Case study : RIO VENA (Seasonal Storage Solar DH Study)

Name of the project:	RIO VENA (Seasonal)
Adress of the project:	Burgos, E-09006 Burgos (Spain)
Name and type of the owner:	VEOLIA, utility company
Owner contact person:	Oscar Hidalgo, Ingeniero de Proyectos. oscar.hidalgo@veolia.es

A/ Context of the study

A.1/ Motivations

Veolia Environment (Spain) is an energy services company engaged in the maintenance management, conservation and adequacy of buildings, facilities and complexes of different nature. The objective of Veolia in Spain is to provide innovative solutions for sustainable development of cities and enterprises, through the operation and maintenance of district heating and cooling networks, and other energy services in buildings and industry.

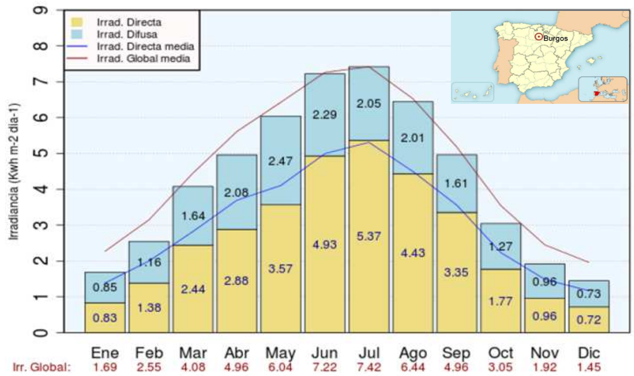
Rio Vena in the center of Burgos (Spain) is a residential area that consists of 23 buildings and 704 dwellings in total. The district heating network supplies space heating and domestic hot water to the entire residential area by boilers as well as a cogeneration equipment providing electricity to the installation. Veolia show its interest in studying combination of solar production into their DH in Spain. This paper analyzes Solar Thermal Storage System (STES) new installation connected to an actually existing district heating in Burgos, considered a very favourable region for STES systems due to its climate conditions.

A.2/ Description of the existing DH

District Heating in Rio Vena, in the city center of Burgos, consists of a 23 buildings (located in Pedro Maldonado, Antonio Jose and Comuneros Squares) and 706 dwellings in total.
Actual DH consists of three boilers supplying space heating and domestic hot water demands, and a cogeneration system feeding electricity to the Heating Station. Each building has its own substation (23 in total). Substations consist in a heat exchanger in order to supply space heating and 3.000 L buffer storage tanks are used for domestic hot water.

A.3/ Environment data

Analyzed system, located in Burgos, in northern Spain, has Continental Mediterranean climate. Winter always includes snow and temperatures very often drop below freezing, while the summer months see average high temperatures due to high solar radiation. In short, Burgos has large solar potential (5.457,8 MJ/m2 year) and high heating demand (average heating demand of 110,9 kWh/m2 year). This converts Burgos in a very interesting place in Spain in order to take STES Systems into account.



A.4/ Opportunities and barriers

Main opportunities:

.- To reduce fuel consumption and related economic savings.

.- To develope renewable DH and decrease de CO2 content of the network.

Main barriers are described below:

.- The lack of availability of land to establish a centralized solar collector field.

.- Large initial investment associated with solar solutions that have in return a very low operating cost

Besides, other experience or cultural barriers could consider:

.- Lack of motivation of architects and urban planners for integrating large solar area and storage tank into de districts.

.- Lack of operating experience in Spain.

B/ Methodology and tools used in the study

B.1/ DH load profile

.- Last four years registration has been taken into account for estimating total annual demands. Results below show demands by District Heating Network, not differing space heating and domestic hot water demand, and also including heat overproduction respecting to the district heating losses.

.-TOTAL: 7.327,98 MWh

a) Space Heating: 80%

b) Domestinc Hot Water: 20%

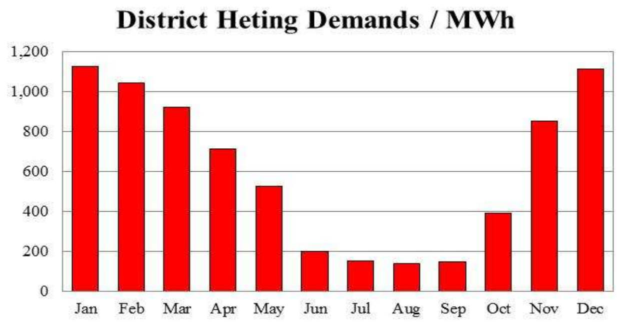
.- Centralized production boilers:

a) Two boilers of 4.500 kW each.

b) Cogeneration System:

.-342 thermal kW and,

.-250 electric kW capacity.



B.2/ SDH design and sizing, energy balance

In order to dimenssion STES system integrated to DH in Rio Vena, a dynamic system simulation model was developed. This study includes how the sizing of main components influences in performance, environmental aspets and economic feasibility. A parametric simulation study of solar collectors field and storage volume has been done. Indicators used in order to define most suitable system configuration are:

.- System Solar Fraction.

.- Solar Heat Costs.

.- Stagnation hours in collectors.

B.3/ Economics

System Investment:

Investment calculations consider main components, i.e. solar collector field and storage tank, and the aditional costs are considered as additional percentages charges. The adiditional charges considered on the total investment are System installations (7%), Building and terrain (5%) and control system (3%). Besides, adittional 10% charge is considered being centralized system.

Maintenance and Operation Costs:

The annual O&M costs are calculated for each main component according to:

$$Z_i = Inv_i \cdot \left(f_{ope} + i \cdot (1+i)^{ni}/((1+i)^{ni} - 1)\right)$$

where:

.- i: annual interest rate (3%)

.- n_i: equipment life-time.

.- f_{ope}: annual O&M cost.

Conditions of the economical calculation

	Life time years	Maintenance costs	Operation costs
Flat-Plate Collectors	25	0.50%	0.50%
Heat Storage	40	1.00%	2.50%
Solar Net	40	1.00%	0.00%
System Installations	15	1.50%	0.75%
Building	50	1.00%	1.00%
Control System	20	1.50%	1.00%

Solar Heat Cost:

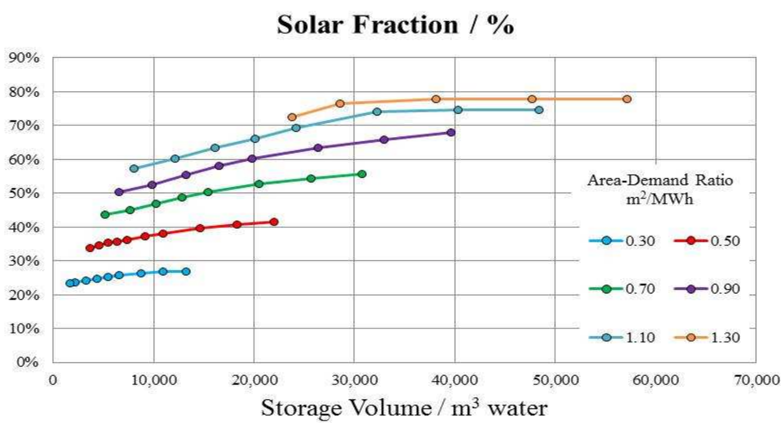
System heat cost is defined as solar generation marginal costs, i.e. the ratio between annual cost and system load.

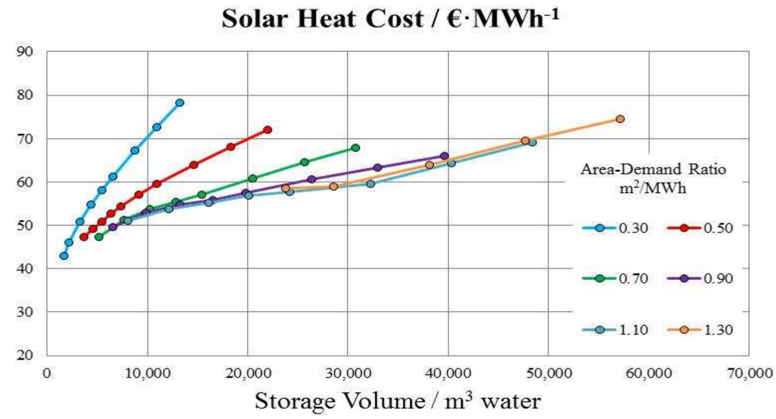
C/ Results of the study

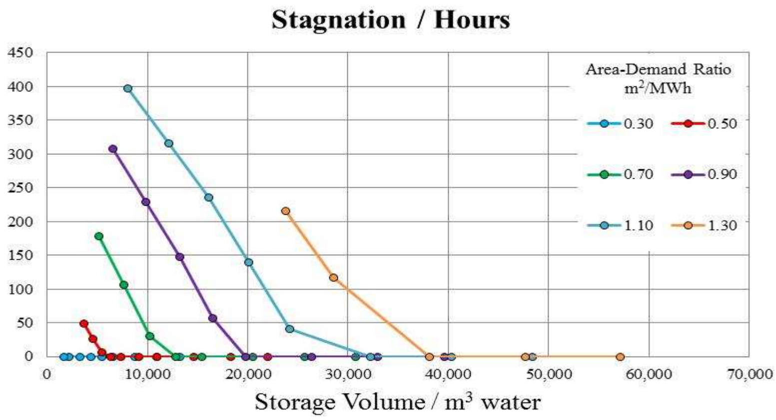
C.1/ SDH system design, energy balance and performance

System Dimensioning:

The figures and numbers presented in the following have been derived by system simulation. Figures show solar fractions, solar heat cost and stagnation hours estimation of the collectors for different combinations of solar collectors area and storage volume. The solar collectors performance parameters are: η_0 = 0,75; a_1 = 4 $W \cdot m^{-2} K^{-1}$; a_2 = 0,01 $W \cdot m^{-2} K^{-2}$



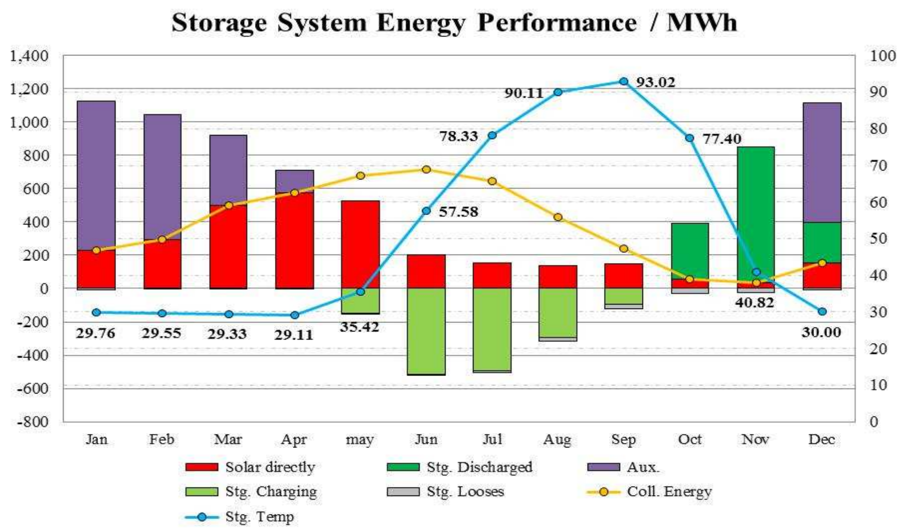




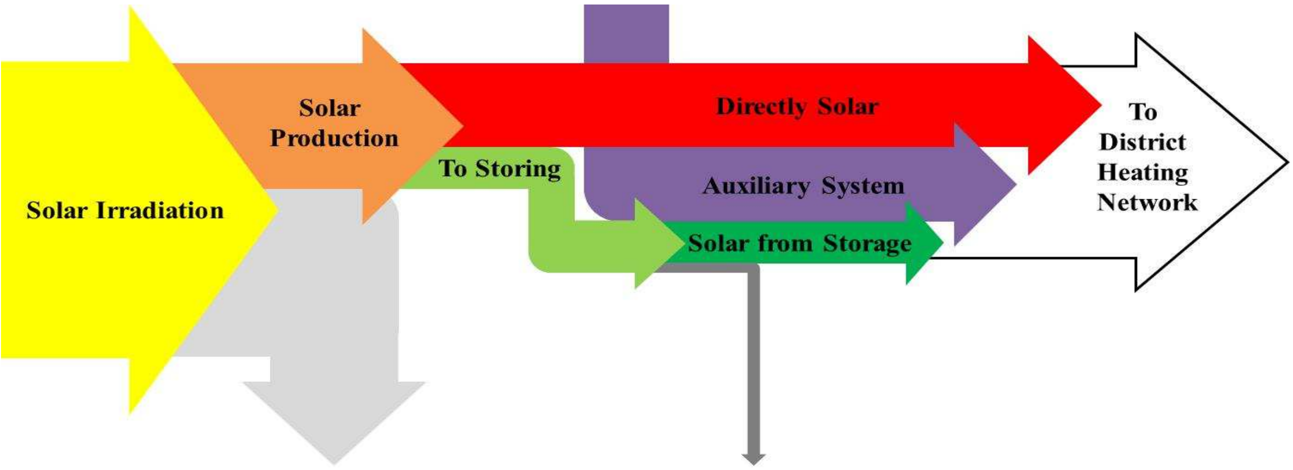
From figures was decided that system configuration combining collectors total area of 6.595,15m^2 (Area-Demand ratio of 0,9 m^2/MWh; purple line) and storage volume of 19.785,56 m^3 (Volume-Area ratio of 3,0 m^3/m^2) looks promising for a solar fraction of 60,12% and solar heat cost of 57,47 €/MWh . Besides, no stagnation hours are considered with this configuration.

Storage System Performance:

Once most favourable configuration is selected system monthly energy balance is shown. During summer period heat demand from district heating network is too low comparing to energy produced in solar collector field. This summer demand, mainly DHW, is directly supplied **(red column demand)** by solar **(orange line)**, and remaining is stored **(light green column)**. As summer period passes, heating demand rises and solar collectors are not able to cover it at all. The part of demand not covered directly by solar is covered by storage system **(dark green)**. If demand could not be covered even with storage auxiliary boilers cover the rest of the demand **(purple column)**. **Blue line** shows storage water temperature evolution during whole year, achieving its maximum temperature at the end of September, 93.02ºC.



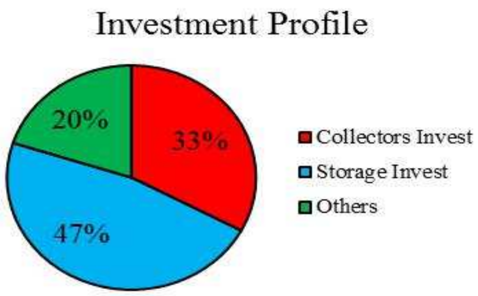
STES System Performance Sankey Diagram



C.2/ Economics at SDH level and at network level

The required initial onvestment of STES system proposed is:

.- Collectors: 1.424.842 €
.- Storage System: 2.044.749 €
.- Other indirect systems: 867.398 €
.- TOTAL: 4.336.990 €



Annual O&M costs and Solar Heat cost:

.- Annual costs: 253.190 €
.- Solar load: 4.405,75 MWh
.- Solar Heat Costs*: 57,47 €/MWh

* Generation Marginal Costs only taking into account M&O costs.

C.3/ Overview of possible business models

The actual DH operator does the investments, operates the solar plant and is remunerated on the sale of heat. The heat price in Rio Vena will be the same as nowadays.

The investment should also include some economical support fo regional, municipal and local authorities.

Authors

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