ΚΑΠΕ
CRES

Solar Systems Applications in the Dairy Industry

ENERGIE

SOLAR SYSTEMS APPLICATIONS IN THE DAIRY INDUSTRY

Industrial Applications of Solar Thermal Systems

The main application fields of large central solar-thermal systems are ranked as follows:

- Hot water production
- Domestic applications (hotels, houses, large apartments buildings)
- Large public and commercial buildings (hospitals, prisons, schools, sport centers)
- Industrial applications
- Greenhouses (floor and space heating)
- Space heating and air-conditioning

- Desalination

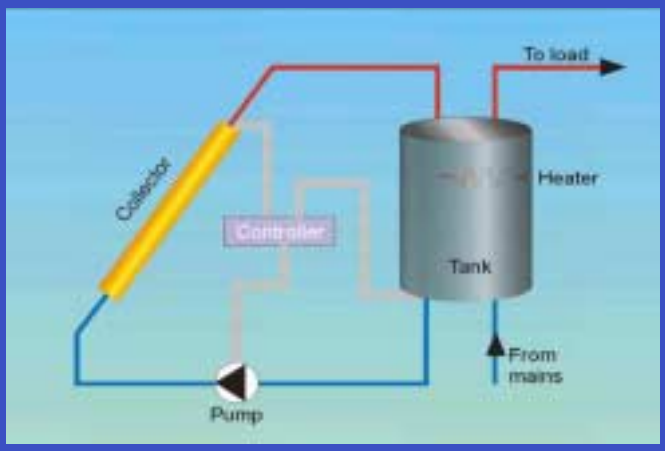
Solar-thermal systems are particularly efficient in industries that require the use of low-temperature water (i.e. 40 - 80 ^{0}C)

In **industrial applications** there are some cases in which the penetration of the thermal-solar systems can be particularly substantial. These are industries which have relatively low energy consumption and the energy derived from the thermal-solar system substitutes an important part of conventional fuels in their energy balance. These industries are the following:

- **Food industry** (dairy products, frozen products, meat processing industries, sweets, olive oil etc.)

- **Agriculture** (kilns, nurseries, greenhouses, slaughterhouses, meat processing, stockbreeding installations etc.)
- **Textile industry** (tannages, leather processing, dyers etc.)
- **Chemical industry** (cosmetics, detergents, wax, pharmaceuticals, tires etc.)
- **Beverage industry** (wineries, distilleries, breweries etc.)

TECHNICAL CHARACTERISTICS OF SOLAR THERMAL SYSTEMS



A central solar system consists of the following parts:

- **Collector** -This is where solar radiation is absorbed and converted into heat
- **Tank** - This is a thermal storage container for the storage of the collected thermal energy
- **Pump** - This is a device which allows the circulation of the thermal transfer fluid (antifreeze liquid or air) through heat collectors and heat exchangers
- **Control Systems** - these are devices (thermostats, valves etc.) which ensure the efficient and/or optimal operation of the system
- A **heat exchanger**, can be inserted between the collector and the tank in order to transfer heat between the two liquids

SOLAR SYSTEMS APPLICATIONS IN THE DAIRY INDUSTRY

Solar thermal systems can greatly contribute to energy savings during the production processes in the dairy sector, which demand water temperatures of <80^{0}C. The hot water produced by the solar collectors can also be used for pre-heating the water entering the installation's steam boiler. In this case, the energy contribution of the solar system is relatively small both in comparison with the total energy demand, as well as in absolute figures.

Low temperature processes <80^{0}C

Such processes are:

- Bottle washing 60^{0}C
- Pasteurization 70^{0}C
- Yogurt maturation 40-45 ^{0}C
- CIP (Cleaning-in-Place) 70-80^{0}C

High temperature processes >100^{0}C

Such processes demand hot water of very high temperatures. More precisely:

- Bottles sterilization
- UHT treatment (milk sterilisation)
- Multiple stage evaporation
- Spray drying

Indicative values of specific energy consumption per process in the dairy sector (t = ton of final product)

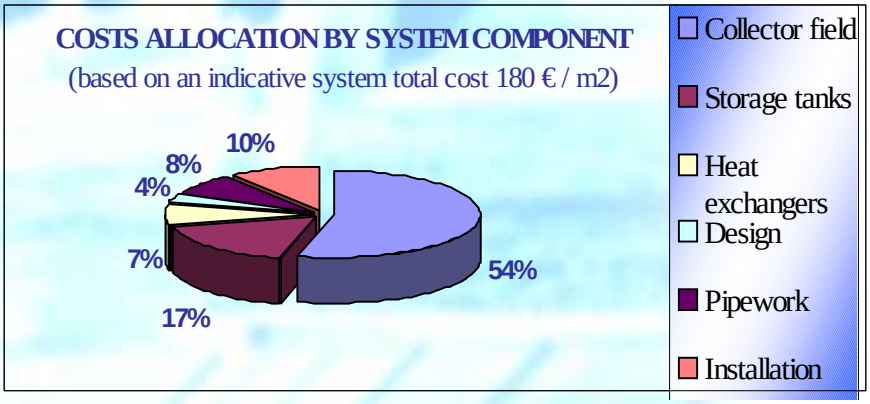
Process	Heat (kWh/t)	Electricity (kWh/t)
Pasteurisation	12	5
Sterilization in bottles	92-140	3-12
Bottle washing	28 -118	3-12
UHT indirect (sterilisation)	17-24	
UHT direct (sterilisation)	118	
Homogenization		6-10
Packing	14-28	
Cleaning-in-Place	56-168	
Evaporation	7-168	
Spray drying	123-179	

ECONOMIC EVALUATION OF SOLAR THERMAL SYSTEMS IN INDUSTRIAL APPLICATIONS

Solar Thermal System Costs

By examining all solar thermal plants in industrial applications in Greece during the '90s and the most recent years, it comes out that an indicative cost of such a system for industrial applications is about 180 EUROS/m^2 excluding VAT.
The chart depicts the allocation of the various costs versus the different system components in terms of percentage in reference to the total cost of the system.

The main cost of solar thermal systems comes from the collector field (54%), the storage tank and the heat exchanger (24%).



Comparison with the conventional energy systems

Based on the analysis of the financial indicators and the payback period of such systems, the solar thermal systems can compete favorably with heating systems that use industrial fuels, such as diesel and LPG. Therefore, solar systems comprise an economically preferable option in diesel and LPG consuming industries. On the other hand, petrol and LPG are widely used in many other commercial sectors in Greece (i.e. hotels, swimming pools, bakeries, confectioneries etc.)

ECONOMIC EVALUATION OF SOLAR THERMAL SYSTEMS

Economic evaluation	Fuel	Fuel Price March 2000	Payback (years) 180 Euro/m^2	Payback (years) 90 Euro/m^2
	Diesel	0,0519 €/Kwh	3,6	1,8
	LPG	0,0417 €/Kwh	4,2	2,1
	Fuel 1500	0,0252 €/Kwh	7,7	3,9
	Natural gas **	0,0265 €/Kwh	8,1	4

The assumptions for the calculation of data of the table are: interest rate = 8%, boiler efficiency = 0.8- 0.85, solar collector performance = 800 kWh/year/m2 and process load factor = 0.8. Full investment cost (180 Euro/m2) is analyzed in the third column allocated by type of industrially used fuel (Prices being given for the March 2000. In case that there is 50% subsidy for the investment of the solar system, we have the results of the last column.

*** Natural Gas Values are not yet definite*

MEVGAL S.A.: SOLAR SYSTEMS FOR WATER HEATING FOR CIP WASHING MACHINES AND THE WATER PRE-HEATING IN STEAM BOILERS

General Characteristics

Company name: Mevgal S.A
Activity: Dairy Industry
Staff: 800 employees
Location: Thessaloniki

CPC + flat plate collectors on the roof

Process hot water requirements

Factory operation hours: 24 hours a day, 7 days a week
Hot water consumption: 120-150 m^3/day
Temperature of process water:
a) washing machine: 20-80^{0}C
b) other processes: 20-130^{0}C

Installation Description

The hot water from the closed-loop hydraulic circuit of the selective flat plate solar collectors, heats (via an internal heat exchanger) the water in two, 2500 liters solar storage tanks. The hot water leaving the solar storage tanks is then used for the washing machine. Any auxiliary heating required is provided by the steam boilers. The hot water from the closed-loop hydraulic circuit of the CPC and flat plate solar collectors heats (via an internal heat exchanger) the water in two, 2500 liters solar storage tanks. The hot water leaving the solar storage tanks is used for preheating the water entering the steam boiler. The installation belongs to CRES and was financed 73% by the OPE (Operational Programme for Energy), 6,5% by the Agricultural bank and 20% by MEVGAL with a GSR (Guaranteed Solar Return) type of contract.

Selective flat plate collectors on roof

TECCHNICAL CHARACTERISTICS

Provider:	Intersolar S.A
Year of installation :	1999
Collector's area **:**	a) 168 x 2.4 m^2 = 403.2 m^2 (selective flat plate collectors)
	b) 108 x 2m^2 = 216 m^2 (flat plate collectors)
	c) 40 x 2.7m^2 = 108 m^2 (CPC collectors)
Inclination of flat plate collector:	45^0 South
Hydraulic circuit:	closed loop water /propylene glycol
Collector's field layout (selective flat plate collectors):	14 parallel branches with 12 collectors per branch
Collector's field layout (CPC):	8 collectors connected in parallel
Collector's field layout (flat plate collectors):	9 parallel branches with 12 collectors per branch
Capacity of solar storage tanks:	2 x 2.5 m^3 (in series) – selective collectors
	2 x 2.5 m^3 (in parallel) – CPC + flat plate collectors

ALPINO S.A. : SOLAR SYSTEMS FOR WATER PRE-HEATING IN STEAM BOILERS

General Characteristics

Company name: ALPINO S.A.
Activity: Dairy
Staff: 110 employees
Location: Thessaloniki

Solar collectors on roof

Process hot water requirements

Factory operation hours: 8 1/2 hours a day, 7 days a week
Hot water consumption: 30-40 m^3/day
Temperature of process water:
a) for washing machines: 20-80^{0}C
b) other processes: 20-130^{0}C

Installation Description

The hot water from the closed-loop hydraulic circuit of the two branches of the flat solar collectors heats (through an internal heat exchanger) the water in two closed storage tanks (of a total capacity of 25m^3). The hot water leaving the storage tanks is then used for the pre-heating of the water that enters the steam boiler. Any other demand for heating is ensured by the steam boilers.

Auxiliary heating

3 steam boilers (2x1.2Mcal+1x4.8Mcal) of hard oil

Solar collectors on roof

The installation was financed by 50% by the OPE with a GSR (Guaranteed Solar Result) contract.

TECCHNICAL CHARACTERISTICS

Provider:	Sunny S.A.
Year of installation:	1999
Collector's area:	a) 126x2 m^2 = 252 m^2 (branch I)
	b) 162 x 2m^2 = 324 m^2 (branch II)

*** Both branches incorporate flat plate collectors
Inclination of flat plate collector: 45 ^{0} South
Hydraulic circuit: closed circuit water/ propylene glycol
Collector's field layout (branch I): 14 parallel branches with 9 collectors in each branch
Collector's field layout (branch II): 18 parallel branches with 9 collector in each branch
Capacity of solar storage tanks: 1x10 m^3 - branch I
1x15 m^3 - branch II

MANDREKAS S.A.: WATER HEATING BY SOLAR SYSTEMS FOR YOGURT MATURING PROCESS

General Characteristics

Company name: Mandrekas S.A.
Activity: Dairy
Staff: 15 employees
Location: Korinthos

Solar collectors on the roof

Process hot water requirements of Mandrekas S.A

Factory operation hours: 8 hours a day, 5 days a week
Hot water consumption: 0,5 m^3/day
Temperature of process water:
a) for yogurt: 30-70^{0}C
b) for pasteurizing: >100^{0}C

Installation Description

The hot water from the solar collectors heats the water in the two tanks through an open circuit.

The hot water leaving the solar storage tanks either for:

a) directly supplying the factory's WC, or
b) it is used for the preservation of the yogurt maturing temperature between 40-45^{0}C.

The hot water then circulates in the storage tanks. Any additional need for heating is provided through a heat exchanger placed next to the solar storage tanks.

Yogurt production

Auxiliary heating

A steam boiler (with 600kg capacity)-LPG.
The system is in operation and the energy saving in the yogurt production process is quite remarkable.
The project was financed by 50% through the Plan for Regional Development.

TECCHNICAL CHARACTERISTICS

Provider:	Thia S.A.
Year of installation:	1993
Collector's area:	66 x 2,6 m^2 = 170 m^2
Inclination of flat plate collector:	45 ^{0} South
Hydraulic circuit:	water open circuit
Collector's field layout:	13 branches connected in parallel with 5 collectors per branch
Capacity of solar storage tanks:	2x1000 lt

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The department for Solar Thermal Systems of CRES provides the following services:

1) Auditing and monitoring of energy consumption prior to the installation of solar thermal systems.
2) Basic design and electromechanical studies of solar thermal systems
3) Supervision, adjusting and monitoring of installed systems
4) Training of installers, designers and architects
5) Support and collaboration with companies that are interested to participate in solar thermal projects in the framework of National and European financing programmes.

For more information please contact:

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