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Institut de Recherche Dupuy de Lôme
UMR CNRS 6027

Interreg North-West Europe
ICARE4FARMS
European Regional Development Fund

Parametric study and long-term prediction of the production of a solar water heaters installation

AE - 0027

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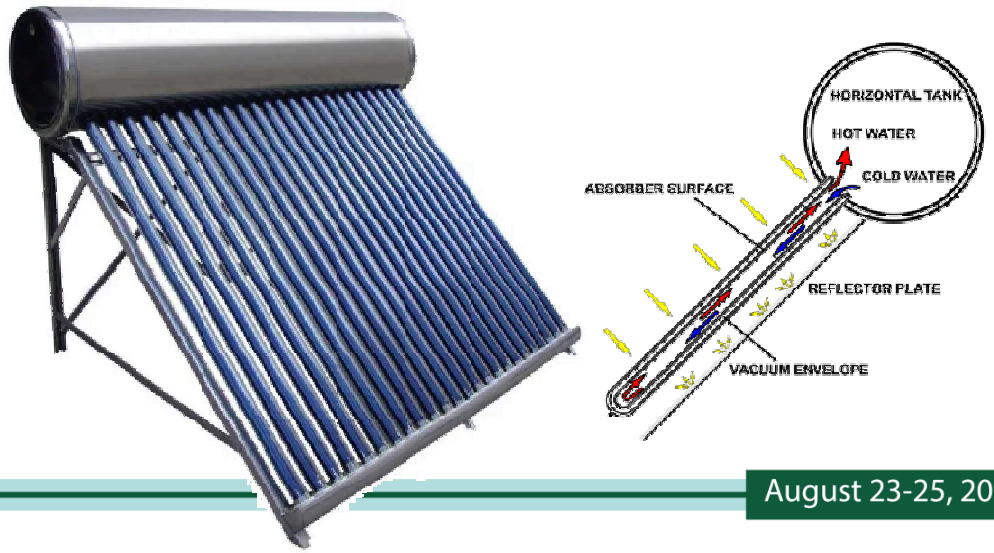


Calf rearing farm in France (near Le Mans)

Context

European projet ***ICaRE4Farms*** intends to

- boost solar thermal energy in NWE
- contribute to reduce GHG emissions
- increase the share of renewable energies

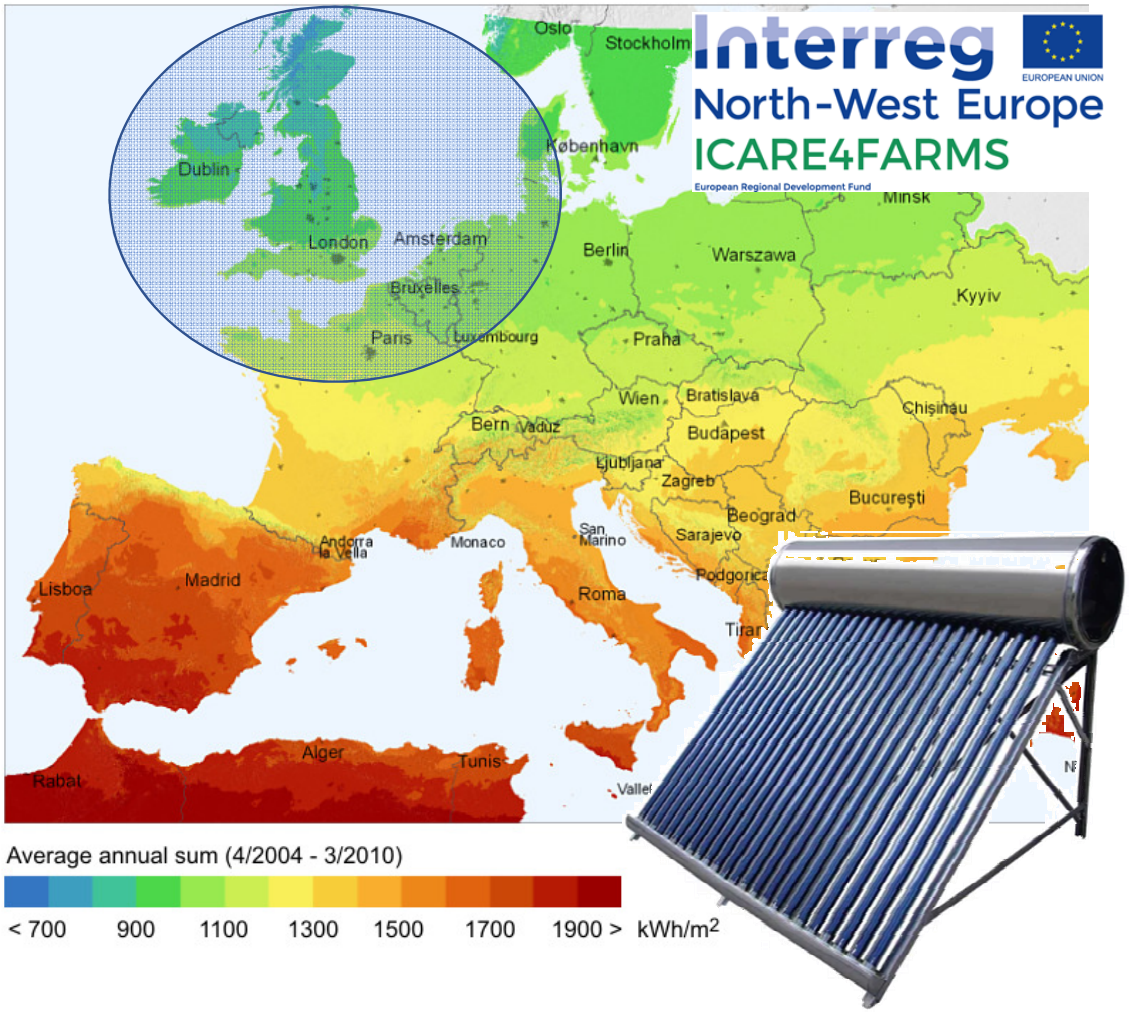
Our work is to assess the interest of thermal solar solutions for the agricultural sector in NWE (where annual GHI<1190 kWh/m²)

The studied installation was designed by a partner of the project, the Fengtech company from Laval.

It is a specific arrangement of Water-in-Glass collectors, optimized for low level irradiation sites.

Presentation contents

- Description Installation
- Modelling and Validation
- Parametric study



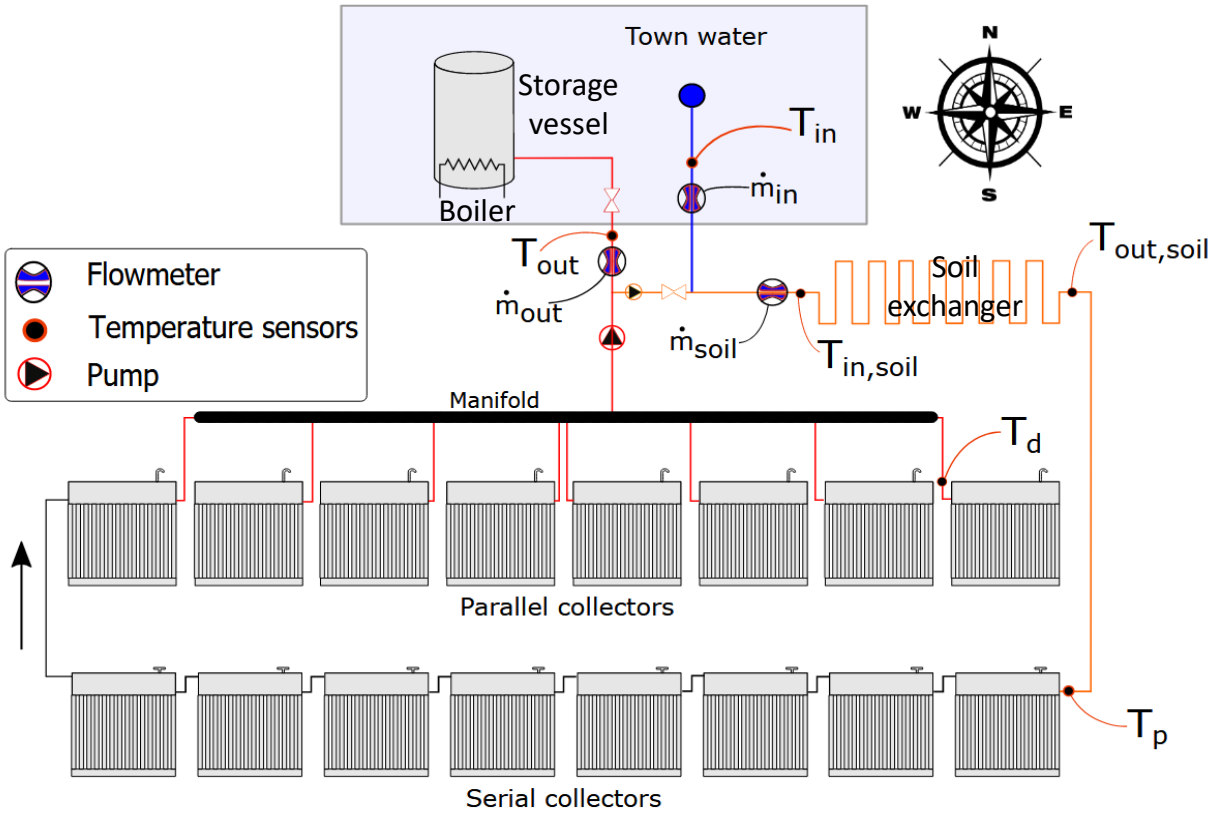
The solar installation

Installation located in France (lat. 48.2°N , long. 0.50°E)
Provides hot water (85°C) for a calf rearing farm.

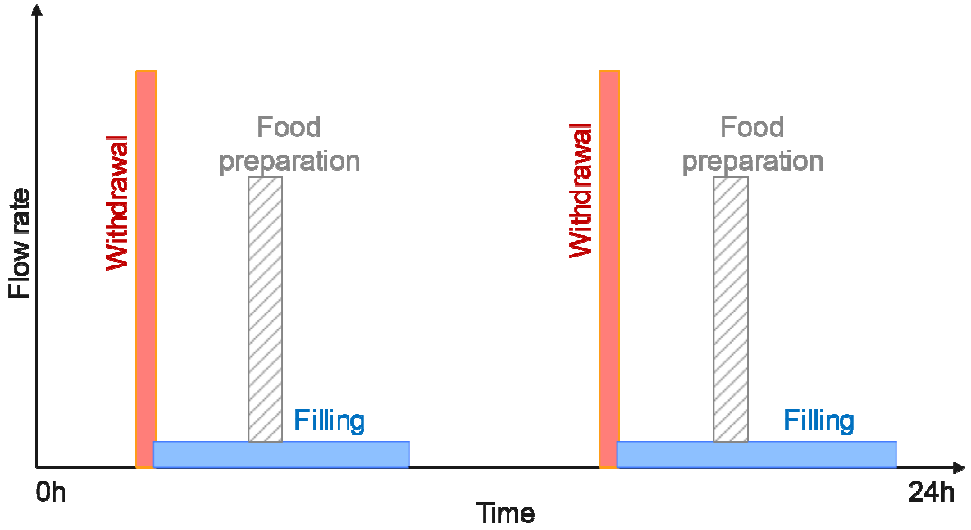
16 “Water-in-Glass” evacuated tubes collectors
- first row solar water heaters in series (preheating)
- second row in parallel (final heating and storage)

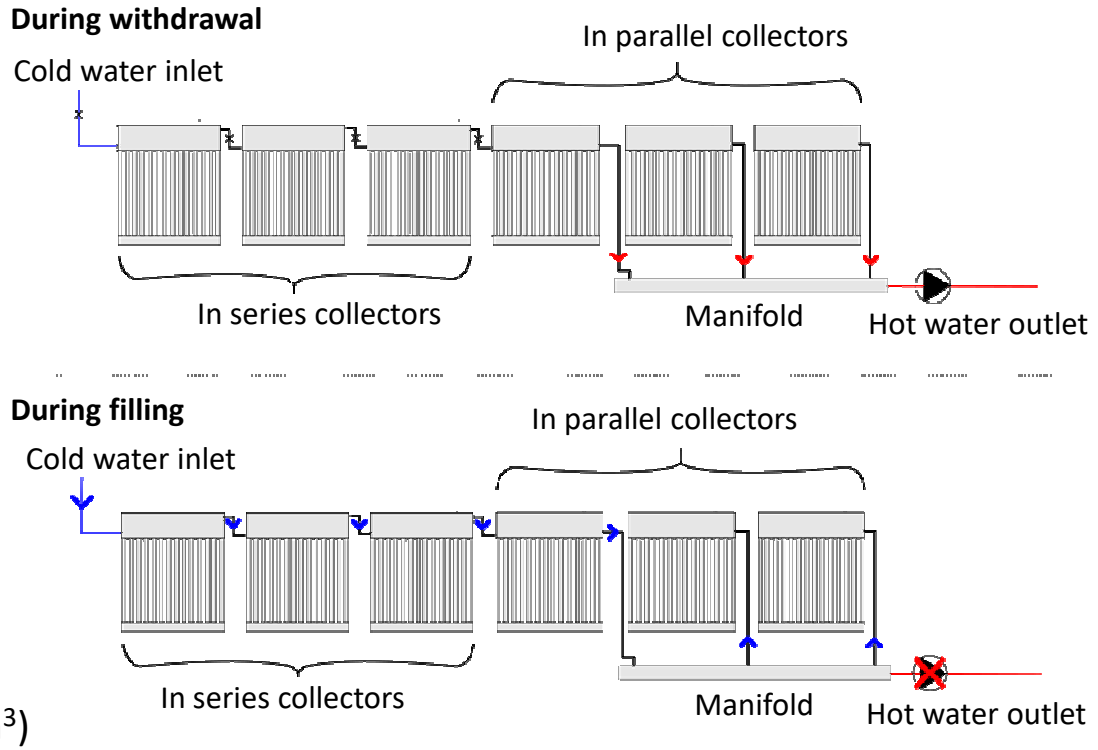
A soil dissipation system has been installed mainly to handle overheat

Instrumentation:
- Hydraulic circuit flow meters and temperature sensors
- On-site weather station with pyranometer



Hydraulics

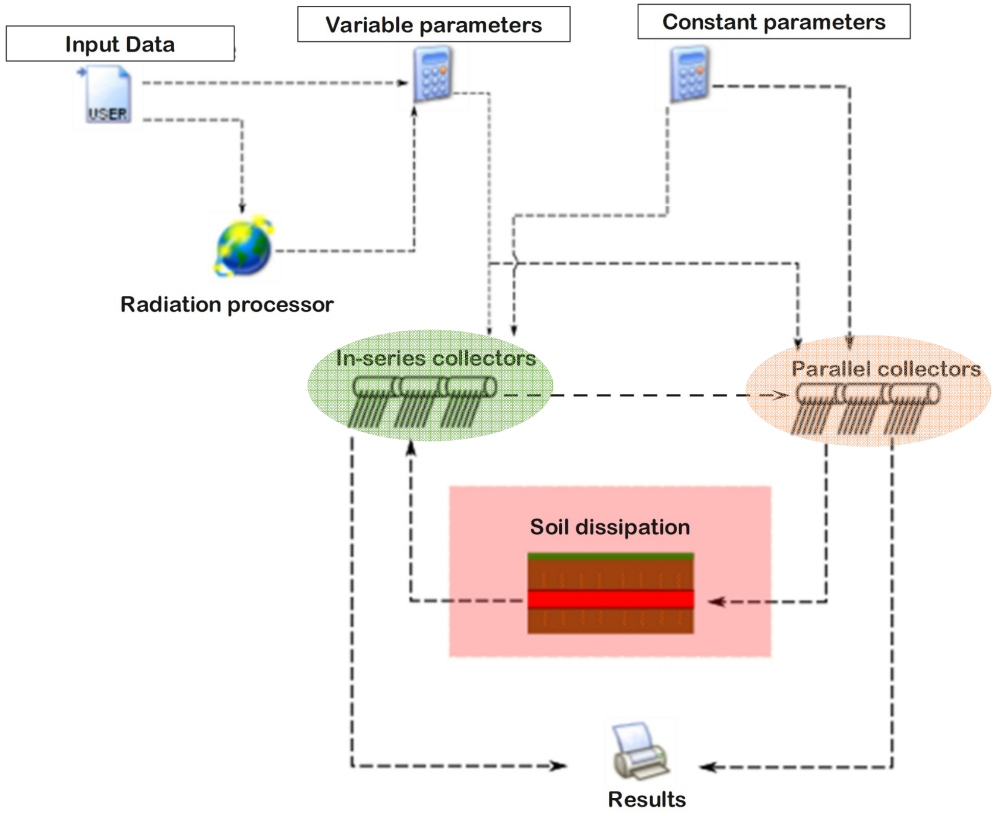




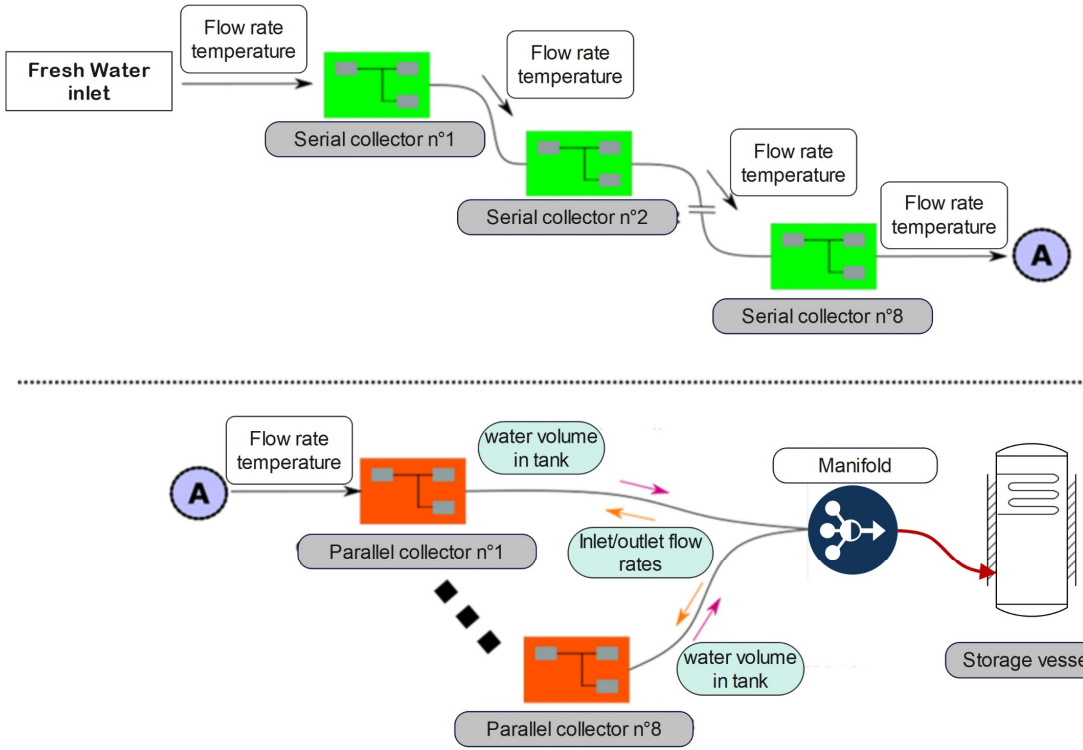
Main features:

- Two withdrawals per day, only parallel tanks are emptied
- Water requirements are function of cycle progress
- Quick withdrawal (0.5h) towards storage vessel (up to 1.8 m^3)
- Slow filling (7h) to enhance stratification in the tanks

Modeling of the installation (Trnsys 18)



based on existing types adapted to the configuration of the system.
The aim is to calculate the energy supplied by the installation



Energy calculations

Daily supplied solar energy

$$Q_{sup} = \int_0^{24h} \dot{m}_{out}.c_p.(T_{out} - T_{in}) \cdot dt$$

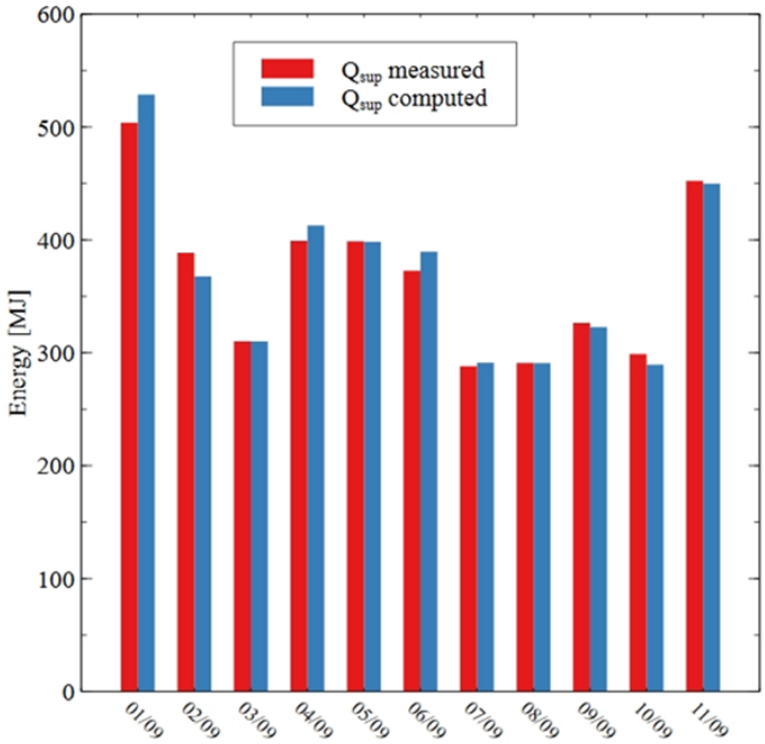
Daily required energy (T_{req}=85°C)

$$Q_{req} = \int_0^{24h} \dot{m}_{out}.c_p.(T_{req} - T_{in}) \cdot dt$$

Solar Coverage ratio

$$CR = \frac{Q_{sup}}{Q_{req}}$$

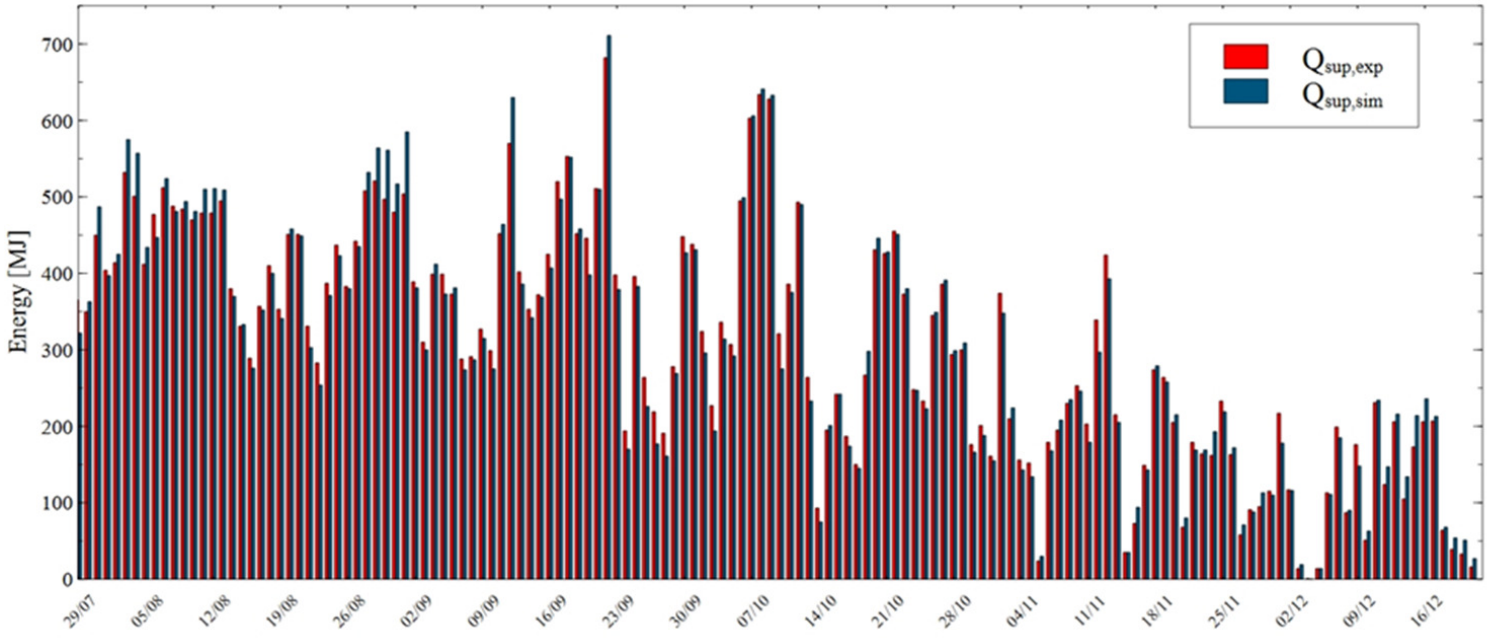
Validation : Simulated values are compared with measurements



The energy supplied Q_{sup} was estimated with a relative error of 0.9% and a daily error averaged at 4.0%.

Long term validation

⇨Simulation on a farm production cycle (≈5 month)



The relative error over the cycle is 0.2% and the average daily absolute error is 16 MJ.

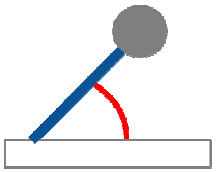
Parametric studies

1) Localisation

- Saint-Georges-du-Rosay
- Herselt
- Sligo
- Marseille

2) Tilt angle

- 15°
- 45°
- 75°

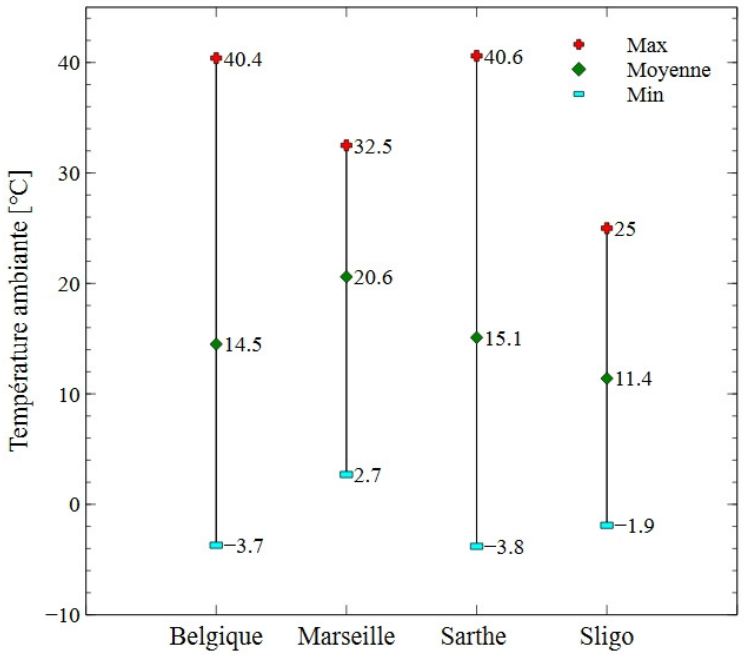


3) Orientation

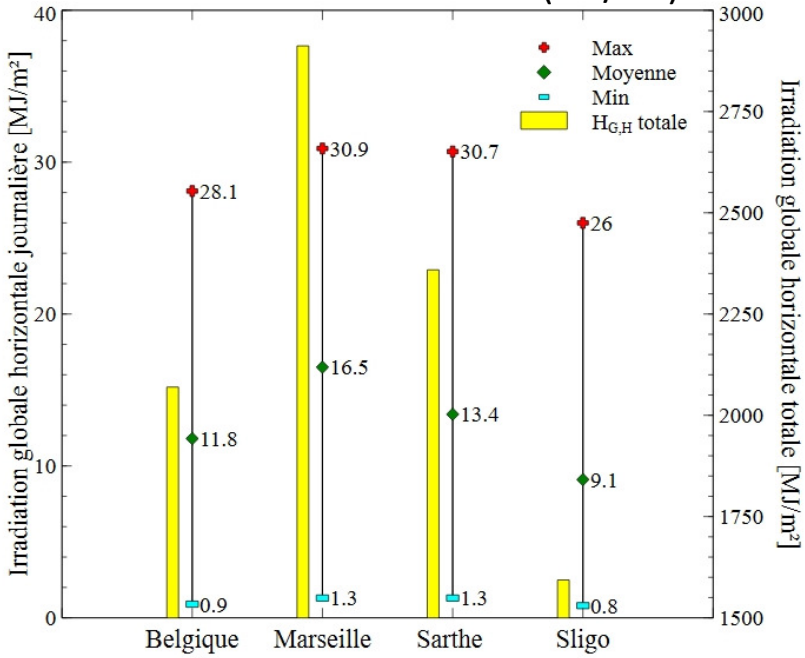
- East
- South-East
- South
- South-West
- West

Weather conditions main characteristics of the 4 locations
(from 2022 *historical* data provided by Solcast Solar API)

Ambient temperature (°C)

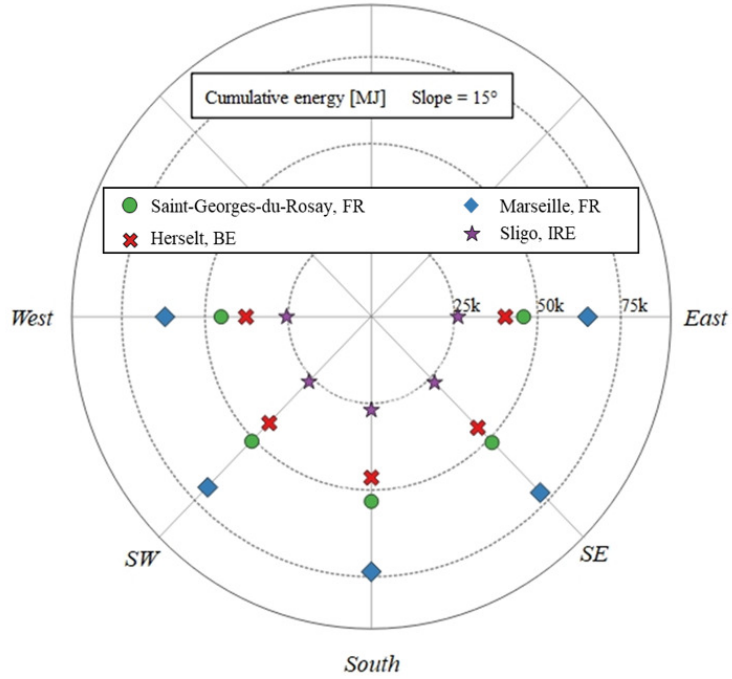


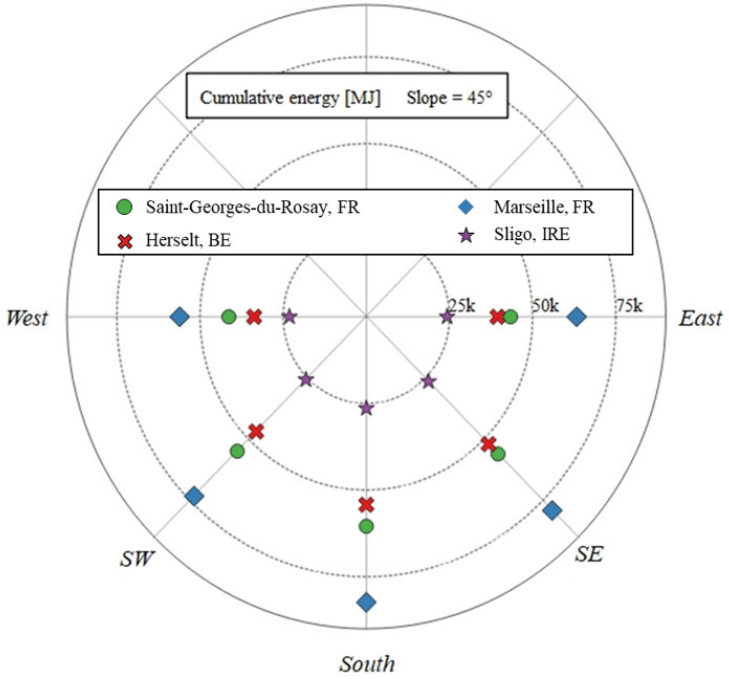
Daily extremes and annual global horizontal irradiation (MJ/m²)

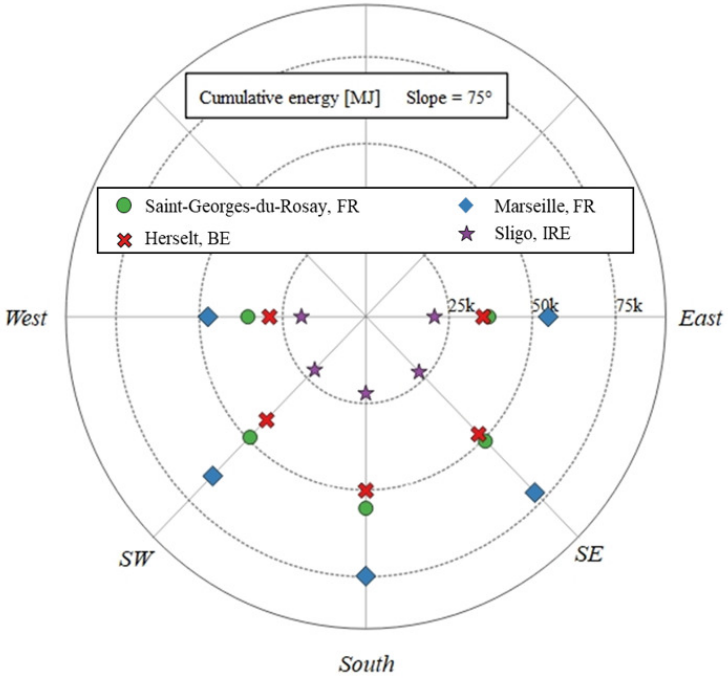


Cumulative energy (MJ) supplied by the solar installation for three tilt angles
Reference Withdrawal volumes = St Georges du Rosay

Graphical results





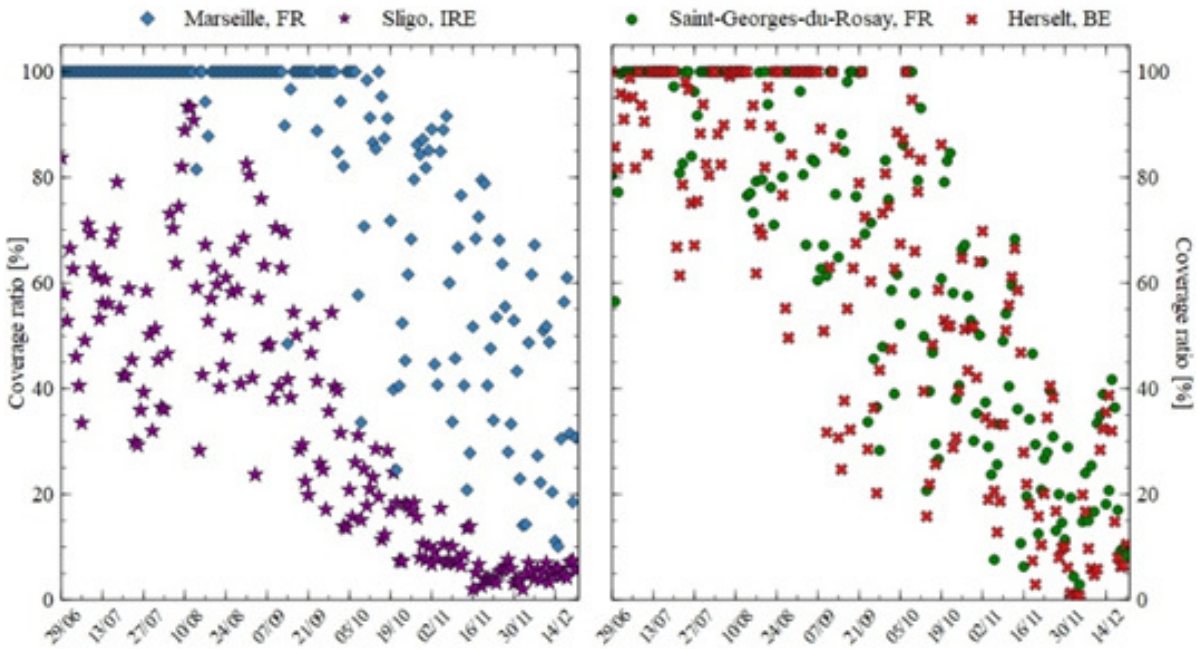


Provided Energies:

	Orientation	Herselt	Marseille	Saint-Georges-du-Rosay	Sligo
15°	E	40,3	65,0	45,8	26,1
	SE	45,3	71,8	51,3	26,9
	S	46,4	73,5	53,3	26,9
	SW	43,4	69,6	50,8	26,5
	W	37,7	62,0	45,1	25,5
45°	E	39,4	63,2	43,4	24,3
	SE	52,0	79,0	56,0	26,4
	S	54,2	82,4	60,4	26,4
	SW	46,8	73,2	54,8	25,7
	W	33,7	56,1	41,3	23,1
75°	E	35,2	54,7	36,9	20,6
	SE	47,9	71,7	50,7	22,6
	S	50,1	74,8	55,2	22,1
	SW	42,1	65,0	49,2	21,7
	W	28,9	47,4	35,4	19,3

Reference : Saint-Georges-du-Rosay (south / tilt 45°)
Other locations same configuration:
Herselt : -10% / Marseille: +36% / Sligo : -50%
Same site ***other orientation***: West: -31%
Same site ***other inclination*** : 15°: -12%

Daily Coverage Ratio:



Cycle cover ratio:

- Saint-Georges-du-Rosay: 65.6%
- Herselt : 58.8%
- Marseille : 89.4%
- Sligo : 28.7%

Conclusion

the dynamic numerical model developed is a great tool to

- ✓ assist in the sizing of installations
- ✓ assess their energy potential for different locations
- ✓ study the effects of varying parameters (orientation, inclination, …)

The experimental measurements and simulation results show that some of the NWE regions can benefit from this solution to reduce their dependence on fossil fuels.

What next?

- ➢ Three other pilots sites have been implemented and are currently under review
- ➢ Run simulations using TMY data files more representative of the real climate.
- ➢ Modify the model to operate autonomously, including ground dissipation, to test the effect of
  - operating parameters such as set temperature and start date
  - the number of collectors in series