



SBE21

Sustainable Built Heritage

14-16 April 2021,
Online conference

DRAFT PAPER

This version is intended for personal use during the conference and may not be divulged to others

The SBE21 Heritage Conference is co-financed by:



International co-promoters:



Under the patronage of:



In collaboration with:



Energy efficiency for a historic market: the case study of the Mercado del Val

J Antolín-Gutiérrez¹, S Álvarez-Díaz^{1,2} and J Samaniego-Muñoz¹

¹ CARTIF Technology Centre, Parque Tecnológico de Boecillo, Boecillo, 47151 Valladolid, Spain

² Corresponding author, sonalv@cartif.com

Abstract. *Mercado del Val* is an iron market located within the old town of Valladolid, Spain, whose construction was completed in 1882, being currently the oldest preserved market in the city. During the period 2013 – 2017, the market was part of a FP7 European demonstration project, called CommONEnergy (Re-conceptualize shopping malls from consumerism to energy conservation) under grant agreement n° 608678, focused on the rehabilitation and energy efficiency improvement of shopping centres. The CommONEnergy project focused on improving the energy efficiency of the market was part of a new integral refurbishment project already planned for the market in 2013. Before the rehabilitation project of 2013, the market presented a decaying appearance. From 2013, the market was fully renovated by recovering a building representative of the architectural and commercial activity of the late 19th century, being respectful of its essence, but transforming it into an innovative building that responds to the commercial needs and potential of the 21st century. The inclusion of the market in the European project made possible to improve the building's energy performance and indoor environmental conditions together with the satisfaction of vendors and customers.

Keywords – Energy efficiency, historic market, building renovation, European project

1. Introduction

This paper presents the renovation process that was carried out in the *Mercado del Val* market during the period 2013 – 2016 and focuses mainly on the aspects of energy efficiency improvement thanks to the inclusion of the market as a demonstrator in the European demonstration project CommONEnergy [1]. The 19th century historic market, located in the old town of Valladolid, Spain, had been renovated previously. In 1982 a first renovation of the building was carry out, basically for the maintenance and renovation of its structure and restoration of the limestone blocks, the brick walls, the louvres, and the roof. The water, electricity and heating facilities were also modernised, but without taking into account any energy efficiency approach. At the end of 1983 the market reopened with 114 market stalls and 2,230 m² in perfect conditions. Since the last intervention until the year 2013, when the building was closed, only maintenance work was carried out, resulting in functional and structural problems of the building. Due to the age of the technical installations and overall deterioration of the building's components, the market presented a decaying appearance without any attraction for customers and vendors.

To be aligned with the different EU directives and recommendations to improve energy efficiency in building renovation [2], the *Mercado del Val* was included as part of the CommONEnergy project. The incorporation of the market as demo site of the European project allowed the implementation of a number of considerable measures to reduce energy consumption and improve the energy efficiency of the building. All the energy improvements made in the building resulted in a reduction of energy

consumption, as well as an improvement in thermal comfort and indoor air quality. The new building reopened in November 2016 after almost two years of construction works, resulting in three floors distributed in 4,792 m²: the basement with the supermarket and technical rooms, the ground floor housing the fresh market, and the first floor with offices and common areas. **Figure 1** shows the state of the market before and after the refurbishment carried out during the period 2013 – 2016.



Figure 1: Mercado del Val before (left) and after (right) refurbishment during the period 2013-2016 (Source: CommONEnergy project, Deliverable 6.4 Energy savings result, 2017 [3] (left); Own source (right).)

The new configuration of the indoor layout and the glazed façade contribute to a better understanding of the global iron structure, increasing natural light and making the commercial activities visible from the outside.

2. Renovation process

2.1. Urban context

As shown in **Figure 2**, the market is near to the *Pisuerga* River and the green areas of *Moreras* Park, located very close to the main square in the city centre of Valladolid. The urban context of the building and its type of activity were considered when defining the energy renovation project. **Table 1** shows general and detailed information of the market.



Figure 2: Location map of the Mercado del Val (in red), in Valladolid (Spain) (Source: © OpenStreetMap contributors [OpenStreetMap®, 2020] [4].)

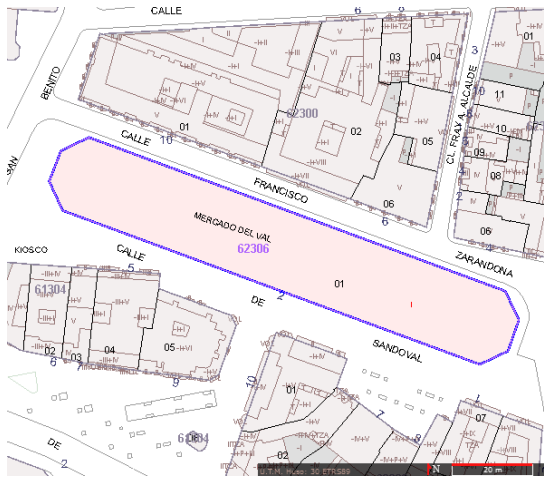


Figure 3: Floor plan layout of the market (Source Spanish Cadastre [*Dirección General del Catastro*, 2021] [5].)

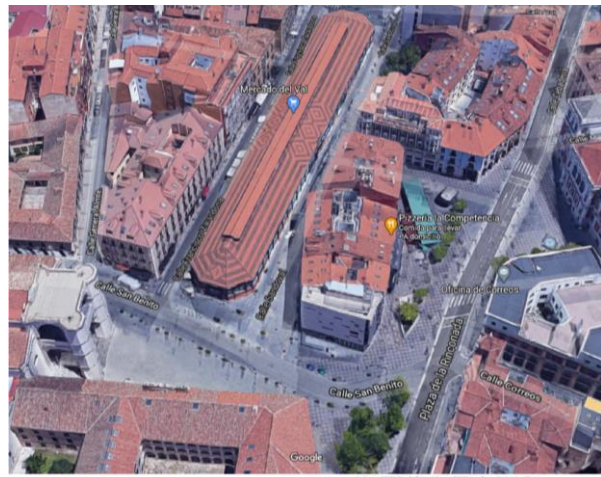


Figure 4: Aerial view of the market (Source: Google Maps, 2021: *Imágenes ©2021 Google, Datos del mapa ©2021 Inst. Geogr. Nacional* [6].)

Table 1: Information of the new *Mercado del Val*

Location	Valladolid, Spain
Latitude and longitude	41.653680, -4.728461
Altitude	690 m a.s.l.
Climate Zone	Csb
Heating degree day (HDD)	1,834
Cooling degree day (CDD)	894
Building Use	Wholesale & Retail
Building typology	Market
Building occupancy	Permanently occupied
Number of occupants/ users	48
Building area	4,792 m²
Net floor area	3,936 m ²
Number of floors	2 + basement
Construction type	Steel frame
External finish	Glazing façade and Brick
Internal finish	Glazing façade
Roof type	Pitched roof

2.2. Heritage value assessment

The level of protection of the market is 3 (P3), according to the PECH of Valladolid (*Plan Especial del Casco Histórico – Special Plan for the Historic Centre*) of 1997, now replaced by the General Plan of Valladolid approved in 2020 [7]. This P3 classification corresponds to structural and typological protection, but at the time of the renovation, the market was only structural protected. The market is classified as DST (singular building non-residential, other public use) [8]. It should be noted that the steel structure of the building is original from 1882.

2.3. Building use pre-intervention

The market consisted of two floors. On the ground floor, there were stalls for the different activities of the fresh product market (butchers, fish shops, fruit shops, etc.), toilets, some rooms for rubbish disposal, and the corridors to connect all the areas. The first floor was only intended to house the technical rooms and offices.

2.4. State of the building pre-intervention

Before the intervention of 2013, the facilities were too outdated and the building components were in an overall state of deterioration, which made the market very inefficient from an energy point of view. Two air/water heat pumps connected to the radiant floor on the ground floor and to the air curtains at each entrance covered the heating and cooling needs. The refrigeration system consisted of individual compressor units located at specific market stalls with the heat produced by the condensers being released inside the building. There was no mechanical ventilation system, being natural ventilation provided through doors and windows. Two lighting systems covered the lighting needs, one for the general lighting of the market composed of lighting balloons suspended from metal arches along the corridors and entrances, and the individual lighting systems corresponding to each individual market stall composed mainly of fluorescent tubes. The artificial lighting system was supported by natural light entering through the windows and skylights.

2.5. Aim of energy retrofit

The planned integral refurbishment project for 2013 aimed to recover a late 19th century building representative of an architecture and commercial activity of that period, preserving its essence but transforming it into an innovative building that responds to the potentials and commercial needs of the 21st century. The main use of the building as a fresh product market was maintained, but in addition, a supermarket was added in the basement of the building.

The objective of the inclusion of the market in the European project CommONEnergy as a demonstrator was to improve the energy efficiency of the building through different solutions as described below.

3. Energy efficiency solutions

In the CommONEnergy project, both passive and active elements of the building were considered in order to achieve the energy efficiency improvement of the building. The aim of the passive solutions was to reduce energy consumption, while the active solutions focused on generating energy in a more efficient way by increasing the performance of the systems. **Table 2** summarises the main characteristics of the market pre- and post-renovation.

Table 2: Status of the market pre- and post-renovation

	Old market	New market
Year	1882 (renovated 1981) – 2013	2016 – Until now
Heating and cooling	2 air/water heat pumps – radiant floor and air curtains	3 reversible ground/water heat pumps – radiant floor, AHU and fan-coils
DHW	Electrical water heater	Geothermal heat pumps
Refrigeration	Individual compressor units	Centralized system with heat recovery
Ventilation	Natural ventilation	AHU with free cooling and heat recovery. Natural ventilation
Lighting	Incandescent lighting balloons and fluorescent tubes	Efficient lighting
Surface	2,220 m ²	4,792 m ²
Floors	1 floor (1 floor technical rooms)	3 floors
Control	No control	Advanced control (iBEMS)

From an energy efficiency point of view, the main passive element added to the market was the installation of a multifunctional facade, consisting of a glazed façade able to adapt at all times to the local climatic conditions of Valladolid and internal market needs. The new façade includes modular elements with advanced control strategies for both natural ventilation and shading. The main active element consisted of the integration of a new complete geothermal system based on reversible heat pumps, which covers all the energy needs of the market in terms of heating, cooling and domestic hot water. An intelligent Building Energy Management System (iBEMS) was also developed and installed

to manage and control all energy systems of the entire market in a more efficient and optimized way. The following sub-sections show more detailed information about these elements.

3.1. Multifunctional façade

The multifunctional façade is made up of modular elements that aim to integrate thermal, daylighting, and ventilation functions, responding when internal and external conditions change.

The main features of the multifunctional façade are the followings:

- Optimized glass wall envelope whose thermal and optical characteristics were selected considering the specific local conditions. Glass properties adjustment was considered depending on each façade orientation with the objective to reduce the solar radiation incident and adapt the thermal transmission and indoor needs.
- Integration of a natural ventilation system through the installation of motorized windows in the façade and skylights which due to the building shape allow exploiting openings to promote stack effect to reduce cooling needs during the summer and the reduction of mechanical ventilation consumption. Windows automation occurs by means of chain actuators connected to the building management system, which controls the opening angle according to indoor and outdoor conditions. Natural ventilation allows also ensuring minimum required air changes rates to keep acceptable level of indoor air quality.
- Control and optimal use of natural light thanks to the motorized shading elements through an exterior lamella system integrated into the south façade of the market. Thermal simulations showed that during summer it was necessary to apply solar protection, but during winter time it is important not to apply the system to collect solar gain and to maintain the unhindered direct view.

All the elements that make up the multifunctional façade were optimized thanks to the support of energy simulations via TRNSYS software. Different glass properties, shading positions, natural ventilation openings and control strategies among others were combined and simulated until achieve the most suitable solution complying with all the existing limitations both technical and economical.

The connection of the shading elements and natural ventilation system to the iBEMS allowed the introduction of a sophisticated control strategy based on internal comfort variables and external weather conditions, optimizing the operation of the systems, operating the HVAC system only at times when the operation of the façade elements do not allow to achieve acceptable levels of comfort.

Thanks to this solution it was possible to reduce the heating and cooling demand of the building, the energy consumption of the mechanical ventilation and the amount of direct solar radiation entering the building. **Figure 5** shows an actual picture of the multifunctional façade installed on the market.



Figure 5: Multifunctional façade installed in *Mercado del Val*
(Source: Own source)

3.2. Geothermal heat pumps based system

To supply both heating and cooling, three reversible ground to water geothermal heat pumps were installed, getting the temperature from vertical boreholes drilled in the ground (42 boreholes of 120 meters). To cover the energy needs, a low temperature heating and cooling system was selected with radiant floor on the ground floor and first floor, and fan coils in the basement. There is also an Air Handling Unit (AHU), which can operate in free-cooling mode and with a heat recovery efficiency of more than 65%. For domestic hot water, the geothermal heat pumps are supported by storage tanks with electric immersion heaters for legionella prevention. Geothermal heat pumps are able to produce both domestic hot water and cooling in summer at the same time.

Here it is important to mention the installation of a centralized fridge system to cover all the refrigeration needs of the whole market. This installation generates a very important amount of heat in the condenser and this heat is used to pre-heat the water circuit for the radiant floor and the AHU in winter, while in summer this heat is dissipated to the ground thanks to the geothermal system.



Figure 6: Reversible geothermal heat pump (left) and centralized fridge system (right)
(Source: Own source)

3.3. Intelligent Building Energy Management System (iBEMS)

The overall system is managed by an Intelligent Building Energy Management System, called iBEMS, which manages the switching on/off of the diverse energy systems in the market depending on the inlet and outlet conditions.

The iBEMS is used to monitor, control, evaluate and detect faults of the different building components and occupied zones. **Figure 7** shows the visual appearance of the Energy Management System.

A large number of sensors were installed in the building for control and evaluation purposes. The innovative integration of the multifunctional façade, the geothermal heat pump system and other devices required the integration of a large number of sensors. A weather station was also installed on the roof of the building collecting data on outdoor weather conditions (temperature, wind, radiation, etc.).

Through this solution it was possible to implement advanced control strategies to control shadings and windows for natural ventilation, control the AHU, monitor energy and comfort, optimize the operation of all the systems, and quantify and verify the energy savings achieved with the implementation of CommONEnergy solutions.

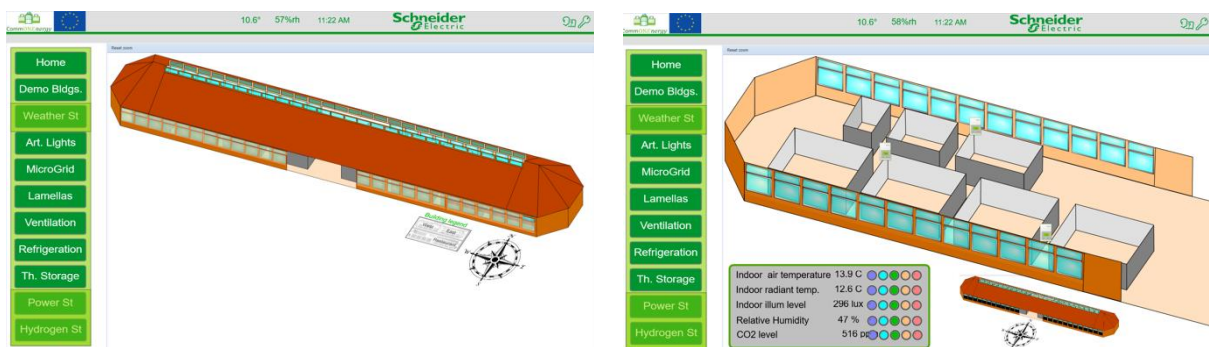


Figure 7: Intelligent Building Energy Management System (iBEMS) installed in *Mercado del Val* (Source: Screenshot obtained from the *Mercado del Val* iBEMS developed in CommONEnergy project)

4. Results – Energy savings and IEQ analysis

All the renovation projects are divided in two time periods: the baseline period, which is the period before the intervention, and the reporting period, which represents the period post-renovation.

In case of *Mercado del Val*, the baseline period is the period before the closure of the building at the end of 2013. It was difficult to collect reliable data on the market’s energy consumption during the baseline period, due to the fact that almost every market stall had its own individual energy meter. In addition, the few electrical bills collected were not very clear as to the type of use they referred to. As the building had not been operational since 2013, it was not possible to perform direct measurements on it, so the energy demand had to be estimated by energy simulations using TRNSYS software.

The reporting period started after the completion of the renovation interventions and the commissioning and testing of the different systems in the building. According to the implementation plan, the reporting period started in January 2017.

To evaluate the energy savings achieved in the market, option D “Calibrated simulations” of the IPMVP (International Performance Measurement and Verification Protocol) was used, as complete baseline information was not available. **Table 3** reports the final energy demand of the building before and after renovation for the different end-uses.

In terms of final energy, the total savings are 75% being lighting and cooling the ones experimenting higher savings above 80%.

Table 3: Final energy demand of the market before and after renovation for the different end-uses

End-use	Old market [kWh/m ² y]	New market [kWh/m ² y]	Savings [%]
Lighting	318.2	49.5	84
Appliances	36.5	25.2	31
Refrigeration	55.0	19.0	65
Ventilation	31.7	19.0	40
Heating	61.7	20.0	68
Cooling	38.0	3.4	91
TOTAL	541.1	136.1	75

Measurements on the thermal comfort and Indoor Air Quality (IAQ) were performed in the market, but only during the reporting period, since, as mentioned above, the market was already closed at the time the project started. The IAQ assessed the concentration of formaldehyde and different Volatile Organic Compounds (VOCs) measured at different points inside and outside the market, but also the concentration of carbon dioxide level according to EN 15251. Thermal comfort was evaluated based on the international standard ISO 7730 (Ergonomics of the thermal environment).

Thermal comfort results showed that the highest distribution of hours was in category IV, which means that it did not comply with the standards. Here, it is important to remark that the energy systems were still under optimization of their working conditions. Regarding the assessment of the IAQ, only the concentration of formaldehyde and xylenes were much higher than outside, while the others were very similar to outside conditions, although the concentrations of all the components were still below the thresholds. As regards the assessment of CO₂ emissions, the concentration inside the market met the requirements of the standard.

5. Conclusions

The renovation project carried out in the *Mercado del Val* market has recovered a building that is representative of the architecture and commercial activity of the late 19th century, transforming it into an innovative building that responds to the needs of the 21st century and increases its attractiveness for customers and vendors. The inclusion of the market in the European project CommONEnergy allowed mainly to improve the energy performance of the building thanks to the inclusion of the innovative solutions developed in the framework of the project, such as the multifunctional façade, the geothermal heat pump based system and the intelligent building energy management system.

The main use of the building as fresh product market was maintained, but a supermarket was added in the basement of the building.

Thanks to the sustainability criteria applied in the renovation of the building, a reduction in energy consumption was achieved, as well as an improvement in thermal comfort and indoor air quality conditions.

The building is now more sustainable and energy efficient, thus being aligned with EU directives and recommendations on energy efficiency that promote the development of more sustainable buildings that emit less CO₂ emissions into the atmosphere.

6. References

- [1] CommONEnergy consortium project, "CommONEnergy project," 2013. [Online]. Available: <https://cordis.europa.eu/project/id/608678/es>. [Accessed January 2021].
- [2] The European Commission, "Commission Recommendation (EU) 2019/786 of 8 May 2019 on building renovation," Official Journal of the European Union, pp. L127/34-79, 2019.
- [3] CommONEnergy consortium project, "Deliverable 6.4 Energy saving results," 2017. [Online]. Available: <https://sintef.brage.unit.no/sintef-xmlui/handle/11250/2502059>. [Accessed January 2021].
- [4] OpenStreetMap, 2021. [Online]. Available: <https://www.openstreetmap.org/>. [Accessed January 2021].
- [5] Catastro, "Sede electrónica del Catastro," 2021. [Online]. Available: <https://www.sedecatastro.gob.es/>. [Accessed January 2021].
- [6] Google Maps, 2021. Mercado del Val, Valladolid, Spain [Online]. Available: <https://www.google.com/maps/@41.6535718,-4.7315355,296a,35y,90h,39.63t/data=!3m1!1e3>. [Accessed January 2021].
- [7] BOCYL, "Revisión del Plan General de Ordenación Urbana," 19 June 2020. [Online]. Available: <http://bocyl.jcyl.es/boletines/2020/06/19/pdf/BOCYL-D-19062020-17.pdf>. [Accessed January 2021].
- [8] Ayuntamiento de Valladolid, "PGOU 2020 Valladolid. Fichas de elementos del catálogo de Arquitectura e Ingeniería. DST 003: Mercado del Val," 3 June 2020. [Online]. Available: http://www.jcyl.es/plaupdf/47/47186/296992/DST_003_firmado_firmado.pdf. [Accessed January 2021].

Acknowledgments

Authors wishing to acknowledge the partners involve in the CommONEnergy project, grant agreement n° 608678.