TRNSYS SIMULATION OF SOLAR ENERGY SUPPLY TO A MILK PROCESSING PLANT

Joana Tarrés, Detta Schaefer, Alaia Sola, Laura Sisó and Jaume Salom
IREC, Catalonia Institute for Energy Research

Xavier Felipe and Marta Garrón
IRTA, Research & Technology Food & Agriculture

CONTEXT OF THE PRESENT STUDY

Saving water and energy for resource efficient food processing

- ✓ 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

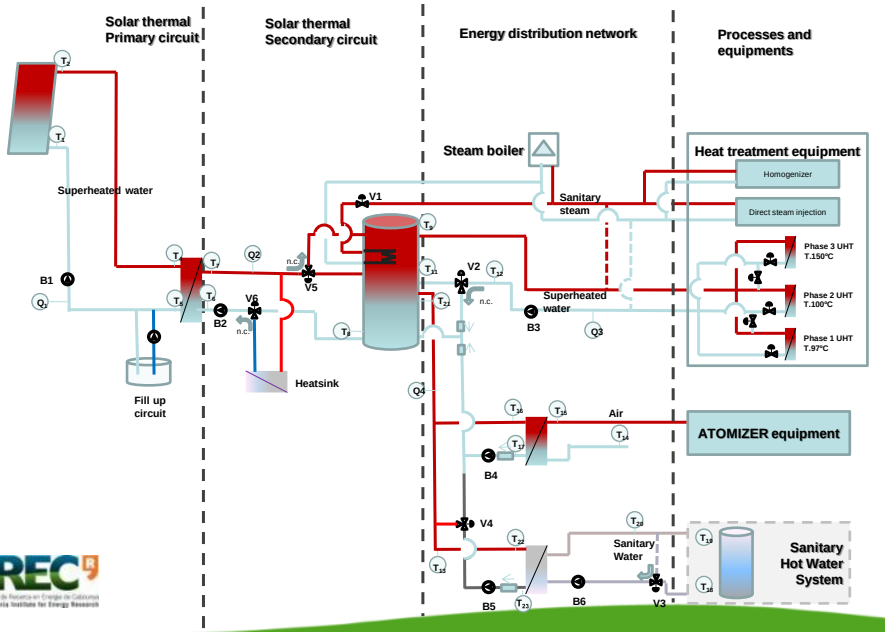
Challenges

- ✓ 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 150ºC for experimental UHT applications in a southern European country

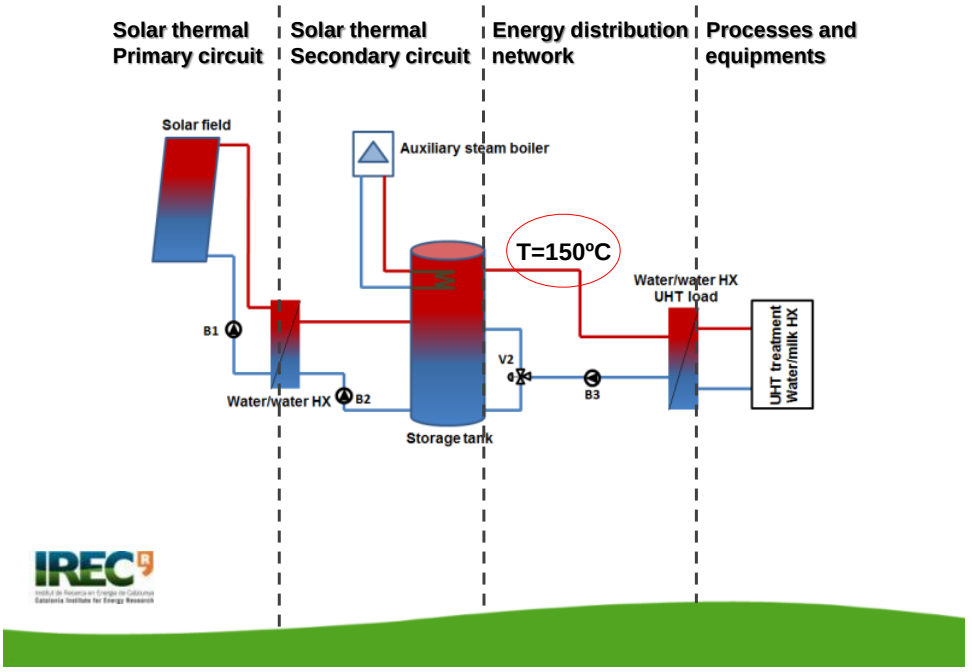
Outputs from TRNSYS simulations

- ✓ 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

SCHEME OF THE PILOT FACILITY

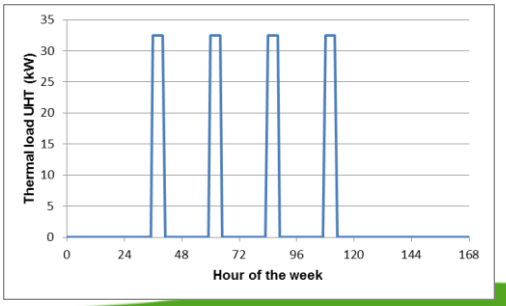


TRNSYS SOLAR THERMAL SYSTEM MODEL



TRNSYS SOLAR THERMAL SYSTEM MODEL

Working fluid	Superheated water at 150ºC Hydraulic system pressure 8.5 bar
Solar field	Direct-flow evacuated tube solar collector Model: Buderus - LOGASOL SKR12.1 Collector absorber area = 2.57m^2 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



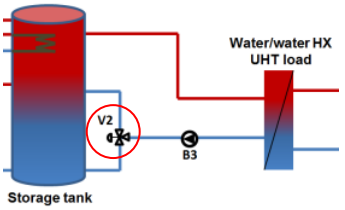
RESULTS FROM PARAMETRIC ANALYSIS

(1) INTRODUCTION OF STRATIFICATION VALVE V2

(2) NUMBER OF SOLAR COLLECTORS AND TANK SIZE

(3) INTRODUCTION OF STRATIFICATION VALVE V5

RESULTS FROM PARAMETRIC ANALYSIS
INTRODUCTION OF STRATIFICATION VALVE V2



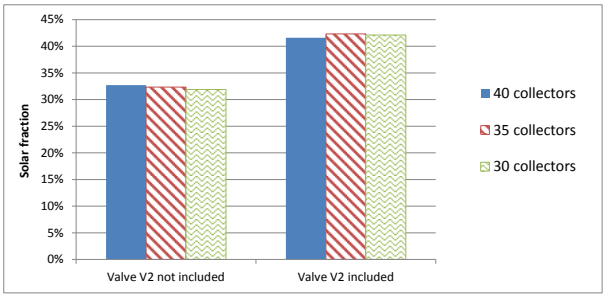
✓ Fixed tank size (5 000 L)

$$SF = \frac{Q_{UHT} - Q_{boiler}}{Q_{UHT}}$$

✓ Better stratification in the tank

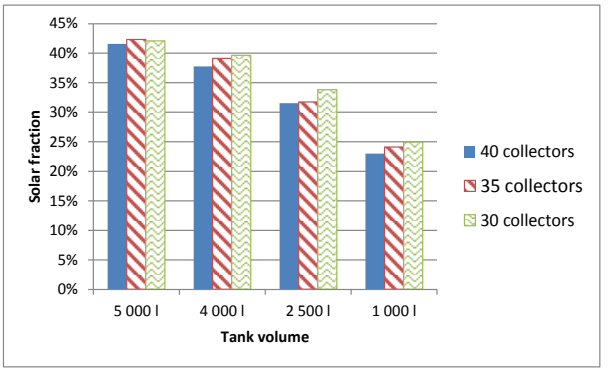
✓ Lower boiler usage

✓ Higher solar energy

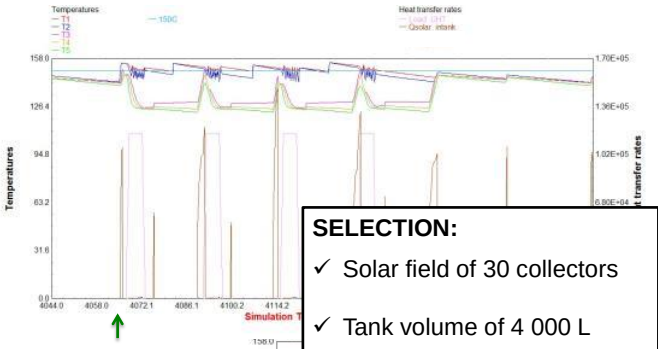


RESULTS FROM PARAMETRIC ANALYSIS
NUMBER OF SOLAR COLLECTORS AND TANK SIZE

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

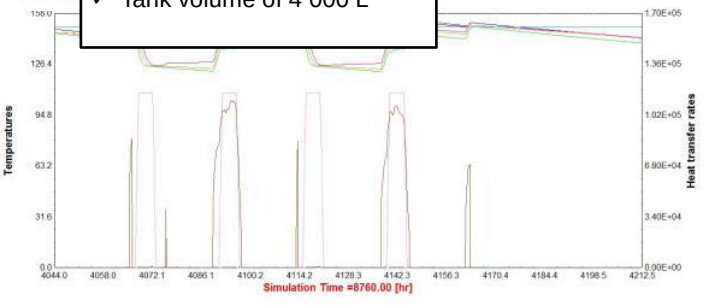


RESULTS - TANK TEMPERATURES AND SOLAR ENERGY



40 solar collectors
4 000 L tank

30 solar collectors
4 000 L tank →



SELECTION:

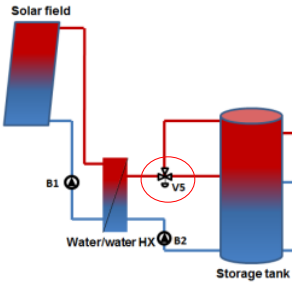
- ✓ Solar field of 30 collectors
- ✓ Tank volume of 4 000 L

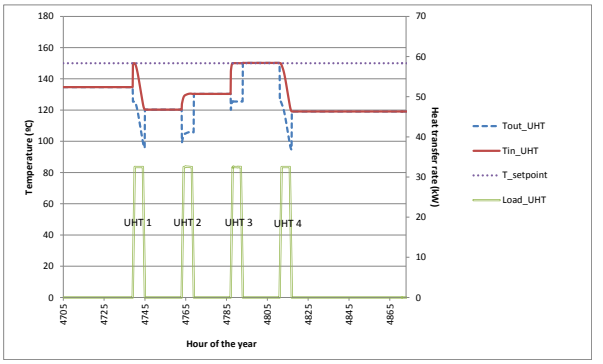
Legend:

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

RESULTS FROM PARAMETRIC ANALYSIS
INTRODUCTION OF STRATIFICATION VALVE V5

Valve V5	Time when Tin_UHT ≥ 150ºC	Nr. of days when complete UHT process experiment is exclusively supplied by solar energy
	Hours / year	Days / year
Not included	3.50	0
Included	56.88	4





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 → 100% solar fraction is accomplished during few days per year with continuous 150ºC 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 m², 30 ETC, 2.57 m²/u (absorber area)
  - Storage tank: 4 000 L

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