# LARGE ACTIVE SOLAR SYSTEMS: TYPICAL ECONOMIC ANALYSIS

**V.G. Belessiotis**
*Head, Laboratory for Solar and Other Energy Systems, NCSR "Demokritos", Greece*

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## Summary

Large active solar systems provide hot water to any thermally operated systems including desalination. They are cost intensive installation and operating systems. An extended global cost analysis of installation and operation is necessary for the proper economical and reliable operation of such a system. A methodology and a comparison methodology is presented for large active systems.

## 1. Introduction

The cost of energy in solar energy systems is high, because capital costs are such a large share of the cost of solar energy. This affects the cost of hot water from flat-plate collector fields, for any application, such as domestic use of hot fluid for heating and cooling, but especially for industrial process heat, where large amounts of hot fluids are necessary. The total initial capital cost of a solar energy flat-plate collector field includes: the cost of land for the collector field and the auxiliary buildings, which in general are of large surface area, construction, equipment and all components for collecting, storing, converting the energy and delivering to the final user. This chapter analyses a standard that refers to the life cycle cost method for the economic evaluation of solar systems for the production of service water which applies to central solar systems producing hot water for domestic and industrial use.

## 2. Cost of a Solar Hot Water System

In a system using thermal energy, for the coverage of the total thermal load in hot water, apart from a solar system that uses solar energy for the coverage of a percentage of the load, it is assumed that an auxiliary system exists, when necessary, in order to cover the rest percentage of load.

The total cost of a solar system consists of the initial capital cost and the operation costs. In the economic evaluation of solar systems, the determination of the size of the solar system is required that gives the least total cost for the coverage of specific thermal load, solar and auxiliary energy combined. The economic analysis in solar systems contains a comparison of the initial cost and of the operation costs of the solar system to the operation costs of a conventional system.

### 2.1. Initial Capital Cost

The initial capital cost contains the design study, purchase and installation of all main parts of the large active solar system which are:

(a) Solar collectors
(b) Hot water storage tank
(c) Heat exchangers
(d) Pumps
(e) Pipes
(f) Valves
(g) Control system

and all other auxiliary equipment for the operation of the system. Also, the cost of the transportation of the material and equipment to the site and finally delivery and supply of the system to the user or any other supplementary cost according to specific site conditions has to be included in the initial cost.

In the case where solar collectors replace part of the roof or external construction element of a building, this should be considered in the initial cost, since money may be saved with this replacement.

### 2.2. Operational Costs

Operational costs of a solar system are considered to be:

(a) Cost of fuel
(b) Cost of auxiliary electrical energy
(c) Cost of maintenance
(d) Cost for any loans
(e) Cost of insurance

(f) Miscellaneous expenses

The above costs are repeated every year and are necessary for the operation of the system. Any tax earning due to the purchase of the solar system should be subtracted from the operation costs. In the economical analysis, the re-sell price of the whole system or part of it should be considered, since this price is an income for the last year of operation. For the operational costs the following parameters must be considered.

### 2.2.1. Cost of Fuel

This cost refers to the fuel that is consumed by the auxiliary energy system, so that the thermal load which is the difference between the total load and the load covered by the sun, can be covered.

### 2.2.2. Cost of Auxiliary Electrical Energy

This cost refers to the electrical energy necessary for the operation of the pumps, fans, electrovalves and the control system.

### 2.2.3. Cost of Maintenance

This is the cost for repair, cleaning and checking the solar system, including all bits of equipment, devices and other parts of the solar system that have to be replaced.

### 2.2.4. Cost for Loans

This is the annual amount for the re-payment of the loan necessary for the purchase of the solar system.

### 2.2.5. Costs for Insurance

Is the cost of insurance payment for the system.

### 2.2.6. Miscellaneous Expenses

The miscellaneous expenses refer to travelling expenses of the employees, and to the extra expenses that may arise during operation of the solar plant, such as sudden weather damage etc.

## 3. Cost of Conventional Hot Water System

The cost of conventional hot water system contains the operational expenses for the complete coverage of the thermal load in hot water and is supplementary cost adding the solar system.

### 3.1. Operational Costs

Operational costs of a conventional system are considered to be:

(a) Cost of fuel
(b) Cost of auxiliary electrical energy
(c) Cost of maintenance

These costs are based on a year period of operation of the conventional system.

### 3.1.1. Cost of Fuel

This cost refers to the fuel that has to be consumed for the complete coverage of the thermal load for a specific time period.

### 3.1.2. Cost of Auxiliary Electrical Energy

This cost refers to the electrical energy necessary for the operation of the pumps, fans, electrovalves and control system.

### 3.1.3. Cost of Maintenance

It is the cost for repair, cleaning and checking the conventional system, and if necessary for the parts of equipment and devices that have to be replaced.

## 4. Inflation

This is a parameter that affects the total distortion of the balance between the offer of goods and their active demand, resulting from the increase in prices and reduction in the real buying value of money and has an impact on the capital charge rate and the operational costs.

## 5. Rate of Interest

It is yielded by the capital amount, in any currency, for a certain time period, usually 1 year.

## 6. Methods of Life Cycle Cost

### 6.1. General

The total cost of a solar system comprises a high initial capital cost but low operational costs. In the case of a conventional system, the cost of purchase is small but the cost of fuel is high and continuously increasing.

The life cycle cost method is a proper parameter for the economical evaluation of energy systems, the benefit of which is based in the cost of fuel replacement. This economical method compares two energy systems with the same final scope. The first is the solar system equipped with an auxiliary energy source and the second is the conventional energy system. The comparison refers to the initial cost and the operational costs of the solar system with the operational costs of the conventional system. In this comparison, the time value of the money is considered. This is done by interpolation of the expected expenses at present value, i.e. how much money has to be invested today, at the most favorable interest rate, so that there is enough capital available in the future to cover the expected costs. Life cycle cost is defined as the sum of the present values of all the years for which economical analysis has been conducted. A system with the smallest life cycle cost is considered to be the most economical.

## 6.2. Present and Future Costs

Money has not the same value today as money to be paid in the future. The interpolation in present value of the expected expenses defines the life cycle according to the value of money in the years considered. The amount of money, *P*, which may be invested today, with a rate of interest, *d*, after *N* years of time they will increase in value by $(1 + d)^N$. Thus in order to have after *N* years an amount of A with the above rate of interest, *d*, today an amount, *P*, has to be invested as (Bradenmuehel 1977; Ruegg 1976):

$$P = \frac{A}{(1+d)^N} \tag{1}$$

The ratio $P/A = (1 + d)^N$ is called the "present worth factor" (RWF). In case of inflation, *i*, the amount of *A* at the end of period *N* will be:

$$A(1+i)^{N-1} \tag{2}$$

Thus the invested amount of money, *P*, has a present value corresponding to:

$$P = \frac{A(1+i)^{N-1}}{(1+d)^N} \tag{3}$$

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