Conference Proceedings

EuroSun 2016
Palma de Mallorca (Spain), 11 – 14 October 2016

Open data solar thermal meter for smart cities

A. González Valero [1], J. Cadafalch [2]. R. Consul [2] y R. Ruiz [2].

[1] RDmes Technologies S.L., Terrassa (Spain).

[2] Universitat Politècnica de Catalunya BarcelonaTech, Barcelona (Spain).

Abstract

In the near future, with the introduction of the Smart City concept, all systems and elements placed in a city will publish their performance data through open platforms. This paper presents an open data solar thermal meter component for the Smart City platform Sentilo. The solar meter includes four different sensors with instantaneous values of the solar energy yield, equivalent CO_2 emissions savings, economical savings and system status.

The paper describes the solar meter and how it is implemented within Sentilo, gives directions on how to create a solar meter using the data of any on-line connected solar thermal system, and gives examples on the data obtained from several solar thermal meters installed in different cities nearby Barcelona.

Keywords: *open data, solar thermal meter, Sentilo, smart cities*

1. Introduction

Solar thermal technology for domestic water heating (SDHW) is already a mature technology competitive to other conventional energy based systems. This has motivated some countries, regions or local authorities worldwide (Spain, Portugal, Italy, Chile...) to implement solar ordinances or regulations to obligate the use of solar thermal or other renewables in new and refurbished buildings. As a result, the number of residential apartment buildings (RA buildings) with SDHW systems has increased considerably during the last years. Only in Spain a total number of about 50.000 RA buildings with SDHW with a minimum collector area of about 15 m^2 are estimated, while more than 1 Million are estimated worldwide.

Practical experience, however, has shown as an important part of the SDHW in RA buildings are not performing appropriately resulting into reduced solar energy savings and bad reputation for the solar thermal technology.

Based on market experience, the authors have developed a low-cost smart solar thermal meter to support maintenance and operation of the SDHW systems. Research has been undergone in order to focus on costs (including devices and communications), standardization and best practices, effective and continuous metering and continuous communication with all involved bodies: users, O&M companies and public organizations as municipalities. Main technical results have already been patented, see González Valero et al. (2016).

With the increasing introduction of the Smart City concept, there is a need of further development of open data transversal platforms including standardized procedures to manage specific components data.

Cities in the area of Barcelona have been leading the implementation of Smart City solutions by making use of the horizontal, global and open platform called Sentilo, see www.sentilo.io (2016). Among others, the platforms sites for Barcelona and Terrassa are already available at http://connecta.bcn.cat and http://sentilo.terrassa.cat respectively.

doi:10.18086/eurosun.2016.04.06 Available at http://proceedings.ises.org

The number of instantaneous city data type uploaded to Sentilo is increasing constantly, ranging from sound sensors, trash-containers tracking, lighting, to electrical consumption.

Among the different systems in a city, solar thermal energy systems also play their role. There are many questions still to answer around the installed solar thermal systems related to their maintenance and real performance. The upload of instantaneous performance parameters of the solar thermal systems in an open Smart City platform will provide data that can be post-processed by anyone connected to the platform in order to obtain a response of these questions, and that will definitively contribute to improve the solar thermal technology reputation and dissemination.

The paper gives an overlook on the smart low-cost solar thermal meter developed by the authors, and how it is implemented as a component of the platform Sentilo. More than 30 SDHW plants in the area of Catalonia have already been equipped with this technology. Some examples on data obtained from these plants are also here presented.

2. The smart solar thermal meter

With the sensor technology available nowadays is of course possible and easy to monitor any data in a solar thermal system in small temporal intervals (in the range of seconds or even smaller) and send them to the cloud where the Sentilo platform lives through any kind of internet connection. However, the larger the number of sensors are installed and the smaller the temporal communication intervals the total implementation and communication costs increase.

In order to develop a solar thermal meter that would be accepted by the market, the costs of communication and devices (including sensors) to be installed must be reduced as much as possible.

The meter here described has been specifically designed for solar thermal plants with a maximum pick power of 70 kW. A scheme of the meter is shown in Figure 1. Metering is performed in two steps. The first step takes place in-site and the second step is done at the cloud by an instantaneous post processing of the data obtained in the first step.

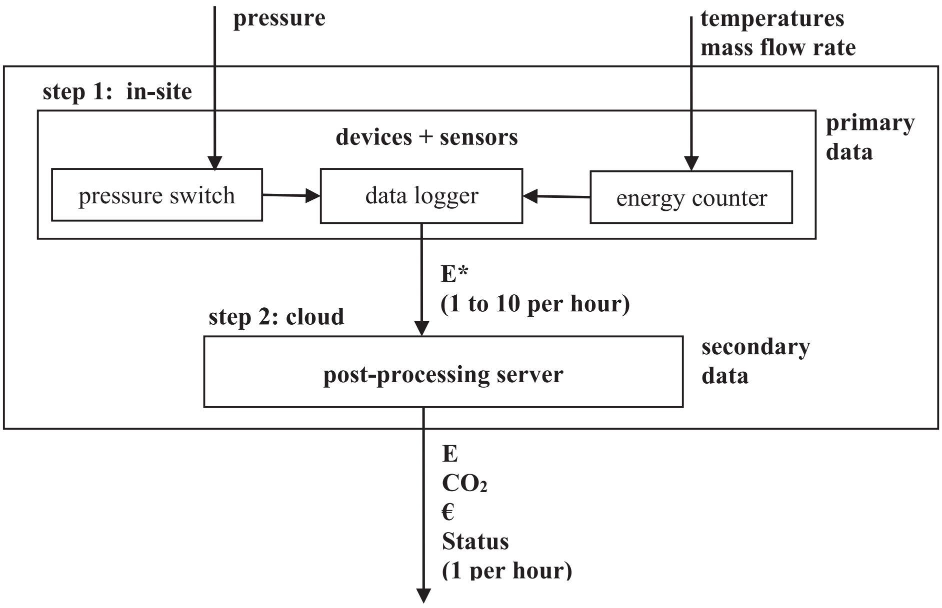

Fig. 1: Scheme of the smart solar thermal meter.

A data logger, a thermal energy counter and a pressure switch are installed in-site. The data logger must be connected to the internet. The value of the energy produced within the communication intervals is transmitted to the cloud. A frequency of communication of 2 to 10 transmissions per hour is suggested. This drastically reduces the communication data (and therefore costs) while, according to authors experience, having enough practical instantaneous data to monitor the plant status.

The pressure switch is installed at the primary loop (solar loop of the plant) and electrically connected to the electrical power input of the data logger. Therefore, in case the pressure at the loop decreases, which is one of the major failures in these plants, the data logger stops communication and no data is transmitted to the cloud.

Therefore, the only communication data used by the smart solar thermal meter is the energy produced in intervals of 1 to 10 transmissions per hour, whenever the pressure in the solar loop is enough to guarantee proper operations conditions. Otherwise, no value is sent. This energy production is called as smart energy yield, and is represented by the symbol E*.

At the cloud, a server instantaneously receives the value of the smart energy yield and calculates the instantaneous equivalent reduction of the CO_2 emissions, the economical savings and the Status de of plant. These three values, together with the value of the smart energy yield are then sent to Sentilo.

An important point to highlight is that the cost of the communication data from the step two (server at the could) and Sentilo is 0 because they both live in the cloud and are already connected to internet. However, the transmission data from the in-site infrastructure to the server at the cloud has a cost that may depend on type of communication used (e.g. Ethernet or SIM card).

The instantaneous value of the plant Status is to be calculated by software and in accordance to what is expected to be the theoretical production of the plant. Four status of the plant are considered:

- OK: the plant is working properly
- Overproduction
- Underproduction
- No reading: in case the instantaneous value of E* has not been transmitted to the cloud

A simple algorithm to determine the status when a value of E* is available, is to set the status at Overproduction in case E* is larger than the maximum energy production capacity of the plant during the communication interval, to underproduction in case E* is below 0 (this would mean a failure in the energy counting) and set the status to OK otherwise. This algorithm can of course be improved by providing intelligence to the server like statistical analysis of the instantaneous production of other equivalent solar plants.

The two steps could also take place in-site. However, this introduces two major additional difficulties. From one side, the amount of data to be transmitted from the in-site infrastructure to the cloud increases significantly resulting in larger communication costs. From another side, the data to be calculated in step two (CO_2 equivalent emissions, economical savings and plant status), require specific information of the plant that needs updating during all the meter life time. This introduces additional communication costs while when the second step takes place at the cloud this can be done automatically with no costs.

3. Coupling of the smart solar thermal meter with Sentilo

3.1. Sentilo configuration

All devices that send data to Sentilo have to be defined in an internal Sentilo data base. The smart solar thermal meter is defined as a new Sentilo component with four sensors as described in Table 1. The first sensor is the energy yield from the last communication step to the current communication step. As it is directly measured from in-site sensors it is labelled as a primary sensor. The other three sensors are secondary sensors calculated from the instantaneous value of the smart energy yield, and are the instantaneous plant status, and the economical savings and equivalent CO_2 emissions reduction corresponding the energy yield.

Extensive information on how to set-up a Sentilo server, define the data bases, sign up new sensors and download and upload data can be found in http://www.sentilo.io (2016).

Tab. 1: Sensors of the solar thermal meter component

Sensor	Type	Description
Energy Yield	Primary	Energy counter
Installation status	Secondary	Alerts generated from the energy yield
CO_2 equivalent emissions	Secondary	Post-processed value derived from the energy yield
Economical savings	Secondary	Post-processed value derived from the energy yield

3.1. Data flow

The smart solar thermal meter is designed to send cost-effective data of the solar thermal plants to those persons that may be interested. These persons will be identified as the data target. They can be classified in different groups depending of their role and connection to the solar thermal plants. Table 2 shows a simple classification in four groups, the plants owners, the O&M companies, public organizations and general public.

Tab. 2: Data target: classification in groups

Group Name	Description/role
Owner	Plant owner/s
O&M companies	Maintenance and operation performers
General public	Third parties
Public organization	City councils, energy agencies and policy makers

The data flow from the domestic hot water system to the target making use of the smart solar thermal meter and the platform Sentilo is represented in Figure 2. Sensors of temperature, mass flow and pressure (pressure switch) placed at the domestic hot water system, provide instantaneous data to the smart solar thermal meter. The meter, according to the procedure described in section 2, processes the input data and provides hourly values of the energy yield, the equivalent CO_2 emissions, economical savings and plant status to Sentilo. Finally, Sentilo publishes the data through its front-end platform and through its back-end.

The Sentilo front-end shows a map in which all monitored components are geolocated. With a simple click on a component it is possible to view real-time and some historical data of its sensors.

From another side, all data in Sentilo can be downloaded by external applications through its back-end using an API. For example, the authors have developed an application available through the free cloud platform www.omnilus.com (2016), called SeYe. This app is designed to automatize and simplify as much as possible the communication between the target groups and the monitored solar plant and provides three major functionalities: configuration of the solar system plant, edition of historical data and, automatic generation of emails to the different target groups informing about installation status and production.

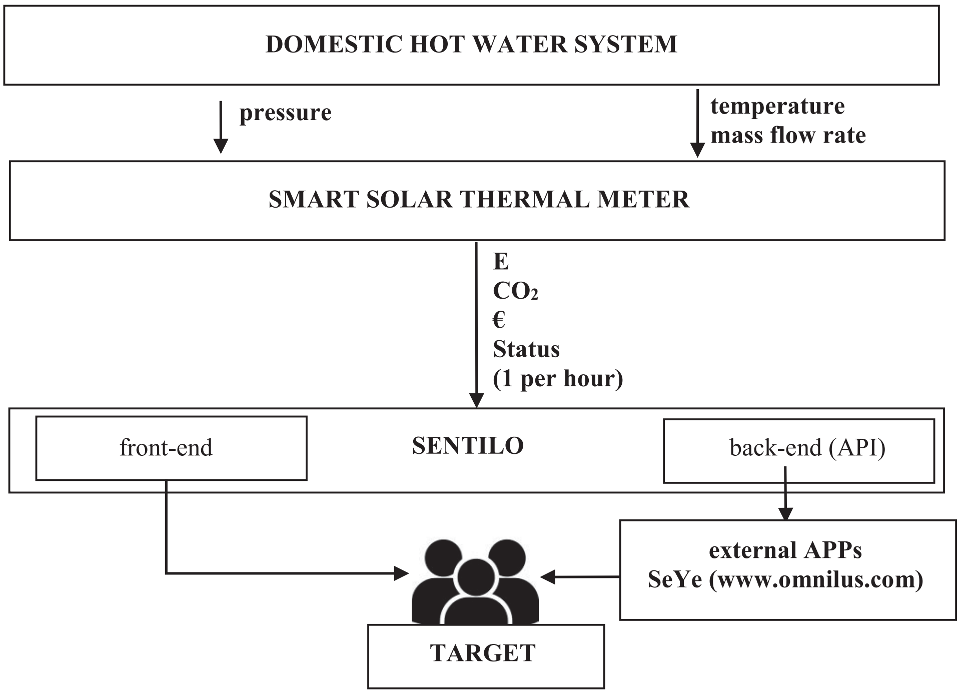

Fig. 2: Scheme of the data communication flow from the DHWS to the TARGET through the smart solar thermal meter and Sentilo.

4. Results

The open data solar thermal meter for smart cities presented in this paper has already been installed in more than 30 different plants located in the area of Barcelona.

As an example, results of plants located in the city of Terrassa will be here presented by making use of the front-end platform provided by Sentilo. The geolocation and some basic data of the solar thermal meter are shown in Fig 3. The solar thermal meter is located in a map among other meters in the area using a symbol made of a green circle with a white sun in it. By clicking on the solar meter symbol, basic data of the sensors are shown.

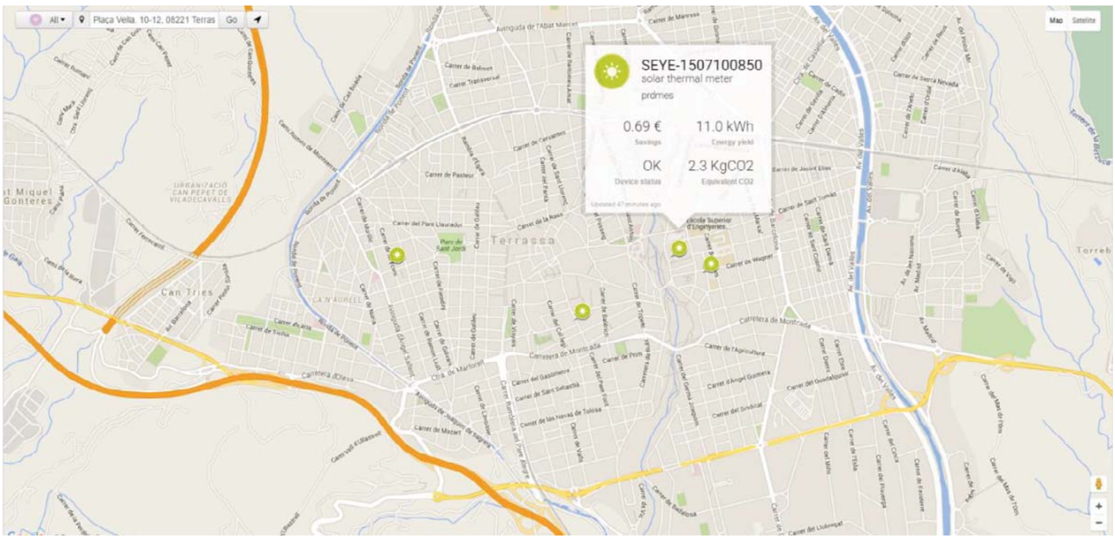

Fig. 3: Geolocation and basic data of the smart solar themal meter as shown on the front-end Sentilo platform.

Some historical data is also stored in the Sentilo platform. Real time value and historical data of the energy yield and the installation status as presented by the Sentilo front-end platform are shown in Figure 4 and 5 respectively.

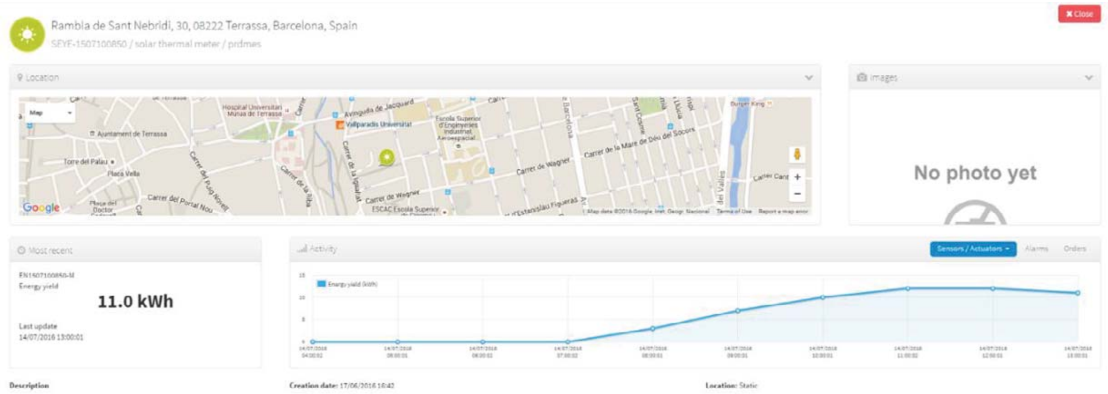

Fig. 4: Geolocation and some historical data of the energy yield as shown on the front-end Sentilo platform.

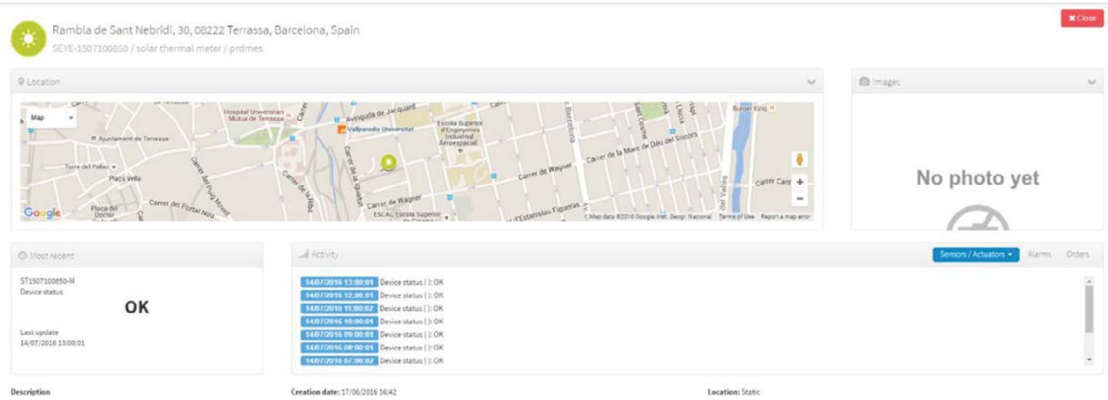

Fig. 5: Geolocation and some historical data of the installation status as shown on the front-end Sentilo platform.

5. Conclusions

With the introduction of the solar city concept, the market is now demanding for meters and sensors of relevant city activities connected to open data platforms. Solar thermal sector must be aware of that, and must provide solutions to publish the data of the domestic hot water systems installed in cities in the open data platforms.

The authors have designed a smart solar thermal meter connected to the open data platform Sentilo where the volume of transferred data is minimized in order to reduce communication and devices costs. The paper describes in some detail the smart solar thermal meter and the procedure adopted to send real time values of the energy yield, CO_2 equivalent emissions reductions, economical savings and plant status to Sentilo.

6. Acknowledgements

This work has partially been financially supported by the Agency for Management of University and Research Grants (AGAUR) of the Generalitat de Catalunya, under the Industrial Doctorates programme DI-2015.

7. References

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