Solar Thermal Action Plan for Europe

Intelligent Energy Europe

Short guide to this document

The present document is the integral version of the Solar Thermal Action Plan for Europe. It is the compilation of the following set of documents that have been published separately:

a) Summary version, published as a printed colour brochure (January 2007)
b) Best practice regulation for solar thermal (ST) (August 2007)
c) Best practice financial incentives for ST (August 2006)
d) Innovative applications: Solar Cooling (August 2006)
e) Innovative Applications: Process heat (August 2006)
f) Quantifying energy delivery of individual ST installations (August 2007)
g) Verifiable targets for ST in Europe (August 2007)

The summary version, i.e. the first chapter of the present document, is a general document targeted at a wide public of people interested in the development of solar thermal energy.

The other sections have been written for a specialised public interest in policy making and in the details of the implementation of solar thermal policies.

Except for some update in the introduction and further minor corrections and updates, the content has is identical to the publications above. The only differences are that this document presents all at once, and that the quality of the brochure's layout has been reduced.

All individual documents above, as well as a number of deepening materials are available at www.estif.org/stap

The Solar Thermal Action Plan has been produced within the framework of the project Key Issues for Renewable Heat in Europe (K4RES-H), co-financed by the Intelligent Energy - Europe Programme of the European Commission and coordinated by ESTIF. Within this project, guidelines for best practice policies on different issues related to renewable heating and cooling are developed.

Solar Thermal Action Plan for Europe (Summary Version)

Solar Thermal Action Plan for Europe – Summary Version

Introduction

Ten years ago, the European Commission published its White Paper on Renewables, proposing a Community Strategy and Action Plan. Since then, European Directives to promote renewables in the electricity sector and in the transport sector have been successful in kicking off substantial growth in these two sectors.

However, the renewable heating and cooling (RES-H) sector has been neglected at EU level and in most Member States. Thus, the fragmented solar thermal development is not surprising. If all EU countries used solar thermal as enthusiastically as the Austrians, the EU's installed capacity would already be 91 GW_{th} (130 million m^2) today, far beyond the target of 70 GW_{th} (100 million m^2) by 2010, set by the White Paper in 1997. However, this target will be missed by a wide margin, due to the numerous countries that are still in the starting blocks.

Differences in the policy framework are a key factor for explaining the gap in solar thermal development. The lack of a European policy framework certainly contributed to the lack of focus on solar thermal that most Member States have been suffering from.

Therefore, ESTIF initiated in 2004 a campaign calling for a European Directive to promote Renewable Heating and Cooling (RES-H). This campaign was first supported by the other renewable energy sectors organized in the European Renewable Energy Council (EREC), and later on by hundreds of stakeholders from all over Europe, including industry, NGOs, academics, energy agency and a growing number of policy makers.

In February 2006, the European Parliament adopted by overwhelming majority a resolution asking for a strong new Directive to promote RES-H. The resolution was originated by an Initiative Report tabled by MEP Mechtild Rothe. At the same time, the European Commission started to integrate RES-H into its strategy papers dealing with renewable energy policies.

ESTIF warmly welcomes the unanimous decision of the Heads of State of the 27 EU Member States to set a binding target of a renewables share of 20% of the total energy consumption by 2020, following the recommendations of the European Commission, in its Renewables Roadmap of January 2007. Beyond the ambitious and necessary 20% target, the big news of 2007 is that, for the first time, RES-H will be fully included into the future new Directive on Renewable Energies.

The 20% target can only be reached if RES-H will grow strongly. And solar thermal will play a growing and major role in the renewable heating and cooling sector. Solar is a completely clean source of renewable heat. And solar does not imply the increased use of scarce resources like biomass fuels or electricity capacity, in the case of heat pumps. Solar thermal can be applied almost everywhere. Already today, it is one of the most cost competitive renewable technologies: in millions of buildings, solar can be deployed today with payback times far shorter than the lifetime of the systems. And solar thermal still has a large potential for economies of scale, cost reductions and technological progress. And solar thermal replaces imported fuels with local jobs: more than 50% of the turnover is inherently local, as it is linked to distribution, system design, installation and maintenance.

While the political debate at EU level develops, all Member States are urged to act as soon as possible to promote solar thermal in their own country.

This Action Plan helps policy makers to identify successful support strategies. The analyses carried out in the course of the Key Issues for Renewable Heat In Europe project clearly show: Public support policies have had a strong impact on the successful development in countries as diverse as Greece, Austria, Germany and recently also France and Spain.

The most successful countries have supported solar thermal over longer periods – thus avoiding a destructive stop-&-go of the market – and have implemented a coherent mix of measures, which address not one but several barriers to growth.

Today & Tomorrow

Solutions for sustainable heating & cooling

The lion's share of solar energy worldwide

With solar energy we can produce heating and cooling (solar thermal) and electricity (photovoltaic and concentrating solar power).
Solar thermal makes up more than 90% of the solar energy capacity installed worldwide. It is one of the most cost effective forms of renewable energy and has an immense potential for growth, within Europe and beyond.
Solar thermal systems are based on a simple principle known for centuries: the sun heats up water contained in a dark vessel. Solar thermal technologies on the market now are efficient and highly reliable, providing solar energy solutions for a wide range of areas of use and potential users.

Areas of use

Domestic hot water and space heating

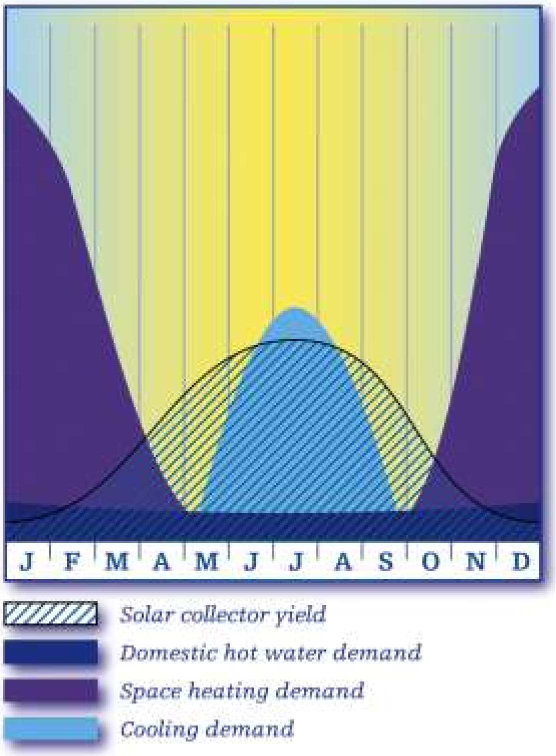
Most of the energy consumption of households is linked to two basic needs: hot water, and warm rooms in winter. To meet them we need low temperatures in the range of 40-60°C, that can be easily supplied from the sun, avoiding an unnecessary waste of oil, gas or electricity.

Even the simplest solar thermal systems can provide a large part of the domestic hot water needs. With some more initial investment, nearly 100% of the hot water demand and a substantial share of the space heating can be covered with solar energy. Natural flow systems work without any need for pumps or control stations. They are widely used in Southern Europe. Forced circulation systems are more complex, and can also cover space heating. These so called Solar Combi systems are more common in Central and Northern Europe.

Solar assisted cooling

A growing number of demonstration projects shows the huge potential for solar assisted cooling. Solar chillers use thermal energy to produce cold and/or dehumidified air. When backed up by biomass boilers, 100% renewable cooling systems are possible. Solar cooling is at the edge of wide market introduction and substantial cost reductions are expected in the next few years, through technological development and economies of scale.

Solar cooling & heating system: demand & supply



Solar thermal can cover a substantial part of the heating and cooling demand in a typical Central European building.

A typical solar cooling system also provides both space heating and hot water – which is why they are often called Solar Combi+ systems. For hot water, the demand is relatively stable throughout the year and can be covered completely by solar energy. The demand for space heating is higher in winter when solar energy is less available. Ordinary solar thermal systems cover only a part of the space heating demand, with the remainder covered by a back-up system.
Cooling demand in summer typically correlates with high solar irradiation. Then, solar energy can easily provide more than half of the energy required for cooling, the remainder being provided by the same back-up system used in winter for heating.
This will be a key answer to the problems created by the growth of cooling demand in many European countries.

Industrial process heat

Solar thermal can also provide the heat needed in many industrial processes. Ordinary solar collectors typically provide temperatures around 60-100°C, that are suitable for many applications like food processing, water desalination, industrial washing processes etc. These uses cause a significant share of the industrial heat demand. Medium temperature collectors for higher temperatures have been demonstrated but further research and development is needed to standardise them and to reduce their costs. Process heat applications are still very rare, but there is a large potential for growth in this area, as solar thermal becomes more cost competitive and awareness of decision makers increases in this area as well. (718)

Swimming pools

Inexpensive unglazed collectors are an ideal solution to achieve a longer bathing season without energy consumption. With glazed collectors, high solar fractions can also be achieved beyond the summer and solar energy can be used for both space heating and clean, hot water.

Market segments in the building sector

Small residential

Roughly 90% of the solar thermal market volume in the EU has so far been in the small residential sector.
In Austria, 15 % of one-family houses are already equipped with a solar system. The market share of Solar Combi systems, providing both domestic hot water and space heating, has recently grown to almost 40%.
In this segment solar thermal has meanwhile become a standard product, installed millions of times in Europe, but most of them in three countries only (see next pages).

Large residential, tertiary and industrial buildings

Solar thermal can be particularly convenient for larger central heating systems, and particularly where there is a relatively constant heat demand. This is often the case in large residential buildings, hotels, elderly or student houses, hospitals, sport centres, shopping centres etc. These kinds of buildings usually offer optimal conditions for the use of solar thermal energy, including cooling.
There is already a broad technical experience with these larger systems, and in Spain they are the dominant system type. In many other countries, however, the level of market penetration is still very low, mainly due to social, legal and economic factors.

For more information and a good practice database, visit: www.solarge.org.

Key benefits of solar thermal
- inexhaustible
- reduces the dependency on imported fuels
- saves CO_2 emissions at low costs
- curbs urban air pollution
- creates local jobs and stimulates the local economy
- is a proven and reliable renewable energy source
- is immediately available – all over Europe

Solar thermal tomorrow

Today, mature products exist to provide domestic hot water and space heating with solar energy. But in most countries they are not yet the standard option in buildings. The European Solar Thermal Technology Platform (www.esttp.org) has developed a vision for solar thermal in 2030, which shows that by then up to 50% of the low and medium temperature heat can be covered by solar thermal. Integration into buildings will be significantly improved, costs will go down and the almost untapped potential in the non-residential applications will be more and more exploited through newly developed technology. Public support for market introduction and for research and development will help to reach this critical mass of the sector, from which it will be able to grow in a self-sustained way.

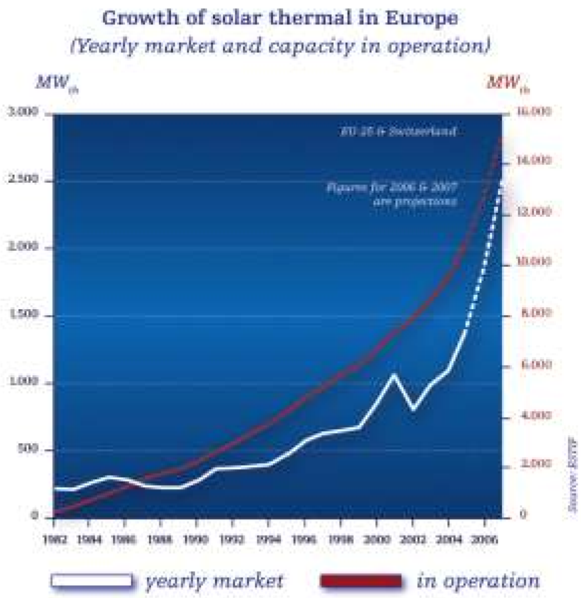
Market growth, targets and potential

A growing market

The European solar thermal market is booming. A growth rate of well over 30% is expected for 2006.

Based on provisional figures, the market volume in the EU-25 has been very close to 2 GW_{th} newly installed capacity in 2006, compared with 0,6 GW_{th} 10 years before. The total solar thermal capacity in operation was 5 GW_{th} in 1997, 10 GW_{th} in 2004 and will reach 15 GW_{th} in 2007.

Around 2 million European families already directly benefit from solar thermal energy, as do other frequent users such as hotels, sport centres, office buildings etc.



Beyond policy support, which is discussed in other parts of this document, the main drivers of these high growth rates are:

- growing awareness for solar energy, at least in some countries;
- increasing prices of conventional energies;
- growing concern over the security of supply with imported fuels;
- the unmistakable and visible signs of climate change.

At the same time, the solar thermal industry has improved its products and services and is widening its distribution networks.

A positive development is the growing market share of Solar Combi systems, which support space heating as well as producing domestic hot water, thus leading to higher energy savings. In Austria, Solar Combi systems already have a market share of more than 35%.

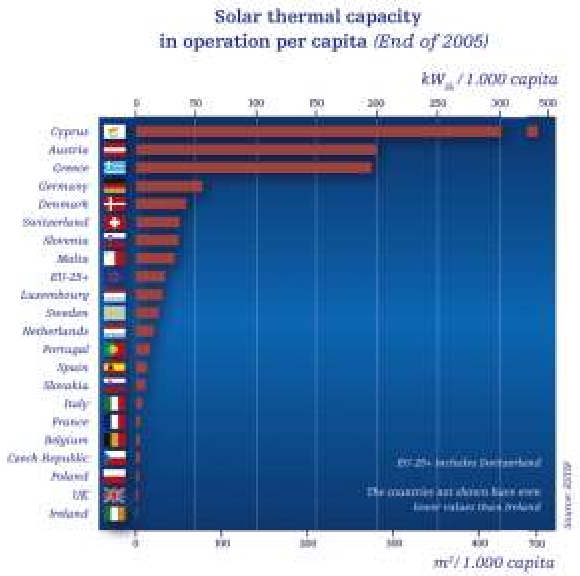
Most countries are still in the starting blocks

However, this growth is still only driven by a few leading countries, whereas most EU countries have yet to begin substantial market development.

For many years, over 70% of the solar thermal sales have only been concentrated in three countries: Germany, Austria, Greece.

France and Spain have had very good growth rates in the last few years, but they still have much smaller markets than Austria or Greece, which only have a fraction of their population.

At the end of 2005, the capacity in operation per capita ranged from 431 kW_{th} / 1000 capita in Cyprus and 199 in Austria to less than 10 in high-potential countries such as Italy, France and the UK.



In comparing the capacity in operation per capita of regions with similar climatic and economic conditions:

- Greece beats Southern Italy nearly 50 to 1;
- Austria beats Northern Italy by more than 20 to 1.

Similar ratios can also be observed when comparing neighbouring regions of France and Germany, or Denmark with the UK.

These huge differences are a problem and an opportunity simultaneously:
Problem: because the low market development in most EU countries tends to be a self-perpetuating situation (see page 18). Economies of scales are missed as long as only a few countries have substantial market volumes.

Opportunity: because the leading countries demonstrate in practice the huge potential which is easily achievable at EU level.

Targets for 2020

15% of detached houses in Austria already use solar thermal. In some villages, solar collectors can be seen on most roofs and people are proud of them. This shows the way ahead for the rest of Europe.

Even in Austria, 85% of detached houses still have no solar heating, of which only a tiny fraction are not suitable for technical reasons. Thus, the potential for growth is immense, particularly considering other market sectors such as multi-family houses, industrial and office buildings, which have been less developed sectors to date.

The ESTIF 2020 minimal & ambitious targets are based on a mix of technical, economic and political considerations.

Technical: market phase-in of new applications, considerable advancement in heat storage and solar cooling which will impact on the market around 2015-2025.
Economic: further cost reduction of solar thermal, and the continuing cost increase of fossil fuels.

Political: business as usual, i.e. fragmented support for the minimal target; strong support EU-wide for the ambitious target.
The following table shows the energy produced by solar thermal systems in the EU in the past and in the future, according to the scenarios and the long term potential discussed below.

	capacity in operation[1] (GW_{th})	kW_{th} per 1.000 capita	Energy produced (tons per oil equivalent)
1990	2,2	5	137.897
2005	11,2	24	686.493
Minimal target 2020	91	199	5.600.000
Ambitious target 2020	320	700	19.650.000
Long term potential	1.200	2.600	73.100.000

[1] The capacity in operation (GW_{th}) is obtained by the globally accepted conversion rate: $1m^2 = 0,7$ kW_{th}. ESTIF assumes an EU average of 500 kWh/year/m^2 energy production. National averages vary strongly depending on solar radiation and other factors.

2020 minimal target (Austria scenario)

The minimum goal for the EU in 2020 should be to reach the solar thermal usage of 199 kW_{th} per 1.000 capita of Austria in 2005, equivalent to a total capacity in operation of 91 GW_{th} in the EU.

This central European country needed 20 years to reach this level, but meanwhile new and improved products have been developed and now there is an established European-wide industry. The market growth rate needed to reach this minimal target is 16% per year, well below the EU average of 2002-2006. However, to reach this target a better political framework is needed throughout the EU, to make sure that the growth is shared in all countries.

2020 ambitious target (1m^2 per capita)

With a suitable support framework it will be possible to reach 1 m^2 of collector (0,7kW_{th}) for every European in 2020, equivalent to a total capacity in operation of 1.190 GW_{th} in the EU.

In the residential sector alone about two million EU families have already installed this amount of solar capacity.
To reach this target, solar will be widely used for both cooling and process heat, though the majority of this capacity will still supply domestic hot water and space heating.

The average yearly growth rate of the EU market necessary to reach this target is 31 % – less than the rate achieved in 2006 and only 7% above the 2002-2006 average.

Long term potential

The long term technical potential assumes that solar thermal is used wherever technically reasonable. This long term solar thermal technical potential for EU-15 was estimated in Sun in Action II (ESTIF, 2003) and extrapolated for EU-25.

In the long term, this will be a foregone conclusion. In a few decades, wasting gas oil or electricity for low temperature uses such as space heating will no longer be an option. There will be strong competition for limited biomass resources. For heating and cooling, solar will be the main outstanding alternative, combined with geothermal where available.

Replacing imported fuels with local jobs

Building up a dynamic industry

What started in the 1970s as garage businesses is now an established international industry. Some of the pioneers are still amongst the market leaders. A number of major players from “neighbouring” sectors entered the market. At the same time, some solar thermal companies are diversifying into other renewable energies such as biomass heating or solar PV.

The large majority of the systems sold in Europe are manufactured within the EU or its Mediterranean neighbours. Imports from Asia are limited mainly to components such as evacuated glass tubes. For European manufacturers, exports outside the EU are becoming a growing market. The main selling point is their high quality and reliability.

The industry is in a phase of dynamic growth. Production lines are constantly being expanded. Employment in the European solar thermal sector already exceeds 20.000 full time jobs.

As in all industrial sectors, manufacturing will be more exposed to global competition as the market develops. However, for solar thermal, nearly half of the jobs are in retail, installation and maintenance. These works are necessarily local, and create jobs mainly in small and medium sized enterprises, directly in the areas where the solar thermal market develops.

For the time being, solar thermal is used together with a source of backup heating. Therefore, solar thermal does not replace another industry's products, but really adds new demand and jobs. This higher initial investment pays off for the investor by reducing the conventional fuel bill over the lifetime of the system. For society it is even better: Solar thermal replaces imported oil and gas with local labour!

With solar thermal going into the mainstream, employment in the sector at EU level will reach half a million full time jobs within the next few decades.

Training and Education

Training and education are key to achieving a wider adoption of solar thermal energy. Of course, it is necessary to increase the awareness of end consumers of solar thermal. However, a decisive role in the market is played by professional groups such as architects, planners and installers, who are the interface between end consumers and industry. These professionals often determine, or have a strong influence on, the end consumers' choice about heating systems.

Usually, the standard education and training of these professionals does not include solar thermal technologies. Unfortunately, this is still the case for the current training patterns in many countries.

For this reason, many of these professionals do not feel comfortable recommending solar thermal to their customers, or even discourage them to avoid dealing with a technology still unknown to them. At the same time, lack of training can lead to poor planning and installation, thus creating quality problems and decreasing the acceptance of solar heating.

Solar thermal is not rocket science, but it should be included in normal training of relevant professionals – all over Europe. This would immediately tear down one of the main barriers to growth today.

European industrial leadership

The European industry is the worldwide technological leader in solar thermal.
High efficiency collectors use highly selective absorber coating, which absorb more solar irradiation and emit less infrared radiation. This increases the overall solar thermal energy production. These coatings are available only from a small number of European manufacturers who export their coated material to collector manufacturers worldwide. Europe is also leading in research and manufacturing of high quality heat tanks.

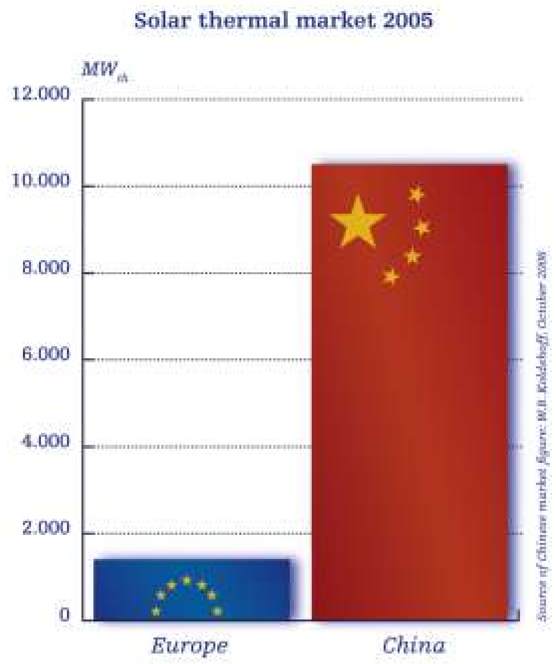
In solar cooling, European researchers and companies have a clear technological lead. Beyond system design and high quality collectors, the key challenge for wide market introduction of solar cooling lies in the development of smaller and more cost-effective thermally driven cooling machines. More recently, products have been developed that can also be used in small residential buildings, opening new market segments for solar cooling. Most of these new machines have been developed in Europe, and various new companies have been founded here to bring them into the market.

Preparing for global competition

A glance at the growing competition for scarce resources on the global energy markets is enough to understand that solar thermal will be used almost everywhere possible during the 21st century.

Conservatively estimated, this market will have a value in the order of 10.000 billion €, without considering replacements and maintenance. Europe is in a good position and has the chance to be the main beneficiary of this new global business field.

In most renewables, Europe is leading both in technology and in the market volumes. However, the latter is not the case for solar thermal, where the Chinese market alone is 7 times bigger than the EU market.



Given the price levels, European manufacturers cannot easily compete in markets like China, India and Turkey. If the EU does not catch up soon with a substantial growth in the domestic market, the European industry will face a hard task in maintaining its technological leadership.

Beyond market growth, maintaining the technological lead requires a joint effort to define and implement the research strategy to answer the energy needs of tomorrow's world. Industry and research, private investors and public authorities co-operate in the European Solar Thermal Technology Platform (ESTTP) to pave the way for solar energy to be the sole source of domestic hot water, space heating and cooling, and a major contributor to low temperature industrial heating in the next decades: The goal is to identify the research issues and lay the foundations to solve them.

Market Growth Strategy

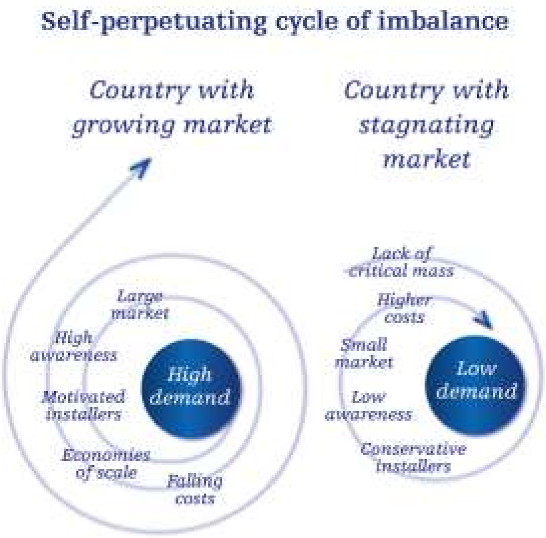
Kicking off growth towards critical mass

Overcoming the chicken & egg dilemma

For two decades a constant feature of the European solar thermal market has been the strong imbalance between a few leading countries with developed markets, and a large majority of countries with very slow market development (see page 8).

This imbalance is self-perpetuating. When a country has reached a minimal market volume, growth tends to become self-sustained, even with very low political support, as is the case in Greece. On the other hand, in countries where there is low demand a vicious circle tends to inhibit growth and the market stagnates.

Political support can help break out of this vicious circle by kicking off, and maintaining, market growth until the critical mass of the market is reached.



Critical market mass

Practical experience shows that most of the barriers to growth for solar thermal are linked to the lack of critical market mass. Where solar thermal has reached a sufficient level of market penetration, these barriers vanish:

- People know about solar thermal and find it natural to use it
- Standard education and training of professionals includes sections on solar thermal
- Architects foresee solar thermal as a standard feature in buildings
- Every installer offers solar thermal systems
- Industry invests heavily into market development, R&D
- Mass production and marketing drives down costs

Other barriers to growth

A few challenges will remain, independent of the size of the solar thermal market.

Tenant-owner dilemma

In rented buildings any measure to improve the energy performance is faced with an important challenge: The owner, who has to invest in a solar thermal heating system for example, typically does not benefit from it directly. The investment reduces the fuel costs for heating, but they are usually borne by the tenant. The tenant himself cannot choose his favourite heating system but has to live with what the owner offers.

Higher investment costs

The great advantage of solar thermal is its potential to save energy used for heating and cooling purposes. This advantage is realised over the full lifetime of the solar thermal system – typically 20 years or more – but comes at higher investment costs. For individuals, who only have a certain amount of money to invest, or for businesses, that plan with payback times of just a few years, this higher investment cost can be an important barrier.

Private investment & political framework

While governments can greatly support the fast market penetration of solar thermal, it is the industry itself, which develops the market and makes the necessary investments. Governments at all levels – local, regional and national – should aim at creating a good investment climate in order to activate private capital and resources. By setting long term targets for solar thermal and by providing a positive and stable framework, public authorities can strengthen the confidence of manufacturers, suppliers and implementers, who will then invest the resources necessary for the further growth of solar thermal.

The regional dimension

Heating and cooling are almost exclusively decentralised and even where district heating networks exist, they only supply local demand. This has direct implications for the development of solar thermal markets: They often start locally before they grow to neighbouring regions. On the demand side, consumers become aware of solar thermal and purchase their next heating system with solar thermal. On the supply side, planners and installers are selling more and more solar thermal systems, which encourages them to invest in training and further marketing of these products.
Therefore public support for solar thermal can be very effectively applied at local and regional level. A more sustainable energy supply, less air pollution and more local jobs are the direct benefits for the region.

The European dimension

With the strong growth of several national markets in the 1980s and 1990s, exports to other countries increased significantly. The development of European Standards and later the Solar Keymark helped overcome barriers to trade stemming from differing local requirements in support programmes (see page 25). The national markets are beginning to merge into one European market and further support for the development or updating of the EN Standards can further this process. This helps develop a strong European industry and increases healthy competition throughout the EU.

While the industry has developed many new products and improved existing components, most solar thermal manufacturers are still small and medium sized companies lacking the necessary R&D budgets for research into new technologies for the coming decades. Today, public R&D funds are necessary to speed up the development of solar cooling solutions, solar industrial process heat plants or advanced heat storage plans. With growing markets, private companies will invest more and more of their own resources into R&D.

Guidelines for Effective Policies

Policy matters!

Experience shows that support policies play a major role in kicking-off the growth of national solar thermal markets. Once a critical mass of the market is reached, the intensity of political support can be gradually reduced until the market is fully self-sustained.

The leading countries

As seen above, three countries make up most of the European market. In all of them, public policies have been decisive, particularly in the starting phase of the market.

Greece

In the 1980-1990s, the Greek Government offered financial incentives, combined with awareness raising activities. Their success made the market reach a critical mass. Several years after the termination of the main support programmes, the market is still flourishing: per capita, it is 16 times bigger than in Italy.

Austria

Per capita, Austria is leading continental Europe in solar thermal. The success is largely based on stable, long term public support schemes in several federal states, which include: awareness raising, financial incentives and training of professionals, R&D funds and demonstration projects. Propelled by the domestic market, the Austrian solar industry has become the number one exporter in the EU.

Germany

The largest market in Europe has been built up with the help of suitable policies. The financial incentive scheme "MAP" now enters its 8th year. Awareness raising campaigns at federal and local level have been implemented. With less sunny conditions than Greece, demand is gradually becoming independent from public support: 2006 was a record year, despite the interruptions and substantial reductions of the financial incentive scheme.

The upcoming markets

Except for Cyprus and Greece, the Mediterranean countries have so far been lagging far behind, despite their enormous potential for quick and extensive growth. Recently, two of them have shown strong growth. In France, the market has tripled in only three years. In Spain, demand has increased considerably stronger than in the past. In both countries support policies are strongly supporting this uptake.

France

In 1999 France launched the "Plan Soleil", a comprehensive set of measures to stimulate solar thermal markets. Awareness raising, qualification of installers, financial incentives, demonstration projects and scientific support have shown good results. A tax rebate on solar thermal systems was introduced in 2005 and upgraded to 50% in 2006. This resulted in very high growth rates, though France is still far behind the leading countries.

Spain

After years of very modest growth, the "Solar Ordinances" in many Spanish municipalities have shown a very positive impact on the Spanish market. These regulations require the installation of solar thermal systems in new buildings. In 2006 this obligation was introduced nationwide through the new technical building code. A much more pervasive growth is expected now, leading to a greatly improved investment climate, with many companies increasing their investments in the development of the Spanish market.

Continuity and coherence needed

As discussed overleaf, public support polices can be a decisive factor for growth, particularly if they are long term oriented, well designed and implemented.

A coherent strategy for strong and sustained growth must take into account the local situation. It should be based on clear targets and include a comprehensive set of measures.

The importance of clear targets

A solar thermal strategy should set and pursue clear growth targets. This helps overcome one of the most common shortcomings of public support policies: the lack of continuity. Policies oriented towards a longer term target are less likely to be frequently interrupted.

Stop-&-go support does not create the necessary confidence of market actors. Both on the supply and on the demand side, decision makers tend to postpone investment decisions, as they take on a wait-and-see attitude. This can even damage the market, if for instance installers experience that their investment in solar training does not pay off, due the abrupt end of a financial incentive.

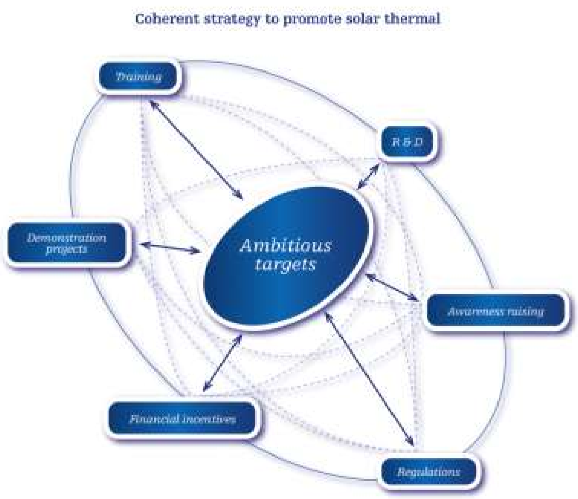
Stable and positive framework conditions must be created over several years, to pave the way for investments in production capacities, training, marketing and distribution, and to mobilise resources for research and development.

At European level, the renewable electricity Directive set national and EU-wide targets for this sector. It is widely accepted that these targets and the policies they induced were vital for the huge investments and successes in electricity generation from renewables. A similar approach must now also be taken for renewable heating and cooling, at national and EU level.

A comprehensive set of measures is needed

Effective support strategies may address not only one, but several barriers to growth. For example: The lack of public awareness can be overcome with an awareness raising campaign. But the higher initial investment costs might be addressed with a financial incentive scheme. The limited availability of informed and motivated professionals can only be tackled by specific training and education programs.

The best support strategies consist of a coherent mix of complementing measures. These measures should be well-targeted and not contradictive: a financial incentive scheme targeted at private households should not come with technical requirements typical for large systems.



Even the most powerful support measure, solar regulations ("Barcelona Model"), should be accompanied by flanking measures. Information campaigns targeted at raising quality awareness amongst consumers and installers ensure that the installed systems are used most effectively. And public authorities can support the fast introduction of the next generation of solar thermal applications by providing funds for R&D work.

Solar Regulations

The long-term begins today

Future new buildings will last into the second half of the 21st century and longer.
By then, fossil fuels will be very scarce and expensive. They will probably still be irreplaceable in sectors like air transport and chemicals. One more reason to accelerate the necessary transition: in the long-term, 100% of the energy needs of buildings has to be covered by renewables.

Adapting the building stock will be a steady process. At least new buildings, and those undergoing major renovation, should be equipped for future conditions.
At EU and national level legislation has been adopted to improve the energy performance of buildings. However, in most EU countries, this legislation is mainly promoting energy efficiency. Higher efficiency is necessary and urgent, but alone will not be enough to keep houses and people warm.

No new buildings without solar!

ESTIF calls for a wide introduction of solar obligations. New buildings, and those undergoing major renovation, must cover a share of their heat demand with solar or other renewables.

Solar thermal obligations have the following benefits:

- The building stock can be gradually prepared for the post-oil & gas era
- Solar thermal is cheaper and more cost effective if installed at the construction stage
- If solar is not included, the window of opportunity will be closed for a long time
- An obligation solves the tenant-owner dilemma: the fuel costs are not paid by the same person who pays for the investment to save fuels
- Implementation requires little administration effort over usual building permits and controls
- Minimal impact on public budgets
- Avoids stop-&-go market dynamics and thus creates a positive investment climate for the solar thermal industry

Positive experience with solar obligations

The City of Barcelona enacted in 1999 its first “Solar Ordinance”, later replicated by many Spanish local councils of different political backgrounds. This paved the way for the solar obligation to be included in the new Spanish national building code, approved in 2006. In the same year, Barcelona upgraded its solar obligation, thereby increasing the number of buildings subject to the obligation.

In Israel, a solar obligation has been in force since 1980. As a result, Israel is the world leader in solar thermal usage. Solar has become a mainstream product. Today, 90% of the market is in voluntary sections: in retrofitting and replacements of old systems.

Solar obligations have positive effects beyond their direct scope, by promoting the voluntary use of solar beyond required levels, and by encouraging private investment of the solar thermal industry.

Guidelines for the implementation

Several countries and regions are considering introducing similar solar obligations. This is welcome and necessary.
In this process, it is necessary to make sure that the regulations are optimally designed and adapted to the local situation. ESTIF has developed guidelines, focusing on the following principles:

- Technical and design requirements should not be overly detailed, to avoid hampering technological development and causing excessive costs
- Any product requirement should be based on European standards, norms and certification, to avoid creating barriers to trade
- Quality assurance clauses should be introduced and randomly checked, to avoid unmotivated owners installing the cheapest low-quality products

Detailed analyses and recommendations, including case studies about Barcelona and Madrid, the city of Vellmar (Germany) and Italy are available at www.estif.org/STAP

Financial Incentive Schemes

Direct grants played an important role in the development of Europe's leading solar thermal markets: Germany, Austria and Greece. The fastest growing market, currently France, is benefiting from a reduction in income tax.

However, the case studies of the K4RES-H study also show examples of Financial Incentive Schemes (FIS) that have not produced the expected result.

FIS for solar thermal can come in various types:

- Direct grants (e.g. German Market Stimulation Programme)
- Tax reductions (e.g. income tax break in France)

- Loans at reduced rates
- Green heat or energy efficiency certificates

So far, most of the FIS were among the first two types. The main finding of the K4RES-H case studies, however, is that the success of a FIS does not mainly depend on the type, but on the continuity and on the quality of design and implementation, including the flanking measures.

A detailed analysis, including case studies is available at www.estif.org/STAP

Success through continuity

The key success factor of FIS for solar thermal has been continuity. Only a long-term approach gives the right incentive to the decisive market actors (installers, designers, architects, construction sector, solar thermal industry) to invest, thus creating the conditions for self-sustained growth. On the contrary, stop-&-go financial incentives discourage long term investment and disrupt market development.

Guidelines for best practice

- FIS should be part of a comprehensive approach, including coherent flanking measures, such as awareness raising, training and demonstration projects
- FIS should last for several years under stable conditions. This maximises the impact on investments and creates conditions for self-sustained growth
- No early announcement of improved financial conditions, to avoid consumers postponing purchase
- Funds must be available to guarantee the continuity of the FIS over some years – if the public budget cannot do it, the “Polluter Pays Principle” should be applied
- Easy and lean procedures increase the effectiveness of the FIS
- Product requirements should be fully compatible with the European standards and certification procedures, to guarantee high quality without creating barriers to trade
- Quality criteria on the installation should be set, in line with the specific situation of the country/region, to avoid low-quality installations without creating artificial hurdles
- The amounts offered should be high enough to provide a real incentive

Role of financial incentives and regulations

FIS should be used in cases where binding regulations are not appropriate: retrofitting of existing heating systems and upcoming solar thermal applications, like cooling or process heat.

Where a binding regulation exists, FIS can also provide an incentive for investments beyond the minimal level required by law, thus saving more conventional energy.

Policies for solar cooling and other emerging applications

New potential beyond today's applications

Domestic hot water and space heating are the dominant solar thermal applications today. And they will continue to lead the market and provide clean solar energy for millions of citizens.

Other applications are still in their infancy but have a huge potential to curb conventional energy use. As these technologies are still emerging, most existing support policies do not yet cover them.

Specific support is needed to address the concrete barriers to growth of each application and market segment.

Current barriers to quick market adoption

Some of the new applications with the highest potential are solar thermal for cooling, for industrial processes and for seawater desalination. All three of them have been demonstrated successfully but optimisation has just begun and broad market penetration has not yet started.

- Selected barriers specific to the emerging new solar thermal technologies:
- Very low awareness amongst decision makers and professionals
- Typically high initial costs
- Shorter track-record of new technology
- Packaged (standardised) products are not available
- Planning is more complex and practical guidelines and software tools often do not exist
- New materials or components need to be developed and tested for the different uses, e.g. higher temperatures

Specific support for the next generation of solar thermal applications

If public support policies ignore the specific barriers to growth faced by emerging and new applications, they will most likely fail to help them into the market. Therefore, the typical support schemes focusing on domestic hot water and space heating should be accompanied by specific measures targeted at new applications.

These are our main recommendations:

- Specific awareness raising campaigns targeted at potential customers of emerging applications
- Large number of demonstration projects in every region – where relevant also in public buildings or companies
- Dedicated financial incentives
- Basic research in new materials and the development of new components
- Applied research and development to optimise the emerging applications and their integration with existing technology
- Funding for the development of planning guidelines and tools
- Inclusion in relevant legislation, e.g. solar cooling should be covered by the Energy Performance in Buildings Directive (EPBD)

Awareness raising and training

Knowledge is key to solar thermal acceptance

In regions where solar thermal is already widely used, awareness is very high: Neighbours and friends use solar thermal and everyone knows that hot water is available even during cloudy periods. Lack of knowledge or doubts about solar thermal is the primary reason for not choosing solar energy for heating in regions where solar is still a niche product.

An uninformed end-consumer will not buy or even enquire about a solar thermal system!

An uninformed architect, planner or installer is an even bigger problem: If professionals do not know about solar thermal or if they feel insecure about it they will not recommend it to their customers. One uneducated or untrained professional means many lost opportunities in the market.

Spreading the word: Public awareness raising campaigns

Nearly every successful support scheme in Europe has included public awareness raising in their policy mix. The concrete measures range from a fully-fledged campaign like "Solar – na klar!" in Germany to specific information portals on the web or the funding of impartial advice to consumers by local energy agencies.

Consumers must be aware of solar thermal products when they need it. And often they need a new heating system urgently – when their old one breaks down and needs to be replaced. In these situations the buyers do not shop around to look for the best overall offer, but choose the technology they are already used to.

Educated consumers will choose solar thermal – ever more often. Public awareness raising can help educate consumers and create market pull.

In the more and more mature markets, marketing by solar thermal suppliers will supersede the need for public campaigns. In those regions, targeted public information campaigns may focus on the next generation of solar thermal applications to help them pave the way into the market.

More training and quality assurance of professionals

Professionals in the construction sector, including heating, ventilation and air-conditioning (HVAC) installers have an important role in the market: More often than not, they are the gatekeepers to the final decision-maker. In effect, they are the ones who decide whether or not a new building is equipped with a solar thermal system and whether the new heating system is based on renewable energies.

Where the market is well developed, professionals will learn about solar thermal or will invest their own resources in training. But where solar thermal is still a niche market, installers do not see the benefit in specialised training.

In many countries, public bodies have supported the development and implementation of training courses targeted at professionals crucial for the success of solar thermal. The training plays a vital role in motivating installers to recommend and actually sell solar thermal products.

At the same time they help sustain a high quality level in a growing market. By having attended basic training in solar thermal, planners and installers learn to avoid simple mistakes, thus improving the high quality experience with solar thermal technology.

Setting and monitoring national targets

Targets – for better focused policies

Solar thermal support policies aim at increasing the share of solar energy used in heating and cooling. To evaluate the overall success of a support policy, it is important to compare the induced market growth with a previously set target.
Targets are a much used tool in business management. The more specific a target is, the more likely it is to be achieved. This principle has been successfully applied in policy making. The European Directives to promote renewable electricity and biofuels have been successful largely because of clear sectorial targets, broken down by countries. Such targets are now needed also for renewable heating and cooling – serving as a guideline also for the development of solar thermal markets.

Setting and monitoring national solar thermal targets

Led by ESTIF, experts from the solar thermal sector have agreed on the following recommendations for how to set (sub-)targets for solar thermal:

What to consider for the target?

The thermal energy gained through active conversion of solar radiation. This excludes energetic gains through "passive solar" (e.g. south-facing windows, orientation of buildings etc.). Not because the use of passive solar wasn't useful but because it is in effect an energy efficiency measure and would be hard to take into account in target setting and monitoring. A detailed recommendation on how to assess the solar thermal energy for statistical purposes can be found at www.estif.org/STAP.

How to assess the potential for growth in the short to medium term?

In the long term, the limited availability of oil and gas will necessarily lead to the full exploitation of the solar thermal potential. For policy making, shorter time periods need to be considered, e.g. a target for 2020. Until then, the solar thermal potential will be far from being realised. In the next two decades, the development of solar thermal will be determined by other factors, such as awareness, costs availability of trained and motivated professionals.

At European level, an ambitious target should be set. Both a minimum and a more ambitious target have been proposed by the solar thermal sector, see page 9.

The national targets should be compatible with the overall EU target. To determine the specific targets for each country, the following factors should be considered:

- Current level of solar thermal use (implying also a certain level of market infrastructure)

- Overall solar thermal potential (local heating/cooling demand, solar irradiation etc.)
- Current energy supply mix
- Use of other renewables for heating and cooling today
- Purchasing power
- Other urgent priorities in the heating/cooling sector (e.g. refurbishment of district heating systems)

Quantifying energy delivery

Often, it is desirable to link support policies to the actual solar thermal energy production. Most financial incentives schemes follow this principle to some extent, e.g. by offering a grant per m² of collector area.

But a closer link is possible. For systems where energy production is typically measured, financial incentives can be based on the actual heat produced. This gives additional benefits to well designed and maintained systems.

In smaller systems the costs of accurate measurement would outweigh any benefit. Their energy production can be calculated upfront, using a calculation method which is more accurate than only the collector surface but based on a few simple parameters.

Within the K4RES-H project, solar thermal experts have developed recommendations on energy measurement and on alternative calculation methods. Policy makers are invited to use these recommendations in their solar thermal support programmes.
Detailed methods and recommendations can be found at www.estif.org/STAP.

Avoiding barriers to trade

Support programmes sometimes create artificial barriers to trade

Sometimes governments have set requirements within their support programmes, which inadvertently hampered the market entry for certain companies or products. In particular this applies for companies operating at EU level, which have to adhere to various different national, regional or local requirements.

Overcoming fragmentation by using European Standards

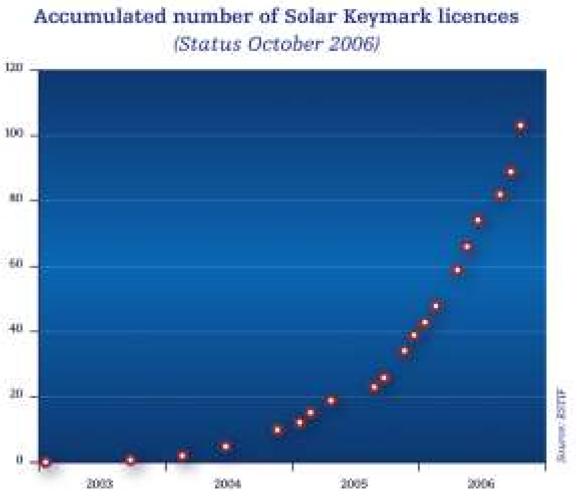
Since the 1990s, European Standards (EN) have existed for collectors (EN 12975), factory made systems (EN 12976) and custom-built systems (ENV 12977). For the energy performance in buildings, CEN (European Committee for Standardisation) has developed a pre-standard to assess the positive contribution of solar thermal in the heating systems of buildings.

European Standards are vital for the creation of a European market. Governments should refer to them wherever possible in financial incentives schemes, solar regulations, or in building codes – instead of adding new, differing local requirements.

Solar Keymark – the one European certification scheme for solar thermal products

Even after the introduction of EN standards, certification requirements still differed among countries. Some countries would not recognise in their financial incentive schemes products tested in other countries. The Solar Keymark, developed by ESTIF in co-operation with CEN and with support from the European Commission, was introduced in 2003 to overcome this last hurdle. Today, almost all countries accept Solar Keymark'ed products as being eligible in their support schemes. Further effort is needed to tear down the last remaining barriers to trade.

For further information, please see www.solarkeymark.org.



Best practice regulations for solar thermal

Best practice regulations for solar thermal

Executive Summary

Regulations can be the single most important means to promote the use of solar thermal energy. Two main areas of action are needed:

- Reducing administrative barriers
- Enacting solar obligations for new buildings or those undergoing major renovation

Concerning administrative barriers: the general principle should be established that the use of solar collectors is allowed without the need of any special authorisation, except for a precisely defined and limited number of buildings of special historical interest. Moreover, it is necessary to make solar friendly the rules concerning the right of use of the roofs in large buildings with many residential or tertiary units.

Concerning solar obligations: the current trend in several European countries and regions is well justified by the manifold benefits of this instrument, which allows for the gradual preparation of the building stock in anticipation of the inevitable future scarcity of fossil fuels. Among other benefits, solar obligations create a minimal critical mass in the solar market and bring about economies of scale that also benefit the voluntary market in the majority of buildings that is not subject to the obligation. Moreover, solar obligations help solve the owner-tenant dilemma and send a strong signal to the users and to all professionals involved in the construction and heating sectors.

However, solar obligations fundamentally change the way the solar thermal market functions. Within a solar obligation, proper quality assurance measures must be foreseen, including quality parameters for the products, installation and maintenance, as well as a clear inspection and sanctioning regime. Without these measures, it is likely that some construction companies will install the cheapest products, thus producing less solar yield than desired. This could reduce the acceptance of the regulation and possibly of the solar technology in general.

This document offers for the first time a comprehensive analysis of the structure of solar obligations and proposes best-practice guidelines.

Introduction

This study is a tool to support the design of effective regulations to promote the use of solar thermal heating and cooling (ST) and to reduce administrative barriers, with the aim of helping policy makers at the local, regional, national and European levels to design policies most suitable to accelerate the growth of ST, as needed to reach the EU's binding target of a 20% renewable share by 2020.

The target public are legislators, public administration officials, energy agencies, NGOs, solar thermal associations, market actors and any person or institution involved in the design and implementation of regulations to promote renewable energy and energy efficiency associated with solar thermal issues. While the study has been developed with a European perspective, we believe that the analysis and guidelines developed here might also be helpful for debate outside the European Union, since the dynamic of ST market development is often similar.

Regulations are defined here as any kind of legislative or administrative rules affecting the growth of solar thermal, both positively and negatively, excluding those linked to financial incentives which are treated in a parallel publication produced within this project.

We do not aim to offer a compendium of all existing or thinkable regulations affecting ST, but to look in detail at selected issues most relevant for market development in Europe in the next years. The following issues are treated in this publication:

- Reduction of administrative barriers
- Solar obligations for new buildings or those undergoing major renovation

The study has been produced within the framework of the project *Key Issues for Renewable Heat in Europe* (K4RES-H), co-financed by the Intelligent Energy - Europe Programme of the European Commission and coordinated by ESTIF. Within this project, guidelines for best practice policies on different issues related to renewable heating and cooling are developed. Regulations are one of these key issues.

All project results about solar thermal, including all detailed case studies on which the present document is based, and the complete *Solar Thermal Action Plan for Europe,* can be found at:
www.estif.org/stap

The central project website is:
www.erec.org/50.0.html

There the parallel studies dedicated to geothermal and bioheat regulations can be found, as well as a number of other studies dedicated to solar thermal policies (financial incentives, policies for innovative applications) and summaries looking at renewable heating as a whole.

Many contributors have provided their knowledge and experience to the present study: the members of ESTIF and particularly the national solar thermal associations from nearly 15 European countries and also many other experts from energy agencies, public administrations, NGOs and others. We warmly thank each of them even though we do not have enough space to mention them all. A particular thanks goes to the main authors of this text, Raffaele Piria and Uwe Trenkner of ESTIF, as well as to Riccardo Battisti (Assolterm), Eddie bet Hazavdi (Ministry for National Infrastructure, Israel), Teun Bokhoven (Conergy), Jesus Ruiz Castellano and Amparo Fresneda (IDAE), Annalisa Corrado (Ministry for Environment, Italy), Jan-Olof Dalenbäck (Chalmers University), Xavier Dubuisson (XD Consulting), Will Foreman (Aperca), Rob Meesters (Solahart), Katja Mensing (Energie2000), Jan Erik Nielsen (SolarKey Int.), Thomas Pauschinger (Solites), Pascual Polo (ASIT), Toni Pujol (Barcelona Energy Agency), Robin Welling (TiSUN), Werner Weiss (AEE Intec), and William Gillett and Krzysztof Gierulski of the Executive Agency for Competitiveness and Innovation of the European Commission.

However, the final version of the document does not necessarily reflect the personal opinion of each of them. ESTIF remains solely responsible for the contents and any possible mistakes or omissions.

Reduction of administrative barriers

In large buildings with shared ownership, where many Europeans live and work, the **rules concerning the right of use of the roof** are in some countries unclear, or they make it very difficult to agree on the construction of a solar system, be it for collective use or for single apartments.
The public authority should enforce, or at least encourage as far as possible, easier procedures, for instance by inverting the burden of proof: stating the right in principle for any building owner to install a solar system on the roof, except other stakeholders can prove serious reasons against.

In some places **lengthy and difficult authorisations** are necessary, even to install small solar systems that are not much bigger and don't look very different from an ordinary roof window.
This problem is mainly registered in very extensive areas of Italy, falling under a national regulation aiming among others at reducing the visual impact of new buildings or building elements. But problems are sometimes encountered also in modern buildings in areas without any special protection.
Some municipal authorities refuse authorisation to install solar collectors, simply because they would be visible from public areas. Sometimes, on the same or on surrounding buildings, a number of traditional TV antennas, satellite dishes, mobile phone masts and roof windows can be observed.
Esthetical opinions can hardly be discussed objectively. Of course, it must be possible to maintain the appearance of the roofs of medieval town halls or cathedrals. However, for a large part of buildings, authorisations procedures and practices should be adapted to the energy and climate policy priorities of the 21st century.
In certain cases, the local authority even requested a full Environmental Impact Evaluation for very small (2-4 m^2) solar systems: the cost of the EIA would be several times higher than the cost of the system itself, and this for a technology producing clean solar energy and known for its minimal environmental impact!

The sheer need of an authorisation is often enough to discourage potential users of solar energy: the right timing (for instance replacement of the heating system) may be short. And there may be a disproportion between the low cost of the solar system and the effort needed to obtain the authorisation.
The general principle should be established that the use of solar collectors is allowed without the need of any special authorisation, except for a precisely defined and limited number of buildings with particular historical or esthetical value. And in these areas, the procedures should be quick and transparent: the public authority should provide a list of acceptable technical solutions for the integration of solar collectors, that should be applicable for as many listed buildings as possible.

Solar obligations

Solar obligations are regulations requiring a minimum share of the heating demand be covered by solar energy. Most refer only to the domestic hot water demand and prescribe a minimal solar share ranging from 30% to 70%. Currently, in Germany, renewable obligations are being discussed that would prescribe a minimal share of 10-20% of the total heating consumption, including space heating. They usually apply to new buildings, those undergoing major renovation and sometimes in the case of replacement of the heating system. Often, they are in fact renewable heat obligations, as the legal requirement can be fulfilled also with other renewable heating sources.

A decade ago, the idea of making the use of solar or renewable energy compulsory sounded radical and politically unfeasible in most parts of the world. Currently, solar obligations have been adopted or are being discussed in a number of countries, regions and municipalities in Europe and beyond.

Security of energy supply and climate change have become top political priorities. Together with energy efficiency, renewables are the only sustainable answer to both problems. Within the renewable energy policy debate, the heating and cooling sector are now fully integrated in the European agenda, after having been neglected for over a decade. The solar industry has grown and a new generation of highly reliable products is on the market.

"The decision by Fingal County Council to specify the highest standards of energy efficiency for building in three local area plans is one of the most significant developments in building for decades. For the first time a local authority sees the wisdom of ensuring that buildings are designed to the highest standards in energy efficiency. This will result in warmer, more comfortable buildings that are healthier to live in and much cheaper to run. I hope this ground-breaking initiative by Fingal County Council will set the standard for developments in Ireland. We don't really need pilot schemes or one-offs, the technology has been proven to work, so these standards can be met, we know that. It will work",

Gerry McCaughey, CEO of Century Homes (now Kingspan Century), Europe's largest timber frame home manufacturer

Solar obligations are probably the single most powerful instrument for promoting the use of renewables in new buildings. However, they do not cover a large part of the potential uses of solar thermal, like space heating and cooling, industrial processes, water desalination, as well as existing buildings that are not undergoing major renovation. While indirect positive effects of solar obligations on these areas can be expected, flanking measures focused on the voluntary market are necessary, like financial incentives and awareness raising, and training.

To our knowledge, no analytical and comparative literature on solar obligation exists. This is the first attempt to give a systematic overview and suggest guidelines based on the available experience and on the knowledge of the industry about solar thermal market development in general. Given the pioneering nature of this exercise, the authors would very much welcome any critical comments and new information, that will be taken into account in future updates.

The history, analysis and guidelines offered here are based among others on a number of case studies reported in the annex.

A short history of solar obligations

The first solar thermal obligation was enacted in Israel in 1980, as an answer to the worries about security of energy supply in the aftermath of the second oil crisis. Despite its success (see annex), it took two decades before the next one was adopted in Barcelona. During the 1980s and 1990s, renewables were not high on the agenda, as energy prices went down and the increasing evidence about climate change unfortunately did not lead to adequate political reaction. At the same time, the solar thermal industry in Europe was not yet developed and active as in more recent years.

From Barcelona to the Spanish model

The first discussion on a solar obligation in Europe started in the city of Berlin in the 1980s. An advanced draft law had been developed, but Berlin finally failed to adopt the obligation, due to a change in the government and to the opposition of the local construction industry.

However, this process helped to stimulate the debate in the City Council of Barcelona, that in 1999 adopted its solar obligation which then entered into force in 2000. The “Barcelona model” (see annex) came from a city with strong charisma, and at the right time: rising energy prices and worries about the security of energy supply and climate change created a receptive political environment. The solar thermal industry had grown and a new generation of reliable products was on the market.

However, even the friends of solar energy were surprised by the speed with which solar obligations spread through Spain and in other European countries. Solar obligations are now in force in more than 50 Spanish municipalities, including large cities like Madrid (see annex) and Sevilla, and covering more than half of the population in Catalonia.

Obligations were adopted by local governments of different political colours. The broad political consensus lead to the inclusion of a solar obligation in the new National Building Code (see annex), that was to a large extent developed by the previous conservative administration, and was tightened and finally adopted in 2006 under the current socialist government. In the same year, Barcelona City Council adopted a revised version (see annex) of its municipal obligation that enlarged the number of obliged buildings, increased the share of solar energy required and tightened the quality assurance measures.

Six years after the “Barcelona model” was launched, solar obligations have stood the first test of time, as shown by the support of different political parties throughout the country by their first significant results in terms of energy savings and improved market conditions, and by their capacity to evolve and improve their details.

The debate at European level and beyond

At the end of June 2007, solar or renewable heat obligations were in force or in advanced state of discussion in a growing number of European countries, regions and cities. These include Portugal, Italy (several municipalities including Rome, two regions and at national level – see annex), Germany, (the town of Vellmar, the Federal State of Baden-Württemberg and possibly at federal level - see annex), the region of Wallonia in Belgium, some Irish counties (see annex) and a number of UK local authorities that followed the example of the London borough of Merton. This list may not be exhaustive, as the number of local initiatives is constantly growing.

At EU level, the decision of the 27 Heads of State in March 2007 to set a binding 20% target for the renewable share of total energy consumption by 2020 is creating a strong pressure to implement more effective policies able to deliver the necessary growth rates throughout Europe.

Currently, the European Commission is preparing the proposal for a new Directive that will cover all renewable energies. For the first time, this Directive will also cover the heating and cooling sector. It is not yet known which specific measures will be included in the proposal, that must then be adopted by the European Council and the European Parliament.

The latter is very likely to send a strong message in favour of solar obligations: on 9th July 2007, its competent ITRE Committee adopted almost unanimously an amendment calling for “the Commission to speed up the widespread adoption in all Member States of best practice regulations making it compulsory, at least in the case of major renovation of buildings and new buildings, for a minimum proportion of the heating requirement to be met from renewable sources as has already been implemented in a growing number of regions and municipalities”. Given the large support received in ITRE, it is likely that this text will be adopted by the plenary of the European Parliament in September 2007, giving a strong signal to include renewable heat obligations in the new European Directive.

However, the main responsibility for the design, implementation and enforcement of solar obligations will remain with the national or local authorities which have the competence for building regulations. For them, there is no reason to wait for the EU Directive to be adopted. The sooner they are in force, the stronger their benefits.

The idea of renewable heat or solar obligations is gaining ground also outside of Europe. In June 2007, speakers at the *estec2007* (European Solar Thermal Energy Conference) reported that solar obligations are being discussed in the Tokyo Metropolitan Area (35 millions inhabitants) and in Minas Gerais, the second most populous Federal State in Brazil, while some Australian Federal States have enacted regulations that make solar thermal one of the favourite options to meet the required efficiency standards. According to representatives of the Chinese Renewable Energy Industries Association, a discussion on solar obligation is also progressing in China.

Benefits and costs of solar obligations

Beyond the available empirical evidence (see annex), this part of the document is based on qualitative analysis, arguments and opinions of experts from the solar and construction industries, local and national governments and energy agencies.

With the notable exceptions of Israel's success story and partly of Barcelona, the existing solar obligations are too recent to allow for a systematic empirical analysis of their impact. This is due to the physiological delay of some years between the adoption of a solar obligation, the time when the systems are effectively installed, and the time when an empirical study of their impact becomes possible.

It must be noted that, in general, the cost and benefits of building practice and regulations are difficult to be empirically quantified. Economic factors are intertwined with historical and cultural heritages. The level of formal and factual compliance with any kind of building regulations varies strongly among different countries, regions and also among different kind of buildings. This is linked to the important role played by the informal economy, particularly in the renovation works and in small residential buildings. Also the ways in which building regulations are enforced by the public authorities vary strongly. In different contexts, the same rule can lead to different and even contradictory results.

Justification and benefits

The long term begins today

The logic of the financial markets implies that buildings are planned with an investment horizon of a few decades, though experience shows that many last longer. Taking into account the amounts of energy needed to construct buildings, it is reasonable to assume that by the second half of the 21st century there will be an increased interest for building conservation, which is not yet reflected in the economic rationale of building developers today. Many future new buildings will last into the 22nd century. By then, fossil fuels used for heating will be very scarce and expensive. They will probably still be irreplaceable in sectors like air transport and chemicals. One more reason to accelerate the necessary transition: in the long term, 100% of the energy needs of buildings have to be covered by renewables.

Buildings are key to any comprehensive energy policy strategy. 40% of the EU's energy consumption originate there, and heating has the lion's share. At the EU and national levels, legislation has been adopted to improve the energy performance of buildings. However, in most EU countries, this legislation is mainly promoting energy savings measures. Higher energy efficiency is necessary and urgent, but alone will not be enough to keep houses and people warm. Particularly for domestic hot water, energy must be consumed and solar can contribute strongly.

Promoting renewable heating through financial incentives taken from the public budget becomes more and more difficult as the market volumes increase. A key advantage of solar obligations is that they have a very limited impact on public budgets (see below). The main costs are carried by the building developers or owners. If the certification of the energy performance of buildings works correctly, the owners will be able to pass the costs on the building users, who also benefit from the reduced energy bill allowed by a solar system.

Adapting the building stock will be a steady process. At least new buildings, and those undergoing major renovations, should be adapted to future conditions.

A solar (or renewable heat) obligation helps gradually prepare the building stock for the post-oil and gas era.

Quantification of the aggregated energy savings

The aggregated energy savings triggered by a solar obligation are a function of manifold factors, among them:
The number of buildings subject to the obligation, depending on its detailed provisions and enforcement (including the exemptions)
The number and types of new buildings in a country, region or city
The specific requirement concerning the share of solar energy to be achieved
The quality of the solar products, their installation and maintenance
The behavioural patterns of the users, mainly the volume and timing of domestic hot water usage
The intensity of the positive effects of the obligation on the voluntary market, i.e. the installation of larger solar system than required, and the increase of solar energy use in buildings not subject to the obligation

A precise quantification would require complex assumptions and modelling, and would have a wide margin of error, especially considering the little empirical data available so far. This exercise was not possible here. However, it may be useful to consider some data that can contribute to a rough estimation.
Domestic hot water contributes roughly 2% of the final energy consumption in the European Union, i.e. equivalent to circa 24 million tons of oil per year. If all buildings covered 50% of their hot water demand with solar energy, the savings would be around 12 mtoe per year. This is equivalent to the total consumption for hot water and space heating of almost 10 million European households.
Taking into account that roughly one third of domestic hot water is currently produced with electricity, the gains in term of primary energy are substantially higher. Of course, depending also on other support measures and on energy prices, it will take a shorter or longer time to cover all buildings, but on the other hand a solar obligation also encourages the voluntary solar market beyond the legal requirement.

If European would cover 50% of its hot water consumption with solar, the savings would be roughly 12 mtoe per year, or 1% of the EU's final energy consumption. This is equivalent to the total consumption for space and water heating of almost 10 millions households.

Seize the opportunity when it comes

Installing a solar system implies works on the roof, piping through walls and finding the place for the hot water tank inside the building, if it is not installed on the roof. All this is easier, cheaper and often more effective if the solar system is included from the earliest stage of planning of a new building.
In existing buildings, there are short windows of opportunities when the installation of the system is usually most convenient, mainly when the (water) heating system and/or the roof are being changed anyway.

Once these opportunities (new built, refurbishment) are missed, the installation of a solar thermal system is usually technically possible, but economically less interesting. One has to take into account not only the direct financial cost of the works, but also the time and effort needed to commission them, as well as the disturbance caused to those living or working in the building.

It is most convenient to include solar at an early stage of planning in new buildings or when a new heating system is being installed in existing buildings. A solar obligation makes sure that these convenient opportunities are not missed.

Tackling the tenant-owner dilemma

Nearly 100% of the costs of a solar system are upfront investment costs, whereas the benefits in terms of energy savings are spread on 20 to 25 years lifetime. This is a major barrier to the use of solar, as most investors look at a shorter time horizon.

In case of rented buildings, the running fuel costs are paid by the tenants, while the investment is paid by the owner. This creates a powerful negative incentive against renewable energies or efficiency measures.

A good step towards reducing this problem is the certification of the energy performance of buildings, introduced by the European Directive on the Energy Performance of Buildings. However, this is being implemented in different ways, and not everywhere the certificates will offer complete information to those buying or renting a building. Moreover, more transparent information is not enough to completely tackle the perverse incentive mentioned above: as long as the use of renewables is not widely spread, buyers and tenants may still face little choice than accepting what offered by the market.

A solar obligation makes sure that renewables are used also when the energy bill is paid by tenants, who cannot decide on structural investments.

Economies of scale through critical mass

Solar obligations create a predictable market for solar or other renewable heating technologies. Different than financial incentives, which often change according to the availability of public budgets, solar obligations are believed to be a rather stable form of support, less prone to unexpected changes.

In such a more stable environment, the whole supply chain is encouraged to invest in the long-term development of the market. In manufacturing, the sheer approval of the Spanish CTE has contributed to trigger substantial investments to expand production lines all over Europe. These investments will benefit the buyers of solar equipment also outside of Spain.
However, the economies of scale in the manufacturing process, are only a part of the benefit of creating a critical mass of the market. On average, more than half of the turnover linked to solar thermal is due to services like system design, marketing and sales, installation and after-sale service. These services are inherently local and benefit the regional economy: solar thermal replaces imported fuels with local jobs.

Within the area of application of an obligation, investments are triggered to expand the distribution networks, to train installers and engineers, and on marketing. These investments contribute to build up the critical mass on the supply-side that is needed to address wider groups of potential users. These investments tend to reduce costs in the medium term and increase the use of solar thermal also in the large number of buildings that are not subject to the obligation: the voluntary market benefits from a broad availability of trained installers and heating engineers, architects gain experience in the integration of solar, and potential users become exposed to spontaneous mouth-to-mouth propaganda.

These effects can make the solar thermal market largely self-sustaining in the medium term, as shown by over two decades of experience in the development of solar thermal in different countries. Comparing Greece with Sicily, or Austria with similar countries, one sees that the same level of public support produces massively higher effects where the market has already reached a significant dimension. Thanks to the strong support in past decades, Greece is one of the leading markets in Europe with hardly any subsidy.

By creating a stable market in a small part of the buildings, solar obligations trigger investments in the whole supply chain, leading to economies of scale and higher use of solar energy.

Positive side effects on the voluntary market

In most cases, solar obligations apply only to new buildings and those undergoing major renovation. By its nature, an obligation covering a large number of buildings can only be based on a minimum common denominator. Therefore, obligations usually require a small share use of solar energy, widely below the technical potential of many obliged buildings.

It is therefore important that solar thermal continues to grow also in the voluntary market, i.e.:

The use of solar in buildings not subject to the obligation
A higher solar coverage then required in buildings subject to the obligation

The arguments above suggest that a solar obligation can have positive side effects on the voluntary market by enhancing awareness among potential users and investors, by increasing the availability of trained installers, engineers and architects, by strengthening the offer of solar thermal systems and by creating economies of scales and thus cost reductions.
27 years of experience in Israel and first hand industry feedback from Barcelona and other localities in Spain (see annex) empirically confirm this positive side-effect.

In the long term, this may become the most important effect of a solar or renewable heat obligation, particularly with regards to the voluntary use of more solar energy than strictly required.

Obligations encourage the voluntary use of solar energy beyond the amounts required by law, and in buildings not subject to the obligation.

Costs

Most of the costs caused by a solar obligation are borne directly by the building owners, or charged to them by the constructors. The effect on the public budget is limited to the enforcement procedures and to the specific costs on publicly owned buildings.

Costs carried by the building owner

The additional costs of installing solar have to be balanced with the financial benefit in terms of reduced energy consumption during the lifetime of the system, which is typically 20 to 25 years.
When calculating the break-even point for solar thermal systems, the main variable is the future price of oil, gas, electricity or biomass, the energy sources replaced by solar. Most analysts assume that their price will continue to grow substantially during the next decades. However, in their daily decisions, many people still tend to calculate break-even based on constant energy prices. This gap between information and behaviour is one key rationale for solar obligations.

At current energy prices, the break-even point of small solar thermal systems typically required by solar obligations is in most cases within the lifetime of the system.

To cover more than 50% of the domestic hot water demand in a one family house, the total costs of a solar system are currently in the range of 700-4000 EUR. The variation is a function of the available solar radiation, of the kind of building and heating system, of the local labour costs and of the quality of the solar products used.

The specific costs are significantly lower for large buildings with central heating systems, and of course for large orders related to many small houses. There is a significant potential for economies of scale.

The cost of the solar obligation as a share of the final price of a new building depends on the general costs of the building and of the ground in each specific location. According to first provisional estimates of the Spanish Solar Thermal Industry Association (ASIT), in most Spanish regions the implementation of the CTE is increasing the total costs of the building by clearly less than 1%, and this share is most likely to go down significantly once the construction companies have become used to regularly dealing with this technology. This level of additional cost is unlikely to create significant disincentives to the construction of new buildings.

Costs carried by the public administration

Compared with other support measures for solar thermal, like financial incentives, obligations cost very little to the public budget.

Enforcing the obligation implies some administrative tasks. Their intensity and costs depend mainly on the chosen monitoring and sanctioning procedures.

The check on the plans previous to the authorisation of the building adds very little to the numerous other checks usually performed by the administration. The same is valid for the checks after construction before the building is commissioned.

If it is chosen, as recommended below, to control ex-post the functioning of a sample of the solar systems installed, some additional costs arise. In order to provide valuable information, such monitoring must be performed by trained personnel with good knowledge of solar thermal heating systems.

The additional costs for monitoring can be kept to a minimum if the sanctioning regime for those responsible for possible malfunctioning is clear, strict and credible. If so, a small number of sample controls will be a sufficient incentive for most installers, solar and construction companies to deliver state-of-the-art installation (see below more details).

The additional cost for controlling must be balanced with the progress in technology, system design and building integration that can be triggered by the knowledge created through the controlling process, if its results are made available to the sector.

The need for quality assurance measures

"Another impression … is the low level of interest the (building) developers have in the quality of the equipment, and their high interest in getting over the new administrative hurdle as cheaply as possible" (page 34 of the K4RES-H case study done by the national Spanish energy agency IDAE, about the Madrid solar obligation, see annex).

The introduction of a solar obligation fundamentally changes the way the solar thermal market functions. Above we have discussed many positive aspects of this change. However, it also entails a danger: without appropriate quality assurance measures, low quality solar installations may occur frequently, leading to a loss of solar energy gains and to a reduced acceptance of the obligation itself and of the solar technology in general.

In an obliged market, if users are unhappy with the functioning of the solar systems, they will tend to react more negatively than in a voluntary market. The construction companies responsible for the choice of the products and their installation will answer that they simply fulfilled a regulation. Therefore, the regulations must be designed in a way to make sure that products, planning, installation and maintenance of the system are state-of-the-art.

Economic interest, behaviour and knowledge

In the **voluntary market**, those who order a solar system have their own motivation to have it working properly, in order to reduce their conventional energy bill, increase their independence and the immaterial value of using clean energy. In most cases, they live or work in the building and they will also use the system. Also in the case of rented buildings where the users are the tenants, if the owner decides to go solar, a special interest from his side can be assumed.
In the voluntary market, the buyer determines the desired level of quality, chooses the product, the installer, and usually can choose to take a maintenance contract or additional warranty. If something goes wrong, the user knows who is to blame. The continuous growth of solar thermal, particularly in those countries and regions where the level of penetration allows for a strong level of mouth-to-mouth propaganda, demonstrates that most users are satisfied.

An **obliged market** is substantially different. The solar systems are generally ordered by construction companies that may have little or no motivation to choose products and services of a quality higher than strictly required by the wording of the regulation. Once the building is sold or rented, they do not benefit from the energy savings. Their main interest is to keep down the investment costs, like for all other building components.
During the first few years of implementation of an obligation, there may be a lack of well qualified engineers & installers, a lack of integration in the mainstream HVAC construction processes and an insufficient knowledge of the technology among architects and construction industry managers.

Also, the users have to be educated. Particularly in countries with a high share of large residential buildings for rent (like Spain), some users may not even become aware that a solar system exists. Most of the users will have very little knowledge about solar. This can lead to false expectations and to a limited capacity to identify and understand even simple faults in the installation or in the operation of the systems.
Some users may be obstructive and tend to carefully check and protest at any sign of reduced performance.
Finally, the skilled solar companies may not be able to satisfy the strong increase in demand triggered by the obligation. New market players with little or no reputation to lose may enter the market and try to make quick money, thereby compromising the reputation of the serious solar companies.

Most of these are problems that a solar obligation will help to solve. But, especially in the first years, some teething troubles are possible.

Quality features of solar thermal systems

Solar thermal systems do not constitute any relevant health or safety risk for the users, nor for craftsmen with a basic training. Also, a loss of comfort caused by the solar system is nearly impossible, since there usually is an auxiliary heating source (gas, oil, biomass, heat pump or electricity) that guarantees availability of hot water or space heating when the solar input is not sufficient.

The quality concerns refer only to the functionality of the system, i.e. to their durability and the solar energy output.

The existence of the auxiliary system implies that the user does not always perceive if the solar system is working perfectly: hot water is there anyway. Underperformance can often be detected only if function control procedures and/or devices are in place.

In the case of **medium or large sized systems**, particularly those also supporting space heating, it is normal practice to install controllers and devices monitoring the system. In some cases, a reduction of solar output can be solved by very simple measures like cleaning the collector surface. In other cases, it is necessary to ask for qualified assistance.
For very large systems, remote monitoring is a standard feature: the system provider or another specialised company receives data from the monitoring devices and software automatically identifies anomalies, often before the user notices them. The monitoring company may be able to remotely intervene on some valves, reducing to a minimum the need for local intervention. This kind of service can be combined with a guaranteed solar result contract or similar, provided by an energy service company.

For large systems, it is therefore important that a solar obligation prescribe that current best-practice monitoring is applied, including a service contract. Monitoring devices and procedures, as well as regular maintenance must be considered as an integral part of the investment in the solar system. Guaranteed solar result contracts should be encouraged, particularly for very large systems, but the offer is not yet developed enough for them to be made compulsory.

However, many **small systems** currently on the market only have rudimentary measuring devices, or none at all. In particular, natural flow systems, which do not need a controller and can cost very little, often come without any monitoring.
This may be rational, as the cost of advanced monitoring devices may not be justified by their practical benefits. In fact, a complete fault of the system can be easily detected even without any monitoring device, by switching off the auxiliary heater, using all the hot water in the tank, and then seeing whether the fresh water has become hot at the end of a sunny day. However, even with a monitoring device, it may not be easy to determine the existence and extent of partial system failures, as their effects are intertwined with several other factors, like variations of solar radiation and external air temperature, and of consumption patterns.
Like for many other relatively cheap household appliances, when underperformance is presumed in a small solar system, it is not always easy to determine its cause and take consequent measures, taking into account that the low purchase cost of small solar systems may not justify overly expensive diagnosis and repair.

For these reasons, in the voluntary market many providers and buyers of small solar systems have so far been happy with or without rudimentary monitoring devices and procedures.

Detailed quality assurance measures for large and small systems are proposed in the annex.

The issues mentioned above should not give the impression that solar systems are particularly prone to failure. The broad majority of solar systems work to the full satisfaction of their users. And there are hardly any household appliances offering the possibility of monitoring or assessing their actual energy consumption.

Most regulatory obligations in the building sector have implementation rates below 100%. For instance, fire extinguishers and detection systems are not always installed and maintained according to law. This does not mean that the rules are useless. One would rather conclude that appropriate monitoring and sanctioning procedures should be enforced to increase the rate of implementation to an economic optimum.

From an aggregated, political point of view, even if the share of the properly working systems does not reach 100%, the amounts of solar energy produced by the majority of well working systems are large enough to justify the obligation and other support measures. However, this is of course no argument from the perspective of the individual users affected by the failures. If people are obliged to purchase a product because it saves energy, appropriate quality assurance measures are necessary to guarantee a long-term acceptance of the regulation.

Recommended quality assurance measures

Due to their technicality, some details are in Annex 6. Here only the general principles are discussed.

The purpose of the quality assurance measures should be to ensure that the cheapest possible solution fulfilling the wording of the obligation will provide convenient solar energy for a long time.

Quality assurance measures should cover the following areas:

Components and system configurations
Installation works, guarantee and after sale service
Function control
Third party monitoring of a sample of the systems installed

A clear sanctioning regime is necessary to give a reasonable incentive to the market actors to comply with these measures.

Components and system configuration

The main features to be taken in consideration are the performance, durability and safety of the components and of the system configuration.

These features are covered by existing European standards for solar collectors (EN 12975) and for factory made systems, i.e. kits including all components that only have to be assembled on the spot (EN 12976).
For custom made systems, a EN standard is in advanced phase of development. All large solar systems are custom made.

Solar collectors: Keymark should be required

Within solar obligations, due to the enhanced quality needs discussed above, ESTIF strongly recommends always requiring a Solar Keymark certification for the solar collector.

The Keymark is a voluntary third-party European certification mark, developed by CEN (European Committee for Standardization). The Solar Keymark has been developed by ESTIF, with support of the European Commission. It certifies compliance with one of the two standards mentioned above[2]. It offers higher benefits reliability than ordinary EN test certificates: the user can be ensured that the Keymarked products sold are equal to those tested, because the latter are randomly taken from the production line by inspectors from accredited test institutes. Furthermore, the Keymark requires the existence of a quality management system comparable to ISO 9000.

[2] If the collector is only sold as part of a Keymark certified system (EN12976), a Keymark for the collector alone is not necessary, as the Keymark system certification assures that the collector fulfils the requirements of EN12975 - except for specific information on collector performance figures.

A wide range of information on the Solar Keymark is publicly available at www.estif.org/solarkeymark

A few years after its introduction (last update: July 2007), over 160 collector models from more than 80 suppliers bear the Solar Keymark. These collectors represent probably more than 70% of the sales in Europe. The number is increasing every month. Since 2007, the German government has required the Keymark as a condition to be eligible for the federal financial incentive. In the context of an obligation, there is no reason not to request this state-of-the-art certification of the collector.

System certification and quality assurance

For factory made systems, at the moment of writing (last update: July 2007), only seven systems from five suppliers bear the Solar Keymark, also due to overly complex certification procedures that will probably be simplified soon. ESTIF is working in this direction with the support of the Solar Keymark-II project, co-financed by the Intelligent Energy Europe Programme of the European Commission. For custom made systems, the EN standard is in advanced state of development.

Therefore, it would be too early to require a Keymark system certification as the only possibility.

ESTIF recommends that any solar obligation accept a Keymark system certification if available. In the annex, we recommend a set of additional and alternative criteria regarding the system configuration and design. Their purpose is to guarantee that the quality and relative sizing of a few key components are reasonable.

Avoid barriers to trade!

It is absolutely necessary to avoid the creation of artificial barriers to trade within the European market. Only within an open and large European market can the manufacturers of solar thermal products achieve the economies of scale needed to reduce costs.

Therefore, ESTIF strongly urges the national or local authorities designing support measures, including solar obligations, to avoid setting product requirements not strictly based on existing European standards and certification schemes. If additional or divergent requirements are created, the markets become fragmented, the competition is reduced, the certification costs increase and in the end the users lose in terms of choice, quality and prices.
European standards and certification procedures can and should be constantly improved. Any new ideas or national input to the European co-operation is welcome if it aims at improving the European norms and is discussed collectively at European level. Instead, additional national requirements or certification procedures only damage the growth of solar energy.

Installation works, guarantee and after sale service

The quality of the installation is essential for the correct functioning of a solar system. Installation mistakes are the most frequent cause of failures.
The industry is developing more and more kit solutions, thus strongly reducing the complexity of the installation and the possible mistakes. However, some specific know-how is necessary, particularly for large systems.
Therefore, a solar obligation must contain requirements for the qualification of the installers. The installion company should be obliged to sign a commissioning check list, to supply a minimum guarantee and after sale service, and to provide the user with the necessary information about the system.
The installing company should be obliged to repair relevant system failures and, if needed, get assistance from the manufacturer. The user should have only one contact company responsible for the functioning of the whole system.

In the annex, more detailed recommendations are provided. However, the context in the different EU countries is very heterogeneous, for instance with regards to the general level of training of the professionals involved in the building sector, the general rate of compliance with regulations, the typical relationships between building developers, subcontractors, owners and users. Specific solutions must be tailored at national or regional level.

Function control

For small systems, a solar obligation should ensure that it is possible for the user or the installer to check if the system is operating and delivering heat.
The user manual should clearly describe how to perform a simple check of the system and list the simple maintenance operations that do not require special skills.
Within a solar obligation, it is reasonable to require the installation of a monitoring device, if its cost is not higher than the value of the energy savings in a half year of system operation. If the cost is higher, the added value of the monitoring device is disputable. It must be noted that this requirement should not apply to the voluntary market, where the user should be free to choose the desired level of monitoring.

For larger systems, more sophisticated measuring and monitoring devices should be required, and the user manual should clearly explain how to interpret the information provided by the device and how to perform the maintenance and checks that do not require special skills.

The purpose of such function control features is on one hand to inform and empower the users and on the other hand to create an incentive for the installing companies and the hardware suppliers to deliver state-of-the-art products and services, in their own interest of reducing the costs of after sale interventions.

Third party inspections of a sample of systems

Foreseeing a scheme of third party inspections is recommended.

After one or two years of operation, a random sample of the systems installed under the obligation could be inspected by qualified third party experts. The experts should have access to any stored data about the operation of the system, and to the physical installation. In case malfunctioning is ascertained, the public authority should have the means to force the installing company to repair or improve the system.

In some countries, regular inspections are foreseen for *all* heating systems, with the aim of controlling their emissions. In these cases, the number of solar systems inspected could be increased, though it must be considered that the inspectors should have specific solar skills.

An analogous inspection scheme has been implemented in France, within the QUALISOL scheme of certification for solar installers. After having followed the training, the certified installers know that some of the systems they install may be checked by an expert. In case of repeated quality problems, the sanction faced by the installer is the withdrawal of its QUALISOL certification, leading the installer out of the solar market, since the use of a QUALISOL certified installer is a precondition for receiving a financial incentive.

At least in anonymous form, the data about the operation of the systems should be made available to the interested public. This could create a broad pool of knowledge, useful to further improve the quality of products, system design and installation procedures. Moreover, consideration could be given to enacting a name and shame system, i.e. publishing the names of the installation companies, and of the manufacturers in case of repeated failures. This would create a powerful incentive for the companies to provide high quality products and services.

Inspections should be applied more frequently to large systems, as the larger solar energy production and costs justify more attention, but a few small systems should also be inspected to make sure there is a strong incentive for quality installations in this market segment too.

Structure for a solar obligation and guidelines

This section analysis the structure of solar or renewable heat obligations, looking at each of their main components:

- Buildings subject to the obligation, exceptions
- Definition of the required solar contribution
- Solar or renewable heat obligations
- Technical parameters for the calculation of the fulfilment
- Definition of the accountable persons
- Control procedures
- Sanctioning regime

Some guidelines are proposed. However, it is very difficult to provide general guidelines applicable to the whole European Union, as the context in the different countries is very heterogeneous in terms of the building stock, the prevailing heating systems, the regulatory and legal background, the market penetration and potential of the different renewable energy sources, the typical training level of installers etc.

Therefore, the guidelines proposed here are of a general nature. Their implementation should always be carefully analysed taking into account national or local conditions.

It must be noted that, on the demand side, the difference in climatic conditions is not very relevant, because the demand for domestic hot water varies only slightly between the North and the South. However, of course, Southern Europe has a stronger potential for cheap solar energy, whereas in Scandinavia biomass is often more convenient than in the South, and obligations may take this into account.

Buildings subject to the obligation, exceptions

When do obligations apply

All new buildings and those undergoing major renovations should be covered by a solar obligation. In these cases, the benefits are obvious and the additional costs caused by the obligation nearly negligible.

A draft law proposed by the government of the German Federal State of Baden-Württemberg foresees a renewable heat obligation also in the case of replacement of the heating system. The same is being discussed in Germany at the federal level. The advantage is that installing renewable heat components is usually cheaper when

this event occurs. Once the replacement has been done, the window of opportunity is closed for one or two decades.
Concerns have been expressed that such a provision might encourage the building owners to postpone the replacement of old gas or oil burners with more efficient condensing boilers. However, this negative incentive is limited in time, because the replacement must occur anyway sooner or later, and can be reduced with a specially designed financial incentive. Moreover, in some countries like Germany there already is an obligation to replace very old and inefficient boilers.
Therefore, ESTIF recommends considering applying solar or renewable heat obligations also in the event of replacement of the heating system, at least in the numerous countries where condensing boilers already have reached a high market penetration.

In which buildings do obligations apply

In Spain, solar obligations apply to nearly all kinds of building uses. In some other countries or regions, applying obligations only to the residential sector is being discussed. From the point of view of energy savings, the latter is not recommendable, because many tertiary buildings (hotels, collective residences for elderly people, hospitals, barracks, swimming pools, sport facilities, large refectories etc.) consume a lot of hot water and offer very good conditions for solar heating or other renewables. Of course, some tertiary buildings consume very little hot water. To take this into account, it is possible to exempt buildings with no or very small consumption, though it must be noted that the City of Barcelona, after some years of experience, decided to abolish this exemption (see annex).
For temporarily used buildings, like holiday houses, exceptions can be foreseen, as in the case of the Spanish CTE.

Exemptions

One of the most frequent exemptions foreseen by existing solar obligations concerns the protection of historic buildings; of course, solar collectors must not necessarily be installed on the historical roofs of the medieval town-hall or cathedral. However, particularly in areas with a large number of listed buildings or with lengthy authorisation procedures, this exemption should be formulated and implemented wisely: antennas and roof windows, which look very similar to some solar collectors, have become ordinary building elements in many historical centres.
Solar energy should not be discriminated against. For instance, in a draft municipal obligation discussed in a large Italian city, a clause foresaw that solar collectors should not be visible from the street level. This would completely exclude solutions based on façade collectors that can be perfectly integrated in glass facades of modern buildings.

And why should solar collectors be hidden? In some neighbouring countries home owners show them proudly, and this contributes to their dissemination. It may be sensible to adapt esthetical conceptions to the upcoming post-oil era, especially considering that a glance over the roofs of the wonderful historic centre of that city is

enough to see hundreds of traditional TV antennas, satellite dishes, mobile phone masts and roof windows.
Other frequent exceptions to solar obligations refer to buildings where other renewable heat sources are used, or with limited access to solar radiation. These are discussed in the next section.

Buildings linked to district heating

Circa 12% of the total heat demand in Europe is covered by district heating, with high shares in some Eastern and Northern European countries. District heating offers a very high potential for integration of renewables, not only biomass and geothermal but also solar thermal. The largest solar thermal heating system in the world (13,8 MW_{th} capacity) is connected to a district heating network on an island in Denmark.
In buildings linked to a district heating network, a solar or renewable heat obligation on the single building would not be reasonable. In this case, the best way to increase the share of renewables is to invest in the district heating network itself. Specific financial incentives should be provided to district heating operators. An obligation should be considered, taking into account the specific potential and conditions of each region.

Definition of the required solar contribution

Most existing obligations require covering at least 30% to 80% of the domestic hot water demand from renewable energies.

It must be noted that these values represent only a small part of the coverage provided by many state-of-the-art solar thermal systems. In Austria, one of the leading markets in Europe, circa one third of the systems installed during the last two years are Combi-Systems, typically covering nearly 100% of the domestic hot water and 10-30% of the space heating consumption, and thus saving more than three times the energy produced by an obliged system defined as above. A large proportion of European buildings is suitable for the installation of solar Combi-Systems.

Of course, an obligation has to be defined moderately, in order to be reasonably applicable to all buildings. For the time being, ESTIF does not recommend requiring space heating in solar obligations, because at the current level of technological development, there is still a relevant share of buildings where space heating cannot be supported with solar at reasonable prices. However, in most European countries, the minimum share of domestic hot water should be at least 40%, as this is easily reachable almost everywhere by small solar systems. In the most Southern parts of Europe, obliged shares of 70-80% are feasible.
A gradation based on the estimated hot water demand for different building uses and sizes, and on latitude, as in the Spanish CTE, is reasonable (see annex).

If the obligation is set too high, it to excluding de facto solar energy. For instance, in a draft discussed in a Mediterranean city, a requirement of 50% of the total consumption for hot water and space heating was being discussed. Taking into

account a space heating season of five months, and a limited available surface for collectors in comparison with the typical building volumes, in most cases such a requirement would have been reachable only with biomass systems that automatically cover 100% of the demand.
However, given the uncertainty about the availability of sustainable biomass supply in the case of expected growth in demand, biomass use should not be obliged as the only possible option. Of course, solar thermal can also be perfectly combined also with biomass heating systems, reducing accordingly their consumption and emissions.

Renewable Heat Obligations that refer to the total demand for domestic hot water and space heating typically require 10% for existing buildings and 15-20% for new buildings. The first requirement can be fulfilled with solar domestic hot water systems, the latter with Solar Combisystems.

Solar or renewable heat obligations

Though mainly known as “solar obligations”, several of those implemented so far are in fact renewable heat obligations, exempting from the solar obligation buildings covering this demand with other forms of renewables.

This approach reflects a political aim to increase the share of renewable energies and to leave to the market the choice of the technology most suitable for each building owner. While this aim is absolutely reasonable, it is useful to mention some comparative benefits of solar thermal that are often not reflected in the market prices faced by the investors.

Solar thermal systems provide completely clean and renewable energy, always resulting in net energy savings, regardless whether they are combined with an auxiliary gas, oil, biomass, electricity or heat pump system. The operation of the solar loop in natural flow systems does not require any electricity consumption and in forced circulation systems the consumption for pump and monitoring devices is negligible compared with the gains.
Therefore, the use of solar systems is always desirable, both from the perspective of the single user and of society.

Most **geothermal heating systems** use heat pumps, producing useful heat taken from a natural source (underground water, sea/lake/river water, air). They need a substantial electrical input. In real life, most heat pumps have a COP (Coefficient of Performance) ranging between 2,5 and 4. This means that they produce 2,5 to 4 units of heat by using one unit of electricity.
Thus, when replacing a conventional electrical heating, heat pumps provide a net benefit. If combined with solar, their benefit is even higher as a part of the electricity consumption, particularly in summer, is covered by solar.

However, when substituting a (more frequent) gas heating system, a heat pump system saves 100% of the gas consumption, but it massively increases the electricity

consumption. Considering the average efficiency of European power plants, the gain in term of primary energy may even be negative. Moreover, a wide use of heat pumps would lead to increases in winter peak electricity demand, causing hidden costs in terms of the necessary enlargement of electricity generation and transmission capacities.
Equipping the same gas heating system with a typical solar thermal Combi-System, gas consumption is reduced by 10-30%, with a very marginal (<1% of the gains) increase of electricity consumption.

In conclusion, the use of heat pump systems is always desirable when they replace electrical heating systems. When they replace gas, biomass or mainly solar systems, their benefits should be weighed with the public costs and risks linked to the massive increase of electricity consumption they imply.
The electricity consumed by heat pumps and the primary energy needed to produce that electricity should be subtracted from the heat produced by the pump, and only the remaining fraction should be considered as renewable.

In the case of **biomass heating systems**, it should be considered that the production and delivery of the fuel is linked with a more or less strong consumption of energy and other natural resources.
While in nearly all cases the CO_2 balance of biomass is clearly better than fossil fuels, some biomass heating systems cause high rates of locally polluting emissions. Furthermore, the use of biomass is also being politically supported for electricity generation and transport, and for the latter biomass represents the only form of renewable energy available today at a significant scale.
If the use of biomass would increase in all energy sectors (electricity, transport, heating) as projected by some analysts, it is doubtful if the availability and sustainability of bioheat fuels will be ensured. A coherent certification scheme for the sustainability of biomass still has to be developed. The biomass consumption and its environmental impact can be reduced in combination with solar thermal.

Therefore, the increased use of bioheat systems is desirable as long as the security and sustainability of biomass supply are reasonably guaranteed and the local emissions are limited. Biomass heating systems should be installed in combination with solar as often as possible.

Summing up: heat pumps and bioheat systems produce renewable energy, but have considerably higher external costs than solar thermal. The increase of winter peak electricity consumption caused by heat pump systems (except when they substitute for electrical heaters) should be taken into consideration. Biomass heat should be promoted, as long as the sustainability and availability of biomass heat fuels is guaranteed.
Therefore: renewable heat obligations should in any case be designed in a way that they support the use of solar thermal. In Southern Europe, there is a case for purely solar obligations, if the available biomass sources are scarce and the capacity of the electrical grid is not sufficient to support the increased demand from heat pumps.

Calculation of the fulfilment

Once the required share of solar or renewable heat is established, procedures for its calculation and possible verification must be defined.
Two pieces data are required: the hot water (and if relevant space heating) consumption and the production from the solar system. For both, it is necessary to define standard criteria, because the first verification of the fulfilment of the obligation is at the planning stage, when measurements are not yet possible.
For the hot water consumption, the Madrid regulation and the national Spanish CTE offer an example of a detailed definition taking into account the use of the building and its size. A similar approach is recommendable, though the data may have to be adapted to the local situation.
For the solar system performance, the calculation methodology should be based on the European standard EN15316-4-3 of 2007: "Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Heat generation systems, thermal solar systems."

Controlling procedures

The effective implementation of the requirements can and should be controlled by the public authorities at three points in time:

On paper, at an early stage of the planning of the building (or of the renovation): comparing the proposed installation with the legal requirements.
Before the building is commissioned, comparing what has been effectively installed with the legal requirement
After one or two years of operation, inspecting a sample of systems to see if they perform according to the requirements

The first and second steps are foreseen with more or less clear provisions by all solar obligations. In Barcelona, for instance, the revised Ordinance of 2006 includes a model declaration to be signed by the installation company after the works are completed. This declaration includes the data needed for the public authority to determine if the installed solar system complies with the requirements.

However, it is not always clear if and how often on-the-spot checks are undertaken. Like for any other building regulations, the rate of compliance will be higher if there is a significant likelihood of an inspection. For solar systems, underperformance is most frequently caused by installation mistakes. Thus, the standard document-based controls should be accompanied by sufficiently frequent inspections on the spot.
These should be performed by specifically trained and motivated staff. If appropriate, this service can be performed by external companies, whereas care must be taken to avoid a conflict of interest between the inspectors and the installing companies.

Particularly during the first period of implementation, low compliance is more likely due to the scarce knowledge and/or willingness within the construction companies. Therefore, relatively frequent inspections should be announced from the first day of implementation of a solar obligation.

To our knowledge, no solar obligations foresee the third kind of inspection[3]. Presumably with the intention of achieving the same effect, the Spanish CTE prescribes instead a number of technical details about the components and the configuration of the system. As discussed below (see annex), such a prescriptive approach has several disadvantages.
Instead, it is recommendable to announce random inspections on a sample of the systems installed under the obligation. On the basis of the required function control devices, skilled staff should check the functionality of the systems, for instance after one year of operation. In case of significant underperformance, the installing company should be obliged to repair or improve the system at their own cost.
The information gathered through these inspections should be made available, at least in anonymous form, to research institutes and industry, that can use it to improve products, system design and installation procedures.
A "name and shame" policy could be considered, giving the installers and manufacturing companies a strong incentive to guarantee high quality products and services.

This third kind of inspection should be applied more frequently to large systems, but also a few small systems should be inspected to make sure that quality issues are not neglected in this area.

The energy agency or the public body with the task of monitoring the implementation of the solar obligation should have the right to access the systems and to adjust the inspection procedures and frequency according to the needs. Presumably, after a couple of years of experience, the increased level of knowledge of the involved companies and staff, as well as the increased awareness of the users and citizens, will allow for a reduced level of inspections.

Sanctioning regime

In a strongly competitive and price-driven market like the building sector, regulations are implemented only if the sanctions are clear, predictable, strong and frequent enough.
In this case, construction companies integrate the check of compliance into their standard quality management procedures. If the sanctioning regime is too weak, no or low compliance may be a rational strategy for construction companies.

This is particularly true for solar regulations in their first period of implementation, as construction companies are not yet used to dealing with solar energy:
the costs of learning how to integrate a new element in the construction process are higher

[3] A kind of exception is a quasi-obligation in the Austrian region of Styria, where the use of renewable heat is a condition for receiving the strong public financial support foreseen for those building their own new residential building. Because (almost) nobody wants to miss this subsidy, (almost) everybody fulfils the requirement. However, this is not an obligation in the strict sense, and was therefore not considered in the present study.

the low level of training makes mistakes more likely
the final users of the solar system, i.e. those who will live or work in the building, are less able to perceive possible underperformance of the systems
the companies might be tempted to "test the public authority" and see what happen if this additional legal requirement is not met

In the field of solar regulations, the case of Vellmar (see annex) is an example of a credible sanctioning regime, but the sanction was too low. In Spain, there are great worries about the effectiveness of the sanctioning regime of the CTE, especially as the monitoring and sanctioning is responsibility of the regional administrations which may have other priorities, while the legislation was adopted at the national level.

A convincing sanctioning regime is strictly necessary for a successful solar obligation. Without it, there is a significant risk of a high rate of low quality systems, possibly leading to a reduced acceptance of the obligation or even of solar energy as such.

The sanctions should be applied after all control phases discussed in the previous section. The installing company should be made responsible for solving, at its own cost, major failures or underperformance, of course without prejudice to the warranty and liabilities of the manufacturers. However, both the users and the public authority should have only one contact person responsible for the whole solar system.

Flanking measures for solar obligations

The main message of the *Solar Thermal Action Plan for Europe*, produced by ESTIF within the K4RES-H project, is that a coherent set of different, long-term oriented measures are necessary to achieve ambitious targets.

Solar obligations should not be seen as an isolated measure, but rather as a part of a wider plan to promote the use of solar thermal. For instance, R&D efforts are necessary to develop tomorrow's solar energy solutions.

In light of the analysis above, to be successful solar regulations need some flanking measures, mainly for two purposes:

maximising their effect in the obliged sector
promoting the use of solar in the voluntary market, i.e. for the buildings or uses not subject to the obligation.

As seen above, solar obligations only cover a small part of buildings and prescribe only a minimal level of solar energy use that can be economically implemented in all new buildings. This means a large part of the potential use of solar thermal cannot be obliged: the use of solar in existing buildings not undergoing a major renovation, and the use of solar beyond the strict legal requirements, for instance for space heating or cooling, in industrial processes, in the agricultural sector, for desalination etc.

If all the usual support schemes like financial incentives, awareness raising, and demonstration projects would be stopped when a solar obligation is adopted, the potential users might see this as an implicit message of the public authority that the use of solar beyond the obligation is not desirable. This impression must be avoided.

Therefore, support schemes focused on the voluntary market should continue. In case of buildings subject to the obligation, of course, the incentive should be given only for the solar capacity above the limit prescribed by the obligation.
Within the K4RES-H project, ESTIF has produced an extensive study with detailed guidelines on best practice financial incentives. For details, please see: www.estif.org/stap

Furthermore, intensive and focused training and awareness raising campaigns are highly recommendable during the first phase of implementation of a solar obligation.

A number of managers of construction companies, architects, heating engineers and installers who never dealt with solar energy before are suddenly forced to use it. If sufficiently trained, they will do so at a state-of-the-art level, and they will become motivated to go solar beyond the legal requirement. If not, there is a higher risk of low compliance or quality problems. Setting up training courses is therefore recommended, as well as a certification scheme to demonstrate the solar qualification of the key professional figures involved.

ANNEXES

Annex 1: 27 years of solar obligation in Israel

Back in 1980, Israel was the first country to make solar thermal obligatory in new residential buildings, with the aim of reducing the country's dependence on imported energy. According to governmental sources, today Israel saves circa 8% of its electricity consumption thanks to solar heating systems.

The obligation applies to all new buildings, except those used for industrial or trade purposes or as a hospital, and those higher than 27 metres. The required daily heat output of the solar system differs according to the use of the building and on the kind of solar system installed.
For ordinary residential buildings, the obligation is defined in terms of daily solar energy output per litre of storage tank capacity: 172 kilojoules for open loop systems, and 192 kilojoules for closed loop systems.
The required tank capacity is determined according to the number of rooms in each residential unit: at least 60 litres for one room apartments, at least 120 litres for two or three room apartments, at least 150 litres for larger ones.

For hotels, guest houses, elderly homes, boarding schools and similar, the obligation is defined in terms of daily solar output per litre of hot water consumption: 126 kilojoules for open and 142 for closed loop systems.

The obligation became a success and made solar thermal a mainstream technology in the water heater market without any financial support. In Israel, solar thermal has reached the critical mass of market size necessary to create self-sustained growth without any subsidy. Systems are available for purchase everywhere, installers know how to set them up, prices have decreased substantially: a small open loop system, including installing costs less than 500 EUR.

With almost 600 kW_{th} solar thermal capacity installed per 1000 inhabitants, Israel is the second country in the world for solar thermal use. By reaching the same level, the European Union would save circa 18 million tons oil equivalent yearly, enough to cover the total hot water and space heating consumption of ten million households.

The law's success has made it largely superfluous. Today, more than 90% of Israel's solar thermal market are in the voluntary segment, like installation on existing buildings, or systems bigger than required by law. Typical payback times are around three of four years. People consider solar thermal systems an obvious component of buildings.

Annex 2: Solar obligations in Spain

This summary is based on following documents produced within the K4RES-H project available, all of them available at: www.estif.org/stap > regulations.

An extensive study about the implementation and revision of the Barcelona obligation, produced by the Barcelona Energy agency. The 50 page version is available in Spanish and Catalan, the summary flyer also in English.
An extensive study comparing the development and the contents of more than 60 municipal obligations, more details about the obligation in the City of Madrid, and a summary of the new national Technical Building Code, This was produced by IDAE (Institute for Energy Diversification and Saving), the Spanish national energy agency. Full version and the summary flyer are available both in English and in Spanish.
A complete English translation of the legal text relevant for solar thermal within the national Technical Building Code of 2006.

It takes several years before solar obligations have a direct impact in terms of installed solar systems. Usually, there is a gap of several months or even one year between adoption and entering in force. The obligation refers to the permission for building. From the permission to the installation of the system, it can take further two years in average, and some more time before the building is inaugurated and the systems start to work.

The solar obligation in Barcelona and its upgrade

The first solar obligation ("Ordinance") was approved by the City Council in 1999, and entered into force in August 2000. After some years of experience, the Ordinance was modified, and the new version entered in force in 2006.

The Ordinance and its revision were approved after an extensive consultation process, including the professional associations of the affected sectors, including constructors, building administrators, architects, engineers, installers, consumers and tenants, solar and renewable energies and others, as well as the local, regional and national energy agency and the public bodies responsible for housing, urban planning, protection of architectonic heritage and environment.

Description of the current Barcelona Ordinance

The current version of the Ordinance is applied to new buildings, those undergoing a complete refurbishment or changing their function, i.e. when an authorisation for construction is required. The Ordinance applies to residential buildings, sport centres, hospitals and other health care facilities, industrial buildings using hot water for their process or for showers, some tertiary buildings, and any other use implying the presence of refectories or common laundries.

The minimum solar output is defined as a share of the energy needed to produce hot water. It depends on the estimated daily demand for hot water in the building, and on the kind of back up energy used:

Daily hot water demand (in litres at a reference temperature of 60°C)	Minimum solar fraction (backup non electrical)	Minimum solar fraction (electrical backup)
< 1.000 1.000-2.000 2.000-3.000 3.000-4.000 >4.000	60	60 63 66 69 70
10.000–12.500	65	-
>12.500	70	-

For indoor swimming pools, at least 30% of the energy consumption shall be covered by solar thermal energy. For outdoor swimming pools, no other heating systems than solar are allowed. For industrial uses up to 60°C, the solar fraction shall be at least 20%.

The Ordinance provides a clear list of conditions allowing for exceptions. A complete exemption from the obligation is allowed in the following cases:
In the buildings where it is not possible to cover more than 25% of the hot water demand by solar heating; however, in the non residential sector this exemption is valid only if the total daily demand that can be covered by solar is not higher than 90 MJ.
The non residential buildings with a daily hot water demand lower than 20MJ.

Under the following conditions, it is allowed to reduce the required solar fraction:
If the building has not sufficient access to the sun due to external barriers
In case of refurbished buildings, if the previous configuration creates serious architectonical barriers
If the surface available to install solar collectors is not sufficient
Where the hot water demand is covered by other renewable energies, cogeneration, waste or free heat: in this case the solar system will be designed to cover only the remaining demand for hot water, if any.

It is important to note that the latter exemption means that, in reality, the Barcelona Ordinance is a renewable heat rather than a solar obligation. The fact that solar is by far the most used option is due to its attractiveness in the context of Barcelona. However, there is no technology bias, as the obligation can be fulfilled also with other forms of renewable energy.

Results of the implementation

Before the adoption of the first ordinance, the use of solar thermal in Barcelona was negligible: with only 1650 m^2, Barcelona had 0,77 kW_{th} / 1000 inhabitants of solar thermal capacity in operation, circa twenty times less than the average of the European Union in that time.

In less than five years, Barcelona multiplied by twenty times its solar thermal use per capita. After the first Ordinance entered into force, 21,7 MW_{th} (31.050 m^2) solar thermal capacity have been added in Barcelona, producing 24.480 MWh of solar energy per year , equivalent the hot water demand of circa 45.000 inhabitants. The solar thermal systems allow for savings of 4.368 ton CO_2. Because the obligation applies to the moment when the building permission is given, there is a natural delay of two to three years until the solar systems are in operation.

63% of the new solar thermal capacity was installed in residential buildings, 20% in hotels, 8% in sport centres, 3% in health care facilities. Roughly 15% of the buildings in principle subject to the regulation were exempted, the main reason being lack of space for the collectors or shadowing from neighbouring buildings.

It must be noted that these data refer to the authorisations awarded until the end of 2005.By that time, only 20% of these systems were already operational, reflecting the physiological delay mentioned above, but also the slow start in the implementation of the Ordinance. By now (June 2007), most of the systems counted above should be operational.

The qualitative change in the perception and handling of solar thermal energy in Barcelona, its surroundings and beyond has probably been even more important than the mere quantitative results in terms of system installed under the obligation.

A large number of installers, architects and building engineers got trained and gained practical experience with solar thermal technology. The constructions companies became used to include solar from the earliest stage of planning, thus reducing the time and costs needed to integrate it at a later point. Citizens and potential users were informed about solar. Though no detailed figures are available, several solar thermal companies believe that the solar obligation led to a sensible increase of installations also in the voluntary market of existing buildings in Barcelona and its surroundings.

Beyond these local effects, the “Barcelona model” was followed by a number of municipalities in Spain and abroad, and is meanwhile being discussed also at national level in several European countries. This debate is encouraging the solar thermal industry to significantly invest in production facilities, distribution networks and marketing, leading to increased production capacities and economies of scale.

Lessons from the Barcelona experience

The experience gained in the implementation of the pioneer solar obligation in Barcelona, and the changes undertaken in its revision, are interesting for the solar industry and for all public authorities considering to implement a similar measure.

"Since its first adoption, we experienced a qualitative conceptual change, as the solar thermal installation is not anymore perceived as an «obligation», but rather as a «guaranteed right»: a norm that guarantees the right to be supplied with solar energy."
(Barcelona Energy Agency, K4RES-H study quoted above).

However, initially, the practical implementation of the obligation was made difficult by the lack of training and practice of installers, architects, building engineers and decision makers in the construction industry. The solar systems were often planned at a later stage increasing costs and sometimes the visual impact, in certain cases the lack of familiarity with the technology caused the use of wrong materials or calculation methods.

This resulted in a higher rate of exemptions during the first period. Some of the solar systems installed did not fulfil the requirements of the obligation. In other cases the wording of the regulation was fulfilled, but the solar systems produced less output than expected due to weak installation works, design or maintenance.

A survey of the users of the solar systems showed a high degree of satisfaction in cases of centralized systems serving a whole building, and a medium level of satisfaction in the case of decentralised systems, serving a single flat each (detached houses are very rare in Barcelona). A survey of the technical state of the installations revealed that the majority is working properly, but there is a significant share of systems with occasional faults, mainly linked to lack of maintenance, overheating, or leaks in the collector loop.

Comparing the 1st and the 2nd version of the Barcelona Ordinance

The main lessons learned by the administration in Barcelona have materialised in the revision of the Ordinance, that started in 2004 and was adopted in 2006.

The main changes reflect the general positive experience with the solar obligation: the number of buildings subject to the obligation increased, as well as the required solar fraction.

At the same time, the revision corrected some of the weaknesses identified during the first period of implementation. In particular, the quality of the installation works has to be certified and a maintenance contract must be provided, thus increasing the quality assurance measures as suggested by the experience mentioned above.

Ordinance of 1999	Ordinance of 2006
Obligation was applied only to buildings consuming more than 2000 litres hot water a day (i.e. larger than circa 14 residential units)	No minimal consumption threshold for a building to be subject to the obligation
Minimal solar fraction for heated swimming pools > 100 m^3 was 30%	Minimal solar fraction for heated swimming pools > 100 m^3 is 60%
Minimum solar fractions varied according to the hot water demand	In all buildings, the minimum solar fraction is at least 60%
No such requirements	A certification of the quality of the installation work and a maintenance contract are required
Higher presence of technical details in the legal text itself	Simplification of the legal text, more technical detail are relegated to annex, therefore easier to be modified

The solar obligation in Madrid

The Madrid solar obligation was officially adopted in May 2003, after one year of consultations and preparation. It entered into force in November 2003.

IDAE played an active role as consultant for the Municipality of Madrid and at the same time, IDAE was also supporting the national government, while preparing the solar chapters of the National Building Code. Therefore, the Madrid regulation is coherent with the latter, discussed below.

Due to the physiological delay mentioned above, the only data available until now are related to the permission of construction, and not yet to installed systems. In the first 26 months of applications, the awarded permissions for constructions included 19,7 MW_{th} (28.197 m^2) new solar thermal capacity, which represents a dramatic increase. Given the structure of the new buildings in Madrid, 23% of the permits refer to large (>100 m^2) solar systems, often in the tertiary sector (shopping centre, office buildings). 45% of the permits refer to systems small (<20 m^2).

Like in Barcelona, also in Madrid the industry is experiencing a significant growth in the voluntary sector as well, i.e. in buildings not subject to the solar obligation. The training, awareness raising and the increased marketing efforts stimulated by the obligation are creating an additional benefit.

Compared with the first Barcelona Ordinance, the Madrid obligation introduced some important changes which have been integrated into the revision of the Barcelona ordinance and, therefore, have been mentioned above. Among them: the required solar contribution is based on the building's consumption, a solar contribution is required also for buildings with small consumption, the design temperature of the solar system is defined at 60°C (instead of 45 °C as in the first Barcelona

Ordinance), and the technical requirements are described in annex and not in the legal text itself.

In order to determine the required solar thermal capacity, the regulation defines standard values of hot water consumption, that vary according to the kind of buildings. The same approach has then been used in the National Building Code.

Type of Demand	Litres of DHWD/day at 60º C	
Single-family dwellings	30	per person
Multi-family dwellings	22	per person
Hospitals and clinics	55	per bed
Hotel ****	70	per bed
Hotel ***	55	per bed
Hotel/Hostel **	40	per bed
Camping	40	per site
Hostel/Boarding house *	35	per bed
Homes for the elderly, student dormitories, etc.	55	per bed
Dressing rooms/collective showers	15	per service
Schools	3	per pupil
Barracks	20	per person
Factories and shops	15	per person
Administrative premises	3	per person
Gyms	20 to 25	per user
Laundromats	3 to 5	per kilo of clothing
Restaurants	5 to 10	per meal
Cafeterias	1	per meal

Besides this, in Madrid it is compulsory to install a measurement and control system which provides information on the basic parameters of the system and its production.

Also taking into account the experience in Barcelona, Madrid paid close attention to the training of the council staff, to ensure a proper implementation of the obligation. At the same time, extensive consultations was carried out with installers, engineers, architects, construction industry and with the solar thermal sector. The result of this consultation reported in the study give an interesting insight.

The national Spanish solar obligation (CTE)

With the approval of the Technical Buildings Code (CTE, Codigo Tecnico de la Edificacion) in 2006, Spain became one of the countries with the most advanced solar legislation in the world. The municipal solar obligations remain in force as long as they have stronger requirements than the CTE.

The CTE has been the most significant reform of the Spanish building sector for decades, covering security of the buildings structure, fire safety, other safety and health issues, sustainability and energy efficiency of the buildings. The latter part goes far beyond the minimal level of implementation of the EC Directive on the Energy Performance of Buildings and includes an obligation to cover 30-70% of the Domestic Hot Water (DHW) demand with solar thermal energy.

The first buildings subject to the CTE have been authorised in late 2006 and will therefore not be finished before 2008. No post-hoc data on its implementation are therefore available.

Based on different scenarios on the development of the construction market, the Spanish government expects between 1050 and 1750 MW_{th} new solar capacity to become operative until 2010, leading to yearly savings between up to 165.000 of tons oil equivalent.

Main clauses of the CTE

The solar thermal part of the CTE applies to any kind of new buildings, independent of their use, and to those undergoing a renovation. Exceptions are foreseen in the case of buildings that satisfy their DHW demand by other renewables or by cogeneration, meaning that also in this case the “solar obligation” is in reality a renewable heat obligation. Other exceptions are buildings with insufficient access to the sun, or under specific historic-artistic protection. In these cases, the reduced or absent solar contribution must be compensated by other measures leading to the same result, like energy efficiency or other renewables.

The required solar fraction of the domestic hot water demand varies from 30-70%, depending on following parameters:

The assumed volume of DHW demand: the larger the consumption, the higher the required solar fraction. This is due to the fact that solar systems are more effective if the heat load (i.e. the consumption) is higher. The CTE defines typical consumption as the Madrid regulation (see table above):

The kind of back-up energy: in case of electricity, the required solar fraction is higher than in case of gas or oil back up.
The level of solar radiation available. The CTE divides Spain in five climatic zones and allocates each province, or in some cases smaller territorial units, to one of these zones.

Having determined the required solar contribution, the CTE contains prescriptions on the method to calculate the system performance and on the required maintenance procedures.
The CTE defines a number of technical requirements on the components, design and installation of the solar thermal system, including sections on the solar collector and its components, the working fluid, the storage systems, the hydraulic circuit, the controllers and the conventional auxiliary system.
These technical requirements cover dozens of pages and can not be discussed in detail here. This high level of detail originates from the wish of the government to assure the quality and the proper working of the solar systems and to reduce the possibility of different interpretations, thus creating more legal clarity. The CTE also contains detailed prescriptions on the regular inspection and maintenance operations to be carried out by trained personnel.

Discussion on the prescriptive approach

Looking at the CTE, several experts from the solar thermal sector expressed doubts whether this approach based on detailed prescriptions is suitable. It is argued that a result-oriented approach would be more desirable: instead of prescribing a number of technical solutions, it might be more useful to foresee checks on the effective performance of the solar thermal systems and foresee sanctions, like an obligation to improve them, if the a significant under-performance is ascertained.

Some of the general arguments against the risk of over-prescriptive regulations are :

The transaction costs implied by the need of justifying special solutions may discourage solar companies from trying to find optimal tailored solutions and lead to the use of sub-optimal solutions explicitly approved by the CTE.
Some solutions may be valid in general, but sub-optimal or even not applicable in specific situations.
The prescriptions risk to be discriminatory against certain kind of solar components, technologies or designs, particularly in the case of niche-solutions that easily tend to be neglected while defining general rules
Development of new technologies or system design may be hampered
The prescriptive approach may deflect attention from the effective purpose of the quality assurance measures: to guarantee that the solar systems installed produce the expected amount of energy for a long time.

Unclear sanctioning regime

However, these prescriptions do not include clear rules about the monitoring of their implementations by public bodies and about the sanctions to be applied if the system is not delivering the expected energy.
The responsibility to monitor the implementation of the CTE and sanction the non compliant constructors is delegated to the regional authorities, which might not have the human resources and/or the political will to follow up closely this matter. Currently, there is not yet any experience with this stage of the implementation of the

CTE, since the first buildings subject to the CTE have been authorised in October 2006 and have therefore not yet been finished. However, the Spanish solar thermal industry believes that this could become a serious limit to the application of the CTE.

Annex 3: The debate on solar obligations in Germany

As mentioned above (Chapter 4.1.), the first place in Europe where a solar obligation was seriously discussed was Berlin in the mid 1990s. Though the Berlin obligation was not approved in the end, the solar thermal market in Germany was boosted by other means: strong awareness raising campaigns, R&D funds and above all the *Marktanreizprogramm* (MAP), a financial incentive scheme that has been running since 1999. For several years, Germany alone has made up half of the solar thermal market in Europe, and benefits from around 40% of the total solar capacity in operation.

On the whole, compared with financial incentive schemes operated in most other countries, the MAP has been a remarkably long-term and relatively stable support scheme. However, the market development in Germany has been characterized by some significant ups and downs, with notable deeps in 2002 and in first half of 2007 (last update: August 2007). Most analysts believe that an important factor in this market instability, at least in 2002, was the frequent uncertainty of the MAP: its dependence on the federal budget makes it vulnerable to political instability.

For details on how to design stable financial incentive schemes, please see the related study produced by ESTIF within the K4RES-H project at www.estif.org/stap

The damage caused by this instability has brought the discussion of a possible solar or renewable heat obligation back to the agenda. The implementation of a “Renewable heating law” is part of the coalition agreement of the current CDU/CSU-SPD government, though at the beginning it was not clear what this law would contain. In June 2007, the conservative (CDU-FDP) government of the Federal State of Baden-Württemberg proposed a law for a renewable heat obligation to be applied in Baden-Württemberg. Consultations are currently ongoing (last update: August 2007). At the federal level, no law has been proposed yet but it seems that the discussion is moving towards a renewable heat obligation accompanied by a continuation of other support schemes like financial incentives, training and awareness raising campaigns.

Beyond the instability of the financial incentive schemes, this political development is sustained by other factors, like the growing urgency of the security of energy supply and climate mitigation policies, as well as by the trend towards solar obligations in other countries.

Moreover, the positive experience with a sort of solar obligation in the town of Vellmar in central Germany has contributed to creating a first experience and model for discussions in this country.

The solar obligation in Vellmar (Germany)

The municipality of Vellmar, with approximately 20.000 inhabitants, set the installation of solar thermal systems as a preliminary condition for the authorisation to construct in the new development area of Osterberg.

Osterberg was a major and, for the foreseeable future, the last residential development area to be authorized in Vellmar. It covers an area of 12 hectares. When fully developed, it will have 200 residential buildings with 350 residential units. Given the size of the town it is a major development, as it could host in the future roughly 5% of the population of Vellmar.

After years of debate, the plan was publicly discussed during the local election campaign in 2001. While the SPD confirmed its absolute majority in the city council, those candidates proposing the solar obligation won a particularly high consensus; this was interpreted as support from the voters for the Osterberg solar plan.

It was the first time in Germany that such a legal scheme was adopted. The clarification of its legal feasibility absorbed a substantial amount of energy of the small city council and caused some delay. The regulation was supported by a very large majority in the city council.

At the same time as constructions in the Osterberg areas were authorized in principle, the city council included in the contract to be signed by the building developers the use of solar thermal energy and other environmental measures as a binding condition. However, as a political compromise, it was possible to be exempted by paying a relatively low fine. This explicit buy-out option was very controversial.

The obligation was only a part of the energy policy of the municipality, under the motto “Fördern und fordern” (promote and require). Other elements were a free energy consultation and a grant for building owners who also installed a rainwater harvesting system.

By summer 2005, the first section of construction was concluded, including 94 buildings with 100 residential units. 73 of these buildings had installed a solar thermal system, with a total capacity of 273 kW_{th} (390 m^2). The second construction section consisted of larger buildings with several residential units each. In summer 2005 it was being realised, with a provisional balance of 7 out of 9 buildings due to install a solar system.

In sum, around 80% of the buildings constructed by summer 2005 had a solar system installed, while a significant minority of 20% opted to pay the fine. It is interesting to note the huge difference in the compliance rate between commercial building developers and households building their own home. Nearly 100% of the latter chose to install the solar system, while slightly over 50% of the former opted to pay the fine.

An extensive scientific survey of the inhabitants and building owners of Osterberg was performed by the Institute of Psychology of the University of Kassel at the end of 2005, supported by the K4RES-H project.

All building owners and inhabitants of Osterberg were approached, and more than 50% participated in the survey, including face-to-face interviews and a questionnaire.

The survey shows a very high acceptance of the solar obligation from those subject to it. The prevailing reasons for choosing to build in that area were not the solar obligation itself, but a broad majority found its existence to be a positive aspect.

Slightly more than 10% of those who installed a solar system voluntarily opted for a Solar Combisystem covering also space heating and thus going far beyond the minimal requirement of the obligation. An overwhelming majority would choose again to install the solar system and would recommend it to a good friend.

This summary is based on a case study and the survey of the inhabitants realised under the coordination of Energie2000, the Energy Agency of the region of Kassel, as a part of the K4RES-H project coordinated by ESTIF.

The following materials (in German only) are available at http://www.estif.org/262.0.html :

Short flyer
In-depth report and analysis with legal background
Report on a survey conducted on the citizens involved
PowerPoint presentation

Annex 4: Solar obligations in Italy

National level

A renewable heat obligation is included in the law implementing the European Directive on the energy performance of buildings. The following information refers to the legislative decree 311 of 29 December 2006, that has amended a previous version.

Concerning the renewable heat obligation, the decree prescribes that at least 50% of the annual domestic hot water demand must be covered by renewable energy sources, whereas in the city centres with historical value the share is reduced to 20%.

The renewable heat obligation will be applied to all buildings, and not only those in public ownership as in the previous version. The obligation will apply to new buildings, major renovations and in case of replacement of the heating system.

The provisions about the renewable heat obligation are not yet applicable, because the implementing decrees ("decreti attuativi") have not yet been adopted.
For the national renewable heat obligation to have a real effect, it is necessary that the implementing decrees are adopted and that they contain clear provisions effectively ensuring a high rate of compliance. Otherwise, there is the danger to replicate the experience of the law 10 of 1991, that was very demanding on paper but to a large extent was not observed in practice.

Local and regional level

Some initiatives at the local level have been developed in recent years. Here the positive example of a number of small communes in the Province of Milan are analysed, as well as a law from the Regione Lazio that is an example of the frequent "nice" laws that are not applied due to a lack of sanctions and realistic enforcement procedures.

Carugate and other communes around Milano

In 2003, the municipality of Carugate, close to Milano, population 15.000, adopted a new building regulation with strong attention paid to the reduction of energy consumption. In particular, it included an obligation to meet at least 50% of domestic hot water demand from solar thermal energy. Other measures like photovoltaic or radiant floor heating are facultative.

The main actors involved in the regulation development and management are:

The Carugate Municipality, which volunteered to promote this "pioneer" experience for mandatory solar thermal in Italy;
The "Rete Punti Energia", a network of energy agencies in the Regione Lombardia, which gave the Municipality the necessary technical support;

Professionals within the building sector (designers, construction companies, etc.), who have been involved in the regulation development from the beginning;
The Province of Milano, which has worked to extend this kind of building regulation to other Municipalities.

Factors that contributed to the approval of this regulation were the discussion about the European Directive on the Energy Efficiency in Buildings, the model of the Barcelona “Solar Ordinance” and the growing general interest of local authorities for the promotion of sustainable buildings.

The regulation has been in force since the end of December 2003. It covers new buildings for several final uses: residential, commercial, industrial, tertiary, and collective use buildings (cinemas, theatres, hospitals, sport halls, schools, etc.).
The main technical requirements are:
At least 50% of the DHW demand is covered by solar thermal (100% in the summer months);
The collectors can be oriented south, south-east or south-west;
On tilted roofs, the collectors shall be installed with the same inclination and azimuth as the roof;
Water storage should be preferably installed inside the building;
On flat roofs, the collectors shall not be seen from street level.

Regrettably, there is no quality requirement on the solar products.

As a technical aid, the Municipality made available a very simple Excel sheet, by which the collector surface needed to reach the 50% solar fraction could be calculated. However, there is no standardised system to determine the expected domestic hot water demand that can be set by the construction company.
Two checks are foreseen: the first one is when the project is evaluated and the designer should fill in a check list highlighting the main parameters of the solar thermal plant. The second check is during the works, when the solar panels are installed.

During the first two years of application, the regulation in Carugate resulted in around 220 kW_{th} of new solar thermal capacity already installed or approved as projects. In a very short time, per capita, Carugate reached a level of solar energy use nearly 30 times higher than the national average. Typically, the additional costs due to the solar obligation are around 0,5% of the total cost of the building, resulting in a substantial reduction of energy bills for the next twenty years at least.

A key positive aspect of the Carugate regulation was its pioneering character in Italy, and the proactive dissemination campaign started in March 2005 by the Province of Milano, in collaboration with the University “Politecnico di Milano” and with 13 Municipalities. They jointly developed common guidelines for sustainable building regulation. A growing number of municipalities have their “sustainable building regulation” approved and some more are on the way. While the largest cities of the area have not yet joined, circa 150,000 people in Regione Lombardia live in communes under such regulations by now.

Another positive aspect was the wide consultation carried out before adoption of the obligation, including all relevant actors such as building companies and final users. This contributed to a high acceptance and to the promotion of awareness and knowledge about energy efficiency and solar energy, also due to special initiatives in schools. Moreover, a local bank offered a 5-year low-interest loan for energy efficiency projects, called “Energy Mortgage”. However, this was weakly communicated to the heating installers, and therefore also many final users did not know about this loan.

On the negative side, the complete lack of quality requirements for solar thermal products and installation could lead to quality problems and this could in its turn lead to a negative attitude towards the solar technology. Currently (last update: October 2006), no specific data in this sense are available. However, as discussed extensively in the main part of this document, quality assurance measures are absolutely necessary when adopting solar obligations.

Moreover, it must be taken into account that the rate of new build in Carugate and in many communes around Milano is not very high, and therefore the global impact of the initiative could be limited if measures are not taken to increase energy efficiency and the use of renewables in the existing building stock as well.

Regional law in Lazio

Regional Law no. 15, passed on 08/11/2004, has the aim of promoting solar energy and rational use of water in buildings. The scope includes new buildings and those under refurbishment, but all buildings located in historical areas are exempted.

The Regional Law does not define any detail of the specific measures to be applied, leaving to the Municipalities the duty to define the details for the practical implementation. This should be done by the Municipalities taking into account their landscape, historical constraints and environment.

The thin text of the regional law is available at:
www.ambientediritto.it/Legislazione/Energia/2004/lazio%20lr2004%20n.15.htm

The regulation concerns solar thermal systems for domestic hot water, rainwater collection and, more generally, the rational use of water. This report focuses only on the solar parts.

No implementation methods are defined in the text of the law, except for the fact that the Municipalities will be in charge of applying the law and also of checking the compliance of the building projects with established rules.

This makes the Lazio regulation very weak, especially taking into account that the Regional government did not take any action to support the Municipalities in their task or, at least, to make them aware of the requirements they have to comply with. It must be noted that the Region of Lazio has a population of around 5.120.000 and 378 communes. One of them is the city of Rome, with more than 2.500.000 inhabitants. Leaving aside some other major towns, one sees that the majority of the municipalities within Lazio have less than 5.000 inhabitants. Accordingly, their human resources are very limited and this makes it impossible for most of them to develop the technical details of such a regulation.

The Municipalities should have complied with the law within 180 days, i.e. by May 2005. As far the authors are aware, by summer 2006 no municipality had effectively enforced the regulation. The Commune of Rome has approved the legal basis for a solar obligation, but also in this case the technical specifications are missing and therefore the obligation cannot be applied.

The fact that the Municipalities so far have not complied with the regional law is due essentially to the concomitance of three reasons:
No sanctions for non-compliant communes are foreseen in the regional law;
The Region did not put any pressure on the Municipalities in order to have the law respected;
There is a lack of knowledge on solar thermal on the side of the Municipalities and therefore no practical actions could be taken.

For the government of the Regione Lazio, the administrative and political costs of approving this regulation for the Regione have been remarkably low: all the work to define the technical parameters and to enforce the regulation is delegated to the communes. Taking into account the clear advantage of having the same technical parameters in all communes of the same region, it would have been reasonable to define them at regional level. Given the small size of most communes in Lazio, it can be easily foreseen that the regulation will never be applied in most of them, unless a further impulse come from other sources

From this point of view, now a first step in a new direction has been taken: the Municipality of Roma is working to publish a regulation obliging the use of solar thermal to meet at least 50% of the sanitary hot water demand for new buildings. This new initiative could act as a starting point to spread the introduction of solar thermal in building regulations to the whole Region.

There was hardly any consultation with the professional groups active in the solar energy and building sector.

No replication is advisable of such a generic regulation. Its real intention seemed to be to attract positive media attention, since solar energy is popular in Italy. However, with the lack of any sanctions, technical parameters and enforcement procedures, in the Italian institutional context such a regional obligation makes little sense.

However, such a regional solar obligation could be very useful if it would entail a complete set of detailed provisions, as widely discussed in the present document, thus empowering the communes to simply transpose the new solar element into their building regulations, taking the regional law as a technical and legal reference. Also, the enforcement procedures, including inspections, should be organised by competent institutions at the regional level, like energy agencies, thus reaching economies of scale. It cannot be expected, and it would not be reasonable, that each small commune train its own solar experts to follow-up a very small number of new buildings.

Annex 5: Solar Obligations in Ireland

Starting at the end of 2005, a number of Irish local authorities introduced building energy standards as part of planning requirements in their jurisdiction. These building energy standards require a substantial increase in the energy performance of new buildings (between 40% and 60% reduction in energy usage) as well as a mandatory contribution of renewable energy to their thermal energy requirement.

The Irish political system is generally very centralised and local authorities have limited power and resources compared to many other European countries. Within the 'geographical' scale of political influence, County Councils are the most influential organ of public authority at a local level. There are 26 counties in the Republic of Ireland.

Until recently, national government had exclusivity in terms of defining energy standards for buildings in the framework of the national Building Regulations. This position was challenged in October 2005 by Fingal County Council, as it introduced improved building energy standards in the Local Area Plan (LAP) for the Cappagh Road (a 29 hectare area of this county rezoned for housing).

The energy standard requirements that all new buildings must achieve as a prerequisite to receiving planning approval are:
Annual heating requirement to be lower than 50 kWh/m^2 per year and;
At least 30% of the building's space and water heating requirements to be supplied by a renewable energy system.

This development has set a very strong example for all local authorities in Ireland as to their capability to set energy standards beyond national standards. It also encouraged the national energy agency (Sustainable Energy Ireland) to review its own targets for the House of Tomorrow programme, a funding initiative for energy efficient housing. It forced building developers and other interested parties to actively deal with energy efficiency and renewable energies and to take a position on their ability and willingness to deliver houses that meet them.

Initially, the proposals were received with a certain degree of scepticism in the Council. The market response to such standards was first tested during discussions with a local developer, Menolly Homes, who wanted to develop land in the county. It has to be noted that a very large proportion of housing construction in Ireland is undertaken by developers i.e. companies who acquire sites and build multiple houses (sometimes by the hundreds) for sale or rent to householders. Thus, developers' response to the proposed standards was fundamental.

The Council put forward as a condition for rezoning the land that Menolly Homes sought to develop that the energy standards originally proposed for the County Development Plan should be achieved, and managed to receive a public commitment from the developer to comply. This gave sufficient confidence for the councillors to submit the following proposals into the Local Area Plan for Cappagh which were successfully voted through in October 2005:

“All new buildings will meet the minimum low energy performance standards (as defined below) as a prerequisite to receiving planning approval (calculation report to be submitted with the planning application). Each building's energy performance calculation must be demonstrated on the basis of a simple approved method (e.g. EN 832) carried out by qualified or accredited experts. Low energy buildings are defined as buildings with an annual heating requirement (space and water heating) not exceeding 50 kWh/m^2 of useful floor area. The development will utilise renewable energy supply systems to meet at least 30% of the buildings space and water heating requirements as calculated on the basis of an approved method carried out by qualified or accredited experts.” [3]

In December of the same year, Fingal County Council demonstrated that their intentions went beyond a one-off trial by voting the same building energy requirements into two other Local Area Plans (North Ballymun and Northwest Balbriggan).

While parts of the construction industry opposed the introduction of these standards, several companies welcomed it.

By June 06, Fingal County Council had also introduced energy standards in several other areas. Some of them include a performance based CO_2 Emissions Target (CET) which requires a reduction of at least 60% in CO_2 emissions deriving from energy usage for space and water heating within the housing development, relative to a baseline of prevailing regulatory and design practice. The 30% contribution of renewable energy systems to meet the collective space and water heating requirements within the housing development was maintained as a requirement in the standards.

Other counties (Dun Laoghaire-Rathdown County, and Dublin/Wicklow Mountain) followed the examples with analogous regulations. Meanwhile, more than 10% of the population of the Republic of Ireland live in counties that have approved a solar obligation.

In all cases, the local authorities require the submission of a report with the results of the calculations of the energy performance of the relevant building(s), as proof of compliance with the planning application. However, there doesn't appear to be any provision in the local planning regulations to check compliance at post-construction stage, nor is there an explicit plan for linking the enforcement of the local building energy standards with the building control system.

The rising tide of local building regulations triggered a discussion also at national level that is currently ongoing. A detailed report on the Irish regulations is available at www.estif.org/stap

Annex 6: Technical specifications for solar obligations

Solar obligations require a number of technical specifications, in order to:
Define the required solar contribution
Calculate and monitor its fulfilment
Enable controlling procedures and sanctions

The reasons and arguments for setting these specifications are extensively discussed above in the chapters 3.3 (Quality assurance measures) and 3.4 (Structure and guidelines for solar obligations). This annex should be considered in light of the arguments above.
The coherence of these specifications is essential to guarantee that the solar obligations reach the desired results in terms of energy savings, and as a basis for the necessary quality assurance procedures.
Therefore, quantitative and qualitative requirements must be set on:
The solar system and its components, both on the quality aspects and the system performance and output. These must be in line with European standards and certification procedures.
The quality of the installation work carried out by qualified (trained, experienced and certified) installers
Clear description and information to the user on installation / commissioning checks, system operating conditions and system + installation guarantees.

Scope of these recommendations

The following refers exclusively to solar obligations. In the voluntary market, also in case of financial incentives, it is not reasonable to set such strict requirements.

The following refers to domestic hot water (DHW) systems only. For the time being, it is not recommended to oblige the use of solar Combi-Systems (supporting domestic hot water and space heating), nor of solar assisted cooling or industrial process heat.

Definition of small vs. large systems

This distinction is defined on the basis of ISO 9459-5 and ISO 9459-2 – the test methods behind system Solar Keymark:

Small DHW systems is defined by:
Collector area ≤ 10 m²
AND tank volume ≤ 600 litres

Large DHW systems are all those not falling into the category of small, i.e. with:
Collector area > 10 m²
OR a tank > 600 litres.

General requirements on system size and performance

As all new buildings in the EU are covered by the EPBD (Energy Performance of Buildings Directive), an energy calculation shall in principle be performed anyway, and a calculation of the solar system should be included in this obligatory calculation.

The recommended requirement is that the calculated output of the solar system should be at least X% of the net hot water load used in the calculation. It is recommended that this minimum solar fraction, X is between 40 and 70% - depending on the available sunshine in the country/region. The method used for the calculation of the solar system performance should be based on the European standard EN15316-4-3.

The requirement should NOT be based on a minimum collector area, as this will favour bad performing collectors and will not sufficiently guarantee the energy output.

Minimum requirements on system and/or main system components

Case 1: Small DHW system

At least one of the following two sets of requirements REQ A/B should be fulfilled:

REQ A:
System Solar Keymark (including performance figures)
Tank volume bigger than the design value for the average daily draw-off

REQ B:
Collector Solar Keymark
Total tank volume bigger than the design value for the average daily draw-off
Tank insulation better than corresponding to a heat loss coefficient of 1 W/K per m² tank surface [corresponds to e.g. 40 mm of mineral wool with a thermal conductivity of 0.04 W/(m*K)] and "thermal bridges" especially in the upper part of the tank should be minimised
Heat exchanger area larger than 0,2 m² per m² of collector area
Pipe insulation thickness ≥ outer pipe diameter, assuming a thermal conductivity of 0.04 W/(m*K) of the pipe insulation material. If thermal conductivity is lower, the insulation thickness can be reduced accordingly.

Case 2: Large DHW system

At least following sets of requirements should be fulfilled:

Collector Solar Keymark
Solar part of the tank volume must be bigger than the solar fraction X times the average daily draw-off (as used in "EPBD calculation"); the solar fraction X is defined in "General requirements" above (values of X are between 0.4 and 0.7)
Tank insulation better than corresponding to a heat loss coefficient of 1 W/K per m² tank surface [corresponds to e.g. 40 mm of mineral wool with a thermal conductivity

of 0.04 W/(m*K)] and "thermal bridges" especially in the upper part of the tank should be minimised

Heat exchanger area larger than 0,2 m² per m² of collector area

Pipe insulation thickness ≥ outer pipe diameter (assuming a thermal conductivity of 0.04 W/(m*K) of the pipe insulation material; if thermal conductivity is less, the insulation thickness can be reduced accordingly).

Minimum requirements on installation/installers

Both for small and large solar DHW systems, a scheme for performing random sample inspections on installation by an independent body is recommended. This inspection scheme could be part of or connected to the scheme anyway required to check the requirements given in the Energy Performance of Buildings Directive (EPBD) related to:

making energy certificates for the building

inspection of boilers

inspection of air-conditioning systems.

It is reasonable to perform random inspections more frequently on large systems than on small systems.

Case 1: Small DHW system

To avoid problems connected with the installations of small solar systems, the installers must know about solar systems and how to install them correctly, and the installer responsible for the installation must be defined. To assure this the following is recommended:

Installers shall have a certificate or other proof of appropriate knowledge to install a solar DHW system. This could be a course of 1-2 days (including examination) about installing small solar systems.

A filled in commissioning check list (as provided by the supplier as part of his guarantee) showing that the system is functioning and that all functions are tested and perform according to specifications must be delivered to the user together with the system. This check list shall also define the responsible installer by name, the system supplier, the installation company, contact data and signature.

Apart from the supplier guarantee, the guarantee on the installation work of the collector shall be at least 5 years. For the rest of the installation work the guarantee shall be at least 2 years. This guarantee will cover all costs related to repairs. It is recommended to combine the guarantees above with a service contract offered by the installer (e.g. including an annual service check of the system).

A user manual must be delivered to the user together with the system giving instructions for operation and maintenance in the local language

Case 2: Large DHW system

The same as above, plus an additional course of 1-2 days (including examination) about dimensioning and installing large solar DHW systems.

Minimum requirements on function control

Case 1: Small DHW system

For small DHW solar systems it should be possible and simple for the user to check if the system is operating and delivering heat:

For pumped closed pressurized systems only:

A pressure gauge with indication of min/max level shall always be installed, and it shall be stated in the user manual, that the pressure meter should be checked by the user e.g. twice a year. The user manual shall state that if problems are suspected, first thing to do is to check system pressure. If pressure is below limit, refill system slowly and check for leakages. If pressure is above limit, call installer.

For drain-back systems only:

A fluid level indicator with indication of min/max level shall always be installed, and it shall be stated in the user manual, how and when to check the level. The user manual shall state that if problems are suspected, first thing to do is to check fluid level. If level is below limit, refill system slowly and check for leakages. If level is above limit, the installer should be called.

For thermo siphon systems only:

It shall be described in the user manual that in case of a suspected malfunction (which cause is not directly visible), first thing to do is to refill system slowly and check for leakages. If refilling is needed frequently, the installer should be called.

For all kinds of small DHW systems:

How to refill system shall be described in user manual
If a scald valve is installed, which needs maintenance (“regular manipulation”), the user manual shall clearly state how and when to do this .
A procedure shall be described in the user manual how to check if the system is collecting/delivering heat. It should basically tell the user to check the temperature increase in the tank a sunny day having any supplementary heating turned off. If the temperature does not increase or increase only very little and refilling system does not help, installer should be called. The check procedure could look something like:

Check weather forecast: it should be a clear and sunny day above 0°C
Start procedure approx. 7 am
Turn off all auxiliary/supplementary heating connected with the solar system
Draw off all hot water in the tank until outlet temperature is at least down to approx 5°C above cold water inlet temperature. This draw off shall be finished before 8 am.
Be sure not to make any draw off’s during the day
Count the hours of full sunshine during the day, there should be least 4
At around 6 pm, make again a draw-off of at least 10 litres.

If the temperature of the water tapped has not increased at least 20°C (compared with the temperature tapped in the end of the morning draw-off), a system malfunction is possible and the system should be inspected by the installer.

Case 2: Large DHW system

For large DHW solar systems it shall be possible for the user/installer to check a bit more in detail if the system is operating as expected:
A pressure gauge (or in case of a drain-back system: a fluid level indicator) with indication of min/max level shall always be installed. It should be stated in the user manual that if problems are suspected, first thing to do is to check system pressure / fluid level. If level is below limit, refill system slowly and check for leakages. If pressure is above limit, call installer.
How to refill system shall be described in user manual
A simple function control alarm device[4] shall be fitted to the system, giving alarm (red light / beep sound) if e.g.:
pressure / fluid level below/above limits: Recommended actions are given above
collector temperature > tank temperature + 50°C: Recommended action: Call installer.
If a scald valve is installed, which needs maintenance ("regular manipulation"), it shall be clearly stated in the users manual how and when to do this.
Thermometers showing the temperature in the lower 3rd and the upper 3rd of the tank shall be fitted.
A display showing the collector sensor temperature shall be fitted.
A monitoring device[5] showing on a display the instant thermal power delivered from the collector loop shall be fitted to the system. It shall be described in the user manual how to check if the system is collecting/delivering the minimum expected thermal power. An example of a check procedure is given here below:
At a clear and sunny day at a point in time of the day when the sun shines at maximum at the collector plane (the angle between the normal to the collector plane and the direction to the sun shall be in the interval 0° ± 30°) read the displayed power and the temperature of the collector sensor. Read/estimate also the outdoor air temperature. Be sure that no clouds or shadows appear. Compare power read with the minimum expected power given in the user manual.(see next paragraph: "Determination of minimum expected power, P_{min} guidelines").
Note: This simple check procedure is to be seen as a function control. It can not check very accurate if the system is exactly performing according to specifications as the irradiation and collector temperature during the test are not measured, but it will say if something is wrong.

It is of course possible to use more advanced/accurate check/monitoring equipment/procedures including e.g. continuously recording of the irradiation and the relevant temperatures in order to give alarm if expected minimum performance is not

[4] For pumped systems, this function control could be integrated in the solar system controller.
[5] For pumped systems, this monitoring device could be integrated in the solar system controller.

reached. For very large DHW systems (> 100 m²) it is highly recommended to require the use such more advanced automatic surveillance equipment as e.g."I/O-C"[6] (input/output control).

Determination of minimum expected thermal power, P_{min} guidelines

P_{min} should be given in the user manual in e.g a table like the one below, showing the temperature limits of the procedure:

Temperature difference: Collector temperature - outdoor air temperature	P_{min} in kW
Below 60 K	P_{min} value
Above 60 K	Method not valid

P_{min} can be determined in the following way:

$P_{min} = F_{loop} * P_{700,50} / 1000$ [kW], where:

$P_{700,50}$ gives the expected output of the collector at a solar irradiation of 700 W/m² and 50 K difference between collector and ambient air. The value of $P_{700,50}$ is given in the power table in the test report according to EN12975-2 and should be stated in the user manual.

F_{loop} is a penalty factor to compensate for heat losses in collector loop. $F_{loop} = 1$ corresponds to no heat losses in collector loop and a constant irradiation of 700 W/m² and a constant temperature difference between average collector fluid temperature and outdoor air temperature of 50 K.

F_{loop} can be calculated as: $F_{loop} = S * [N*P_{700,50} – UA_{pipes}*T_{dif}] / [N*P_{700,50}]$

S: Security factor taking into account uncertainties in the procedure = 0.8

N: Number of collectors

UA_{pipes}: Heat loss coefficient of the collector loop piping

T_{dif}: Temperature difference: Collector temperature – outdoor air temperature; use 60 K

Using S = 0.8 and T_{dif} = 60 K the equation for F_{loop} becomes:

$F_{loop} = 0.8 - 48*UA_{pipes} / [N*P_{700,50}]$

In almost all cases (except when extremely long pipe length / badly insulated piping combined with a low efficiency collector) F_{loop} will be bigger than 0.5. So if the calculations above are not performed, a dummy value of 0.5 for F_{loop} can be used:

$F_{loop,dummy} = 0.5$

Example

[6] An "I/O-C", input/output control device continuously check whether the output delivered corresponds to value expected at the actually operation conditions (solar irradiation, temperature level, etc.)

Collector array power
$P_{700,50}$ = Collector power at 700 W/m² and 50 K = 600 W (given in test report)
N = No. collectors = 10
$N*P_{700,50}$ = 6000 W

UA_{pipes}
Total length of pipes = 30 m
Heat loss per meter = 0.2 W/(K*m)
Other heat losses in collector loop = 2 W/K (to be estimated based on number of un-insulated parts of the collector loop such as: pump, security valve, other valves, etc.)
UA_{pipes} = 30*0.2 + 2 = 8 W/K

F_{loop}
F_{loop}= 0.8 – 48*8 / 6000 = 0.8 - 0.064 = 0.74

P_{min}
$\mathbf{P_{min}}$ = 0.74 * 6000 / 1000 = **4.4 kW**

(using the dummy value of 0.5 for F_{loop} gives P_{min} = 3 kW)
This simple check procedure is to be seen as a function control. It can not check very accurate if the system is exactly performing according to specifications as the irradiation and collector temperature during the test are not measured, but it will say if something is significantly wrong.

Best practice financial incentives for solar thermal

Best practice financial incentives for solar thermal

Executive Summary

Financial Incentive Schemes (FIS) in the form of direct grants have played an important role in the development of the leading solar thermal markets in Europe (Germany, Austria and Greece). And in the fastest growing solar thermal market (France), a reduction of the income tax has significantly accelerated the existing market growth since 2005.

The analysis of case studies from different EU Member States has clearly shown that it is not so much the type of incentive but the concrete design and implementation – including flanking measures such as awareness raising, training of professionals – that makes a FIS succeed or fail.

The single most important success factor for the long-term stimulation of a solar thermal market through a FIS has been continuity: With short-term programmes or insufficient budgets, FIS have failed to create healthy market structures, which are the basis for continuous growth.

From experience, the following lessons have been drawn:

Avoidable weaknesses of FIS for solar thermal

Announcements of new or higher financial incentives in the future have a destructive effect on the market in the near-term, as consumers wait for the FIS to be enacted.
Lack of continuity leads to stop-&-go dynamics, which discourage the industry from investing into solar thermal long-term (e.g. into new production facility, marketing, training of professionals). Under such circumstances a healthy market cannot develop.
Without suitable and targeted flanking measures, FIS typically fail to produce significant growth in the market.
Complicated and slow administration procedures do not work if the consumer needs a new heating/cooling system soon (e.g. because the existing conventional heating system broke down).
Lack of (sensible) quality criteria leads to many low-quality systems being installed, which may undermine the long-term European renewable energy targets.

Positive lessons learned (“best practice”)

A long-term support strategy, consisting of a financial incentive scheme and suitable flanking measures (especially awareness raising, training of professionals) has shown to have the highest impact on market growth.

Specific financial incentives must be high enough to really have an effect on the market.
To guarantee continuity of the FIS, sufficient funds must be available at all times – if this cannot be guaranteed from the public budget, other sources should be tapped.
Easy and lean application and payment procedures (where necessary) are necessary for broad acceptance of the FIS.
Quality requirements which are fully compatible with the relevant European Norms (EN standards) strengthen the consumers' confidence in solar thermal technology and contribute to further market growth.

Introduction

The present study has been developed as a tool to support the design of effective Financial Incentive Schemes (FIS) for solar thermal heating and cooling (ST). It analyses the existing experience with FIS for ST, mainly in European countries. It looks both at best practice FIS that have reached their goals and at schemes or elements of schemes, which have either partially, or completely, failed. The study defines elements of best practice for this type of instrument that can play a decisive role in increasing the use of solar thermal, and thus reducing our dependency on gas, oil and electricity for heating and cooling purposes.

This study is targeted at legislators, public administration officials, energy agencies, NGOs, solar thermal associations, market actors and any person or institution involved in the design and implementation of policies to promote renewable energy and energy efficiency associated with solar thermal issues.

FIS for ST have so far been implemented at local, regional and national level. However the issues reviewed in this study also have a European dimension, as the discussion about a future EU Directive to promote renewable heating and cooling is progressing through the European Parliament and the European Commission. We also believe that the guidelines developed here might be helpful for discussion in countries outside the European Union, since the dynamic of ST market development is often similar in many other countries.

This study is produced within the framework of the project *Key Issues for Renewable Heat in Europe (K4RES-H)*, co-financed by the Intelligent Energy - Europe Programme of the European Commission. Within this project, guidelines for best practice policies on different issues relevant for the promotion of renewable heating and cooling are developed. FIS is one of the issues under review in K4RES-H. In this study, FIS for ST are considered. In parallel studies, FIS for bioheat and geothermal are considered. General conclusions about financial incentive schemes for renewable heating in general are presented in a different chapter[7].

Many contributors have provided their knowledge and experience in the compilation of this study: the members of ESTIF and particularly the national solar thermal associations from nearly 15 European countries and also many other experts from energy agencies, public administrations, NGOs and others. We warmly thank each of them even though we do not have enough space to mention them all.

However, ESTIF remains solely responsible for the contents and any possible mistake should be attributed to our error or omission.

[7] This chapter will be produced at a later time.

Aim and structure of this study

The key question to be answered is how financial incentives schemes should be designed to best promote the uptake of solar thermal.

In the last decade, solar thermal has been promoted by many different kinds of FIS in a number of countries, regions and local communities. In many cases, the FIS worked well and produced a significant effect on market development and so provided energy savings. In other cases, the FIS was not as effective and at worst, sometimes had counter-productive effects. In the present study, the key lessons to be drawn from the existing experience with FIS for ST are analysed.

Whilst there is a very broad range of academic literature available about the effectiveness, advantages and disadvantages of different support schemes for renewable electricity, there is hardly any literature available to date about support schemes available for renewable heating, and specifically for ST.

Some case studies are attached at the end of the main text, showing in detail how FIS for ST work. They have been selected with the aim of presenting different kinds of FIS that, for various reasons, are particularly significant. The case studies presented are:

Germany, Market Stimulation Programme (MSP)
Italy, White Certificate Scheme
Italy, Support from Ministry of Environment for local authorities
Italy, Comparison of two regional support schemes
Austria, Regional support scheme in Upper Austria

Moreover, this analysis is based on the broad knowledge about the functioning of the solar thermal markets gathered by and within ESTIF, through direct contacts with national associations and market experts from many countries in Europe and beyond, notably at the estec (European Solar Thermal Energy Conference), organised by ESTIF in 2003 and 2005.

Definition of Financial Incentive Schemes

Within the K4RES-H project, the following definition of FIS was agreed with the project partners.

Financial Incentive Schemes (FIS) include any public policy giving a financial advantage to those who install a solar thermal system or that use solar thermal energy. For example:
Direct grants (e.g. German Market Stimulation Programme, MSP)
Tax reductions (e.g. income tax break in France)
Loans at reduced rates
Green heat or energy efficiency certificates

Financial Incentive Schemes (FIS) do not include public policies that support the creation of public goods, giving an indirect financial advantage to the solar thermal market. For instance: an awareness raising campaign financed by public money or a program to subsidise training of craftsmen or R&D funds, etc. Obviously, all these instruments create an indirect financial advantage for the companies involved in the market and this advantage is then transferred to the users. However, such instruments are not considered as FIS within the K4RES-H project, because they focus on public goods and therefore the financial incentive cannot be easily quantified.

Definition of solar thermal heating and cooling

The present study deals only with solar thermal heating and cooling. Electricity-producing solar thermal power plants are not included as they should be covered in renewable electricity support schemes.

Justification and limits of Financial Incentive Schemes (FIS)

Some principle of solar thermal economics

The direct economic utility of a solar thermal system for its owner are:
The economic value of the energy it saves
A certain degree of independence from conventional energy supply

The first bullet point depends on the size of the system, its operation by the consumer, the solar radiation levels and most significantly the cost of the conventional energy displaced. The second bullet point can also be important. Depending on the above parameters, nearly all ST systems installed in Europe can cover the full hot water demand for a period varying between 3 to 9 months. Larger solar systems (combisystems) can cover also a significant part of the space heating and cooling load. Solar houses, covering their full heating and cooling demand with passive and active solar energy have been successfully demonstrated, but are not yet a common market option.

Other private utility of a solar thermal system is of psychological nature, such as the positive feeling that comes from caring for the environment. In some countries, a ST system is becoming a positive status symbol. Such benefits are not quantifiable by their nature.

A solar thermal system creates also external utility, i.e. benefits to other people and for the larger community for which the system owner does not gain any financial reward. In other words, an external utility is the opposite of external costs. The main external utility created by a ST system is:
Savings of CO_2 emissions
Savings of other emissions causing local air pollution
Reduction in dependency on energy imports
Reduction in further external costs linked to the use of fossil fuels or nuclear power
When a ST system displaces electrical heating: reduction of peak demand on the national grid

These private benefits and external utility have to be balanced with the private and external costs of a solar thermal system.

The private costs of a ST system consist of:
the investment to buy and install the system
the costs of maintenance and decommissioning
the additional transaction costs linked with a buying decision that in most cases is still unconventional compared with a traditional fossil or electric heating system

Life cycle assessments of solar thermal systems have shown very low environmental impacts and thus external costs, almost all of them in connection with the production of the product or its raw materials. But nearly all materials can be recycled.

Under certain conditions, some have expressed concern about the aesthetical impact of ST systems. But the visual impact of solar collectors is not very different from standard building elements such as satellite dishes or roof windows. Therefore this aspect should not be overestimated and taken into account only in cases of historical buildings and similar structures.

Over the lifetime of a system, the largest part of the cost (usually well over 90%) occurs at the moment of investment, since the maintenance and decommissioning costs are very low. The economic benefit, however, is spread over the lifetime of the system, which is usually over 20 years. Alternatively, in the case of conventional heating and cooling systems, the operational (mainly fuel) and maintenance costs are much higher than the investment costs.

This high share of upfront investment costs is a major barrier to the growth of the use of solar thermal and other renewable and energy efficiency measures.

For many private individuals, the absolute amount of upfront investment costs is the key barrier. And the lower heating costs in the future tend to be undervalued against the investment costs at the beginning.

For many commercial decision makers it is the payback time, which is seen as crucial. Even in the case of high returns on investments (over the lifetime of the system), many companies abstain from solar thermal because their payback time is higher than 5-7 years. Furthermore, the calculation of a payback time depends largely on the assumption of the price of conventional fuels, which are replaced by solar. In the absence of reliable price forecasts, many investors calculate with stable prices of conventional fuels, which may lead to lower estimations on the future energy costs savings through the solar thermal system.

As important as the economic factors are often the information and “transaction costs”. In large parts of Europe, ST systems are still uncommon. In those regions, many people prefer to stay on the traditional path, using what their friends and neighbours use. And many have never even heard of, or been offered, a ST system. Even for those who want to invest in ST, they often find it difficult to locate a high quality experienced installer.

However, even in the areas where the ST market has reached a certain market size, the decision to purchase and install a ST system is often more complicated than installing a conventional heating system. Solar thermal adds some extra components to a fossil fuel heating circuit. The buying decision is often made more challenging because solar is not, at this moment in time, a standard solution. Most architects, heating engineers, designers and installers know less about ST than about conventional heating. If they are not trained and motivated about solar, they tend to discourage their customers from making a ST investment.

Only in very advanced markets, such as Greece, has solar thermal become a mainstream technology. There, almost every installer offers solar thermal systems and knows how to install them. People are used to solar thermal because their neighbours or relatives use it. New buildings are "automatically" equipped with solar thermal.

Justifications for Financial Incentive Schemes for solar thermal

Based on the analysis above, some justifications for the implementation of FIS for ST are described here.

External utility of private investment

Private investment creates external utility: society benefits from the reduction of emissions and other external costs linked with the use of oil, gas or electricity for heating or cooling purposes. The financial incentive rewards private investors for these positive externalities.

Security of energy supply

By decreasing the dependency on imported energy sources, every ST system reduces the need to take public measures such as strategic energy reserves, investment on infrastructure for transport of energy sources, diplomatic and military costs. By increasing national energy supply, in the long term, a financial incentive for ST can be cheaper than alternative measures.

Support to meet the burden of upfront investment costs

For different reasons mentioned above, private investors can be discouraged by the high rate of upfront investment costs as compared with a conventional heating or cooling system. By reducing this financial and psychological burden, investments in ST are encouraged. Thereby, a number of economically sound investments (with payback time shorter than the lifetime of the system and a substantial benefit in terms of energy saving) are encouraged.

Solar thermal replaces imported fuels with local jobs

Regardless where the solar thermal hardware has been produced (in any case, mainly in Europe), a substantial part of the turnover linked to a ST system is inherently local: marketing and distribution, design, installation, training etc. By stimulating investments, a FIS for ST creates benefits for the local and national economy. In some cases, the average amount of the subsidy is lower than the VAT obtained by the government thanks to the ST investment: this applies, among others, for the German market stimulation programme (MSP, see case study below), the financial incentive scheme with the greatest turnover at European level.

Psychological effect: positive signal from the public authority

The fact that a public authority gives a financial incentive shows a positive signal to the citizens, concretely demonstrating public support for this kind of investment. This builds market confidence in both the technology and the installers supported by the FIS.

FIS as a marketing tool

The existence of a financial incentive scheme can be one of several methods for marketing solar thermal products. FIS should always be accompanied by a public awareness raising campaign. At the same time, private market actors will communicate the FIS to their customers. In some cases, the financial incentive is not very high, but its existence still motivates the general public to purchase solar because of the “should not be missed” feeling in a similar manner to a discount campaign.

Creating economies of scale

If the whole EU was at the same level of sales per capita as Austria today, the European ST market would be five times bigger. Therefore, the potential for economies of scale are substantial. This is true not only for the manufacture of the hardware, which is driven more and more by competition at both a European and global level, but also for subsequent steps of the value chain, e.g. in areas like marketing and distribution, system design, installation, customer care, etc. In the majority of cases, these service costs represent well over 50% of the final consumer cost, and they are delivered at a local and regional level. This means that, in the countries with a low level of market penetration, there is a significant potential for economies of scales not only for manufacturing of hardware, but also for the local and regional services. Financial incentive schemes help to create economies of scale at all three levels and so reduce the price of solar energy in the short and long term.

Benefits of Financial Incentive Schemes

There is a wide consensus that financial incentive schemes have played a crucial role in developing the ST market in different countries.

Germany, Austria and Greece represent three quarters of the current European ST market, both in terms of current sales and capacity in operation. France still has a rather small market but the highest growth rates in the period 2000-2005. In these four markets, financial incentive schemes contribute, or have significantly contributed, to market development.

Greece is an excellent example, because it was the first EU country to reach a significant ST sales volume. In the 1980s, market development was boosted by public support in the form of strong awareness raising campaigns, including television advertisements and through financial incentives. The latter was gradually phased out. Since 2003 there have been no financial incentive schemes in Greece except for very small ones targeted at special market niches. In spite of the withdrawal of financial incentives, in 2004 Greece had a level of sales per capita around 30 times higher than Portugal and Southern Italy, and yet all three of these countries have similar climatic and economic conditions. The Greek example shows the true result of a long term, well implemented FIS for ST: once a certain critical mass is reached, the market continues to grow without further public support. Nevertheless, the potential for solar thermal energy in Greece is a long way from being fully exploited. Within a positive framework of support for the full exploitation of solar potential, the Greek market should grow by a factor of 5 to 10 times over the next two decades.

However, financial incentive schemes do not always work as effectively as the cases discussed above. In some countries or regions, FIS have not produced the same long term positive effects. Sometimes the available budget was not fully allocated. In other cases, some opinions have indicated that a specific financial incentive scheme disrupted market development by creating a stop-&-go dynamic that discouraged buyers as well as installers. The most common problems linked to financial incentive schemes are analysed below.

It should be noted that, as in the case of any other socio-economic analysis, it is impossible to isolate the effects of a single measure from all other developments affecting the final outcome. Among the other factors affecting the result in terms of ST capacity installed (and thus energy savings realised), there are other policy measures (regulations, awareness raising campaigns, training, R&D etc), the costs associated with conventional heating supply, general economic conditions and last but not least in the construction sector, the development of a widespread presence of the ST industry and its distribution channels.

Inherent limits of financial incentives

Financial incentives have shown to be a very effective tool to stimulate growth in solar thermal markets. But they are not the solution to everything and in particular they are typically not very effective if applied without suitable flanking measures. This section analyses the limitations of FIS. In the section below, avoidable problems linked to the specific design and implementation issues of FIS are analysed.

The financial aspect is not the only barrier to growth for ST

The financial burden on the investor is not the only barrier to growth. In countries that have a low level penetration of ST, other barriers to growth can be significantly more relevant. Some of these barriers are: lack of awareness from potential purchasers, lengthy or difficult planning procedures, lack of understanding and so motivation of key influencing professional groups such as heating installers, system designers, architects and other construction staff, etc.

Therefore, if a FIS is not accompanied by other associated measures designed to tackle the other barriers to growth existing within the market, the FIS will almost certainly be a partial failure. Without a “systems” approach to the market intervention in favour of ST, growth will be restricted.

A FIS requires financial resources

Obviously, a financial incentive scheme induces a cost burden. Usually, the source of finance is the public budget, either in form of expenditure or of reduced tax revenues. In times of ever scarcer public budgets this has often been a problem: Support programmes were reduced or ended prematurely because either budgets were exhausted or new governments directed priorities away from funding solar thermal FIS.

Following the Polluter-pays-Principle, the money should in any case not be borne by the general public (the tax payer) but by those who use conventional fuels. FIS financed by the users of conventional energies have been successfully applied in the electricity market, where feed-in tariffs for renewable electricity are (indirectly) paid by the normal electricity ratepayer. For solar thermal, and in general for renewable heating, such a scheme has never been employed within Europe. However, it is being successfully applied in Australia, where solar thermal water heaters can participate in the tradable Renewable Energy Certificates scheme of the electricity sector.

It must be noted that the net balance for the public budget of a FIS for ST can be positive. This is the case for the German market stimulation program (see case study below), where the costs of the scheme are balanced by the additional VAT revenues.

A FIS requires administration

Obviously, some administration costs are unavoidable. Even though there are no reliable official figures for an accurate comparisons of the administration costs between different schemes, our knowledge and experience shows that these costs can be significantly reduced if the scheme is well-designed and efficiently managed.

A FIS can create market distortions

Any state intervention in a market can create distortions. These distortions can be easily outweighed by the public benefits arising from the intervention.

One typical distortion is the creation of windfall gains. In a region or country with a FIS for ST, some of the ST systems would be installed with or without the incentive. In these cases, the buyer acquires a windfall gain. However, in the case of FIS for ST, this gain is usually small for the individual investor. From a general perspective, the best strategy to minimise this market distortion is to enact a FIS capable of creating an additional strong growth in ST installations, so as to minimise the impact of any windfall gains.

Another possible distortion may arise from the technical requirements of the FIS: It could favour one technology or application over another. Various examples exist, e.g. in France, there used to be a minimum collector area of 2 square metres, independent from the efficiency of the collector. In certain cases, this has probably resulted in a low performance larger system having been installed, instead of higher performing but smaller system. Any FIS should clearly not favour systems with lower quality over better quality systems. ESTIF recommends to the authorities providing FIS for ST to enact appropriate rules to guarantee the quality of the installed systems.

A FIS does not lead to smaller solar fractions

The purchaser of a ST system still has a strong economic interest to maximise their energy savings, in order to minimise their conventional fuel costs. For the same reason, industries are keen to develop systems that maximise the solar fraction to gain an advantage in the highly competitive market.

Guidelines for best-practice financial incentive schemes for ST

In this chapter we take a deeper look into existing types of FIS, the key parameters of FIS and what lessons can be drawn from the experience and in particular the case studies undertaken.

Types of FIS

This section describes the main types of financial incentive schemes applied, or in principle applicable, to ST systems. This is not a theoretical treatise and it does not intend to cover all imaginable FIS. Attention is concentrated on schemes that are either particularly common or are currently under discussion:

Grants (direct support to investment
Tax reductions (direct and indirect taxes)
Loans at reduced rates
Tradable certificate schemes

Grants (direct support to investment)

A grant is a direct support to investment provided by a public authority to those who either purchase or install a ST system, thus reducing their investment costs.

So far, this has been the most common FIS for ST in Europe. It is, or has been, provided in a number of European countries by local, regional and national governments.

Such a grant scheme always implies an administrative structure for processing the applications as well as a budget to cover the costs. As the budget is limited, the number of acceptable applications must be limited, either on a first-come-first served basis or on other criteria.

Experience with direct support to investment for ST is heterogeneous. In numerical terms of installed ST systems, the most successful scheme of this nature is the German MAP scheme (see case study). At a regional level, such schemes have been successfully employed in Austria which has resulted in the highest level of ST capacity per capita outside of the Mediterranean countries. In contrast, other countries (e.g. see Italian regional scheme case study) such schemes have been far less successful.

Tax reductions (direct and indirect taxes)

Several countries have offered tax benefits to those who installed/purchased solar thermal systems. The first part of this section looks at reductions in income or corporate tax and the second section looks at VAT reductions.

Direct taxes: Personal income or corporate tax

Part, or all, of the investment in a ST system can be made deductible from income tax or corporate tax.

For example, this type of scheme has been used in France since 2005 with excellent results, and led to an acceleration of the already significant market growth. In 2005 the market more than doubled compared with the previous year. In the past, tax reductions were also successfully applied in Greece.

In monetary terms, tax breaks can give the same incentive as direct grants. However, because they work differently, it has been argued that their impact could be lower than direct grants.

Firstly, a reduction in the income or corporate tax leads to a benefit only one or two years later (when the income is declared and the tax returned). But typically a benefit at some point in the future is valued less by people than an immediate payment (which could be accomplished with a grant). The longer spread between the expenditure (purchase of a solar thermal system) and the incentive (tax reduction or return) means that the person has to finance the whole investment for a longer time, which could furthermore reduce the value of the incentive.

At the same time, the very successful French example, introduced in 2005, shows that the positive effects of a tax reduction can be substantial and outweigh any disadvantage: The tax reduction/return removes the need to apply for a grant before purchasing a solar thermal system. This drastically reduces the procedure for receiving the FIS and removes the waiting period between the application for a grant and the approval of it.

It should be noted that a real tax reduction can have socially unjust implications: As low-income households typically pay no or very low taxes, the absolute tax reduction may be lower as for the medium to higher income persons. However, in the current French tax break scheme, the purchaser of a solar thermal system receives 50% of the hardware costs back – independent of the total taxes he has to pay.

For the government, an income or corporate tax reduction has the advantage that it does not require significant additional administration.

For the solar thermal industry, a tax reduction has the benefit of not being tied to a limited budget: As long as the scheme is applied, there can be no limit on the number of accepted applications. This contributes to creating a more positive framework for the industry to invest in market development, particularly if there is confidence that the tax break will last for several years.

Indirect taxes: Value added tax (VAT)
In principle, a reduction, or abolition, of the VAT applied on the solar thermal products and services needed to install and maintain a solar thermal system can be a very effective financial incentive for private individuals: Like a grant it immediately

lowers the overall investment costs to the end consumer. And it does not involve the processing of any grants or additional items in a tax declaration and is thus very simple to apply.

However, according to current EU law, it is forbidden to apply a reduced VAT rate to ST products and services. Directive EC/388/77, amended many times since 1977, does not allow the Member States to apply a reduced VAT rate on products or services not explicitly mentioned by the Directive. Among them, the "supplies of natural gas and electricity provided that no risk of distortion of competition exists".

Some EU countries have in fact applied a reduced VAT to gas and/or electricity – but not to solar thermal products – and thus created a clear disincentive for private persons to invest in solar thermal systems.

The only category under which ST products could be awarded a lower VAT rate would be the "supply, construction, renovation and alteration of housing provided as part of a social policy". However, this provision could lead to the inclusion of a variety of other buildings products, including those with a negative impact on energy efficiency or the use of renewable energy. Therefore, the specific incentive for solar thermal is low or non-existent.

In recent years, according to ESTIF information, at least two Member States have refrained from lowering the VAT rate on solar thermal systems due to the provisions of Directive EC/388/77. Amendments to this Directive can be proposed by the European Commission or by any Member State and they must be approved unanimously by the European Council.

Loans at reduced rates

The investment on a ST system can be supported by loans offered at a lower-than-market interest rate. So far, such loan schemes alone have not had a significant impact on the development of the solar thermal market in any European country.

However, they can be an interesting complement to other support measures. In Germany, the public KfW bank offers low interest loans for the overall improvement of the energy performance of existing buildings or the new construction of low-energy or passive houses. Solar thermal systems are included in the list of possible improvements and thus benefit from the favourable loans. Even solar thermal companies have tried to offer their customers a loan to finance the purchase of their products.

But due to the rather small size of the typical solar thermal investments (often in the range of 1.000-5.000 Euro), a loan for a solar thermal system alone does not seem very attractive to many consumers, as the overhead costs for both the bank/government and the end-consumer are quite high. Only as part of a package, as in the above mentioned German KfW-programmes, has it shown to have an impact.

In principle, a privileged loan is an appropriate answer to one of the main barriers to growth for ST, i.e. the high rate of upfront investment cost. The loan leads to spreading of the investment costs so that the energy cost savings of the solar thermal system can be used to pay off the loan.

Under present conditions, low interest loan programmes could be very useful if targeted at large ST systems purchased by commercial users; such as HVAC systems used in large residential buildings and hotels, solar process heating systems and solar cooling systems. In these cases, the investment volume is higher and so the propensity to take loans increases.

Apart from public loans, some companies offer contracting models, in which the solar thermal company builds, owns and operates the (large) solar thermal system and the customer only pays for the usage of it, just like he would pay for oil or gas. Such offers, where the solar thermal company effectively operates as an Energy Service Company (ESCO) have become known as “Guaranteed Solar Results” contracts. Their market share is still very limited but with a growing solar thermal market it can be expected that their impact will rise. By providing low interest loans, governments can support the development of viable markets for solar thermal ESCOs.

Tradable certificate systems

In a Tradable Certificate Scheme (TCS), those investing in a ST system obtain certificates that represent the energy saved through the system. The certificates can then be sold on a certificates market, which is typically driven by a requirement on certain stakeholders (e.g. energy suppliers) to cover a share of their energy trading with certificates.

Two examples of such systems in which solar thermal heating and cooling are eligible to obtain certificates are analysed in the case studies below. In both cases, the TCS has not been developed specifically for the heating sector: in Australia it is mainly a system for green/renewable electricity and the obligation lies on the electrical utilities; whilst with the Italian White Certificate, the scheme aims to develop energy efficiency measures and the obligation lies with the large electricity and gas utility suppliers. The certificates are expressed in energy units (MWh for Australia, toe in Italy).

In the electricity sector, TCS typically award certificates for each produced and measured unit of energy. As the price of the certificates varies according to supply and demand, the income from certificates is not known in advance. This, critics of TCS have often maintained, would not create the market stability needed for the young and growing RES-electricity sector.

It should be therefore noted that in both schemes analysed, the quantity of certificates awarded for the installation of a ST system is fixed upfront and based on known system parameters. Therefore, solar thermal systems do not need a metering system for these TCS. In Australia, ST systems receive, according to the specified parameters, advance certificates equivalent to 10 years of operation. In Italy, the White Certificate Scheme is not yet mature enough to know whether the risk of price fluctuation will affect the ST market.

As the number of certificates is known, the financial benefit from the certificates can be calculated upfront. To the consumer such a TCS appears like a grant.

Theoretically, ST could be included in the European CO_2 emission trading scheme. However, this is unlikely to happen because of the small dimensions of the typical ST system. Moreover, since CO_2 savings are only one of the advantages of solar thermal, it seems reasonable to consider support schemes targeted at this particular technology.

What is the best kind of FIS for ST?

All of the systems described above have advantages and disadvantages. Some of the schemes discussed worked well under certain market conditions and not as effectively in other situations. Depending on the legal and political framework, on the state of development of the solar thermal market and on other factors, each region or country may have good reasons to choose one or other of the schemes.

According to the experience from many countries, the type of financial incentive scheme seems to be less relevant to its success than the quality of its design and implementation as well as the choice and implementation of flanking measures. In the next section we will look at a number of parameters that should be established by financial incentive schemes. The choice of the FIS is only one of these parameters. The correct setting and fine-tuning of the scheme to adapt them to the specific situation is essential for the success of the FIS.

Key parameters of any FIS

When a Financial Incentive Scheme (FIS) for ST is designed, a number of parameters need to be defined, such as:

- Continuity of the FIS
- Coherence of the parameters
- Clear target
- Quality criteria
- Monitoring and evaluation of the FIS
- Financial resources
- Basis of the financial incentives: Collector area or energy yield

- Specific amount of the incentive
- Simplicity of the application and payment procedures
- Flanking measures

In the following section, some aspects of these constituent parameters are analysed.

Continuity of the FIS

This factor is very important. Short term or sporadic support is the single most important factor leading to the failure of a FIS. In some cases, sporadic availability leads to a stop-&-go market dynamic that seriously disrupts the development of healthy market structures. This sometimes outweighs the benefits of the financial incentive scheme.

The most obvious effect of erratic support is that people postpone their purchase until the support is available. In numerous cases, this had a strong slowing effect on the market. By discussing, or even announcing, a support scheme in the future, the market actually decreased rather than increased.

The most striking example of such problems can be observed in Italy. For several years, within the framework of a national programme which has provided 50% of the regional funding, financial incentives for solar thermal has been provided by the Regions (see comparative case studies below). But in most regions, it took up to two years before the regional scheme was implemented. And then, frequently, the financial support was only available for one or two months. After this time, the public expected that a new support scheme would be offered. Under these conditions, many decisions to invest in a ST system may be delayed until an indefinite future time when an effective FIS is available. It seems likely that in certain cases, the number of discouraged purchases was actually higher than the number of systems installed under the FIS.

Another problem with such short term FIS is the lack of incentives for the supply side to invest in the development of healthy market structures, e.g. by building up a sales network, by training installers and other professionals etc. On the contrary, such a stop-&-go dynamic encourages the emergence in the market of “gold diggers”, short term companies aimed only at making a quick buck. As these “cowboy” companies install low quality systems with low or non-existent after-sales customer care, the reputation of the whole solar thermal industry can be seriously damaged.

Following certain negative experiences with changes of the Market Stimulation Programme in Germany, the responsible authorities and the industry associations have learned to not disclose changes in the programme until very shortly before they come into effect.

Coherence of the parameters

The requirements in a FIS must be tailored to the targeted technology/application/target group. Otherwise they quickly become incoherent and thus hamper the success of the FIS: A prime example of such incoherencies is the FIS in the Italian Regione Campania (see case study); there, small systems were strongly discouraged through the requirement of a guaranteed results contract as such a contract would be too costly for small systems. At the same time, other parameters of the scheme, such as very short time slots for application and low grant amounts, were not appropriate for large systems and so this FIS produced very little effect in the market.

Clear target

A Financial Incentive Schemes can be targeted at a very specific application or market segments (e.g. only at individual domestic hot water systems, or at large collective combisystems, at swimming pool heating or at solar thermal heat for industrial processes). Others try to target a variety of applications and technologies.

Targeting a FIS at a specific application allows the scheme designer to fine-tune the parameters to specific characteristics. However, such targeted schemes also risk involuntarily giving a message to the market that certain applications are "worth more" than others.

Sometimes, it can make sense that the same FIS differentiates between different kinds of applications or technologies. In several FIS, Evacuated Tube Collectors (ETC) receive a higher amount in terms of €/m² installed than Flat Plate Collectors (FPC). This is reasonable because ETCs typically have a higher annual energy yield and are also more expensive than FPCs. Since 2005, the German Market Stimulation Programme provides to "combisystems" (ST systems that generate hot water and space heating as compared to the "standard" systems which only generate hot water) a higher level of support per surface area installed. This approach is reasonable because even though combisystems are more expensive to install they replace significantly more conventional energy.

In the future, special attention should be paid to applications with a particularly high social value. For instance, solar assisted cooling reduces electricity demand during peak loads and so has extra benefits for the community.

When a FIS is targeted at a specific customer group, it is essential that group specific awareness raising campaigns are enacted. The very low support scheme success rate achieved by the FIS of the Italian Ministry for the Environment is an example of such problems (see case study). In Italy, one provincial administration offered a FIS for ST targeted exclusively at agricultural companies. The idea was good because of the substantial potential for solar thermal within this sector. However, parts of the funds remained unspent for a long time due to a lack of applications. This was caused by difficult application procedures in combination with a lack of awareness of this FIS, due to not having planned a specific awareness raising campaign.

Quality criteria

A FIS should always include minimum quality requirements in order to prevent bad quality systems from receiving financial support. In order to guarantee open markets in Europe and to avoid any trade barriers, they must be fully compatible with the relevant European standards (EN 12975, EN 12976 and EN 12977) and certification scheme (Solar Keymark).

Monitoring and evaluation of the FIS

While not strictly necessary for the well functioning of a FIS, it is very important that the FIS is continuously monitored and the results evaluated. It allows governments to fine-tune the working of the scheme and prevent major problems in the future.

Evaluation should be done in close cooperation with market experts (solar thermal industry, installers, architects, construction companies etc.). They often know best why certain FIS work well or not.

Financial resources

Any financial incentive must be financed by someone, somehow. The different FIS models are not only different in terms of how they set the incentives, but also in where the financial resources come from.

The most typical FIS, a governmental grant scheme, is usually financed through the public budget, i.e. through taxes. This means that all taxpayers contribute to the financial incentives granted for solar thermal. It also means that the budget is limited – as approved by the parliament. And this often creates problems: As the government sets-up a grant scheme, they define the amount of the grant, e.g. based on the estimated energy savings from the solar thermal system. When the total amount of grants issued, nears the available budget, the government has three choices. Either a) it continues spending the money until the budget is exhausted, or b) it reduces the specific amount granted, in order to stretch-out the FIS, or c) it asks the parliament to approve a budget increase. All three approaches have been seen throughout Europe.

The typical consequences are: In case a) – termination of the FIS, when the budget has run out – the market recedes or even collapses. This is the most undesirable consequence and should be avoided by all means. It seriously hampers the development of healthy market structures and leaves the industry always waiting to see what will happen next. Under such situations, manufacturers will not invest in new capacity, installers will not invest in solar-specific training, and traders will limit their risk, by stocking only limited numbers of solar thermal products.

Case b) is better in the sense that it reduces the symptoms encountered in case of a complete stop of the FIS. It may even help bridge the time until a new year/new budget is reached and the FIS can be re-started. However, the impact on the market development is difficult to foresee, as has been the case in Germany: In 2002, the decline in the financial incentive unfortunately coincided with other adverse market conditions for solar thermal (see case study for details) and together they led to a shrinking of the market of approximately 40%. In 2006, the specific amounts of the Market Stimulation Programme were reduced twice, but this time the market conditions were favourable enough so that it did not have a considerable negative impact on the market development.

Case c) is obviously the optimal one in terms of contribution to healthy growth and market structures. However, even the discussion about a possible change in the FIS, or its continuation, can have unwanted effects on the market. Often customers rush to apply for the seemingly last financial incentives, only to learn later that the FIS continues anyway. This leads to unease in the market, and delays in delivery/installation followed by a certain slow down of the market growth.
Therefore, it is of utmost importance for any government that sets up a FIS, to plan long-term, to have budgets approved, which allow for enough market growth in the future.

Several experts have proposed to use a grant-like scheme, but to finance it not from the public budget but through the sales of conventional fuels. This model has been very successfully employed in the electricity market. Several European countries, e.g. Germany, have a feed-in tariff for RES-electricity, which is eventually financed by all electricity consumers. However, it must be noted, that such a model has not been tried in the heating/cooling sector so far, partly because of the different nature of the market itself (non-existence of a central grid). In Germany, such a model has been elaborated and promoted by the German Solar Industry Association (BSW) and other renewable energy associations. Under their proposal, the suppliers of gas and oil to end consumers would have to finance the installation of solar thermal and other renewable heating systems. Those companies could then add those costs to the cost of the gas and oil they sell, thus letting the end consumer of those fuels finance the renewable energy installations.

Such a model would have several benefits compared with a traditional governmental grant scheme:
It would remove the constraint stemming from the public budget (both in terms of total amount available, and approval procedures)
It would satisfy the Polluter-Pays-Principle, as it would put the burden on the user of conventional energy.
It would minimise the administrative burden for the government
Because the funding would be outside the public budget, such a model would more likely lead to more stable support over time. Of course, the parliament can and should adjust the “grant” given to solar thermal from time to time, but such a decision would not have to be taken every year under the pressure of budget talks in the parliament.

Tax reductions would have an effect on the budget, as they would lower the income. But the total amount of the financial incentive would remain unlimited as long as the tax reduction was in place. Thus, tax reductions too, provide a better framework for continuous market growth, and the French income tax scheme introduced in 2005 proves that it can be highly effective.

Basis of the financial incentives: Collector area or energy yield

As explained above, financial incentives for solar thermal shall help increase the use of solar thermal technologies and thus contribute to tackling several important energy policy goals, mainly: Securing the energy supply and avoiding environmental costs attached to conventional fuels. Eventually financial incentives aim at reducing the consumption of conventional and mostly imported energy. Therefore, the amount of the incentive given is typically related to the size or capacity of the supported system: Larger systems receive higher incentives than smaller ones. Traditionally the incentive has been based on the square meters of collector area, sometimes differentiating according to certain size brackets, applications or technologies.

Alternatively it would be possible to base the financial incentive on the expected or real solar energy yield of the system. This would add complexity, and thus costs, to the FIS, and any such linkage of incentives to the energy production should therefore be carefully weighed against the additional costs of such a procedure.

Determining the energy yield of a solar thermal system: Two different approaches are available: Actual measuring of the solar energy production and (ex-ante) calculation of the annual energy yield of the solar thermal system.

The actual measurement requires the installation of metering equipment, and the reading and processing of the data. Typical metering technology for solar thermal systems – including their benefits and costs – is discussed in detail in another report produced within the K4RES-H project. That report concludes that due to the relatively high costs of the metering equipment such a solution should only be required in cases where energy measurement is typical anyway. As with electricity or gas meters, the consumer would be asked to send in his annual meter readings, based on which he would receive financial incentives for that year. The collection and processing of the data could be outsourced to the Energy Service Company in charge of electricity and/or gas supply in that area. As long as the incentive paid per kWh is known at the time of installation of the system, the incentive for the operator of the solar thermal system would be similar as a feed-in tariff for electricity from renewable energy: He would have a fixed price income but take over the weather risk (i.e. less solar irradiation than in a typical year). This system would inherently provide incentives to keep the solar thermal system in good working condition as it would increase the annual income from the energy based incentive.

The (ex-ante) calculation of the energy yield should be chosen, where the costs of installing and maintaining a metering and meter reading procedure would outweigh any benefit from it. This is typically the case in small(er) solar thermal systems. In

these cases it is recommended to base the financial incentive on a few simple parameters: the collector performance (as tested under EN test conditions), the collector area and the geographical venue of the system (to take into account different climatic conditions). An individual simulation of smaller systems must be avoided in order to keep the system simple. Even a calculation based on individual system types can quickly become a complicated process: In Australia for example, more than 5.000 different systems/configurations with their specific values are listed in the database of the tradable Renewable Energy Certificates scheme.
A suitable method for the calculation of the energy delivery of individual solar thermal systems has been proposed and will most likely be included in the European norm EN 12975. As it is still under discussion amongst solar thermal experts, this methodology will be published as soon as it is generally agreed.

Specific amount of the incentive

Experience with many FIS shows that the absolute amount of financial incentive given is not the most important factor. The correlation between the amount and the market growth does not seem to be high. There is no “right” amount.

If the overall market framework conditions for solar thermal are good, then the amount can be lower and still present a good enough incentive to increase the number of newly installed systems. On the other hand, the decrease of financial support can have very disruptive effects on the market, if it comes at the wrong time. The German solar thermal market in 2002 recorded a very bad year, as a consequence of a number of factors ranging from high and increasing unemployment, a sluggish economy, political uncertainty (federal elections), consumer unease with the new EURO currency. Under those circumstances the reduction of the financial support under Germany’s Market Stimulation programme contributed to a 40% decrease of the solar thermal market, compared with 2001.

In times of high and rising energy prices, on the other hand, even relatively small amounts of incentives help trigger considerable market growth as could be seen in 2005 in many European countries.

It is obvious that while ST becomes a mainstream product – first for domestic hot water, then also for space heating, later for other applications – the specific investment costs go down. Studies have shown steady cost decreases of domestic hot water systems in Germany since the 1980s. Mass production and -marketing will lead to further cost reductions and thus make financial incentives for standard products less and less necessary. The amount of support for a certain application should therefore be digressive over the years.

Simplicity of application and payment procedures

Not surprisingly, simplicity of the application and payment procedure should be sought. The more complicated it is for the consumer to benefit from a FIS, the less incentive the FIS provides to install a solar thermal system. At the same time, governments also benefit from lean procedures as it avoids unnecessary bureaucratic overhead.

As discussed above, tax reductions are typically the easiest to administer: If countries could lower the VAT on solar thermal systems, the consumer would benefit without having to apply for the incentive. If the tax reduction was on the income (or corporate) tax, he could declare the investment without seeking prior approval.

In the case of grants or low interest loans, the application procedure should be as easy as possible. Forms should be short and easy to fill in, even by laymen. It should be possible to file applications by post or even electronically in order to avoid having to go to authorities personally. In many countries, installers or traders help their customers file applications.

Many people purchase a solar thermal system when their existing heating system reaches the end of its lifetime. Then, the customer often needs a new heating system very soon (short window of opportunity). Therefore, a FIS should be offered all year long and – where prior approval is necessary – be granted as quickly as possible. Any delay could mean a lost opportunity for solar thermal.

However, it is important that any FIS procedure foresees the collection of as much information as is necessary to check the fulfilment of the requirements of the scheme. E.g. in order to be able to assess whether or not a certain product fulfils the technical and quality requirements, it may be necessary to collect data about the concrete product that will be installed.

In order to avoid misuse of financial incentives, governments should check at least randomly, if the systems, for which financial incentives were claimed, were actually installed.

In various cases throughout Europe, consumers can benefit from more than one financial incentive scheme (e.g. from the national government and additionally from their local municipality). In those cases, attention should be paid to streamline the requirements and procedures of applying for grants etc. E.g. the municipality can give additional money based on the prior approval of a grant by the national authority. This helps avoid unnecessary administrative burdens.

Overall, there is a high potential for learning between public authorities (within one country and between countries): The problems encountered while administering a FIS are often similar and could be avoided by learning from the procedures applied by other authorities. Good examples often come from the bigger markets, which have longer experience with FIS for solar thermal, e.g. the Upper Austria province has provided financial incentives for solar thermal for 30 years and has continuously improved their administrative procedures. Internationally, the authors hope that this study contributes to learning between countries.

Authorities involved in the management of FIS

Which agency is best suited to manage a FIS cannot be decided per se (energy agencies or other specialised agencies, local, regional or national authorities). It depends on the type of FIS, as well as on the structures on competencies of the relative governments.

It is more important that the responsible authority is motivated to support solar thermal and to actually spend the money. Bad examples come from Italy, where in several regional support schemes, a part of the money was provided by the national government and the regional authorities had an incentive to not spend it on incentives for solar thermal.

As with the FIS itself, the responsibility for the administration of a FIS should be kept as stable as possible. Building up a broad FIS has a certain learning curve and the shifting of responsibilities for the administration of a scheme disrupts the learning and thus the effective working of a FIS.

Flanking measures

The importance of flanking measures cannot be underestimated – a FIS alone almost never has a significant impact on the uptake of solar thermal. The most successful support policies for solar thermal target the different barriers to growth for solar thermal and provide a package of measures. The upfront investment costs are only one issue, yet an important one.

FIS – like other support measures – should aim at creating stable and positive market framework conditions, which allow solar thermal to reach self-sustained growth. Once a critical mass is reached, public support such as FIS or awareness raising campaigns can be reduced and finally ended. Then the solar thermal sector can market their products alone, and costs of solar thermal systems will have fallen to a point where it is attractive for large parts of the potential market.

Any FIS is typically useless if nobody knows about it: Public relations are an absolute must for any FIS.
If the general public is not informed about solar thermal applications any FIS will reach only those, who already know about the benefits of solar thermal: Especially in the less developed solar thermal markets, awareness raising campaigns are immensely important. People who have not heard about solar, who may think it cannot be applied in their geographic region, who have doubts that solar energy can really provide enough heat for essential functions such as domestic hot water, will not invest in solar thermal – even if they are offered financial incentives. Awareness raising campaigns are a very powerful tool to get people interested in solar thermal.
The public will believe in the benefits of solar thermal more if the public sector also uses it: Solar thermal installations in schools, public swimming pools, town halls etc. can set a good example for private and commercial decision makers, who have to decide about their next heating system.

The impact of a FIS remains limited if there are not enough professionals who sell, plan and install solar thermal systems: Education and training of professionals (installers, planners, architects etc.) is important in order to help solar thermal into the market and to guarantee a sufficient quality of the installation.
FIS fail to attract many suppliers, if building regulations (or the FIS itself) has technical requirements, which are not in line with the relevant European standards: Different technical, testing or certification requirements in FIS, in building regulations etc. have severely hampered the development of a single European market for solar thermal products. In those cases, fewer companies and products are on the market, and consumers are deprived of their free choice.
Tomorrow's markets must not be forgotten: As solar thermal is still a relatively young technology, it is important to support R&D into new applications and technologies. FIS are typically focussed on products available in the market today, but in order to exploit the full potential of solar thermal, research must be done, which will lead to higher efficiencies, lower costs and new market opportunities for solar thermal.

Avoidable weaknesses of FIS for solar thermal

The most important problems identified above are:
Announcements of new, or higher, financial incentives in the future, have a destructive effect on the market in the near term, as consumers wait for the FIS to be enacted.
Lack of continuity leads to stop-&-go dynamics, which discourage the industry from investing into solar thermal long-term (e.g. into new production facility, marketing, training of professionals). Under such circumstances a healthy market cannot develop.
Without suitable and targeted flanking measures, FIS typically fail to produce significant growth in the market.
Complicated and slow administration procedures do not work if the consumer needs a new heating/cooling system soon (e.g. because the existing conventional heating system broke down).
Lack of (sensible) quality criteria leads to many low-quality systems being installed, which may undermine the long term European renewable energy targets.

Positive lessons learned ("best practice")

A long-term support strategy, consisting of a financial incentive scheme and suitable flanking measures (especially awareness raising, training of professionals) has shown to have the highest impact on market growth.
Specific financial incentives must be high enough to really have an effect on the market.
To guarantee continuity of the FIS, sufficient funds must be available at all times – if this cannot be guaranteed from the public budget, other sources should be tapped.
Easy and lean application and payment procedures (where necessary) are necessary for broad acceptance of the FIS.

Quality requirements which are fully compatible with the relevant EN standards strengthen the consumers' confidence in solar thermal technology and contribute to further market growth.

Annex I: Case Study of Market Stimulation Programme – Solar Thermal Energy Germany

Identification of the Financing Scheme

Title of the financing scheme

The programme is called “Programme to stimulate measures for using renewable energy sources”, in short “Market Stimulation Programme (MSP)”.

Brief description of the financing scheme

In the market stimulation programme (MSP), solar thermal systems are supported through a financial incentive of 105 € per m² of collector area for systems, which are used for heating domestic hot water and 135 € per m² of collector area for systems, which also support space heating (so called combisystems). Systems larger than 200 m^2 receive a subsidy of 60 € per m^2 for each square meter, which exceeds 200 m^2. The financial incentives cover around 15% of the investment costs. Those entitled to apply include amongst others, private individuals, small and medium-sized companies, municipalities and registered associations. This application must be filed prior to placing the order. There is no legal title to receiving the subsidy. Over 90% of the solar thermal systems installed in Germany receive incentives through the MSP.

Promoter

The MSP is a financial incentive scheme of the German Federal Ministry for the Environment.

Type of actor

The MSP is implemented and financed by the German Federal Government (out of the public budget).

Financing scheme priorities

The MSP is a German financial incentive scheme. All types of solar thermal systems are supported: for heating domestic water, supporting space heating, large-scale systems for apartment buildings, district heating systems, generating process heat and solar cooling systems.

The scheme requires that the collector used has a minimum annual energy yield of 525 kWh per m^2 of collector area at a solar fraction of 40% at the city of Würzburg. This means that plastic absorbers typically used for heating swimming pools as well as other unglazed collectors are not supported.

Description of the Financing Scheme

General description of the financing scheme

Background

The MSP was introduced in 1999. A predecessor programme has existed since 1994; however, its financial backing was insufficient and therefore it did not have a significant impact. In 1999, the funds for the MSP were significantly increased so that it is assumed that since that time, 90% of the collector area installed in Germany has received support under the MSP.

Financing scheme design/management

The market stimulation programme is part of the political strategy of the German Federal Government to expand the share of renewable energy. In addition to the subsidies in the MSP, low-interest loans for solar thermal systems are also available in the CO_2 reduction programme. However, these loans have been utilised only to a very limited extent.

At the end of 2002, the responsibility for the MSP shifted from the German Federal Ministry of Economics to the German Federal Ministry for the Environment (BMU). The BMU controls the programme, establishes the guidelines and provides the funds. The programme is implemented by the German Federal Office of Economics and Export Control (BAFA) in Eschborn (www.bafa.de). The applications must be filed there. The BAFA staff review the applications and authorise financial incentives. Once the installation of a solar thermal system is completed, the investor informs the BAFA and claims the allotted subsidy. The BAFA is also responsible for executing the payment.

The solar industry associations are in close contact with the German Federal Ministry for the Environment to discuss at an early stage any possible guideline changes. The Ministry coordinates programme changes and the financial planning with the members of parliament, since the funds must be approved by parliament each year as part of the federal budget.

Objective of the financing scheme

The motivation for implementing the programme is specified in the preamble of the MSP: “In the interest of a future-oriented, sustainable energy supply and in view of the only limited availability of fossil energy sources as well as to protect the environment and the climate, it is necessary to increase the share of renewable energy in the energy market. To achieve this, the market penetration of renewable energy technologies must be strengthened. An incentive to use such technologies is therefore required. For this reason, the federal government supports the increased usage of renewable energy in accordance with these guidelines…. A central objective of the support according to these guidelines is to implement investment incentives, … to strengthen the sales of technologies of renewable energy in the

market and thus lower their costs and to contribute to improving their economic efficiency."
Specific quantity goals have not been identified in the programme. However, at the end of 2002, the German government set a goal of doubling the total installed collector area by the end of 2006 (as of the end of 2002: 4,35 million m^2). The MSP is the most important programme in achieving this goal.

Actions

In 1999, the MSP began with the goal of substantially increasing the use of solar thermal energy, which – partly also because of the sharply increasing oil prices – was initially extremely successful and in 2001, led to a record number of applications. Since the funds were insufficient to cover the large demand, the specific financial incentives were significantly reduced in 2001. As a consequence, and also because of the significantly decreasing oil prices, the number of applications drastically diminished. Since 2003, the demand has again greatly increased and in 2005, it surpassed the record value of 2001 for the first time.

The specific financial incentives and the annual number of applications and the collector area applied for are listed in the following table:

<table>
<tr><th>Year</th><th>Specific financial incentives</th><th>Number of grant applications / collector area applied for</th></tr>
<tr><td>1999</td><td rowspan="2">Programme start date was 1/09/99
Incentive for flat plate collectors < 100 m²: 250 DM/m² (128 €)
Evacuated tube collectors (ETC) < 75 m²: 325 DM/m² (166 €)
Expansion of existing systems: 100 DM/m² (51 €)
By the end of 2000: Incentive for installing a functional control device/heat volume meter
Simultaneous boiler installation renders an incentive of 20%, max. the sum of the solar energy incentive
Minimum collector output: 350 kWh/m²</td><td></td></tr>
<tr><td>2000</td><td>93.541 applications
751.260 m²</td></tr>
<tr><td>2001</td><td>Change in specific financial incentives as of 23/03/01
Simultaneous boiler installation guarantees a lump-sum incentive of 500 DM (256 €)
Max. 50,000 DM (25.565 €) per system
incentive is applied for each m^2 of collector area*
Change in specific financial incentives as of 25/07/01
Flat plate and ETC collectors < 100 m²: 170 DM/m² (87 €)
Incentive no longer available for simultaneous boiler installation</td><td>101.789 applications
875.519 m²</td></tr>
</table>

2002	Change in specific financial incentives as of 23/03/02 Flat plate and ETC collectors: 92 €/m² Max. 25,000 €	58.589 applications 524.059 m²
2003	Change in specific financial incentives as of 01/02/03 Flat plate and ETC collectors: 125 €/m²	152.647 applications 1.506.228 m²
2004	Change in specific financial incentives as of 01/01/04 Flat plate and ETC collectors: 110 €/m² Expansion of existing systems: 60 €/m² The size of the system is no longer restricted As of 01.06.04: Minimum collector output: 525 kWh/m²	83.908 applications 814.881 m²
2005	Change in specific financial incentives as of 01/07/05 Up to 200 m² of collector area: - Systems for heating drinking water: 105 €/m² - Systems for heating drinking water + backup heating: 135 €/m² More than 200 m² of collector area: 60 €/m² Expansion of existing systems: 60 €/m²	approx. 150.000 applications approx. 1.350.000 m²

*Since 23/03/2001, the incentive has not been based on the actually installed collector area, but on every commenced square meter of collector area, e.g. a system with 5.2 m^2 of collector area, receives a financial incentive for 6 m^2. This significantly simplified processing the applications. This means that the collector area applied for listed in column three is approximately 10% higher than the actual collector area applied for.

The changes in the specific financial incentives took place for the following reasons:
The grant levels increased in order to increase the market stimulation effect since the previous market development was not satisfactory (this was the case on 23/03/02, 01/02/03 and 01/07/05),
The grant levels decreased if the funds became insufficient to authorise all applications (this was the case on 23/03/01 and on 25/07/01) or
The grant levels decreased at pre-defined times as a result of the general digressive design of the programme and in order to be able to authorise more systems under the assumption that if a subsidy is successful the specific incentive could be continuously reduced (this was the case on 01/01/04).

The fundamental problem of the government-financed programmes lies in the difficulties of providing sufficient funds in the annual budget, despite strong fluctuations in the demand.

The fluctuations of the monthly number of applications as well as the heating oil prices since the project's beginning are shown in the following graph. Both the effects of the specific financial incentives and the oil price are clearly depicted.

As a result of the significant increase in applications in 2005, all funds were depleted by mid-October and the grants in the market stimulation programme were halted. The grants are expected to resume again in the spring of 2006, however, the grant level will be moderately reduced.

Alongside the programme, the government also co-finances solar thermal campaigns. From 1999 to 2001, the “Solar – na klar!” solar thermal campaign and since 2003, the “Initiative Solarwärme plus” have been supported. Since 2005, the “Wärme von der Sonne” initiative has also been co-funded by the German Ministry for the Environment. The initiative supports regional solar energy initiatives in holding information and publicity events. The financial support typically covers 50% of the campaign costs.

Possible changes to the MSP guidelines to take effect in spring of 2006 are currently being deliberated. In addition, a renewable heating law, which will replace the market stimulation programme, is to be instituted by 2009.

Prompt and non-bureaucratic processing times are a decisive requirement for the programme’s success. Over the years, the German Federal Office of Economics and Export Control (BAFA) has optimised the administrative processes and simplified filling in applications so that it usually takes only 2 to 4 weeks for an application to be authorised.

Timing

The MSP started in 1999 and is currently limited until 31.12.2006. In the fall of 2005, the new federal government announced its decision to continue the programme until 2009. A corresponding provision is expected to be incorporated in the guideline change during the spring of 2006.

Costs of implementing the financing schemes

Similar to the strong fluctuations in the number of applications, the costs for the MSP subsidies strongly fluctuate from year to year. In 2005, subsidies totalling approximately 130 million €, which accounted for roughly 15% of the investment costs, were allocated for solar collectors. That means that the German government collects more money in value-added tax from the system investment than it distributes in funds. In the years to come, increasing financial requirements are expected as a result of market growth.

The administration costs of the MSP are not known.

Finances

The programme will is financed from the federal budget, which must be approved each year.

Financing Scheme Results

Quantitative results

From 01/09/1999 up until 30/09/2005, the following results were achieved in the MSP:

Number of received applications	598.532
Funds applied for	740.655.004 €
Planned investment volume	4.607.322.721 €
Subsidy ratio	16%
Collector area applied for	5.561.312 m²
Net collector area applied for (less the rounding up of collector area)	approx. 5,0 million m²
Portion of systems not implemented	15%
Implemented collector area	approx. 4,3 million m²
Implemented collector capacity	approx. 3,0 GW
Annual solar energy yield	approx. 1.720 GWh per annum

Environmental

Boiler efficiency	75%
Annual final energy conservation (oil/gas)	approx. 2.300 GWh per annum
Annual CO_2 conservation	530.000 tonnes of CO_2 per annum

Local indicators

Costs kWh oil/gas (average)	3,5 ct/kWh
Reduction of oil/gas import costs = local increase in purchasing power	80 million € per annum

Replication potential

A financial incentive programme, such as the MSP, will work also in other countries, if it is attractive enough.

Communication

The MSP is publicised primarily by the solar energy industry and the installers. In addition, the associations frequently mention the programme in their press reports. The solar awareness raising campaigns inform the general public about the advantages of using solar thermal energy and the financial incentive scheme, primarily through the print media.

Monitoring & Lessons Learned

Monitoring

The German Federal Ministry for the Environment commissions an independent institute to evaluate the programme at irregular intervals. The institute is selected through a call for tender. The evaluation reviews the effectiveness of the programme, the efficiency, possible windfall gains and the advances of the technologies. Suggestions are made regarding the further development of the programme.

The last evaluation took place over the time period between January 2002 and August 2004 and was carried out by the Centre for Solar Energy and Hydrogen Research in Baden-Württemberg and the Fraunhofer Institute for System and Innovation Research.

Monitoring of the installed and supported systems in order to inspect the quality of the installations and the functional capability of the systems, has not taken place so far.

Analysis and lessons learned

The strong fluctuations in demand, the programme interruptions and regular programme corrections clearly indicate that a subsidy programme can only be successfully implemented under the following conditions:
The programme must be established over the long term, for at least 5 years.
The programme must run continuously by ensuring that sufficient funding is provided so that applications can be continuously authorised.
The sum of the subsidy must create a sufficient subsidy effect. The amount depends on the motivation of the investors, and a 15% subsidy is considered the lower limit (ideally, the subsidy should cover the additional costs of the solar thermal system compared to other energy sources).
The annual funds provided must be sufficient to ensure that the applied for collector area can be granted and an annual market growth is possible, i.e. the funds must increase annually if the programme is successful and stimulates market growth.
The process of filling out the application must be as simple as possible, and the processing of the application must be prompt and guaranteed within a few weeks so no administrative barriers are created.
In addition to the subsidy programme, it is advisable to hold awareness raising campaigns for solar thermal in order to stimulate the demand.

It should be noted that the MSP almost only reaches private investors, who use the solar thermal energy in private residential buildings. The amount of the incentives are not attractive enough to also stimulate investments in systems for commercial applications, as in the rental apartment market, hospitals, retirement homes, hotels or commercial businesses. In addition, there are further barriers, which must be overcome in these areas, such as e.g. invoicing the tenant for solar thermal energy.

If you consider the following elements, how would you describe

their relevance/importance or priority in the development of the financing scheme

Under the specified conditions, a subsidy support programme is an excellent instrument to stimulate market growth in an emerging solar thermal market. However, experience has shown that the risk of having to repeatedly stop the programme is great, since the demand is not constant and continuously providing funds poses a problem. In developed solar thermal markets, the subsidy must be made independent of a budget, since the funds are difficult to provide and stopping the subsidy programme can massively jeopardise the developing solar energy industry.

Effects of existing financial schemes

Since solar thermal incentives are almost only focused on the MSP, there are no other programmes with noticeable influences.

Annex II: Case studies for Italy: Public support from the Ministry of Environment to Local Authorities

Summary

The support programme of the Ministry of Environment (MATT) for the installation of solar thermal plants, targeted to Local Authorities and municipally-owned Gas Distribution Companies, was a very good idea to foster the spreading of solar thermal technology in public bodies.

The programme had a quite good start and even a specific awareness raising campaign had been planned, basing on contacts with associations of local administrations. Unfortunately, the campaign was interrupted because of the changing in Italian government.

So far, only 1 M€ has been assigned in more than 4 years, leading to total investments of about 3,3 M€ and therefore to about 3,5 MW_{th} of thermal power installed (5.000 m^2 and clean energy production of 3.500 MWh/year, considering a system yield of 700 kWh/m^2 year).

1 M€ corresponds to about 17% of the total resources and therefore the programme had a quite negative exit.

The main reasons for that are:
the absence of an awareness raising campaign;
as a consequence of the above issue, the lack of interconnection between the centralized administration of the programme and the Local Administrations;
the subsidy share (30%) was too low to be “appealing” for Local Administrations; that is a typical share for private investors, but, for public subjects, a 50% share could have been more helpful.
no technical skill of the internal personnel of Local Administrations for developing the feasibility study required for submitting the project application;
scarce knowledge of the technology and of the most suitable applications; many Local Administrations were interested in schools, even with a very low hot water consumption, instead of focusing on gyms, sport centres, swimming pools, etc.;
the foreseen contract for the guarantee of solar results could act as a barrier, given the fact that the solar thermal market in Italy is not at a very developed stage and therefore the small actors operating could be not able to sign and respect this kind of quite strict contracts; in this programme, however, the real barrier was the lacking of demand by the Local Administrations.

Identification of the Financing Scheme

Title of the financing scheme

Support programme of the Ministry of Environment (MATT) for the installation of solar thermal plants, targeted to Local Authorities and municipally-owned Gas Distribution Companies.

Brief description of the financing scheme

This national subsidy programme started in 2002 and it foresees a maximum 30% contribution (VAT excluded) on turn-key plant costs, for the installation of solar thermal systems by Local Authorities and municipally-owned Gas Distribution Companies.

Details are provided in the following sections.

Promoter

The only promoter of this subsidy programme is MATT. There are no Regional Authorities involved in the scheme. All applications are submitted directly to MATT and also subsidies are provided by MATT.

Type of actor

MATT is responsible for both developing the subsidy scheme and administering the resources. ENEA (National Energy for Research on Energy and Environment) wrote the technical guidelines which, however, were not developed specifically for this programme, but for the whole solar thermal subsidy action, therefore for the regional subsidy schemes.

Financing scheme priorities

The financing scheme includes low-temperature solar thermal systems, namely for domestic hot water, swimming pool heating and space heating and cooling, installed on buildings (roofs or façades).

The incentive scheme is working at national level.

Description of the Financing Scheme

General description of the financing scheme

Background

The public sector has always been a focal point for energy efficiency in Italy. About 95% of the Italian solar thermal market is due to private initiatives, while a good energy efficiency policy in the public sector is out of doubt lacking.

In 1991, Law no. 10 stated that the use of energy efficiency measures and renewable energy sources was of high priority. This law was scarcely applied, because of the absence of corresponding fines and of the lack of specific knowledge on the side of technical personnel of Local Authorities.

Financing scheme design/management

This subsidy scheme was initiated by MATT as part of a larger strategy, which included also co-financing of Regional subsidy programmes.

The plant size must be above 20 m^2, but this minimum size could also be reached by adding several plants (minimum sub-plant size: 6 m^2).

The applications must include a preliminary project of the plant and are evaluated by a specific commission chaired by MATT, which assesses the technical level of the projects and then ranks them on a “first come, first served” basis.

The costs that could be covered by the subsidy include design, components (also the monitoring system) and installation. If the application is accepted, the owner receives 50% of the subsidy when the construction starts and the remaining 50% when the plant has been built.

The plant owner must assure that the plant will be kept in operation for at least 10 years.

Regarding quality and guarantee, it should be highlighted that:
The monitoring of the plant is mandatory, to measure both the total heat consumption and the thermal energy delivered by the solar plant (and therefore the solar fraction); the monitoring system could be included in the subsidised turn-key cost, with a maximum of 10% of the overall cost and with a maximum of about 8.000 €.
The installing company should sign a contract for the guarantee of solar results; this contract foresees a guaranteed minimum energy yield, in terms of minimum solar fraction, measured by the plant monitoring system, which delivers data about the energy supplied by the solar plant and the energy consumed by the user.
The solar collectors used should be certified and/or qualified by European or Italian Institutes and an installation manual should be provided; this statement was rather

vague in the text of the financing scheme, but from a practical point of view, the certification according to the EN standard was accepted.

Objective of the financing scheme

The main objective of this programme was to raise interest towards solar thermal by public actors, given their scarce participation so far in this field (see above description of the background).
The total installation foreseen was about 21 MW_{th} (30,000 m^2), basing on the total resources available and on the turn-key cost of solar thermal systems in the Italian market.

Actions

A specific awareness raising campaign had been planned, basing on contacts with associations of local administrations. Unfortunately, the campaign was interrupted because of the changing in Italian government and therefore in the main personalities in the Ministry of Environment, in particular the General Director of the Renewable Energy Sources section.

However, the programme has always been presented in workshop and seminars.

Timing

The subsidy programme started in 2001 and it is still open; the current status is still uncertain, but it is likely that the programme could be interrupted very soon, given the scarce answer by the public sector.

So far, a huge amount of resources is still available (see Finances).

Costs of implementing the financing schemes (costs on the side of the administration and on the side of the investor)

The support given to the beneficiaries is a subsidy on plant investment cost, with a maximum value of 30% (VAT excluded). A smaller value could be given in case of non-optimal yield foreseen for the plant, for instance if shadowing issues or bad collector tilt or orientation could not be avoided.

The cost for MATT is roughly 3 man-years for developing and administering the subsidy scheme, while the consultancy given to ENEA for developing the technical guidelines is not easily quantifiable, since these guidelines were developed also for the regional subsidy programmes.

Finances

About 6 millions of Euros were stored by MATT for the subsidy programme, 2/3 of which for Local Authorities, while 1/3 for municipally-owned Gas Distribution Companies for installing systems for public or private subjects.

So far, only about 1 M€ has been assigned; this will lead to a total investment of about 3,3 M€, corresponding to about 3,5 MW_{th} of thermal power installed (5.000 m^2).

Today 5 M€ of resources are still left and, although there are no official communications about the end of the programme, it is likely that, given the long time since the beginning of the availability of the subsidy scheme, the resources will be retired in a very short time.

Financing Scheme Results

Quantitative results

A complete assessment of the results of the programme is not available up to now, since it is still open.

However, some global results are worthy to be highlighted:
Total budget for the programme: 6 M€
Assigned resources: about 1 M€, leading to:
- total investments of about 3,3 M€
- about 3,5 MW_{th} of thermal power installed (5,000 m^2)
- clean energy production of 3.500 MWh/year (considering a system yield of 700 kWh/m^2 year)

Resources still available: about 5 M€

Replication potential

The chance of promoting the use of solar thermal in public bodies is quite interesting; therefore, the replication potential of the herein presented scheme is definitely high, providing the following suggestions are taken into account:
enhance the connections between the programme management (e.g. the central government of the Ministry) and the local actors by specific awareness raising campaigns;
provide a higher contribution on investment cost (about 50%)

Communication

No specific communication policies and awareness raising campaigns were developed (see above), though target-oriented actions had been planned at an early stage of development of the programme.

Monitoring & Lessons Learned

Monitoring

MATT is updating the list of all the applications submitted as well as of the projects realized or in progress.

The list of applications approved by MATT is available at:
http://www2.minambiente.it/sito/settori_azione/iar/FontiRinnovabili/solare_termico/progetti/progetti_programma_st.asp

The project realised or in progress are listed at:
http://www2.minambiente.it/sito/settori_azione/iar/FontiRinnovabili/solare_termico/progetti_ministero/progetti_ministero.asp

Additionally, as already stated above, MATT will collect the data coming from the monitoring systems of the largest plants co-financed by the programme.

Analysis and lessons learned

The programme had a negative exit, given the large resources still left available after 4 years of the subsidy scheme being running.

The main problems faced by this programme are:
on MATT side

- the absence of an awareness raising campaign;
- as a consequence of the above issue, the lack of interconnection between the centralized administration of the programme and the Local Administrations;
- the subsidy share (30%) was too low to be "appealing" for Local Administrations; that is a typical share for private investors, but, for public subjects, a 50% share could have been more helpful.

on Local Administration side:

- no technical skill of the internal personnel for developing the feasibility study required for submitting the project application;
- scarce knowledge of the technology and of the most suitable applications; many Local Administrations were interested in schools, even with a very low hot water consumption, instead of focusing on gyms, sport centers, swimming pools, etc.;

on installer side:

- the foreseen contract for the guarantee of solar results could act as a barrier, given the fact that the solar thermal market in Italy is not at a very developed stage and therefore the small actors operating could be not able to sign and respect this kind of quite strict contracts; in this programme, however, the real barrier was the lacking of demand by the Local Administrations.

However, in the last year (2005), an acceleration of the submissions has been noticed, mainly depending on:
wider promotion of the programme through workshop, seminars, technical courses, etc.;
ever growing interest in the renewable energy sector in general.

Annex III: Case studies for Italy: Regional subsidy schemes – Two examples

Summary

The Italian regional programmes were born in the framework of a wide initiative coming from MATT side, which provided the Regions with 50% of the resources needed to launch subsidy schemes for solar thermal at regional level. Such programs have been implemented in most of the 20 Italian regions. This study compares two of them, that led to very different results.

The regional programs are usually based on a common scheme: the Region provides the final user (both private or public) with a contribution on the investment cost of the solar plant or an amount of money proportional to the expected thermal energy production.

Huge differences were observed, however, in the Regions, given the following:

- large cultural and technical gaps, regarding renewables and energy in general: some Regions (e.g. Lombardia) replied very quickly and very precisely to the input from MATT, while the same cannot be said about Campania;
- regional autonomy in Italy foreseen for the Regional Administrations.

Coming to the analysed case studies (Lombardia and Campania), we should highlight a positive exit of the Lombardia programme, for following reasons:
the "open-tender" approach: as soon as new resources are available, an announcement is made on the programme web site;
a list of installers available on the programme web site, which increases the confidence of the final user;
the submission by the installer and not by the final user;
the electronic procedure for the submission of applications.
On the contrary, the Campania regional programme showed a quite negative exit, for the following reasons:
wrong (too low) figures for the turn-key cost of the solar plants, leading to subsidies of 10%-20% of the investment cost; instead, the programme meant to give a subsidy share of about 30%;
the programme demanded a monitoring system also for very small domestic plants; in this case, the cost of the monitoring system could raise even to 30% of the total investment cost;
the programme had the usual "closed tender" approach and, furthermore, it was launched in the summer months (almost at the end of July);
lacking of specific communication policies and awareness raising campaigns.

Identification of the Financing Scheme

Title of the financing scheme

Subsidy programme of Italian Regions for financing solar thermal (ST) plants. The cases of Lombardia and Campania will be here analysed, to pinpoint analogies and differences.

Brief description of the financing scheme

The Italian regional subsidy programmes are usually based on a common scheme: the Region provides the final user with a contribution on the investment cost of the solar plant or an amount of money proportional to the expected thermal energy production.

See point below for details.

Promoter

The promoter of this subsidy programmes is the Ministry of Environment (MATT), which provides the Regions with 50% of the resources needed to activate the programme.

Type of actor

As already stated above, the role of MATT is to promote this programmes.
Regions are then in charge of:
providing the missing 50%;
administering the resources and the programme;
reporting the final results to MATT.

Lombardia
Region Lombardia manages the programme through his web site, receiving the applications and providing the subsidies. Actually, the subject managing the programme on behalf of Region Lombardia is the Associazione Rete di Punti Energia, a sort of association of local energy agencies.

The other actors officially involved are the registered installers, a list of whom is included in the web site and is accessible by the applicants (see below).

Campania
Campania Regional Administration provided resources to the Provinces, which should then manage the subsidy scheme at provincial level, also reporting the results to the Region. The Region is then in charge of providing general statistics and figures about the programme.

The installation of a monitoring system in all plants is mandatory and the owner of the plant shall send to the Province Administration, at least for 3 years, a form filled up with the operating results of the solar thermal system.

The managements sounds quite more complicated than in the Lombardia programme.

Financing scheme priorities

The financing scheme refers to solar thermal plants for both private entities and public bodies. Usually not every solar thermal application (domestic hot water, space heating, etc.) is explicitly foreseen in the programme official text, but it is a matter of cultural approach.

Lombardia
In Lombardia, for instance, the programme supports ST plants using both water or air collectors, for domestic hot water preparation and heating purposes, both installed on buildings (roofs or façades) or mounted on the ground.

Furhtermore, all application sectors (residential, commercial, industrial, etc.) are included in the scope of the programme.

Campania
Here, that level of detail is not provided and the financing scheme refers in general to solar thermal systems for domestic hot water preparation and heating purposes.

Description of the Financing Scheme

General description of the financing scheme

Background

As reported above, the regional programmes were born in the framework of a wide initiative coming from MATT side, which provided the Regions with 50% of the resources needed to launch subsidy programmes for solar thermal at regional level.

We should also take into account that large cultural differences, regarding renewables and energy in general, are to be expected between the Regions. Lombardia, for instance, replied very quickly and very precisely to the input from MATT, while the same cannot be said about Campania.

Financing scheme design/management

The technical requirements of the plants for these regional subsidy programmes are based on a text developed by the Italian Agency for Energy and Environment (ENEA). However, given the autonomy of the Regions in energy matters, every Region only partially adopted this text, often raising "technical nonsense".

Lombardia
Subsidy: the subsidy is given basing not on the investment cost, but on the expected annual yield of the plant. The tariff foreseen is 0,30 €/kWh. However, the subsidy cannot be higher than 25% of the plant investment cost and, in any case, the maximum subsidy foreseen for a single system is 50.000 €.

An additional subsidy of 130 € is given in case the installation of the plant needs special permitting requirements.

Application submission: the applications for getting the subsidy go through an internet-based procedure, on the web site of Region Lombardia. The applicants should choose one of the authorised installers (classified by Province and Municipality) listed on the web site. Afterwards, the installer will look after the application and the subsidy.

The applications are ranked basing on chronological order.

Campania
Subsidy: the maximum investment cost that could be subsidised is calculated on an energy production basis:
1 €/kWh for plants with a total yearly energy output lower than 10.000 kWh/year;
0,6+4.000/E (€/kWh) for plants with a total yearly energy output higher than 10.000 kWh/year ("E" is the yearly thermal energy output).
However, the investment cost could never be higher than the values reported in the table below ("S" is the plant surface area).

Maximum turn-key cost foreseen for the solar thermal plants

Collector technology	Plant surface area (m^2)	
	<20	>20
Flat plate or integrated storage	600 €/m^2	360+4.800/S €/m^2
Evacuated tubes	720 €/m^2	440+5.600/S €/m^2
Unglazed	360 €/m^2	220+2.800/S €/m^2

The maximum subsidy foreseen is 30% of the total investment cost (VAT excluded; VAT on solar thermal systems is, at the time of writing, 10%).

Let's make an example: a 2 m^2 ST plant (with flat plate collectors) for domestic hot water installed in Rome could have an energy yield of 1.600 kWh/year, therefore the maximum allowable cost is:

Basing on energy production: 1 (€/kWh) * 1.600 (kWh) = 1.600 €
Basing on plant surface area (see table): 600 (€/m^2) * 2 (m^2) = 1.200 €

The maximum turn-key cost foreseen has to be chosen looking at the minimum value, therefore 1.200 €. Basing on this value, the user could apply for a 30% contribution, therefore 400 €.

If we look at the real turn-key cost of such a small solar thermal plant in Italy, including also bureaucracy and monitoring system costs, this contribution represents a quite smaller share, let's say 15-20%.

Application submission: the applications for getting the subsidies should be sent to the Provincial Administrations within 60 days from the scheme publishing date.
The documentation needed for applying include: a technical sheet of the proposed plant, a preliminary project and also the percentage of contribution required (max. 30%).

The applications are ranked basing on chronological order. If two applications are sent on the same date, they will be ranked based on the percentage of contribution required: the lower the percentage, the higher the ranking.

Objective of the financing scheme

The main objective of this programme was the installation of solar thermal plants as specified above.

Actions

No specific awareness raising campaigns were developed. However, in Lombardia, the programme was widely advertised at regional level.

Timing

Lombardia

The subsidy programme started in 2002 and then more resources were added in 2004. No deadline is foreseen, since the programme is open as long as resources are still available.

Campania

The subsidy programme was officially launched on 18/07/2005. At the time of writing, no news are available on the possibility of a new programme which could substitute the previous one, given its quite negative exit.

Costs of implementing the financing schemes (costs on the side of the administration and on the side of the investor)

The cost on the side of the regional administration is due to the work needed to:
prepare the programme tender;
possibly launch awareness raising campaigns;
receiving and analysing the applications;
reporting the final results to MATT (however, this task is almost never fulfilled).

The cost on the side of the investor is the paper work needed to submit the application. From this point of view, the Lombardia programme was quite good, since the final user, just going on a very user-friendly web site, could choose an installer, which will be then responsible for carrying out the application.

Finances

Lombardia

The total resources for this programme are about 950.000 €.

Campania

The total resources for this programme are about 2 M€: 70% for private bodies and 30% for public bodies. The total budget was divided among the five Provinces in the Region, according to the amount of population.

Financing Scheme Results

Quantitative results

No official statistics about the regional subsidy programmes are available so far. However, MATT is in charge of these tasks, that will be developed hopefully in the next months.

For Campania, even though there are no official statistics, according to our knowledge, the programme had a very negative exit, leading to a quite low number of applications submitted.

Replication potential

Actually, many regional subsidy programmes were launched in the last years, but the replication potential of some specific issues of the Lombardia programme is very high, namely:

the internet-based submission;

the "open-tender" approach (see point 4 for further details).

Communication

See Actions.

Monitoring & Lessons Learned

Monitoring

No statistics are available so far (see Quantitative Results).

Analysis and lessons learned

Lombardia

The main positive differences which this programme showed with respect to other similar regional initiatives are:

the "open-tender" approach: as soon as new resources are available, an announcement is made on the programme web site;

a list of installers available on the programme web site, which increases the confidence of the final user;

the submission by the installer and not by the final user;

the electronic procedure for the submission of applications.

Campania

The main reason for the negative exit of the programme are:

wrong figures for the turn-key cost of the solar plants; a maximum total cost of about 600 €/m2 was foreseen; therefore, given the real turn-key cost of small plants (see calculation example in paragraph 6.b), the subsidy was bewteen 10% and 20% of the investment cost; instead, the programme meant to give a subsidy share of about 30%;

the programme demanded a monitoring system also for very small domestic plants; in this case, the cost of the monitoring system could raise even to 30% of the total investment cost;

the programme had the usual "closed tender" approach and, furthermore, it was launched in the summer months (almost at the end of July);

lack of specific communication policies and awareness raising campaigns.

Assolterm asked for substantial changes in the subsidy programme, especially regarding the cost issue. It is likely that the programme will be revised and launched a second time in the first semester of 2006.

Annex IV: Case studies for Italy: White Certificates scheme for energy saving and energy efficiency

Summary

The new mechanism for the promotion of energy saving and energy efficiency has its basis on the fact that large gas and electricity distribution companies must meet annual mandatory targets for energy savings in final uses.

The scheme, which operates at national level, aims at reaching energy saving targets for both electric and thermal energy; therefore any project leading to heat or electricity savings, in principle, could be included in this scheme.

Solar thermal is one of the technologies involved explicitly, with even a standard calculation sheet to assess the savings obtained by using solar thermal plants.

In order to meet their obligation, the involved companies can, first of all, build up their own energy saving projects. For instance, an electric utility could distribute low consumption bulbs to all their customers, then certifying the overall savings.

Another possible solution for the companies is to buy “White Certificates”, which correspond to energy saving projects carried out by other subjects, the ESCOs (Energy Service Companies).

Even though in Italy this “White Certificate” scheme is quite important to spread also the culture of energy efficiency, such an incentive system has out of doubt some weak points:

the selling of White Certificate is done on a market basis, so general uncertainty about the prices is expected; this means that energy efficiency and renewables cannot rely on fixed incentives;

as a consequence, as in the Green Certificates schemes, ESCOs prefer to carry out energy saving projects with a low payback time; therefore the “competition” among different solutions is based almost completely on the economic issue; this could lead to a mass spreading of, for instance, low consumption bulbs and to a very few solar thermal installations

the working principle is not so “user-friendly” and for a small operator, typical of the Italian market, not always easy to be understood; this is due above all to the large amount of actors involved and to the high number of deadlines and papers to be submitted.

Identification of the Financing Scheme

Title of the financing scheme

White Certificates scheme for energy saving and energy efficiency.

Brief description of the financing scheme

The herein described new mechanism for the promotion of energy saving and energy efficiency has been in operation in Italy since January, 1st 2005.

The key concept of this scheme is that large (more than 100.000 customers) gas and electricity distribution companies must meet annual mandatory targets for energy savings in final uses, expressed in Mtoe (tons of oil equivalent)/year.

Promoter

The promoter of this scheme is the Ministry of Industry, but several different actors are involved in the operation of the mechanism (see Type of Actor below).

Type of actor

The main actors involved are the following:
the Ministry of Industry (MAP): it was responsible for developing the general framework for the scheme operation;
the Ministry of Environment (MATT): it helped MAP in developing the regulatory framework;
the Italian Authority for Gas and Electricity (AEEG): it is in charge of delivering the technical guidelines;
large gas and electricity distribution companies, which are obliged to meet the established targets;
the Energy Service Companies (ESCOs): they can carry out energy saving and efficiency projects, then selling the obtained savings to the distribution companies (see below for the details about the working principle);

Financing scheme priorities

The scheme, which operates at national level, aims at reaching energy saving targets for both electric and thermal energy; therefore any project leading to heat or electricity savings, in principle, could be included in this scheme.

Solar thermal is one of the technologies involved explicitly, since AEEG delivered even a standard calculation sheet to assess the savings obtained by using solar thermal plants.

Description of the Financing Scheme

General description of the financing scheme

Background

The first National Decrees which introduced the White Certificates scheme were published in 2001. Then AEEG did not accomplish its duty, providing technical guidelines for the actual application of the Decrees. In the meanwhile, due to a strong pressure from some stakeholders (large energy distribution companies above all), the Decrees had been revised: this process led to 3 years delay, with the final Decrees together with the application rules being published in 2004.

Financing scheme design/management

As already reported above, the key concept of this scheme is that large (more than 100,000 customers) gas and electricity distribution companies must meet annual mandatory targets for energy savings in final uses, expressed in Mtoe (tons of oil equivalent)/year.

In case these companies fail their objectives, they will face a proportional fine, higher than the average investment cost that would have been necessary to reach those targets.

The measures that could be used include everything which brings to real energy savings, e.g. replacing old lamps with high efficiency bulbs or electric boilers with gas boilers, use double glasses, improve walls and roof insulation, improve electric motors efficiency, use low-consumption electrical appliances (fridges, washing machines, etc.), adopt water-saving devices (e.g flow reductors or air/water mixers), install solar thermal collectors or photovoltaic modules, use heat pumps, etc.

In order to meet their obligation, the involved companies can, first of all, build up their own energy saving projects. For instance, an electric utility could distribute low consumption bulbs to all their customers, then certifying the overall savings.

Another possible solution for the companies is to buy “White Certificates”, which correspond to energy saving projects carried out by other subjects, the ESCOs (Energy Service Companies). Therefore, the White Certificates system works very similarly to the Green Certificates scheme.

Let us suppose that an ESCO carry out an energy saving project (e.g. the installation of a solar thermal system for hot water supply to a dairy); then the ESCO applies for the amount of White Certificates corresponding to the obtained savings in toe/year. The savings are usually calculated basing on standard parameters, provided by AEEG, and White Certificates are given yearly to the ESCO for a total period of 5 years for solar thermal plants. The last step is the selling of the White Certificates from the ESCO to the interested companies; this selling could be done on a bilateral contract or in a specific market for White Certificates. The price depends, as in any market, on the matching between offer and demand, but the maximum price foreseen is 100 €/toe saved.

Going back to the example given above, let us say that the solar thermal plant installed by the ESCO covers a total area of 100 m^2, uses flat plate collectors, is located in Roma and will operate together with an electric boiler. For the assessment of the energy savings that could be certified, a calculation sheet has been made available from AEEG. This sheet reports the Gross Specific Saving, expressed in toe/m^2 of solar collectors installed. The GSS values depend on: the installation site (Italy is divided into five areas, basing on solar resource), the solar collector technology (flat plate or evacuated tubes) and the energy replaced by the solar heat (gas, electricity, oil, etc.). Incorrectly, the calculation sheet does not take into account at all the tilt and the azimuth of the collectors.

From the table below, we can see that the GSS for the project under study is $181 \cdot 10^{-3}$ toe/m^2 year and therefore the total savings could be easily calculated: 18 toe/year for 5 years.

Assuming the maximum price of 100 €/toe saved, this would mean additional income for the ESCO of 1.800 €/year for 5 years.

Example of Gross Specific Savings due to the installation of a solar thermal plant

	Flat plate collectors		Evacuated tubes collectors	
	Replaced energy			
	Electric boiler	Gas/Oil	Electric boiler	Gas/Oil
Gross Specific Saving	10^{-3} toe/m^2 year	10^{-3} toe/m^2 year	10^{-3} toe/m^2 year	10^{-3} toe/m^2 year
Milano	122	61	153	76
Roma	181	90	209	104
Catania	247	123	269	134

Objective of the financing scheme

The overall goal of this system is raise a total energy savinge of 2.9 Mtoe in the time period 2005-2009, of which 1,6 Mtoe for electricity and 1,3 Mtoe for gas.

Actions

The White Certificates scheme has been widely advertised, thanks to the large number of stakeholders involved (MATT; MAP, AEEG; ESCOs, etc.).

Timing

The subsidy programme started in January 2005; the first step will end in 2009 and then MAP, MATT and AEEG will revise the scheme working mechanism and the mandatory targets for the following period.

Costs of implementing the financing schemes (costs on the side of the administration and on the side of the investor)

The costs on the side of the administration are very hard to quantify, given the large number of actors involved (see Part I, Type of actor). However, AEEG is in charge of the heaviest task, since it is supposed to check the compatibility of the applications and also to verify the fulfilment of the annual targets.

Some work is also expected by the Electric Market Manager Authority (GME), but it is not easy to estimate this amount of work, since the market has just started.

It is also worthy to highlight that the solar thermal is just a fraction of this complicated mechanism, therefore only a fraction of these costs on the side of the administration should be allocated to the solar sector.

On the side of the investor (distribution companies and ESCOs), the costs to be considered are related to the preparation of the projects to be submitted to AEEG; even though for solar thermal plants, the procedure is very easy (see Financing scheme design/managment), since the calculations are based on standard sheets, it is however additional work.

Finances

Just as happens with the PV feed-in law in Italy, a fraction of the expenses faced by the distribution companies to reach their targets could be charged on electricity and gas tariffs. Therefore, part of the cost of the scheme is faced by the final consumers, even though this amount has not been decided yet.

Financing Scheme Results

Quantitative results

So far, no quantitative results are available, but the whole scheme and especially the checking of annual mandatory targets will be monitored by AEEG.

It is interesting to mention the fact that there are already, in Italy, ESCOs which carry out projects on solar thermal plants.

Replication potential

The replication potential is the White Certificates scheme is quite high, given the following reasons:
in most of the countries, the potential of energy saving and energy efficiency in reducing consumption and polluting emissions is very high;
the selling of White Certificate is done on a market basis, so it could be adapted to national conditions; however, this kind of “market-based” incentives are quite dangerous, since they create general uncertainty about the prices, therefore not promoting easily the diffusion of renewables and energy saving measures.

Communication

As stated above, the White Certificates scheme has been widely advertised, thanks to the large number of stakeholders involved (MATT; MAP, AEEG; ESCOs, etc.).

AEEG web site (www.autorita.energia.it) is a quite good and complete communication tool, since all relevant technical and regulation documents regarding the White Certificates system could be find there.

Monitoring & Lessons Learned

Monitoring

So far, no quantitative results are available, but the whole scheme, including the verification of the annual mandatory targets will be monitored by AEEG.

Analysis and lessons learned

It is too early to do a complete assessment of the scheme, but several positive issues should be already highlighted:
the involvement of ESCOs is leading to the birth of new companies;
the improvement of an "energy efficiency culture";
the White Certificate acts as an additional incentive for the installation of solar thermal systems.

The negative sides are:
the working principle is not so "user-friendly" and for a small operator, typical of the Italian market, not always easy to be understood; this is due above all to the large amount of actors involved and to the high number of deadlines and papers to be submitted.
as in the Green Certificates schemes, ESCOs prefer to carry out energy saving projects with a low payback time; therefore the "competition" among different solutions is based almost completely on the economic issue; this could lead to a mass spreading of, for instance, low consumption bulbs and to a very few solar thermal installations.

Annex V: Regional case study for Austria – Upper Austria

Summary

Upper Austria is the most successful region in solar thermal penetration in Austria. One out of four solar thermal systems in Austria have been installed in this province so far. For almost 30 years, solar systems have been subsidised without any interruption, based on a balanced network of long term thinking regional politicians, active solar companies and the regional energy agency "OÖ Energiesparverband" as driving force and mediator. Subsidies have been given for new houses market as well as for renovation houses market.

The financing scheme is enacted and administered by the regional government of Upper Austria. The regional energy agency "OÖ Energiesparverband" is in charge of energy consulting for private and commercial costumers and of monitoring the financing scheme. Based on this monitoring changes of the financing scheme (subsidy level) always have been suggested by the energy agency to the government. Private house owners, housing associations, installers and solar companies have been the beneficiaries of the financing scheme, as it has led to the only continuously growing solar market over decades in Austrian provinces so far.

The official aim of the government of Upper Austria is to double the total installed collector area up to 1M m² until 2010. By then the province should have 0,72 m² collector area per inhabitant.

For sure a lesson to be learned of Upper Austria is that long term establishment of a continuously growing solar market needs stable conditions in terms of uninterrupted subsidy, awareness campaigns and training activities for installers and a stable communication network of public authority and private companies to secure stable conditions.

Identification of the Financing Scheme

Title of the financing scheme

Upper Austria is the most successful region in solar thermal penetration in Austria. One out of four solar thermal systems in Austria have been installed in this province so far. For almost 30 years solar systems have been subsidised without any interruption, with subsidy levels slowly increasing during the years. Subsidies have been given for new houses market as well as for renovation houses market.

Brief description of the financing scheme

Direct subsidy for private houses with three flats maximum and attached houses: for solar domestic hot water systems and solar combisystems for domestic hot water and space heating, also in combination with heat pumps. Direct subsidy is also given for enlargement or exchange of existing solar systems. The up-to-date subsidy is about 20 to 30 percent (depends on system size) of total investment costs or 50 percent of total investment costs (excl. VAT), maximum subsidy is 3.000 Euro.

Promoter

For almost 30 years the successful financing scheme of Upper Austria is based on a balanced network of long term thinking regional politicians, active solar companies and the regional energy agency “OÖ Energiesparverband” as driving force and mediator.

Type of actor

The financing scheme is enacted and administered by the regional government of Upper Austria. The regional energy agency “OÖ Energiesparverband” is in charge of energy consulting for private and commercial customers and of monitoring the financing scheme. Based on this monitoring changes of the financing scheme (subsidy level) always have been suggested by the energy agency to the government. Private house owners, housing associations, installers and solar companies have been the beneficiaries of the financing scheme, as it has led to the only continuously growing solar market over decades in Austrian provinces so far.

Financing scheme priorities

The financing scheme priorities are solar domestic hot water systems and solar combisystems for domestic hot water and space heating, also in combination with heat pumps. The scheme does not aim to district heating, air-conditioning and industrial process heating. For these applications a national financing scheme granting 30 percent of total investment costs is valid.

Description of the Financing Scheme

General description of the financing scheme

Background

The financing scheme of Upper Austria is a rare example of an uninterrupted scheme with continuously increasing subsidy levels over almost 30 years. Also previously the scheme is not limited in time.

Financing scheme design/management

The financing scheme of Upper Austria was initiated by the regional government as a reaction to the first oil crisis in the 1970s. Meanwhile the financing scheme for solar subsidies is part of the Upper Austria Energy Strategy “Energy 21” including all issues relevant to energy consumption. The scheme is operated by the regional government, in strong cooperation with regional solar companies and the regional energy agency “OÖ Energiesparverband”. Evaluation of the indicators for success and quantifiable benefits of the financing scheme is done by the regional energy agency “OÖ Energiesparverband”, which also suggests scheme changes to the government.

Objective of the financing scheme

The official aim of the government of Upper Austria is to double the total installed collector area up to 1M m² until 2010. By then, the province should have 0,72 m² collector area per inhabitant.

Actions

Training activities for installers have been started in the 1980s and progressed to date, leading to hundreds of well trained installers for solar systems in Upper Austria in the meanwhile. The training activities were promoted and operated by trade training organisations and vocational schools delivering technical training facilities. These training activities will be prolonged because more trained installers are still needed for enhanced solar market penetration in the region.

The financing scheme has been accompanied by several awareness campaigns in the last decades, with the latest campaign in autumn 2005. Meanwhile most of the costumers and companies in Upper Austria know about the solar subsidy given by the government. Nevertheless continued awareness activities are necessary for enhanced solar market penetration in the region.

Timing

The financing scheme of Upper Austria was started in the 1970s and is still ongoing without a closing date.

Costs of implementing the financing schemes (costs on the side of the administration and on the side of the investor)

The costs for the administration side are for enacting the financial scheme and administration of the thousands of application forms for solar subsidies. Additionally the regional energy agency, "OÖ Energiesparverband", is supported by the government to energy consult custumers and evaluate the financing scheme. In the last years around 45.000 m² collector area has been installed annually, leading to approximately 3.500 subsidised solar systems per year (average subsidy around 2.000 Euro per solar system), with less than 8M Euro solar thermal subsidies by the government in total.

Finances

See the above section.

Financing Scheme Results

Quantitative results

The quantitative results of the financing scheme in Upper Austria is an annually installed collector area about 45.000 m² during the last years, leading to an energy delivery of 15 GWh solar heat per year or environmental savings of more than 7.000 tons of CO_2 per year. Financial investments by costumers in solar systems in total reached over 30M Euro annually in the framework of the financing scheme in the last years.

Environmental

Estimated reduction of CO_2 emissions by year: over 7.000 tons of CO_2.

This might be difficult for local actors and depends strongly on the energy locally used and replaced by the RES heating technology. ESTIF suggested adopting a conversion factor for a certain energy mix like the IEA solar heating task force did.

Replication potential

For certain, a lesson to be learned of Upper Austria is that long term establishment of a continuously growing solar market needs stable conditions in terms of uninterrupted subsidy, awareness campaigns and training activities for installers and a stable communication network of public authority and private companies to secure stable conditions.

Communication

Over 15.000 energy consultations of costumers annually in Upper Austria, done by the regional energy agency “OÖ Energiesparverband”, have been a major factor in the communication strategy to promote the financing scheme in the last decades.

Monitoring & Lessons Learned

Monitoring

See above.

Analysis and lessons learned

A well established communication network of all relevant market actors, a sufficient budget for solar subsidies also in a growing market, a commitment of the relevant market actors for duration of the financing scheme, an unbureaucratic system of financing scheme management and a high quality of solar systems on the market – these factors all together are highly favourable to lead to market success over a longer period.

Innovative Applications of Solar Thermal

Innovative Applications of Solar Thermal

Introduction

Solar thermal heating and cooling has a potential far bigger than the most typical applications today. While the heating of the built environment (space heating, domestic hot water) will continue to be the most important market segment, other applications will grow to significant market shares.

A few selected applications with a significant potential are highlighted in this section: Solar heat for industrial processes and for solar assisted cooling. Their success in the market will play a decisive role in transforming the heating/cooling market from conventional – mainly fossil – fuels to clean and secure renewable energy.

Most policies, which aim at raising the usage level of solar thermal are targeted at typical applications available on the market already today. For example, many EU Member States have financial incentive programmes in place, which give financial incentives to the installation of solar thermal systems for domestic hot water production or space heating.

This type of support has been very important for the growth of solar thermal markets. And while the supported technologies move towards the mainstream, it is important to bear in mind that other solar thermal applications have not yet reached the level of maturity, and are thus sometimes forgotten in promotional programmes.

The current main barriers for these applications are typical for “early-stage technologies”:

- Higher upfront investment costs
- Lack of awareness amongst decision makers
- Lack of trained professionals
- Lack of mature and possibly standardised products

In order to overcome these barriers, the following recommendations are made:

- Funding for demonstration projects and awareness raising
- Increased funding for R&D on these applications
- Training of professionals (planners, installers)

- Inclusion of these applications in RES-H targets as well as in policy measures, such as the implementations of the Energy Performance in Buildings Directive

Solar Assisted Cooling – State of the Art

Executive Summary

Solar cooling technologies use solar thermal energy provided through solar collectors to power thermally driven cooling machines. Cooling demand is rapidly increasing in many parts of the world, especially in moderate climates, such as in most EU member states. This results in a dramatic increase in electricity demand on hot summer days, which causes an unwanted increase in the use of fossil and nuclear energy and furthermore threatens the stability of electricity grids.

As many cooling applications, such as air conditioning, have a high coincidence with the availability of solar irradiation, the combination of solar thermal and cooling obviously has a high potential to replace conventional cooling machines based on electricity. Larger solar cooling systems have been successfully demonstrated and smaller machines, which could be used in (small) residential and office buildings, are entering the market.

Because solar cooling is not yet widely available, it is important to understand its specific barriers to growth and consequently the best strategies to help overcome these barriers. The following short list will help policy-makers develop and implement suitable support policies for solar cooling. A more detailed list can be found at the end of this document.

Barriers to growth

Technical barriers - Hardware

- Lack of units with small capacities
- Lack of package-solutions for residential and small commercial applications
- Only few available medium temperature collectors
- Low thermal efficiency (COP)
- Often: Need for wet cooling tower

Technical barriers – Software (e.g. planning guidelines, training)

- Very important: no skills today among professionals
- Lack of standardised hydraulic schemes, planning guidelines and simple design tools

Lack of awareness

- Lack of awareness of solar cooling will become a key barrier to growth in the near future

Costs

- Higher initial investment costs compared with conventional cooling systems
- To date, not cost efficient from a business point of view
- Often forgotten in today's financial incentive schemes for solar thermal

Recommendations

Specific RD&D

- Fundamental research:
  - Development of new cooling cycles
  - Development of systems with high temperature lift
- Applied research and development:
  - Improvement of new components, such as small capacity systems
  - For small systems: Development of concepts which lead to pre-engineered solutions
  - For large systems: Development of hydraulic concepts, design guidelines and proven operation and maintenance concepts
  - Development of advanced modelling and simulation tools
- Large number of demonstration projects
  - Essential to achieve a high standardization and proven guidelines
  - Also important to have good references and showcases

Training and awareness raising

- Specific training courses for professionals
- Inclusion of solar cooling technologies into standard education for engineers etc.
- Later: Broad awareness raising campaigns targeted at suitable decision-makers and industry multipliers
- Requirement on EU member states to keep statistics on the energy demand for cooling purposes

Financial incentives

- Inclusion of solar cooling into financial incentive schemes for solar thermal

- Inclusion of solar cooling into White or Renewable Energy Certificate schemes

Regulatory measures

- Inclusion in building regulations: use of renewable energy for cooling
- Discouragement or prohibition of refrigerants with high global warming potential (GWP)

Other policy measures

- Inclusion of cooling into RES-H targets at European and national level

Introduction

The present document was produced within the framework of the Intelligent Energy-Europe project Key Issues for Renewable Heat in Europe (K4RES-H). The project looks at providing guidelines for best practice policies to support renewable heating and cooling (RES-H) technologies. Because most of the current support policies for RES-H focus on commercially available products, this document aims at highlighting one of the promising, upcoming applications for solar thermal: Solar Industrial Process Heat (SHIP)

In solar cooling systems, solar heat is used to drive the cooling process. Thermally driven cooling machines, such as ab- or ad-sorption chillers have been used for decades, but have been powered mainly by industrial waste heat or by district heat. In recent years, demonstration projects have shown the potential to use solar thermal energy to drive those chillers. Because most of the available thermal chillers have large cooling capacities (often several hundred kW), the focus of R&D was largely on developing smaller cooling units as well as to improve the system design. About 100 systems have been installed in Europe and several companies are offering solar cooling solutions as part of their product and service portfolio.

Components of a solar cooling system

A solar cooling installation consists of a typical solar thermal system made up of solar collectors, storage tank, control unit, pipes and pumps and a thermally driven cooling machine. To date, most collectors used in solar cooling systems are the high-efficiency collectors available in the market today (often double-glazed flat plate collectors or evacuated tube collectors). New developments for the medium temperature range (100-250°C) could increase the overall efficiency of the cooling systems.

Technical information on thermally driven chillers

Thermally driven chillers may be characterized by three temperature levels: a high temperature level at which the driving temperature of the process is provided, a low temperature level at which the chilling process is operated, and a medium temperature level at which both, the heat rejected from the chilled water cycle and the driving heat, have to be removed. For this heat removal, in most cases a wet-cooling tower is used.

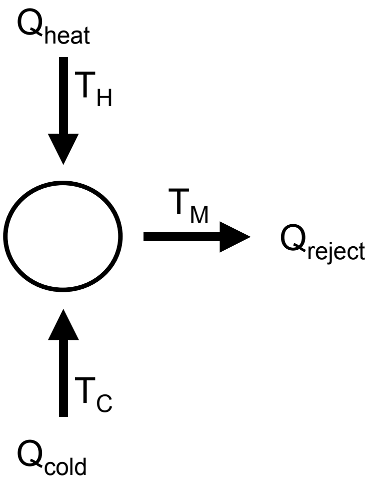


Figure 1: Basic process scheme of a thermally driven chiller

Basic process scheme: Q_{cold} is the heat rejected from the chilled water in the evaporator of the chiller (chilling power), Q_{heat} is the required heat in the generation part to drive the process, and the amount of Q_{reject} , the sum of Q_{cold} and Q_{heat} , has to be removed at a medium temperature level T_M. Q_{heat} is deliverd either by the solar system or by backup heat sources, e.g. by district heat or by a gas burner.
A key figure describing the efficiency of a thermally driven chiller is the thermal Coefficient Of Performance (COP), defined as the fraction of heat rejected from the chilled water cycle ('delivered cold') and the required driving heat, i.e. $COP_{thermal} = Q_{cold} / Q_{heat}$. This is different to the COP_{conv} of a conventional eletrically driven compression chiller, defined by $COP_{conv} = Q_{cold} / E_{electric}$, with $E_{electric}$ representing the electricity consumption of the chiller.

This definition of the $COP_{thermal}$ does not include any additional electric power consumption. A realistic comparison of different technologies thus requires the consideration of the total energy input for heat as well as for pumps, fans, etc. It has to be noted that the smaller the COP, the more heat input is required and the more heat has to be removed by the cooling tower. Vice versa, a high COP value is of advantage in reducing both heat input and electric power for the pumps in the heating cycle and in the re-cooling cycle.

The required chilled water temperature depends on the installed cooling system in the rooms. In cases where dehumidification of the air is required, e.g. falling below the saturation point of the room temperature by using fan coils, chilled water temperatures in the range of 6°C-9°C are required. For the removal of sensible cooling loads only, which can be achieved with cooled supply air or with room installations such as chilled ceilings etc., a chilled water temperature of 12°C-15°C is sufficient, allowing the chiller to operate with a higher performance.

ABSORPTION CHILLERS

Absorption chillers are the most widely used chillers throughout the world. A thermal compression of the refrigerant is achieved by using a liquid refrigerant/sorbent solution and a heat source, thereby replacing the electric power consumption of a mechanical compressor. For chilled water above 0°C, as is used in air conditioning, a liquid H_2O/LiBr solution is typically applied with water as a refrigerant. Most systems use an internal solution pump, but consume only little electric power. In the operation of an H_2O/LiBr absorption chiller, a crystallisation of the solution has to be avoided by internal control of the heat rejection temperature in the machine.

The main components of an absorption chiller are shown in the figure below. The cooling effect is based on the evaporation of the refrigerant (water) in the evaporator at very low pressure. The vaporised refrigerant is absorbed in the absorber, thereby diluting the H_2O/LiBr solution. To make the absorption process efficient, the process has to be cooled. The solution is continuously pumped into the generator, where the regeneration of the solution is achieved by applying driving heat (e.g. hot water). The refrigerant leaves the generator by this process, condenses through the application of cooling water in the condenser, and circulating by means of an expansion valve again into the evaporator.

Typical chilling capacities of absorption chillers are several hundred kW. Mainly, they are supplied with district heat, waste heat or heat from cogeneration. The required heat source temperature is usually above 80°C for single-effect machines and the COP is in the range of 0.6 to 0.8. Double-effect machines with two generator stages require driving temperatures of above 140°C, but the COPs may achieve values up to 1.2.

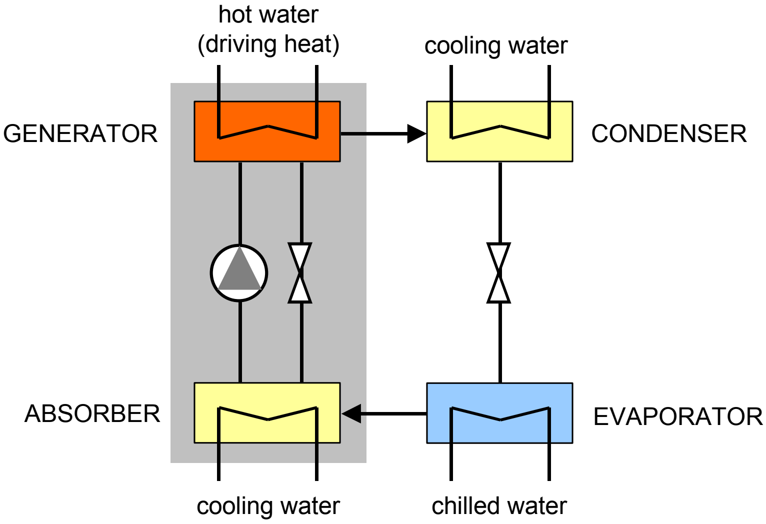


Figure 2: Principle of an absorption chiller

A few absorption chillers with capacities below 50 kW are available. In solar assisted air conditioning systems with absorption chillers, these small units are often implemented. A machine type, developed recently for small capacities, enables part-load operation with reduced chilling power at heat source temperatures of 65°C already and with a COP of still approx. 0.7, which is promising in combination with solar heat. This indicates that there is still potential for performance improvement for absorption chillers.

ADSORPTION CHILLERS

Here, instead of a liquid solution, solid sorption materials are applied. Market available systems use water as a refrigerant and silica gel as a sorbent. The machines consist of two sorbent compartments (denoted as 1 and 2 in the figure below), one evaporator and one condenser. While the sorbent in the first compartment is regenerated using hot water from the external heat source, e.g. the solar collector, the sorbent in the compartment 2 (adsorber) adsorbs the water vapour entering from the evaporator; this compartment has to be cooled in order to enable a continuous adsorption. The water in the evaporator is transferred into the gas phase being heated by the external water cycle; here the useful cooling is actually produced. If the cooling capacity reduces to a certain value due to the loading of the sorbent in the adsorber, the functions of the chambers are switched over. To date, only a few Asian manufacturers produce adsorption chillers. Under typical operation conditions, with a driving heat temperature of about 80°C, the systems achieve a COP of about 0.6, but operation is possible even at heat source temperatures of approx. 60°C. The capacity of the chillers ranges from 50 kW to 500 kW chilling power.

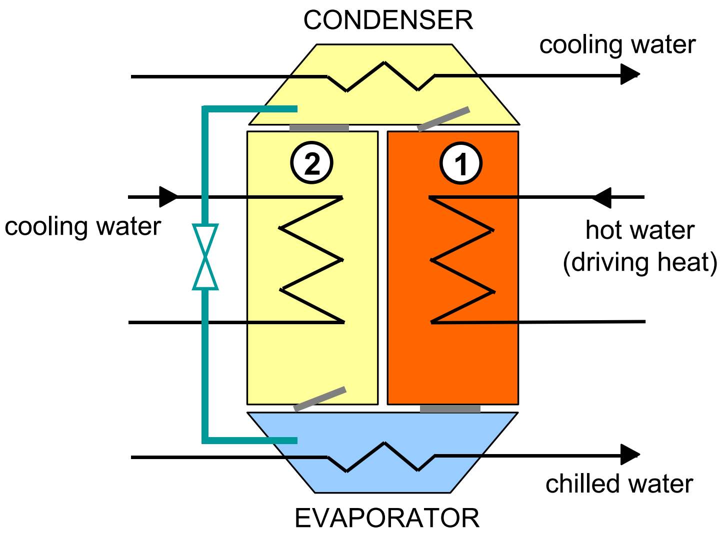


Figure 3: Principle of an adsorption chiller

The simple mechanical construction of adsorption chillers and their expected robustness is an advantage. There is no danger of crystallisation and thus no limitations in the heat rejection temperatures exist. An internal solution pump does not exist and hence only a minimum of electricity is consumed. A disadvantage is the comparatively large volume and weight. Furthermore, due to the small number of items produced, the price of adsorption chillers is currently high. A large potential for improvements of the heat exchangers in the adsorber compartments is expected; thus, a considerable decrease in volume and weight can be assumed in future generations of adsorption chillers.

Technical information on desiccant cooling systems

Desiccant cooling systems are basically open cycle systems, using water as a refrigerant in direct contact with air. The thermally driven cooling cycle is a combination of evaporative cooling with air dehumidification by a desiccant, i.e. a hygroscopic material. For this purpose, liquid or solid materials can be employed. The term 'open' is used to indicate that the refrigerant is discarded from the system after providing the cooling effect and new refrigerant is supplied in its place in an open-ended loop. Therefore, only water is possible as a refrigerant since a direct contact to the atmosphere exists. The common technology applied today uses rotating desiccant wheels, equipped either with silica gel or lithium-chloride as sorption material.

SOLID DESICCANT COOLING WITH ROTATING WHEELS

The main components of a solar assisted desiccant cooling system are shown in the figure below. The basic process in providing conditioned air may be described as follows.

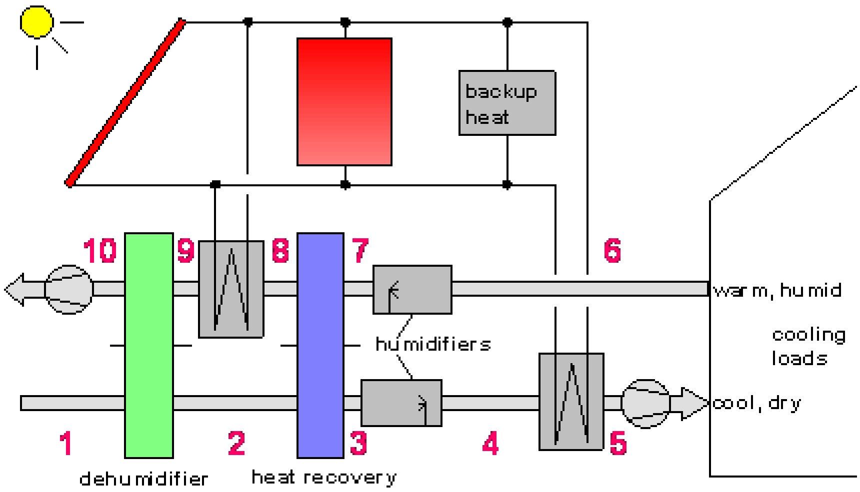


Figure 1

A: Cooling case

Warm and humid ambient air enters the slowly rotating desiccant wheel and is dehumidified by adsorption of water (1-2). Since the air is heated up by the adsorption heat, a heat recovery wheel is passed (2-3), resulting in a significant pre-cooling of the supply air stream. Subsequently, the air is humidified and further cooled by a controlled humidifier (3-4), according to the desired temperature and humidity of the supply air stream. The exhaust air stream of the rooms is humidified (6-7) close to the saturation point to exploit the full cooling potential in order to allow an effective heat recovery (7-8). Finally, the sorption wheel has to be regenerated (9-10) by applying heat in a comparatively low temperature range from 50°C-75°C, to allow a continuous operation of the dehumidification process.

B: Heating case

In periods of low heating demand, heat recovery from the exhaust air stream and enthalpy exchange by using a fast rotating mode of the desiccant wheel may be sufficient. In cases of increased heating demand, heat from the solar thermal collectors and, if necessary, from a backup heat source (4-5) is applied.

Flat plate solar thermal collectors can be applied normally as a heating system in solar assisted desiccant cooling systems. The solar system may consist of collectors using water as fluid and a hot water storage, to increase the utilisation of the solar system. This configuration requires an additional water/air heat exchanger, to connect the solar system to the air system. An alternative solution, leading to lower investment cost, is the direct supply of regeneration heat by means of solar air collectors.

Special design of the desiccant cycle is needed in case of extreme outdoor conditions such as e.g. coastal areas of the Mediterranean region. Here, due to the high humidity of ambient air, a standard configuration of the desiccant cooling cycle is not able to reduce the humidity down to a level that is low enough to employ direct evaporative cooling. More complex designs of the desiccant air handling unit, employing for instance another enthalpy wheel or additional air coolers supplied by chilled water, can overcome this problem.

LIQUID DESICCANT COOLING

A new development, close to market introduction, are desiccant cooling systems using a liquid Water/Lithium-Chloride solution as sorption material. This type of system shows several advantages such as higher air dehumidification at the same driving temperature range as solid desiccant cooling systems, and the possibility of high energy storage by storing the concentrated solution. This technology is a promising future option for further increasing the exploitation of solar thermal systems for air-conditioning.

Solar assisted air conditioning

One of the most widely used applications for solar cooling is air conditioning (often termed "solar assisted air conditioning). The most common technologies used in combination with solar heat are shown in Table 1. Thus, solar assisted air conditioning systems operated to date may be classified into:
closed systems: these are thermally driven chillers which provide chilled water, that is either used in air handling units to supply conditioned air (cooled, dehumidified), or that is distributed via a chilled water network to the designated rooms to operate decentralized room installations, e.g. fan coils. Market-available machines for this purpose are absorption chillers (most common) and adsorption chillers (a few hundred machines worldwide, but of rising interest in solar assisted air conditioning);
open systems: allowing complete air conditioning by supplying cooled and dehumidified air according to comfort conditions. The "refrigerant" is always water,

since it is in direct contact with the atmosphere. Most common systems are desiccant cooling systems using a rotating dehumidification wheel with solid sorbent.

method	**closed cycle**		**open cycle**	
refrigerant cycle	closed refrigerant cycle		refrigerant (water) is in contact to the atmosphere	
principle	chilled water		dehumidification of air and evaporative cooling	
phase of sorbent	**solid**	**liquid**	**solid**	**liquid**
				
typical material pairs	water - silica gel	water - water/ lithiumbromide, ammonia/water	water - silica gel, water - lithiumchloride	water - calcium chloride, water - lithium chloride
market available technology	adsorption chiller	absorption chiller	desiccant cooling	close to market introduction
typical cooling capacity [kW cold]	adsorption chiller: 50-430 kW	absorption chiller: 15 kW - 5 MW	20 kW - 350 kW (per Module)	-
typical COP	0.5-0.7	0.6-0.75 (single effect)	0.5->1	>1
driving temperature	60-90°C	80-110°C	45-95°C	45-70°C
solar collectors	vacuum tubes, flat plate collectors	vacuum tubes	flat plate collectors, solar air collectors	flat plate collectors, solar air collectors

Figure 2: Overview of the most common solar assisted air conditioning technologies

Overview of selected demonstration projects

To date, about 100 solar cooling and air-conditioning (A/C) systems have been installed in Europe. Their specific collector area is ~3 m^2/kW for water chillers, or 10m^2 per 1000 m^3/h of air volume flow in desiccant systems. Their primary energy savings potential is between 30-60%, but these potentials are often not yet realised with the current systems (due to sub-optimal design, installation, operation). Cost wise the systems have a pay-back period of 6 years (best systems) to over 20 years, at today's energy prices.

Most of the systems realised so far have been installed in Germany, Spain and Greece:

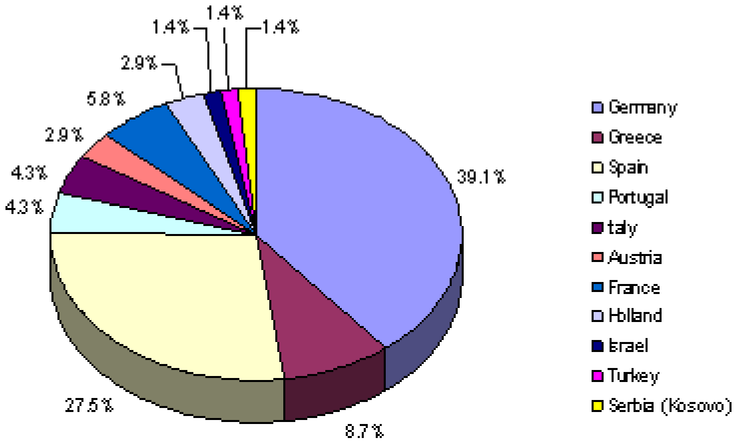


Figure 3: Geographical distribution of solar cooling demonstration projects

Following are selected examples of existing systems.

Air-conditioning of a factory

- Use: air conditioning of the production facilities in a cosmetics factory
- Site: Inofita Viotias (appr. 50 km north-east of Athens)
- Solar thermal collector field: 2700 m² flat plate collectors
- Chillers:
  - 2 adsorptions chillers with 350 kW each
  - 3 compression chillers with 350 kW each
- Specifics: This solar cooling system is the largest to-date

Wine store cooling

- Use: cooling of a wine store
- Site: Banyuls (south France)
- Solar thermal collector field: 130 m² evacuated tube collectors
- Chiller: absorption chiller with 52 kW cooling capacity
- Specifics:
  - no back-up system, the system operates autonomously and has no buffer storage
  - one of the oldest systems; operated more than 13 years without any problems


Air-conditioning of a seminar room

- Use: air-conditioning of the seminar room and the cafeteria in an office building of the local chamber for trade & commerce
- Site: Freiburg (south-west Germany)
- Solar thermal collector field: 100 m² of air collectors as the only heat source
- Cooling system: desiccant cooling system (10.200 m³ per hour) with silica gel rotor
- Specifics:
  - no back-up system, no storage
  - simple solar system, simple integration into the air-conditioning plant


Hotel air-conditioning

- Use: air-conditioning of a hotel and steam supply for the hotel laundry
- Site: Dalaman (Mediterranean coast Turkey)
- Solar thermal collector field: 180 m² parabolic trough collectors (aperture area)
- Chiller: double effect absorption chiller (cooling capacity 116 kW, 4 bar saturated steam; COP > 1.2)
- LPG-fired back-up steam boiler
- Specifics:
  - First system with double effect chiller
  - High temperatures: parabolic trough collectors produce steam at 180°C
  - High overall conversion efficiency


Energy and environment

Although electrically driven chillers have reached a relatively high standard in terms of energy consumption, they still require a high amount of electricity and - even more importantly - cause significant peak loads in electricity grids. This is becoming a growing problem in regions with cooling dominated climates. Figure 7 below shows the total newly installed electric capacity due to room air-conditioner (RAC) units since 1998, assuming a replacement of 10% per year and an average electric capacity of 1.2 kW per unit. In recent years, an increasing number of cases have occurred in which summer electricity shortages were created due to air-conditioning appliances. In some regions or municipalities, building regulations were set up in order to limit the application of active air conditioning systems, unless they were operated with renewable energies.

This underlines the necessity of new solutions with lower electricity consumption, and in particular reduced consumption at peak load of electricity conditions.

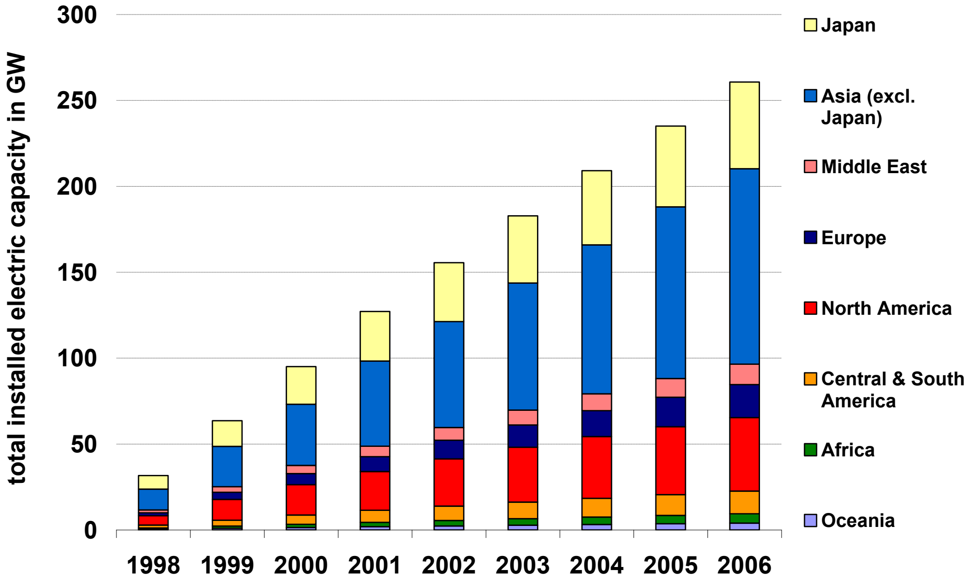


Figure 4: Cumulative newly installed electric capacity due to RAC units

Another topic related to environmental issues concerns the global warming potential of refrigerants. Refrigerant leakage in air-conditioning appliances - in particular in the automotive sector - led to several legislative initiatives towards limitation or even prohibition of classical fluorized refrigerants. Almost all thermally driven technologies use refrigerants which have no global warming potential.

Market potential

A tremendous increase in the market for air-conditioning can be observed worldwide. Figure 8 below shows the sales rates of room air-conditioners (RAC units) in different regions of the world. The number of sold units increased from about 26 million units worldwide in 1998 to more than 40 million units in 2006 (forecast). At the same time, the market for centralized cooling equipment remained almost stable. Which technology is employed - small RAC split units, multi-split systems, centralized chilled water technology, centralized air handling units - depends strongly on both region and load type. However, the dominance of small-split systems in private residences is a common trend worldwide. Therefore, in order to limit the negative impact on the energy consumption and on the electricity network management, new environmentally sound concepts for the small capacity range are of particular importance.

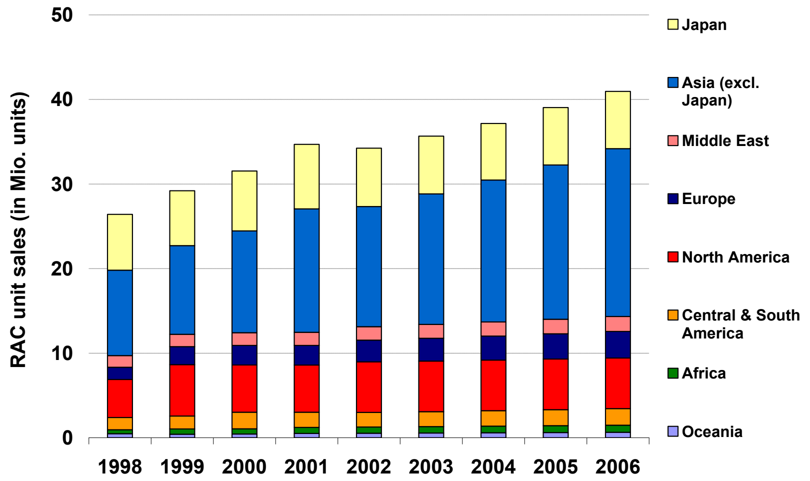


Figure 5: Annual sales of small room air conditioners (RAC units)
(source: F. Butera: The use of environmental energies for sustainable building in Mediterranean climates; Intelligent Building Middle East, Bahrain, December 2005)

Typical solar cooling applications today

Hotels: For this commercial sector, solar air-conditioning offers an interesting marketing opportunity as it makes their hotels more attractive to the rising share of environmentally-conscious tourists. Although the annual cost of a solar assisted air-conditioning system is higher than a conventional system, the resulting additional accommodation costs per guest and per night are expected to be low compared to the average accommodation cost. A further advantage is that existing, medium cooling capacity systems can be employed which are already on the market. Since the maximum required cooling demand is often seen in hotels in the afternoon and evening, appropriate measures in building construction and system design are necessary to optimise the solar system utilisation and to minimize the use of backup cooling systems (e.g., high thermal inertia of the building, night ventilation,..). A market potential is envisaged for southern Europe countries with hot and humid climate.

Private building sector: Private houses with solar thermal systems for combined domestic hot water production and heating support in transition periods (combisystems). The market share for these systems has been increasing in Central Europe in recent years. The systems consist of a comparatively large solar thermal collector system, and use either selective coated flat plate collectors or evacuated tube collectors. For example, for a four-person household a collector area between 10-25 m² is often recommended for combisystems, depending on the type of collector (in 2001, 150.000 m² of vacuum tube collectors were installed in Germany, corresponding to 17% of the total installed collector area). These installations uncover an interesting option to considerably increase the utilization of the large systems for solar air-conditioning in summer. Despite rising energy efficiency standards in the private building sector, rising comfort habits also cause an increasing interest in active cooling systems. A market niche for small solar cooling systems could be seen in the near future if:

the additional costs for cooling installation are low, e.g., reversible heat pumps for heating and cooling and no additional cooling backup;

small units of thermally driven air-conditioning units with sufficient low driving temperatures (e.g. adsorption heat pumps) are market-available.

Thus, the market potential would be limited more to central European countries with moderate climates, where cooling in summer is an additional comfort, but is not critical if the system does not work in case of low radiation availability. The utilization of the system is optimal through use for heating support, domestic hot water production and cooling. However, the market potential is not expected to be very large.

Wine cellars: This kind of building is well-adapted to solar cooling systems because wine storage offers a high thermal mass. Generally, the size of a solar cooling system is restricted by the load profile, which is strongly dependant on the climatic conditions and the building structure. However, in this case, the correlation between solar production and cooling load is respected. The marketing impact of the winery installation is very important: For example, the solar cooling system in Banyuls (France) has shown that the owners have benefited from numerous press and TV reports since 1991.

Factories: In Europe, more and more large companies have to respect environmental standards. Special environment departments are now present on company organisation charts and large budgets are available for high environmental quality systems. Solar cooling is highly seductive for company profiles. Most factories have offices for their administration and accounts department. As a first step these offices can become the principal target for solar cooling systems. In a second phase, the industrial process buildings and in particular the laboratories could be persuaded to use solar cooling. Of course, the solar fraction will not be very high in most cases, due to the large areas involved. But if the cooling load is significant throughout the year, the solar cooling system will be operational all the time. Another asset for such a configuration is that the projects can be built faster than in the case of conventional offices, or of public buildings that require public funds.

Office buildings: This type of building has been the most popular among the 60 solar cooling systems installed in Europe since the 80’s. In the demonstration project phase, public office buildings can benefit from high grants. The cooling load (with significant internal loads due to computers) corresponds quite well to the solar production, however planners have to be vigilant about an eventual holiday break during July or/and August, making the project economically uninteresting. In the future, this targeted group will remain a niche market for buildings where passive techniques are used in the architecture that means where the owner is engaged in an environment-friendly policy.

Barriers to growth

Technical barriers – Hardware

- Lack of units with small capacities (Long term: technical alternative to split units needed)
- Lack of package-solutions for residential and small commercial applications (domestic hot water, space heating, air conditioning)
- Only few available solar collectors for medium temperatures (100-250°C), which could to drive double- or even triple-effect chillers
- Low thermal efficiency (COP)
- Often: Need for wet cooling tower

Technical barriers – Software (e.g. planning guidelines, training)

- Very important: no skills today among professionals (planers, installers)
- Designs of hydraulic systems not yet standardised, lack of suitable planning guidelines and simple design tools for planners

Lack of awareness

- The technology is still emerging, but as solar cooling systems become more standardised, the lack of awareness - by consumers and professionals - will become a key barrier to growth

Costs

- Higher initial investment costs compared with conventional cooling systems
- To date, not cost efficient from a business point of view
- Often forgotten in today's financial incentive schemes for solar thermal

Recommendations

Solar cooling has the potential to curb the ever-increasing demand for conventional energies used for cooling purposes. Because of this, it contributes to lessening our dependence on imported fuels and to avoid CO_2 emissions. And by lowering electricity demand at times of peak loads, it increases the stability and costs of the electricity grids.

As solar cooling is still an emerging technology, it faces many growth barriers which are different from other heating and cooling technologies.

Because of these strong benefits, the market penetration of solar cooling should be supported by governments. The following recommendations will help governments focus on overcoming the barriers which are currently most problematic.

Specific RD&D

To date many of the growth barriers are still technological. Therefore, the availability of funding for specific R&D is a key condition for the fast market penetration of solar thermal cooling technologies

- Fundamental research:
  - Development of new cooling cycles and their assessment in comparison to existing technology. For this purpose advanced methodologies such as e.g. exergy analysis need to be developed and applied.
  - Development of systems with high temperature lift in order to remove the need for wet cooling towers
- Applied research and development:
  - Improvement of new components, such as small capacity systems, in order to allow broad market introduction.
  - For small systems: Development of concepts which lead to pre-engineered solutions that can be handled by an installer without particular planning effort.
  - For large systems to be applied in non-residential buildings (hotels, office buildings): Development of hydraulic concepts, design guidelines and proven operation and maintenance concepts.
  - Development of advanced modelling and simulation tools in order to support system planning and design.
- Large number of demonstration projects:
  - Essential to achieve a high standardization and proven guidelines
  - Also important to have good references and showcases.

Training and awareness raising

- Specific training courses for professionals (planners, installers)
- Inclusion of solar cooling technologies into standard education for engineers etc.
- Later: Broad awareness raising campaigns targeted at suitable decision-makers and industry multipliers (house builders, architects/installers, installers, electricity supply companies etc.).
- Requirement on EU member states to keep statistics on the energy demand for cooling purposes.

Financial incentives

- Inclusion of solar cooling into financial incentive schemes for solar thermal.

- Inclusion of solar cooling into White or Renewable Energy Certificate schemes.

Regulatory measures

- Inclusion in building regulations (based on the Energy Performance in Buildings Directive): Reduction of cooling loads through solar cooling and/or use of renewable energy for cooling.
- Discouragement or prohibition of refrigerants with high global warming potential (GWP), which are used in most conventional cooling machines.

Other policy measures

- Inclusion of cooling into RES-H targets at European and national level.

Solar Industrial Process Heat – State of the Art

Executive Summary

The major share of energy which is needed in industrial production processes is below 250°C – a temperature level, which could be well supplied by solar thermal technologies. The lower temperature level (< 80°C) can already be provided today with commercially available solar thermal collectors.

Most solar applications for industrial processes are on a relatively small scale and are mostly experimental in nature. There are currently about 85 solar thermal systems supplying heat for industrial processes. These plants have a total installed capacity of 27 MW_{th} (38,500 m²)[4].

Solar Heat for Industrial Processes (SHIP) is still in its infancy and yet, as discussed in the market potential section of this report, there is potentially an enormous range of Solar Thermal applications within this sector which can supply a large portion of our total energy demand.

Current SHIP applications are based on presently available technologies. RD&D is performed both on developing new components with a quality suitable for specific industrial applications, e.g. higher temperatures, and on refining configurations of products which are already available. As new developments become available, more SHIP applications will become viable.

Because solar industrial process heat is not yet widely available, it is important to understand its specific barriers to growth and consequently the best strategies to help overcome these barriers. The following short list will help policy-makers develop and implement suitable support policies for SHIP. A more detailed list can be found at the end of this document.

Barriers to growth

- Awareness: The number of solar thermal installations for industrial processes is very small, and most decision makers in relevant industries have never heard of, or even seen, a SHIP system. This is a key barrier to the broad adoption of SHIP.
- Confidence only in long-term proven technology: Most managers are very conservative when it comes to basic infrastructure needs. Especially when mission-critical heating processes are concerned, they will almost always choose conventional, long-term proven technology. Any potential day of delay or interruption seems more dangerous to them than reliance on unpredictable future prices of conventional fuels.
- System cost: Like most renewable energy technology, SHIP systems have typically higher investment costs, but save conventional energies throughout

operation. With current technology, financial payback times are often beyond commercial requirements.

- Lack of technology: Many industrial processes require higher temperatures than the typical solar thermal applications (domestic hot water, space heating, swimming pool heating). New designs, sometimes new materials, are needed to cater for these higher temperature demands.
- Lack of suitable planning guidelines and tools: So far, only few engineering offices and research institutes have experience with SHIP installations. Planning guidelines and tools for typical industrial use cases are still missing.
- Lack of education and training: Only few professionals have attended courses on SHIP. Without that knowledge, very few will offer SHIP solutions to their (potential) customers.

Recommendations

- Specific awareness raising campaigns targeted at decision makers in the industries most suitable for solar thermal process heat, e.g. food and textile industry.
- Large number of demonstration projects – to gain more experience, develop planning guidelines and to increase confidence in this emerging technology.
- Financial incentives to companies, which install solar thermal systems to drive their industrial processes.
- Funding of R&D into new technologies, which can improve the viability of SHIP installations, e.g. medium temperature collectors, improved heat transfer fluids.
- Training courses for professionals – to raise awareness and to overcome the current lack of expertise amongst professionals (planners, installers).

Introduction

The present document was produced within the framework of the Intelligent Energy-Europe project *Key Issues for Renewable Heat in Europe (K4RES-H)*[i]. The project looks at providing guidelines for best practice policies to support renewable heating and cooling (RES-H) technologies. Because most of the current support policies for RES-H focus on commercially available products, this document aims at highlighting one of the promising, upcoming applications for solar thermal: Solar Industrial Process Heat (SHIP)
If one compares the energy consumption of the industrial, transportation, household and service sectors, then one can see that the industrial sector has the biggest energy consumption in the OECD countries at approximately 30%. The major share of energy, which is needed in commercial and industrial companies for production, processes and for heating production halls, is below 250°C.

Components of solar thermal systems for industrial processes

The low temperature level (< 80°C) complies with the temperature level which can easily be reached with solar thermal collectors already on the market. However, for many industrial applications higher temperatures are needed. While pipes and pumps from conventional heating systems designed for this temperature range can be used, the solar thermal collectors must be specifically made to provide heat at temperatures above 80-100°C.

Solar thermal collectors for SHIP

Today, the most common collectors used are water-based flat plate collectors and evacuated tube collectors. They have undergone a great deal of development in the last few decades and are typically very efficient, using selective coated absorbers, and highly transmissive glass, sometimes in connection with anti-reflective coating. These collectors work very effectively up to 80°C and are frequently used in SHIP applications.

As discussed above, SHIP applications often require temperatures from 80°C to 250°C, which require medium temperature collectors, of which only few are available in the market today and which need optimising and developing further. Therefore, the International Energy Agency's Solar Heating and Cooling Programme (IEA-SHC) develops and tests three categories of medium temperature collectors as part of their Task 33:

- Improved flat plate collectors
- Concentrating flat plate and evacuated tube collectors
- Other – more highly – concentrating collectors

Improved flat plate collectors

To enable flat plate collectors to provide hot water at 80-120°C, various possibilities exist. Most importantly, the thermal losses of the collector must be reduced without losing too much optical efficiency. This can be achieved by, for example:

- multiple glazing with anti-reflective glass
- filling a hermetically sealed flat plate collector with a noble gas
- evacuating a hermetically sealed flat plate collector

Figure 1 shows the efficiency curves for single, double and triple-glazed collectors covered with newly developed anti-reflective glass.

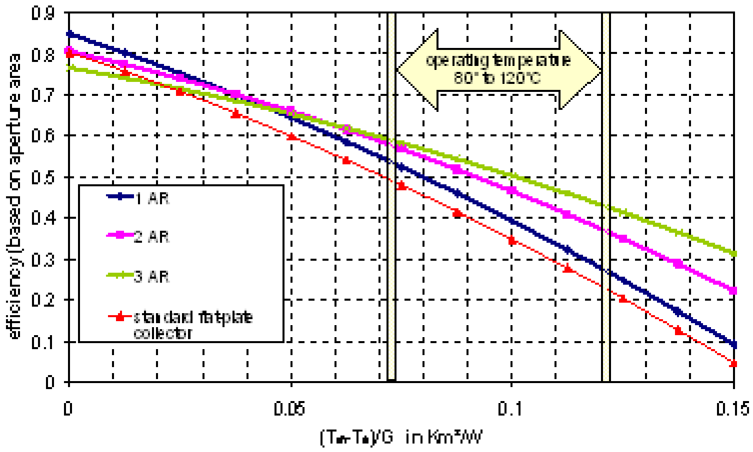


Figure 6: Comparison of the efficiency curves for a standard flat-plate collector (normal solar glass) and the curves for single, double and triple- anti-reflective (AR) glazed collectors (G=800 W/m²). Source: M. Rommel, Fraunhofer ISE.

Concentrating flat plate and evacuated tube collectors

Thermal losses of the collector can also be reduced by using concentrating technologies, which reduce the surface of the heated area. Compound Parabolic Collectors (CPC) are based on this principal. Their concentration factor is around 2 and no sun-tracking devices are required. Figure 2 shows the construction of a CPC, in which the absorber fins, which absorb on both surfaces, are mounted in the reflector troughs perpendicular to the aperture opening.

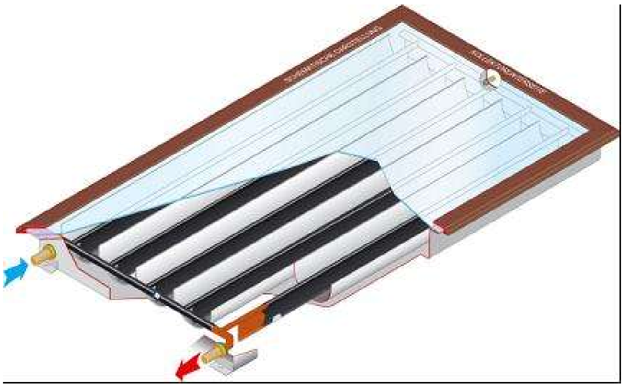


Figure 7: CP collector. Source: Solarfocus

Other – more highly – concentrating collectors

For temperatures of 150°C to 250°C, it is interesting to consider more highly concentrating collectors. These, however, can no longer be mounted in a fixed position but require at least one-axis tracking. Most of the new developments use parabolic mirrors to concentrate the sunlight onto the receiver; others use the Fresnel principle to achieve a similar effect. At present, at least seven concentrating collectors are in development. Success here will make new SHIP applications possible. Further information on these developments can be found in the brochure "Medium Temperature Collectors", available at www.iea-ship.org/3_1.html.

Figure 8: Testing of two PTC 1000 modular parabolic trough collectors at DLR in Germany.

Heat storage

In many cases, solar thermal can be used directly, in other cases a heat storage is required or advantageous. To date, most heat storages are water based and their capacity depends largely on the storage size and operating temperature. In order to expand the solar thermal usage, new storage concepts and technologies must be developed – not only for industrial processes. Where large water tanks are not feasible, either thermo-physical methods (e.g. using phase-changing materials) or thermo-physical processes could store large amounts of energy in the future.

The European Solar Thermal Technology Platform (ESTTP) has therefore identified advanced heat storage as one of the key R&D topics for the solar thermal sector. The aim is to store more thermal energy in smaller volumes and without (significant) losses. An improvement of the storage density by the factor 8 compared with water, would for example allow 100% solar heat supply of buildings without increasing today's storage volumes. The development of such technologies would also benefit other applications, such as SHIP.

Controllers

Due to the variety of industrial processes, standardised controllers for SHIP do not exist. While the hardware (sensors, controllers) is readily available, the configuration is the key challenge: The control strategy must be tailored to the concrete heat demand and system. This is where more experience – more demonstration projects – will help develop best practice guidelines and partially standardised solutions.

Market Potential

Industrial sector	Process	Temperature level [°C]
Food and beverages	drying washing pasteurising boiling sterilising heat treatment	30 - 90 40 – 80 80 – 110 95 – 105 140 – 150 40 – 60
Textile industry	washing bleaching dyeing	40 –80 60 – 100 100 – 160
Chemical industry	boiling distilling various chemical processes	95 – 105 110 – 300 120 - 180
All sectors	pre-heating of boiler feed water heating of production halls	30 – 100 30 – 80

Table 1: Industrial sectors and processes with the greatest potential for solar thermal uses

The most significant current SHIP application areas are in: the food and beverage industries, the textile and chemical industries and for simple cleaning processes, e.g. car washes. This is, above all, due to the low temperatures required for the processes in these sectors: 30°C to 90°C, allowing the use of commercially available flat plate or vacuum tube collectors which are very efficient in this temperature range. Solar heat is used not only to provide process heat but also to heat industrial buildings.

Table 1 also shows that, alongside the low temperature processes up to 80°C, there is also significant potential for processes in the medium temperature range up to around 250°C.

Industrial process heat is one of the least developed solar thermal applications so far. The potential is huge, but the variety of industrial applications makes it difficult to standardise solar thermal systems. Without suitable support measures solar thermal will only penetrate the industrial heat market slowly.

On the demand side, industry is a huge consumer of energy. In OECD countries, it accounts for 30% of energy consumption[ii]. In the EU, 2/3 of these 30% consists of heat rather than electrical energy[iii].

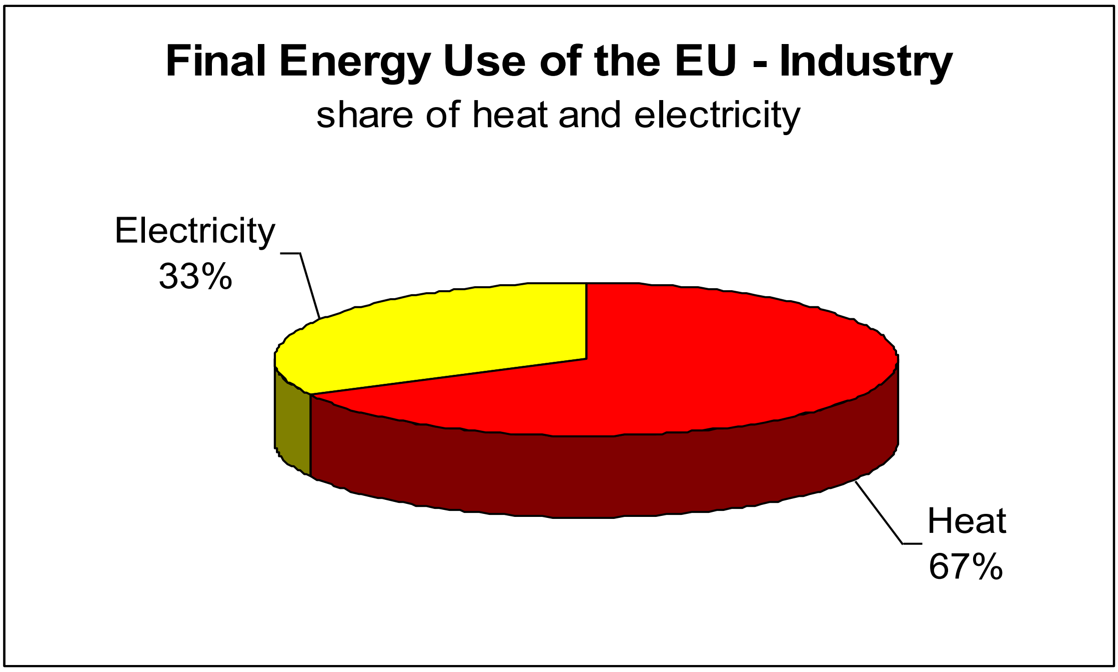


Figure 9: Final Energy Use of EU - Industry[iv]

Much of this industrial energy is in the form of heat below 250°C, a large proportion of which can be supplied by current or close-to-market solar thermal technologies. In 2000, the energy demand in the EU-15 for industrial process heat up to 250°C was estimated at about 300 TWh.

In the 1980s and 1990s several studies were carried out on the industrial heat demand at different temperature levels for various industrial countries[v]. Theses studies give a representative overview of the typical process heat demand up to 250°C. In spite of particular differences among these countries, some general conclusions were drawn out of the analysis:

- The studies confirm a general tendency: About 50% of the industrial heat demand is located at temperatures up to 250°C.
- The biggest heat demand is located in the paper and food industries. A considerable heat demand is also found in the textile and chemical industries.
- A very high percentage of heat demand in the medium and medium-high range is found in food, paper, textile and chemical industries.
- In the range from 100 to 200°C most of the process heat is used in food, textile and chemical industry for such diverse applications as drying, cooking, cleaning, extraction and many others.

Overview of selected demonstration projects

More than 85 existing plants in the industrial sector, with a total installed capacity of 27MW$_{th}$ and a collector area of 38.500 m^2 have been documented as part of Task 33/IV of the IEA-SHC Programmevi. The food industry had the largest number of solar thermal demonstration plants, followed by the chemical industry and transport *companies.*

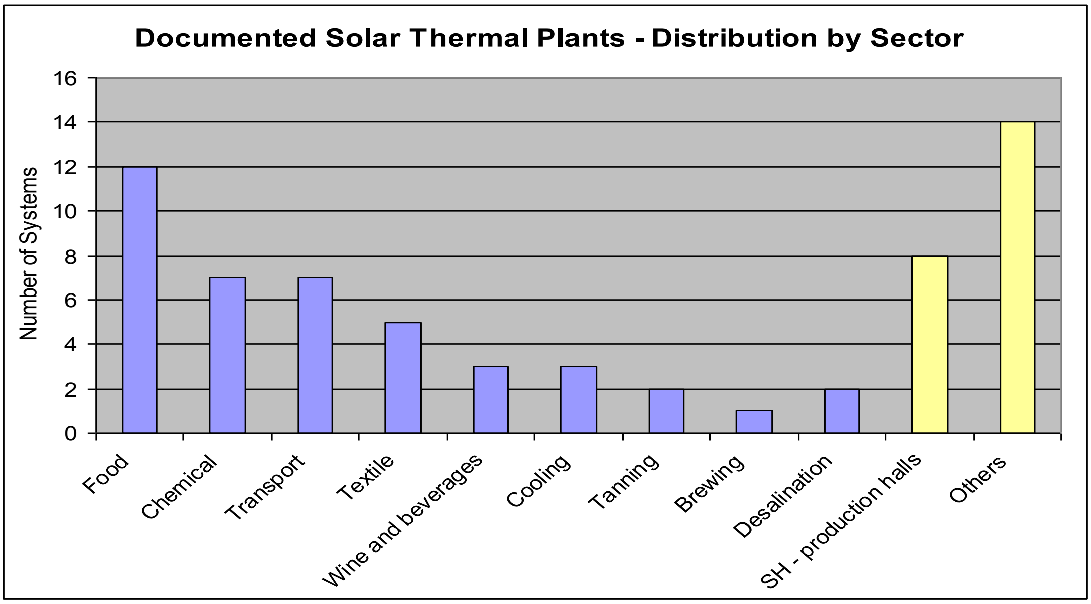


Figure 10: Distribution of the documented solar plants for process heat applications[vii]

Washing processes

Cleaning processes are a typical application in many industries, and for most of them hot water is needed at a temperature level between 40 to 90°C, which can be easily provided by today's flatplate or vacuum tube collectors. Because the two systems operate in a similar temperature range, the system design is quite similar to large-scale hot water systems for residential properties. Typical applications for solar thermal washing systems are feed water for bottle washing and washing processes in the textile industry and transport sector.

Example:
In Austria, a transport sector system was created for the Hammerer transport company. A 126 kW capacity system (180 m² collector array) was installed to produce hot water to clean transport containers for trucks as well as for space heating of the offices[viii].

Figure 11: Demonstration plant "Hammerer", Austria.

Drying processes

Removing moisture from a dissolved solids/liquid mixture, paper, spools of dyed thread, hanks of yarn, fresh cut lumber, and countless other industrial products can be achieved through various thermal methods (cans, ovens, rotary, flash, dehumidification & spray dryers), for which solar thermal energy can be used. One typical drying process is crop drying, which usually occurs between 30 and 80°C.

A typical air-based drying system using solar thermal energy – often combined with bioheat – is described below. Systems like this have been devised in several projects in the recent years[ix]. The intake air for the biomass boiler is heated in the solar collector array, made up of glazed or unglazed air collectors. Since the system concept is quite simple and there is no storage needed, the system cost for installed systems is around €100/m^2.

Systems of this type have been produced for coffee, tea, maize and tobacco drying.

Figure 12: Coffee drying, Coopeldos, Costa Rica. Installed capacity: 595 kW$_{th}$ (850 m² Solar Wall® collector)

Distilling and chemical processes

For industrial processes where temperatures between 120°C and 250°C are required, concentrating solar collectors, such as parabolic trough collectors have to be used. The heat carrier in these systems is either oil, pressurized water or steam.

Example:
In Egypt, just outside of Cairo, a solar thermal plant based on 1.900 m^2 of parabolic trough collectors provide 1,3 t/h of saturated steam for a pharmaceutical plant. The steam is produced by the reduction of the pressure of water in the collector loop via a flashing valve and is delivered to an existing saturated steam network operating at 7.5 bar.

Figure 13: El NASR Pharmaceutical Chemicals, Egypt. Installed capacity: 1,33 MW$_{th}$
Source: Fichtner Solar GmbH. Germany

Barriers to Growth of the SHIP Market

So far, the main markets for solar thermal technology have been domestic hot water, space heating and swimming pool heating. However, by comparison to these markets, solar thermal technology has hardly even begun to penetrate the potentially huge industrial heat energy market.

The main barriers to further market penetration of SHIP technologies are:

- Awareness: The number of solar thermal installations for industrial processes is very small, and most decision makers in relevant industries have never heard of or even seen a SHIP system. This is a key barrier to the broad adoption of SHIP.
- Confidence only in long-term proven technology: Most managers are very conservative when it comes to basic infrastructure needs. Especially when mission-critical heating processes are concerned, they will almost always choose conventional, long-term proven technology. Any potential day of delay or interruption seems more dangerous to them than reliance on unpredictable future prices of conventional fuels.
- System cost: As most renewable energy technology, SHIP systems have typically higher investment costs but save conventional energies throughout operation. With current technology, financial payback times are often beyond commercial requirements.
- Lack of technology: Many industrial processes require higher temperatures than the typical solar thermal applications (domestic hot water, space heating, swimming pool heating). New designs, sometimes new materials, are needed to cater for these higher temperature demands.
- Lack of suitable planning guidelines and tools: So far only few engineering offices and research institutes have experience with SHIP installations. Planning guidelines and tools for typical industrial use cases are still missing.
- Lack of education and training: Only few professionals have attended courses on SHIP. Without that knowledge, very few will offer SHIP solutions to their (potential) customers.

Recommendations

Solar heat for industrial processes has a great potential to curb demand for conventional energies and thus to lessen our dependence on imported fuels and to reduce CO_2 emissions.

Because of these strong benefits, the market penetration of solar industrial process heat should be supported by governments. The following recommendations will help governments focus on overcoming those barriers, which are currently most problematic.

- Specific awareness raising campaigns targeted at decision makers in the industries most suitable for solar thermal process heat, e.g. food and textile industry.
- Large number of demonstration projects – to gain more experience, develop planning guidelines and to increase confidence in this emerging technology.
- Financial incentives to companies which install solar thermal systems to drive their industrial processes.
- Funding of R&D into new technologies, which can improve the viability of SHIP installations, e.g. medium temperature collectors, improved heat transfer fluids.
- Training courses for professionals – to raise awareness and to overcome the current lack of expertise amongst professionals (planners, installers).

Quantifying the energy delivery of individual solar thermal installations

Quantifying the energy delivery of individual solar thermal installations

Overview of the state of the art heat measurement technologies for larger solar thermal systems

Introduction

Objectives

This report provides an overview of the state of the art of measuring heat delivery in larger solar systems, looking also at the costs and accuracy of the measuring systems.

The present document was produced within the framework of the Intelligent Energy-Europe project Key Issues for Renewable Heat in Europe (K4RES-H)[8]. The project looks at providing guidelines for best practice policies to support renewable heating and cooling (RES-H) technologies.

Definitions

K4RES-H addresses the total amount of produced renewable and useful heat. This definition comprises the following specifications:

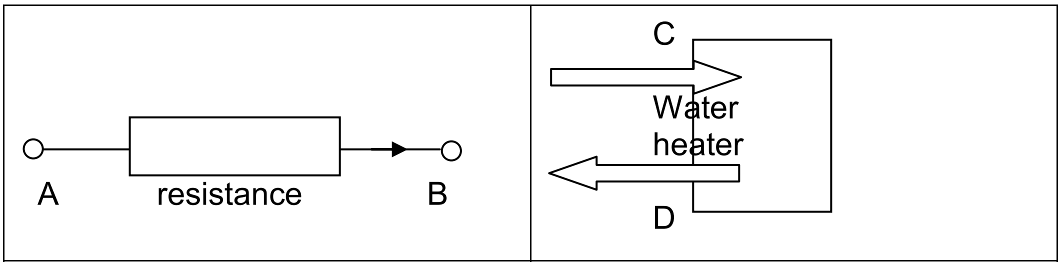
- The heat is measured directly after the conversion which means that all storage and transfer issues are neglected. Biomass is measured after the combustion, solar thermal after the collector and geothermal after the heat exchanger (direct system) or after the heat pump
- Auxiliary energy supply within the conversion process is only considered when being a considerable amount (suggestion for more than 5 %). It is expected that only Heat Pumps will find consideration as auxiliary systems.
- The energy used to produce and transport biomass shall not be considered

[8] The K4RES-H homepage can be found at: http://www.erec-renewables.org/projects/proj_K4_RES-H_homepage.htm

Basic Principles of Heat Measurement

Principle

The measurement of a flow of thermal energy is based on the measurement of two physical properties: flow rate and temperature difference. The analogy with the measurement of electrical energy is illustrated in the figures below.



Electrical energy measurement	Thermal energy measurement

Figure 14: Measurement of electricity and of heat

The electrical energy [Wh] consumed in the resistance is calculated from the potential difference [V] measured between point A and B, and the flow of electrons, current [A]. The equivalent to consumed thermal energy is calculated from the temperature difference between point C and D [degree C] and the flow of water [m^3/s].

The measurement of thermal energy is in principle similar to electrical energy, however due to the physical differences, like dimension of water pipes, complexity of installations it is in practice more difficult than electrical energy measurement. The accuracy of the measurements depends not only on the sensors and instruments used but also on the correct place where the sensors are positioned.

There are different types of parameters which have to be measured for calculating the quantity of heat produced:

- the flow rate F [m^3/s]
- the temperature:
  - the in temperature tin [K]
  - the out temperature tout [K]
- the time t [s]

Those parameters allow calculating the heat power P [kW]:

$$P = \rho * c_p * V * (t_{in} - t_{out})$$

With :

- ρ : the density [kg/m^{33}]
- c_p : the specific heat capacity [J/(kg*K)]

The density and the specific heat capacity depend on the type and temperature of the fluid used (and if the fluid is a gas also on the pressure). For example, if the water contents glycol in a certain percentage, it is necessary to adapt the cp. If the fluid is a gas and the pressure varies, it is also necessary to measure the pressure.

The following definitions are required:
Specific heat capacity: The quantity of energy needed to increase the temperature of one unit of mass by one degree. [GIECK, 1997]

With the power, it is possible to calculate the quantity of heat energy Q [kJ]:

$$Q = P * t$$

Main measurement parameters

Heat counters, from the smallest domestic appliances to the largest industrial equipment with far more than 10 MW ratings, consist of three basic components:

Flow meter (water is used almost exclusively as heat transfer medium)
Temperature sensors (to measure the temperature difference)
Processor (often also called integrator)

Technological specifications for all three components are given in the following.

Flow meters

Various principles to measure the flow rate exist. The most prominent flowmeters are:

- electromagnetic flowmeter (used for conductive liquid: e.g. water, water with glycol)
- ultrasonic flowmeter
- vortex flowmeter
- flowmeter with rotating impeller
- (coreolis mass flow meter - normally only for laboratory/calibration use – very expensive – not relevant for field measurements)

Principle of the electromagnetic flowmeter

Faraday's law of induction states that a conductor moving in a magnetic field induces an electrical voltage. With a magmeter, the flowing fluid is the moving conductor.
The constant-strength magnetic field is generated by two field coils, one on either side of the measuring tube. Two measuring electrodes on the inside wall of the tube are at right angles to the coils and detect the voltage induced by the fluid flowing through the magnetic field. The induced voltage is proportional to flow velocity and thus to volume flow.

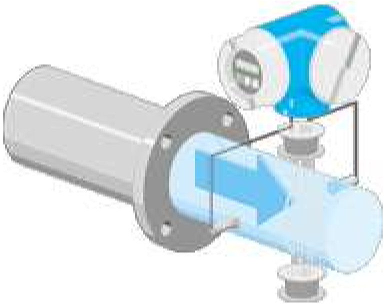


Figure 15: Electromagnetic flowmeter (source: www.endress.com)

The magnetic field is generated by a pulsed direct current with alternating polarity. This ensures a stable zero point, and makes the measurement insensitive to influences from multi-phase or inhomogeneous liquids or low conductivity.

Advantages of electromagnetic flowmeter

- The principle is virtually independent of pressure, density, temperature and viscosity
- Even fluids with entrained solids can be metered (e.g. ore slurry, cellulose pulp)
- Large nominal-diameter range available (DN 2...2000)
- Free pipe cross-section (CIP/SIP cleaning, piggable)
- No moving parts
- Minimum outlay for maintenance and upkeep
- No pressure losses
- Very high turndown, up to 1000:1
- High degree of measuring dependability and reproducibility, good long-term stability

Principle of the ultrasonic flowmeter

Swimming against the flow requires more power and more time than swimming with the flow. Ultrasonic flow measurement is based on this elementary transit time difference effect. Two sensors mounted on the pipe simultaneously send and receive ultrasonic pulses. At zero flow, both sensors receive the transmitted ultrasonic wave at the same time, i.e. without transit time delay. When the fluid is in motion, however, the waves of ultrasonic sound do not reach the two sensors at the same time. This measured "transit time difference" is directly proportional to the flow velocity and therefore to flow volume.

Advantages of ultrasonic flowmeter

- Non-contact measurement from outside. Ideal for measuring highly aggressive liquids or fluids under high pressure
- With homogeneous fluids, the principle is independent of pressure, temperature, conductivity and viscosity
- Usable for a wide range of nominal diameters (DN 15...4000)
- Direct meter installation on existing pipes. Retrofitting is also possible
- Commissioning without process interruption
- Non-invasive measurement
- No pipe constrictions, no pressure losses
- No moving parts. Minimum outlay for maintenance and upkeep
- High life expectancy (no abrasion or corrosion by the fluid)

Doppler ultrasonic flowmeters operate on the Doppler shift principal, whereby the transmitted frequency is altered linearly by being reflected from particles and bubbles in the fluid. The net result is a frequency shift between transmitter and receiver frequencies that can be directly related to the flow velocity. If the pipe internal diameter is known, the volumetric flow rate can be calculated. Doppler meters require a minimum amount of solid particles or air in the line to achieve measurements. Within the Time Meter Measurement Principle are made by sending bursts of signals through a pipe. The measurement of flow is based on the principle that sound waves travelling in the direction of flow of the fluid require less time than when travelling in the opposite direction. At zero velocity, the transit time or delta T is zero. If we know the diameter of the pipe, the pipe wall thickness and the pipe wall material the angle of refraction can be calculated automatically and we will know how far apart to space our transducers. The difference in transit times of the ultrasonic signals is an indication for the flow rate of the fluid. Since ultrasonic signals can also penetrate solid materials, the transducers can be mounted onto the outside of the pipe. Fast

Digital Signal Processors and signal analysis guarantee reliable measuring results even under difficult conditions where previously ultrasonic flowmeters have failed.

Thermal Mass Flow Meters are based on an operational principle that states that the rate of heat absorbed by a flow stream is directly proportional to its mass flow. As molecules of a moving gas/liquid come into contact with a heat source, they absorb heat and thereby cool the source. At increased flow rates, more molecules come into contact with the heat source, absorbing even more heat. The amount of heat dissipated from the heat source in this manner is proportional to the number of molecules of a particular gas/liquid (its mass), the thermal characteristics of the gas/liquid, and its flow characteristics.

Principle of vortex flowmeter

This measuring principle is based on the fact that vortices are formed downstream of an obstacle in a fluid flow, e.g. behind a bridge pillar. This phenomenon is commonly known as the Kármán vortex street. When the fluid flows past a bluff body in the measuring tube, vortices are alternately formed on each side of this body. The frequency of vortex shedding down each side of the bluff body is directly proportional to mean flow velocity and therefore to volume flow. As they shed in the downstream flow, each of the alternating vortices creates a local low pressure area in the measuring tube. This is detected by a capacitive sensor and fed to the electronic processor as a primary, digitized, linear signal.

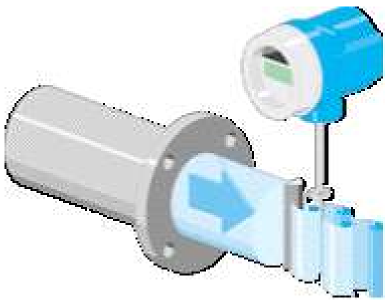


Figure 16: Vortex flowmeter (source: www.endress.com)

The measuring signal is not subject to drift. Consequently, vortex meters can operate an entire life long without recalibration.

Capacitive sensors with integrated temperature measurement can directly register the mass flow of saturated steam as well, for example.

Advantages of vortex flowmeter

- Universally suitable for measuring liquids, gases and steam
- Largely unaffected by changes in pressure, temperature and viscosity

- High long-term stability (lifetime K factor), no zero-point drift
- No moving parts
- Marginal pressure loss
- Easy to install and commission
- Large turndown of typically 10:1 to 30:1 for gas/steam or 40:1 for liquids
- Large temperature range from -200...+400 °C

Flowmeter with rotating impeller

This measuring instrument determines the flow with the rotation velocity of the impeller. After flow of a specific volume, the flowmeter sends an impulse to the calorimeter.

Figure 17: Flowmeter with irradiation impeller (source: www.resol.de)

Temperature sensors

Sensors and instruments are available on the market that perform the same measurement but vary significantly in accuracy and precision. To measure temperatures in a flow of water, usually thermocouples or platinum resistance (PT-) sensors are used. Thermocouple sensors are available for different temperature ranges each with its own accuracy. A PT100 temperature sensor can have a higher precision than a thermocouple. Note that the quality of the instruments and sensors are not related to the measurement itself. A PT100 temperature sensor can be measured in different ways (2-, 3- or 4-wires) with different accuracies.

2 types of temperature sensor can be used in this application:

- the resistance temperature detector
- the thermocouple thermometer

Resistance temperature detector

A Resistance Temperature Detector (RTD) is a temperature responsive device based on a predictable resistance change in the sensing element. The EN 60751 standard

specifies requirements for industrial Platinum resistance sensors and covers the PT 100 thermometers.
The PT 100 sensing element has a resistance of 100 Ω at 0°C.
According to EN standard and most common industrial applications, the PT 100 type sensors are used for temperature measurement and control in the range from -50°C to 400°C or -200°C to 600°C.

Advantages of RTDs:

- high accuracy
- excellent long-term stability
- high signal output level which allows transmission over long distances without ancillary equipment.

Basic construction of Platinum resistance elements cannot be used directly in contact with process environments, hence the complete thermometers are built as assemblies which can withstand light, medium and heavy duty industrial conditions.
In general, the sensor assembly includes three components:

- the resistance thermometer inset
- the protecting tube (thermowell)
- the terminal housing.

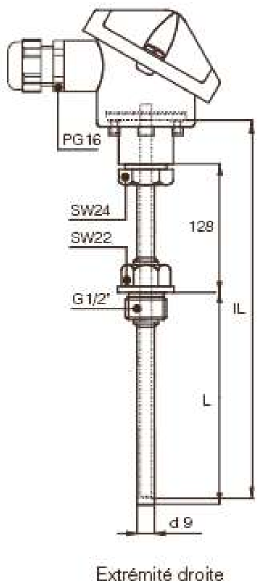


Figure 18: Resistance temperature detector RTD PT 100

Thermocouple thermometer

A thermocouple (TC) consists of two wires of different conductive material, connected each other by means of two junctions forming an electrical circuit. If one junction is at temperature T1 and the other at T2, then an electromotive force is generated in the circuit, and it depends on the materials and temperatures T1 and T2 (Seebeck effect). In an industrial TC thermometer one junction is the measuring joint, and the other is a reference one which is usually located in correspondence of the conversion electronics (transmitter).

According to EN/ANSI standards and most common industrial applications, the thermocouple sensors are used for temperature measurement and control in the range from -40°C to 1800°C.

Advantages of thermocouples

- Good accuracy
- excellent response time
- wide measuring range.

Basic construction of thermocouple sensing elements cannot be used directly in contact with process environments, hence the complete thermometers are built as assemblies which can withstand light, medium and heavy duty industrial conditions.
In general, the sensor assembly includes three components:

- the thermocouple inset
- the protecting tube (thermowell)
- the terminal housing

Calculator

With the flow rate and temperature sensors, the parameters are measured. It is now necessary to calculate the thermal power and the thermal energy with a calculator/processor, using (temperature dependent) values of density and specific heat capacity of the circulating fluid.

Accuracy of Heat Measurement Systems

Introduction into accuracy requirements

In the accuracy of Heat Measurement Systems the technical accuracy and non-technical mistakes are to be differentiated.

Technical accuracy (measurement system related)

In principle one may recognize three main sources for errors related to reported results. These errors are identified by the origin of it in the overall process to assess reporting data from physical observations.

The three main sources of errors are due to:
1. The instruments and sensors applied for the measurements
2. The measurement of physical parameters itself
3. The numerical analysis of obtained results to assess a desired parameter

The assessment of the technical accuracy of heat measurement systems can be based on the settings of the EU Directive 2004/22/EC on measuring instruments. This Directive defines the following accuracy classes:

Class	$E = E_f + E_t + E_c$ total Error of **heat meter**	E_{min}
1		~ 2%
2		~3%
3		~4%

Example: class 2 instruments are allowed to show a total error of 3%.

Recommendations for accuracy in solar thermal systems:

Systems with more than 1.000 m^2 collector area:	2% (Class 1)
Systems with more than 500 m^2 collector area:	3% (Class 2)
Systems with more than 100 m^2 collector area:	4% (Class 3)
Systems with more than 50 m^2 collector area:	5%
Systems with more than 10 m^2 collector area:	10%

Non technical accuracy and errors

Errors due to installation, dimensioning of the application or operating conditions are often more problematic than the errors on the hard-/software side of the measurement system.
Example: for solar thermal the varying density of the glycol in the collector circuit has a significant effect on the energy measured.

Accuracy of heat measurement in solar thermal

For solar thermal the non-technical issues are most determined for the measurement accuracy, as they are often more problematic than the errors on the hardware side. These items should be discussed in the fields of:

- Installation
- Dimensioning
- Operation conditions

Attention is here drawn to one specific operating condition: The fluid circulating in the solar collector loop. To protect against freezing solar thermal systems often use anti-freeze fluid; typically based on a mixture of water and propylene glycol. Using normal heat meters for water in a solar loop with a typical glycol mixture of 30-40% will lead to an over-estimation of the delivered energy of approx. 5%.

Simple correction can be made using a constant correction factor to be multiplied to the value determined by the “water” heat meter. The factor depends on the propylene glycol mixture-%:

Glycol mixture %	*Correction factor*
10	*1.00*
20	*0.99*
30	*0.97*
40	*0.94*
50	*0.91*

Some uncertainty is introduced using this simple correction as the anti-freeze fluid is seldom pure propylene glycol – and the fluid data is depending on the temperature level; but normally this correction will be true within ± 2%.

The calculator/processor converting flow rate and temperature into thermal power and energy should use correct temperature dependent data for the actual fluid when high accuracy is required (very large systems).

System costs

The costs of one specific system can be very different (calculation tax excluded). Based on concrete configurations of different existing products, the following example calculations were produced:

Measuring systems based on a **flowmeter with impeller**:

- 1 flowmeter with impeller (DN 20: 147 € - DN 32 : 315 €)
- 2 resistance temperature detector PT1000 (14 € * 2 = 38 €)
- 1 calculator (136 €)
- Total costs: 320 – 490 €

Measuring systems based on an **ultrasonic flowmeter** (verified to accuracy classes: 2-3):

- 1 ultrasonic flowmeter (DN 20 - DN 50)
- 2 resistance temperature detector PT500
- 1 calculator (based on water data)
- Total costs: 450 – 1090 €

Measuring systems based on an **ultrasonic flowmeter**:

- 1 electromagnetic flowmeter (DN 50: 1 711 € - DN 200: 3 062 €)
- 2 resistance temperature detector PT100 (2*237 €)
- 1 calculator (726 €)
- Total costs: 2910 – 4260 €

The first two systems would be typically used in practical field applications, whereas the third one is targeted at industrial and scientific applications.

Investment for heat meters
Examples of costs of heat meters are given above; installation costs can be estimated to 0,5-1 hour: approx.: 50 €; extra price for a calculator programmed to water/glycol depends very much on the size of the market (80 € corresponding to a substantial market is included in the Figure 19).

It is immediately seen that adding a heat meter to a small thermo siphon solar system with a cost of approx. 1000 € will increase the price more than 33%.

For pumped systems the costs for the heat meter is compared with the costs of the solar system in Figure 19. The figure is based on prices of Kamstrup and Resol heat meters and the system price is estimated using the rather rough price equation:

Costs/collector area = 800 € - 80 € * ln(Collector area) (ex. VAT)

From Figure 19 it is seen that for small systems the heat meter adds significantly to the solar system costs, but for larger systems >70 kW (100 m²) the relative costs of a heat meter is below 2% of the solar system costs.
Adding investment costs (approx. 150 €) for remote reading service (M-bus and modem / radio) has significant influence only on the investment cost ratio for small systems.

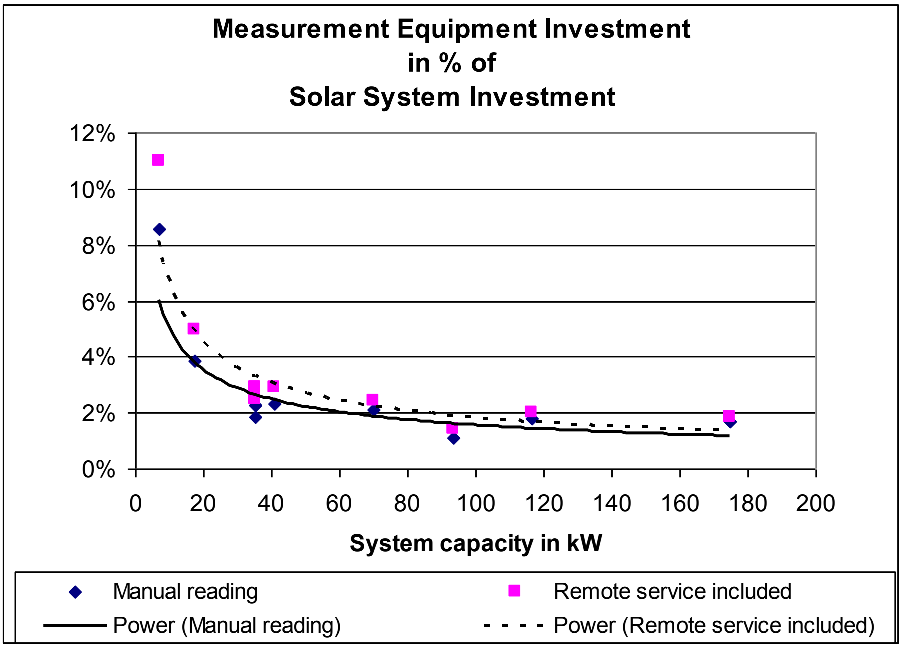


Figure 19: Heat meter investment costs (with and without remote reading service) compared to solar system costs

Operating costs
Simple/manual operation: The heat meter should be read and recorded at least once a year (negligible costs in comparison with larger solar thermal systems)
Remote monitoring/reading: Depends very much on number of systems and degree of details wanted: 5-50 € per year and per meter.
For initial verified meters the accuracy is normally defined for a period of time. To keep this guaranteed accuracy calibration is necessary every 3-6 years, each time approx. 100 € + de- and re-installation

System life expectation

Estimated expected technical life time is approx.10-15 years, depending on the actual measurement principle and system used. Calibration should be done according to recommendations from the manufacturer of the heat meter

Cost benefit ratio

Small systems below 50-100 m^2 are seldom metered due to the relative high cost of metering for small systems.

References

Scientific sources and papers

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GIECK K. + R. (1997) Formulaire technique. Gieck Verlag, D-82110 Germering

Product specific resources

RESOL Elektronische Regelungen Gmbh (www.resol.com, April 2006)

Endress+Hauser (www.endress.com, April 2006)

Objective methodology for simple calculation of the energy delivery of (small) Solar Thermal systems

The present document proposes a simple calculation methodology to determine the energy yield of small solar thermal systems. Such a methodology could then be used, e.g. by public authorities to base financial incentives on the expected solar thermal energy production rather than on more generic parameters like the collector area.

For small solar thermal systems both, the actual heat metering and the individual simulation of energy production would be prohibitively expensive. Therefore, this document proposes a simple method, which is based on a few selected parameters and the assumption of a constant mean temperature in the collector.

NB: At the time of writing, it is expected, that this calculation methodology will be introduced in the next version of the European Standard for solar thermal collectors, EN 12975.

Solar collectors are described by their efficiency parameters:

- Zero-loss efficiency: n_0
- 1st order heat loss coefficient: a_1
- 2nd order heat loss coefficient: a_2

Using these parameters, the **collector efficiency** can be expressed as:

$$n = n_0 - a_1*(T_m-T_a)/G - a_2*(T_m-T_a)^2/G \quad (1)$$

and hence the **power**:

$$P = A*(n_0*G - a_1*(T_m-T_a) - a_2*(T_m-T_a)^2) \quad (2)$$

where:

G = solar irradiation W/m²
T_a = ambient air temperature
T_m = collector mean temperature
A = collector area (corresponding to the efficiency parameters)

Known parameters
To calculate the annual output, the values of G, T_a and T_m have to be known at all times.

G and T_a are weather data defined by the location; their values are (at least in principle) known for most European places.

Assumption on T_m

T_m is normally not known. Its value depends not only on the weather, but also on the load and the design and the components of the system (collector area and efficiency parameter, storage capacity, heat losses, control, ...), i.e. on the actual system and the actual operation conditions at a given point in time.

But if T_m is assumed constant all the time the case is very simple: When the collector and the location is known/specified the power output is determined at every point in time by eq. (2) below using always the same value of T_m.

The difficult task is now reduced to estimating a typical operation temperature depending on the application: At which temperature delivers the collector typically most energy to the system. Some suggestions for such temperatures are given in table 1.

Resulting annual energy output

Assuming a constant collector temperature, the annual energy output is calculated by integrating eq. (2) over a year including all positive contributions (as it is assumed that the collector loop is never operating when the contribution is negative).

$$Q_{annual} = \int [A*(n_0*G - a_1*(T_{m,constant}-T_a) - a_2*(T_{m,constant}-T_a)^2)]^+ \, dt$$

In practise it is now easy to calculate the annual output per m^2 of a given collector operating at a typical mean temperature using e.g. hourly weather data and the collector efficiency parameters.

To use this simple model to estimate real collector/system output and system savings it is needed to:

- define typical/representative collector mean operating temperatures in typical applications (see table 1 for suggestions)
- convert collector annual output to system output
- convert system output to system savings

Due to big difference from country to country (definitions/conversions depend on national traditions for hot water and heating system, solar system type and back-up system type), this should be left to decision on national or even local level – but some recommendations/suggestions are given in table 1 below.

Application	Recommended T_m [°C] for	$F_{col-sys}$	$F_{sys-sav}$	$F_{col-sav} = F_{col-sys} * F_{sys-sav}$

	calculating annual collector output	Factor for converting collector output to system output	Factor for converting system output to system savings	Resulting factor for converting collector output to system savings
Swimming pools	30	0,76	1,31	1,00
Domestic hot water DHW* Boiler Back-up	50	0,86	1,38	1,19
Domestic hot water DHW* Eletricity Back-up	50	0,86	1,00	0,86
Combi systems HW/SH	60	0,77	1,31	1,01
District heating without seasonal storage	Average return temperature from district heating network + 5	0,95	1,05	1,00
Cooling / AC	90	0,90	1,11	1,00
Process heat	Process temperature + 10	0,90	1,11	1,00

Table 1. Recommendations for typical T_m's and factors for converting annual collector output to system output and to annual energy savings using the factors $F_{col\text{-}sys}$, $F_{sys\text{-}sav}$ and $F_{col\text{-}sav}$. See table 2 below for the data used to make the numbers in table 1.
*) Fig.1 in the end of this section indicates that using 50°C as constant temperature for DMW systems is valid for even very different climates.

The factors $F_{col\text{-}sys}$, $F_{sys\text{-}sav}$ *and* $F_{col\text{-}sav}$ are defined by the following equations:
{System Output} _______ = $F_{col\text{-}sys}$ * {Collector Output}
{System Savings} ______ = $F_{sys\text{-}sav}$ * {System Output}
{System Savings} ______ = $F_{col\text{-}sav}$ * {Collector Output}
$F_{col\text{-}sav} = F_{col\text{-}sys} * F_{sys\text{-}sav}$
$F_{col\text{-}sys}$ takes into account losses in the solar system:
$F_{col\text{-}sys}$ = {Collector Output} – {Pipe Losses} – {Extra Tank Losses})/{Collector Output}

{Extra tank Losses} are extra heat losses due to higher temperatures in summer (and bigger volume) in a solar tank (compared with non-solar tank).

$F_{sys\text{-}sav}$ takes into account losses in the back-up system:
$F_{sys\text{-}sav}$ = ({System Output}/η_{boiler} + {Saved Stand-by Losses}/ η_{boiler}) / {System Output}
η_{boiler} = {Boiler Efficiency}

{Saved Stand-by Losses} can be obtained if the boiler is off during summer.
If the back-up system is electricity, η_{boiler} = 1, and {Saved Stand-by Losses} = 0, hence:
$F_{sys\text{-}sav}$ = 1 in case of electrical back-up

The data used for calculating the values in table 1 are given in table 2.

Application	Pipe Losses in % of Collector Output	Extra Tank Losses in % of Collector Output	Boiler Efficiency in %	Boiler Stand-by Losses in % of Collector Output
Swimming pools	5%	20%**	85%	10%
Domestic hot water DHW Boiler Back-up	10%	5%	85%	15%
Domestic hot water DHW Electricity Back-up	10%	5%	100%	0%
Combi systems HW/SH	10%	15%	85%	10%
District heating without seasonal storage	5%	0%	95%	0%
Cooling / AC	5%	5%	90%	0%
Process heat	5%	5%	90%	0%

Table 2. Data used for calculating the values in table 1.
**) The pool is here acting as “tank” for the solar system – the 20% tank losses indicate that in very sunny and warm periods the pool is heated above the necessary temperature level.

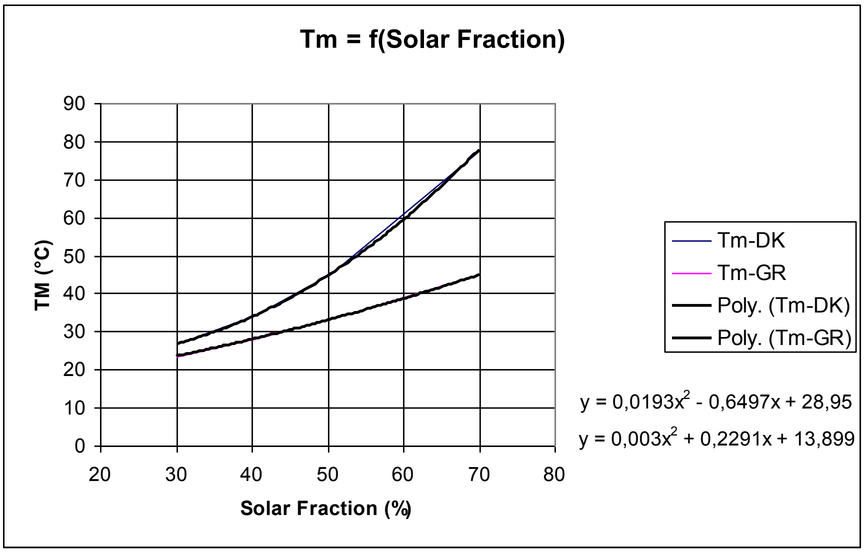

Figure 1. T_m can for each climate be correlated to the solar fraction of a typical DHW system by finding the solar fraction at which the solar input equals the collector output at T_m (°C). The figure shows this function for a typical DHW system in Greece and Denmark. The solar fraction is here defined as the fraction of solar input to the tank to the total input to the tank:

Solar fraction = Solar input / (Solar input + Supplementary input).

It is seen that T_m = 50 °C corresponds to a solar fraction in DK of 53% and in Greece of 75%, which actually correspond to typical solar fractions in the two counties.

Verifiable targets for solar thermal

Verifiable targets for solar thermal

Solar thermal statistics in Europe

Introduction

The present document was produced within the framework of the Intelligent Energy-Europe project Key Issues for Renewable Heat in Europe (K4RES-H)[9]. The project looks at providing guidelines for best practice policies to support renewable heating and cooling (RES-H) technologies.

In order to evaluate the success of such support policies, it is important to monitor the development of RES-H markets: Have the policies contributed to increasing the uptake of solar thermal, bioheat and geothermal technologies? This document describes the current state of solar thermal statistics, and proposes concrete steps to improve their accuracy and comparability.

[9] The K4RES-H homepage can be found at: http://www.erec-renewables.org/projects/proj_K4_RES-H_homepage.htm

Collection, evaluation and compilation of available statistics

Overview and description of available statistics and information sources

The solar thermal statistics in Europe stem from very different sources, use different definitions of solar thermal and are generally of varying quality in terms of (assumed) accuracy.

Even the data available at European level (e.g. Eurostat, Eur'Observer, ESTIF, IEA-SHC) show considerable variations, often due to different methodologies used.

Raw data

Until today, the raw data collected did not refer to the energy produced by solar thermal technologies, but typically to the solar thermal collector area.
Differences in the raw data most often stem from the use of different sources (i.e. from different persons/organisations collecting and aggregating the data) and their different methodologies.
The most typical reasons for differences are: In- or exclusion of unglazed collectors, and survey-based data collection vs. expert based data.

Different definitions used

Most obviously, solar thermal statistics depend very much on the definitions used: While some solar thermal statistics include all active solar thermal technologies (glazed and unglazed collectors) others only show data for glazed collectors. Unfortunately, some statistics do not immediately state what the data refers to. And although glazed collectors make up the largest part of the market in Europe, there is a considerable market for unglazed collectors, which are typically used to heat the water of swimming pools.

There is a particularity, which leads to the IEA's massive understatement of solar thermal energy in their publication *Energy Statistics of OECD Countries. 2002-2003*: In these statistics, the IEA only show solar thermal energy, which was used in the "Transformation Sector". This means that only part of the solar thermal energy was counted, that was fed into a (district) heating grid. This excludes 99,8% of the solar thermal energy production, which takes place locally – without feeding into a grid. As it is the only place where solar thermal energy is shown in that publication, it gives the impression, that this energy source is absolutely negligible. Other IEA publications, namely the annual *Renewables Information* show a more complete picture of the market.

Different collection of data

In several countries, the "official" data (i.e. those published by national statistics offices, energy agencies, ministries etc.) are based on surveys of solar thermal companies active in that country (manufacturers or importers). These surveys are

carried out by solar thermal associations or governmental agencies. The accuracy of this data depends on the coverage of the market – e.g. have all relevant companies been identified? have all of them answered the survey? – and the truthfulness with which the survey was answered. For different reasons, companies may have a reason to under- or overstate their own sales figures, especially where the raw data could become public.
Other statistics are based on the estimations of one or several market experts. The accuracy of those statistics then depends on the good knowledge and honest estimation of the expert.

Different assumptions on the base of installed systems

A typical source for deviations between different statistics for the same country is due to a different concept of cumulative installed capacity vs. capacity in operation.

Cumulative installed capacity

Those statistics which are based on the first concept typically add all solar thermal capacity (either expressed in square metres of collector area or in kW_{th} of installed capacity) installed in the past. The market data for the latest year (newly installed capacities) is added to the total cumulative capacity. This, however, does not take into account that any heating system – including solar thermal systems – is replaced at some point in time. Thus the concept of cumulated capacities overstates the really existing capacities.

Capacity in operation

This is where the second concept, based on capacities in operation, provides a more realistic picture. It is based on an assumed life expectancy of the solar thermal systems or on (regular) surveys of heating systems in buildings. So far, only the assumed life expectancy has been used in solar thermal statistics: In our 2003 study Sun in Action II – A Solar Thermal Strategy for Europe, ESTIF introduced this concept by assuming a life expectancy of 20 years for solar thermal systems installed since 1990 and of 15 years for older systems. While typical solar thermal systems today could work for much longer than 20 years, it is safe to assume that even a share of the working systems are replaced or decommissioned at some point, e.g. because the building they were built into was torn down, because the use of the building changed, making the solar thermal system superfluous, or because the roof was refurbished without putting the existing solar thermal collectors back in place. Based on the ESTIF assumptions, systems installed before 1990 are not “in operation” anymore.

As in most European countries, as most of the installations took place after 1990, this assumption does not make a big difference in the final data today. However, in a few countries such as Greece or Cyprus, many solar thermal systems were already installed in the 1980s. In ESTIF’s statistics these installations are not included anymore, while others still count them in. For example: For Cyprus, the data of IEA-SHC are based on the cumulative capacity, showing 514 MW_{th} of installed capacity. ESTIF on the other hand shows a capacity in operation of 315 MW_{th}.

Aggregation and conversion of raw data

The existing statistics show a different degree of detail. While some of them explicitly show installed capacities of flat plate collectors, vacuum tubes or unglazed collectors, others show only aggregated and/or converted data. E.g. Eurostat does not directly publish solar thermal energy production. Instead the publication *Energy: Yearly Statistics* gives the primary solar energy production. The solar thermal energy production must then be inferred by subtracting the given electricity production of photovoltaic modules.
Aggregations and conversions of data sometimes make it difficult to understand the cause of differences between different statistics.

Conversion from m^2 to kW_{th}

The conversion factor from square metres of collector area into kW_{th} of solar thermal capacity has been generally accepted to be 0,7 kW_{th}/m^2 (for details see the information at www.iea-shc.org or www.estif.org) This number gives the installed nominal capacity (similar to the peak capacity of photovoltaic modules). In many statistics, the nominal capacity more and more replaces the old collector area. Even the IEA has announced that kW_{th} as the unit for solar thermal statistics should be used from 2007 onward.

Conversion from m^2 to kWh

Several energy statistics report the energy production from solar or solar thermal. However, since a generally accepted conversion methodology does not exist yet, each statistic and country often uses a different methodology.

Differences stem from different definitions as well as from different assumptions. The definitions for solar thermal energy range from the solar thermal irradiation meeting the collector surface (primary energy used) to the (conventional) energy saved by solar thermal. Eurostat and IEA use the concept of collector output, i.e. the energy that is available after the conversion of the sunlight in the collector. But even that assumption can be interpreted differently: Some statistics use the output as calculated based on the collector performance in the European norm EN 12975. Others calculate the energy production of the collector as if it was built into an existing system (with parameters different from the test procedures).

A calculation of the Eurostat data shows that the annual energy production of one square metre of collector area was assumed to be 451 kWh/(m^2*a) in Germany but only 357 kWh/(m^2*a) in Austria, although both countries use very similar technologies and applications. In Belgium this factor would be as high as 1600 kWh/(m^2*a), which is physically impossible.

Conclusions

The biggest differences between different statistics are due to two reasons:

- Different raw data (due to different collection or methodology/definitions)
- Different aggregation and conversion methodologies

The existing statistics approach solar thermal in different ways, sometimes with very different results. In many cases this is not a question of high or bad quality of the data, but rather a question of definitions and methodologies used. Differences between statistics for the same country thus do not mean that one is right and one is wrong. Rather they show different views of solar thermal energy production.

This poses a problem when comparing different statistics/countries: 100 GWh of solar thermal energy may have different meanings in statistic X and statistic Y.

It is desirable that (solar thermal) energy statistics are harmonised at least in their definitions and methodologies. This would help make different statistics comparable, which again would help in setting European solar thermal targets broken down by country.

Recommendations to improve the quality of solar thermal statistics in Europe

There are several ways in which solar thermal statistics should be improved:

Improvement of the data quality

- (1) Improvement of data collection
- (2) Non-inclusion of old systems, which can be assumed not to be in operation anymore

Furthermore, it would be highly desirable to come to a more harmonised approach when aggregating and converting the raw data. This is not so much a recommendation for improvement of the individual statistics but for making different statistics more comparable.

Improvement of comparability of statistics

- (3) Inclusion of all active solar thermal systems
- (4) Unified definition of solar thermal energy production
- (5) Unified conversion methodology (from m^2 or kW_{th} into kWh)

(1) Improvement of data collection
Whilst no national register of solar thermal systems exists (“what is where installed and in operation?”), data collection should be based on:

- Surveys of solar thermal manufacturers/importers, which are done in co-operation with the relevant national trade association and which keep the individual data confidential
- Data obtained from financial support schemes at national level, if they are generally believed to cover most of the solar thermal market (i.e. only few installations are done, which do not receive these financial incentives)
- Ideally, the two methods are used together in order to cross-check the data and to fill potential information gaps

(2) Non-inclusion of old systems, which can be assumed not to be in operation anymore

Statistics which do not foresee that old systems are decommissioned at some point in time will show less and less realistic figures.
ESTIF strongly recommends using a uniform assumption on the usage time of solar thermal systems: Due to various reasons, solar thermal systems are decommissioned after 20 years (15 years for systems that were installed before 1990). This means that systems installed before 1990 are not included in today's data of solar thermal systems in operation.

(3) Inclusion of all active solar thermal systems
For many reasons, ESTIF and others have only included in their statistics systems which are water-based and use glazed collectors. Although these systems make up the large majority of the market and systems in operation, it is desirable to include all active solar thermal systems. This would include systems which use unglazed collectors (typically for swimming pool heating) or air collectors.

(4) Unified definition of solar thermal energy production
Energy statistics are gaining importance at national and international level. In order to facilitate the comparability of different (country's) statistics, it is important that the growing use of solar thermal technologies is represented based on comparable definitions.
ESTIF recommends that for statistical purposes solar thermal energy should be defined as the energy output of the collector under conditions of a real (reference) system.

(5) Unified conversion methodology (from m^2 or kW_{th} into kWh)

The approach mentioned in (4) allows for a formula, which is both reasonable (science-based) and simple. Different countries/regions could use different factors to accommodate for different climatic conditions and reference systems. ESTIF is currently in the final phase of agreement with IEA-SHC and other experts on such a unified methodology.

Setting verifiable targets for Solar Thermal

Introduction

The present document was produced by ESTIF (www.estif.org) within the framework of the Intelligent Energy-Europe project Key Issues for Renewable Heat in Europe (K4RES-H)[10]. The project looks at providing guidelines for best practice policies to support renewable heating and cooling (RES-H) technologies.

Targets and target-setting have become a powerful tool in policy-making. From municipal targets to reduce local particulate imissions to specific acceptable levels up to international treaties such as the Kioto treaty to reduce greenhouse gas emissions to clearly defined levels within a certain timeframe, targets are serving as a yardstick against which policies and developments are measured.

The Heads of State of the 27 EU Member States decided in March 2007, to increase the share of renewables in Europes energy mix to 20% by 2020. Soon, the Member States will be asked to draw up national action plans for each energy sector, to show how much renewable energy will be introduced until 2020.

Summary

Verifiable targets for solar thermal can be set with reasonable effort and accuracy. For shorter periods (e.g. up to 2020) the target should be set based on the existing penetration of solar thermal, measured in kW_{th} per capita. Benchmarks should be the penetration level achieved already in other countries and regions. As a minimum, each Member State should aim at achieving by 2020 the solar thermal penetration in Austria today. And as a whole, the EU should be able to reach at least 1 m^2 of solar thermal collectors in operation per capita.

In order to make the targets verifiable a system of monitoring the development of solar thermal capacities in operation must be put in place. This could be achieved either by collecting data on newly installed capacities and subtracting old systems, deemed to have gone out of operation. Or to directly assess the capacity in operation, e.g. by building up and maintaining a national register of existing solar thermal systems, verified each year by competent inspectors of heating systems (such as the chimney cleaners in Germany and other countries.

[10] The K4RES-H homepage can be found at: http://www.erec.org/50.0.html

Short term targets and long term potential

The long term potential of solar thermal in Europe has been estimated to be at least 100 times higher than today's usage. But it cannot be fully realised in a few years. For (shorter) periods for which operational targets are needed (e.g. 2020) the technical potential will definitely not be a limiting factor, not even in the most advanced ST markets. For the shorter term questions of today's usage and achievable growth rates are of utmost importance. Targets and measures to achieve them are inevitably interdependent. With stronger measures, higher growth and ultimately higher targets can be achieved. And setting of ambitious targets should help focus on strong measures to achieve them.

Importance of intermediate targets

If targets are to have an effect as guideline for policy making and as a benchmark for the success so far, then it is clear that intermediate targets are essential. Waiting until 2020 only to find out that a target was missed, is not sensible. Instead the progress must be verified in frequent intervals and policy measures adapted where necessary.

Short to medium term target (up to 2020)

Ideally the target should be determined in a detailed bottom-up study taking into account demand in different sectors, availability of suited roof and facade areas, development of the availability of skilled professionals etc.

But such a detailed study takes time to produce and therefore a more pragmatic approach should be applied: Meaningful targets for 2020 can be set also based on estimations, comparisons, and analogies.

The two approaches shall be outlined below, beginning with the pragmatic one that could be used by EU Member States in the development of their national action plans to fulfil the new binding target of 20% RES in Europe by 2020.

In any case the target should be set based on a simplified statistical conversion from solar thermal capacity (or collector area) to solar thermal energy production.

Based on the works of the International Energy Agency's Solar Heating and Cooling Programme (IEA-SHC), ESTIF uses a European average collector energy yield of 500 kWh/(m^2 * a). This factor takes into account the energy produced by 1m^2 of collector area in typical local solar thermal systems and weighs the different country-factors according to their relative market size. Each country may in the future calculate its own specific factor based on the typical systems, applications and specific energy productions in their country.

Approach 1: Programmatic setting of ST target

In the heating sector changes do not come over night and any policy measure introduced now will take time to take full effect. Therefore, it is fair to say that 2020 is already very close. The typical opportunity for including solar thermal into buildings or industrial processes comes with the new installation or renewal of the heating systems. This is one of the factors limiting the fast penetration of solar thermal technology.

Until 2020 there will be a lot of technological advancement in this market but a large part of the new installations will be with products of today or similar to today's. Even a breakthrough in the field of e.g. advanced heat storages by 2015 would not have a huge impact on achieving a target for 2020. This would be radically different if the time horizon was 2030 or even further.

This means essentially, that for the setting of 2020 targets, one can start with what has been achieved today and extrapolate from this level taking into account the positive framework conditions that are to be realised to promote solar thermal.

The analysis of different countries shows that the very different penetration of solar thermal does not depend much on climatic conditions (two of the leading solar thermal markets in Europe, Austria and Germany, are not in the sunny Mediterranean region, whereas Italy, France and Spain have much lower solar thermal penetrations). Therefore, it is reasonable to benchmark most European countries not against neighbouring countries but against the market leaders and.

Two benchmarks are of highest relevance in this context:

- Solar thermal capacity in operation per capita

  This parameter is both, closely linked to energy production (because it looks at the installed capacity) and it takes into account the different size of the national markets. It shows very well the relative penetration of solar thermal in different countries.

- Actual past growth rates of the solar thermal market

  This parameter can be used as "reality check". What growth rate would be needed to achieve a certain target in 2020, and has such a growth rate been realised in at least one country over a longer time span, i.e. could it be used as a yard-stick for the period 2007-2020.

Solar thermal capacity in operation per capita

The EU leaders in this category are Cyprus (479 kW_{th}/1.000 capita at the end of 2005), Austria (199 kW_{th}/1.000 capita) and Greece (193 kW_{th}/1.000 capita). For comparison: The EU-average is 24 kW_{th}/1.000 capita.

As a central European country, Austria is a very interesting example and can serve as a benchmark for the rest of the EU. This country has taken 20-30 years to reach this level of solar thermal usage. When solar thermal started to grow in Austria, there were hardly any commercial solar thermal systems and most systems were self-built. Over the years a strong industry has developed and technology has become highly efficient and reliable.

With today's products and know-how it should take other countries much less time to achieve similar rates. The "Austria Benchmark" should serve as a minimum target for 2020 for any EU country.

Depending on many country-specific factors, higher numbers seem well achievable in many Member States.

The European Solar Thermal Industry Federation is advocating a 2020 target of 1m^2 of collector area per European. These are 700 kW$_{th}$/1.000 capita and would translate into 320 GW$_{th}$ installed capacity in 2020.

This target applies for the average of the EU. Some countries, like Cyprus, Austria, Greece, Germany should achieve even higher levels while others will not be able to reach 1m^2 per capita by 2020. As a very minimum each of them should target the "Austria Benchmark" of 199 kW$_{th}$/1.000 capita.

	Capacity in Operation 2005 GW$_{th}$	**Capacity in Operation 2020 GW$_{th}$**	**ST Energy 2020 mtoe/a**	**Average market growth rate 2006-2020 % p.a.**	**Capacity in operation per capita 2020 kW$_{th}$/ 1000 capita**
"Austria scenario" (minium target)	10,9	91,2	5,6	16%	200
"1m^2 per capita scenario" (ambitious target)		320,4	19,7	31%	700

Actual past growth rates as "reality check"

If the market grew with a constant growth rate until 2020, how fast would it have to grow to achieve a certain target in terms of capacity in operation per capita. In many countries, the solar thermal market is still in its infancy and therefore very high growth rates can be expected in the coming years. But the question is, what growth rate can be realistically achieved on a longer-term, e.g. from now until 2020.

For the EU to achieve the ESTIF target of 1m² per capita by 2020, the EU market would have to grow at around 31% every year from 2007 to 2020.

In order to check how realistic such a growth rate is, it could be compared to the biggest national solar thermal market over a time span of the same length (1993-2006): During this period, the German solar thermal market grew at least by 20% in 11 out of these 14 years, and in 6 of these the growth rate exceeded 30%. For a country that has relied so far on “soft” support measures such as awareness raising campaigns and financial incentives, this is a remarkable achievement. One can only speculate what could have been achieved with stronger measures, such as solar thermal (or renewable heat) obligations for new buildings and for those buildings undergoing major renovations.

A sustained growth rate of 31% seems to be a well achievable rate, where a government is serious about the continued support for solar thermal.

Adjusting targets to country specific conditions

ESTIF’s overall target for the EU in 2020 needs to be broken down by Member State. As pointed out earlier, not every single country will reach 1m² of collector area by 2020.

- Instead the European target should be adjusted to the local conditions. Important success factors for the near term future are:
- Current level of solar thermal usage (implying also a certain level of solar thermal awareness and of market infrastructure)
- Current level of usage of other RES-H technologies
- Current energy technologies used for heating and cooling
- Cost competitiveness with existing heating technologies
- Other (policy) priorities in the heating/cooling sector (e.g. efficiency measures in buildings, district heating networks)

Approach 2: Detailed bottom-up study to set ST target

Another approach to set a target for the short- to medium term (up to 2020) is to conduct a detailed study on the realisable potential in this time span.
In this case it should be assessed how much low-temperature heat is currently being used, in which market segments and for what applications. Based on the rate of new-built heating systems as well as the typical renewal rates for existing heating equipment in the different segments and applications, the immediately available potential for the introduction of solar thermal should be assessed. This potential needs to be adapted to take into account that not every low-temperature heat demand could be covered by solar thermal (e.g. because of lack of suitable roof or facade area in high-density urban environments).

Outline of a detailed target-study:

- Total potential: Low- to medium temperature heat demand
- Short-term technical potential: Low- to medium temperature heat demand that could be covered by solar thermal technology available today or in a few years.
- Realisable technical potential 2020: Share of heat demand, which is covered by heating systems, which are to be newly built or renewed between now and 2020
- Solar thermal target 2020: Based on this realisable technical potential 2020, governments need to determine how much of this they want to realise. This would be their 2020 solar thermal target.

The policies they enact should then be targeted at reaching that share.

Monitoring of progress towards reaching a target

After having shown how targets for solar thermal could and should be set at national or local level it is important to point out how these targets can be made verifiable. A target without frequent and verifiable monitoring of the development of solar thermal installations would be meaningless. How could policy makers assess the success of their support policies without a feedback on the number of existing installations.

Two options are feasible:
Collecting data on newly installed capacities and subtracting capacities assumed to not be in operation anymore. The continued survey of the solar thermal market would allow keep track of the newly installed capacities. From the accumulated capacity, the very old systems, which are believed to have gone out of operation, must be subtracted in order to receive a realistic figure for the “capacity in operation”.

Directly collecting data of solar thermal capacity in operation: If done correctly, this would give higher quality results. But it creates additional costs for the collection of these data.

Collection of data on newly installed capacities and assumption on life time of solar thermal systems

This approach has been used so far by EU Member States, national solar associations and other bodies publishing solar thermal statistics. A thorough analysis of such statistics has been conducted within the K4RES-H project (see Deliverables 2 and 4) and recommendations on how to improve the quality of solar thermal statistics have been given therein:

(1) Improvement of data collection
Whilst no national register of solar thermal systems exists (“what is where installed and in operation?”), data collection should be based on:

- Surveys of solar thermal manufacturers/importers, which are done in co-operation with the relevant national trade association and which keep the individual data confidential
- Data obtained from financial support schemes at national level, if they are generally believed to cover most of the solar thermal market (i.e. only few installations are done, which do not receive these financial incentives)
- Ideally, the two methods are used together in order to cross-check the data and to fill potential information gaps

(2) Non-inclusion of old systems, which can be assumed not to be in operation anymore

Statistics which do not foresee that old systems are decommissioned at some point in time will show less and less realistic figures.

ESTIF strongly recommends using a uniform assumption on the usage time of solar thermal systems. In the ESTIF statistics the average usage time of a solar thermal system is assumed to be 20 years (15 years for systems that were installed before 1990). While there are many systems running already for 30 years, many systems are decommissioned earlier, e.g. because the building is demolished or has changed its use. The ESTIF assumption means that systems installed before 1990 are not considered anymore in today's statistics of solar thermal systems in operation.

Direct collection of data on solar thermal capacity in operation

In various EU Member States frequent checks of heating systems are required by law. In Germany for example, chimney cleaners measure emissions of ovens and boilers on an annual basis. And as most solar thermal systems have a back-up heater typically burning either gas or biomass it would be simple to add a requirement on having a look also at the solar thermal part of the heating system. Such a requirement would allow building up and maintaining a register of currently existing solar thermal capacities and it could help ensure that the systems are functioning properly.

Longer-term targets (beyond 2020)

The longer-term target should be to cover as much as possible (i.e. close to 100%) of the low-temperature heating and cooling demand with solar thermal.

On the longer-term, today's level of solar thermal usage has almost no influence on the overall result: Even a country which has only little usage so far has enough time to close the gap to today's front-runners and to eventually overtake them. Therefore, an extrapolation from today's penetrations would not be appropriate to set a longer-term target.

A longer-term target would have to take into account longer term scenarios for the heating and cooling demand as well as the expected – or possible – technical development.

In the solar thermal sector, the European Solar Thermal Technology Platform (ESTTP), which was officially launched in May 2006, is already working on these issues and aims at developing a comprehensive roadmap for solar thermal in Europe, encompassing technological and non-technological barriers to growth and measures to overcome them. Any government aiming at setting longer-term targets for solar thermal should support the ESTTP work in this field and take the results of the ESTTP as input to their own studies, where suitable.

Conclusion

Verifiable targets for solar thermal can be set with reasonable effort and accuracy. For shorter periods (e.g. up to 2020) the target should be set based on the existing penetration of solar thermal, measured in kW_{th} per capita. Benchmarks for the target setting in one country or region should be the penetration level achieved already in other countries and regions. For each EU Member State the minimum target for 2020 should be to achieve a solar thermal penetration reached already today by Austria. As a whole, the EU should be able to reach at least $1m^2$ of solar thermal collectors in operation per capita.

In order to make the targets verifiable a system of monitoring the development of solar thermal capacities in operation must be put in place. This could be achieved either by collecting data on newly installed capacities and subtracting old systems, deemed to have gone out of operation. Or to directly assess the capacity in operation, e.g. by building up and maintaining a national register of existing solar thermal systems, verified each year by competent inspectors of heating systems (such as the chimney cleaners in Germany and other countries.

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[i] The K4RES-H homepage can be found at: http://www.erec-renewables.org/projects/proj_K4_RES-H_homepage.htm

[ii] Müller, Thomas et al:" PROMISE – Produzieren mit Sonne. Endbericht", Gleisdorf, Austria 2004.

[iii] Weiss, Werner: Presentation held in the plenary session ESTTP launch on 30th May 06 (see www.esttp.org)

[iv] European Commission:"Green Paper – Towards a European Strategy for the Security of Energy Supply", Brussels, 2001.

[v] Schweiger, Hans et al:" The Potential of solar heat in industrial processes. A state of the art review for Spain and Portugal", Copenhagen, Denmark, 2000.

[vi] http://www.iea-shc.org/task33/

[vii] Weiss, Werner et al: Overview on technology and market potential for industrial process heat and other medium temperature applications. In: estec2005 Proceedings. Freiburg, Germany, 2005.

[viii] Jähnig, Dagmar and Werner Weiss:" Solar beheizte Industriehallen in Österreich". In: erneuerbare energie, 2005-03, Gleisdorf, Austria, 2005.

[ix] www.iea-shc.org/task29/