Final Deliverable report for C6 activity

Contracting Models for Solar Thermally Driven Cooling and Heating Systems

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IEA Solar Heating and Cooling Program

The *International Energy Agency* (IEA) is an autonomous body within the framework of the Organization for Economic Co-operation and Development (OECD) based in Paris. Established in 1974 after the first "oil shock," the IEA is committed to carrying out a comprehensive program of energy cooperation among its members and the Commission of the European Communities.

The IEA provides a legal framework, through IEA Implementing Agreements such as the *Solar Heating and Cooling Agreement*, for international collaboration in energy technology research and development (R&D) and deployment. This IEA experience has proved that such collaboration contributes significantly to faster technological progress, while reducing costs; to eliminating technological risks and duplication of efforts; and to creating numerous other benefits, such as swifter expansion of the knowledge base and easier harmonization of standards.

The *Solar Heating and Cooling Programme* was one of the first IEA Implementing Agreements to be established. Since 1977, its members have been collaborating to advance active solar and passive solar and their application in buildings and other areas, such as agriculture and industry. Current members are:

Australia	Finland	Singapore
Austria	France	South Africa
Belgium	Italy	Spain
Canada	Mexico	Sweden
Denmark	Netherlands	Switzerland
European Commission	Norway	United States
Germany	Portugal	

A total of 49 Tasks have been initiated, 35 of which have been completed. Each Task is managed by an Operating Agent from one of the participating countries. Overall control of the program rests with an Executive Committee comprised of one representative from each contracting party to the Implementing Agreement. In addition to the Task work, a number of special activities—Memorandum of Understanding with solar thermal trade organizations, statistics collection and analysis, conferences and workshops—have been undertaken.

Visit the Solar Heating and Cooling Program website - **www.iea-shc.org** - to find more publications and to learn about the SHC Program.

Current Tasks & Working Group:

Task 42	*Compact Thermal Energy Storage*
Task 43	*Solar Rating and Certification Procedures*
Task 45	*Large Systems: Solar Heating/Cooling Systems, Seasonal Storages, Heat Pumps*
Task 46	*Solar Resource Assessment and Forecasting*
Task 47	*Renovation of Non-Residential Buildings Towards Sustainable Standards*
Task 48	*Quality Assurance and Support Measures for Solar Cooling*
Task 49	*Solar Process Heat for Production and Advanced Applications*
Task 50	*Advanced Lighting Solutions for Retrofitting Buildings*
Task 51	*Solar Energy in Urban Planning*
Task 52	*Solar Energy and Energy Economics in Urban Environments*
Task 53	*New Generation Solar Cooling and Heating (PV or Solar Thermally Driven Systems)*

Completed Tasks:

Task 1	*Investigation of the Performance of Solar Heating and Cooling Systems*
Task 2	*Coordination of Solar Heating and Cooling R&D*
Task 3	*Performance Testing of Solar Collectors*
Task 4	*Development of an Insolation Handbook and Instrument Package*
Task 5	*Use of Existing Meteorological Information for Solar Energy Application*
Task 6	*Performance of Solar Systems Using Evacuated Collectors*
Task 7	*Central Solar Heating Plants with Seasonal Storage*
Task 8	*Passive and Hybrid Solar Low Energy Buildings*
Task 9	*Solar Radiation and Pyranometry Studies*
Task 10	*Solar Materials R&D*
Task 11	*Passive and Hybrid Solar Commercial Buildings*
Task 12	*Building Energy Analysis and Design Tools for Solar Applications*
Task 13	*Advanced Solar Low Energy Buildings*
Task 14	*Advanced Active Solar Energy Systems*
Task 16	*Photovoltaics in Buildings*
Task 17	*Measuring and Modeling Spectral Radiation*
Task 18	*Advanced Glazing and Associated Materials for Solar and Building Applications*
Task 19	*Solar Air Systems*
Task 20	*Solar Energy in Building Renovation*
Task 21	*Daylight in Buildings*
Task 22	*Building Energy Analysis Tools*
Task 23	*Optimization of Solar Energy Use in Large Buildings*
Task 24	*Solar Procurement*
Task 25	*Solar Assisted Air Conditioning of Buildings*
Task 26	*Solar Combisystems*
Task 27	*Performance of Solar Facade Components*
Task 28	*Solar Sustainable Housing*
Task 29	*Solar Crop Drying*
Task 31	*Daylighting Buildings in the 21st Century*
Task 32	*Advanced Storage Concepts for Solar and Low Energy Buildings*
Task 33	*Solar Heat for Industrial Processes*
Task 34	*Testing and Validation of Building Energy Simulation Tools*
Task 35	*PV/Thermal Solar Systems*
Task 36	*Solar Resource Knowledge Management*
Task 37	*Advanced Housing Renovation with Solar & Conservation*
Task 38	*Solar Thermal Cooling and Air Conditioning*
Task 39	*Polymeric Materials for Solar Thermal Applications*
Task 40	*Towards Net Zero Energy Solar Buildings*
Task 41	*Solar Energy and Architecture*
Task 44	*Solar and Heat Pump Systems*

Completed Working Groups:

CSHPSS; ISOLDE; Materials in Solar Thermal Collectors; Evaluation of Task 13 Houses; Daylight Research

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1 Executive Summary

The IEA Task 48 focuses on projects which make solar thermally driven heating and cooling systems at the same time more efficient, reliable and cost competitive. Within the four subtasks, quality procedures on component levels, quality procedures on system levels, market support measures and dissemination and policy advices were elaborated.

This Subtask C6 report´s activity will emphasize contracting models for solar cooling systems. For that purpose, a narrow collaboration was established with ongoing IEA SHC Task 45 on large systems for district heating and cooling systems.

This analysis focuses on details, such as investment models, contracts and other relevant issues with regard to which information on ESCos is limited and dispersed in the EU and worldwide. The work will also deepen our understanding of hurdles which ESCos are faced with and will provide information on ways of overcoming such hurdles in practice.

Solar thermal technology is defined as a technology used to harness energy from the sun for use in a thermal process. There are a wide variety of applications for this technology, including, but not limited to, water/process heating, radiant heating and air conditioning. In each application, solar energy is obtained through a solar collector and transferred to a thermal process. Given the proper conditions and system design, solar thermal technology can provide a reliable and cost-effective energy source in residential, commercial, and industrial applications.

In the field of solar air conditioning, an exponential increase of activities occurred during the last years. Some solar cooling systems are available at small scale, starting at approx. 15 kW. Below this figure a lot of research was done to achieve satisfactory results in regard of the systems´ thermal efficiency. Most solar cooling installations were realized in the scale between 15 kW and 500 kW, being perfectly suitable for all buildings that have a continuous and regular load profile (e.g. public buildings, offices, hospitals…). Since 2011, there are also solar thermal cooling systems with cooling powers beyond 1 Megawatt in operation, like in Singapore and the USA. These systems were the first solar cooling systems based on ESCo financing models.

Solar collectors for air conditioning of buildings are generally also used for other applications, such as space heating and domestic hot water preparation. Latter usually contributes to a reduced payback time of the investment. The technologies of concentrating solar cooling applications as well as the technology of solar flat plate cooling applications have their specific advantages or disadvantages in each case, depending on location and application characteristics. Components have to be carefully selected and developed through an integrated design approach to become a functional system.

ESCos for solar thermal air conditioning are in many cases a competitive energy service concept to execute energy efficiency projects in buildings or production facilities. Further work will be done in the IEA SHC Task 48 and other projects to make this financial service more competitive and superior to other products.

Rationale

Air-conditioning represents a growing, worldwide market in commercial and residential sectors.

Main reasons for the worldwide increasing energy demand are increased living standards and occupant comfort demands as well as building-architectural characteristics and trends. Air-conditioning can include both, temperature and humidity control of indoor air. Particularly for large solar thermal systems in the range of about 35 kW and above, proven heat driven cooling technologies are available on the market which can be used in combination with solar thermal collectors.

At cooling powers beyond 500 kW, the administrative efforts for ESCo solutions can be viable.

At the moment, the risks and uncertainties perceived by energy users decrease the prospect for switching to sustainable methods of either generating or using renewable energy. It is envisaged that by managing these risks with systems like ESCos, they will bring a change in the perceptions of potential recipients and required innovations in the air conditioning sector will be achieved.

2 Work performed in Activity C6

2.1 Report Background

This report highlights new perspectives of financing large solar thermal cooling projects. It is the objective to expand the use of solar cooling technologies in the public as well as in the private sector through improved understanding of the approaches adopted by contracting models. Furthermore, promotion of this newly acquired knowledge among the worldwide solar thermal industries as well as potential users would be another objective. At the end, new solar thermal cooling plants, based on energy service companies´ financial models are envisioned to be realized.

The report´s activities were develop in narrow collaboration with the ongoing IEA SHC Task 45 on large solar thermal systems, which specifically works on this topic but focuses on both, large district heating and cooling systems.

Information to complete this study was therefore collected from a variety of sources, but especially from Task45. It further includes company web pages, articles, reports like the St-ESCOs Guide of the European Union, and several solar energy projects. These sources provided information on contracting systems, available investment schemes, technology applications, equipment specifications, solar resource data and pricing.

2.2 Energy Service Company (ESCo)

An Energy Service Company (ESCo) is a professional business partner, offering consumers the opportunity through a wide range of energy services to reduce their energy consumption and energy costs. This wide range of energy services can include energy analysis and audits, energy management, project design, implementation, maintenance, operation, power generation, energy supply, monitoring, evaluation or facility and risk management.

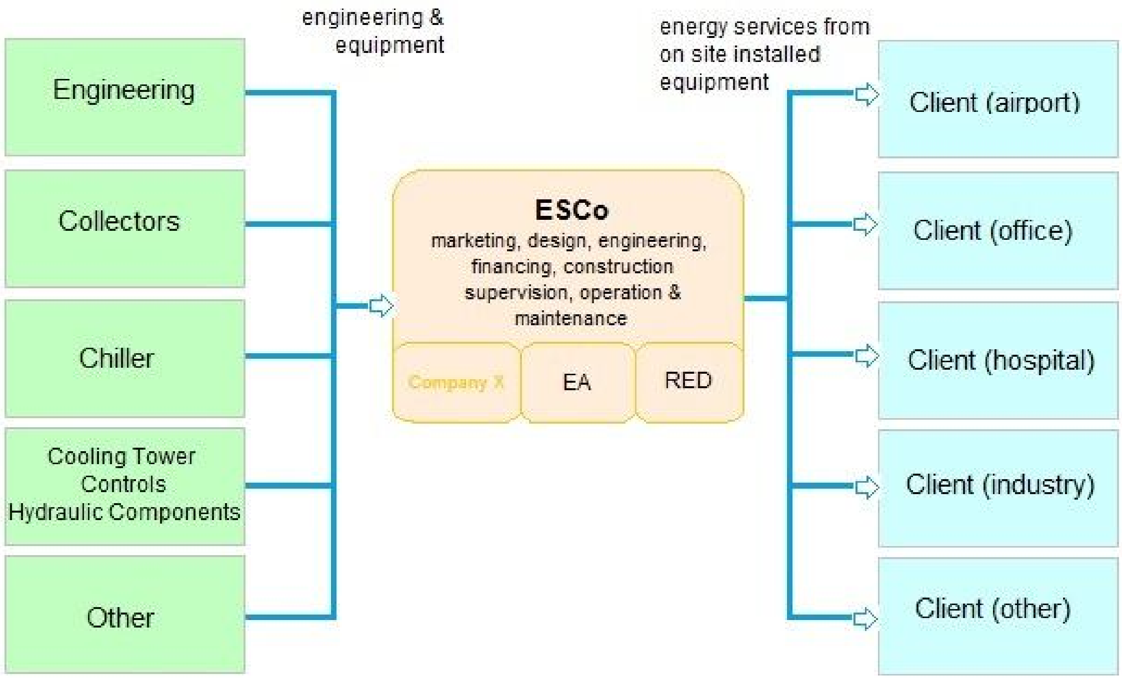

Figure 1: Main ESCo system components, working schemes and theoretical processes, modified by SOLID GmbH, 2014.

Several solar thermal cooling and heating applications became technologically mature over the last decade, and ESCos are economically advantageous for them. Still, ESCos have little penetration in the European and also World ESCo market compared to their potential. One main reason is that end users (especially large ones) still face high initial investment costs to initiate renewable energy projects.

In order to characterize a company as an ESCo and to differentiate itself from other companies providing energy services, additional features will be presented below.

ESCos are described in the EU Energy Service Directive (ESD) (2006/32/EC) together with energy performance contracting (EPC) and third party financing (TPF). ESCos are important instruments that can be used by EU Member States in order to achieve energy efficiency and reach energy savings. ESD defines ESCos as *natural or legal persons delivering energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accept some degree of financial risk.* The payment for services delivered is based (either wholly or in part) on the achievement of energy efficiency improvements and on the meeting of various agreed performance criteria.

Following features do not necessarily apply for all ESCos, but can be identified with varying degree:

- Some ESCos guarantee energy savings and/or provisions of the same level for energy services at lower costs. Performance guarantees can take several forms. They can revolve around the actual flow of energy savings from a project, stipulate that the energy savings will be sufficient to repay monthly debt service costs; or, the same level of energy service is provided for less money.

- The remuneration of some ESCos is directly tied to the new system´s energy savings achieved.
- By providing a savings guarantee, an ESCo can finance or assist in arranging financing for the operation of an energy system.
- An ESCo can retain an on-going operational role in measuring and verifying energy savings over financing terms.

In most cases, ESCo projects are energy supply contracts or energy performance contracts (EPC).

2.2.1 ESCo Opportunities

The public sector has been and still is a very important trigger for the development of ESCo markets in many countries. The public sector is perceived as being a safer client, usually not going out of business easily. Central are project standardization and energy consumption potentials.

A lot of reasons exist, arguing for an ESCo project implementation:

- No or very low investment cost for the customer, minimizes the financial risk
- Guaranteed development of the solar energy price, advantage compared to other energy sources
- Complete energy service packages provided by one company, thus customer can focus on other core activities
- Guarantee of state-of-the-art technical and economic solutions, maximum solar output (lies as well within the ESCOs´ interests)
- 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)
- As a big advantage, ESCos give the opportunity to pay the lowest price possible for heat or cooling energy.

One of the main arguments is that prices for solar air conditioning are competitive – if not the lowest on the market – and offer flexible packages that suit individual and business needs.

2.2.2 ESCo Challenges

Barriers responsible for the weak development of ESCo projects cover a wide range of policy, administrative, financial, and contractual or market hurdles. Some of the barriers are commonly met among EU countries, while some others are related to specific conditions in each country. In a lot of countries, ESCo markets are still in the initial phase.

Several barriers have been recognized to impede the implementation of ESCo projects in the public sector. Complicated public procurement procedures, e.g. separate calls for a project design and for project implementation, basing public procurement decisions only on the best price without taking into account lifecycle costs, associated energy savings during the lifetime of an ESCo project or a lack of clear rules how to treat ESCo projects within public budgeting are examples.

Barriers for solar cooling ESCo projects include low awareness on the demand side, financial institutions not willing to finance ESCo projects or provide bad lending practices, lack of standardized documents and procedures, lack of existing ESCo projects/expertise or a lack of energy consumption data. The main strategy should be designed to overcome barriers which often prevail. The following measures are necessary and recommended to overcome barriers:

- More and specific information about ESCo-services addressing planners, architects, customers / companies and installation firms
- Workshops and training for installation companies, planners
- Guarantees for customers and voluntary agreements
- Excursions to already realized solar thermal cooling projects
- Creating new synergies with actors already involved for a better dissemination of information

2.3 Project Acquisition and Development

An ESCo project acquisition entails following steps to address potential costumers:

- Selection of a suitable project
- Energy audit – building or industrial process specific assessment and evaluation of the status quo (required cooling supply system, etc.)
- 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
- Technical design (cooling demand, secondary network dimensioning parameters, defining interfaces, conventional cooling back-up)
- Description of supply tasks
- Requirements of cooling supply (especially temperature levels), heat rejection and solar thermal system
- Definition of the contractor’s service requirements
- Design of a contract (cooling supply contract)
- Contract negotiations
- Finalization and signing of the contract
- Project realization

2.3.1 Potential Customers

Target groups can be large building owners, housing associations, elderly homes, hotels, industry buildings etc. In general, targeted are building owners with large buildings or industrial processes which have cooling and hot water demand, as often seen e.g. in the food industry. Large central cooling units are important; small split systems can be replaced by large solar cooling absorption machines only at much higher cost.

In order to make a solar thermal cooling system economically more attractive, it is important that there is also a significant, all-year round hot water demand. As a rule of thumb, it can be assumed that this hot water demand should be at minimum of 1.000 kWh per day, also in summer months.

Potential customers (within the target group) can be addresses by newsletters, Email contact, personal information or events at best practice examples (study tours if possible).

Solutions to overcome existing barriers (additional planning and information, financing model etc.) include consulting in energy relevant aspects, solar workshops and information events or creating an info point (e.g. web site).

Having identified a target group, a marketing concept has to be elaborated to reach goals like the initiation and support of solar projects in larger residential buildings or starting a marketing campaign for solar systems in larger residential buildings.

The first steps to promote solar systems can be direct marketing, info-events for planners and architects or direct mailings.

Examples of institutions interested in ESCo projects are:

[1] Medical service institutions – Hospitals are beneficial for ESCo projects due to their continuous occupancy and energy consumption. Moreover, other medical institutions, such as public health centers or clinics, should be more considered as well.

[2] Student homes, retirement homes – Buildings in this category are alike hospitals in their energy use due to all-day occupancy and supporting facilities (kitchen, laundry room etc. require cooling). On the other hand, they might be smaller energy consumers than hospitals and have a seasonal occupancy. However, project standardization potential is high in this field as well.

[3] Buildings in the ownership of state/regional/local authorities – The principle is the same as for office buildings, including the possibility to make standardized contracts with one institution, e.g. state, county or a city. Normally, only suitable when high hot water demand, e.g. buildings with over-night stay.

[4] The industry sector also has very big potential in the field of solar cooling. Especially the food processing industry and chemical industry.

[5] Within the residential sector, saving potentials exist and could be easily implemented. Usually, many private owners exist, increasing the complexity of a project. Moreover, many energy efficiency projects in this sector are too small to attract the attention of large financial institutions. Due to these reasons there is necessity for pooling smaller projects, e.g. buildings, into one larger project.

[6] Hotels are significant consumers of energy, offering high potentials for ESCo cooling projects. Their suitability for an ESCo project involving solar energy will depend on their seasonal occupancy and location (i.e. climatic conditions).

[7] Utilities that operate district heating or cooling grids for towns or quarters.
Normally, these utilizes operate heat and cold generation plants by their own. But for new technologies like solar thermal cooling, they might be interested to cooperate with ESCo companies which have more experiences in this sector.

2.3.2 Required Project Information

To implement a solar cooling ESCo project successfully, some aspects are of particular importance. It is crucial to know how to identify buildings which are suitable for contracting projects. Furthermore, information is necessary to clearly establish targets to be reached by the project, to know which points to consider if awarding an ESCo contract, to know which elements should be included in a contract, to identify which will be duties of the local government, which support/subsidies can be obtained and to establish a clear and close cooperation with property owners.

2.3.3 Decision Process Strategy

A lot of barriers exist, hindering the implementation of solar thermal cooling projects. These hurdles are based on facts like missing know how of architects and planners about the “new technology“, higher investment costs, more complex and expensive planning phases, not enough information for planners, architects or housing companies about subsidies, new solar systems/technologies or unknown pilot projects. Other hurdles are that costumers and companies don’t believe that the simulated solar results will be realized or dislike aesthetic aspects about the system, like building integration issues. Sometimes, system and installation quality need to be questioned. Several arguments are frequently used against the implementation of solar cooling ESCo projects:

Table 1: Arguments against ESCo Projects, Source: SOLID GmbH, 2014.

Perceived Problem	**Consideration**
Long contract periods of over 5 years	Most buildings and their energy systems are used much longer than 5 years
Outsourcing the energy supply means less control over energy supply	Using fossil fuels, one is much more dependent on a well functioning supply chain than if using solar energy
Solar energy prices are too high (compared with up-to-now used energy sources)	Solar energy process are much more predictable than future fossil fuel prices

Several aspects support a decision making process in favor of ESCo projects. Here, lessons learned from some experienced ESCos are of high value. Energy agencies providing expertise and assistance to customers in implementing contracting projects are crucial for increasing the uptake of contracting schemes. A well organized contracting business sector is necessary to provide information on contracting schemes, to standardize definitions and procedures, to provide advice and to provide tools to sell to the sector. The establishment of a clear legislative framework capable of regulating all the contract related details is considered important since uncertainties resulting from unclear legal status are a main barrier to contracting uptakes.

Contractors offering the whole array of technologies can provide the most efficient concept depending on the project situation. Contracting is often not applicable in smaller projects with low investments. By the pooling of buildings, project volumes can be increased. Standardized measurements and verification procedures are necessary, as well as project risk forecasts and clear risk analyses. A clearly identified need for increasing public awareness about ESCo projects and their economical and environmental benefits exists.

2.4 Legal Considerations

Worldwide diversity exists in what concerns the ESCo market´s development, structure and regulations. In some countries (e.g. UK, GR, FI. PT) at least up until now, there is no particular legal format for ESCos. Constitutions can be any of the recognized formats in the country's law. Also, there are no particular rules relating to the provision of ESCos´ private finances others than those applying to general contracts.

For example, in the UK and Ireland, Private Limited Companies would be the most appropriate vehicles for most ESCos as they are the most flexible ones.

Within the Energy Service Directive – ESD (2006/32/EC) -which was passed for all EU member states in 2006- the lack of specific legislative frameworks of the energy service market was expected to change. In this way, the operation of ESCos is legally clarified and the energy service market gets support to move forward and develop. The ESD, which should have been transposed into national legislation by all member states by May 2008, aims a cost effective improvement of energy efficiency in end-use, by indicating target values, removal of market barriers, and stimulation of the energy service market.

In Germany, the term ESCo is hardly used. Instead, this business model is referred to as *Contracting*. In order to prevent confusion concerning the terms focusing contracting, the DIN 8930-5 "Contracting" (2003) defines the basic terms, several alternative contracting schemes, service components, pricing for services, application areas and the legal background.

It has long been claimed by ESCos that the engagement of the private sector to provide complex solutions for the public sector would be beneficial and could deliver innovative solutions. PPP is a sort of "umbrella notion" covering a broad range of agreements between public institutions and the private sector, aimed at operating public infrastructures or delivering public services. In what concerns the implementation of ESCo projects in the public sector, under these special and formal agreements, multi-year concession contracting regarding the installation, operation and maintenance of leased/outsourced energy efficient equipment in public buildings can theoretically be realized. The PPPs allow the public sector to pay the private company's remuneration periodically during the project, and allows that payment being based on performance indicators previously set out in the contract (instead of being purely revenue based). In order to further increase the effectiveness of this regulation, public accounting rules should also be revised and the separation of operation and investment budgets should be overcome in the case of ESCo projects. In these projects it is very important that savings in operational budgets could be used as a levy for investments in energy efficiency. Moreover, public procurement rules should be revised to allow including energy performance criteria.

In the Baltic countries (Latvia, Estonia, Lithuania) unstable and not well defined regulatory frameworks as well as unfavorable procurement procedures contribute to slowing the initialization of market growth.

ESCo schemes and contracts are rather complicated. Laws regulating specifically contracting services would help to overcome basic insecurities. Furthermore, public procurement processes should be adapted in order to open a market for ESCo services.

2.5 Equipment Ownership

Once the contract has terminated, equipment ownership and future purchase options can be offered to end-users.

A long term energy supply contract is best for most ESCo´s financial performance. Different economic possibilities exist, offering various agreements between ESCos and customers after the end of the energy supply contract. An ESCo has following ownership options:

[1.] *The customer pays a fixed part of the investment at the plant´s delivery:* In part, this can be interpreted as a connection fee, but in contrast, it also includes a fee to cover the uninstalling process and those parts of the equipment which cannot 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 or energy storage tanks) can be used again by the ESCo in a future project. The reasonability of this solution strongly depends on technical conditions. E.g., a flat roof with sophisticated 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 at energy-supply contract´s end.

[2.] *At the end of the contract, the customer pays a flexible part of the investment*: In this model, the customer contributes no or little to the investment at the plants delivery date. In return, the following approach reflects the ESCo´s financial guarantee: depending on the number of years the customer remains under the energy supply contract, the customer is charged a variable fee at the end of the contract. The longer the customer remains under the contract, the less the customer pays – as a bigger share of the investment has already been paid back by the bought energy. 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 a solar collector field and serves as the solar tech room. The great advantages of this approach are:

- the mobile tech package can be pre-assembled
- 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)
- it can be easily removed from the original spot and brought to a different place

This solution demands a great deal of technical know-how for planning the tech package correctly for different usages.

2.5.1 Ownership Options

Possibilities after the (first) energy supply contract has run out are:

The solar plant must be uninstalled: This is actually the worst solution for the ESCo. The ESCo has to bear high costs for uninstalling the system. This is the case if

a) At the end of the energy supply contract, the customer does not want to renew or extend the contract
b) It was not fixed that the customer assumes the ownership of the plant. This is reflected in the abbreviation *BOT (Build - Operate - Transfer)*, i.e. the plant is transferred to a new client.

Together with difficult conditions in the energy supply contract, costs of uninstalling a solar plant can lead to economic losses.

It is possible to pass the solar plant on to the customer. After the expiration of the (first) energy supply contract, the customer takes over the solar plant. Frequently, customers want to extend a contract for the ESCo´s further plant operation, service and maintenance. The ESCo´s economic favorability of this version depends on the plant´s technical quality and on an estimation of future maintenance costs. This option is favorable for an ESCo if the duration of the first contract was long enough to guarantee an adequate return-on-investment.

Another possibility is to keep the ESCo´s ownership position and the contract gets renewed. This solution guarantees a customer continuing of established 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 all operation, service and maintenance expenses.

2.6 Financial and Contractual Aspects

An ESCo market´s development is highly dependent on financial circumstances and possibilities. In order to implement ESCo projects, a party able and willing to finance these projects is inevitable.

In some countries where large ESCos exist (e.g. FR), project financing is done by a company's own capital. For example, ESCos in France are large companies which have the financial means to finance projects if necessary, thus the role of banks is limited under these circumstances. In other countries, where there is either no ESCo market developed yet, or there are only small ESCos active in the market without possibilities to finance large projects, it is necessary to have financial institutions willing to finance ESCo projects. Unfortunately, in some countries, financial institutions are not familiar with the concept of ESCo projects, thus they provide conservative lending practices, resulting this way in a lack of commercially viable project financing. In other countries -like in Hungary- third party financing from banks is not an issue, as banks are willing to finance performance contracts. TPF is not very common in Sweden, as the majority of clients are public bodies, which can provide funding from their own sources.

2.6.1 Financial Analysis

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

The choice of financial schemes largely depends on the ESCo´s financial reputation and on the conditions it can get at a financing institution. These conditions might vary and depend on personal contacts as well.

2.6.2 Financial Schemes and Business Models

Banks do often not have the know-how to assess installations´ technical setup. Especially energy saving potentials and technical risks are difficult to estimate.

In many countries, financial schemes and mechanisms do support projects in the fields of energy efficiency and renewable energies. Most of the time, these financial schemes include subsidies or low-interest loans. Many support mechanisms focus on energy efficiency while others include solar thermal cooling.

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

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

Independently of the model chosen, a certain amount of money should be agreed upon in the case the customer wants to exit the energy supply contract before the contract´s agreed validity period ends.

In financial negotiations with customers -if the ESCo decides to foster a certain model- the ESCo should also keep in mind a project´s technical background. No financial scheme suits best for all types of projects. If an ESCo trusts the customer (both technical preconditions and financial situation) then it may opt for lowering basic prices and go for higher energy prices.

If a customer seems not very trustworthy, then the basic price should be kept high, together with a bank guarantee option. This assures the plant´s payback to some extent. Projects with a too high risk should simply be declined by an ESCo.

The choice for a financial scheme largely depends on an ESCo´s financial reputation and conditions achievable at financing institutions. These conditions vary and depend on personal contacts and experiences.

Three different schemes regulate billing solar energy between a customer and an ESCO. Most implemented schemes are based on one of the following schemes:

- **Energy price only**: A customer pays a certain energy price per kWh of solar thermal energy. Energy is billed once every month or once every two months. The ESCo´s payback is based on energy sold. A big share of a customer's payments is generated during high sun radiation periods. When most heat is available for a solar technology's working progress, most cooling demand can be satisfied.
- **Energy price and basic price:** Additionally to costs per kWh, a customer is also charged a basic monthly price payable regardless of energy delivered. In return, the price for one kWh solar energy is lower. This model provides increased security for an ESCo as it will get regular payments in any case. This scheme entails regular payments, also during possible low solar radiation performance periods.
- **Energy price and connection fee:** Similar to installation fees, a customer is charged for being connected to a district heating net. This scheme includes a customer´s upfront payments for system installation. The payment can be denominated as connection fee and may be calculated based on per year delivered kWh or installed collector area and system design. In return, a customer´s energy price can be reduced. Therefore an ESCo needs to perform a very thorough economic feasibility calculation.

Independently of the scheme chosen, a certain amount of money (penalty fee) should be agreed upon as mentioned- in the case the customer wants to exit the energy supply contract before the agreed contract validity period. No financial scheme exists, best suited for all types of projects.

To sum up, following questions need to be answered as it is central for both contract parties to agree upon a model which also serves both sides' interests:

- Same price for the whole year or a difference between summertime and wintertime prices?
- Solar energy indexed to consumer price index, energy price index or any other reasonable factor?
- 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?

2.7 Conditions and Guarantees

There are certain preconditions usually included in an energy service contract which guarantee favorable conditions for both contracting parties. The detailed scopes of these conditions depend on the project´s technical characteristics as well as on specific circumstances. Technical and financial conditions fixed in the contract are closely related and are crucial for a solar thermal ESCO project´s economic feasibility.

Technical guarantees:

The ESCo´s system operation guarantee: In most cases, customers demand the ESCo to guarantee for the system´s correct and efficient operation. This includes the solar plant behavior in the case of inefficient system stages.

Energy supply guarantee:

Most customers demand a guaranteed energy output (kWh/m²*year or MWh/year for the whole plant) from the solar plant. Predefined energy needs have to be satisfied, also by secure backup systems.

If the ESCo not only installs and operates a solar thermal plant but is responsible for the whole energy service, a guaranteed whole year energy supply must be given. It is central to identify correct restrictions within an energy supply guarantee in the case the customer does not fulfill agreed technical specifications.

Financial guarantees:

If the ESCo goes bankrupt, the financing institution has the right to take over the solar system. This is a crucial aspect at negotiations about the solar system´s financing plan with financing institutions. In some cases, it is even possible to get some sort of bank guarantee from public administrations, or federal banking institutions are even set up for this special aim.

2.8 Financial Institutions

Most financing institutions expect pay back times below certain years for projects´ financial support. 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.

Investor groups are of interest if projects are realized in close cooperation with companies that work in the environmental or ecological sector. Past successful implementations of solar thermal ESCo plants show how important contacts to financial institutes are.

2.9 Contractual Principles and Structures

In general, contracting schemes with reliable long-term backflows of funds are attractive for financial institutions, especially when the client belongs to the public sector. However, banks have to consider a number of risks:

Not only has the client's solvency posed a risk in the past. The contractor's reliability has to be considered as well. These risks are minimized if contractors can refer to a large number of contracts and risks are divided.

The viability of contracts has to be assessed. This can be difficult since the related contracts are very complicated. Issues concerning price adjustments, ownership structures, distribution of duties and risks to the contract partners have to be solved. Banks should be included in the contract design at an early stage in order to prevent problems.

Main topics of an energy service contract are:

- o Subject of the contract
- o Duration of the contract
- o Installation of the solar plant, property line

- Solar energy measurement and charging
- Solar energy price
- Details on the energy supply and plant operation
- Other contract clauses

The type of contract used in a certain region to implement ESCo projects ranges from most well-known schemes like Energy performance contracting (EPC), Third-party financing (TPF) to Energy delivery contracting (EDC):

[1.] Energy performance contracting (EPC): A contractual arrangement between the beneficiary and an ESCo to improve energy efficiency measures.

Investments in measures are paid for in relation to a contractually agreed levels of energy efficiency improvements.

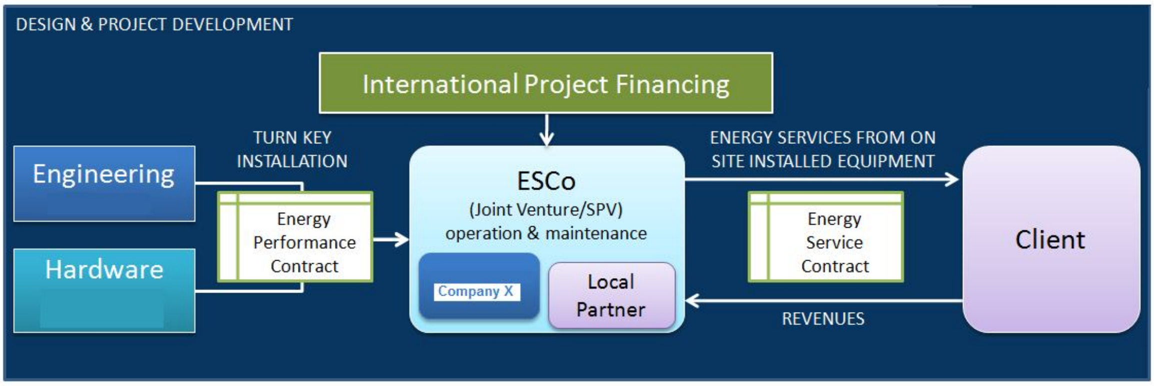

Figure 2: Energy performance contracting (EPC), modified by SOLID GmbH, 2014.

[2.] Third-party financing (TPF): A contractual arrangement involving a third party.

In addition to the energy supplier and the beneficiary of the energy efficiency improvement measure — it provides the capital for measures and charges the beneficiary a fee equivalent to a part of the energy savings achieved as a result of the energy efficiency improvement measure.

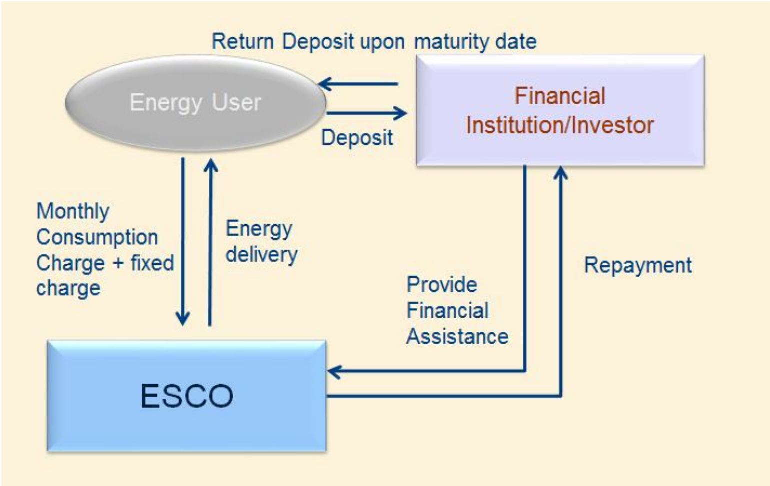

Figure 3: TPF Third party finance scheme, modified by SOLID GmbH, 2014.

[3.] Energy delivery contracting (EDC): A contractor plans, finances and constructs new heat production facilities or takes over an existing heating infrastructure.

During the contract´s duration, the contractor is responsible for plant operation, maintenance and attendance. The contractor buys primary energy and sells heat to the customer. Energy savings are part of these projects since new or refurbished systems work more efficiently. The customer usually pays a basic price which covers the contractor's investment costs, including loan repayment. The basic price also has a component covering plant maintenances. This cost component is flexible regarding the increase of average salaries. The second part of e.g. a monthly payment depends on energy consumption.

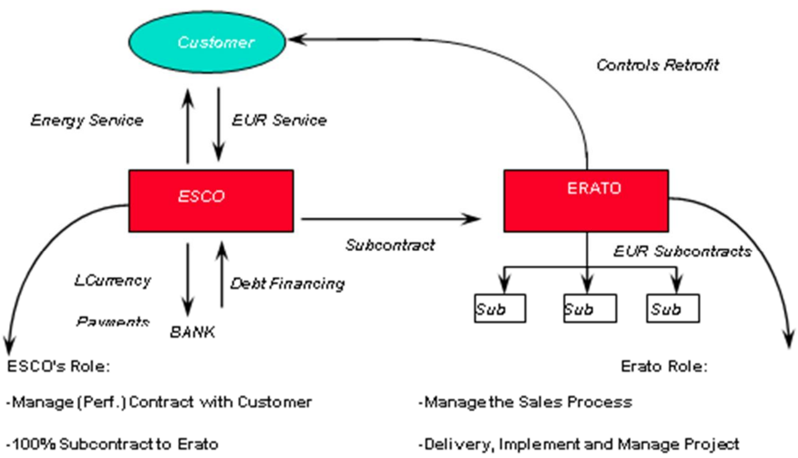

Figure 4: Energy Delivery Contracting (EDC), modified by SOLID GmbH, 2014.

2.10 Insurance and Liability Schemes

As a matter of principle, a solar thermal system built by a system provider and run by an ESCo is generally insured by the ESCo, not by the system provider (i.e. the engineering company which built the plant). This is due to the fact that the ESCo buys the plant from the system provider. Only the plant owner insures against various risks.

Following list covers frequent aspects of an insurance scheme:

[1.] Insurance of equipment:

a. Extreme weather conditions.

For each of those conditions, precise specifications (extreme limits) have to be defined. If weather conditions exceed specifications set, then the insurance will cover the damages.

b. Thievery or vandalism

c. Fire or other well defined causes originated from the building or from surrounding objects

[2.] Insurance of investments done and economic obligations stated in the contracts

The following Figure shows insurance options which could be adapted to suit ESCo´s particular needs:

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)

Figure 5: ESCOs insurance types, Source: St-ESCOs Guide, European Union, p.17.

The insurance scheme requires a clear reference to the fact that there are two different owners involved in an ESCo agreement: the owner of the solar plant and the owner of the building (place) where (On which) the solar plant is installed.

2.11 Solar Cooling - Technical Capabilities

Innovative cooling supply requires the connected energy concept´s individual integrated planning process. Calculations focus an optimum balance between energy savings, energy efficiency and renewable energy use. A solar thermal plant -concerning its capacity and characteristics- needs to be integrated and adapted to the whole concept.

The air conditioning market grows worldwide, leading to enormous additional energy consumptions and electricity supply problems. Solar air conditioning systems are therefore very interesting applications, in particular because the major air conditioning loads coincide with high solar radiation availability in hot climates or during hot seasons.

Flat plate collectors and concentrating collectors provide energy for solar cooling systems. Every geographic location has its own conditions and therefore one technology might be better suitable than another on a case by case basis. The main advantage of solar cooling -cooling is provided when the sun is shining the most- applies to both technologies.

Solar powered systems demand a higher initial capital investment than conventional systems, like electric chillers. This can be a strong reason in the planning process to choose conventional systems, rather than going for a system with lower operation costs and long pay-back periods. Pay-back time depends on prices, on the type of system and the climate. An integrated design approach is critical for an operation´s success. However, rising electricity prices and subsidies –which exist in many countries-, have a very positive impact on solar cooling payback times.

2.11.1 Engineering Aspects

In order to run a successful ESCo project, technical plant characteristics are central. Even more so in the field of solar thermal cooling applications, as very few companies worldwide are capable of realizing sophisticated systems:

Basically, a refrigeration machine (fridge)and a solar thermal cooling system both follow the same working principle. A refrigeration machine consumes energy and transfers heat from a source at a lower temperature to a sink at a higher temperature level.

The technique for solar cooling consists of passive and active systems. Both types can be driven by flat plate collectors as well as by concentrating solar collectors. The most promising approaches concerning active systems are the heat actuated absorption machines, adsorption machines and the desiccant dehumidification systems (DEC).

Applying sorption based cooling technology requires a more integrated design approach than having standard compression chillers in place. Absorption/Adsorption based chillers have a more sluggish start/stop characteristic than standard chillers. Moreover, stringent requirements on the re-cooling system must be considered. The start-, stop characteristic has an impact on the chiller´s lifetime. The re-cooling temperatures have a significant impact on the thermal EER and boundary conditions for operations.

Most common types of thermally driven chillers are based on absorption or adsorption technologies. Solar cooling in combination with those two technology types can be considered as state of the art.

Closed cycle systems produce chilled water which can supply any type of air-conditioning equipment (e.g. air handling units, fan-coils, chilled ceilings).

Open cycle systems, also known as desiccant systems, are a combination of sorptive dehumidification and evaporative cooling to provide fresh air at a comfortable temperature and humidity level.

Closed cycle systems are equipped with thermally driven chillers, which provide chilled water that is either used in air handling units to supply cooled and dehumidified air or that is distributed via a chilled network to decentralized room installations such as fan coils or chilled ceilings. Available absorption chillers are most common. Adsorption chillers are currently offered by few manufacturers only. A component necessary in all chilled water systems is a heat rejection system.

Open cycle systems allow complete air-conditioning by supplying cooled and dehumidified air. The “refrigerant” is water, which is brought into direct contact with the atmosphere. The most common open systems are desiccant cooling systems with a rotating dehumidification wheel and a solid sorbent.

Among the thermally driven cooling systems, closed cycle systems currently have a central position.

Solar cooling comes on top of the above mentioned characteristics. The availability of thermal energy depends on weather conditions and the collector type.

Similar or identical chilling machine techniques also include similar chemical processes, based on physical laws. If temperatures for cooling are required to be beyond 0°C, a combination of ammonia and water is suitable. This system is used for single-effect cycles for flat plate and concentrating collectors. Ammonia-water chillers could generate evaporator temperatures down to -60°C, which are useful for industrial cold processes.

Lithium-Bromide -„LiBr” systems- are preferred over an ammonia system for solar energy applications. Lower generator temperatures are required. Permissible generator temperatures for a water-cooled LiBr system range from 70 °C to 100°C compared to 95°C-120°C temperatures required for a water-cooled ammonia system.

LiBr has a lot of advantages compared to other system types. Basically, it is salt with an especially strong attraction to water. It has a higher thermal energy efficiency ratio (EER_{th}) compared to other single-stage units at same cycle temperatures. Furthermore it is composed of simpler components since it can work efficiently without the need of rectification columns. Also less pump work is needed compared to other units due to operation at vacuum pressure.

2.11.2 Collector Types

Major component of any solar system is the solar collector. Solar thermal collectors capture direct and indirect sunlight, redistribute it or absorb it into a transport medium. Heat exchangers transform solar radiation energy into a transport medium´s internal energy.

Solar collectors are produced in a large variety of shapes, sizes and for different purposes.

Basically, two types of solar collectors are common: non-concentrating or stationary and concentrating collectors. Non-concentrating collectors have the same aperture area like concentrating solar collectors, which usually have concave reflecting surfaces to focus the sun’s beam radiation to a smaller receiving area. In this way, radiation flux increases. A large number of solar collector specifications are available on the market.

The following collector types are especially central:

- **Flat plate collectors**

  Solar cooling through flat plate collectors was the first kind of solar cooling which has been used and is therefore one of the most advanced technologies in this field. Flat-plate collectors are still the most widely used kind of collectors for solar space cooling worldwide.

- **Evacuated tube collectors**

  There are several types of evacuated tubes in use in the solar industry. A lot of collectors use the most common principle of "twin-glass tube". This type of tube is chosen for it´s reliability, performance and also low manufacturing costs.

- **Concentrating collectors**

  Solar thermal power plants, also called Concentrating Solar Power (CSP) plants, use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beamer.

2.11.3 Solar Collectors and Solar Cooling Systems - Special Characteristics

For every new project, pros and cons can be figured out to identify the best collector technology for air conditioning purposes and therefore suitable for the ESCo project.

In some cases, flat-plate collectors have been considered for use as pre-heaters for concentrating collectors because of their potential to produce more low-temperature energy for given costs.

Evacuated tube collectors can be constructed in most – and also cold- areas, followed by flat plate collectors in moderate climates and concentrating collector systems in hot climates with special air humidification.

Flat-plate collectors cost less than concentrating collectors, as well because of the lack of need for a complex tracking system. Also part of the reason is that today, more flat-plate than concentrating collectors are produced.

Non-concentrating and concentrating collectors both lead to significant CO_2 savings. Peak power demand can be cut from the grid for conventional power. This is not only an advantage for the client or customer of a solar cooling system, but also for many countries close to the equator with a high density of air conditioning. For those countries, solar cooling can contribute to reducing peak electricity demand, increasing energy security and reducing externalities to the public.

In addition to cooling, solar flat plate collector systems can also easily provide thermal energy for domestic hot water preparation and space heating support. This leads to a further reduction of emissions. Noise emissions are also significantly lower since machines work without compressors.

As already mentioned, evacuated tube collectors perform well in direct and diffuse solar radiation. Vacuum used as an insulation layer also minimizes heat losses which make collectors well suited for cold areas or winters. Although evacuated-tube collectors achieve higher temperatures and higher efficiencies than flat-plate collectors, their market penetration is still below its competitor´s. Specific unit prices are higher than flat plate collectors´.

Concentrating collectors have the advantage to reach much higher temperatures than flat-plate collectors and thus are also suitable to supply electricity generating facilities. One problem is that they can only focus direct solar radiation, which leads to the effect that their performance is limited on foggy or cloudy days. Concentrating collectors are mostly used in commercial applications. Collectors are expensive and need frequent maintenance. Most residential concentrating collector systems use parabolic-trough systems which can provide hot water (for heating and cooling), or alternatively support water purification / desalination processes. Concentrating collector systems have higher emission reduction potentials than other collectors because of their higher energy gains per area. However, location is critical. Concentrating systems are well suited for areas of high irradiation, like close to the equator or in some deserts. The collector area should always be clean which often requires a significant cleaning effort. Effects of new investments in large scale productions, increased project capacities, and technology know-how are observed.

High technological know-how is required to realize new concentrating collector systems, which makes it difficult for new players to enter the market. However, a trend towards increased competition -including new players- can be noted in all fields.

Economic aspects always depend on local and technical circumstances and can't therefore be compared in general. Operation costs for cooling, heating, or power can be reduced within all solar thermal systems.

Besides decreasing the operation costs and decoupling the operation costs from the national grid supply, environmental aspects are a strong positive point of solar thermal air conditioning as well. CO_2 and fossil energy savings, ecological working fluids and electricity demand reductions are arguments to develop it further, support and expand solar air conditioning by R&D, public financing, integrated design and business models like ESCos.

2.11.4 General Aspects of System Planning

Numerous planning handbooks for solar systems are available, giving detailed planning rules and specifications, taking into account specific national, technical and legal boundary conditions. Various general aspects should be considered in the initial phase of a plant realization period, since they are often crucial for a successful plant operation and for reaching customer satisfaction.

The system selection is mainly based on climate and load condition analysis as well as on energy (electricity, back-up fuel) and water costs, including availability. Central is the selection of a proper technical solution for climate and load conditions.

In order to achieve cost-effective plants, all partners involved in the realization of a plant cooperate already at an early project stage. This leads to cost-effective installations and integration of all system parts into one construction. Actors involved are ESCos, building companies, planners/engineers, architects, plant management and administration.

2.11.5 Technical Growth Barriers limiting ESCo projects

Barriers hindering growth within the solar thermal cooling industry are mainly based on aspects of hardware, software, lack of awareness or costs:

Technical barriers – Hardware:

- Lack of units with small capacities
- Lack of package-solutions for residential and small commercial applications
- Few available solar collectors for medium temperatures (100-250°C),
- Low thermal efficiency (EER_{th})
- Sometimes need for wet cooling towers

Technical barriers – Software (planning guidelines, training,..):

- Lack of skills among professionals (planers, installers)
- Designs of hydraulic systems not yet standardized, lack of suitable planning
- Missing guidelines and simple design tools for planners

Lack of awareness:

- The technology is still seeking further awareness, but as solar cooling systems become more standardized, the lack of awareness - by consumers and professionals – is a key barrier to growth

Costs:

- Higher initial investment costs compared to conventional cooling systems
- Often forgotten in today's financial incentive schemes for solar thermal systems

2.11.6 Operation, Maintenance and Audit

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 around 20 years) and required efforts are based on low costs. Apart from pure maintenance, most necessary actions during the plant's operations are periodic inspections. Examples for periodic inspections 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

Figure 6: List of maintenance actions and periodic inspections for solar plants Source: St-ESCOs Guide, European Union, p.44.

Boundary conditions, under which an ESCo needs to consider and to decide about the installation and operation of a solar heating plants are 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, ESCos need a structured and reliable solar focused audit procedure as technical base for feasibility studies, decision making and planning. The recommended audit procedure presented in this section exemplifies following steps:

[1.] The ESCo project´s initiator (this can be the object owner or the ESCo itself) carries out a data base collection in order to get an overview of the general situation and possibilities for installing a solar thermal plant and for entering an ESCo project

[2.] An energy concept is elaborated for the object, presenting the integration of a solar heating plant without/with other renewable energies, energy efficiency or 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 within the database available

2.12 Plant Measures and Verification (M&V)

ESCos operate and maintain solar plants for long periods and will sell a lot of solar energy to customers. This role of ESCos implies particular objectives and requirements on the measurement and verification procedure applied to the solar cooling systems.

Specific objectives are:

[1.] Cost effective plant control

[2.] Monitoring and optimal plant operation

[3.] Measurement of energy billed to the customer

2.12.1 Monitoring

Several particularities regarding a solar thermal plant´s control strategies have to be taken into account and obeyed in order to safeguard an optimal operation. Monitoring is central, as it focuses proper plant functioning and therefore is the calculation´s secure basis for billing customers and investment paybacks. Two types of controllers can be used for solar heating plants:

a) freely programmable mainframe controllers

b) freely programmable solar controllers

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

Freely programmable solar controllers, produced by specialized 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.

Some ESCos provide an automated operational surveillance of their solar thermal installations. The software is able to correspond on different types of controlling units and is independent on special measuring equipment.

Features:

- quality assurance and energy output monitoring of solar thermal installations
- sends automatic notifications to the plant operator in case of a malfunction
- standardized monitoring at low ongoing costs

Most controllers have the option for online plant functioning verification. Relevant temperatures and statuses are continuously verified against functioning criteria implemented in the controller´s software. In case one of the criteria is not matched, a warning is send to the plant operator in order to immediately recognize any operation problems.

2.12.2 Measurement Techniques

Proven energy savings are playing a significant role in financing energy management programs. ESCos are therefore relying on correct plant data. Measurements are central.

Solar radiation: Solar radiation is the basic energy input for solar thermal systems and needs to be measured in order to assess a systems´ heat output. 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). An alternative to radiation measurements are data obtained from satellite pictures. These data can show high deviations for instantaneous measurements but produce fairly good agreements on a monthly base.

Temperature Measurement: The availability of temperature measurements at several locations within the system is useful for detecting possible faults and error sources

Heat Metering: Heat meters need to be calibrated to local conditions and then need to be re-calibrated by the manufacturer

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 control strategy mismatch.

Online functioning verification: Most controllers have the feature for an online plant functioning verification. 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.

Daily plant yield verification: A plot of daily plant yield versus the daily radiation allows for a simple verification of the plant´s efficiency. During regular operation periods, measuring points should grow up close to a linear dependency of these two quantities. Reasons for low measured plant yields 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 possible causes.

2.13 Accreditation and Qualification Recommendations

An ESCo -in order to be accredited- should follow certain accreditation criteria:

- Present its full range of activities and measures offered to the client
- Present a reference list with a number of similar plants
- Comply with ethical business practices
- Fulfill quality specifications of project planning, project management and procedure handling
- Carry the technical, operational & economic risks of the project
- Have cooperation skills and structures
- Have solid capital structure
- Have technical faculty for maintenance
- Be capable for metering, monitoring and verifying energy – cost savings
- Perform specialized training and transfer know-how to end-user's stuff

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

3 Conclusions

An Energy Service Company (ESCo) is a professional business partner. The partner offers consumers the opportunity through a wide range of energy services to reduce energy consumption as well as related costs.

Worldwide experiences can be shared and lessons learned from solar thermal ESCos. They can be found in varying geographic and political areas. However, circumstances to start and undertake ESCo projects are highly different across regions, especially since barriers and their measures have to be often very case-specific.

It is of high relevance to stimulate further developments in the field of energy service companies. Benefits, released by a stronger focus on these projects would lead to a much more rapid uptake of renewable energy projects on varying scales, which could be based on one of ESCos´ financial schemes.

At the moment, a lot of perceived risks and uncertainties are blighting the prospect for change to sustainable energy methods. These methods could stimulate the generation of clean energy for air conditioning in small buildings and facilities as well as in large scale applications.

ESCos introduced in this report can make a difference and jumpstart conscious management, possible by overcoming financial and long term risks. Actions to stimulate new investment models and financial schemes should speed up the rate at which organizations go forward with renewable energies, especially in the field of solar thermal cooling.

Lessons learned from several ESCo projects are presented in the current report. The report contains a lot of information for future solar thermal energy application possibilities, here focusing on solar cooling.

Summarized, main findings of the analysis presented in this report are:

[1.] Energy agencies are crucial in providing expertise and assistance in implementing ESCo projects for increasing the uptake of contracting schemes

[2.] A well-organized, international ESCo business sector would be beneficial to provide information on different energy service schemes, chosen based on project requirements

[3.] The establishment of a clear, international legislative framework which is capable to regulate all contract related details would support multinational project activities

[4.] Systems should facilitate operations for contractors offering the whole supply chain for solar thermal air conditioning, including operation and maintenance

[5.] Standardized measurement and verification procedures are necessary in order to support innovative solar cooling technologies; like provided by IEA SHC Task 48

[6.] Before plants can be realized, project risk forecasts and clear risk analyses are necessary in order to realize ESCo projects

[7.] The analysis identified a need to increase the public awareness of ESCo project opportunities and their economic and environmental benefits

The analysis identified that various international opportunists for solar cooling ESCo projects exist, and that further cooperation and realization in the field of financial project backgrounds would be would be highly beneficial.

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