Solar Systems Applications in the Dairy Industry
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

**TECHNICAL CHARACTERISTICS OF SOLAR THERMAL SYSTEMS**

**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 °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, dyes etc.)
- **Chemical industry** (cosmetics, detergents, wax, pharmaceuticals, tires etc.)
- **Beverage industry** (wineries, distilleries, breweries etc.)

**INDUSTRIAL APPLICATIONS OF SOLAR THERMAL SYSTEMS**

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- Hot water production
- Domestic applications (hotels, houses, large apartments buildings)
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Solar thermal systems can greatly contribute to energy savings during the production processes in the dairy sector, which demand water temperatures of <80°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°C**

Such processes are:
- Bottle washing 60°C
- Pasteurization 70°C
- Yogurt maturation 40-45°C
- CIP (Cleaning-in-Place) 70-80°C

**High temperature processes >100°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)

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

Process hot water requirements
Factory operation hours: 24 hours a day, 7 days a week
Hot water consumption: 120-150 m³/day
Temperature of process water:
  a) washing machine: 20-80°C
  b) other processes: 20-130°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.

TECHNICAL CHARACTERISTICS
Provider: Intersolar S.A
Year of installation: 1999
Collector’s area:
  a) 168 x 2.4 m² = 403.2 m² (selective flat plate collectors)
  b) 108 x 2m² = 216 m² (flat plate collectors)
  c) 40 x 2.7m² = 108 m² (CPC collectors)
Inclination of flat plate collector: 45° 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 m³ (in series) – selective collectors
  2 x 2.5 m³ (in parallel) – CPC + flat plate collectors
General Characteristics
Company name: ALPINO S.A.
Activity: Dairy
Staff: 110 employees
Location: Thessaloniki

Process hot water requirements
Factory operation hours: 8 1/2 hours a day, 7 days a week
Hot water consumption: 30-40 m³/day
Temperature of process water:
  a) for washing machines: 20-80°C
  b) other processes: 20-130°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 25m³). The hot water leaving the storage tanks is then used for the preheating 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

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

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°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.

Process hot water requirements of Mandrekas S.A
Factory operation hours: 8 hours a day, 5 days a week
Hot water consumption: 0.5 m³/day
Temperature of process water:
  a) for yogurt: 30-70°C
  b) for pasteurizing: >100°C

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

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.

TECHNICAL CHARACTERISTICS
Provider: Thia S.A.
Year of installation: 1993
Collector’s area: 66 x 2.6 m² = 170 m²
Inclination of flat plate collector: 45° 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
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.

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