



ST-ESCOs Guide

***For ST-ESCOs developers,
end-users and investors***

Intelligent Energy  **Europe**

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1 Introduction

This Guide is developed in the scope of the “Intelligent Energy – Europe” project “Development of pilot Solar Thermal Energy Service Companies (ST-ESCOs) with high replication potential”.

The objective of the project “ST-ESCOs” is to promote the creation and development of Solar Thermal Energy Service Companies (ST-ESCOs) and therefore to assist in accelerating the growth of the solar thermal market in Europe. One of the most important goals of the project is to prepare detailed, real cases of ST-ESCOs agreements and their practical implementation.

The ST-ESCOs selling the solar energy (and not the solar plant) at a competitive price and carrying out the plant's operation and maintenance can completely remove barriers such as high initial investment cost, doubts for the reliability and durability of solar installations. As a result ST ESCOs open the way for a rapid expansion of solar thermal installations throughout Europe in all potential private and public sectors (e.g. residential, services and industry).

The Guide refers to crucial aspects that have to be taken into account on ST-ESCO contracts. Financial, contractual, legal, marketing as well as technical aspects will be included along with best practice examples and recommendations.

The Guide was designed, structured and elaborated by Graz Energy Agency with major involvement of the project partners and is a valuable tool for future ST-ESCOs actors (ST-ESCOs developers, end-users and investors).

2 Marketing Aspects

Strategies that ESCOs should adapt for market penetration are described in this section.

The goal of this chapter is the elaboration of a marketing strategy to convince the end user to install solar plants in each country. As for each marketing strategy the framework conditions play a major role, the strategy has to fit in the circumstances which vary from country to country. The strategy described here is based on the conditions which prevail in Austria and does not focus on country specific circumstances.

Based on this the strategy to reach the target group follows four steps which are:

1. Identification of target group
2. Addressing the potential customer
3. Concrete information about a contracting project
4. Concrete project acquisition and project development / support by local energy agency or independent consultant

These four steps are described below (chapter 1.1 – 1.4).

Analysis of strategies for relevant decision-makers of the identified target groups (e.g. housing companies, public authorities, utilities etc.)

Barriers for the increased application of solar thermal plants are:

- Cultural barriers:
 - “new technology” for planners , architects and also for banks or other financial actors (missing know-how about subsidies, solar systems/technologies, pilot projects)
 - customers / companies don’t believe that the simulated solar results will be realised
 - system and installation quality, doubts of the costumers
- Economic and financial barriers:
 - higher investment costs for the costumer/company
 - more complex and expensive planning
- Other barriers:
 - not perfect matching between the characteristics of solar plants and other parts of the project; for example, when installing a solar plant in a building, the

warranty offered for the solar components could be shorter (e.g. 5 years) than the warranty required to a builder (e.g. 10 years)

- aesthetic and system – building integration issues

Arguments frequently used against the implementation of ST ESCO projects:

- Long contract period
- Payment for outsourcing the energy supply
- Solar energy price too high (compared with up to now used energy source); customers often have the opinion that solar technologies should face huge technological breakthroughs before lowering cost significantly, thus having access to the market; therefore customers often see solar thermal as a “future option”
- Specific technical arguments against the integration of solar thermal plants in existing heat supply systems (e.g. for industrial users, the solar plant could interfere with the existing heat distribution system and possibly even with the industrial process itself, thus leading to a negative attitude of the potential customer towards the possibility to adopt a solar plant)
- Confidence that the fossil energy prices will continue to be favourable

Therefore the strategy should be designed to overcome barriers which often prevail. There are a lot of reasons for the customer which argue for the implementation of ST-ESCOs, e.g.:

- no or very low investment cost, minimizes the financial risk
- guaranteed development of solar energy price, advantage compared to other energy sources, which are likely to increase
- complete energy service package provided by one company, no implication of the customer with technical issues
- guarantee of state-of-the-art technical and economic solution, maximum solar output (is in the ESCOs interest)
- no problems with respect to operation and maintenance of the system
- take advantage of grants
- constant framework conditions for the establishment of a fruitful business
- prestige (standing out from one’s competitors, a positive attitude towards new technologies)
- Marketing strategies (to also sell ecological advantages, to sell engineering)

The following measures are necessary and recommended to improve the current situation (to overcome the above mentioned barriers):

- For cultural barriers:
 - more and specific information for the planners, architects, customers / companies and installation firms (e.g. folders, marketing campaigns, ...)
 - workshops and training for installation companies, planners
 - meetings between ESCOs and Banks (or other Financial Institutions)
 - meetings of potential customers with customers who have already chosen a successful ESCO service
 - excursions to already realised solar projects
- For economic and financial barriers:
 - TPF-models (guarantees for the customer)
- For other barriers:
 - voluntary agreements
 - use of standardised, reliable and widely accepted calculation tools to simulate system performance
 - creation of new synergies with actors already involved, for better dissemination of information

2.1 Identification of target group

The target group will consist mainly of large building owners (both private and public), housing associations, elderly homes, hotels, industry (textile, dairy ...) etc..

To keep it simple – building owners with large buildings or industrial processes which use low temperature heat and a high energy demand are the best suitable targets for ST-ESCOs.

Target groups:

- Housing-companies
- Municipalities and local governments
- Tourism industry
- Private building owners
- Companies and industrial firms
- District heating network operating companies

Buildings and facilities, which are suitable for large solar thermal plants:

- Multifamily residences (existing and new buildings)
- Tourism facilities (e.g. hotels)
- Hospitals and old people's homes
- Sport centres (gymnasia, swimming pools, etc.)
- Industry buildings, especially food and beverage industry, textile and chemical industry
- Office buildings
- District heating networks (feeding-in)

These buildings have in common, that they need lots of hot water and mostly independent of the season. The decision maker should also be interested in the increase of prestige deriving from using solar energy.

2.2 Addressing the potential customer

Addressing the potential customer (within the target group) by means of:

- Newsletter & Email contact
- Personal information
- Showing of best practice examples (study tours if possible)
- Solution to overcome existing barriers (additional planning and information, financing model etc.)
- Consulting in energy relevant aspects
- Solar workshops and information events: these workshops should be as specific as possible. For example, a workshop could be organized from an ESCO to involve dairy industries in a given region; in this case, the information provided in the workshop should be strictly referred to the situation (energy prices, energy consumption, etc.) of that industrial sector.
- Creation of an info point (e.g. web site)

Having identified a target group, e.g. housing company, a marketing concept to reach the following goals has to be elaborated:

- Initiation and support of solar projects in larger residential buildings
- Starting a marketing campaign for solar systems in larger residential buildings

The first steps to promote solar systems e.g. in multi-family houses will be:

- Direct marketing
- In-house presentation by housing companies
- Info-events for housing companies, planners, architects, plumbers, etc.
- Direct mailings
- Marketing-support packages for housing companies, architects, planners (e.g. best practice examples)

2.3 Concrete information about a contracting project

Therefore it is of particular importance:

- to know how to identify buildings that are suitable for contracting projects
- to clearly establish the targets to be reached by the project
- to know which points to consider when awarding a contracting contract
- to know which elements should be included in this contract (Sample contracts!)
- to know what will be the duties of the local government
- which support/subsidies can be obtained
- to establish a good and close cooperation with the building owner

2.4 Concrete project acquisition, project development / support by local energy agency or independent consultant

- Acquisition of projects (addressing the potential customer)
- Selection of a suitable project
- Energy audit – building or industrial process specific assessment and evaluation of the status quo (heat supply system ...)
- Identification of customer needs and requirements
- Quick assessment of suitability of the project for an ESCO, quick check of the economic situation (probability of success, risk for ESCO, secondary aspects such as economic situation of the customer, ...)

- Project monitoring by means of an independent consultant if necessary and desired (e.g. energy agency)
- Technical design (heat demand, secondary network dimensioning parameters, defining interfaces)
- Identify cost for management
- Description of supply tasks
- Requirements of heat supply and solar thermal system
- Definition of the contractor's service requirements
- Design of contract (heat supply contract)
- Invitation of tenderer
- Elaboration of offers (of the potential contractors)
- Discussion and evaluation of received offers
- Contract negotiations
- Finalisation and signing of the contract

3 Financial, Contractual and Legal Aspects

3.1 ST-ESCOs Financial Analysis and Principles

In the following ST-ESCOs financial analysis and principles are described.

3.1.1 Financial mechanisms / schemes

In general there are no fixed rules for agreements between the customer and the ESCO for what concerns the financial schemes, i.e. the payback of the investment (from ESCO's point of view) or the payment of the energy (from customer's point of view).

The choice of financial scheme largely depends on the financial reputation of the ESCO and on the conditions it can get at a financing institution; these conditions might vary (in the range of 100%) and depend on personal contacts with the bank.

Anyway, there are three different schemes for billing the solar energy between the customer and the ESCO. Most schemes which are implemented in real projects follow one of these schemes or a mix of these:

- Energy price only:
- Energy price and basic price:
- Energy price and connection fee:

These three schemes are described in chapter 3.5.2 in detail.

Independently of the model chosen, a certain amount of money (penalty fee) should be agreed upon in the case the customer wants to exit the energy supply contract before the agreed validity period of the contract.

In the financial negotiations with the customer, if the ESCO decides to foster a certain model, the ESCO should also keep in mind the technical background of the project: there is none financial scheme which is best suited for all types of projects. E.g. if the ESCO trusts the customer (both technical preconditions and financial situation) than it may opt for lowering the basic price and instead go for a somewhat higher energy price. On the contrary, if the customer seems not very trustworthy, then the basic price should tried to be kept high as this – together with the option of a bank guarantee – assures the payback of the plant to some extent. Of course, projects with a too high risk should simply be declined by the ESCO!

3.1.2 Conditions and guarantees

There are certain preconditions usually included in the energy service contract (see respective section) which have the task of guaranteeing favourable conditions for both contracting parties. The detailed scope of these conditions depends on the technical characteristics of the project as well as on the specific situation of the customer and of the ESCO (financial questions). Technical and financial prerequisites and conditions fixed in the contract are closely related and are crucial for the economic feasibility of a solar thermal ESCO project. This is going to be even more important in future when the size of an average large-scale solar thermal system is going to rise, and therefore economical questions such as the return-on-investment and the cash flow situation of the investment (i.e. the solar plant itself) become much more important than they are today.

Technical guarantees:

System operation guarantee of the ESCO: In most cases, the customers demand the ESCO to guarantee for the correct operation of the system; this includes the solar plant behaviour in the case of stagnation. Usually, the compliance with the respective security standards suffices this demand.

Energy supply guarantee: Most customers demand a guaranteed energy output (kWh/m²*year or MWh/year for the whole plant) from the solar plant to see that the system will suffice their energy needs and also to provide for an appropriate backup system. If the ESCO not only installs and operates a solar thermal plant but is responsible for the whole energy service of the customer, a guarantee for the energy supply for the whole year must be given. E.g., the ESCO could also install and operate (or buy the energy from) a biomass boiler or buy energy from a district heating net, and then sell this energy to the customer thus providing for the total customer's energy need.

It is important for the ESCO to find the correct restrictions to an energy supply guarantee in the case the customer does not fulfil the agreed technical specifications. Most of the problems with low energy output are due to

- bad system design (find a solar energy system supplier with more experience)
- less energy use by the customer than stated in the contract (agree for a minimum energy consumption and include penalty payments)
- basic technical conditions not as agreed, e.g. return temperature to solar plant too high (this is a delicate issue; must be solved individually with each customer). It is important for the ESCO to rely on temperature levels and energy consumption numbers which really can be achieved; otherwise the financial risk can be very high.

Most of the time, the calculation of the energy output values by aids of a simulation program or the proof of the provided numbers by some test certificate do not satisfy

the customer's demand of a guaranteed energy output for a specific plant site! Instead, most customers want to see the respective numbers of similar plants built by the same system supplier and run by the ESCO in a reference list.

Financial guarantees:

In general, the bank or financing institution has the right to take over the solar system if the ESCO goes bankrupt. This is a crucial aspect at negotiating about the financing plan of the solar system with the bank.

Bank guarantees: Bank guarantees are an important tool for a larger ESCO which has already gathered a vast experience with the contracting, the operation, the installation and the maintenance of large-scale solar thermal systems. A bank guarantee allows such an ESCO to head for projects with a higher risk (e.g. very large projects with large investment amounts to be financed in advance or projects with a more difficult technical background, or projects abroad where many conditions may be different).

The bank guarantee is some sort of contingent liability which can be used in the case the customer can not pay the energy bills on which the ESCO bases its back payment to the bank. In such a case the bank guarantee comes to effect and the ESCO gets the money from the bank. The cost of a bank guarantee must be individually fixed between the ESCO and the bank and depends strongly on the customer's financial situation.

In some cases, it is even possible to get some sort of bank guarantee from public administration or federal banking institutions set up for this special aim. E.g. in Austria, the ÖKB (Österreichische Kontrollbank) provides bank guarantees for projects abroad, but they are usually interested in very large projects only (investment > 1 mill. Euro).

3.1.3 Appropriate financial institutions

In general financing institutions expect that ST-ESCO financing should have a pay back time below 5 years. Loan contracts for more than 10 years are especially with large Austrian Bank institutions not realizable. Bank institutions have problems because of their rigid hierarchy so therefore access via local, smaller banks is probably more successful. The attitude of a bank towards solar ESCOs seems to be largely depending on the internal structure and the personal experience of the decision makers with renewable energy projects. Investors groups are of interest when realizing a close cooperation with companies that work in the environmental or ecological sector.

Past successful implementations of solar thermal ESCO plants have shown that contact with financial institutes which shall carry out the financing of the investment cost is a crucial aspect. In all successful ST-ESCO examples in Austria, the contact to small, local financial institutions with flat command structures have shown to be the most promising way. Personal contacts to the upper management of a small bank with the appropriate person being positive about the project, has turned out to be a good approach.

In the case that solar thermal projects shall be implemented internationally, it probably makes more sense to start at the same level where the first third-party-financed solar thermal projects started, i.e. at small, local banks with good contacts to the bank director. In order to minimize the financial risk for the contractor, a suitable bank must also be chosen for the bank guarantee for the solar plant. This bank guarantee becomes effective in case the customer is unable to pay the TPF fee to the contractor.

3.2 Insurance Schemes

As a matter of principle, a solar thermal system built by a system provider and run by a solar thermal ESCO is generally insured by the ESCO, and not by the system provider (i.e. the engineering company that built the plant). This is due to the fact the ESCO buys the plant from the system provider and only the plant *owner* can insure against the various risks. I.e., the insurance holder must be the owner of the solar plant.

Generally, the choice of an insurance scheme for an ESCO is a question of personal taste. It is also strictly related on the hardware cost and the capability for and immediate intervention (in case of damage). Depending on the corporate philosophy, an ESCO can affect insurances for a lot of different risks. On the other hand, many events of damage are quite infrequent. Thus, an approach to insurance schemes that tends to some more risk could exclude all uncommon events of damage.

3.2.1 Insurance schemes required

Following a list of the points that an insurance scheme (under an ST-ESCOs agreement) has to cover:

1. Insurance of equipment¹ against the following:
 - a. Extreme weather conditions. For each of those conditions, precise specifications (extreme limits) have to be defined; when the weather conditions exceed the specifications set then the insurance will cover the damages. (Example: the ESCO sets the extreme limit of external ambient temperature -25°C that the solar field can stand without freezing problems. The insurance will cover the cost for all damages caused by a certified extreme temperature that is lower than minus 25°C). The certification body has to be defined in the insurance scheme. The most important extreme conditions for solar thermal plants are the following:
 - hail for collectors' glasses
 - thunder for the control unit (difficult to set specifications in this case)

¹ According to experts on the field, there is no need for distinction between fixed and movable parts of the installation.

- extremely strong wind that may draw away some collectors
 - Extreme freezing conditions that may damage tubes in the collectors or the external hydraulic circuit
 - b. Thievery under some conditions (e.g. the access on the collectors' field and the other components of the solar plant has to be well defined).
 - c. Fire or other well defined causes originated from the building or from surrounding buildings or objects.
2. Insurance of the investments done and the economic obligations stated in the contracts.
 3. The insurance scheme should have a clear reference to the fact that there are two different owners involved in the ST-ESCO agreement: a) the owner of the solar plant (ST-ESCO) and b) the owner of the building (place) where the solar plant is installed (the End-User).

Aspects that insurances cannot cover are the following:

- Damages that may occur due to casual external factors (e.g. animals that may damage the pipes' insulation or collector sensors).
- Generally speaking, casual events that are not well defined in the insurance scheme cannot be covered.
- Damages that the solar plant may cause to the building or people (e.g. damage on the roof due to leakage, injury against people in case of a falling solar system component etc.). All these aspects should be subject of another scheme that should be a "Third party Liability" scheme. (note: In Italy this is a must - always requested)

3.2.2 Existing insurance schemes

Austria:

One typical insurance package includes all damages by *windstorm, fire and hailstorm*. This package is usually always included in an ESCO insurance model. It is not very expensive and covers a high damage event.

Another typical type of insurance is an insurance against *vandalism* (malicious destruction of the solar plant or its components).

The insurance value of these two packages should be equal to the nominal value of the system, i.e. equal to the total investment cost of the solar plant.

Usually, solar thermal plants are also insured against *lightning*. This type of insurance is often a first loss insurance, so the cost of a claim can be defined between the

insurance holder (the ESCO) and the insurer. For first-loss covers, no underinsurance is possible in the case of damage (waiver of underinsurance on part of the insurer).

For the lightning insurance, it is particularly important for the ESCO to assert that the solar system supplier has provided all necessary electrical and / or electronically means of protection for the solar system!

An insurance against *flood damages* is only needed in areas which are easily affected by inundations, but in those cases it generally makes sense to sign such insurance, so this can be an insurance type often signed by an ESCO.

As every company will probably already have, a *public liability insurance* is important also for solar thermal ESCOs. This insurance covers all damages to a third party. However, it might be worth also including insurance coverage against *environmental damage or loss* (some environmental damage done directly to air, water, soil,...), *roof damage* (in case the solar system is placed on top of some building roof) and *gradual loss* (i.e. all damages by long-term action of some detrimental event on the system leading to gradual or also sudden failure).

Usually, public liability insurances can be easily included in an insurance pool that contains this same type of insurance for more than one solar plant. Of course, in this case, the insurance sum has to be adapted to the new situation.

In other cases, it results to be cheaper to sign a separate insurance policy for every single plant, and not for a whole bunch of plants. This might be the case for the windstorm, fire and hailstorm insurance.

A type of insurance which can be quite important for an ESCO is a *loss-of-use insurance*, in the case no energy can be delivered by the solar plant due to some system malfunction or failure. This type of insurance covers all *ongoing costs* of the company or the solar plant. But – more important – it also covers the *loss of profit* for not being able to sell energy.

In the occurrence of the event insured, most insurances cover the additional work and expense (and financial outlay) that the ESCO has to bear in order to supply energy to the customer. The importance of this fact depends on the contents of the energy supply contract. Thus, a loss-of-use-insurance is much more important if the ESCO is *committed* to deliver a certain amount of energy to the customer, i.e. the ESCO has a delivery obligation. The loss-of-use-insurance is less important if the ESCO has only agreed upon a *right* to deliver the solar energy to the customer.

In the former case (commitment of delivery), in the damage event, the ESCO would have to take over all the additional costs for supplying the amount of energy to the customer which has been agreed upon in the energy supply contract. In the latter case (right to deliver), the ESCO damage is limited to a loss of earnings and maybe to some technical disadvantage due to the collector stagnation, but the ESCO does not need taking over the costs for the energy supply to the customer.

As is well-known from any kind of insurance, fixing a certain *franchise* (retained amount) drastically reduces the insurance rate (insurance premium). So, it might be sensible to accept a franchise of a few hundred Euros.

Hellas:

There are no special insurance schemes regarding ESCOs in Hellas, there exist only insurance schemes for usage of renewable energies in general.

The insurance companies are reluctant to insure renewable projects and especially small ones. There exist cases of insurance schemes on large scale projects but they consider them as any other electromechanical project or equipment. Even for these cases, the insurances cover the projects only against natural disasters, terrorist acts and fire.

Even for these cases, for example in the case of a thunder, the insurance company covers only the expenses of the hardware of the renewable plant. For example in the case of a wind turbine the insurance will cover the expenses of the damages of the wind turbine itself (i.e. the wings, etc.) and not other damages after that, for example electronic equipment, electrical installations, etc.

Italy:

Generally speaking no obligation at legislative level exists.

In practice, an insurance cover is required in every public call for tender as regards to third parties civil liability (people or things). This kind of insurance is common even where there isn't any obligation.

For this case, the possible options are two:

- The responsibility for the installed plants is included in the enterprise RC policy (that even if not obligatory, has a distribution on quite the total of companies);
- An ad hoc policy is drawn up. This usually is the case of large scale plants or big projects, regarding various kinds of interventions; so this are private negotiations, in which economic and contractual conditions depend from the relations between the enterprise and the insurance company. The reference insurance form is the plants management one.

The insurance cover for natural disaster has a quite recent distribution. No specific insurance products are available for solar thermal plants, but all the main companies draw up these kind of policies and the reference is, generally, plants. The insured value is the plant value (a part from pipes, valves, installation cost, etc), taking in account its decreasing value during its life. The insurance cost strictly depends from the total cost of the plant and the relations with the insurance company. At a first analysis, a range for the insurance cost is between the 2.5 % and the 4% of the insured value.

A third kind of insurance cover is related to designing and installation errors. Born specifically for PV plants, is now used also for solar thermal plant. It is not possible to define general values for these kind of policies, while they strictly depend from the kind of plant, the final use, the contract stipulated between ESCO and end-user, the analysis capacity of the insurance company, etc. At the moment this is still a really little diffused phenomenon, and no significant diffusion is expected in the next future.

3.2.3 Improvements of existing insurance schemes

The following insurance options could be adapted to suit the particular needs of an ESCO:

| Insurance type | Importance for solar thermal ESCO |
|-------------------------------|---|
| windstorm, fire and hailstorm | almost always included insurance value should be the same as solar system investment cost |
| vandalism | almost always included insurance value should be the same as solar system investment cost |
| lightning | almost always included ESCO should make sure the solar system provider installed all necessary means of protection! |
| Damages by flood | usually included only if plant is situated in high-risk area (often affected by inundations) |
| public liability insurance | always included ESCO should consider including insurance against environmental damage, roof damage and gradual loss, injuries against people in case of a falling solar system component |
| loss-of-use insurance | covers ongoing costs and loss of profit importance for ESCO depends on details of the energy supply contract (commitment or right of energy delivery) |

With present energy and solar system prices, every single expense factor is crucial for the economical success of an ESCO-operated solar plant. Of course, for monetary reasons, not every risk factor can be covered by insurance. So, the ESCO still bears a considerable risk in realizing a solar thermal system with a BOT model. In most cases it is therefore sensible to build up a network between new and existing ESCOs in the solar thermal market in order to minimize the described risk.

Finally, it may be said that the evaluation of the importance of different insurance schemes strongly depends on the ESCO's knowledge of the product – i.e. the solar thermal plant – they purchase and operate.

3.3 Equipment Ownership and Future Purchase Options

Equipment ownership and future purchase options offered to the end-user, once the contract has terminated, are described in the following.

3.3.1 Possible solutions for equipment ownership / future purchase options

Obviously, the ESCO should try to fix the longest possible term for the energy supply contract with respect to the technical costs (service and maintenance fees) which are supposed to increase over the years.

There are different economic possibilities for an agreement between ESCO and customer after the end of the energy supply contract. Basically, these are the possibilities that an ESCO currently has:

1. *The customer pays a fixed part of the investment at the delivery of the plant:* In part, this can be interpreted as a connection fee, but in contrast to that it also includes a fee to cover the uninstalling process and those parts of the equipment which can not be uninstalled (e.g. large rising ducts or the collector's substructures or mountings). That part of the equipment which can be uninstalled (mainly pumping units, collectors, maybe energy storage tank) can be used again by the ESCO in a future project.

The reasonability of this solution strongly depends on the technical conditions. E.g., a flat roof with good static properties (yields the load of the collectors and concrete foundations) is well-suited for a "modular solution" with the option of uninstalling the system after the end of the energy-supply contract. All solutions that include more complex steel-constructions adapted to a particular roof present bad conditions for a modular solution as many parts can not be used elsewhere and the uninstalling costs are high.

2. *The customer pays a flexible part of the investment at the end of the contract:* In this model, the customer contributes no or little to the investment at the delivery of the system. In return, the financial guarantee for the ESCO lies in the following approach: depending on the number of years that the customer remains under the energy supply contract, he is charged a variable fee at the exit of the contract. That means that the longer the customer remains under the contract, the less he pays – as he has already paid back a bigger share of the investment by the bought energy.

Of course, this model is more difficult for the ESCO to estimate and must therefore be subject to a rather thorough economic feasibility analysis. The big advantage of this model is the fact that most customers, especially big industrial clients, prefer this model as they have both advantages of (1) having to pay no or little initial investment contribution and (2) of not being bound to the energy service contract for a predefined number of years.

3. *Combine one of the above mentioned financial models with a mobile energy solution which can easily be installed and removed:* This variant consists of a mobile and easily transportable technical equipment group which is directly connected to the solar collector field and serves as the solar tech room. The great advantages of this approach are
 - a. the mobile tech package can be pre-assembled
 - b. it can be installed out of a building (the ESCO and the solar supply company do not have to bother with individual solutions for a specific building)
 - c. it can be easily combined with a more comprising energy solution (e.g. including biomass, etc.)
 - d. and very important: it can be easily removed from the original spot and brought to a different place.

Of course, this solution demands a great deal of technical know-how for planning the tech package correctly for different usages. Moreover, the combination with other energy sources in order to provide a more comprehensive energy supply solution is a challenge. Also the economic aspects of the usage of a determined size of the tech package must be thoroughly calculated by an ESCO.

Financial schemes are given in section 3.1.1. A list of possibilities after the (first) energy supply contract has run out can basically be reassumed as follows:

1. *The solar plant must be uninstalled:* This is actually the worst solution for the ESCO as it means the ESCO has to bear a high cost for the uninstalling the system. This can only happen if (1) at the end of the energy supply contract, the customer does not want to renew or extend the contract, and if (2) it was not fixed that the customer assumes the ownership of the plant; this is often the case and is reflected in the abbreviation BOT (Build Operate Transfer), i.e. the plant is transferred to the client.

Together with difficult conditions in the energy supply contract (short duration of the contract, high temperature level, therefore not very high energy output,...), the cost of uninstalling the solar plant can pull the project's economics into the negative area. Therefore, this variant should be avoided!

2. *The solar plant passes on to the customer:* This is the standard variant: after the end of the (first) energy supply contract, the customer takes over the solar plant and is therefore the owner. The ESCO does not necessarily stay in any longer contact with the plant or the customer. However, it is often asked by the customer

that a further contract for operation, service and maintenance of the plant is signed with the ESCO.

The economic favorability of this version for the ESCO depends on the technical quality of the solar plant construction and – based on that – on an estimation of the maintenance cost that the ESCO will have to bear. This option after the end of the (first) energy supply contract is favorable for the ESCO only if the duration of the first contract was long enough to guarantee an adequate return-on-investment for the ESCO!

3. *The ESCO keeps the ownership of the plant, the contract is renewed:* This solution is often asked by the customers as it guarantees them a continuation of the energy supply. Moreover, as the plant has already been paid back, the ESCO may offer a very competitive price to the customer, a price low enough to convince the customer to renew the contract, but high enough to cover for all operation, service and maintenance expenses of the ESCO.

3.3.2 Advantages for the ESCO and the end user

Description of the advantages for the ESCO and the end user of the different possibilities after the (first) energy supply contract runs out:

1. The solar plant must be uninstalled:

Advantages for the ESCO: This is actually the worst solution for the ESCO as it means the ESCO has to bear a high cost for the uninstalling the system.

Advantages for the end user: The end user has not to uninstall the plant, if he does not need the solar thermal energy anymore and so he does not want to renew or extend the contract.

2. The solar plant passes on to the customer after the end of the energy supply contract.

Advantages for the ESCO: The end user often wants a further contract with the ESCO for operation, service and maintenance of the plant. The economic favorability of this version for the ESCO depends on the technical quality of the solar plant construction and – based on that – on an estimation of the maintenance cost that the ESCO will have to bear. This option is favorable for the ESCO only if the duration of the first contract was long enough to guarantee an adequate return-on-investment for the ESCO.

Advantages for the end user: The end user owns the plant after the duration of the contract.

3. The ESCO keeps the ownership of the plant, the contract is renewed:

Advantages for the ESCO: The ESCO will have a further contract for operation, service and maintenance of the plant.

Advantages for the end user: This solution guarantees the end user a continuation of the energy supply. Moreover, as the plant has already been paid back, the ESCO may offer a very competitive price to the customer.

3.4 Legal situation

Below the legal situation in Austria, Hellas and Italy is described.

Austria:

In order to attain the ambitious goal to reduce emissions of the six "Kyoto-greenhouse gases" by 13 % by the target period 2008 to 2012 as compared to the 1990 values, the National Council adopted an "Austrian Climate Strategy 2008/2012" (<http://www.accg.gv.at/englisch/e-strategie.htm>), combining the efforts on the part of the Federal Government and the Laender into a co-ordinated strategy. The Climate Strategy is the basis for different special programmes.

In Austria the legal framework conditions for TPF projects are the same as for every other legal contract. However, difficulties can occur by awarding performance contracts. The law of public procurement regulates the award of contracts by contracting authorities on the basis of a "model approach". In case of a private purchaser, the project in question can be negotiated and awarded without the obligation to observe the provisions of the law of public procurement.

The measures taken in connection with a more efficient supply and utilisation of energy are various and diverse. This results in a variety of different implementation "models" and consequently leads to a range of different goods and services offered. This in turn determines the type and number of the parties involved, the required contracts and the types thereof, the financing terms, equipment ownership and future purchase options etc.

The general legal framework for contract awarding by public clients can be assessed as "predominantly positive". On principle, the regulations for awarding contracts do not provide any obstructions for the use of energy services by public clients. There are certain "problem areas", however, such as classifying Third Party Financing projects within certain categories of orders. It is therefore recommended that attention is paid to the relevant legal framework during the organisation of the project.

The law of public procurement is the dominating law within the legal framework conditions for Energy Performance Contracting (EPC) and Third Party Financing (TPF).

At least public authorities, who want to increase the energy efficiency of their buildings and who were the main target group for EPC and TPF until now, have to follow the rules of law.

However, among public authorities the phenomenon of legal uncertainty frequently occurs with regard to the award of performance contracts. The law of public procurement regulates the award of contracts by public authorities on the basis of a "model approach". In case of a private purchaser, the project in question can be negotiated and awarded without the obligation to observe the provisions of the law of public procurement.

Hellas:

Below the legal situation in Hellas is described.

Following the Kyoto world summit, Hellas has undertaken the commitment that the CO₂ level in 2010 will not exceed the respective values of 1995 by more than 25 %. This is an ambitious target, taken into account the fact that energy intensity in Hellas is increasing, which is partly due to the increased development rate of the National Economy.

In 1995, the Ministry of Environment, Urban Planning and Public Works (MEUPPW) prepared an Action Plan, entitled "Energy 2001", aiming at promoting the use of renewable energy sources (RES), as well as the application of energy efficiency technologies, in the building sector. The Action Plan was carried out in order to define specific measures for the reduction of greenhouse gas emissions (namely of CH₄, CO₂, N₂O, CO, NO_x and non-methane volatile compounds) in the building sector, in accordance with the National Action Plan for the abatement of CO₂ and other greenhouse gases. These measures focused on five (5) broad fields, namely:

- a. interventions in existing residential buildings
- b. interventions in public buildings and buildings of the broader public sector
- c. interventions in traditional (old) buildings and urban settlements
- d. implementation of the bio-climatic design principles in new buildings and urban settlements
- e. energy installations, amongst others those of active solar systems for hot water production.

As a result of that further laws and circulars have been issued in order to achieve the aforementioned targets. These are:

1. Law 3017/2002 "*Ratification of the Kyoto Protocol to the Framework-convention on climate change*", the Greek Parliament put on an official footing of the country's commitment for actions running against the aggravation of the "greenhouse effect".

2. Two Circulars of the Ministry for Public Administration (1997) and the Joint Ministerial Decision (JMD) 21475/4707 on the reduction of CO2 emissions via improved building energy efficiency (1998), which have introduced the TPF/EPC option in the public building sector within a mandatory, well defined energy management procedure with complete energy auditing, monitoring and targeting actions.
3. The implementation of OPC 2000-2006 Actions 2.1.1 (design, promotion and support activities) and 2.1.4 (public sector part) of the OPE 2000-2006, as detailed in the OPC Programming Supplement, which foresees the design and application of a special financial support scheme for the performance of energy investments (RUE/CHP/RES) in the public sector via the mechanism of TPF/EPC provided from private ESCOs
4. Decision 2000/2002 provides an updated Licensing Code of installation and operating permits of RES plants.
5. There exists a detailed legal framework for the liberalization of the energy market (Law 2773/1999 and Law 3175/2003) but, unfortunately, refers only to the electricity production.

Italy:

Below the legal situation in Italy is described.

Implementation of the Kyoto Protocol:

Law 120/02: ratification and fulfilment of the Kyoto protocol to the United Nation Convention on climate change.

Law by decree (DL) 273/04: urgent dispositions for the application of 2003/87/CE directive, in matter of greenhouse gases emission's credits exchange inside the European Community.

CIPE resolution 123/02: revision of guidelines for national politics and measures on reduction of greenhouse gases emissions. Among the considered measures appear the energy efficiency decrees and the diffusion of solar thermal energy.

Energy efficiency:

An important instrument for the application of the mentioned targets is the intervention on the demand side.

The ministerial Decrees (DM) 20/7/04 have formalised a framework (also known as energy saving certificates or white certificates mechanism) for promoting energy efficiency in final uses and renewable sources, implementing the legislative decrees for liberalisation of energy markets (legislative decree (D.lgs) 79/99 transposition of

Community Directive EC/96/92 for electricity, and Dlgs 164/00 transposition of Directive EC/98/30 for natural gas).

The Decrees impose to electricity and natural gas distributors annual energy savings, achieved directly or indirectly purchasing the energy saving certificates obtained by an ESCo.

To realize this blueprint, the Electricity and Gas Authority (AEEG) made out a list of ESCos stating their participation to the mechanism; this gave a strong stimulus to ESCo's market. As of July, 6th 2006, the web site of AEEG reports 56 ESCOs.

The first results are very encouraging: until May, 31st 2006 the average selling price for White Certificates has been about 77 Euros/toe (tons of oil equivalent) for electricity replacing and about 94 Euros/toe for gas replacing. These average prices are high enough with respect to the feed in tariff price, fixed by AEEG at 100 Euros/toe.

For Solar Thermal applications a standard procedure to simplify the achievement of white certificates already exists. It links energy savings directly to the installed square meters and to the climatic zone and to the energy source replaced (electricity, gas, oil or other fuels).

Moreover in the annex the installation of solar thermal panel for hot water and air conditioning is expressly quoted. Solar thermal plants can benefit from White Certificates in the first 5 years of operation.

Decree of the President of the Republic (DPR) 412/93 and subsequent modifications and integration, the, introduced the option of "heat service". The ministerial memorandum 273/98 of Finance Ministry and the 103/E/98 resolution, defined the rate of VAT of 10% for the heat for domestic uses sold through a "heat service" contract, (otherwise the VAT is usually 20% on fuels and electricity) if some conditions are verified.

D.lgs 192/05 transposition of Community Directive EC/02/91 (Energy performance of buildings), states that Solar Thermal applications are mandatory for Public Buildings, while for private buildings the obligation is for the predisposition for solar thermal plants.

Speaking again about buildings, several Municipalities (so far only small ones, with the exception of Rome) have introduced the so-called "Solar Ordinances", foreseeing solar thermal as a mandatory energy measure in all new (and in some cases also refurbished) buildings, to cover at least a fraction (about 50-70%) of the domestic hot water demand. Also some Regions introduced this concept in their framework laws on energy. Therefore, it is likely that, in the short and medium term, several opportunities will arise in Italy for installing large scale solar thermal plants in buildings, thus opening a huge potential market for ESCOs which will be able to develop this kind of projects.

DM 24/10/05 extends the Green Certificates benefits (a mechanism to promote electricity generated by renewable energy sources) to co generating district heating plants for the first 8 operating years. This will stimulate the creation of new district

heating plants, and once ended the benefits, there will be rich soil for large scale solar thermal integration plants.

Public procurement:

The legal framework for public procurement is essentially the Law 109/94 and subsequent modifications and integration, (also known as Merloni's law), the implementing regulations DPR 554/99 and subsequent modifications and integration and the DM 19/4/00 n. 145, regulations for tender of public procurement.

This legal set together with the one on company's qualification, fully define all the possible cases of goods acquiring and works execution, adjudication's rules, etc.

D.lgs 157/95, transposition of Community Directive EC/92/50 on public procurement, and subsequent modifications and integration (including D.lgs 65/00), norm the services acquiring statement.

Inside these two legal set previously explained, stand or can be deduced all application and development modes of TPF, Project Finance, etc.

For ST-ESCO the legal framework is between those two extremes (service and work); providing the needed heat is a service, while design and build of the plant is a work.

The first example of TPF for energy services and energy efficiency implementations (in hospitals) is the scheme for tender made by Regional Council of Piemonte in 1998, meeting the expectations of the Community Directive EC/93/76 and the DPR 412/93.

Solar plant's propriety is problematical; the ESCo wants the propriety as guarantee and to put it as an active item into the company's balance sheet, and therefore in the financial statement of the company.

Likewise the public institution aims to obtain plant's propriety since the contract starts, both because the plant ground on one of its proprieties, as a guarantee and as required by its regulations. The institution's regulations for account discipline indeed impose that any payment must follow the supply of services or the acquisition goods.

3.5 Contractual Principles and Structure

3.5.1 Structure of an Energy Supply Contract

The energy supply contract is one of the core pieces of a solar thermal ESCO project. It fixes all important issues between the ESCO (the energy supplier) and the customer (the energy consumer). An energy supply contract is always an integral part of a solar thermal ESCO project. Its contents are crucial to the economic feasibility of the particular project, but also for the economics of the ESCO in general and on a long

term. The energy supply contract fixes several important topics that are related to the risk accepted by the ESCO in acquiring the project. An example of the contents of an energy performance contract is attached in annex 1 of this guide.

These are the main topics to be covered by the energy supply contract:

1. Subject of the contract
2. Duration of the contract
3. Installation of the solar plant, property line
4. Details on the energy supply and the operation of the plant
5. Solar energy price
6. Measurement and charging of the solar energy
7. Other contract clauses

Here are, in brief, the key articles of each of the above topics in the energy supply contract:

1. Subject of the contract

Fixes the basics of the solar energy supply:

- who is the ESCO, who is the customer
- general information on the system integration of the solar thermal plant
- start of the energy supply, usually fixed within a certain period of time or with a latest starting date. So if the plant has not been completed yet, the ESCO takes the responsibility and the risk for the completion in time!

2. Duration of the contract

Fixes the beginning and the end of the energy supply, and additionally:

- exit clauses and exit terms for contracting out of the agreement for both contractual parties. This can be a tricky paragraph, and it is important to negotiate conditions which assure long-term stability for selling the solar energy!
- might include the relations between the customer and its other partners (e.g. if the customer is not the owner of the building or the area which is going to bear the collectors)

3. Installation of the solar plant, property line

- who is responsible for the installation of the technical equipment

- describes in all detail where the limits of performance are drawn, in particular the customer's responsibilities are defined. Moreover, the energy delivery point (usually position and integration of heat exchanger) is specified
 - certifications requested
 - who pays the electrical energy for pumps and other equipment?
 - who cares for the ongoing service and maintenance of the solar plant?
 - property structure of the areas which are going to be affected by the solar plant in some way (tech room, roof, space for piping,...)
4. Details on the energy supply and the operation of the plant
- fixes all details between the ESCO and the customer that are related to the solar energy supply service:
 - for the ESCO, is there an obligation or a right to deliver the system's energy output to this specific customer?
 - for the customer, is there an obligation or a right to buy the solar energy?
 - eventually, fix energy consumption limits (minimum required)
 - what about the integration of the solar plant into the existing energy supply system of the customer?
 - what about the behaviour of the customer to all other possible sources of energy or energy savings which could compete with solar thermal? E.g. the customer uses other energy sources even though solar energy is available, so the ESCO does not sell the produced solar energy.
 - all the risks concerning damage of the solar plant and damages or consequential damages that are due to some improper operation of the plant, are for the ESCO's account
 - date for earliest and / or latest begin of the energy delivery to the customer
5. Solar energy price

This part specifies all questions related to the tariff model of the solar energy. It is completely arbitrary for both contract parties to agree upon a model which serves both sides' interests.

- same price for the whole year or difference between summertime and wintertime?
- solar energy indexed to consumer price index / some other energy / any other reasonable factor? What's the effective date that serves as a basis for the indexing calculations?

- what happens if one of these factors changes drastically? New definition of this part of the contract?
 - what happens if solar energy prices are related to other fossil fuel prices?
6. Measurement and charging of the solar energy
- how is the solar energy measured?
 - any prerequisite for the measuring facilities or the measurement system in general?
 - how is the solar energy going to be metered and charged to the customer?
 - who calibrates the measurement equipment?
 - term of payment for the solar energy invoices
7. Other contract clauses
- how are withdrawals from the energy supply contract handled? States all circumstances under which one of the contract parties could exit the contract without legal consequences.
8. Legal venue
- fixes the legal venue for any misconceptions between the contract parties

Usually, there are appendices to the energy supply contract. Most commonly, the following appendices are included:

- hydraulic scheme of the energy delivery station with integration of the solar plant
- hydraulic scheme of the solar thermal plant

3.5.2 Methodology for billing the solar yield

Methodology for billing the solar yield

In Austria, the solar yield of solar thermal plants is measured with the aid of ultrasonic heat meters installed in the systems. To actually measure the solar energy delivered to the customer, the heat meter is installed in the secondary circuit (i.e. after the heat exchanger solar to the customer). The ultrasonic heat meters are the technical state-of-the-art today: they contain no moving parts, are therefore non-wearing and have long durability, and that means little maintenance costs for the ESCO. How heat meters work is described in chapter 4.5.2.4.

In nahwaerme solar plants, the energy delivered to the customer is automatically measured by means of a tele-monitoring system. Then, it is charged to the customer by means of an energy bill about once every month (in summertime) or once every 2 months (in wintertime). A fully-automatic billing program would be a desirable development.

There are three different schemes for billing the solar energy between the customer and the ESCO. Most schemes which are implemented in real projects follow one of these schemes or a mix of these:

Energy price only: the customer pays a certain energy price per kWh of solar thermal energy. The energy is usually billed once every month or once every two months. This means that the payback for the ESCO works only by means of the energy sold, and a big share of the customer's payments arrive in summertime. Usually, for domestic hot water the ESCO and the customer agree for a different summer and winter price (summer price higher, as conventional boiler systems have lower efficiency in summertime, thus specific end energy prices are higher). Usually for space heating the energy price is every month the same. This scheme is generally favourable for the customer.

Monthly amount charged to customer²: $MA = SE_m \times SEP_h$

Energy price and basic price: Additionally to the cost per kWh, the customer is also charged a basic monthly price which he is asked to pay regardless of the energy delivered. In return, the energy price for the kWh of solar energy is lower. This model provides some more security for the ESCO as it will get the monthly payments in any case. Moreover, the ESCO gets some money out of the system also in wintertime, when the earnings based on the solar energy output are close to zero.

Monthly amount charged to customer³: $MA = BP + SE_m \times SEP_l$

Energy price and connection fee: Similar to the installation fees which a customer is charged for being connected to a district heating net, in this scheme the customer pays (some share or 100% of) the installation cost of the system. This amount of money is often denominated a connection fee and may be calculated based on the kWh delivered per year or based on the installed collector area and system design. In

² MA = montly amount paid by customer and earned by ESCO

SE_m = solar energy in MWh in current month

SEP = solar energy price per MWh solar energy (high)

³ BP = basic price paid by customer every month

SEP = solar energy price per MWh solar energy (low)

return, the energy price for the customer is reduced, so the ESCO needs to perform a very thorough economic feasibility calculation.

Monthly amount charged to customer: $MA = SE_m \times SEPI$

Connection fee has to be paid once at the delivery of the solar plant.

The solar energy price is usually linked to the consumer price index (general index which reflects the course of the inflation); this does generally not create any problems in the financial negotiations. With the current development of the world's primary energy prices in mind, it is also a good idea to link the solar energy price to the price of oil or gas. Here is one possible model: the oil price of a defined date is taken as reference, and every month (or every year) the oil price increase is measured relating to the reference date. The solar energy price may be increased by a certain percentage of this oil price increase.

3.5.3 Call for tenders material

3.5.3.1 Steps of a tendering procedure

The tendering procedure involves in general three steps:

1. Pre-selection of qualified ESCOs:

The first step includes the preparation of project information, public advertising and informing potential bidders and evaluation of all documents sent by the ESCOs. Based on the results of the evaluation a recommendation of qualified ESCOs will be given to the building owner.

2. Call for tenders - documents:

The second step includes the development the solar thermal energy service contract, preparation of the documents for the call for tenders and sending the documents to the ESCOs.

The Call for tenders material is based on a number of documents, which are the following:

- Hints for tender preparation and awarding principles
- Bidding form and short questionnaire for offer
- Energy Service Contract for solar thermal plant with annexes
 - a. Description of the building with abstract of cadastral register, plans and photos
 - b. Description of performance

- c. Capital expenditure and structure of investment, List of measures, list of products
- d. Service offering of energy controlling system
- e. Formula to calculate the guaranteed solar yield per year (reassessed)

3. Selection of the best offers and negotiations:

The last step of the tendering procedure includes the evaluation of the bids, negotiation of bids and contract with the 3 best ESCOs and the final assessment of the bids and recommendation (report).

3.5.3.2 Call for tenders documents

Following the call for tenders documents are described.

1. Hints for tender preparation and awarding principles

In this document is specified how to attend at the tendering and the tendering procedure. There are lists with the tendering documents and the documents which have to be submitted.

Explanations to the tendering material are also mentioned, e.g. how to fill in the forms, place for the submittal of quotation, contacts for information, etc.

Schedule for fixed dates and terms after assignment:

- Dates for a site visit for interested ESCOs
- Deadline for submission of quotation
- Presentation of the quotations
- Deadline for completion of the plant
- Date for test run of the plant
- Date for acceptance from the customer
- Penalty per day if the plant doesn't work properly (as agreed in the contract)

Principles for awarding of contract are described in this document. Statement about how the award procedure works (structure of the procedure).

The phases of the award procedure are described. In general there are 3 steps in the negotiation procedure:

Step 1- Pre-selection of qualified ESCOs:

Preparing project information, public advertising and informing of potential bidders, evaluation of all documents sent by ESCOs and recommendation of qualified ESCOs to building owner.

Step 2 - Documents for the call for tenders:

Developing the service contract, preparing the documents for call for tenders and sending the documents to the ESCOs

Step 3 - Selection of the best offers and negotiations:

Review written proposals and select top candidates, negotiation of bids and contract with the top candidates (usually no more than 3), final assessment of the bids (cost-benefit analysis) and recommendation (report for building owner)

2. Bidding form and short questionnaire for offer

The bidding form includes the main information about the project, like customer, place of the site, schedule for fixed dates, contact details of the tenderer.

The short questionnaire for offer includes beside the contact of the tenderer the guaranteed solar yield, price for solar energy (price per MWh solar energy) and basic price, also the investment costs for the installation of the plant.

3. Energy Service Contract for a solar thermal plant with annexes

The main topics of the energy service contract are (for detailed description see 3.5.1):

- Subject of the contract
- Duration of the contract
- Installation of the solar plant, property line
- Details on the energy supply and the operation of the plant
- Solar energy price
- Measurement and charging of the solar energy
- Other contract clauses

Annexes:

- Description of the building

The description includes information about the building like year of construction of the building itself and the hot water preparation and heating system, utilisation of the building.

The hot water preparation system, which will be connected with the solar plant, is described detailed.

An abstract of cadastral register, plans and photos of the building are attached.

- Description of performance (form)

Short description of the services which the contractor will perform (structural and other measures), relevant dates (e.g. of completion, acceptance, etc.), special characteristics of the place where the plant will be installed (place has to be accessible to install the plant), list of documentation which has to be done (plans, operation manual, connection diagram etc.)

- Capital expenditure and structure of investment, List of measures, list of products

This document includes a description of the structure of the investment and lists of the measures and used products are attached.

- Service offering of energy controlling system

The energy controlling system is described.

- Formula to calculate the guaranteed solar yield per year (reassessed)

The solar yield per year (e.g. 300 kWh/m² this is equal to an absolute solar energy yield of 30.000 kWh per year) which the contractor guarantees, reference conditions and how to reassess the metered solar yield are displayed. The reassessment of the metered solar yield considers the proportion of reference solar radiation and hot water demand to metered solar radiation and hot water demand in the accounting period.

3.5.3.3 Evaluation of tenders

In the tendering documents the basis for the evaluation of the tenders is defined.

The criteria are:

- Overall costs per year: capital costs for investment + yearly price for service + yearly price for energy (hot water) supply
- Quality of the technical solution and guaranteed solar output
- Concept of the energy management

These criteria are weighted, that means in the evaluation a maximum of 100 points is possible and e.g. the overall costs are with max. 80 points, the quality of the technical solution and the energy management are each with max. 10 points valued.

4 Technical Aspects

4.1 Solar heating plant technologies

This clause gives an overview over the various technologies of solar heating plants, relevant for ST-ESCOs. In general those applications will be of interest that show-up a significant system dimension (at minimum 100 kW_{th}) and a sound cost-efficiency.

4.1.1 Domestic hot water plants for residential buildings or other large consumers

In many cases, the heat demand for domestic hot water is more or less constant over the year and is therefore suitable for solar heating plants, which basically cover the full heat demand in the summer period and a part of the total heat demand all over the year. Depending on the climatic conditions, a solar heating plant may reach solar fractions of 30 – 80 %, referred to the energy demand for domestic hot water. Higher solar fractions lead to lower yearly average efficiencies of the plant. Preheating systems with undersized collector fields are therefore economically more feasible.

Following applications are common today:

Multi-family houses: Due to the high number of flats, a minimum domestic hot water demand is available all over the year. A centralised hot water system is required, in order to provide solar heat to each flat. A solar tank is usually installed in the heating central, storing hot water during the day and making it available during draw-off periods.

Hotels: Large hotels have a high heat demand for hot water and are often equipped with centralised heating systems. Solar plants are therefore a very interesting application, especially for hotels which have their maximum visitors rate in the summer.

Houses of elderly: Houses of elderly have a constant need for hot tap water all over the year, which does not strongly depend on the seasons. This makes this target extremely suitable for solar plants.

Sport centres: The hot water demand for showers in sport centres can be very high. An energy audit, however, should verify the seasonal use of a centre and verify that heat is required also in the summer period.

Another interesting application are **student homes, hospitals and clinics**. The Italian Ministry of Justice ran a programme on solar heating systems for **prisons**, integrating also resocialization measures for the inmates.

Solar plant for DHW in Turin

A 98 kWth (140 m²) flat plate collectors plant is installed on a hotel of the environmental education centre in Pracatinat, Turin. The hotel has 200 beds, further the plant is connected to the hotel kitchen and laundry, in order to cover about 55 % of the total hot water demand of 10 m³ per day.



Figure 4.1: Solar plant in Pracatinat, Turin (Italy) (source: Ambiente Italia)

4.1.2 Large solar combisystems

The energy demand for hot tap water may be generally estimated to 15 – 30 % of the total thermal energy needs in a building. To reach higher solar fractions the solar heating plant can be integrated also in the space heating system in a so called 'solar combisystem'.

Solar combi-system in Salzburg

A large solar thermal system in Salzburg (Austria) works as a combi-system: it provides both hot water production and space heating to some 370 apartments at Bolaring (Salzburg) and to an old people's home.

The total collector area of the plant is 1056 m², with an average specific solar output of 350 kWh/m² per year. The plant has been awarded with the Austrian Solar Award 2001.



Figure 4.2: Solar combisystem, Solar plant in Salzburg, Austria (source: nahwaerme)

The system dimensions of a solar combisystem are typically one to two times the dimension of a domestic hot water system, leading to solar fractions up to 30 - 40 % of the total heat demand. Experiences from Austria show a 10 % increase of the

system yield , due to the integration of the space heating system, also in cases where the system size was not increased compared to the domestic hot water system.

Basic pre-conditions for solar combisystems are:

- low-temperature space heating system
- possibility to sufficiently incline the collector (40 - 90° tilt angle)
- significant length of the heating season

Solar combisystems are particularly suited for new constructions, where the heat can be distributed from the heating central via a two-pipe distribution net and heat transfer units in each flat (see also clause 3.3.2).

4.1.3 Solar district heating systems

Solar heating plants can be also integrated in district heating networks of small towns or city quarters, which are equipped with a common distribution network. Solar heating plants integrated into district heating systems are fairly large, reaching up to several MW thermal capacity, and thus show favourable specific costs.

Collector fields are either ground-mounted or on the building roofs. Special technology is available for large fully roof integrated collector fields, substituting also the layer of the roof tiles.

Solar district heating plants can be integrated with medium-term or long-term seasonal storages, a big underground water or ground storage volume which is loaded with heat during the summer, which in autumn and winter is transferred to the distribution network for heating purposes. Medium- and long-term storages allow to significantly increase the solar fraction and thus to develop solar thermal to its full potential.

Solar district heating in Marstal

Danish cities are often served by a district heating network and are therefore suitable for big solar systems. In Marstal about 12 MWth (17.000 m²) of flat plate collectors with a seasonal storage provide heat for the town. The plant was built in the middle of the 90ies, then it was enlarged in 2003. It belongs to the local energy utility. More information is available at <http://www.solarmarstal.dk>.



Figure 4.3: Solar district heating in Denmark (source: Marstal Fjernvarme Amba)

4.1.4 Solar Process Heat

Solar thermal systems can be also used in the industrial sector. Due to the large variety of existing processes, following parameters have to be considered in order to decide whether solar thermal can be adopted or not:

- required temperature – temperatures up to 250 °C are suitable for solar thermal. Different collector types are available according to the temperature level (flat plate collectors, evacuated tubes, parabolic collectors).
- seasonal and daily trend of thermal energy demand – the process should require heat all over the year, especially in the summer. A constant demand during all days of the week is a good basis for the application of solar thermal plants.

The most interesting applications concern the food, the chemical and the textile industry.

The International Energy Agency is promoting a research task dealing with solar thermal heat in industrial processes (see reference below).


| | |
|--|---|
| <p>Solar heating plant in a washing industry</p> <p>The Spanish company Contank, (washing of containers) built a solar thermal plant in 2005. The system preheats cold water, which is later heated up to 70 – 80 °C by vapour. The conventional heating system works with natural gas.</p> <p>The 360 kWth (510 m²) flat plate collectors produce about 430 MWh/a</p> |  |
|--|---|

Figure 4.4: Contank company in Castelbisball, Spain (source: IEA Task 33)

4.1.5 Solar Cooling

The market of air conditioning is growing world wide leading to enormous additional consumptions and electricity supply problems in many countries. Solar air conditioning systems are therefore a very interesting application, in particular because the major air conditioning load coincide with high solar radiation availability of hot climates.

Following solar air technologies are available:

- closed systems adopt either absorption or adsorption machines, which usually produce cold water. Operating temperatures vary between 60 °C (solid sorption medium) and 160 °C (double effect machines using liquid sorption medium).
- open systems are based on desiccant and evaporative cooling (DEC) and directly produce cold air. These machines work at temperatures of 45 – 95 °C. Since DEC plants need air canalisation, they are often deeply integrated into the building HVAC system. For this reason they may be less interesting for ST-ESCOs compared to the closed systems.

Solar cooling plant in France

A 91 kW_{th} (130 m²) vacuum tube plant is installed on the roof of a wine cellar.

The system is used for both, heating and cooling of the cellar.

The cooling absorption machine works with a liquid medium and is connected with a cooling tower installed on the northern facade of the building.



Figure 4.5: Solar cooling of a wine cellar in Banyuls, France (source: IEA Task 25)

More specific and detailed technological information and many best practice examples are presented on websites which are listed in chapter 6.

4.2 General-aspects of system planning

This guide does not treat the design of large scale solar heating plants in detail, since numerous planning handbooks are available, that give detailed planning rules and specifications, taking into account the specific national technical and legal boundary conditions. However, this clause discusses several general aspects which should be considered in the initial phase of the plant realisation period, since they are often crucial for a successful plant operation and for reaching customer satisfaction.

4.2.1 Large scale solar heating plants as part of a comprehensive energy concept

Innovative heat supply requires an individual integrated planning of the energy concept for the object in question (building, industry or other), which finds an optimum balance between energy saving, energy efficiency and renewable energy use. The solar thermal plant, concerning its capacity and characteristics needs to be integrated and adapted to the whole concept. More detailed information are presented in clause 3.4.

4.2.2 Project partnership

In order to achieve cost-effective plants all partners involved in the realisation of the plant and building should cooperate already at an early stage of the project. This will lead to a **cost-effective installation and integration** of all parts of the system in the building and in the conventional heating plant. Following actors are usually involved:

- building company
- planners/engineers
- architects
- plant management
- administration

4.2.3 System dimensioning

The base data for dimensioning solar heating systems is the actual heat load, in most cases the actual heat load for domestic hot water preparation, which remains the only relevant heat load during the summer period. The latter can show significant variability between the week days and also the months of the year. It is crucial for an ST-ESCO to determine this load as realistic as possible, in order to install well dimensioned plants and to avoid unprofitable heat production surplus in periods of reduced load.

Three main possibilities are available for determining the heat load:

Analysis of existing data: In case of already existing objects (buildings, industries etc.), energy bills or meter readings of the past years are often available and can be analysed in order to reconstruct a medium heat load on a monthly base.

Measurements: In case such data are not available, measurements of the heat load can be performed over a limited period. Recommendations for such measurements are given below.

Load estimates: In case of new buildings, for which in many cases the future inhabitants are not even yet known, load estimates can be carried out following the technical recommendations of standard HVAC handbooks, where typical values for residential buildings, hotels, hospitals etc. are reported. It is recommended to critically evaluate these recommendations because in many cases they lead to significant overestimations of the actual load.

The German technical guideline **VDI 6002** gives following recommendations for the measurements of the heat load:

- the cold water volume entering the conventional hot water preparation unit shall be metered. This should neither include the cold water used for the mixing valve, nor the recirculation line flow rate.
- in addition the cold water and hot water supply temperature shall be monitored.
- the measured heat load shall be logged in daily intervals.
- the ideal measuring period is the summer period with reduced load.
- the measurements shall be performed at least for 4 weeks
- the additional load for the recirculation line shall be added in case a system scheme is chosen, which allows to cover recirculation losses with the solar heating system during the summer period.

The same **VDI 6002** recommends to dimension the solar heating plant based on a medium load of a summer period with reduced load. Practically this means that the solar heating plant will cover only the heat load of this period to approximately 100 %. On the other hand unprofitable stagnation cases are avoided in this way.

It can be assumed that on a good summer day the solar radiation on 1 m² solar collector is about 8 kWh/d, which the collector will transfer with an (annual) average efficiency of 50 % to about 4 kWh/d of useful heat. This is approximately the energy needed for heating 100 l of water from 10 °C to 45 °C.

solar fraction

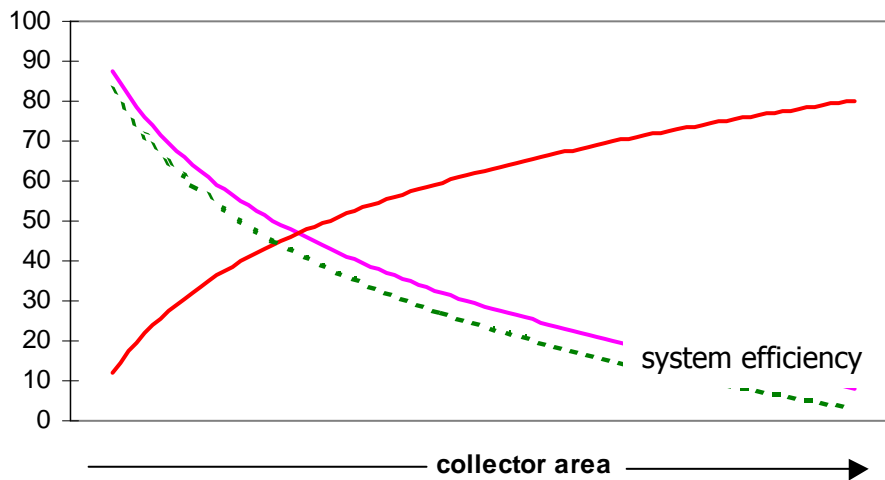


Figure 4.6: Solar fraction and system efficiency for increasing collector area

Since a solar heating plant is usually coupled with a conventional boiler, the dimensioning criteria are basically not strictly defined. The collector area can be oversized or undersized according to the desired solar fraction. Nevertheless an important principle has to be considered: the overall system efficiency decreases with the increase of the solar fraction, as shown in figure 3.6. I.e. that the choice of the system dimensions will always be a compromise between the solar fraction achieved on one hand and the cost-effectiveness on the other hand. Pre-heat systems with rather low solar fractions (e.g. 20 - 30 % referring to the domestic hot water load) show-up a sound economy. Whereas large solar district heating systems with seasonal storage are able to cover over 50 % of the total heat load, however, at a relatively high specific solar heat price.

The above simple hypothesis leads to a dimensioning ratio of 1 m² collector area per 100 l of daily consumption at 45 °C. Systems dimensioned in this manner will show moderate solar fractions, but rather low solar heat prices.

It is evident that this simplified procedure gives only indicative results. System dimensioning strongly depends on the climatic zone, the specific application, the customers and ST-ESCOs requirements. Several handbooks, but also software programmes are available for detailed considerations and dimensioning.

4.2.4 Success factors in the design of a solar plant

A solar plant will achieve good results if following factors are taken into account [Solarunterstützte Wärmenetze im Geschoßwohnbau, AEE, 2005]:

Low average collector temperature:

The system efficiency increases with the decrease of the collector operating temperature. Following aspects are crucial for maintaining low collector operating temperatures:

- proper integration and control of the boiler
- sufficient dimensions of the heat exchangers
- stratified solar tanks
- low return temperatures of the heat distribution system

Reduction of heat losses:

- piping should be as short and simple as possible
- A single and large storage tank has lower losses than many small tanks, due to a better area/volume ratio
- tanks and piping must be well insulated
- all other components (e.g. heat exchangers, pumps, thermometers, valves...) must be well insulated



Figure 4.7 Tanks and piping for a multi-tank and a single tank system (source AEE)

Radical reduction of investment and operation costs:

- The use of large (> 10 m²) flat-plate collector modules with selective coating, collector fields according to the low-flow principle as well as their roof or façade integration allow for major cost reductions. If possible advantage should be taken of additional benefits (e.g. use of the collector as shading element).
- Outside or underground piping create higher cost and system losses.
- The plant scheme and so its regulation system shall be kept as simple as possible in order to build robust and cost-effective plants.

4.2.5 Modular plants

A certain flexibility in the installation, disinstallation and modification of the solar heating plant can be of advantage for the ST-ESCO in numerous cases:

- construction of the object (e.g. residential houses) in several building phases
- reduction of the initial load due to an unforeseen event
- breakup of a contract with a customer

Both collector arrays and storages can be set-up in subunits which can be added or eliminated according to the new conditions. The cost of such modifications can be reduced, if appropriate connections and closing valves are foreseen right from the beginning.

The following example shows the principle of modularity for two systems with a large different in size but with the same design principles.

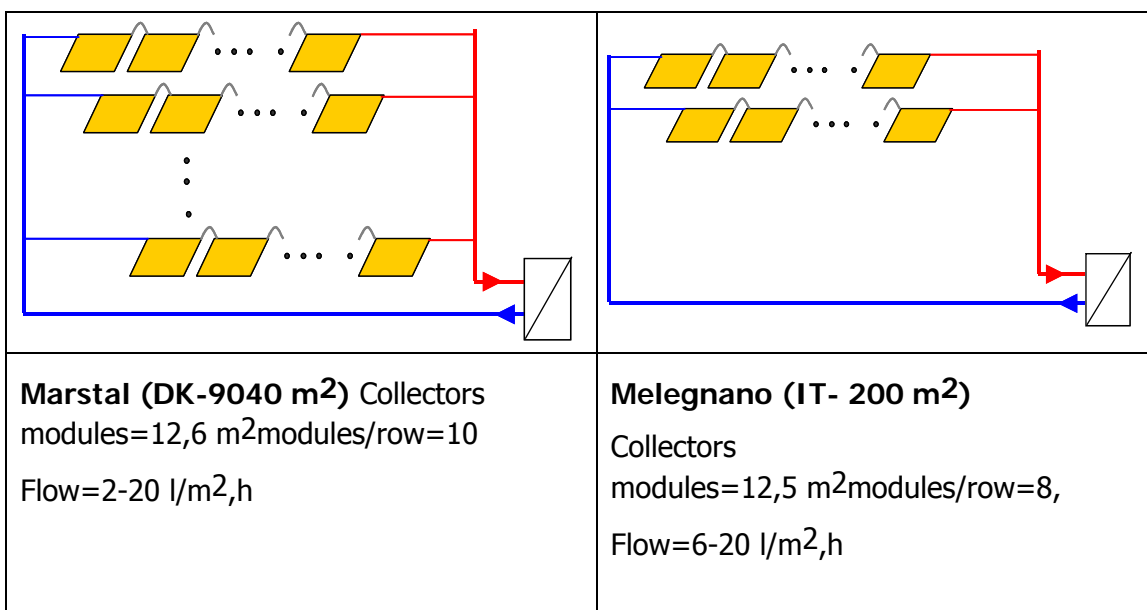


Figure 4.8: Similarity of the characteristics for two “Large” but different size plants

4.2.6 Operation and maintenance

from the CRES Procesol manual

Once the design and construction phases have been concluded properly, solar thermal plants require little maintenance in order to operate efficiently for their lifetime (estimated to be about 20 years) and the actions required are low cost. Apart from

pure **maintenance**, most of the necessary actions during the solar plant's operation are **periodic inspections**. They are listed in the table below, together with an indication as to their frequency:

| Maintenance or periodic inspection | Frequency | Comments/ clarifications |
|---|---|---|
| Condition of collector array | Once a year | Visual inspection of possible internal or external degradations (broken glass, loose-jointed frames and connections etc). Remove and replace broken or damaged parts. |
| Transfer fluid testing | Twice a year (before summer and winter) | Check the antifreeze solution percentage (by measuring its density) and the pH level (pH level should not fall below 7). |
| Pressure of the primary circuit should be constant | Twice a year or more often if easy | The inspection should be carried out when there is no incident radiation (e.g. in the evening time). |
| ΔT created by the collectors (during sunny hours) should be near the design value (e.g. about 20°C) | Twice a year | A higher value indicates a flow reduction due to obstacles or pumping problems. Lower values indicate either a too high flow or efficiency problems. |
| Collector temperature should be almost equal to the collector array outlet | Twice a year | These temperatures are near to each other. Differences in the controller indications are due to malfunction of the sensors or of the controller itself. |
| Primary circuit pump is off when there is no sun. | Twice a year | If not, there is some problem either with the sensors or the controller. |
| Presence of air in the primary circuit (noise) | Once a year | Remove trapped air – refill circuit at correct pressure (if needed). |
| Collector glass should not become dirty | Once a year | This is rare; glass needs to be cleaned only when very dirty and it has not rained for a long time. |
| Energy meter in "good operating conditions" should show more than about 3 kWh /m ² in one day | Twice a year or more often if easy | "Good operating conditions" here means a sunny day with normal heating load |

Table 4.1: List of maintenance actions and periodic inspections for solar plants

4.2.7 Failure check

Following table shows eventual failures of solar thermal plants and their possible causes.

| Malfunctioning | Possible cause |
|--|--|
| Pressure drop in the solar circuit | <ul style="list-style-type: none"> • solar liquid leakage • wrong dimensioning of the of the expansion vessel, solar liquid exits at the security valve • circuit breaking during a cold period |
| The pump does not start automatically | <ul style="list-style-type: none"> • no power is available • regulation system is turned off • maximum temperature has been reached in the storage tank • a temperature sensor is damaged • the pump is damaged |
| The pump starts automatically but no heat from the collectors is available | <ul style="list-style-type: none"> • one or more valves in the solar circuits are closed • air blocks the solar circuit • liquid turns to vapour in the collectors due to delayed start of the pump or to low flow in the circuit • the collectors' glasses are dirty |
| Delayed start of the pump | <ul style="list-style-type: none"> • wrong regulation settings • the temperature sensor in the collectors is damaged • the temperature sensor is not directly in contact with the absorber |
| The storage tank cools down quickly | <ul style="list-style-type: none"> • insulation has been installed in a wrong way • piping has not been insulated or has been insulated badly, causing thermosiphon effect in the pipes • the pump works during the night • the check-valve is damaged • the cooling is caused by the auxiliary heating system (check valve is damaged) • wrong regulation of the circulation pump |

Table 4.2: possible causes of malfunctioning

4.3 Recommended plant schemes

This clause presents several validated plant schemes for large domestic hot water systems and large combisystems. Each of them has its specific advantages referring to specific integration modes or applications.

Plant schemes can basically be subdivided into the following categories:

| Large solar domestic hot water plants | | | Large solar Combisystems | |
|---------------------------------------|------------------|---------------------|---------------------------|---------------------------|
| buffer and hot water tank | only buffer tank | only hot water tank | 2 – pipe distribution net | 4 – pipe distribution net |

Table 4.3: Plant categories subdivision

4.3.1 Large domestic hot water plants

4.3.1.1 Systems with buffer and hot water tank

Scheme A1: auxiliary heating in the buffer tank

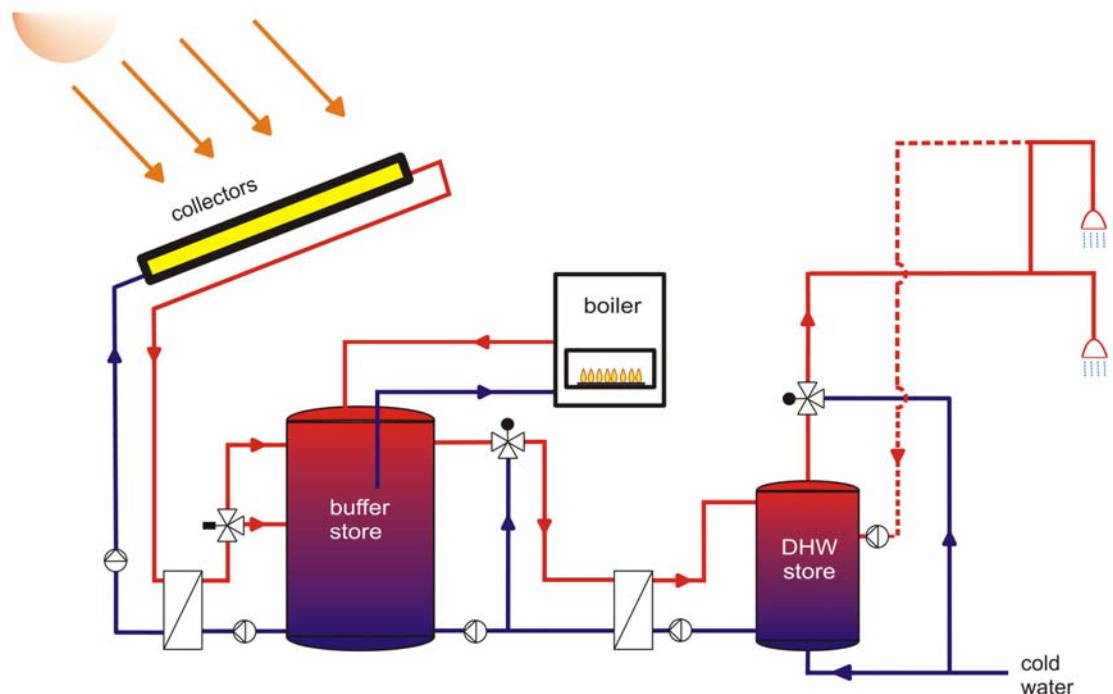


Figure 4.9: Plant scheme A1 - auxiliary heating in the buffer tank

- Storage tank:** the buffer tank (large volume at low cost) is directly heated by the collector circuit. This heat is transferred via heat exchanger to the domestic hot water tank. A cold water mixer avoids scaling in the heat exchanger.
- Auxiliary heating:** the auxiliary boiler feeds in the upper part of the buffer tank.
- Hot water:** hot water is prepared in the domestic hot water tank (low volume, DHW quality).
- Recommended:** this scheme can be used in new buildings with no high peak loads (e.g. multi-family houses)

Scheme A2: auxiliary heating between buffer and hot water tank

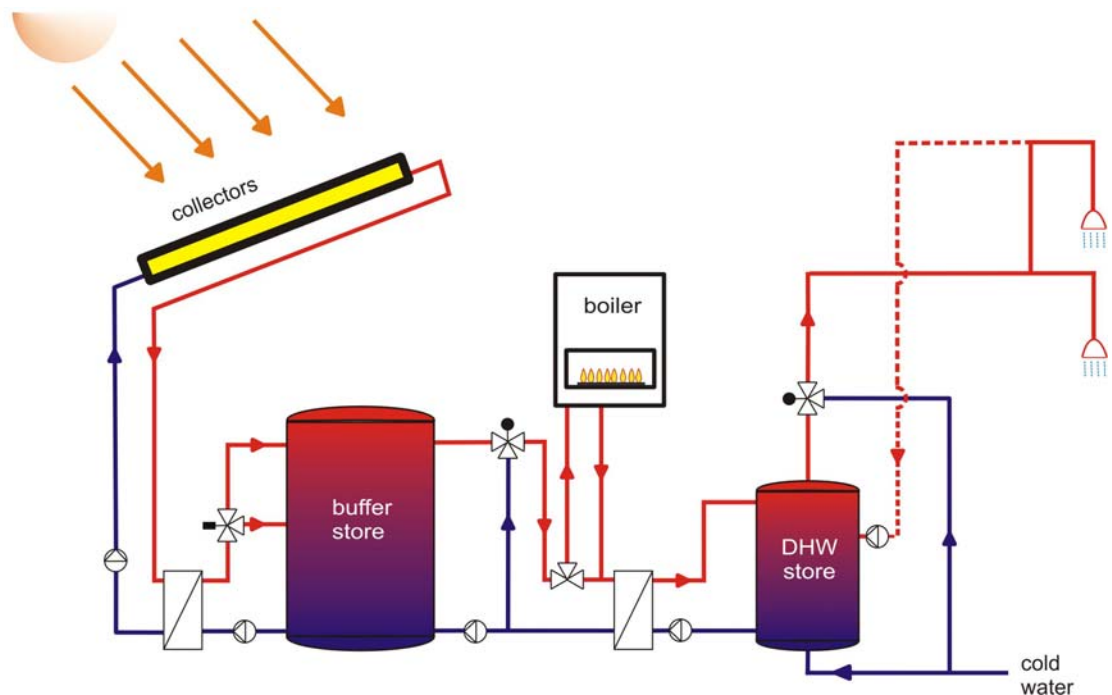


Figure 4.10: Plant scheme A2 - auxiliary heating between buffer and hot water tank

Like scheme A1, however, the boiler feeds directly into the charge circuit of the domestic hot water tank. The advantage of this configuration is that the boiler does not interfere with the heat and the stratification in the buffer storage.

Scheme A3: auxiliary heating in the hot water tank

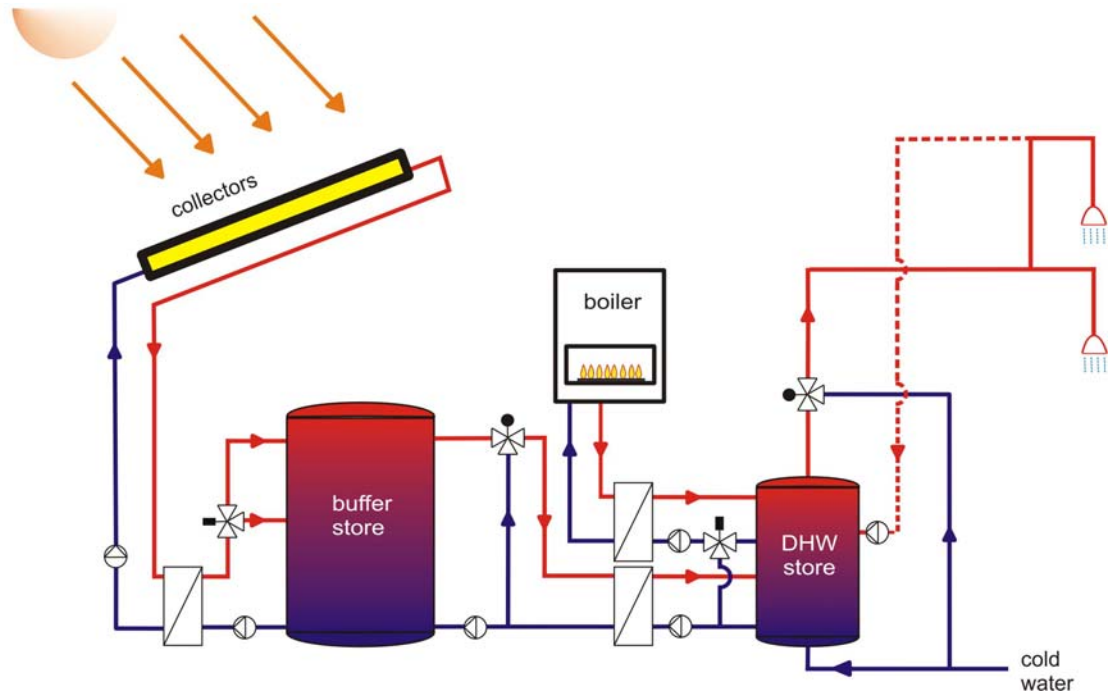


Figure 4.11: plant scheme A3 - auxiliary heating in the hot water tank

Like scheme A1, however, the boiler feeds directly into the domestic hot water storage. Disadvantages of this configuration are that an additional heat exchanger is needed between the boiler and the domestic hot water storage and that only a limited part of the domestic hot water storage is available for feeding in the solar heat.

Scheme A4: auxiliary heating in a second hot water tank

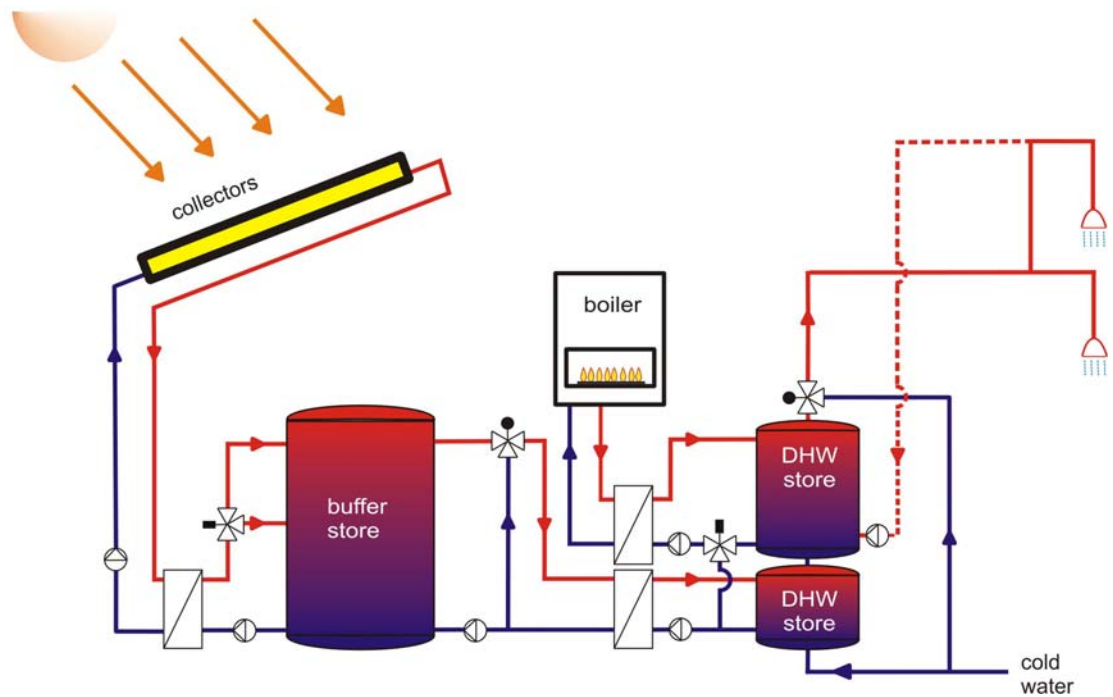


Figure 4.12: plant scheme A4 - auxiliary heating in the stratifying hot water tank

Like scheme A3, but with two separate domestic hot water tanks. This configuration is often used, when an already existing domestic hot water system is integrated with a solar heating plant.

4.3.1.2 Systems with instantaneous hot water preparation

Scheme B1: System with domestic hot water storage and instantaneous hot water pre-heating

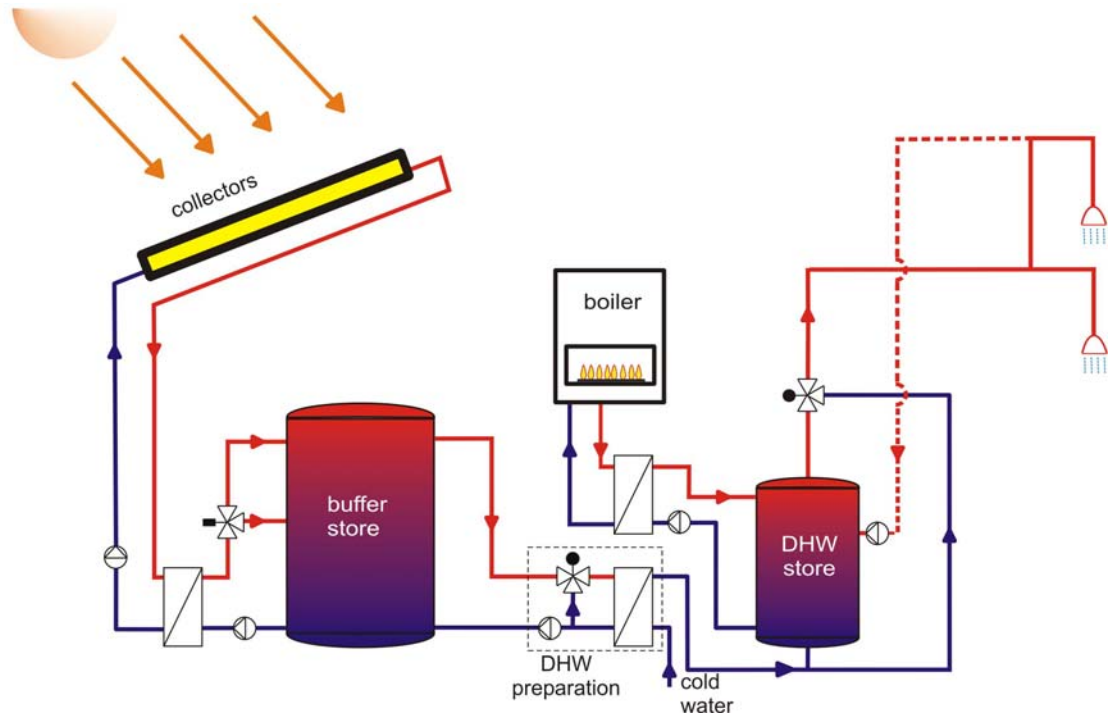


Figure 4.13: Plant scheme B1 - System with domestic hot water storage and instantaneous hot water pre-heating

- Storage tank:** the buffer tank is directly heated by the collector circuit. During draw-offs cold water at the inlet of the domestic hot water storage is pre-heated via a heat exchanger.
- Auxiliary heating:** the auxiliary boiler heats up directly the hot water tank via heat exchanger.
- Hot water:** hot water is prepared either with solar heat before the hot water tank or by the auxiliary heating inside of the hot water tank.
- Recommended:** This scheme is recommended for systems with relatively low solar fractions (pre-heating systems) and a fair distribution of draw-offs through out the day.

Scheme B2: System with buffer storage and instantaneous hot water preparation

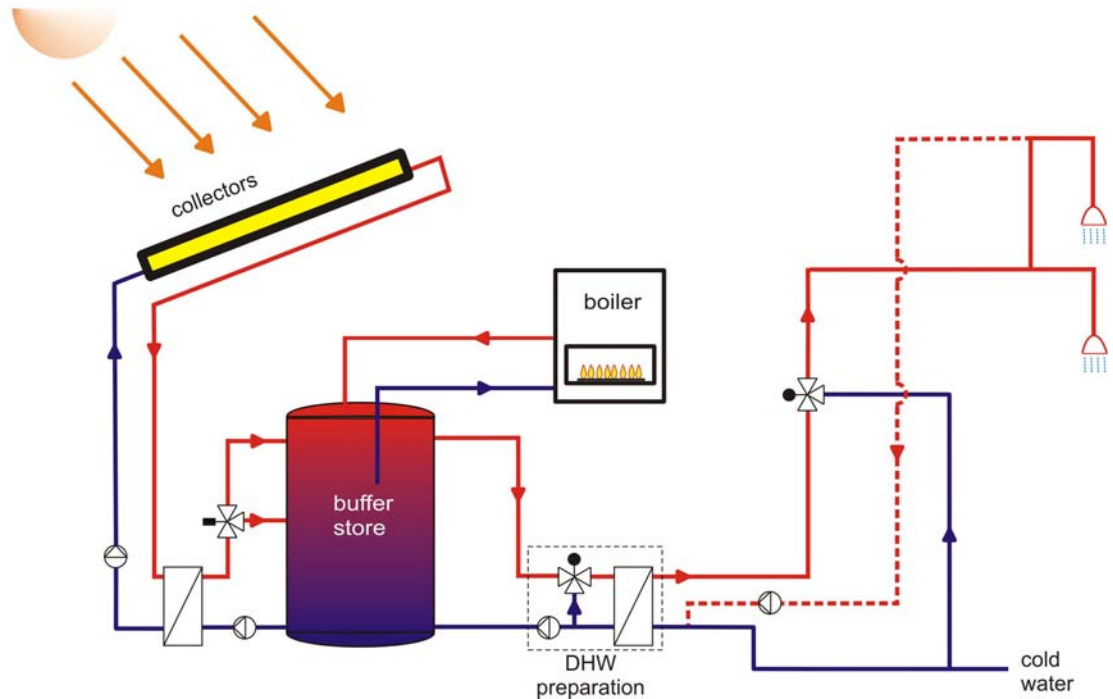


Figure 4.14: Plant scheme B2 - System with buffer storage and instantaneous hot water preparation

- | | |
|--------------------|---|
| Storage tank: | the buffer tank is directly heated by the collector circuit. |
| Auxiliary heating: | the auxiliary boiler heats up directly the buffer tank |
| Hot water: | hot water is instantaneously prepared via a heat exchanger. |
| Recommended: | this scheme safeguards a hygienic domestic hot water preparation. The heat exchanger for domestic hot water preparation becomes rather large and costly in case high draw-off flow-rates have to be provided. |

4.3.1.3 Systems with large domestic hot water storages

Scheme C.1: System with domestic hot water storage and no buffer

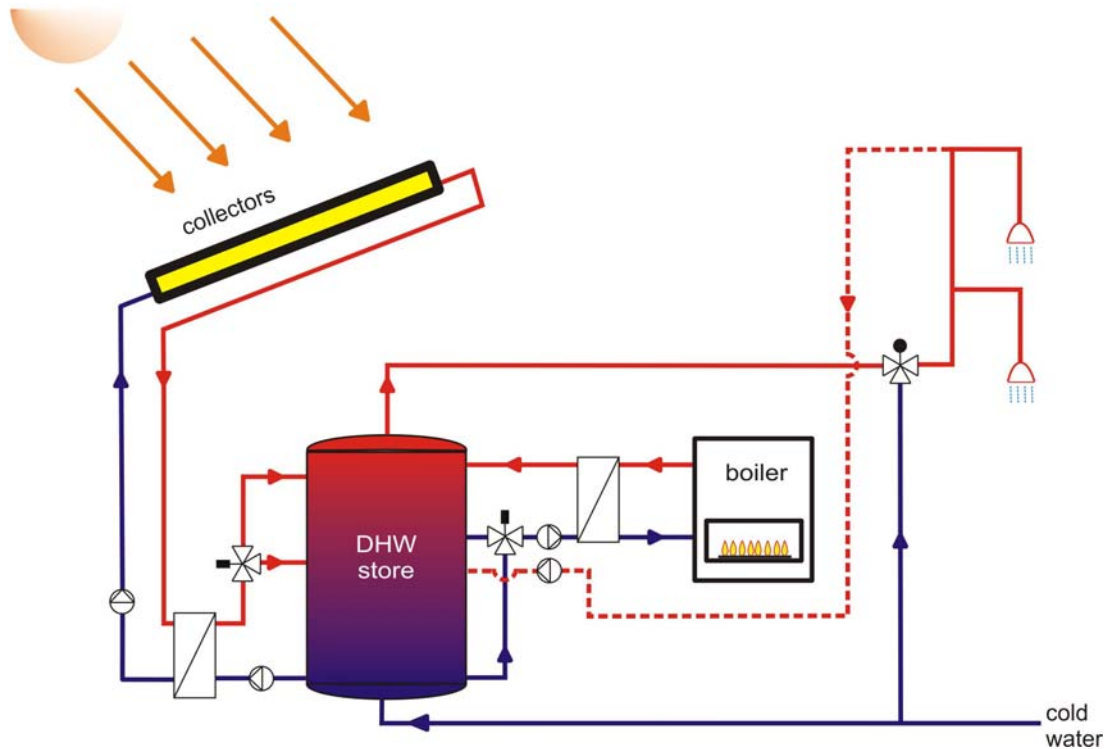


Figure 4.15: plant scheme C1 - System with domestic hot water storage and no buffer

- Auxiliary heating:** the auxiliary boiler heats up directly the hot water tank
- Hot water:** domestic hot water is directly heated by the collector circuit.
- Recommended:** the major advantage of this configuration is that very high draw-off rates can be realised, like they are for example necessary in hotels during the morning hours. Disadvantages are the rather high cost for large storages in domestic hot water quality. Thermal antilegionella disinfections has to be foreseen according to the national regulations.

4.3.2 Large solar combisystems

Scheme D1: Solar combisystem with heat distribution via a two-pipe net

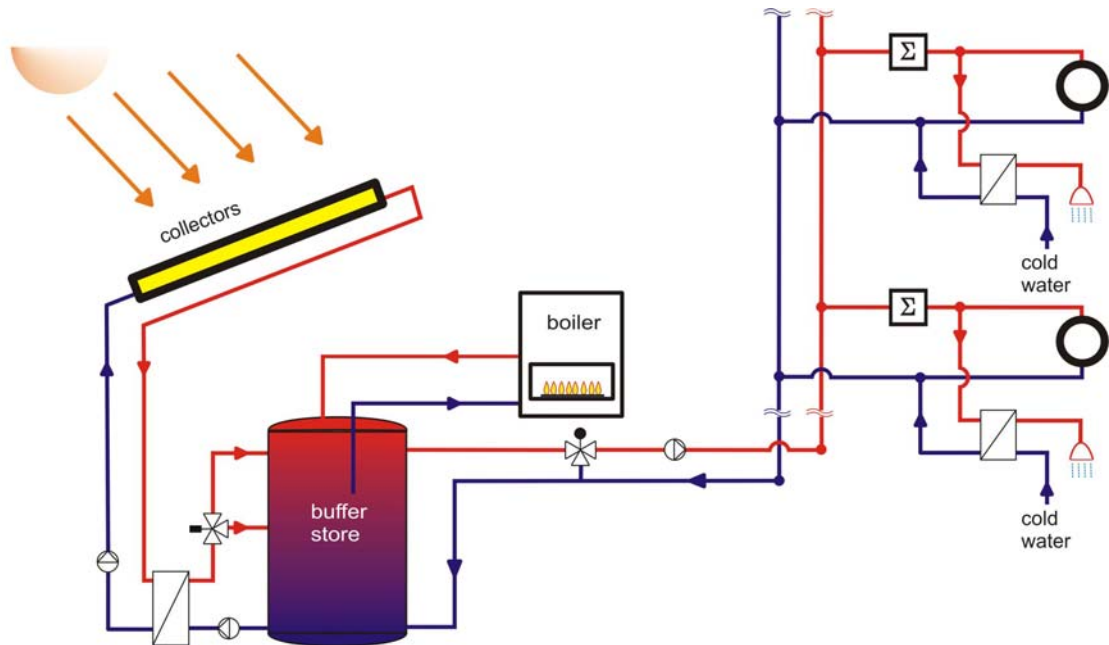


Figure 4.16: Plant scheme D1 - Solar combisystem with heat distribution via a two-pipe net

- Storage tank:** the collector circuit feeds into the buffer storage. Heating water flows into each apartment, where a substation is located. In the substation the heating water is directed to the space heating system and domestic hot water is produced via heat exchanger.
- Auxiliary heating:** the auxiliary boiler heats up directly the buffer tank
- Hot water:** hot water is prepared in the substations in each apartment.
- Recommended:** This configuration represents a very innovative solution especially for new constructions. Heat losses are reduced to a minimum due to the low number of circuits and lines.

Substations for two-pipes networks

The substation is integrated in a primary network providing heat from both, the solar and the conventional plant.

A part of the flow is diverted to the radiators of the apartment and to a heat exchanger for the heating of hot tap water. The rest of the flow continues its way to the other substations.

This solution can be adopted with a two-pipes network to integrate solar energy in both, space heating and hot tap water heating.



Picture 4.1: Substation for a two-pipes distribution network (source: AEE INTEC)

Scheme D2: Solar combisystem with heat distribution via a two-pipe net and small domestic hot water storages in each apartment

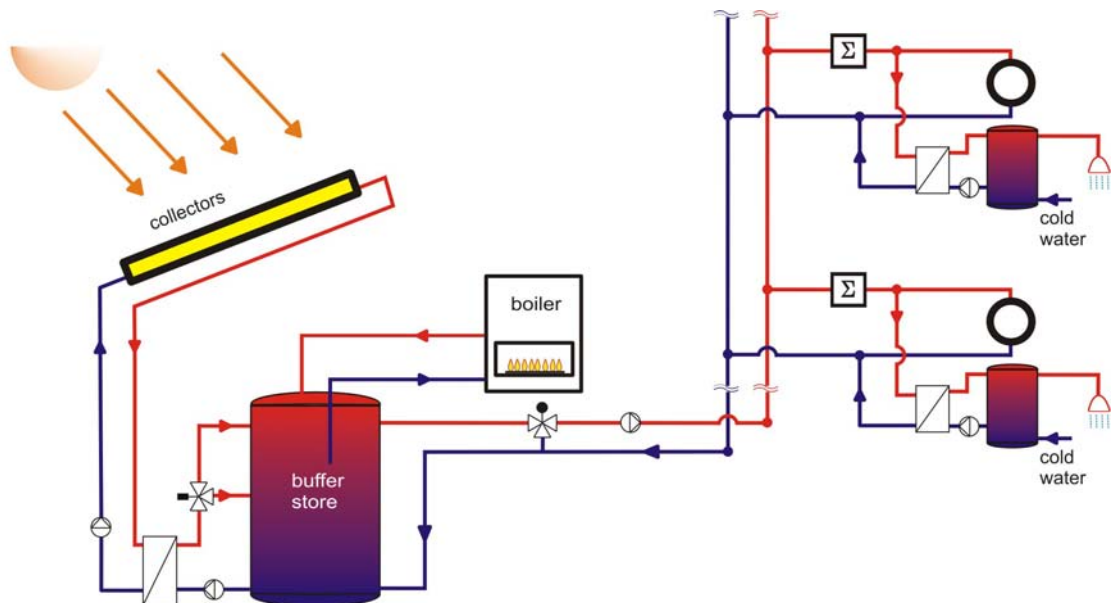


Figure 4.17: Solar combisystem with heat distribution via a two-pipe net and small domestic hot water storages in each apartment

Like D1 but with small domestic hot water storages in each apartment. This configuration is recommended in climatic zones, where the heating season is short.

The additional storages allow to reduce the distribution network operation time during the summer period and thus to reduce its heat losses. The storages are charged 2 to 3 times a day. Emergency heating resistances in the storages guarantee hot water at any time of the day.

Scheme D3: Solar combisystem with heat distribution via a four-pipe net

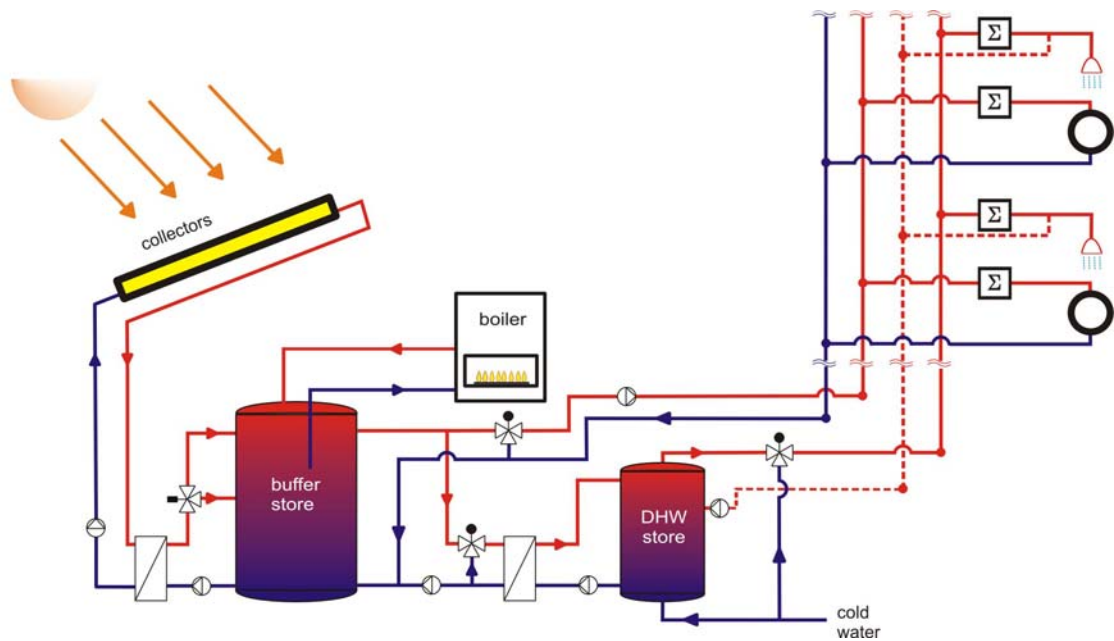


Figure 4.18: Solar combisystem with heat distribution via a four-pipe net

- Storage tank: the collector circuit heats up the buffer tank, from where space heating is provided for each apartment
- Auxiliary heating: the auxiliary boiler heats up directly the buffer tank
- Hot water: domestic hot water is heated via a charge circuit between the buffer tank and the domestic hot water storage and from there it is directly supplied to the apartments in separate tubes.
- Recommended: this scheme is suitable for existing buildings with already existing supply lines.

4.4 “Solar Focused” Audit Procedure

The boundary conditions, under which a ST-ESCO will need to consider and to decide about the installation and operation of a solar heating plant, will be rather variable. Processes will be different for a large ground mounted plant feeding into a district heating net than for a system, mounted on a residential building. Nevertheless ST-ESCO need a structured and reliable solar focused audit procedure as technical base for feasibility studies, decision making and planning. The audit procedure presented in this section recommends the following steps:

1. At first, the initiator of the ST-ESCO project, this can be the object owner or the ST-ESCO itself, carries out a **base data collection** in order to get an overview on the general situation and possibilities for installing a solar thermal plant and for entering as a ST-ESCO into the project
2. An **energy concept** for the object is elaborated, presenting the integration of the solar heating plant with other renewable energy, energy efficiency and conventional technologies.
3. A **visit to the object** or construction site is organized together with all partners involved in the realization of the project.
4. If necessary a **short term measuring program** (6 - 8 weeks) is carried out in order to verify the load assumptions made in the base data collection

This audit procedure follows the procedure used within the German large scale solar heating plant RTD program 'Solarthermie2000plus' (www.solarthermie2000plus.de) for evaluating the feasibility of new demonstration plant proposals.

4.4.1 Base data collection

The base data collection is performed by means of the questionnaires presented in annex 2 and 3 of this guide. The scope of the questionnaire covers domestic hot water systems and solar combisystems for single buildings and building groups.

Similar questionnaires for solar air conditioning systems and solar district heating system are available under www.solarthermie2000plus.de/st2kplus/index.php (in German language).

4.4.2 Energy concept

Innovative heat supply requires an individual integrated planning of the energy concept for the object in question (building, industry or other), which finds an optimum balance between energy saving, energy efficiency and renewable energy use. The size of the solar thermal system depends on its rank in the whole concept. The ST-ESCO need to consider, whether it will limit itself on the solar part or whether it will extend it services

to other parts of the energy concept (e.g. the whole heating central including a biomass boiler, a conventional backup-boiler plus the solar heating plant).

The energy concept covers following aspects:

1. description of all measures included in the energy concept
2. calculation of the heat demand considering the insulation standard, energy saving and passive solar measures
3. covering fractions by the solar heating plant as well as other renewable or conventional heat generators
4. dimensions of the major solar heating plant components
5. definition of the interfaces between the parts of the heating system operated by the ST-ESCO and those operated by other parties

The MEVGAL project included energy efficiency as well in the form of heat recovery on the steam plants. See respective best practice example (chapter 5.1.4).

4.4.3 Visit to the object

In case the base data collection and the energy concept demonstrate interesting boundary conditions for entering as ST-ESCO into the project a visit to the object or construction site and a meeting with all partners involved in the realization of the project is organized. The purpose of this visit is to clarify still open questions of the questionnaire and the energy concept, but also to get a general appraisal of the object and of the project as a whole.

4.4.4 Short term measuring program

In case of a further positive assessment of the project, it is recommended to perform a short term measuring program of 6 to 8 weeks. For this period the heat consumption of all consumers that will be connected to the solar heating plant will be monitored. These measurements allow verifying and, if necessary to adapt the energy concept, the foreseen solar fraction and solar heating plant size to the real load.

4.5 Crucial Aspects of Measurement and Verification (M&V) Procedures

Examine crucial aspects of measurement and verification (M&V) procedures.

4.5.1 Objective of plant measurement and verification (M&V)

ST-ESCOs operate and maintain solar plants on longer periods and bill the produced solar heat to the customer. This role of the ST-ESCO implies particular objectives and requirements on the measurement and verification procedure applied to the solar heating systems.

The specific objectives of M&V are:

1. cost effective control of the plant
2. monitoring of an optimal plant operation
3. measurement of the heat to be billed to the customer
4. rapid fault detection

Corresponding requirements are

- ad 1. remote availability of data of the system status and remote access to the controller parameters
- ad 2. e.g. daily measurement of the crucial quantities and comparison with expected values
- ad 3. certified heat meters with sufficient accuracy (see clause 2.4.2)
- ad 4. fault analysis routines incorporated in the controller software

4.5.2 Simple plant tele-monitoring and control techniques

4.5.2.1 Controllers used for large solar heating plants

The control of solar heating plants is in general not complicated; however, several particularities regarding their control strategies have to be taken into account and obeyed in order to safeguard an optimal operation.

In principle two type of controllers can be used for solar heating plants:

- freely programmable mainframe controllers
- freely programmable solar controllers

Mainframe controllers offer the maximum freedom regarding their configuration and extension to data acquisition, processing and remote access. However, in many cases the choice of this type of controller led to practical operation problems, since the solar specific particularities were not satisfactorily programmed due to the lack of expert knowledge of the programming personnel.

Freely programmable solar controllers, produced by specialised manufacturers, offer pre-configured routines for these particularities and thus ensure a more robust operation. Several commercial products are available and extendable for data acquisition, processing and remote access.

4.5.2.2 Solar radiation measurement

Solar radiation is the basic energy input to the solar heating system and needs to be measured, in order to assess the heat output of the system. Radiation data are mainly used for daily, monthly or yearly system yield verifications, therefore no high-level measurements are needed

In most cases, only total radiation is measured (no separation of beam and diffuse radiation).

Two sensor types are available on the market:

- PV sensors, which due to their wavelength-dependent sensitivity have a rather limited accuracy
- Pyranometers working more accurate based on a thermal effect. The accuracy classes are defined in ISO 9060 resulting in accuracies for the measured daily radiation of approximately $\pm 3\%$ for secondary standard, $\pm 5\%$ for first class instruments and $\pm 10\%$ for second class instruments. Pyranometers are sensitive against sensor pollution and have to be cleaned at regular intervals, depending on the actual and local pollution conditions.

An alternative to radiation measurements can be data obtained from satellite pictures. These data can show high deviations for instantaneous measurements but produce fairly good agreements on a monthly base. Accuracies versus ground measured data of $< 5\%$ are reported. A satellite radiation data base was developed under the Satel-Light project www.satel-light.com.

4.5.2.3 Temperature measurement

The availability of temperature measurements at several locations within the system are useful for detecting possible faults and error sources (e.g. too high return temperatures of the collector field circuit).

Most commonly used temperature sensors are Platinum-resistance-thermometers of the PT 100, PT 500 or the PT 1000 class. Basic recommendations for the installation of temperature sensors are:

- Sensors must be in good thermal contact with the measuring medium (well insulated immersion sensors rather than clamp-on)
- Sensors and cables installed in the collector circuit should be resistant up to 200 °C
- 2-wire-cables are sufficient for control purposes. For measuring purposes 4-wire-cables are recommended, in order to eliminate cable length influence.

4.5.2.4 Heat metering

The ultrasonic heat meters are the technical state-of-the-art today: they contain no moving parts, are therefore non-wearing and have long durability, and that means little maintenance costs for the ESCO.

The heat energy transported in a pipe is measured by means of the following formula: $Q_p = V_p \times \rho \times c_p \times \Delta T$. So, the heat meters have fixed values for ρ and c_p (it is essential to input the correct volume fraction of antifreeze!), and they measure V_p and ΔT via supply and return temperatures. The V_p is measured without any moving part by an ultrasonic pulse (measurement of the signal transition time), the temperatures are usually measured with PT100 or PT500 temperature sensors, depending on the specific model.

The measurement error of an ultrasonic heat meter depends on the values of V_p and ΔT , hence it is important to choose the correct size (nominal V_p value) of the heat meter in advance (the higher the V_p for a certain sized heat meter, the lower the measurement error). The standard in force that defines the maximum error allowed for a heat meter is the EN 1434, but a good heat meter has about half the error defined in the European standard.

In Austria the most commonly employed heat meters manufacturers are Landis & Gyr (e.g. 2WR5 type; Landis & Gyr are identical in construction with the Siemens heat meters) and Kamstrup (e.g. Multical series). Both manufacturers produce the same type of heat meters and are very reliable from a technical point of view. Heat meters need to be calibrated to the local conditions (like every temperature sensor in the solar plant) and then need to be re-calibrated by the manufacturer about once every five years. The heat meters should be M-Bus-capable; this system connects the heat meters with the solar plant control and is a defined protocol for reading the solar energy yield.

4.5.2.5 Pump and valve status monitoring

In case time series are taken from radiation and temperature data, it is recommended to also monitor the status of pumps and valves in order to identify any controller strategy mismatch.

4.5.2.6 Online functioning verification

Most controllers have the feature for an online plant functioning verification, i.e. relevant temperatures and statuses are continuously verified against functioning criteria implemented in the controller software. In case one of the criteria is not matched a warning is sent to the plant operator, in order to immediately recognize any operation problem. Examples for such criteria are:

- significant irradiance, but the pump is deactivated
- night time, but the pump is activated or the collector is warm
- the pump is activated and the temperature difference between flow and return pipe of the collector circuit are excessive
- the pump is activated and the temperature difference between collector and collector circuit flow pipe are excessive
- the system pressure is low (if measured)

4.5.2.7 Daily plant yield verification

A plot of the daily plant yield versus the daily radiation allows for a simple verification of the plant efficiency. During regular operation periods, measuring points should row up close to a linear dependency of these two quantities. Reasons for low measured plant yield can be either days with significantly lower heat loads than expected or plant operation problems. In both cases the ESCO should be notified in order to verify the cause.

Programmes like TSOL or TRNSYS allow to produce more refined correlations between the expected system yield, the radiation, the load and other relevant quantities. Such correlation allow to better assess the actual efficiency of solar heating systems. This kind of verification can be automated and implemented into the controller software.

5 Best Practices – Recommendations

5.1 Best Practice Examples

Detailed description of Best-practice examples

5.1.1 Stadium Liebenau Graz

The solar plant at the “Arnold Schwarzenegger Stadium” Graz (Austria) was put into operation in June 2002 and can be considered as the pilot project of feeding solar thermal energy directly into a district heating system. From the technical point of view, the main reason for the construction of the solar system was to develop and optimise the engineering for feeding solar energy into an urban district heating net. As a result, this solar plant is Europe’s Premiere for solar district heating.



Technical aspects

The solar collectors were mounted on a steel substructure on the roof of the skating hall of the Arnold Schwarzenegger Stadium in Graz. The collector area of 1,407 m² is arranged in 11 rows, each bearing 9 collectors in series. The employed collectors are 14.3 m² large area flat plate collectors of the type “Gluatmugl”. These collectors are especially designed for high temperature use, which means that they have increased insulation in order to lower heat losses below approx. 3.0 W/m²*K. The gained solar energy output reaches about 560-600 MWh per year (Graz has a yearly solar radiation of 1130 kWh/m²).

The district heating net in Graz has a minimum consumption of 10 MW also in summertime, and this solar plant reaches a maximum output of about 800 kW. The solar energy is directly transmitted to the heating net by an external heat exchanger. Large storage tanks are not necessary due to the constant energy consumption. Concerning CO₂-emissions, this plant saves about 250 tons CO₂ a year when compared with an oil fired boiler with a total efficiency of 70 %.

Economical aspects and partners

The plant is operated and financed via a third-party financing model. This pilot project is moreover supported by the city of Graz, the Steirische Wirtschaftsförderung and the Kommunalkredit Austria.

The project was developed in collaboration of the following 3 partners:

- S.O.L.I.D. Gesellschaft für Solarinstallation & Design mbH
- nahwaerme.at Energiecontracting GmbH & CoKG
- ÖkoTech Produktionsgesellschaft für Umwelttechnik mbH

S.O.L.I.D. was responsible for the design and the construction of the plant. The company nahwaerme.at took over the financing and operation of the plant by a third-party financing concept. The collectors were produced and mounted by the company ÖkoTech (Graz), they received the Austrian Environmental Award.

As this project is based on a third-party financing model, the operating company nahwaerme.at took over the total costs of construction including the integration in the district heating net. The operating costs of the solar plant (e.g. maintenance, power etc.) are also taken over by the operating company.

Between the company nahwaerme.at and the stadium administration a user agreement for the roof was signed. Also, between nahwaerme.at and the Grazer Stadtwerke (district heating section) a heat delivery contract concerning the feeding of solar heat into the district heating net was signed. The duration of the contract is 15 years with an option of prolongation.

Project development

The first concept of this project was made by the general managers of S.O.L.I.D. Gesellschaft für Solarinstallation & Design mbH, nahwaerme.at Energiecontracting GmbH & Co KG and ÖkoTech Produktionsgesellschaft für Umwelttechnik mbH at the beginning of 2001. Then first contacts to the energy and environmental referee, the stadium administration and the district heating section of the Grazer Stadtwerke (non-ST ESCO running the district heating system) were established, followed by contacts to financial support institutions. After promise of financial support by the state of Austria and the city of Graz the detailed planning began in autumn 2001. The project was promoted from the beginning by the energy and environmental referee of the city Graz. Due to the good co-operation with the partner companies and subcontractors, the construction of the plant was finished by mid of June 2002.

5.1.2 Solar plant “Berliner Ring”

The “Berliner Ring” is a residential area in Graz-Ragnitz (Austria). It consists of 25 multi-storey buildings which comprise 756 apartments. Before the installation of the

solar system, hot water preparation and heating were entirely done by fuel oil. The total consumption amounted to about 1 million of light fuel oil per year. Yet, the reasons for the construction of the plants are not only economical (high consumption of fossil fuels with the old system), but also include economical and environmental aspects.

Technical aspects

On the roof of selected buildings of the "Berliner Ring" residential area, a solar thermal plant was constructed. A second part of the plant is currently yet under construction, and a third part is in the planning phase. The completed part of the system amounts to 479 m². When completed, the collector area of the solar system totals approx. 2600 m². The system is then expected to deliver approx. 1 GWh of solar thermal energy to the district heating net per year. The same amount of energy would free approx. 375 tons of CO₂ when supplied with an oil fired boiler with a total efficiency of 70 %. Primarily, the solar plant feeds the local district heating system; in the case of surplus energy available from the collectors, the solar output is fed into the large-area district heating system of the city of Graz.

Economical aspects and partners

The plant is operated and financed via a third-party financing model. The project was developed in collaboration of the following 3 partners:

- S.O.L.I.D. Gesellschaft für Solarinstallation & Design mbH
- nahwaerme.at Energiecontracting GmbH & CoKG
- ÖkoTech Produktionsgesellschaft für Umwelttechnik mbH

S.O.L.I.D. was responsible for the design and the construction of the plant. The company nahwaerme.at took over the financing and operation of the plant by a third-party financing concept. The collectors were produced and mounted by the company ÖkoTech (Graz), they received the Austrian Environmental Award. As this project is based on a Third-Party-Financing Model the total investment costs for the construction including the integration in the district heating net were borne by the operating company nahwaerme.at.

Project development

The energy supply in the district heating net is provided by the company Wärme-Direkt-Service (WDS) of the Energie Graz (the local non-ST ESCO). WDS takes the energy either from nahwaerme.at or from the large-area district heating system of Energie Graz.

Heat supply contracts are signed between nahwaerme.at, Energie Graz and WDS. In these contracts, the details regarding the feeding of the district heating nets are laid

down. Moreover, a contract is signed with the homeowner community in order to manage the usage of the roof areas.

5.1.3 Friedrich Schiller Dormitory

General Presentation

The Friedrich Schiller dormitory has been renovated and enlarged with an extension in autumn 2001. The target was to reduce energy costs and costs of operation with the installation of a solar plant with 116 m² collector area. The solar plant prepares the domestic hot water with support of the district heating net. In sum 103 dormitory rooms (20 new built and 83 renovated rooms) with 72 washrooms are connected to a central domestic hot water system.



Technical Aspects

Measures:

- Renovation and extension of the dormitory
- Third party financing model
- Design and installation of the solar plant
- Installation of the thermo technical equipment incl. domestic hot water system
- Operation management
- Implementation of an energy controlling system

Results:

- Guaranteed annual solar yield: 301 kWh/m² with an annual domestic hot water use of 819 m³ (with 55 C°).
- Investment costs: 93430 Euro
- Annual contracting rate: 2538 Euro excl. VAT
- Inception of contract: 01.09.2001

- Expiration of contract: 31.08.2016
- Duration of contract: 15 years
- Reduction of CO₂ emissions per year: 9 t
- Fixed hot water price: 1,438 Euro/m³ (excl. VAT)

Contractual aspects

The ESCO assumes operation management, service and maintenance of the plant parts inserted by the ESCO. The financing of the solar plant has been carried out by the management of the dormitory, the contractor did not pre-finance the plant. The solar yield is guaranteed and a measurement concept for account and providing evidence of the solar yield was arranged. The annual base price is the payment for the following benefits of the contractor: technical operation management, implementation and operation of an energy controlling system, guarantee etc.

The energy price includes the consumption-bound costs (district heat and electricity).

5.1.4 Mevgal solar thermal and heat recovery installation

General Presentation

The project regards a TPF action in "Mevgal S.A." industry for a solar thermal application combined with a heat recovery measure.

Mevgal S.A. is a dairy industry situated in Northern Hellas (between Thessaloniki and Giannitsa).

The heating requirements (mainly for pasteurisation and cleaning) are covered by a steam network. The steam boilers are running on heavy oil and are fed by cold water; daily water requirements are about 75 m³.

Technical Aspects

The total collectors area is 727m². A combination of three collectors types has been used: selective flat plate (403m²), black painted flat plate (216m²) and 108m² of CPC (Compound Parabolic Concentrators).

The heat produced by the collectors' field is used to preheat the water feeding the



steam boiler. Two accumulators are used with a total volume of 10 m³.

The mean annual value for the total solar gain is about 270 MWh.

The solar plant is only a part of an installation which includes a heat recovery system from the steam boilers blow-down.

Thermal energy savings are split as follows: 30% from solar and 70% from the blow-down heat recovery system.

Contractual aspects

The project was financed (with a TPF scheme) in the frame of a national programme (Operational Programme of Energy 1994 – 1999) and CRES was the contractor of the project. The bodies of project implementation were CRES and MEVGAL S.A. The system is in operation from 1999. Subcontractor for the installation of the whole system was the company Intersolar S.A.

The operation and maintenance of the system has been arranged by a private agreement between CRES and MEVGAL S.A. Based on this agreement, CRES has the responsibility of system's monitoring, operation, service and energy measurements. Once the payback period has been completed, the system will become exclusive property of the End-User. The contract agreement sets the kWhth price to be equal to the cost of the kWhth produced by the cheapest conventional fuel available (a continuously updated value). The total TPF investment for the whole application (solar plant and heat recovery measure), was about 130000 €. The mean annual energy savings are about 900 MWh and the price for each MWh equal to 25 € (in year 2005).

5.2 Examples and Analysis of Failure

One practical technical aspect learned is the following: the person responsible for the maintenance (from the ST-ESCO's side) should have relatively easy access to the plant (e.g. up to 100 km distance). Delegate this responsibility to a third person is possible only if he is an expert on solar thermal plants. The same is valid for the operational responsibility: count on a third person (e.g. a technician from the End-user's side) for crucial technical operational aspects, could generally create problems.

One "lesson learned" concerning formal aspects is that there must be a guarantee in an ST-ESCOs contract in the case the End-User is unable to pay (e.g. bankrupted). This problem could be overtaken with a "Bank Guarantee" initially provided by the End-User.

From a technical point of view, the most common example of failure is an incorrect freezing protection. This is, most often, strongly connected with the stagnation protection of solar thermal plants.

What happens during stagnation (i.e. the condition of available solar radiation but no thermal load), in brief, is that the antifreeze primary loop liquid becomes a vapor and, consequently, the pressure increases. If the system is not designed properly, some relief valves may open (due to the high pressure), thus resulting to some loss of antifreeze liquid. If there is an automatic refill valve (as unfortunately happens in many solar systems), this will cause the introduction of water into the primary circuit, thus decreasing dramatically its antifreezing properties.

The correct dimensioning of the solar plant components in order to face stagnation, the absence of any automatic refill valve in the primary circuit and the use of the correct antifreeze liquid are the measures to take in order to avoid the above problem.

5.3 ST-ESCOs Accreditation and Appropriate Qualifications of ST-ESCOs Personnel

Recommendations for ST-ESCOs accreditation and the appropriate qualifications of ST-ESCOs personnel

5.3.1 Definition of minimum requirements for accreditation and qualification

Following ESCO accreditation criteria are listed.

An ESCO, in order to be accredited should:

- present in a precise way its full range of activities & measures offered to the client
- present a reference list with a number of similar plants, i.e. solar thermal installations technically like the tendered one (same kind of application which may be DHW and space heating, or district heating, or ...). The installations included in the reference may only count if they are built by the same supplier, i.e. they use the same technical solution in detail.
- comply with ethical business practices
- fulfil quality specifications of project planning (basic & detailed), project management and procedure handling
- have capital's sufficiency
- have technical faculty for maintenance and retrofitting
- offer specific maintenance contracts

- be capable for metering, monitoring & verifying energy – cost savings
- carry the technical, operational & economic risks of the project
- perform specialized training and transfer know-how to end-user's staff
- offer at least the contracting typologies that are most common in the Country

The ESCO is asked to show that it has sufficient knowledge and experience to successfully work in all the above topics.

5.3.2 Guidelines on quality certification/labels

5.3.2.1 for components and types of systems to be used

The standards' state of art at European and international level is as follows: mainly CEN standards are implemented in Europe. In other countries, apart from CEN, the ISO standards are also used.

A list of the applicable standards (as of March 2006) is presented in Annex 4.

It is worth mentioning that an increasing number of manufacturers are choosing to label their solar collectors with the "SOLAR KEYMARK". This voluntary mark has been developed by CEN, together with the European Solar Thermal Industry Federation (ESTIF). It aims at combining the EN 12975 and EN 12976 for testing solar thermal collectors with other quality issues, such as the factory production control (more information at www.solarkeymark.org)

Certainly, the CE mark (ensuring safety) should be a minimum requirement for components used by an ST-ESCO. However, reports according CEN standards and and/or solar key mark would increase the credibility of the ST-ESCO companies and will be, in any case, a useful tool for the energy calculations at the system design stage.

Finally, for those components that are common to conventional hydraulic installations (pumps, expansion vessel, valves etc.) there exist already mandatory quality requirements that have to be applied.

Specific aspects for Hellas

Hellas, being a member of EC, follows CEN standards (through its national standardization body – ELOT) regarding collectors (standards' series EN 12975), factory made systems (EN 12976) and custom built systems (EN 12977 – under development).

All test reports in Hellas are carried out according to the above mentioned standards and issued by the National research centre "Democritos". Test reports are mandatory in order for a company to become member of EBHE (Hellenic Association of Solar Industries).

5.3.2.2 for measurement procedures

The international performance measurement and verification protocol (IPMVP) might be a good approach to standardize the internationally different ways to measure the energy output of a solar thermal (TPF) project. However, the complexity in the implementation of such a measurement protocol must not create expenses which make the system economically unattractive or much more difficult to implement. An internationally similar approach to the monitoring and verification of a solar thermal plant might also be an important topic when it comes to homogeneous European guidelines and subsidies for TPF solar thermal projects.

5.3.3 Additional aspects

In order to ensure good quality ST-ESCO installations some quality criteria (if there are any) regarding installers and installations should be implemented. For example, in France, to obtain subsidies for solar thermal plants, the installer should be certified according to the "Qualisol" mark. "Qualisol" is a voluntary quality mark, which the installer could achieve after a specific and standardised training course. Even though the mark is voluntary, since it is so strictly linked to subsidies, it has become more or less mandatory and now about 10.000 installers in France have the "Qualisol" mark.

6 Further Sources of Information

<http://www.cres.gr/st-escos/>

Homepage of the project Solar Thermal-ESCOs

<http://www.estif.org/>

ESTIF engages in many different issues relevant to the solar thermal industry - from lobbying for favourable legislative framework conditions to work on standards & certification.

<http://www.iea.org/>

An intergovernmental body committed to advancing security of energy supply, economic growth and environmental sustainability through energy policy co-operation.

<http://www.iea-shc.org/>

This site is designed to describe the activities of the International Energy Agency Solar Heating and Cooling Programme to web users.

www.iea-shc.org/task25/index.html

IEA SH&C Solar air conditioning

www.iea-shc.org/task33/index.html

IEA SH&C Solar process heat

www.solarge.org

Solarge - Enlarging solar thermal systems in multi-family houses, hotels, public and social buildings in Europe

www.enerma.cit.chalmers.se/default_e.htm - projects

ELSSHN - European Large Scale Solar Heating Network

<http://www.soltherm.org/>

The Soltherm Europe Initiative is an action network with the goal to make a contribution to the further market expansion of solar thermal collectors in Europe.

In German:

<http://www.austriasolar.at/>

Austria Solar is an association which represents the leading solar thermal industry in Austria. This website includes information about the usage of solar thermal energy for one-family houses, multifamily residences and tourism industry.

www.solarthermie2000plus.de

'Solarthermie2000plus' is a German large scale solar heating plant RTD program for evaluating the feasibility of new demonstration plant proposals.

In Italian:

<http://www.autorita.energia.it/>

The web site of AEEG, the Italian Authority for Electricity and Gas, in charge of managing the ESCOs and the White Certificates system in Italy.

<http://www.mercatoelettrico.org/>

The web site of the Electricity Market Manager, where the White Certificates are sold. Here information on average prices and availability of White Certificates could be found.