DHW/Cooling hybrid strategy for solar cooling:

Practical successful monitoring results in South of France

D. Mugnier (TECSOL)

Introduction

* Long history in France for solar cooling (1980-2013)

However, special national conditions for solar cooling :

- **Mild** climate (cooling season especially in South of France)
- **Low energy price** (one of the lowest in the World for electricity)
- **Mitigated feedback** until now on performance levels (technical dysfunctionning, low economical interest, lack of providers)

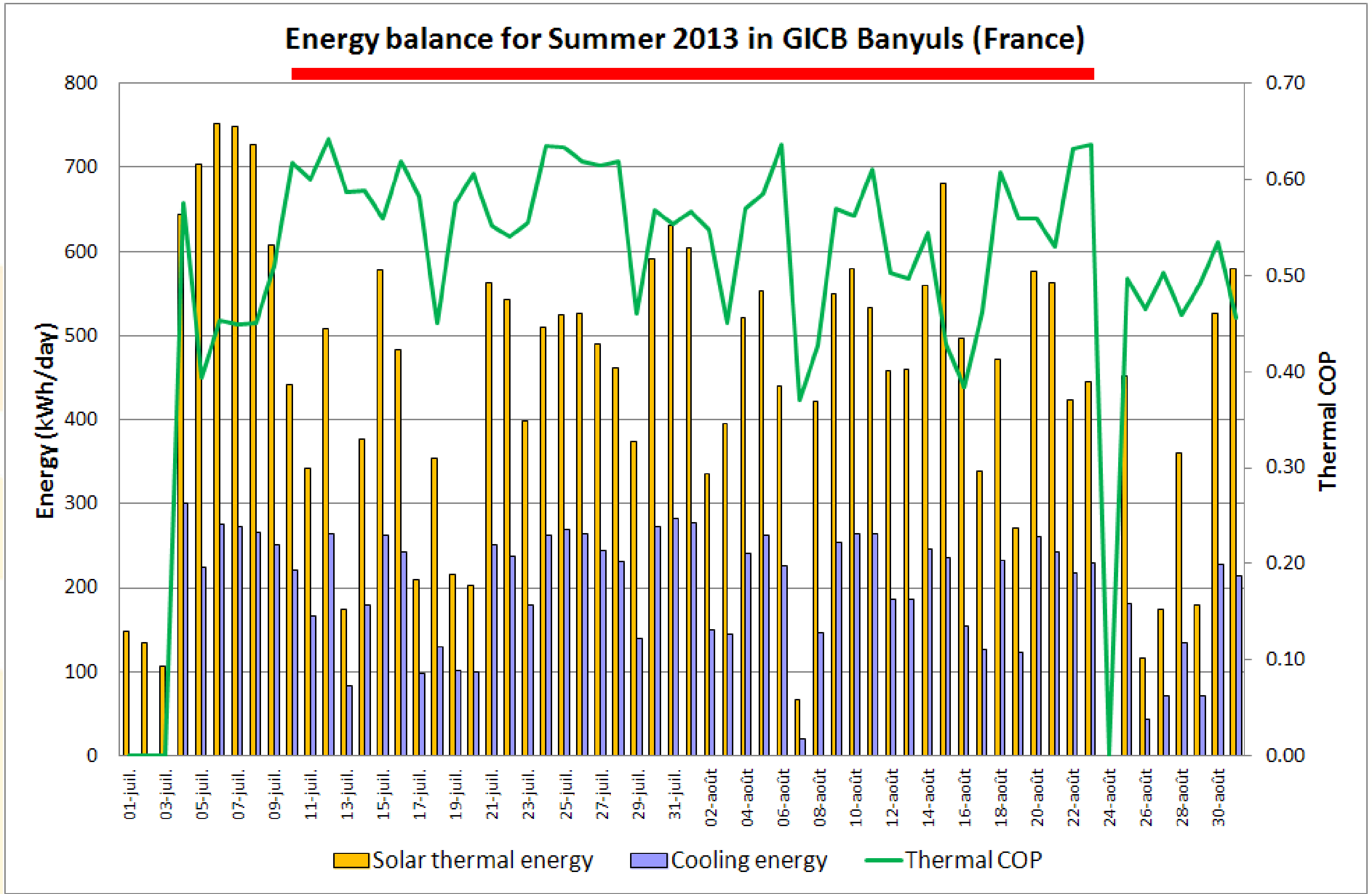
⇒ Important need to structure the sector & get Full Best practice

Big challenge : which system/project to follow up the story in 2013 ?

GICB : a 20 year Solar cooling system

Reminder :

SOLAR COOLING = VERY RELIABLE TECHNOLOGY



OTTI SAC – Bad Krozingen 25-27th Sept. 2013

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Introduction

Solution to create a dynamics for the sector :

- Emergence Program (high incentive against guarantee of results)
- Extend the solar ressource use as much as possible
  $\Rightarrow$ Idea to go to a mix DHW (instead of heating) + cooling system
- Find sites where the system integration is possible including a simple scheme and simple working conditions
- Find motivated customers for such an application

One example : « Amiral block » Solar DHW/Cooling project in Montpellier !

Targeted building description

Montpellier Heating and System net utilities
=> System owner

TECSOL : engineering company

AXIMA GDF SUEZ : Company in charge of the works

Building A view

Existing Building block in ZAC Jacques Coeur in Port Marianne area (Montpellier, France, built in 2010)

2 parts : building A & B (mini district)

Building A : 11 000 m² for offices and shops

Building B : 10 600 m² with 167 dwellings

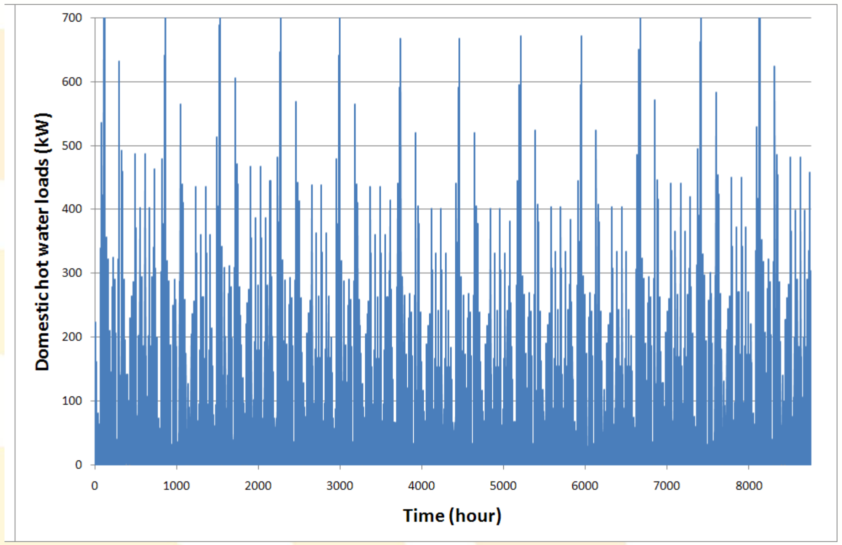
Buildings situation

Load

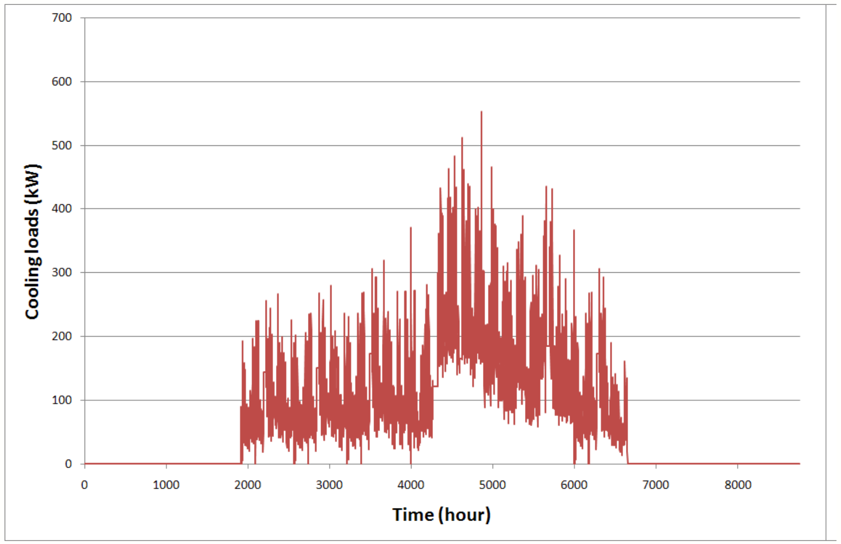
<u>Load</u> : real monitored data from 2010 to 2011

DHW + cooling = 46 kWh/m².y => 1 GWh/y

Heating + cooling equipements : compression chillers + gas burners
(900 kW) (700 kW)



DHW load on a yearly basis



Cooling load on a yearly basis

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Load & system strategy

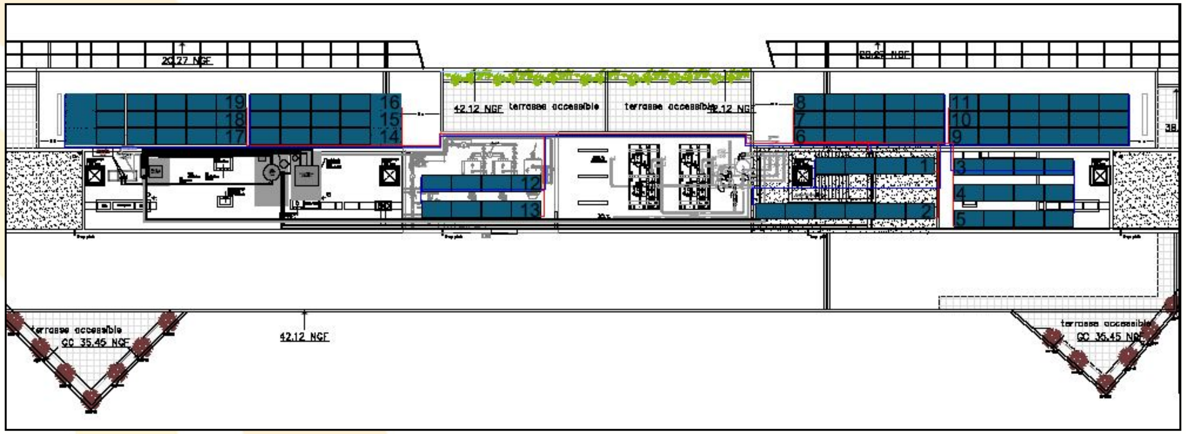
Picture of the collector field

<u>Sizing strategy</u> :

- available place on the roof
- simplicity & maximum yield

⇒ nearly 500 m² available on different locations on the Block A roof => 240 m² solar collector

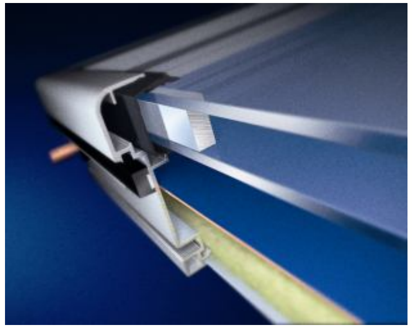
- DHW only in Winter + cooling (if possible +DHW) in Summer



Solar collector position on the roof

System description

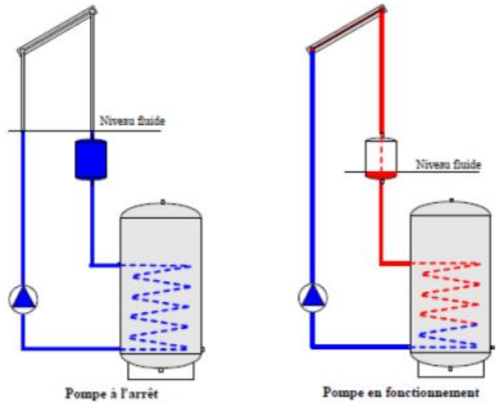
- **240 m² double glazed flat plate collectors**
- **one 35 kW absorption chiller**



Double glazed solar collector

- solar circuit in drainback mode (with water glycol + HX)

Solar collector fields in drainback mode

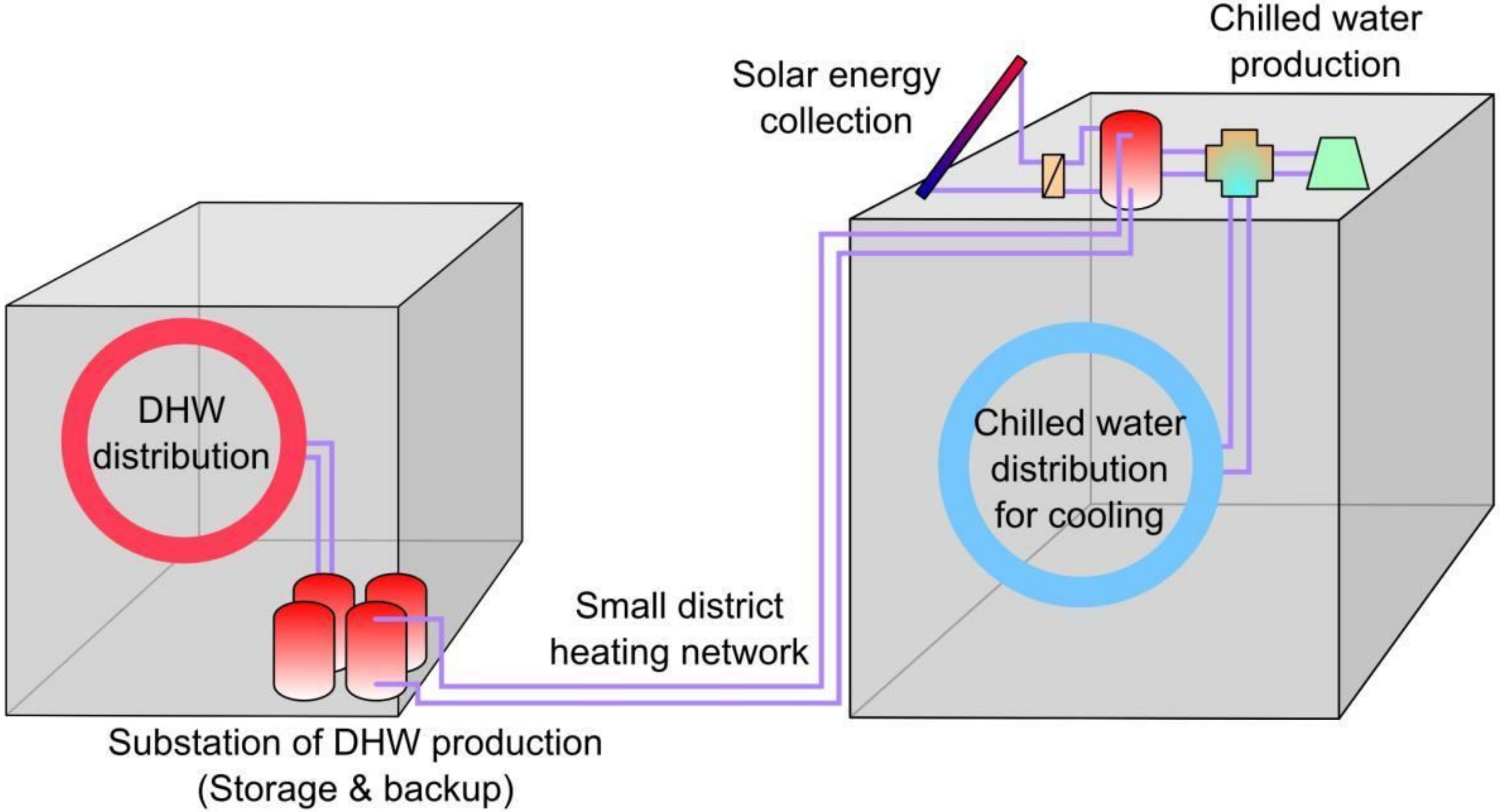


Drainback principle

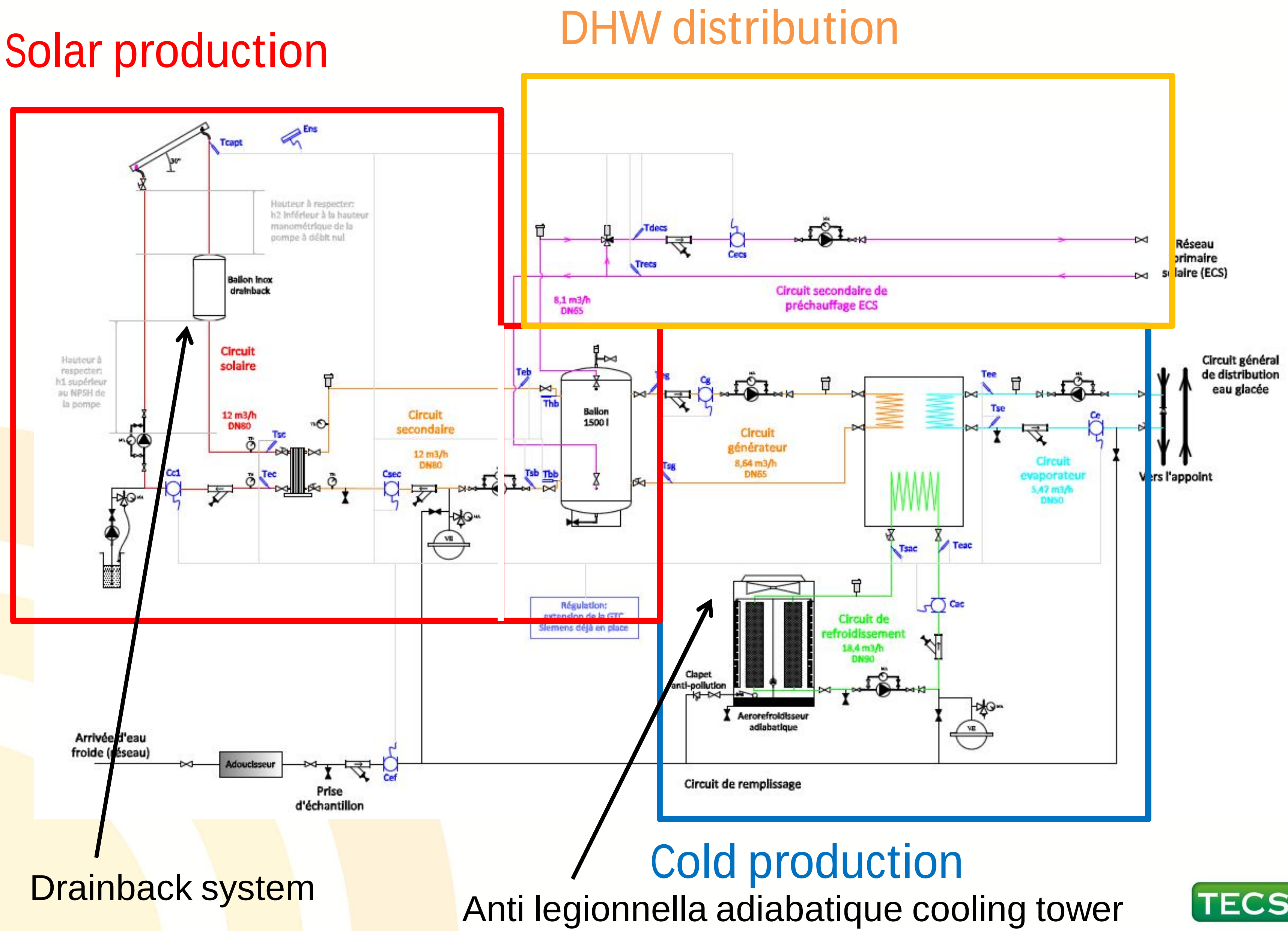
- one **1500 liter hot buffer storage tank**
- DHW preheating

(+ 10 m3 DHW additional storage capacity in Building B for dwellings)

Hydraulic principle



Hydraulic scheme



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Lessons learnt from installation & running

• **Architectural issues** :
Existing building with a lot of caution in the architectural integration process

• **Installer skills** : very few installers skilled for both absorption / solar / control => learning process and high importance of engineering coordination

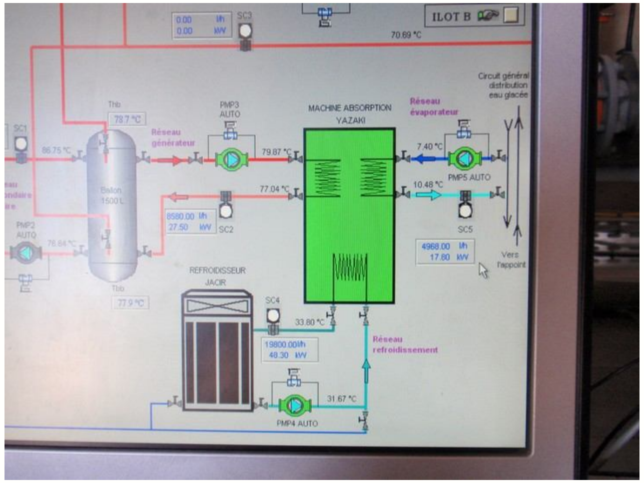
• **Building in use** : preventing any disturbance to companies/organizations working in the lower floors of the building

• **Real cooling load** : in office buildings in August, the cooling load can become very very low (some tens of kW against some hundreds)

First monitoring results in 2012

* **Nominal working conditions for domestic hot water production** since May 2012

* **Excess of available heat** in sunny days : perfect safety functionality of the Drainback system against overheating



Screen snapshot showing working system

* Short test sequences :
- **checked capacity to run properly** the chiller
- **power balance** around the chiller **:**
  - Generator : 28 kW – 80/77°C
  - Evaporator : 18 kW – 7,5/10,5 °C
  - Heat rejection : 46 kW – 31,5/34°C

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Monitoring results in DHW mode

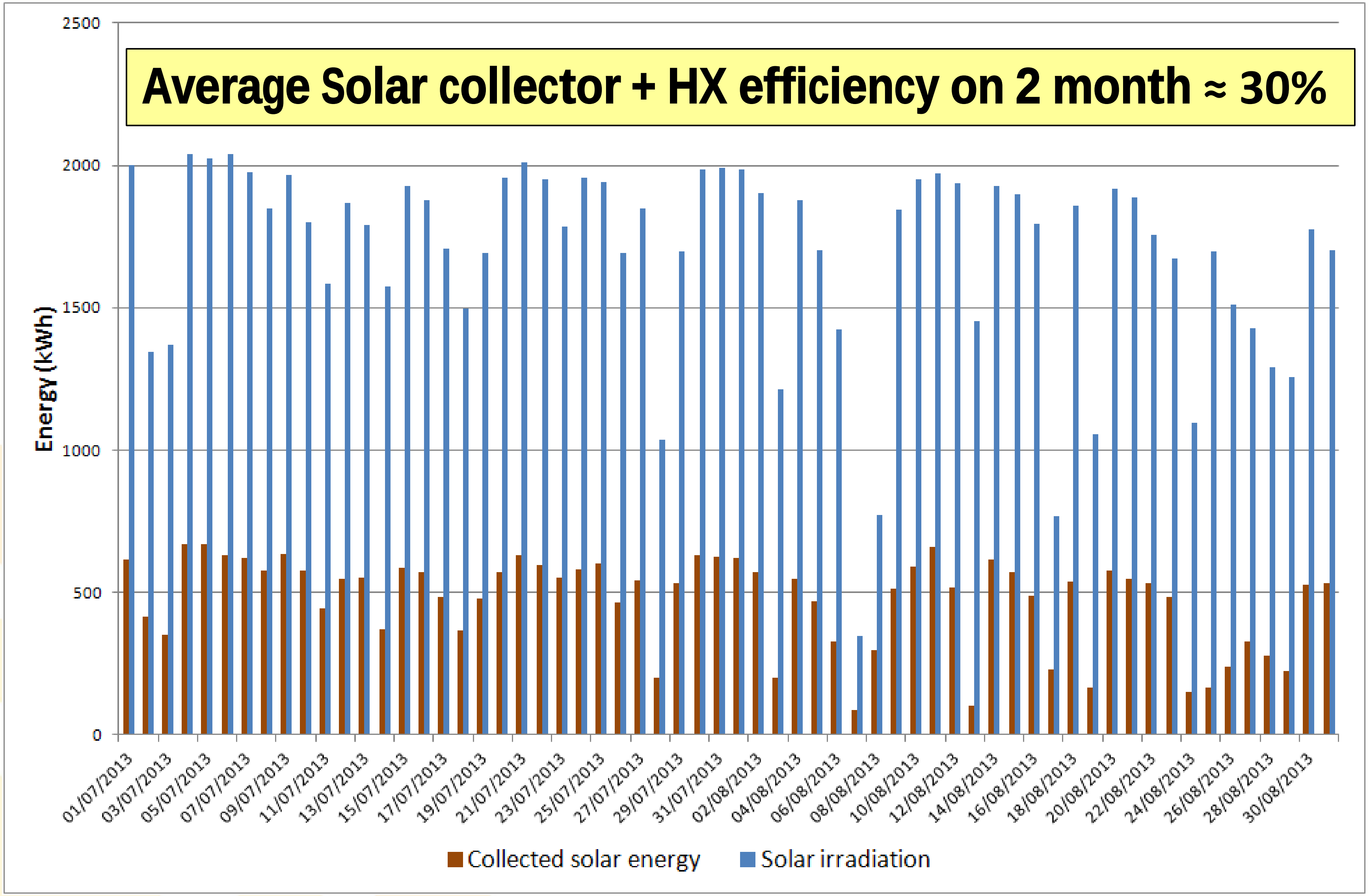
DHW monitoring results for a Winter day

Date	18 march 2013	
Energies		
Available solar energy	1491,28	kWh
Collected solar energy (secondary circuit)	563,48	kWh
Solar DHW distributed (after the buffer tank)	494,17	kWh
Electrical energy consumed	12,29	kWh
Ratios et calculations		
Collector & Heat exchanger yield	37,78	%
Buffer tank yield	87,70	%
Installation yield (from solar to DHW)	33,14	%
Electrical COP	40,22	-

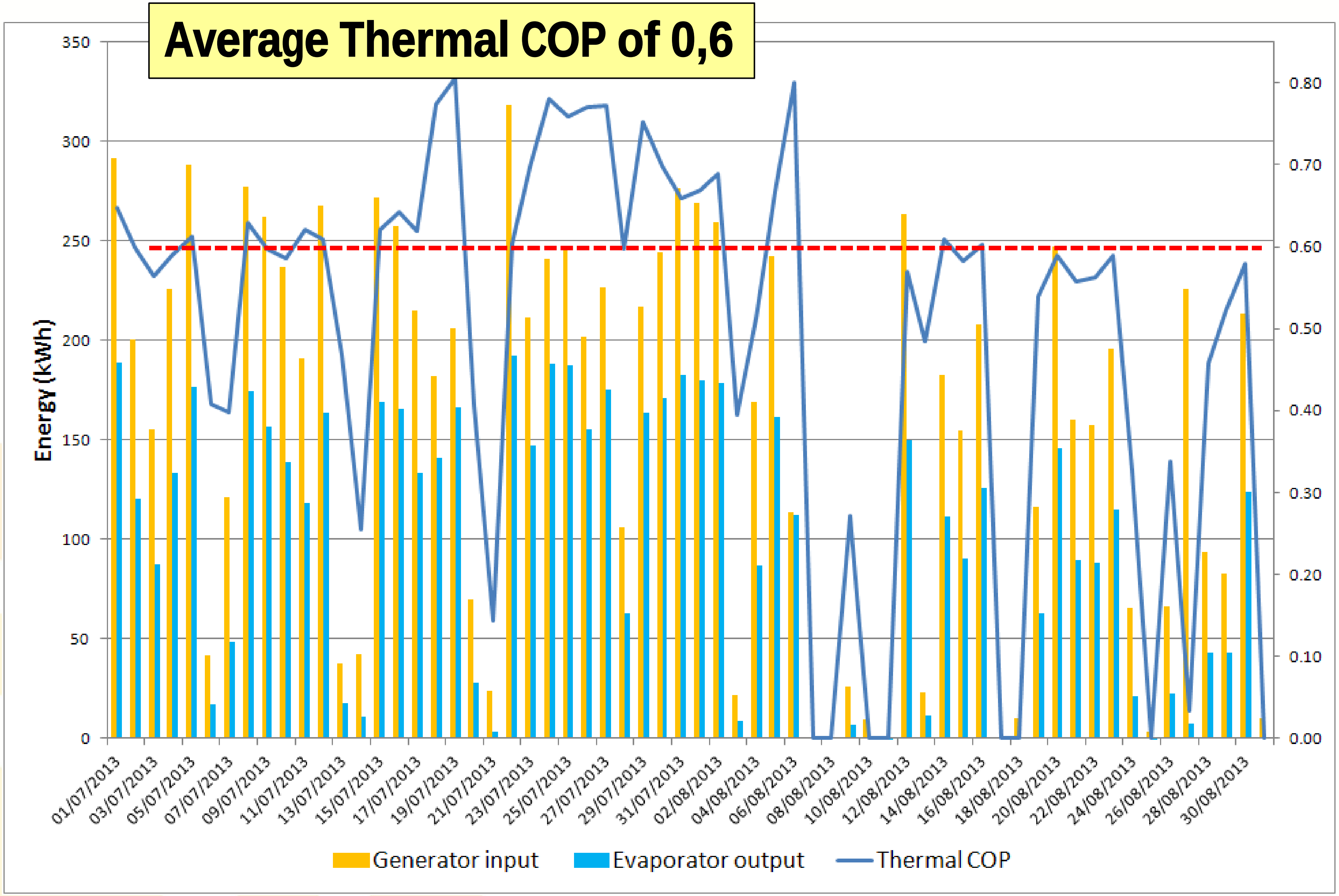
Energies and energies ratio for March 18th 2013

The installation performances on a sunny day in March are quite good with **an electrical COP reaching 40**

Monitoring results for Summer 2013



Monitoring results for Summer 2013



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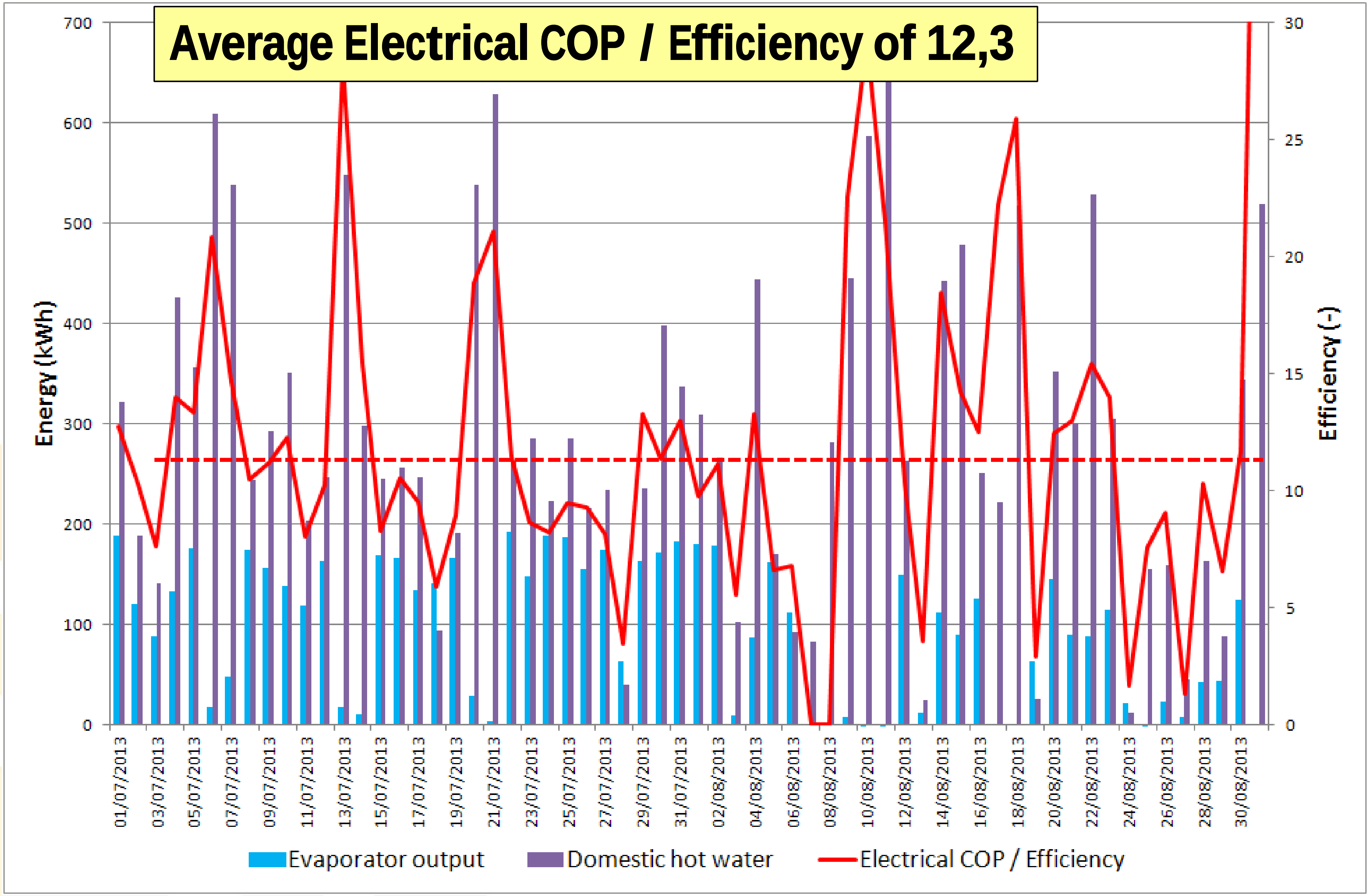
Monitoring results for Summer 2013



Summary for the 2013 cooling season

	Unit	Value
Solar irradiation	kWh	104 000
Collected solar energy	kWh	30 000
Generator input	kWh	9 800
Evaporator output	kWh	6 000
Domestic hot water	kWh	18 000
Electricity consumption	kWh	2 000
Thermal COP	**(-)**	**0.60**
Electrical Efficiency /COP	**(-)**	**12.2**
Water consumption (m3)	m3	60

Big advantage of this system : complementarity between cooling & DHW function

Simplicity of functionning : no issue on the control (Cooling -> DHW)

Conclusions

- Project **running since May 2012**
- Very **learnful feedbacks**
- **Complete monitoring system** permitting full feedback on energy performance level
- Very interesting 2013 cooling season with high electrical COP
- **Interesting new concept** for DHW/solar cooling :
  - **Maximal usability** of solar ressource & simplicity ot the system
  - **Economical optimum** (gains for DHW + Cooling production)
  - **No risk of regular oversizing**
  - **Drainback strategy** in case of dysfunctionning
  - **First application** of the French Incentive Emergence Program
  - One case of mini **Solar District Heating/Cooling system**

Thanks for your attention !

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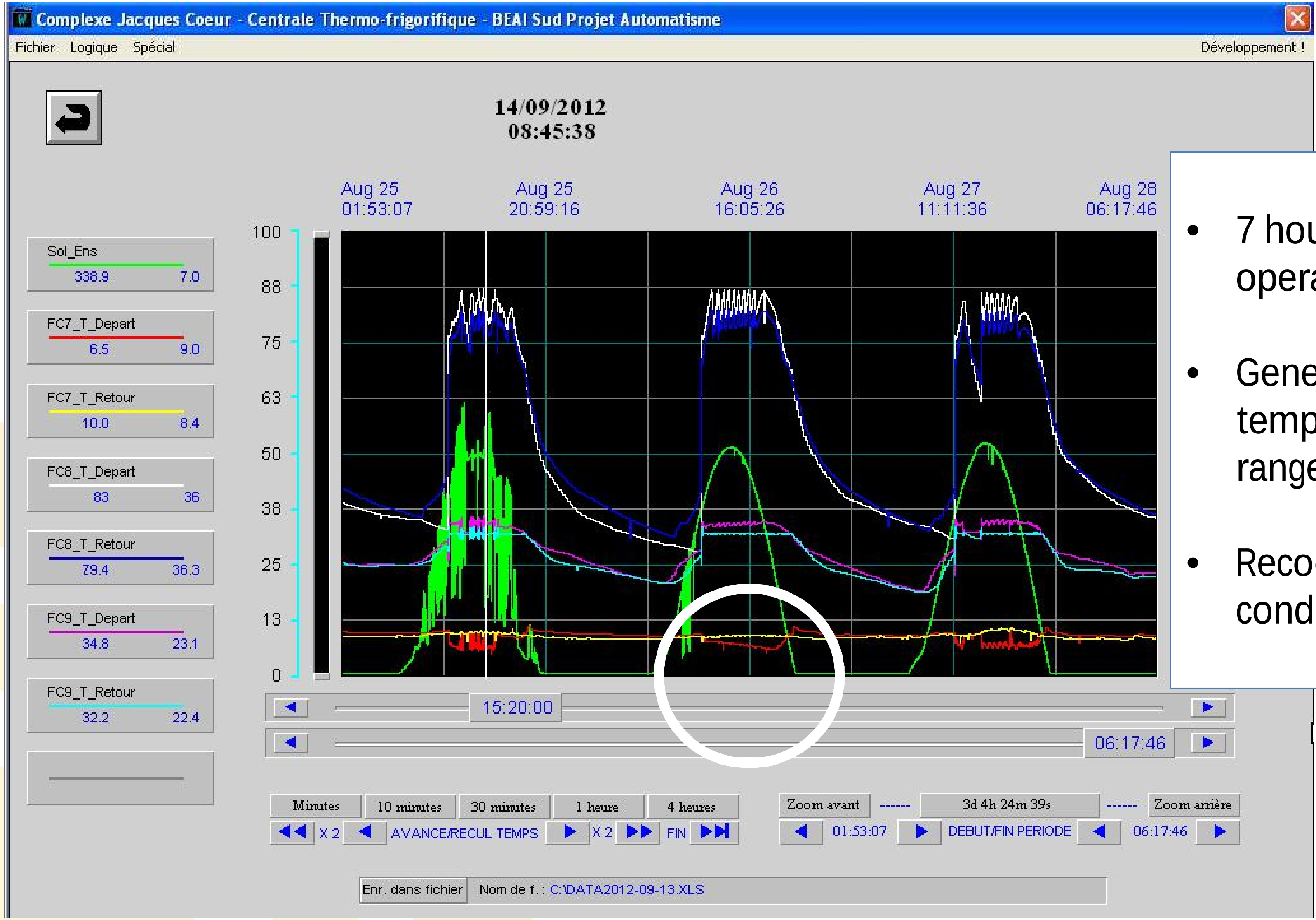
First monitoring results

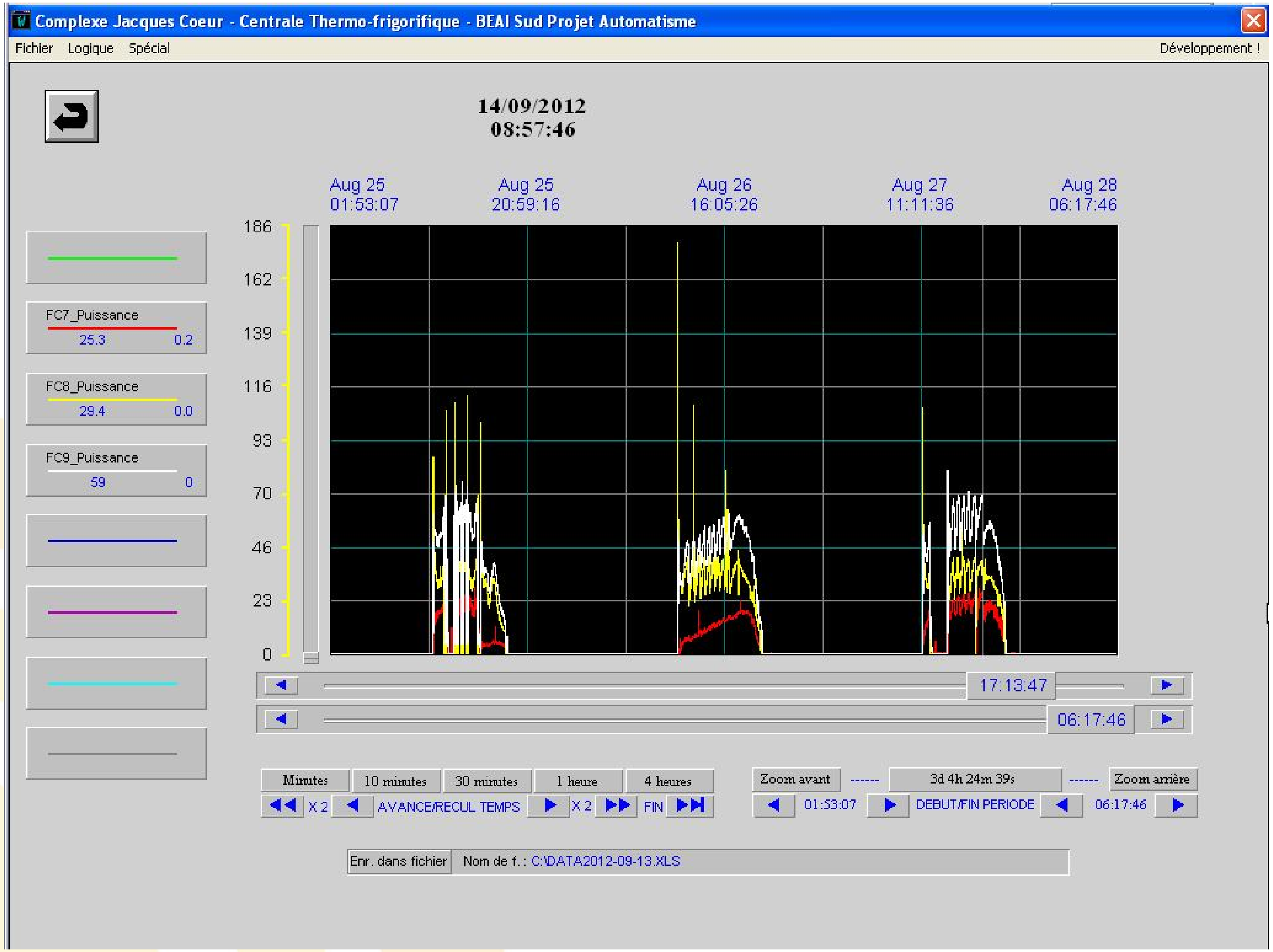
* Nominal functioning from August (fully sunny day / average sunny day)



- 7 hours operation
- Generator temperature range : 80-88°C
- Recooling stable conditions

First monitoring results

* **Monitoring campaign ongoing** (after cooling season, heating season now)



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First monitoring results

* DHW monitoring results for a Winter period

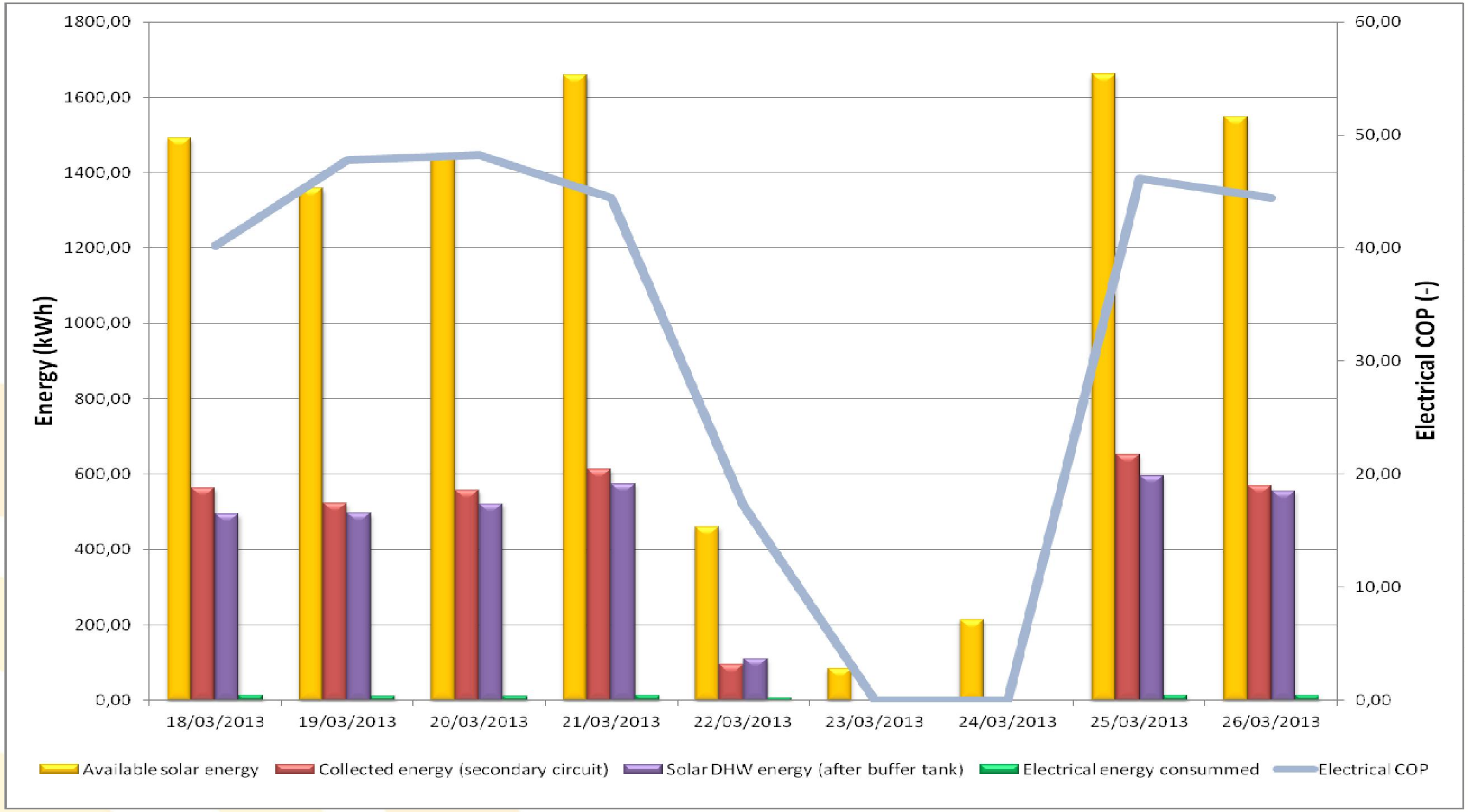
Date	9 days period	
Energies		
Available solar energy	9922,98	kWh
Collected solar energy (secondary circuit)	3569,40	kWh
Solar DHW energy distributed (after the buffer tank)	3345,92	kWh
Electrical energy consumed	78,16	kWh

Ratios et calculations		
Collectors & Heat exchanger yield	35,97	%
Buffer tank yield	93,74	%
Installation yield (from solar to DHW)	33,72	%
Electrical COP	42,81	-

Energies and energies ratio for a 9 days period in March 2013

First monitoring results

* DHW monitoring results for a Winter period



Energies and electrical COP for a 9 days period in March 2013

Economics

Total cost of the project (cooling + DHW) : **330 000 €** (w/o eng.)

Public funding available for the project : **50%**

Final investment cost for the customer : ≈ **165 000€**

Savings :

- For cooling: * electric central heat pumps with average electrical SEER = 2

  * electricity price = 0,04664 €/kWh

- For DHW production : * gas boiler (average η = 80%)

  * gas price = 0,04182 €/kWh

Annual gross saving of ≈ 8 000 €/year

Annual actualized saving during 20 years : **11 100€/year**

(average 6% /year increase for energy price)

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Economics & Environment

ROI of the project not very performing (≈ 15 years) ...**BUT**

-Guarantee for the customer of performances (Emergence system)

-Considered as a Demo project (experiment + no profitable project (cover total coast on system life)

CO2 savings from this solar cooling/DHW installation.

<u>Hypothesis</u> :

- For electricity: 120 g of CO2/kWh
- For gas: 273 g of CO2/kWh

1 car making 2 500 km/y produces **350 kg** CO2

=> **40 tons CO2 / y**

Equivalent to **25 cars travelling 11 500 km/y**

Expected results

	DHW production (kWh)	Cooling production (kWh)	Electric consumption (kWh)	Solar productivity* (kWh/m²)	Electrical COP (-)	Solar fraction (%)
January	2 476	0	256	10,3	9,7	7,7 %
February	4 694	0	371	19,6	12,7	19,1 %
March	11 073	0	566	46,1	19,6	22,2 %
April	16 252	228	723	68,7	22,8	17,3 %
May	18 556	1 843	892	85,0	22,9	18,7 %
June	14 002	3 033	938	71,0	18,2	16,8 %
July	12 083	7 348	1329	81,0	14,6	9,8 %
August	11 583	6 281	1207	74,4	14,8	11,6 %
September	7 939	1 340	661	38,7	14,0	9,2 %
October	8 896	0	547	37,1	16,3	25,6 %
November	3 450	0	293	14,4	11,8	12,7 %
December	2 077	0	234	8,7	8,9	6,6 %
TOTAL	**113 080**	**20 073**	**8 017**	**554,8**	**16,6**	**13,9 %**

** Solar productivity: Calculated in winter as the distributed hot energy divided by the collector surface, and in summer the distributed cold energy is divided by the collector surface but also by the thermal COP of the chiller.*

Emergence program : mini annual thermal performance levels to reach

- Solar yield is estimated to 554,8 kWh/m².year **>> 350 kWh/m².year**
- **Electrical COP** is estimated to **16,6 >> 5**

⇒ **Project eligible to the Emergence funds**