irradiance (3Tier)

2.2. Current technologies

Solar thermal systems use collectors to absorb solar irradiance to produce heat, which in turn is used for water and space heating or indirectly for cooling. The most typical and widespread application is represented by domestic solar water heating (SWH) systems. A SWH system is composed of two main components: a collector and a tank. Whereas water is the best heat transfer fluid (flows in a circuit), propylene glycol (used in industry) is well suited for freezing areas. Selective absorbers, in particular, are more efficient as they retain more energy, and thus reduce heat loss.

Solar thermal collectors

Solar thermal collectors are the main element in converting solar energy into heat. Whereas concentrating collectors (required for high temperatures above 150 ˚C) need Direct Normal Irradiance (DNI), non-concentrating collectors (needed for low temperature systems- up to 80 ˚C) require Global Horizontal Irradiance (GHI). Solar thermal collectors can be classified following three criteria: the motion of the system (stationary, single axis-tracking, two axes-tracking); the absorber type (flat, tubular or point) and the concentrating or non-concentrating characteristic of the system as shown in Table 1. A fourth criterion is the working fluid which can be water, air or oil.

Table 1: Solar thermal collectors' characteristic

Motion	Collector type	Absorber type	Concentration	Indicative temperature range (°C)
Stationary	Flat plate collector (FPC)	Flat	No	30-100
	Evacuated tube collector (ETC)	Flat	No	50-130
Single axis-tracking	Linear Fresnel reflector (LFR)	Tubular	Yes	60-400
	Parabolic trough collector (PTC)	Tubular	Yes	100-450
Two axes-tracking	Parabolic dish reflector (PDR)	Point	Yes	100-500
	Heliostats field collector (HFC)	Point	Yes	150-2000

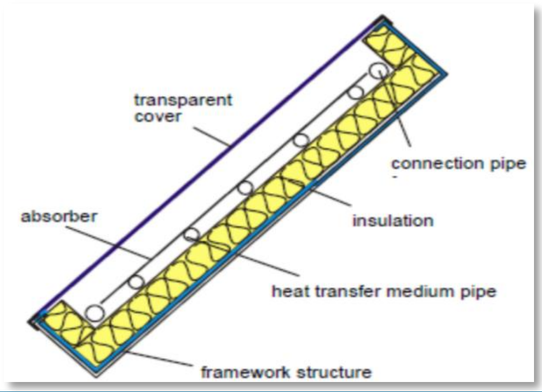
Source: S.A. Kalogirou, 2004; T.A. Reddy and al., 2007; IEA SHC Task 33/IV, 2008

Regarding the solar water heating, two main types of non-concentrating solar thermal collectors are used: flat-plate (glazed, unglazed) and evacuated tube collectors.

Table 2: Main solar thermal collector used for water heating purposes

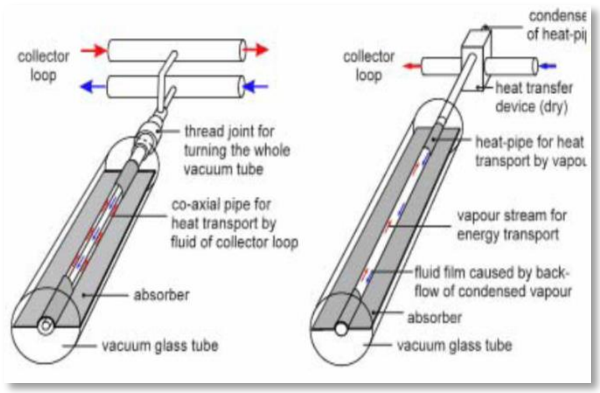
Collector type	Description

Flat-plate Collector



Glazed Flat-plate collectors are composed of transparent front cover, a frame, collector housing and an absorber. Whereas the absorber (usually black) is generally made of metal (aluminium, copper or steel), the collector housing could be made of metal, plastic or wood. Selective coating is used to increase an absorber's efficiency. Unglazed Flat-Plate collectors consist of an absorber that is composed of a rubber-like Ethylene Propylene Diene Monomer (EPDM) mat and metal (Baechler et al, 2007). A housing is used for unglazed collectors, which reduces heat loss from the absorber and the fluid circuit heat exchanger and protects them from degradation.

Evacuated-tube collector



Evacuated tube collectors consist of a metal absorber sheet with a heat pipe (has temperature-sensitive fluid) inside a closed glass tube that acts as a thermo to hold heat. The housing is a glass tube with vacuum inside. Evacuated tube collectors are either direct flow tubes or heat pipe tubes. These are more efficient than other types of collectors in cloudy weather with lower solar irradiation.

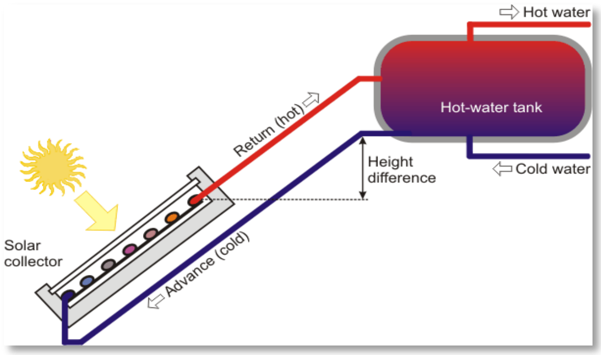
Source: AEE INTEC, 2009 (up), H. Müller-Steinhagen, 2008 (down)

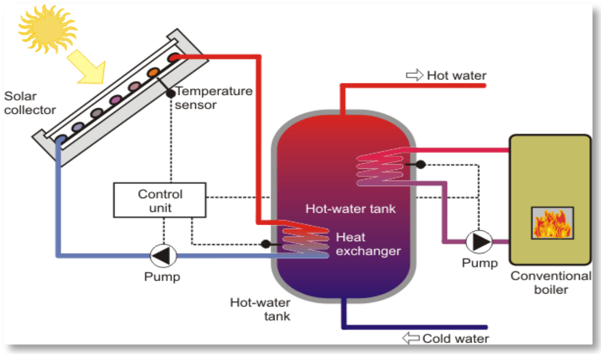
SWH system types

SWH systems can be classified into active vs. passive and into direct vs. indirect systems. Whereas passive systems depend on gravity and thermal stratification; in an active system, however, a pump circulates fluid from the tank to the collector. Direct systems use potable water as the heat transfer fluid which is then used directly for domestic hot water. Indirect systems use heat exchangers to isolate fluids from potable water. Whereas in an active direct system it is advisable to use a pump with a bronze steel housing and impeller to avoid corrosion, a cast iron pump could be used for an active indirect system (Baechler et al, 2007). In terms of technology, there are two main technology systems; thermosyphon and forced (pumped) circulation systems

Table 3: Solar water heating system types' description

System type	Description
Thermosyphon	Thermosyphon (natural flow) is a passive direct system where the heat transfer medium (water) flows naturally from the collector to the tank using gravity. Given its higher specific density, cold water goes down thereby requiring the collector to be installed below the water tank. The system has the advantage of being simple and less costly. It is not well integrated into buildings, however, as it is used mainly on roofs (ESTIF, 2012). The thermosyphon passive indirect system, however, includes heat exchangers within their tanks and could also have the propylene glycol fluid against freezing.
Forced circulation	Forced circulation systems are more flexible in terms of where to install the tank as the transfer fluid is regulated by a pump. This is more complex, however, requiring extra technology items such as a pump, controller, and sensors. The controller switches on or off the pump depending on the difference between temperatures in the solar collector and the tank that is monitored by the sensor. They are mainly in low temperature zones and they are well integrated into the buildings (ESTIF, 2012)





Source: www.volker-quaschning.de

2.3. Solar thermal applications

Solar thermal technologies are used in several applications. They are used for water and space heating, cooling, process heating and other applications.

The solar thermal technologies have been used by all types of buildings. They could be used in single-family homes, multifamily and commercial buildings, hospitals, schools, and traditional public baths, etc (Table 4).

Table 4: Solar heating and cooling applications

Application	Description
Domestic Solar Water Heating	Solar thermal system for domestic water heating is the most common application used worldwide. Two main applications exist, namely for individual housing needs or collective system for buildings. Both thermosyphon and pumped systems could be used for domestic water heating.
Combined Water and Space Heating (combi-systems)	This technology delivers both heat and hot water. This is used mainly in big buildings, especially in hotels, office buildings and multi-family buildings. The combi-systems use mainly forced circulation systems and usually require an auxiliary energy source to cover the unmet demand by solar thermal. The combi-systems are not widely used (could account for 50% of annually installed capacity in some countries like Germany and Austria, however) because of the lack of low-cost compact thermal storage (IEA, 2012a)
District Heating	This system uses a central storage tank that is heated by collectors installed either on single houses or are centrally installed in one single place. Heat is used for either residential or commercial heating purposes.
Solar heat for industrial processes	Solar thermal could also be used in industrial processes such as industrial washing, drying, space heating in industrial buildings, etc. Solar thermal technologies could be used for industrial applications for low-, medium- and high-temperature applications
Solar Thermal Cooling	Solar thermal cooling systems are usually composed of an absorption chiller, a collector, a cooling tower and a smart control system. Several pilot systems are installed, especially in Europe, but the technology is not mature yet.

Source: OME, IEA

Other solar thermal applications include water treatment and seawater desalination, solar cooking, and swimming pool heating.

Figure 2 gives an overview of the solar thermal collectors used for different applications depending on the working temperature

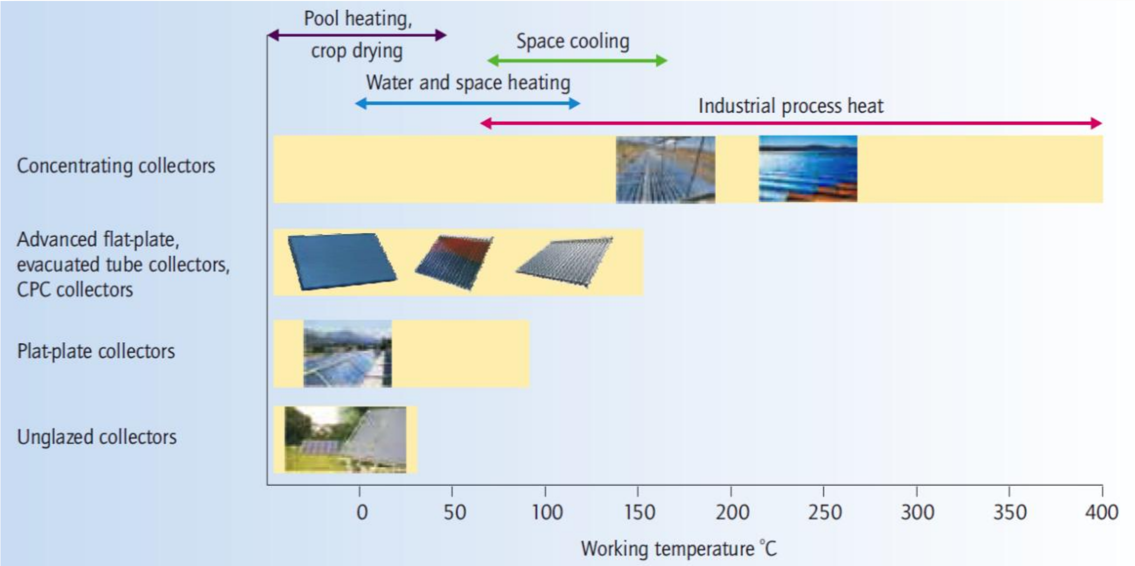


Figure 2: Solar collectors and working temperatures depending on applications (IEA, 2012a)

2.4. Market trends

The most established solar thermal technologies in the market are those requiring low-to medium temperatures. Total installed capacity reached around 200 GW_{th} in 2010. China accounted for the largest share with 59% of the global installed capacity, followed by Europe (13%) and North America (8%). These three regions together amount for more than 80% of the global installed capacity (Figure 3). The South and East Mediterranean Countries accounted for 9.3% reaching around 19 GW_{th}.

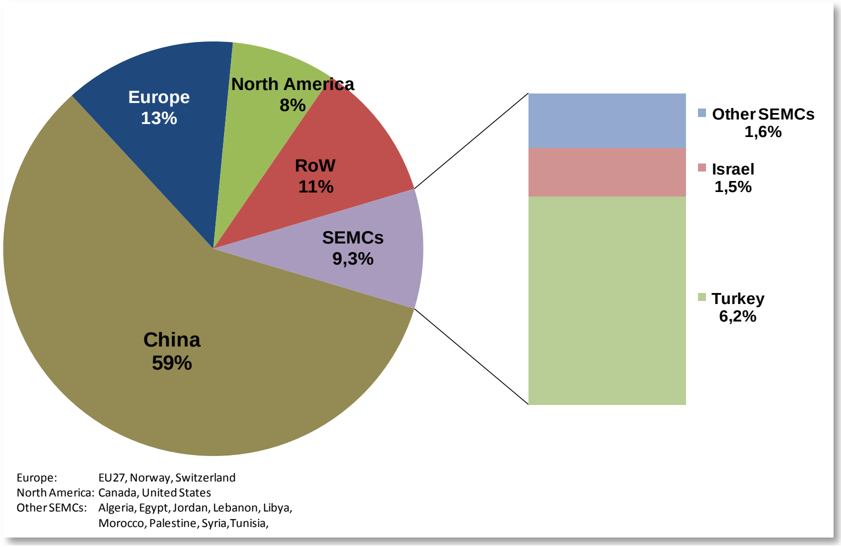


Figure 3: Share of the total installed capacity in operation by regions at the end of 2010 (OME, IEA, 2012a)

Historically, Europe (mainly Austria, Denmark and Greece) and United States were the most dynamic markets but since the beginning of the 2000's, the Chinese market is booming and is driving the global market, being the market leader in terms of installed capacity.

Between 2000 and 2010, the global annual installed capacity increased six-fold led by Chinese, European and North American markets (Figure 4 - left).

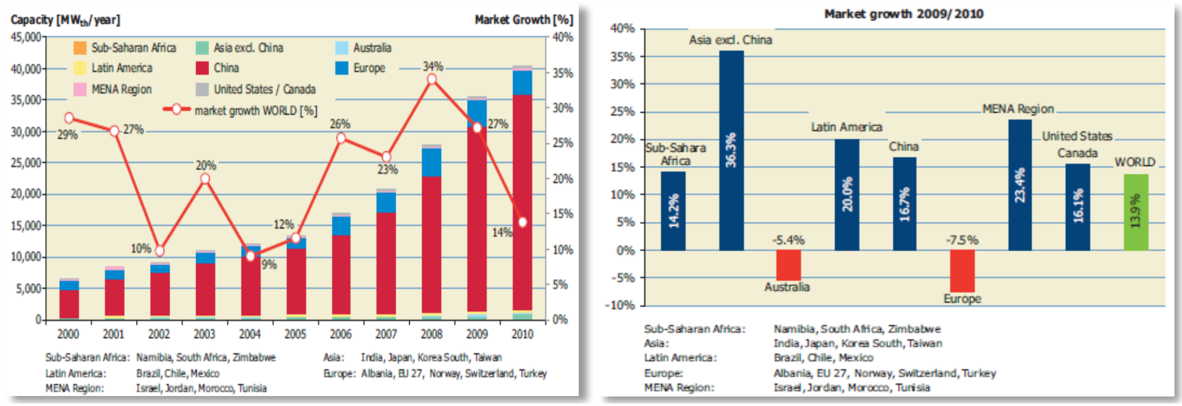


Figure 4: Worldwide annual installed capacity of flat plate and evacuated tube collectors from 2000 to 2010 (left), Market development of the worldwide newly solar thermal installed capacity between 2009 and 2010 (right) (source: Weiss and al., 2012)

The year 2010 recorded the lowest growth rate since 5 years. During 2010, the newly installed capacity reached 42.2 GW_{th} (corresponding to 60.2 million m^2 of solar collectors), meaning an increase of about 14% compared to 2009. Asia is leading the market growth (mainly thanks to China and India) while the market in Europe has witnessed a significant decrease (-7.5%) (Figure 4 - right).

SEMCs have recorded high market growth with a 23% average growth rate (Israel, Jordan, Morocco, and Tunisia).

In terms of per capita solar thermal installed capacity, Cyprus has the highest ratio with 577 KW_{th}/1,000 inhabitants, followed by Israel (397), Austria (388), Barbados (323) and Australia (271) (Weiss, 2012).

2.5. Economics

Factors affecting the cost of heat from a SWH system include life-span, solar irradiance and energy tariffs. The total investment cost of a SWH system could be split into costs of collector, tank, installation and other services. In general, the collector and tank account for the largest share of the total investment cost, with minor operating costs. Contrary to thermosyphon system working on natural circulation, the pumped system usually requires additional features such as controllers, valves, pumps, etc, thereby raising its total investment cost.

The cost of a SWH system could differ around the world by a factor of 10 (from USD 250/kW_{th} to USD 2,400/kW_{th}) based on system type, size, application, market conditions, and costs of labor (IEA, 2012a).

Economies of scale play an important role in reducing investment cost of large-scale solar hot water systems used in district heating and industrial applications or commercial buildings applications. In Denmark, for example, investment costs range from USD 350 to USD 400/kW_{th} for the most competitive systems and heat prices between USD 35 to USD 40/MWh_{th} (IEA, 2012a).

Despite the difficulty in assessing solar cooling investment costs because of the emerging status of the technology, estimates for some existing solar cooling installations (medium to large systems) in tropical regions, are between USD 1,600/$kW_{cooling}$ to USD 3,200/$kW_{cooling}$ for medium to large systems.

Figure 5 shows regional (US, China, Europe) ranges of solar heating and cooling costs compared to gas and electricity costs (in USD/MWh_{th}). The most competitive SWHs are those in southern United States (large scale systems), China (thermosyphon SWH), and South Europe (thermosyphon SWH).

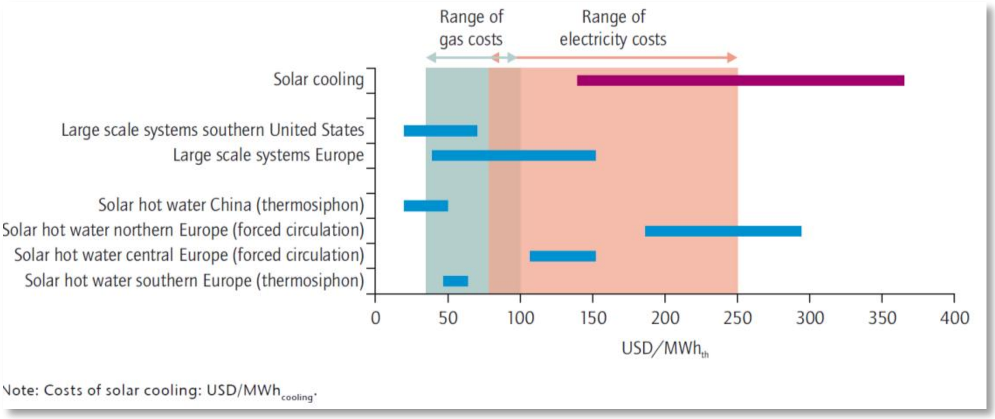


Figure 5: Costs of solar heating and cooling (source: IEA, 2012)

Cost competitiveness is a determining factor for a wide scale market penetration. Several solar thermal applications are already cost-effective while others are still more expensive compared to fossil-fuel based systems. In perspectives, the cost of generated heat from solar thermal systems is expected to witness significant decreases, thereby making solar thermal technologies far more competitive than conventional-based heat. Table 5 shows the range of prices for solar based heat versus other systems using natural gas and electricity for 2007 and 2030 for end users in central and southern Europe.

In 2007, the cost of solar thermal-based heat is already competitive compared to the other sources. In perspectives, the cost of heat would be far below than other substitutes, including natural gas and electricity. By 2030, the range of solar thermal is expected to be between 2.6 and 5.2 USD-cent/kWh in the Southern Europe while natural gas and electricity are expected to have ranges of 22 - 75 and 18 - 86 USD-cent/kWh, respectively. The variations observed between central Europe and Southern Europe could be attributed to different climatic conditions, and in particular to solar irradiation. Thus, given the potential of cost reductions in the future, it is more likely that people opt for SWH system applications compared to other conventional fuels-based systems.

Table 5: Cost of heat (in USD-cent/kWh), 2007-2030

	2007		2030	
	Central Europe	Southern Europe	Central Europe	Southern Europe
Solar thermal	9.1 - 20.8	6.5 - 15.6	3.9 - 7.8	2.6 - 5.2
Natural gas	11.1 - 37.7		22.1 - 75.4	
Electricity	9.1 - 42.9		18.2 - 85.8	

* Costs of solar heat include all taxes, installation and maintenance. Exchange rate used (1€=1.30USD)

Source: OME based on European Solar Thermal Technology Platform (ESTTP)

2.6. Regulatory and policy framework

Policy support mechanisms have been adopted worldwide for promoting the wide scale deployment of renewable energy technologies, and they have been behind the increasing market rates in many countries. According to REN21 (2012), the number of renewable heating/cooling policy support mechanisms have been increasing, with at least 19 countries having set renewable heating/cooling targets (including for solar water heating) and 17 countries and states having obligations/mandates to promote renewable heat, for example through building codes.

Financial incentives for solar water heating installations are widespread and, together with regulatory policies, have stimulated continued global growth in installations. There is limited national policy support in place for encouraging new district heating and cooling schemes, although these are usually instigated by policies made at the local government level (REN21, 2012).

2.7. Research and development (R&D)

Whereas a number of low-temperature systems are already cost competitive and are widely used, especially domestic solar water heating, others still require more research and development to be economically viable.

Several R&D developments related to solar heating and cooling systems have taken place worldwide at both collector and storage levels. The solar collector's main developments concern cost and weight reductions. By contrast, the increase of volume, new designs and cost reductions are some of the main R&D achievements for storage

Table 6 gives a summary of such latest developments and their features for solar collectors and heat storage (Ehrismann, 2012).

Table 6: Latest R&D developments in solar collector and heat storage

Solar collector	Features
Polysol collector (all polymeric collector)	Weight and cost reduction; use of recycled polymeric materials; made by extrusion; overheating protection by temperature dependent emissivity and pressure resistant.
Gas filled flat plate solar collector	Filling gas (e.g. Xenon, Argon, Krypton); higher thermal performance; thinner collector design and reduced weight.
Façade collector based on vacuum tubes	Combination of glass façade and evacuated tubular collector; CPC mirror is perforated to allow light to enter the building.
Solar heat for industrial processes	Solar thermal could also be used in industrial processes such as industrial washing, drying, space heating in industrial buildings, etc. Solar thermal technologies could be used for industrial applications for low-, medium- and high-temperature applications
Industrial Solar Fresnel collector field	4 collector strings with 16 modules each; gross area approx. 2100 m2; total aperture area 1408m2; pressurized water circuit at 16 bar; provided temperatures of 200 C; used to drive an absorption chiller.
Heat storage	**Features**
Water stores	Large volumes by cascading; disadvantages: large space requirement, effort for installed and control, high thermal losses due to large surface.
Large water stores	Large stainless steel store (pressurized); new buildings: installation during construction phase; existing buildings: welding at the place of installation.
Cylindrical polymeric stores	Made up of fiberglass-reinforced plastic; volume: 1-100 m^3, with this flexibility only available as unpressurised store.
Cubical polymeric water store	Optimal use of space due to cubical shape; steel frame with polymeric panels; construction and sealing on-site; individual sizing to fit the room; unpressurised.
Pressurised polymeric water stores	First pressurized cylindrical polymeric store made from fiberglass-reinforced plastic; low thermal conductivity; corrosion-free; low weight; stratified charge and discharge device.
ModSto-Modular hot water store	Less space compared to cylindrical stores; pressure resistant up to 2.5 bar; module volume 1.3 m^3; total vol. up to 10 m^3; low heat losses; quick & easy installation,
Underground stores	Large volume achievable; possible installation in building stock; unpressurised stores up to 7 m^3; pressurized stores up to 11 m^3; significant costs for ground works. In development: diffusion resistant foil bag instead of a steel store.
Vacuum super insulated water store	Very low heat losses with a rate for 16 m^3 store: 1.98 W/K (typical value for a standard 250 l store); perlite powder as filling material: low costs 50€/m^3 and density 30-100 kg/m^3, small pores 10-100µm, high porosity 75-97%.
Latent heat storage in ice stores	Very large heat of fusion; low material costs. Field of operation: in combination with heat pump systems; for "cold storage" in solar thermal cooling systems.
Thermo-chemical heat stores	open adsorption/hydration system with ambient or exhaust air; salt with an active / passive porous matrix; material: CaCI2 and MgSO4; external cross-flow reactor; regeneration temperatures (120-180 C); storage density: 230 kWh/m^3

Source: Ehrismann, 2012

3. Current picture in the Mediterranean

3.1. Solar resources

Solar thermal technologies offer promising opportunities in the Mediterranean region. Most SEMCs lie in the so-called Sunbelt, with global horizontal irradiance (GHI) values ranging from 1,600 $kWh/m^2/y$ in coastal areas to 2,600 $kWh/m^2/y$ in the desert, and direct normal irradiance (DNI) values varying from 1,800 $kWh/m^2/y$ to more than 2,800 $kWh/m^2/y$ (Figure 6)..

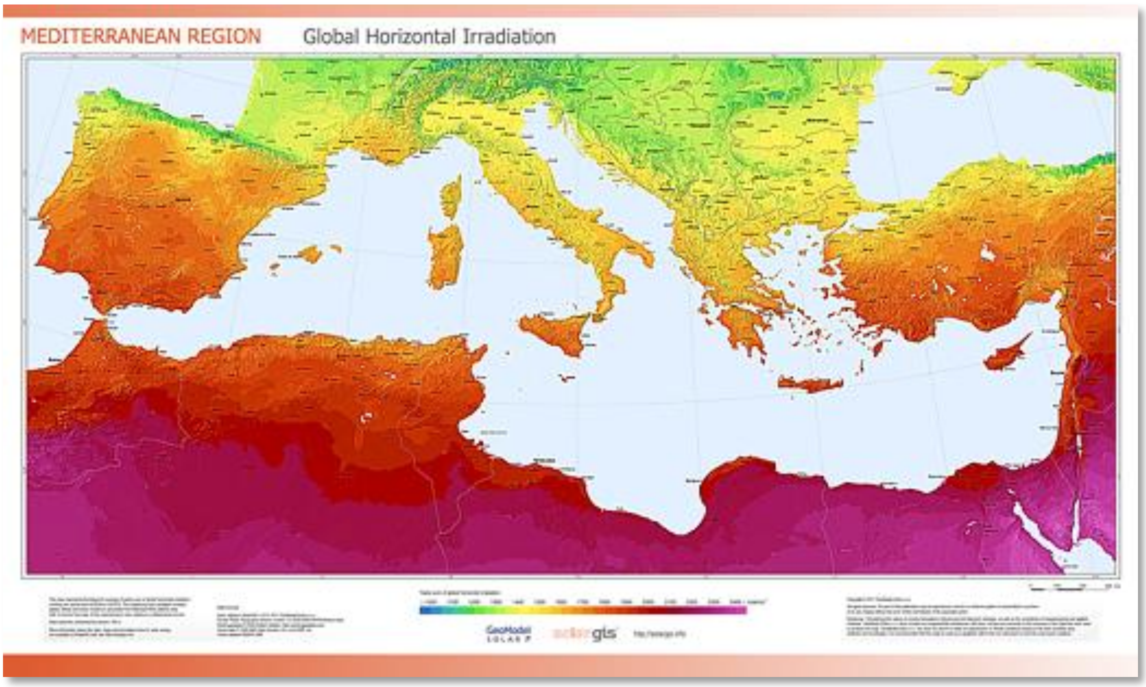


Figure 6: Global horizontal Irradiance (GHI) in Mediterranean area *(PVGIS)*

3.2. Market trends

Among the SEMCs, solar thermal is widespread in Israel, where the use of solar energy for water heating dates back to 1970s. Tunisia has established a comprehensive programme to promote the use of solar energy in the residential, tourism and industrial sectors. A solar thermal market also exists in Turkey, Egypt, Jordan, Lebanon, Morocco and Syria.

The installed solar thermal capacity in the SEMCs reached around 18.5 GW_{th} in 2010, representing more than 9% of world solar thermal installed capacity. Turkey alone accounts for the largest share with 67% (18 million square meters) of installed capacity in the SEMCs, followed by Israel and then by the Palestine (Figure 7 - left). Together, these three countries account for around 88% of the solar thermal capacity in operation in the Mediterranean region.

In terms of per capita solar thermal installed capacity, Israel has the highest ratio with 397 KW_{th}/1,000 inhabitants, followed by Palestine (260), Turkey (172), Jordan (121) and Lebanon (52) (Figure 7 - right).

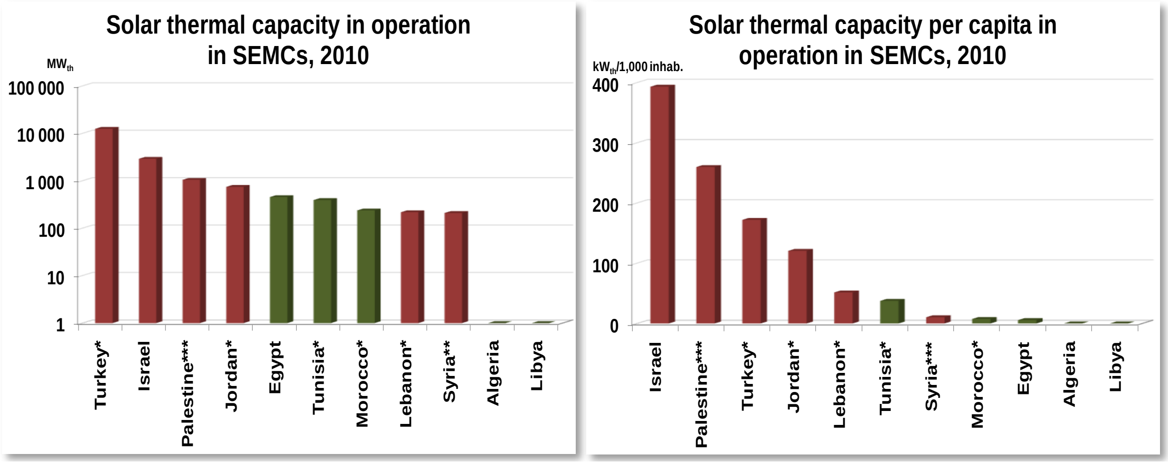


Figure 7: Solar thermal installed capacity in SEMCs (left); Per capita installed capacity in the SEMCs (right) (OME database)

Solar Heat for Industrial Processes (SHIP) in SEMCs

SHIP applications are still at an early stage of development. At present, around 200 operating solar thermal systems for process heat are estimated worldwide (Weiss, 2010), for a capacity of 42 MW_{th} (60,000 m^2), or only 0.03% of the total solar thermal capacity installed. Most of these systems are of small-scale experimental nature. In the European region, Austria is a pioneer in the use of this technology; several North Mediterranean countries including Greece, Italy, Portugal and Spain are also active.

In the SEMCs, most countries are still keeping their solar potential largely untapped. There is limited experience in SHIP applications in the Mediterranean, and a general lack of well documented information. Among SEMCs, Egypt has produced perhaps the most analytical documentation on its experience with SHIP. The Egyptian government formulated a programme for testing and disseminating solar process heat and waste heat recovery systems in the local industry in the 1990s. The programme aimed at reducing dependence on fossil fuels of this compartment, as Egyptian industry is responsible for about 50% of final energy consumption - and approximately 60% of this portion is for process heat.

Other countries like Jordan, Morocco, Tunisia and Turkey have developed or are in the process of developing solar systems for heat applications in their industries. As far as Jordan is concerned, a solar thermal field has been installed in a dairy factory in Russeifa. The garment manufacturer American Jordanian Industrial Company for Apparel also installed solar panels to heat water for wet processing on its factory roof. More recently Nur Solar System company has installed a solar system in an aluminium factory with a pay-back period for such installation of about 10 months.

So far, both Lebanon and Morocco have used the Clean Development Mechanisms (CDM) as an opportunity to finance small scale solar process heating installations. The Lebanese project consists of a solar based steam production system using a 10.3 MW_{th} CSP plant at the Zeenni Trading Agency in the city of Bsarma; the Moroccan project aims at producing steam for eight fish meal factories in Laâyoune from a solar plant using Fresnel technology plus hot water from flat-plate collectors.

As for Tunisia, so far there is no SHIP installation in operation. However, following the success of the PROSOL programme in the residential and service sectors, a similar initiative has been launched, which targets industries called “PROSOL Industrial”, which is currently in the preliminary stages of implementation. Energy audits have been conducted on Tunisian manufacturing companies from the agro-food, textile, chemical and paper sectors. Next step of the PROSOL industrial is to implement a demonstrative sola plant in a low temperature industrial process and analyse real figures from this pilot plant.

Finally, Turkey is gradually discovering solar process heat, given the high potential which is estimated at around 14 million m^2 (Paul, 2008). In particular, the textile and food processing industries seem to represent two potentially attractive markets.

Source: OME, 2012.

3.3. SWH system costs

The cost of a SWH system is quite different across the South and East Mediterranean countries. The average cost of a system ranges from $ 500 USD in Palestine to $ 1300 in Lebanon based on the system configuration. In terms of the investment cost (in $/kWth), it ranges from $ 516 in Lebanon to $ 635 in Tunisia and $ 757 in Morocco, far below than what is marked in some regions of the world.

Table 7 gives a summary of the average cost of a SWH system in the Mediterranean.

Table 7: Average costs of a SWH system in the SEMCs

Country	Average cost of system [USD]	System configuration
Algeria	820	n/a
Egypt	700	Thermosyphon – 150 lit/day
Israel	n/a	n/a
Jordan	930	Flat plate-locally manufactured + hot water tank + cold water tank + stands for tanks
Lebanon	1,300	FP collectors of 3.6 m^2 + 200 liters tanks
Libya	n/a	n/a
Morocco	1,060	2 m^2 with 160 to 200 liters tank
Palestine	500	Thermosyphon
Syria	n/a	n/a
Tunisia	890	Thermosyphon system [2 m^2 surface & 200 L capacity]
Turkey	920	Open-loop, pressureless thermosyphon (180 lit hot water, 70 lit feeding tank)

Source: OME database

In terms of cost by component, the collector and tank account for the largest share of total investment cost. It accounts for more than 75% in Morocco, Lebanon, and Tunisia. In Turkey, however, both installation and the main equipments (collector and tank) account for 45% of total investment cost each (Figure 8: Cost breakdown of SWH system in the SEMCs (OME database)). The high cost of installation of countries like Turkey could be attributed to the relatively high cost of labor. Contrary to other conventional energy sources, renewable energy technologies have low operation and maintenance (O&M) costs.

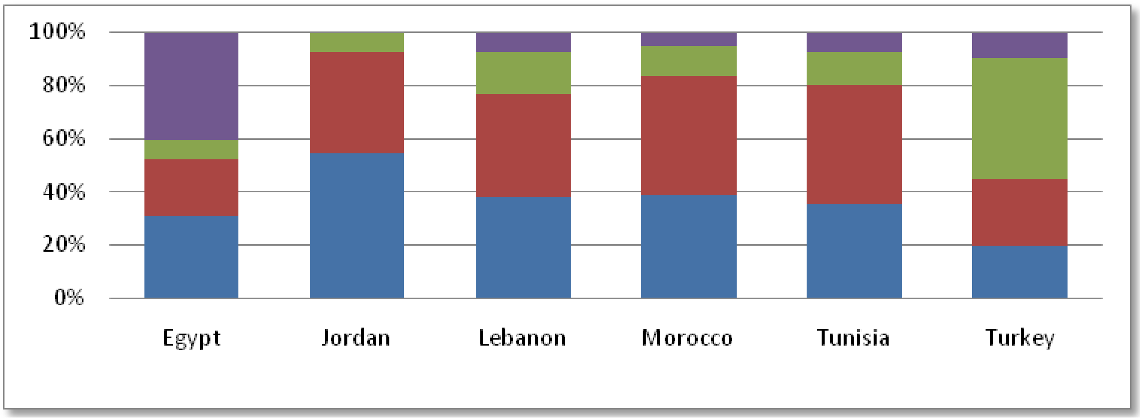


Figure 8: Cost breakdown of SWH system in the SEMCs (OME database)

3.4. Industry actors

The solar thermal industry differs from country to the other and is mainly characterized by small and medium sized enterprises, including small manufacturing workshops.

The solar thermal industry, especially manufacturing, is concentrated in only few countries in the Mediterranean region. Turkey leads the region with more than 30 manufacturers, which well positions it as an exporter of SWH systems in the region.

Table 8 lists the number of industry actors by type in the Mediterranean countries.

Many of the SWH companies are integrated companies or involved in other activities. In Morocco, for example, most solar thermal industry actors are integrated companies (installation, distribution and maintenance).

Besides, the 2 existing manufacturing companies in Morocco are active in solar photovoltaic as well. Likewise, in Turkey almost all the companies are involved in manufacturing, import/export and distribution activities.

Whereas the growth of the SWH industry has grown naturally in some countries like Turkey, the increase of the number of SWH industry actors could be attributed to the adoption of policy support mechanisms in others.

In Tunisia, for instance, the PROSOL Program has induced a significant increase in industry actors, especially suppliers (moved from 6 in 2005 to 49 in 2012) and installers (moved from 120 in 2005 to 1150 in 2012).

Table 8: Solar thermal industry sector in the SEMCs

Country	Industry association	Manufacturer	Retailer	Installer
Algeria	No	2	n/a	n/a
Egypt	The Solar Egyptian Development Association (SEDA)	4	14	5
Israel	Renewable Energy Association of Israel (REAI)	10	6	
Jordan	No	3	10	13
Lebanon	Lebanese Association of Solar Industrialists (LASI)/ Lebanese Solar Energy Society (LSES)	12	100	105
Libya	no	n/a	n/a	n/a
Morocco	Association Marocaine des Industries Solaires et Eoliennes (AMISOLE)	2	50	200
Palestine	No	15*	n/a	n/a
Syria	No	25**	8	n/a
Tunisia	Chambre Syndicale Nationale des Energies Renouvelables (CSNER)	10	49	1,150
Turkey	GUNDER, Turkish division of the International Solar Energy Society	90	800	3,000

*These are mainly workshops; ** Manufacturers including small workshops.

Source: OME database

Industry associations are very important in advocating the industry's interests. They contribute to establishing dialogue between decision makers and firms by bridging the differences between public and private actors and thus contribute to improving the policy making process. Industry associations could also be enablers for innovation. For example, the European Solar Thermal Industry Federation (ESTIF) has an active role in liaising with EU institutions and providing policy advice, facilitating trade, strengthening research and development and lobbying.

Among the SEMCs, several countries have already established a solar industry association.

AMISOLE: Moroccan Association of Solar and Wind Industries

AMISOLE is an industry association gathering thermal, PV and wind actors and which contributes to establishing a dialogue between decision makers and firms and to improving the policy making process. Established in 1987, renewable energy actors in Morocco created AMISOLE to promote their interests and to develop a renewable energy industry. In addition to installation, distribution and maintenance, AMISOLE includes 2 solar thermal manufacturers.

Guidelines of AMISOLE actions in the near future: 1) accelerate the market through regulatory measures, removing subsidies on butane or providing subsidies to SWH, and providing financial support for local manufacturing; and 2) protect the consumer through making testing and labeling more attractive for products certification and certifying installation companies besides technicians.
For more info: www.amisole.com

Source: Amin Bennouna, AMISOLE, Solar Thermal Workshop, Beirut 18-19 April 2012.

3.5. Regulatory & policy framework

Several SEMCs have provided policy support and incentives to SWHs. Nevertheless, some of these support mechanisms in some countries are projects' oriented and thus have limited time frame.

Thanks to solar ordinances for new buildings set up in 1980, Israel's solar thermal market today is beyond what was required by such ordinances. After the 1997-2001 GEF and the Belgian co-operation for a 35% subsidy, Tunisia launched its PROSOL programme in 2005 in cooperation with the Italian Ministry of for the Environment, Land and Sea and UNEP. In Egypt, a solar obligation (not generally applied or enforceable) was introduced in 1987 mandating the design for the use of solar hot water heater in new buildings.

In 2002, with the support of UNDP, Morocco launched its PROMASOL project and ADEREE is designingthe implementation of the "SHEMSI" (National programme for SWH development) based on four elements: financing, labelling, communication, regulatory and legislative framework.

After its 2007-2011 incentive scheme, Algeria launched the ALSOL programme (to 2014) providing for a 45% subsidy of the investment cost. In addition to being an implementing partner of the GSWH initiative and the incentive mechanism based on low interest rate credit by private banks, Lebanon has established a financing mechanism called NEEREA (National Energy Efficiency and Renewable Energy Action) offering loans for SWH installations with 0% interest rate and a 5-year repayment period (starting from 2010).

In 2008, Jordan established a solar thermal obligation for new buildings within the Energy Efficient Building Code.

In Syria, government subsidies and low interest rate loans from private banks are available. Surprisingly, Turkey has an incentive mechanism only for families living in remote areas ("forest villages"), granting an interest free credit by covering 100% of the investment cost, which would be repaid in three equal instalments.

PROSOL

The PROSOL Program was set with the aim of overcoming barriers and thus creating a long-term market for solar thermal in Tunisia. It is based on several components; financial mechanism, VAT exemption, reduced custom duties for SWH, capacity building, awareness raising and carbon finance, and it targets the following sectors:

Residential: a subsidy is granted from the National Fund for Energy Management and a loan to be paid over 5 years. Support measures and success factors include loan guarantee through STEG, synergy between public and private actors, involvement of private financing sector, and a comprehensive communication and awareness campaign.

Tertiary: a subsidy of 30% of the investment with a ceiling of ceiling €75/m^2 financed by the FNME, support for the cost of the study and control and other subsidies from the funds IMELS-UNEP equivalent to 20%. Some of the support measures and success factors are: training leading to a qualification, elaboration of a membership process to the project, coaching for the first projects (study and implementation) and achievement of the different support of the communication plan.

Industry: a subsidy (by FNME) of 30% of the investment with a ceiling of €75/m^2. This mechanism has been accompanied by the achievement of 40 prefeasibility studies for the 40 industrial establishments, information and awareness to indentify interested industrials, the finalization of 10 detailed feasibility studies and the implementation of a pilot project of SHIP.

Source: Souheil Ksouri, Solar Thermal Workshop, Beirut, 18-19 April 2012.

In terms of solar thermal heating/cooling targets, five countries have set such targets, namely Jordan, Lebanon, Morocco, Syria and Tunisia. These targets are, however, indicative and non-binding.

The Tunisian SWH program, for example, has been one of the most successful initiatives in the region. The box above gives an overview of the PROSOL program, its components, targeted sectors, incentive mechanism and success factors.

Table 9 summarizes the main support schemes in the Mediterranean region. In the SEMCs, several policy support mechanisms are in place.

Table 9: Existing support mechanisms in the SEMCs

Support mechanism (they are usually projects' oriented initiatives)	Algeria	Egypt	Israel	Jordan	Lebanon	Libya	Morocco	Palestine	Syria	Tunisia	Turkey
Financial incentives											
Capital grant subsidy	X	X			X		X		X	X	
Operation grant subsidy		X									
Tax incentives				X			X			X	
Low/exemption of customs duties		X		X						X	
Soft loans and loan guarantees					X				X	X	X
Regulatory incentives											
Building regulations/code		X	X	X	X		X				
Equipment standards		X	X	X	X		X	X	X	X	X
Educational incentives											
Technical assistance										X	
Labelling							X				
Training programs										X	
Awareness raising programs							X			X	
Solar heating and cooling targets											
				X	X		X		X	X	

Source: OME

3.6. Research & Development

Research and Development (R&D) activities in the Mediterranean region are not well developed and are mainly financed by governments through public agencies that usually carry out R&D activities. The weak R&D infrastructure and the financing bottleneck which characterize most of the manufacturing companies in the region are key behind such gap.

Although thermosyphon solar water heaters are becoming well established in the SEMCs, with some manufacturing capacities, there is a quite huge potential for the improvement of these system in terms of compactness, reduction of heat losses and the use of advanced material like polymeric materials.

In addition, the use of solar thermal energy in the commercial (mainly tourism) and industrial sector is insignificant, even though these applications have an important potential given that 30% of the overall energy demand in the SEMCs is in the industrial sector (with a majority of heat below 250°C). Further technological improvements would allow solar to contribute significantly to industrial energy requirements.

A very promising technology is solar cooling systems. This technology will benefit from the climate conditions as cooling demand is high during summer time; a very suitable natural condition for such technology. Solar cooling allows for "*avoiding peak load electricity demand and need for additional power production and transmission capacities.*" (IEA, 2012a)

While already established in some countries, research and development activities are evolving and getting consolidated in others. In Morocco, for example, the R&D gap has been recently filled with the creation of IRESEN (*Institut de Recherche en Energie Solaire et en Energies Nouvelles*) to promote and coordinate R&D projects in renewable energy. IRESEN sets 10 calls for projects for the 2012-2016 period. MAD 250 million (around €22 million) has been allocated for the first projects for that period. The first two projects (InnoTherm I & InnoTherm II) were launched in February 2012 and are to be financed by MAD 20 million each (Ikken, 2012). CRTEn, a non-profit institution in charge of R&D projects in Tunisia, is also worth highlighting. It is very active in the development and exploitation of renewable energy (thermal, photovoltaic, wind). CRTEn has extensive expertise in the field testing of renewable energy systems, PV cells & PV systems realisation and modelling and control of PV and thermal systems.

Table 10: Main R&D agencies/institutions in SEMCs

Country	R&D Agency / Institution
Algeria	Institut national des énergies renouvelables; New Energy Algeria (NEAL); Centre de Developpement des Energies Renouvelables (CDER); Centre de Recherche et de Développement de l'Electricité et du Gaz (CREDEG)
Egypt	New and Renewable Energy Authority (NREA); The National Research Center (NRC); Helwan University Solar Thermal Laboratory
Israel	National Solar Energy Center
Jordan	National Center for Research and Development; National Energy Research Centre (NERC); Royal Scientific Society, Water and Environment Research and Study Center (WEEC) – University of Joradan
Lebanon	National Council for Scientific Research (NCSR); Lebanon Industrial Research Institute
Libya	Centre for Solar Energy Studies (CSES)
Morocco	Institut de Recherche en Energie Solaire et en Energie Nouvelles (IRESEN); Agence de Développement des Energies Renouvelables et de l'Efficacité Energétique (ADEREE)
Palestine	Palestinian Energy and Environment Research Centre (PEC)
Syria	National Energy Research Center (NERC); Higher Institute for Applied Science & Technology
Tunisia	Research and Technology Centre of Energy (CRTEn); Centre Technique des Matériaux de Construction, de la Céramique et du Verre (CTMCCV)
Turkey	Center for Solar Energy Research and Applications

Source: OME

Centre de Développement des Energies Renouvelables (CDER)

The Development Centre of Renewable Energies is a government-funded research organization, under the administrative authority of the Algerian's Ministry of Higher Education and Scientific Research. Founded in 1982 and reorganized in 1988 by governmental decree, CDER conducts applied research and development in the fields of renewable energy. CDER carries out application oriented research and development and collaborates closely with universities and industries.

CDER conducts applied research and development in the fields of renewable energy. Its activities include national and international research projects in renewable energy. CDER is globally active in all fields of renewable energy with a strong focus on materials, components, processes and systems for photovoltaic, solar and wind energy. CDER is organized in three units: development unit of solar equipments, applied research unit in renewable energy and research unit in renewable energy in Saharan environment.

Source: www.cder.dz

3.7. Standards & Testing

Standardization, quality and testing are central components of the development of a sustainable solar thermal market. They increase the potential market for products and their acceptance by the final consumers, allow for the elaboration and the implementation of common regulations, and guarantee the access to the market of new players and generate confidence all along the value chain.

The current state of the solar water heating systems market in the Mediterranean countries is quite varied. To increase product quality in the region that is characterized by non-mandatory and not accompanied by third-party verification certification or national standard scheme, the "ArSol"[2] (Arab Solar network) initiative – a regional certification scheme for solar water heaters that is based on the Solar Keymark European voluntary scheme - is under preparation in order to harmonise standard and testing systems throughout the region, thereby increasing quality and performance of solar water heaters, facilitating trade within the region and with the EU and thus creating a sustainable market development of solar thermal products.

[2] ArSol members of official representatives of the national organizations of renewable energies, testing facilities for SWHs, and standardization agencies in the Arab states.

Under this certification scheme, the requirements for ArSol certification of solar collectors and solar water heaters and test methods to be used will be defined. Comparison of test results and products on the same basis would be possible through using the same test methods and same conformity attestation. Membership to ArSol is open to certification bodies, testing laboratories and inspectors in the Arab countries.

In terms of certification for installers, Morocco and Tunisia provide for such certifications to installers to be eligible in their solar water heating programs. Whereas ADEREE (Morocco) grants such certifications, the "Qualitisol.tn" certificate is granted to installers in Tunisia to be eligible for the PROSOL program.

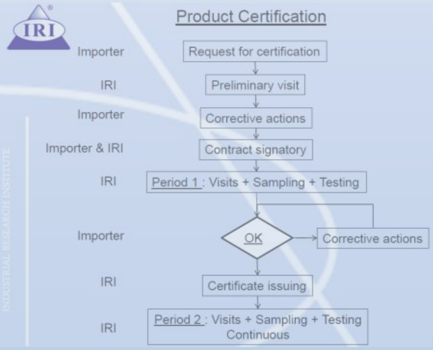
Table 11 gives an overview of the standards, standardization agencies, testing laboratories and certification schemes in the Mediterranean countries.

Industrial Research Institute (IRI)

IRI was established in 1953 and is responsible for studies, research, scientific testing and analysis. IRI has a testing facility for SWH systems.

There are 7 Lebanese norms that have established by LIBNOR and are in line with European standards. Standards are imposed on collectors, pre-manufactured systems in a manufacturing facility, and manufactured systems.

The decree 5305 of 28 October 2010, set certification procedures for SWHs for both imported and locally manufactured products. For the imported products, control is made at the pre-shipment level through inspection and conformity test and control of inspection at the country of origin level. For locally produced systems, a certification scheme is also in place. The graph below shows product certification procedures followed in Lebanon.



Source: Chehade, Solar Thermal Workshop, Beirut, 18-19 April 2012.
For more information: www.iri.org.lb

Photo: http://solimpeks.com/company/

Table 11: Overview of the standardization and certification framework in the SEMCs

Country	Standards Available	Mandatory	Standardization agency	Testing Laboratories
Algeria	N/A	N/A	Entreprise Nationale d'Agréage et de Contrôle Technique	N/A
Egypt	Yes	No	Egyptian public authority for standards and quality	RE Testing & Certification Centre: testing and certifying of ST components and system according to ASHREAE 93/86
Jordan	Yes	No	Jordanian Standardization Organization	Testing of collector performance in line with international standards)
Lebanon	Yes	Yes	Lebanese Institute for Norms and Standards (LIBNOR)	Industrial Research Institute of Lebanon; testing and certification of ST system components
Libya	N/A	N/A	Libyan National Center for Standardization and Metrology	A testing facility has been established
Morocco	Yes	No	Moroccan Institute for Standardization (IMANOR)	ADEREE (formerly CDER) (testing in line with Moroccan norms and quality certification delivering labels)
Palestine	Yes	No	Palestinian Standardization Organization	Testing of collector performance in line with international standards)
Syria	Yes	No	Syrian Arab Organization for Standardization and Metrology (SASMO)	-Higher institute for applied sciences and technology: testing of thermal performance of solar collectors; -Center for Studies and Scientific Research of Syria -Center for Tests and Industrial Research: ensure conformity of SWH systems
Tunisia	Yes	Yes	National Institute for Standardization and Industrial Property (INNORPI)	-Centre Technique des Matériaux de Construction de la Céramique et du Verre (CTMCCV) and Laboratory of « Eco-park de Borj Cedria" (testing in line with standards)
Turkey	Yes	No	Turkish Standards Institution (TSE)	Yes

Source: OME

4. Developing a solar action plan

The suggested solar thermal strategy is built around the main three elements: i) addressing and overcoming the main barriers; ii) highlighting the benefits of SWH; and iii) enhancing public support through strengthening the regulatory framework, standardization and certification, awareness raising, strengthening R&D capacities and strengthening regional cooperation, to overcome such barriers and thus contribute to a market up-take of SWH systems in the region.

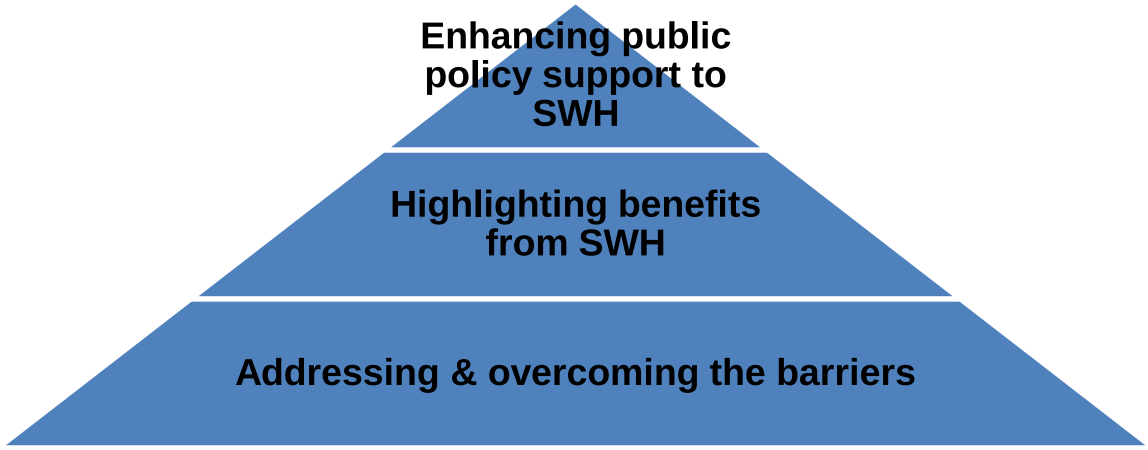


Figure 9: Key pillars in developing solar action plan

4.1. Step 1: Addressing and overcoming the barriers

Several technical and non-technical barriers exist against the uptake of solar water heating systems, thereby necessitating a number of critical factors and policy actions for a wide scale deployment. **Erreur ! Source du renvoi introuvable.** is non exhaustive list of the main existing barriers in the Mediterranean region.

A main barrier which is common to most renewable energy is the high investment cost compared to traditional systems. Overcoming this barrier requires the implementation of specific incentive programs, which help reduce the cost gap between solar thermal technologies and their traditional alternative. This is an issue in many SEMCs, as subsidies are given to fossil fuels and electricity, thus reducing the market prospects for renewable technologies.

A specific barrier which is particularly relevant in the SEMCs is represented by the subsidies given to fossil fuels, which prevent the creation of a level playing field for renewable energy technologies. Shifting these subsidies from fossil fuels to solar (and other renewable) technologies would be therefore the main recommendation in order to foster the development of a sustainable and long-lasting solar industry in the region.

Another barrier which is common to many renewable energy technologies is represented by a certain mistrust vis-à-vis new technologies. Therefore, awareness raising accompanied with the implementation of mandatory certification schemes, with high quality standards, are needed in order to prove that these technologies are reliable and can become competitive if the right signals are given to market operators. In this respect, the ArSol initiative represents a significant step forward.

Also, the lack of synergies among agencies promoting SHW in the region might have a negative impact on the solar thermal market growth. Therefore, stronger coordination at the institutional and regulatory level would be beneficial.

Furthermore, there is lack of reliable data and statistics on the development of SWH applications. The issue of lack of documented return on experience was raised also on the occasion of the regional workshop organised in Beirut in April 2012 (OME, 2012). Developing and maintaining a database is of paramount importance if we want solar thermal technologies to become mainstream. In this respect, initiatives like the "Global Solar Water Heating Market Transformation and Strengthening Initiative" represent a very relevant step forward in terms of knowledge sharing and access to data.

Another shortcoming which was raised during the regional workshop in Beirut is the issue of space availability for solar thermal systems on the roofs. Indeed, in several countries roof surfaces are occupied by other equipments as water tanks, satellite dishes, etc. A more accurate planning and awareness raising campaigns are needed to solve this problem. Building codes are also recommended in this respect.

Table 12: Main identified barriers for SWH deployment in SEMCs

Barriers	Recommendations	Example
High costs of solar systems compare to purchasing power	As many other renewable energy technologies, solar systems are capital-intensive and have high investment costs. However, in the long-term, using these technologies will allow saving conventional energies throughout their operation life. A way to bridge the financial gap is to implement financial incentives	Such mechanisms as the one developed in Tunisia within the "PROSOL" program, would make the access to the technology easier.
High subsidies for conventional energy/electricity	Subsidized fossil fuels or electricity competing with solar water heaters lead to make less attractive solar water heaters. To remove these subsidies will allow SWH to become attractive.	Morocco, within its SHEMSI Program, made a study concluding that the earnings coming from the avoided subsidies to butane will allow the state to invest on SWH through subsidy scheme.
Lack of quality control regulations (testing labs, standards, certification)	The lack of quality control regulation leads to the penetration of low quality products which causes a mistrust vis-à-vis the solar technology from end-users. Put in place a certification scheme in order to ensure the quality of the products put in the market will increase the end users' trust regarding SWH systems.	The Lebanese Center for Energy Conservation (LCEC) has successfully implemented a prequalification scheme for solar water heater manufacturers and suppliers. The scheme enables SWH companies to benefit from the national subsidy programme, which offers SWH clients a USD 200 subsidy in addition to an interest-free loan.
Low awareness of end-users	To overcome this barrier, the setting up of specific awareness raising campaigns could be an adequate solution, targeting not only end-users but also decision and policy makers.	All programmes promoting SWH system such as PROSOL (Tunisia), PROMASOL (Morocco), or ALSOL (Algeria), include an awareness rising component through advertising (TV, radio, etc.).
Surface availability on roofs	Establish building codes including requirements for SWH systems installations and other equipments. Awareness raising campaigns.	Jordan is preparing a Solar Law mandating new buildings to install solar water heating systems, taking into account the roof space challenge, and conflicting use of space.
Lack of data/documentation and monitoring	Most often, data on SWH market are not gathered or access to these data is difficult.	To develop and maintain a database. Initiatives like the "Global Solar Water Heating Market Transformation and Strengthening Initiative" represent a very relevant step forward in terms of knowledge sharing and access to data

Source: OME, 2012

4.2. Step 2: Highlighting benefits

Savings of energy (less consumption of finite fossil fuels) and cost (shorter pay-back period, thereby making SWH systems free afterwards), reductions of polluting emissions (avoids GHG emissions) and job creation are some of the benefits of renewable energy in general and of SWH systems in particular. Thus, a wide scale deployment of solar water heating systems is very important in saving costs for both end users and governments subsidizing electricity or other fuels.

Energy and CO_2 emission savings

Energy savings is one of the benefits renewable energy in general and solar thermal in particular have. The calculations are made based on the assumption that all collectors are glazed using average GHI by country (taken from the market assessment report, OME, 2012) for domestic hot water. The following equation is used to calculate the collector yield.

Glazed collector output, (domestic hot water) = 0.38 (yield) + 15% (pipe losses) = 0.44 * H (horizontal irradiance) * Aa (collector aperture area)

Total energy savings in the SEMCs is estimated at 17895 GWh (=64423 TJ), corresponding to an energy savings equivalent to around 1.6 million tons of oil equivalent (Mtoe). The total annual avoided CO_2 emissions are estimated at 4.7 million tons. Table 14 summarises the main benefits in terms of reduced energy consumption and avoided emissions, both per country and for the total SEMCs.

Table 13: Energy savings and avoided CO2 emissions in the SEMCs

Country	Total collector area (m^2)	Total capacity (MW_{th})	Collector yield (GWh/y)	Collector yield (TJ/y)	Energy savings (toe/a)	CO2 reductions (tCO_2/a)
Algeria	3000	2,1	2,9	10,4	253,9	761,7
Egypt (2010)	650000	455,0	639,1	2300,8	56259,9	168779,7
Israel	4168245	2917,8	3643,0	13115,0	320690,7	962072,0
Jordan (2011)	1066122	746,3	861,9	3102,9	75872,0	227616,1
Lebanon (2011)	311205	217,8	238,3	857,8	20974,1	62922,4
Libya*	6000	4,2	7,3	26,2	640,3	1920,8
Morocco (2011)	340000	238,0	271,2	976,2	23869,6	71608,8
Palestine (2007)	1500000	1050,0	1292,0	4651,2	113731,6	341194,7
Syria (2008)	300000	210,0	229,7	826,9	20218,9	60656,8
Tunisia (2011)	561690	393,2	466,4	1678,9	41053,8	123161,4
Turkey (2011)	17880000	12516,0	10243,6	36876,9	901723,3	2705170,0
Total	26786262	18750,4	17895,3	64423,0	1575288,1	4725864,4

** There are 6000 solar heaters in Libya as of 2012, Abdulwahab Misherghi, Ministry of Electricity and Renewable Energies, Renewable Energy in Libya: Potential, current situation and way forward, Berlin, June 26, 2012*

Source: OME

Job creation

Investments in solar thermal technologies also contribute to economic development, including transfer of know-how, local industry development and capacity building through research, education and training as well as generating employment. Job opportunities exist at both upstream (manufacturing) and downstream (installation, operation and maintenance) levels.

Worldwide employment in 2011 is estimated at about 5 million people (REN21, 2012) in the renewable industry either directly (manufacturing, installation, etc…) or indirectly (jobs related to industry like suppliers of certain items such as copper smelting plants supplying solar hot water manufacturers). Renewable jobs are, however, concentrated in few countries, including China, Brazil, the United States, and the European Union. Both bioenergy and solar hot water industries account for the largest shares in terms of renewable energy jobs. According to the REN21-2012 report, offshore wind and solar thermal heating will witness the greatest growth in terms of jobs, which will be determined by several factors, including policy decisions (REN21, 2012).

In the Mediterranean context, even though the manufacturing jobs are located in a few countries (Turkey), other jobs like distribution, installation and maintenance of solar water heating systems would be across the whole region, thereby contributing to economic development in all the region. Thus, regardless of the manufacturing origins of solar thermal systems, jobs related to distribution, installation and maintenance stay local. Therefore, a wide market penetration of

SWH systems is more likely to generate more employment opportunities in the Mediterranean.

Reducing subsidies

The high up-front investment cost is one of the major barriers for the development of renewable energy technologies, in general, and for SWH systems in particular. Subsidies to fossil-fuel or electricity based water heating constitute a major obstacle for a wide scale market penetration of SWH systems in the SEMCs. This creates market distortions and undermines the growth potential of renewable energy in the region. Figure 10 gives an overview of electricity prices in SEMCs (in USD/kWh).

Thus, it is of paramount importance that SEMCs reform their subsidies system. This could be done through a gradual phase-out of subsidies (either given to butane and LPG, or to electricity generation) and shifting them toward SWH systems. In Morocco, for example, ADEREE (Mezzour, 2012) has found out that investment needed for installing SWH in new building could be compensated through the earnings coming from the avoided subsidies to butane. 1 Dirham invested by the State in the Moroccan National Programme for SWH Development "SHEMSI" could bring 4.3 Dirhams (USD 0.48) back, through the avoided subsidy to butane.

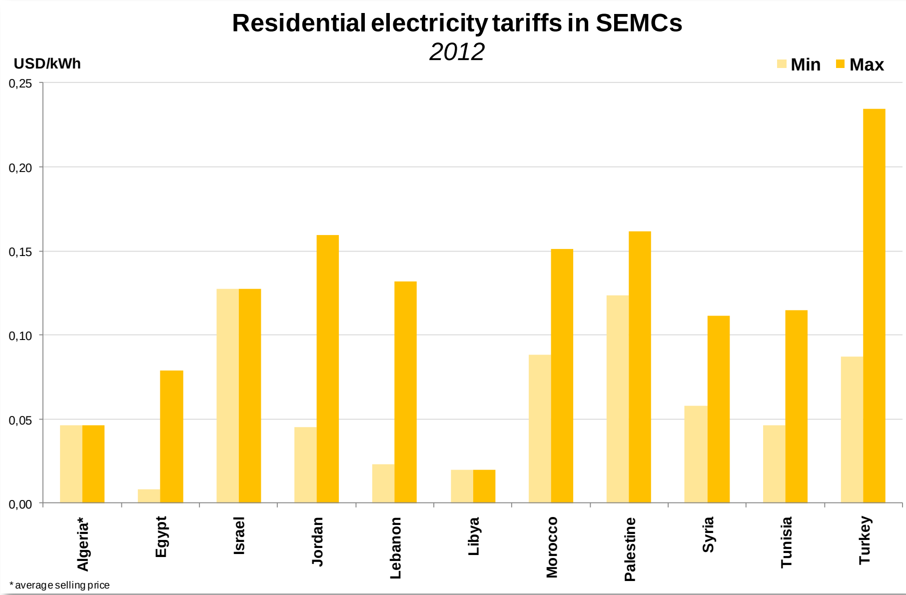


Figure 10: Residential electricity tariffs in the SEMCs (OME)

4.3. Step 3: Enhancing public policy support

To overcome these barriers and thus promote the wide scale deployment of SWH systems, policy makers and stakeholders should enhance public policy support through formulating a comprehensive strategy that considers some of these priority actions, including regulatory and policy support mechanisms (targets, solar obligation, financial incentives, etc); standardization & certification; awareness raising, education and training; promoting technological improvements through RD&D programmes; and enhancing regional cooperation.

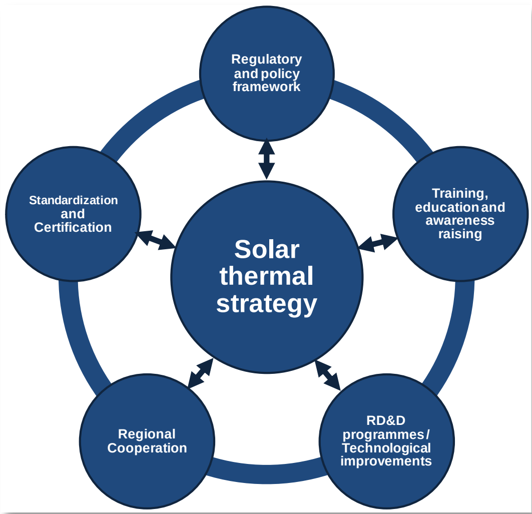


Figure 11: Strategy for solar thermal promotion; *(OME)*

4.3.1. Regulatory and Policy framework

A regulatory framework that provides for policy targets by sector and support mechanisms based on application including new emerging applications is key in the SWH market uptake.

Renewable Heat Targets:

Setting up binding, measurable, achievable and enforceable progressive targets is a significant step towards a large scale penetration of SWH systems. Progress monitoring could play an important role in achieving those targets. However, targets need to reflect the market potential given technical and economic considerations. Thus, each country has to identify the share of renewable energy in its energy needs, including those of heating and cooling targets; specific targets by sectors are of paramount importance as well, thereby necessitating particular evaluation of potential of each sector while taking into account technical challenges related to building integration, storage, etc.

Therefore, for countries that have not yet set such targets, it is necessary that governments integrate policy targets for SWHs in their respective energy policies and energy laws and regulations as well as identify actions needed to achieve those targets. Putting in place higher targets for public buildings like schools, hospitals, etc could promote the adoption of such SWH systems. Setting indicative or very ambitious targets (which cannot be achieved due to economic or technical challenges) alone might not be enough, however, if they are not accompanied with support measures.

Policy Support Scheme:

A stable legislative and regulatory frameworks providing for such policy support mechanisms and incentives are key in the wide scale deployment of SWHs. Policy support mechanisms are important in terms of correcting for market failure. An innovative support scheme that avoids “stop and go” problems and guarantees a sustainable SHW growth is essential in any policy action. Predictability and transparency are very important elements in such policy support schemes as they give a clear signal to market operators/investors about the government’s objectives and targets.

Solar regulations and mandatory obligations, in particular, could be an interesting policy support mechanism to be widely applied in the region. This scheme would be mandated on real estate developers and individual homes, where possible, for new buildings. Some of the guidelines for the implementation of solar obligations developed by ESTIF (2007) are: i) avoid overly detailing technical and design requirements, ii) standardized product requirements across the whole region and iii) quality assurance to be introduced and randomly checked.

To overcome the high up-front investment costs, innovative financial incentives should be created. This could be achieved through gradually de-subsidizing fossil fuels and shifting these subsidies to renewable energy in general and to solar technologies, in particular. Overcoming this barrier requires also the implementation of specific incentive programs, which help reduce the cost gap between solar thermal technologies and their traditional alternatives. For best practice of financial incentives (ESTIF, 2007), they should be part of a comprehensive approach, designed for several years under stable conditions, avoid early announcement of improved financial conditions, making sure the availability of funds while considering introducing “Polluter Pays Principle” in case of lack of such funds, easy and lean procedures, standardized product requirements and certification procedures across the region, tailored quality criteria on the installation of each country, and sufficient amount to provide a real incentive.

Access to finance for SWH systems could also play a role in the market uptake. Engaging banks in providing loans as has been done in Tunisia is an important element in reducing the burden on state budget and thus avoiding “stop” and “go” problems that might be due to unsustainable government subsidized programmes.

4.3.2. Awareness Raising, Education and Training

Awareness raising is a key element in bridging the knowledge gap about a certain technology in society and, thus, overcome the social acceptance barrier vis-à-vis solar thermal technologies. As was highlighted in the regional workshop on solar thermal held in Beirut, awareness was one of the main issues explaining the lower penetration rate of solar water heating systems in the region. That said, policy makers, public agencies in particular responsible for the promotion of renewable energy and energy efficiency, need to fill up this knowledge gap to promote a wide scale deployment of SWH systems. Several tools could be used in this regard, including spots on radios, TV, newspapers, and on their own websites.

The GSWH awareness raising guide provides steps before initiating an awareness raising campaign: 1) using data and market surveys, 2) building on and learning from previous campaigns and marketing activities, 3) ensuring that supply could meet demand, 4) assuring quality and performance of supplied products, 5) evaluating market conditions (SWH market, renovation and construction sectors, prices of fossil fuels), 6) having a positive and favorable policy and regulatory framework (ESTIF, 2012).

Actors that could be involved in an awareness raising campaign: 1) government and other public bodies (government, local authorities, agencies responsible for energy, and international bodies), 2) industry associations and companies, and 3) others (installers, plumbers, specialized retailers, roofers and carpenters; certification bodies, test laboratories, research & development institutes; consumer organizations and civil society) (ESTIF, 2012).

In terms of education and training, well prepared professionals, including architects, planners and installers would be key in promoting a wider penetration of solar thermal application systems.

Technical and vocational education is of paramount importance in preparing highly qualified technicians. Thus, tailored programs on solar thermal technologies should be designed and integrated in training programs related to renewables.

Integrating knowledge materials in education could help bridge this knowledge gap. Such educational tools could include elements such as: energy costs, while highlighting subsidized products such as gas, oil and electricity; benefits of solar thermal applications in terms of energy savings and CO_2 reductions; and energy security. It could be useful underlining also the incentives the government provides and the administrative procedures to benefit from such incentives. It is worthwhile highlighting the initiative taken in Libya (Agha, 2012) about integrating energy issues in elementary education to raise awareness among students about renewable energy.

4.3.3. Standardization and Certification

Standardization and certification of products is another added value in the region, especially in intra-regional trade and ultimately for export to other regions. Most of the SEMC countries have set up a certification scheme or a national standard for solar thermal collectors and systems. However, these mechanisms are not mandatory and are not accompanied by third-party verification. Therefore, imposing mandatory certification schemes is necessary to prove that these technologies are reliable, thus giving a positive signal to stakeholders. Certification and accreditation could also be required for installers

The “ArSol” initiative is worth emphasizing as a step towards harmonization of standard testing systems in the region. The “ArSol” initiative has been launched by the League of Arab States, the Arab Industrial Development and Mining Organization (AIDMO) and the Regional Centre for Renewable Energies and Energy Efficiency (RCREEE) to establish a regional certification scheme for solar water heaters. Adopting the scheme by the Arab Ministerial Council of Electricity is more likely to overcome market barriers, enhance the quality of products, and thus promote more trade. Once in force, all the countries need to accept the ArSol certified products so that they promote more intra-trade among each other and trade with other countries as well.

4.3.4. Technological improvements/RD&D programmes

Technological improvements are key in a wide scale deployment of SWH systems. Technological developments have been done on several components to increase thermal efficiency, which would therefore contribute to the decreasing cost of heat from solar thermal systems. Research needs identified by the RHC-Platform (2011) regarding solar thermal are:

- Solar collectors: i) improvement of cost and performance of low temperature collectors; and ii) create a mass market in process heat collectors with working temperatures up to 250˚C
- Compact, high density heat storage and refrigeration
- Multi-functional building elements like fully integrated façade and roof collectors
- System designs for industrial applications

The IEA has developed several renewable energy technology roadmaps, including solar thermal for heating and cooling, by outlining actions needed, milestone timeline (2012-2030) and stakeholders involved (research institutes, SHC and cooling industry, universities, etc).These roadmaps draw specific recommendations for each component, including flat-plate and evacuated tube collectors, concentrating solar for heat applications, solar heat for cooling, thermal storage and hybrid applications and advanced technologies. Below are some of these recommendations that the SEMCs could consider to enhance their R&D capacities, excluding concentrating solar for heat applications and hybrid applications and advanced technologies.

Table 14: Technology roadmap actions

Item	Actions
Flat-plate & evacuated tube collectors for heat	▪ Integrate solar collectors in building surfaces; ▪ Use alternative materials, technologies and manufacturing techniques for system cost reduction and performance improvement; ▪ Address challenges in system design by development of standardized kits and plug-and-function systems; ▪ Expand development of collectors that cover temperature gap between 100˚C and 250˚C; ▪ Address challenges in development of medium to large-scale systems by developing pre-engineered solutions and improving system design knowledge
Solar heat for cooling	▪ Increase thermal COP and electric efficiency of solar thermal driven cooling systems (COP), including developing new cycles and storage; ▪ Address challenges in system design by developing standardized kit solutions and plug-and-function systems; ▪ Develop small scale thermally driven solar cooling technology for single family and multi-family dwellings; ▪ Develop integrated thermally driven solar cooling and heating technology, including compact storage; ▪ Explore potential for retrofitting existing vapour compression systems into solar thermally driven cooling
Thermal storage	▪ Continue developing promising materials for compact thermal energy storage, particularly phase change materials, sorption and thermochemical materials. ▪ Validate stability of materials and performance characteristics. Create linkages with other sectors, for instance R&D into thermal storage for CSP and industrial processes; ▪ Research new materials for medium-temperature storage, between 100C and 300 C, such as phase change, sorption and thermochemical materials. Demonstrate systems in which the new storage technologies are integrated.

Source: OME based on IEA Technology roadmaps

4.3.5. Regional Cooperation

Creating a regional platform for dialogue, experience sharing, and collaborative programs could also contribute to a wide scale deployment of SWH systems in the region. A plat-form that brings together industry associations is to be considered. Setting such association would require strong commitment from stakeholders, especially in terms of financing. Such cooperation could be at several levels, including the institutional and regulatory levels. It is worthwhile highlighting the creation of the Regional Centre for Renewable Energy and Energy Efficiency (RCREEE) to promote more regional cooperation in this regard.

In this respect, for example, a "regional workshop for the Transformation and Strengthening of the Solar Water Heating Market in the Mediterranean" under the GSWH initiative was held in Beirut on 18-19 April. Lebanon was chosen as it is one of the implementing countries of the global initiative in the region. This event was organized by OME, UNEP and UNDP in collaboration with the Lebanese Center for Energy Conservation (LCEC), and under the auspices of the Ministry for Energy and Water of Lebanon.

Regional cooperation could also be strengthened through financial instrument like the Mediterranean Investment Facility (MIF). It is an initiative promoted by the Italian Ministry for Environment, Land and Sea (IMELS) in partnership with UNEP to develop a sustainable market system in the Mediterranean and Balkan regions. The IMELS has provided a financial contribution amounting to USD 10 million to increase available financing for RE and EE systems in Morocco, Egypt, Tunisia, Macedonia and Montenegro (Moretta, 2012).

In addition to the ArSol initiative for standardization and certification, other aspects of regional cooperation could be through joint R&D programs and building a regional database for knowledge sharing. Establishing joint research and development (R&D) programs among key research institutions in the region, form one hand, and between south countries and European research centres on the other hand, could be effective in fostering more regional know-how transfer and regional cooperation. Given the lack of reliable data and statistics on the development of SWH applications as well as the lack of documented return on experience in the region (OME 2012), developing a database for knowledge sharing is very important in this regard.

Table 15 gives a summary of the main actions that need to be taken to enhance the policy support landscape and thus contribute to the wide scale deployment of the SWHs in the SEMCs.

Table 15: Summary of the identified actions for solar thermal promotion in SEMCs

Areas of intervention	Identified actions
Regulatory and policy framework	▪ Setting up binding targets with progress monitoring; ▪ Adopting a legislative framework providing for support mechanisms, including solar regulations; ▪ Phasing-out of fossil fuel subsidies; ▪ Engaging banks in providing loans for SWHs
Training, education and awareness raising	▪ Conduct awareness raising campaigns including spots on radios, TV, newspapers and websites, etc; ▪ Involving all the stakeholders in the design of such awareness campaigns; ▪ Design education tools including energy costs, subsidies, benefits of solar thermal application, etc; ▪ Design special program in the technical and vocational training
Standardization and certification	▪ Imposing mandatory certification schemes ▪ Requiring certification and accreditation for installers ▪ Adopting the “ArSol” scheme at the national level
Technological improvements/ RD&D	▪ Strengthening R&D capacities for the following components: solar collectors, storage, multi-functional building elements like fully integrated facade and roof collectors, and system design for industrial applications
Regional cooperation	▪ Creating a regional platform for dialogue, experience sharing and collaborative programs like regional industry association; ▪ Establishing joint R&D programs; and ▪ Developing a database for knowledge sharing

Source: OME

5. Conclusion

The objective of this action plan was to identify the enabling environment for boosting and investing in solar water heating in the South and South East Mediterranean Countries (SEMCs) by showing the status of solar thermal technologies, their potential benefits and prerequisites for an uptake of this market.

Several barriers were highlighted during the Regional Workshop organized by OME in Beirut within the Global Solar Water Heating Market Transformation and Strengthening Initiative framework. Experts raised questions related, in particular, to high up-front investment costs, institutional gaps and low awareness among the end users, etc.

The present action plan highlights some of the critical factors that are prerequisites for a wide scale deployment, including regulatory and policy framework, technological improvements and cost reduction, and social acceptance. These success factors should be well tailored to each country's priority needs. The action plans further provides for priority actions that need to be taken in order to overcome such barriers, including regulatory and policy support schemes (targets, financial incentives, etc), standardization and certification, awareness raising and promoting regional cooperation.

This action plan complements the Regional Workshop and the Market Assessment Report under the framework of the fore-mentioned initiative. The workshop "proved to be a very effective way for enhancing regional coordination, learning through case studies and best practices, and increasing knowledge sharing." The Market Assessment Report presents "updated information on the state of the art of the SWH market in the Mediterranean region as a whole, and in 13 selected countries."

For the next steps, a Business to Business (B2B) workshop is fore-seen for early 2013 to bring together the private sector stakeholders. As was highlighted during the Regional Workshop through the workshop evaluation questionnaire, industry actors expressed their interest in the organization of such event. They, in particular, showed interest in i) subcontracting or co-sourcing agreements, ii) exportation/importation, iii) technological partnerships (transfer of know-how, exchange of staff), iii) establishment of new business activities (through, e.g.: subsidiary company representative office, etc) and iv) strategic partnerships (through, e.g: joint venture, representative agreements, etc.)

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