CONTEXT OF THE PRESENT STUDY

✓ Integration of solar heat into dairy industry processes will be demonstrated by IRTA

✓ The research work associated with the solar system design and sizing was developed by IREC

✓ **Pilot facility**: Combination of experimental solar system + experimental milk treatment system
OBJECTIVES OF THE STUDY

Challenges

✓ To optimize the system configuration in order to increase solar thermal contribution (or solar fraction)

✓ To show that it is possible to achieve with conventional direct streamed Sidney vacuum tube solar collectors a middle temperature range of 150°C for experimental UHT applications in a southern European country

Outputs from TRNSYS simulations

✓ Size of storage tank and solar field

✓ Outcome of possible system configurations to define optimal installation and control schemes

✓ Assessment of duration of periods with 100% solar operation to feed-in the storage tank and UHT process
TRNSYS SOLAR THERMAL SYSTEM MODEL

Working fluid
- Superheated water at 150°C
- Hydraulic system pressure 8.5 bar

Solar field
- Direct-flow evacuated tube solar collector
- Model: Buderus - LOGASOL SKR12.1
- Collector absorber area = 2.57 m²
- Number of collectors in series = 5
- Total number of collectors = 40; 30; 20

Storage tank
- Volume = 5 000 L, 4 000 L, 2 500 L; 1 000 L
- Hydraulic system pressure 8.5 bar
RESULTS FROM PARAMETRIC ANALYSIS

(1) INTRODUCTION OF STRATIFICATION VALVE V2
(2) NUMBER OF SOLAR COLLECTORS AND TANK SIZE
(3) INTRODUCTION OF STRATIFICATION VALVE V5

\[ SF = \frac{Q_{UHT} - Q_{boiler}}{Q_{UHT}} \]

- Better stratification in the tank
- Lower boiler usage
- Higher solar energy

Valve V2 not included
Valve V2 included

Valve fraction

40 collectors
35 collectors
30 collectors

Fixed tank size (5 000 L)
RESULTS FROM PARAMETRIC ANALYSIS
NUMBER OF SOLAR COLLECTORS AND TANK SIZE

- The larger the tank, the larger the solar fraction obtained.
- The configuration with 30 collectors gives a larger solar fraction.

RESULTS - TANK TEMPERATURES AND SOLAR ENERGY

Legend:
- T1 … T5 = Tank nodes temperatures
- Load_UHT = Heat load in UHT
- Q_solar_intank = Heat provided by solar system to tank

Selection:
- Solar field of 30 collectors
- Tank volume of 4000 L
RESULTS FROM PARAMETRIC ANALYSIS
INTRODUCTION OF STRATIFICATION VALVE V5

<table>
<thead>
<tr>
<th>Valve V5</th>
<th>Time when $T_{in_UHT} \geq 150^\circ C$</th>
<th>Nr. of days when complete UHT process experiment is exclusively supplied by solar energy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours / year</td>
<td>Days / year</td>
</tr>
<tr>
<td>Not included</td>
<td>3.50</td>
<td>0</td>
</tr>
<tr>
<td>Included</td>
<td>56.88</td>
<td>4</td>
</tr>
</tbody>
</table>

CONCLUSIONS

✓ Solar fraction is enhanced by installing 30 collectors in front of 35 or 40 collectors in the present system

✓ Introduction of stratification valve V2 in the cold return from UHT process leads to an increase of the annual solar fraction of 10%

✓ Introduction of stratification valves V2 and V5 $\rightarrow$ 100% solar fraction is accomplished during few days per year with continuous 150$^\circ C$ water supply to the experimental milk treatment process

✓ Size of the facility to reach a maximum annual solar fraction of 39.6% assessed using TRNSYS:
  - Solar field: 77 m$^2$, 30 ETC, 2.57 m$^2$/u (absorber area)
  - Storage tank: 4 000 L