# Project FLEXUM - D3: Demo evaluation, dissemination and exploitation plan

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# About OneNet

The project OneNet (One Network for Europe) will provide a seamless integration of all the actors in the electricity network across Europe to create the conditions for a synergistic operation that optimizes the overall energy system while creating an open and fair market structure.

OneNet is funded through the EU's eighth Framework Programme Horizon 2020, "TSO – DSO Consumer: Large-scale demonstrations of innovative grid services through demand response, storage and small-scale (RES) generation" and responds to the call "Building a low-carbon, climate resilient future (LC)".

As the electrical grid moves from being a fully centralized to a highly decentralized system, grid operators have to adapt to this changing environment and adjust their current business model to accommodate faster reactions and adaptive flexibility. This is an unprecedented challenge requiring an unprecedented solution. The project brings together a consortium of over 70 partners, including key IT players, leading research institutions and the two most relevant associations for grid operators.

The key elements of the project are:

1. Definition of a common market design for Europe: this means standardized products and key parameters for grid services which aim at the coordination of all actors, from grid operators to customers;
2. Definition of a Common IT Architecture and Common IT Interfaces: this means not trying to create a single IT platform for all the products but enabling an open architecture of interactions among several platforms so that anybody can join any market across Europe; and
3. Large-scale demonstrators to implement and showcase the scalable solutions developed throughout the project. These demonstrators are organized in four clusters coming to include countries in every region of Europe and testing innovative use cases never validated before.



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# Table of Contents






*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957739*

# List of Figures





*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957739*

*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957739*

# List of Tables





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# List of Abbreviations and Acronyms

| Acronym | Meaning |
|---|---|
| BMS | Building Management System |
| BUC | Business Use Case |
| DSO | Distribution System Operator |
| ENTSO-E | European association for the cooperation of transmission system operators (TSOs) for electricity |
| FSP | Flexibility Service Provider |
| HVAC | Heating, Ventilation and Air Conditioning |
| i-DE | Iberdrola Distribución Eléctrica (Iberdrola Electric Distribution) |
| OMIE | Operador del Mercado Ibérico de Energía (Iberian Peninsula energy market operator) |
| MVP | Minimum Viable Product |
| R&D | Research and Development |
| TSO | Transmission System Operator |
| UMU | Universidad de Murcia (University of Murcia) |


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# Executive Summary

This document describes the work done in the final part of the project. It is mainly focused on two areas, namely, evaluation of the solution in the demo scenario and activities done in the context of dissemination and exploitation.

In terms of evaluation, the results of the tests have been analysed to check whether the minimum required flexibility according to the local market flexibility request agreements has been achieved, how flexibility can help solve congestion problems and how to acquire that flexibility through local markets, as defined in the Spanish Business Use Cases (BUCs):

- WECL-ES-01: Long-term congestion management.
- WECL-ES-02: Short-term congestion management.

As part of the dissemination activities, online promotion has been done using ODINS' website and social networks. The solution has also been promoted in the Barcelona Smart City Expo World Congress 2022.

Regarding exploitation, a market analysis and an exploitation plan have been included as well.

As a summary of the results, both from a technical and a business perspective, it has been demonstrated that the developed solution has fulfilled the expectations and there are great opportunities for flexibility service providers in the chosen market, including a significant number of countries in Europe which have their grids interconnected.

It is also clear that this emerging technology can be improved and there are a number of things that represent an opportunity for further scientific and technological developments.



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# 1 Introduction

This is the final deliverable of FLEXUM. After having done a flexibility characterisation of the demo scenario in Deliverable 1, Deliverable 2 was focused on the implementation of the solution, including not only the flexibility services, but also the integration with OMIE which is the energy market operator of the Iberian Peninsula.

This final deliverable analyses the solution and the results obtained when using the developed technology on the demo site scenario during the tests carried out in July and September. These tests were carried out to test whether flexibility can work to solve energy congestion problems e.g. energy peak consumptions on demand. In addition to test how flexibility is acquired through local markets. The one used in the project was the platform of OMIE.

Both Spanish demo BUCs provided in WP2, as described in *D2.3 Business Use Cases for the OneNet* [5], were tested:

- WECL-ES-01: Long-term congestion management.
- WECL-ES-02: Short-term congestion management.

The main objective of the WECL-ES-01 is to ensure that the DSO can procure flexibility in advance to solve specific local system loading issues on the distribution system, thus deferring/eliminating the need for traditional system upgrades.

The WECL-ES-02 demonstrates the short-term congestion management procurement of local flexibility products by the DSO. It describes the exchanges of information and the processes that should be established between DSO, MO and FSP to solve distribution network local congestions. Two timeframe markets are considered: Day-ahead and intraday.

On the other hand, the dissemination activities executed in the context of the project will be described, as well as the strategy plan defined which is compatible with two exploitation models, one commercial (sales of services per use) and another focused on reusing the obtained knowledge in future R&D projects.

# 2 Demo evaluation

Throughout this section will be described on the one hand the procedure to be followed for carrying out the flexibility request to the final flexibility tests. Tests of July 27th, 2022, were not associated with any flexibility request agreements, while tests of July 28th and September 2nd, 2022, had them.

On the other hand, it is detailed the evaluation of the results of these tests, as well as the monitoring of temperatures of some areas during the performance periods. Finally, it is concluded whether or not the agreed flexibility requirements have been achieved.



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## 2.1 Flexibility request agreement

The flexibility request agreement was between the DSO and the FSP by using the OMIE platform. As mentioned in previous deliverables, the FSP was the University of Murcia with Campus of Espinardo. Therefore, in this section it is detailed how was the proceed of the flexibility request agreement for two days with a total of three tests, namely, long-term market, short-term day-ahead and short-term intraday markets. Specifically, there were two tests on July 28th related to the short-term day-ahead and a short-term intraday agreements and one test on September 2nd related to the long-term agreement. Section 2.5 is focused on the evaluation of these tests. In addition, the flexibility pre-tests executed on July 27th are also discussed. These tests were done without having any associated flexibility request agreement related to the local markets.

First of all, the FSP and the DSO (as i-DE) have registered on the OMIE platform as users through a user access certificate provided by OMIE. This allows access to the different actions that are defined according to the type of user they are in the platform. The FSP is the one that registered the installation for the demo. The installation consisted of heat pumps of the Campus of Espinardo of the University of Murcia. Afterwards, it will be seen that the tests were carried out with the buildings chosen from Deliverable 1 [2].

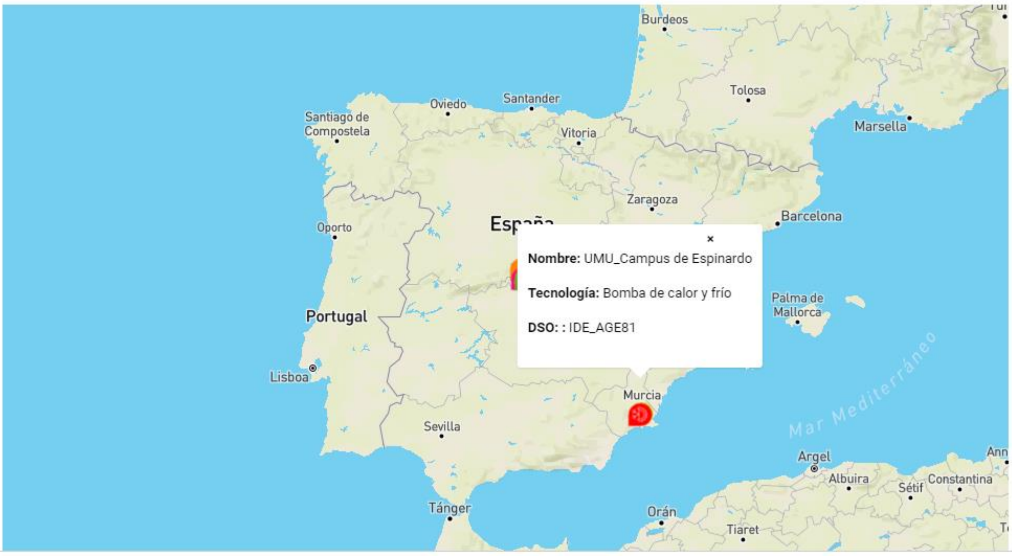


*Figure 1 – Installation registered in OMIE platform [2].*

Once the access was available, the next step was to define the flexibility request in OMIE platform in one of its two types of local flexibility markets. The short-term market subdivided in day-ahead and intraday market, and long-term market. Both are based on how the hourly Spanish market is defined. The DSO made a requirement for the flexibility request to OMIE who validated the information.

In the case of the demo carried out in the short-term market, the requests were basically focussed on when the activation had to be executed and the required power in MW to reduce consumption. Meanwhile, in the


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long-term market, availability and actuation were contracted at the same time, but the activation was done when it was necessary, during the contracted availability window.

The general process for reaching a flexibility agreement can be seen in Figure 2.

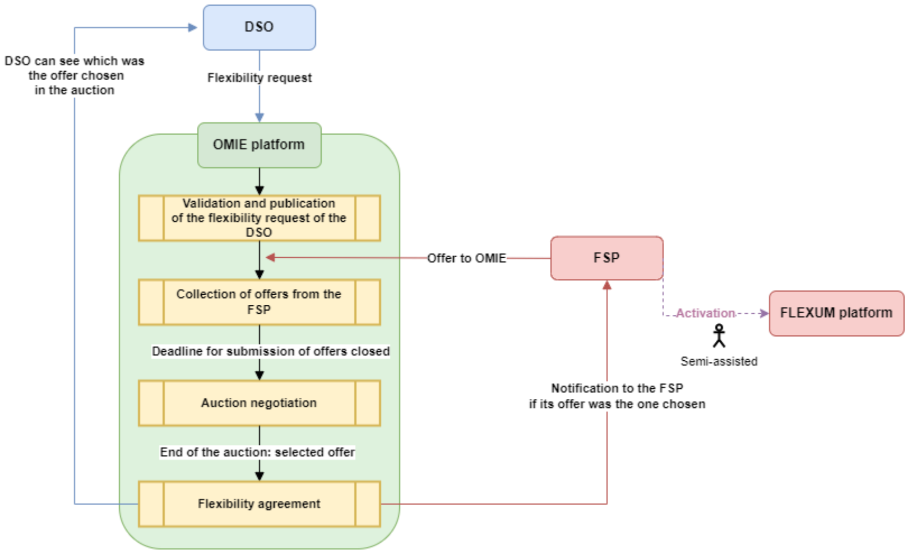


*Figure 2 – Flexibility request agreement process.*

It consists of, once the flexibility request is defined by the DSO, validated, and published by OMIE, the FSP answered with an offer[1] by manually introducing it in the platform of OMIE. Offers are not public and not shown to the DSO until the auction has finished. After this, the deadline of providing offers closes, and the auction is carried out through OMIE platform. Automatically, once the negotiation of the auction has finished, the FSP was notified if it was chosen his offer as the final one. Therefore, the flexibility agreement is closed. The following step is activation (always for short-term market agreements and only if confirmed for long-term market agreement). The FSP should achieve the agreed flexibility within the defined period.

The following procedure for the *requirement*, *offer* and *negotiation* for each test carried out in July and September are shown below:

- Day-ahead 1st short-term test of July 28th,2022: the *requirement*, insertion of *offers* (15:00-15:45) and *negotiation* (15:45) were done in the short-term day-ahead market on July 27th, 2022. The activation was carried out on the day established for the test in the flexibility requirement. It was from 9:30 to 10:00 on July 28th, 2022. Figure 3 shows the results of the auction conducted for this first short-term July 28th activation test. The data shown are in Spanish, indicated below:
- *Cód. Contrato:* it refers to the contract code of the auction. Each new auction is associated with a different code number.

[1] It should be noted that the offer is per unit and not per installation.



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- *Zona:* the zone where the offer takes place, which was in Espinardo.
- *Estado:* it is the state of the auction. As it is indicated, it was finished.
- *Fecha de entrega:* it represents the date of delivery when the flexibility will be delivered by the FSP.
- *Periodo:* it means the period in which the agreed flexibility is to be fulfilled. It corresponds to one hour because the platform did not allow to add half hours, but the activation was only required half hour from 9:30 to 10:00.
- *Cantidad:* it is the amount of flexibility agreed in the negotiation. As the OMIE platform does not support 30-minute intervals, the value expected to obtain during these 30 minutes (0.4 MW) had to be extrapolated to a 60-minute interval. Hence, the value has been introduced as energy (0.4MW * 0.5h = 0.2MWh) as shown in Figure 3. However, it is important to notice that although the sum of certain consumption (power) in a period of time is represented as energy, the goal of the tests was to ensure a reduction in instant power during the whole period. That is why all the analysis has been focused on measuring power and not energy, and this extrapolation was only forced from a representation perspective by the functionality offered by the OMIE platform.
- *Tipo:* it is the type of request. C is the initial capital letter in Spanish for purchase.
- *Inicio:* when the auction has started.
- *Fin:* when the auction has finished.

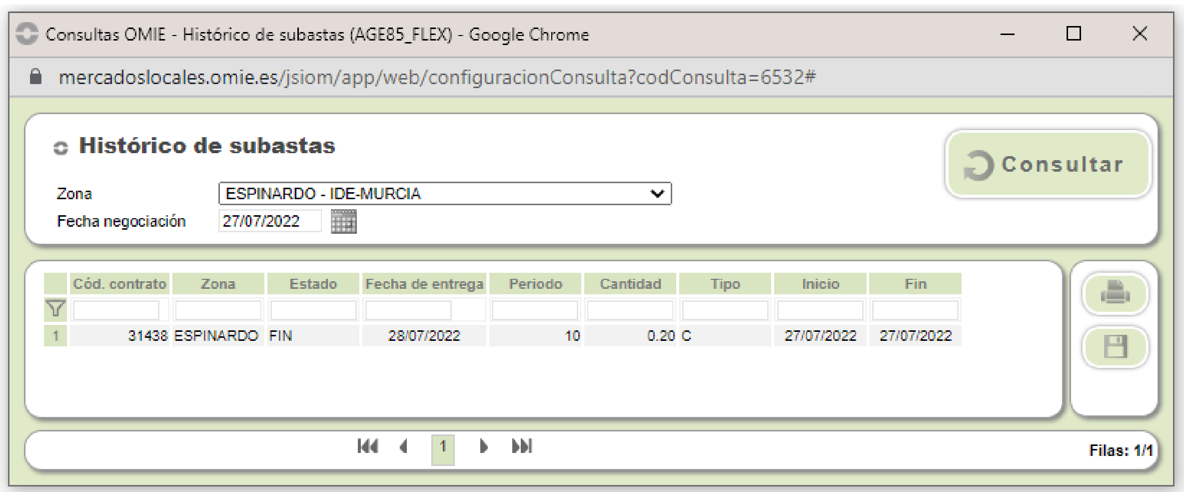


*Figure 3 – Auction history for the day-ahead first short-term test of July 28th, 2022, perform in the platform of OMIE [2].*

The offers for the two tests on July 28th can be seen in Figure 4, where one of the bids made by the FSP changed. The one with the code offer of 1900 change to 1903. The objective was to see if it matched with the request. The price was decreased to ensure that the offer would be chosen in the auction.


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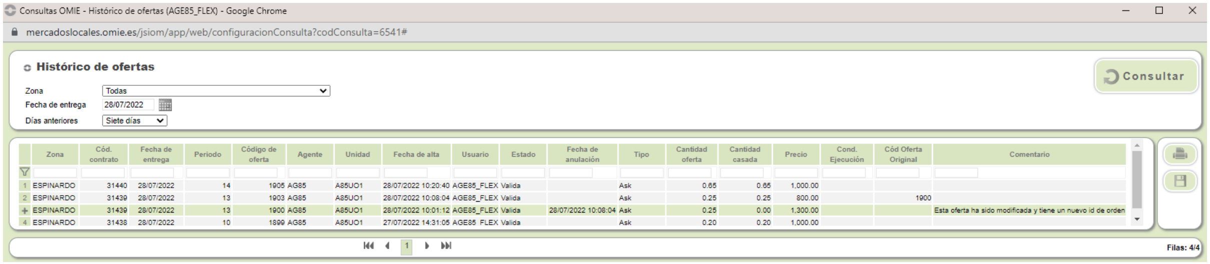

Consultas OMIE - Histórico de ofertas (AGE85_FLEX) - Google Chrome
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**Histórico de ofertas**

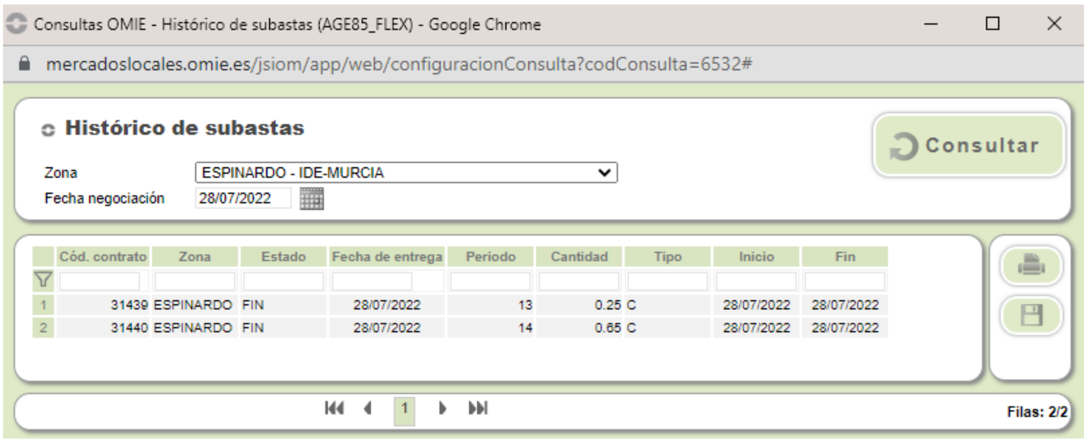
Zona: Todas
Fecha de entrega: 28/07/2022
Días anteriores: Siete días

| | Zona | Cód. contrato | Fecha de entrega | Periodo | Código de oferta | Agente | Unidad | Fecha de alta | Usuario | Estado | Fecha de anulación | Tipo | Cantidad oferta | Cantidad casada | Precio | Cond. Ejecución | Cód Oferta Original | Comentario |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ESPINARDO | 31440 | 28/07/2022 | 14 | 1905 | AG85 | A85UO1 | 28/07/2022 10:20:40 | AGE85_FLEX | Valida | | Ask | 0.65 | 0.65 | 1,000.00 | | | |
| 2 | ESPINARDO | 31439 | 28/07/2022 | 13 | 1903 | AG85 | A85UO1 | 28/07/2022 10:08:04 | AGE85_FLEX | Valida | | Ask | 0.25 | 0.25 | 800.00 | | 1900 | |
| + | ESPINARDO | 31439 | 28/07/2022 | 13 | 1900 | AG85 | A85UO1 | 28/07/2022 10:01:12 | AGE85_FLEX | Valida | 28/07/2022 10:08:04 | Ask | 0.25 | 0.00 | 1,300.00 | | | Esta oferta ha sido modificada y tiene un nuevo id de orden |
| 4 | ESPINARDO | 31438 | 28/07/2022 | 10 | 1899 | AG85 | A85UO1 | 27/07/2022 14:31:05 | AGE85_FLEX | Valida | | Ask | 0.20 | 0.20 | 1,000.00 | | | |

Filas: 4/4

*Figure 4 – History of offers for both short-term tests of July 28th, 2022 [2].*

- Intraday 2nd short-term test of July 28th, 2022: the *requirement*, insertion of *offers (*10:00-10:45), and *negotiation* (10:45) were done on the same day of the test in the short-term intraday market on July 28th, 2022. The *activation* from 12:00 to 12:30 was done the same day. There were two auctions represented in Figure 5. The first one, is the one required to be achieved in the test. As it was mentioned in the previous test of July 28th, in the OMIE platform each period corresponds to one hour. Therefore, the flexibility requirement of 0.25 MWh indicated in Figure 5 is the interpolated value of the expected flexibility of 0.5 MW during the 30-minute test.



Consultas OMIE - Histórico de subastas (AGE85_FLEX) - Google Chrome
mercadoslocales.omie.es/jsiom/app/web/configuracionConsulta?codConsulta=6532#

**Histórico de subastas**

Zona: ESPINARDO - IDE-MURCIA
Fecha negociación: 28/07/2022

| | Cód. contrato | Zona | Estado | Fecha de entrega | Periodo | Cantidad | Tipo | Inicio | Fin |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 31439 | ESPINARDO | FIN | 28/07/2022 | 13 | 0.25 | C | 28/07/2022 | 28/07/2022 |
| 2 | 31440 | ESPINARDO | FIN | 28/07/2022 | 14 | 0.65 | C | 28/07/2022 | 28/07/2022 |

Filas: 2/2

*Figure 5 – Auction history for the intraday second short-term test of July 28th, 2022, perform in the platform of OMIE [3].*

- Long-term test of September 2nd, 2022: The flexibility *requirement* for the long-term market was sent on July 29th, 2022. On August 5th, 2022, the *negotiation* (10:00-13:00) and insertion of *offers* (13:00) were confirmed. The *activation* was finally done from 12:15 to 12:45 on September 2nd, 2022. An email from DSO to FSP was sent to request the activation during the contracted availability period.



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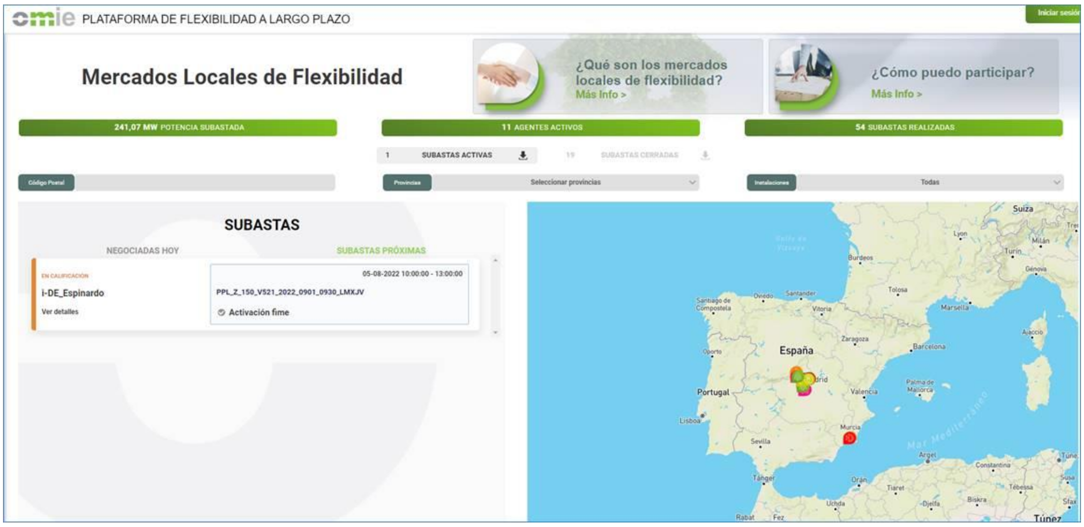


*Figure 6 – Open phase of the auction in long-term OMIE platform for the activation in the test of September 2nd, 2022 [3].*

In this case, the power requirement was increased to 1.1 MW. The objective was to assess whether the required flexibility could be reached after the activation by UMU.


Calificaciones de la instalación: **UMU_Campus de Espinardo**

| SUBASTA | ZONA | FECHA DE LA SUBASTA | POTENCIA CALIFICADA | ESTADO | |
|---|---|---|---|---|---|
| PPL_Z_150_V521_2022_0901_0930_LMXJV | I-DE_Espinardo | 2022-08-05 10:00:00 | 1,10 | Calificada | Ver detalle |

*Figure 7 – Auction in long-term OMIE platform for the activation in the test of September [3].*

The topic of penalties for compliance with the agreed flexibility has not been addressed during the demo flexibility tests. The remuneration in the case of the supplier will be that which corresponds to the approved offer.

Table 2.1 summarises the type of negotiation, period activation and the agreed flexibility required for the flexibility tests.

*Table 2.1 – Final flexibility request agreements.*

| Test ID | Day of the activation test (Year: 2022) | Nº of shutdowns (OFF) | Day of flexibility request (Year: 2022) | Activation period | Type of platform for the negotiation and activation | Flexibility request agreed (MW) |
|---|---|---|---|---|---|---|
| **1** | July 27th (Flexibility pre-tests) | 1st OFF | They not linked with any flexibility request procedure and final agreement | 09:30 – 10:00 | They were not linked with any flexibility request procedure and agreement | |
| | | 2nd OFF | | 12:00 – 12:30 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **2** | July 28th | 1st OFF | July 27th | 09:30 – 10:00 | Day-ahead market in short-term OMIE platform | 0.4 |
| | | 2nd OFF | July 28th | 12:00 – 12:30 | Intraday market in short-term OMIE platform | 0.5 |
| **3** | September 2nd | 1st OFF | July 29th* | 12:15-12:45 | Long-term platform | 1.1 |

* Resources were asked by email, three hours ahead of time, to be activated during the service window on September 2nd from 12:15 to 12:45 to avoid forecasted congestions. As this activation test is a long-term market and timing is different, the request was sent on July 29th and the agreement was confirmed on August 5th (market session).

As a reminder, the flexibility capacity (amount of consumption that can be reduced through an actuation) for each asset has been obtained by a preliminary study of testing the buildings. More details about this and the development and testing of the integration of FLEXUM with OMIE in a simulated environment for the flexibility request, available in Deliverable 2 [2].

## 2.2 Overview of FLEXUM platform

All aspects of the activation process are covered in this section. Once the flexibility request is agreed, the activation phase and the flexibility capacity previously obtained are joined with the semi-assisted service Assisted Synchronous Coordination into the Context Broker component. A common format known as NGSI-LD is used. The devices installed in the buildings that are monitored and can actuate over the systems form the flexibility asset group. They have been modelled and integrated in the platform using the NGSI-LD format and entities. Therefore, the afore mentioned format allows them to be stored in this common format in the Context Broker. From this point onwards, IoT agents connect the platform with each of the devices. as all the information is available in the Context Broker. Therefore, the shutdowns (the procedure of switching on or off) are enabled by sending commands to the systems of BMS of the buildings or directly to HVAC machinery. This has made it possible to carry out the July and September tests defined in the previous section.



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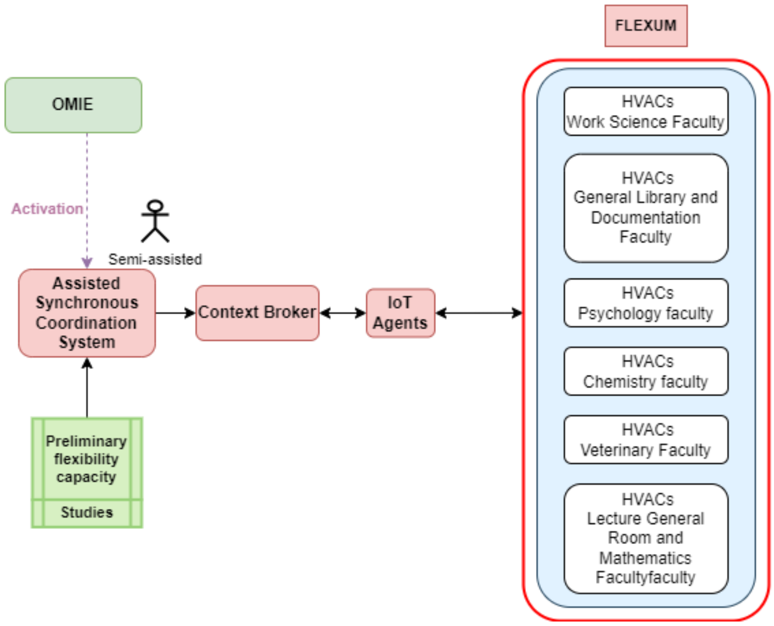


*Figure 8 – FLEXUM semi-assisted platform.*

Due to the nature of the systems involved in the flexibility (those that can be switched on and off by sending commands to the gateways, mostly HVACs), a small change had to be made for the September test. In order to guarantee a reduction of the consumption during all the defined time interval, the shutdowns were sent to the gateways a few minutes before the expected start of the test. Normally HVACs require some time to get fully stopped (they have internal mechanisms to protect the machinery from constant ups and downs) and this delay had to be taken into account if we wanted to prevent interferences in the results.

As a result, all the consumption readings registered by the meter of the medium voltage line that feeds the Campus of Espinardo during the test showed the proper values. In the end, the systems had already been stopped by the time the test started.

## 2.3 Pre-cooling phase

As it will be detailed in the monitoring of temperature section there where some verbal complaints, in some of the buildings, regarding the increase in indoor temperature due to the tests of July 27th and 28th of 2022. A preliminary phase was carried out to prevent the comfort of the occupants from being affected during the shutdown tests. The preliminary phase is called pre-cooling. Pre-cooling phase consists of cooling internally the buildings to balance the increased of the indoor temperatures during the tests.


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Figure 9 shows the total power consumption of Campus of Espinardo[2]. It compares the results from the September 2nd test with a normal consumption day which is the baseline (September 1st, 2022).

The differentiation of the behavioural outcome during pre-cooling and shutdown periods[3] is clearly defined. The pre-cooling phase is identified as the peak prior to the drop in power consumption. This power reduction corresponded to the shutdowns, being the reduced power agreed during the flexibility agreement which is in Section 2.1.

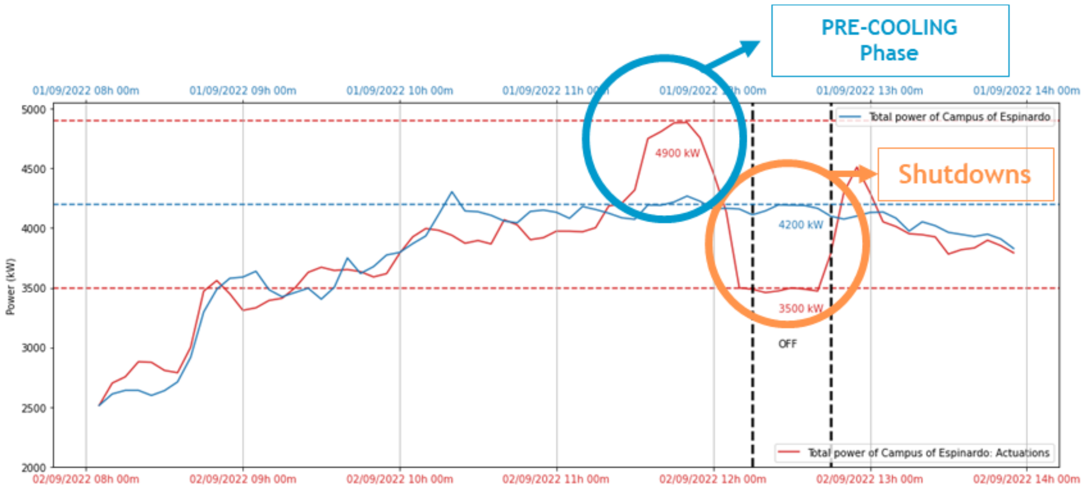


*Figure 9 – Total power consumption of Campus of Espinardo in Murcia's University: comparison between the day of the test (September 2nd, 2022) and the previous day without any anomalous behavior (September 1st, 2022).*

In some buildings, pre-cooling has already been carried out during those tests of July due to the knowledge that they have light infrastructures i.e. low thermal inertia [2] . This will be shown in section 2.5.1 , figures show of power consumption for July 27th and 28th tests. In these figures there are high power peaks during several minutes before the activation of the shutdowns which represent the pre-cooling phase. Therefore, pre-cooling phase was done also in the last test, September 2nd, to solve the issue of the complains about the thermal comfort.

## 2.4 Monitoring of temperatures

The flexibility tests using FLEXUM parameter resulted in an eventual synchronous shutdown of the devices in the rooms of each building that are integrated in the platform. Doing this, the temperature of the rooms was expected to be modified due to the total control over the HVAC devices, which could mean an alteration in the

[2] It should be in mind that in periods such as July or September, consumptions are more conditioned by the activities that are carried out internally in the buildings.

[3] Shutdown period of a test correspond to the activation period when that test is associated with a flexibility agreement.



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comfort of the occupants. It is for this reason that temperature values were monitored on selected areas. This gave us an idea of the impact that the events had on the spaces.

During the flexibility tests, the temperature experimented by the users was the one shown in Figure 10 and Figure 11. On both figures, the blue line represents the temperature, and the green dashed lines represent the comfort band. The comfort band used is based on a technical guide published by the Spanish Ministry of Work [4] which indicates that in the summer period it is recommended to maintain the temperature between 23°C and 27°C in workplaces. The upper dashed green line represents the lower temperature limit of the band being 23°C, while the upper limit is 27°C. The vertical black dashed lines indicate the period in which the first and second tests were performed, being 1st OFF and 2nd OFF, respectively.

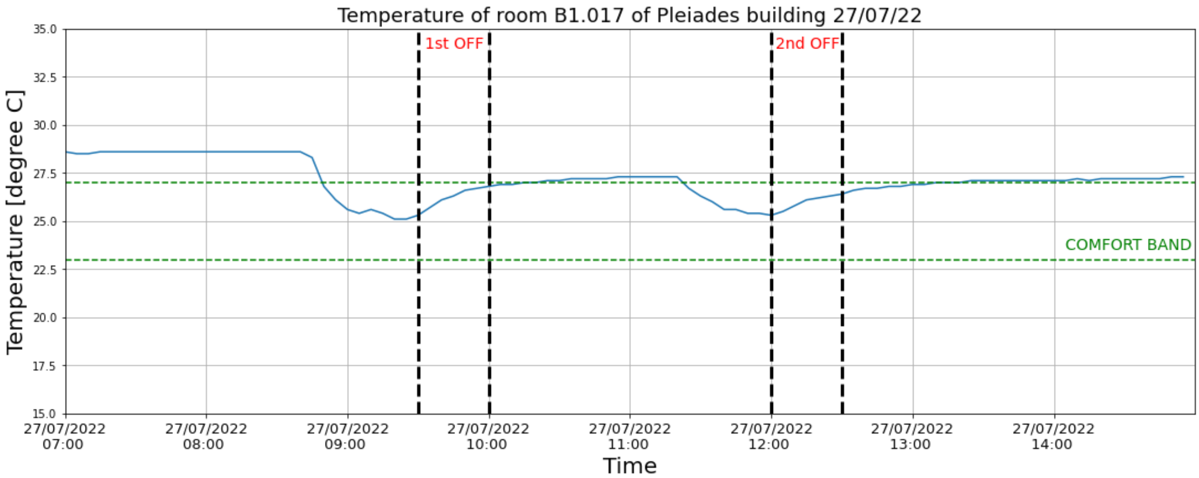


*Figure 10 – Test of July 27th / Monitoring of temperatures in the FLEXUM pilot – Pleiades building.*

Before the 1st OFF and the 2nd OFF, there is a temperature drop (few minutes before 09:00 am and around 11:30 am). This is due to the pre-cooling done in the building (section 2.3). Consequently, the temperature has remained within the comfort band after the temperature drop. When the tests (1st and 2nd OFF of both days of


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tests) were carried out, the temperature gradually rises until it reaches the upper limit of the band and remains within this comfort band.

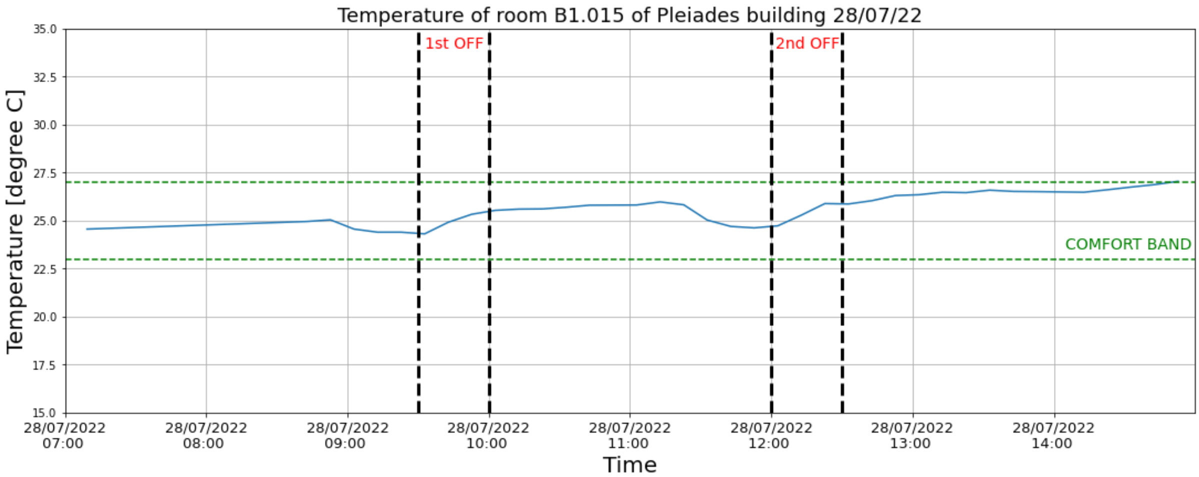


*Figure 11 – Test of July 28th / Monitoring of temperatures in the FLEXUM pilot – Pleiades building.*

The temperatures of the rooms and their dynamics can vary depending on the topology and infrastructure of the building, resulting in a variation of the thermal inertia [2] and in the comfort assessment. After the first automated tests (tests of July 27th and 28th of 2022) that were carried out, there were some complains communicated about the increase in temperature when the actions were carried out by the counselling staff. In particular, this occurred in some of the buildings where the HVACs were directly targeted such as in the Work Sciences Faculty. It should be noted that this faculty has significant amount of glass in its facade and in its entrance doors, which results in low cold retention in summer season. Therefore, during the shutdowns, temperatures may rise faster, which could affect occupant comfort. The feedback received from the occupants was considered for the last test. Therefore, since it was performed pre-cooling, which was explained in the previous section, there was no more complaints about thermal comfort.

## 2.5 Evaluation of the tests at the different buildings

Evaluation and results of the flexibility tests are detailed in the following section, as well as what has been agreed to be reduced in the flexibility agreement in section 2.1. For the analysis and comparison of the results, the baseline used corresponds to the day before the tests (same values from July 26th were use as baseline for tests of both July 27th and July 28th). There were no relevant changes in the weather from one day to the next. This means that there was a day in which no forced interventions in consumption are produced. The test results are compared with this baseline.

There were tests during three different days in the following buildings:



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*Table 2.2 – Selected buildings for the flexibility tests of the real-demo.*

| ID | Building name |
|---|---|
| **1** | Chemistry Faculty |
| **2** | Pleiades building |
| **3** | Veterinary Faculty |
| **4** | Psychology Faculty |
| **5** | General Lecture Room and Mathematics Faculty |
| **6** | Work Sciences Faculty |
| **7** | General Library and Documentation Faculty |

In total, five tests were carried out, four over July and one during September as it is shown in *Table 2.3*. All the activation tests were done during workdays. As it was previously mentioned, both flexibility pre-tests of July 27th were not associated with any kind of flexibility request procedure and local market agreement. In cases where there were two shutdowns on the same day, they have been differentiated as follows: 1st OFF and 2nd OFF, being first and second off, respectively.

*Table 2.3 – Schedule of the flexibility tests.*

| Test ID | Day of activation | Nº of shutdowns (OFF) | Activation period |
|---|---|---|---|
| **1** | July 27th, 2022 (Flexibility pre-test) | 1st OFF | 09:30 – 10:00 |
| | | 2nd OFF | 12:00 – 12:30 |
| **2** | July 28th, 2022 | 1st OFF (short-term day-ahead) | 09:30 – 10:00 |
| | | 2nd OFF (short-term intraday) | 12:00 – 12:30 |
| **3** | September 2nd, 2022 | 1st OFF (long-term) | 12:15 – 12:45 |

The figures of consumption shown throughout this section, represent the power consumption of the day of the activation tests compared with its corresponding baseline (previous day without shutdowns) of each building. The blue curve defines the power consumption baseline; the red and orange curves represent the consumption during the day of the tests.

*Table 2.4 – General legend of the graph representation for the flexibility tests.*

| Test ID | Day of activation | Assigned colour | Baseline day | Baseline assigned colour |
|---|---|---|---|---|
| **1** | July 27th, 2022 (Flexibility pre-test) | Red | July 26th,2022 | Blue |
| **2** | July 28th, 2022 | Orange | July 26th,2022 | Blue |
| **3** | September 2nd, 2022 | Red | September 1st,2022 | Blue |

NOTES

1) **Black vertical dashed lines represent the period of the shutdowns (OFFs)**
2) **Horizontal** dashed **lines** (orange, red and blue) **have been placed on to facilitate the comprehension of** the power values of **the graphs**. The power values shown correspond to the line closest to them, and of the same colour.
3) **Black arrows represent the moment when the power reductions were calculated.**

Once the baseline was defined, the power reduction was calculated for the period of the shutdown. This power reduction was based on the difference of the power for the day of the tests with the power of the baseline, both at the same moment of shutdowns.

$$P(kW)_{reduction} = P(kW)_{Baseline} - P(kW)_{OFF}$$

In addition, the percentage power reduction compared to the baseline has been calculated for each building.

$$P(\%)_{reduction} = \frac{P(kW)_{reduction}}{P_{reduction}(kW)} \cdot 100$$

Section 2.5.3 details the same previous comparison for each building of power consumption on the day of the tests compared to the baseline but for the case of the total consumption of Campus of Espinardo. In addition, in the next section it is summarised all the power reduction results calculated from the test graphs for each building and total consumption of Campus of Espinardo.

## 2.5.1 Test of Wednesday, July 27th and Thursday, July 28th of 2022



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On the 27th and 28th of July, two shutdowns were carried out on each day as it is shown in *Table 2.3*. The results of both days are shown in the same section for the sake of simplicity when analysing the results and obtaining the power.

**1) Chemistry Faculty**

Prior to the shutdowns, there are some power peaks (red consumption curve). These power peaks are due to the pre-cooling phase mentioned above. The power reduction on July 27th was low, about 10 kW for 1st OFF and 20 kW of power reduction for 2nd OFF.

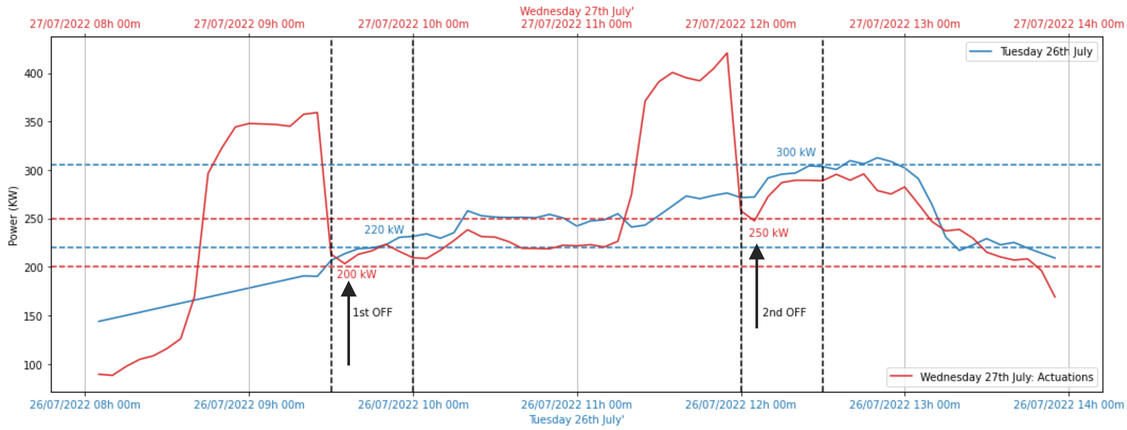


*Figure 12 – Test of July 27th / Chemistry Faculty - Power consumption with shutdowns vs Power consumption baseline.*

Instead, the final power reduction offered on July 28th was about a 20% for both shutdowns, representing, in terms of power, the reduction was about 45 kW and 58 kW, 1st OFF and 2nd OFF respectively.

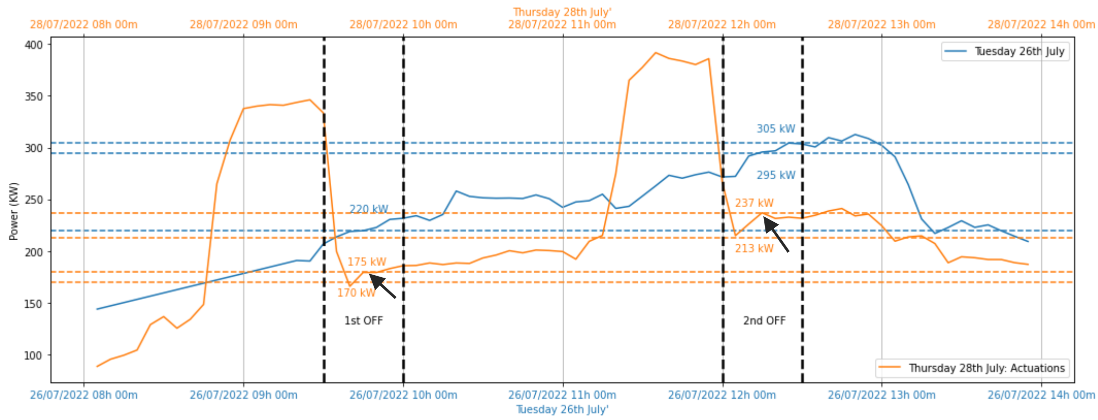


*Figure 13 – Test of July 28th / Chemistry Faculty - Power consumption with shutdowns vs Power consumption baseline.*

**2) Pleiades Building**

While the reduced power on July 27th is from 10 to 32 kW, being between a 9% and 29% of flexibility capacity (maximum consumption), the reduced power for the second day of tests is higher. It was achieved a power



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reduction of 50 kW for 1st OFF and 39 kW for the 2nd OFF on July 28th, which represents a 36 % of the capacity flexibility of Pleiades Building.

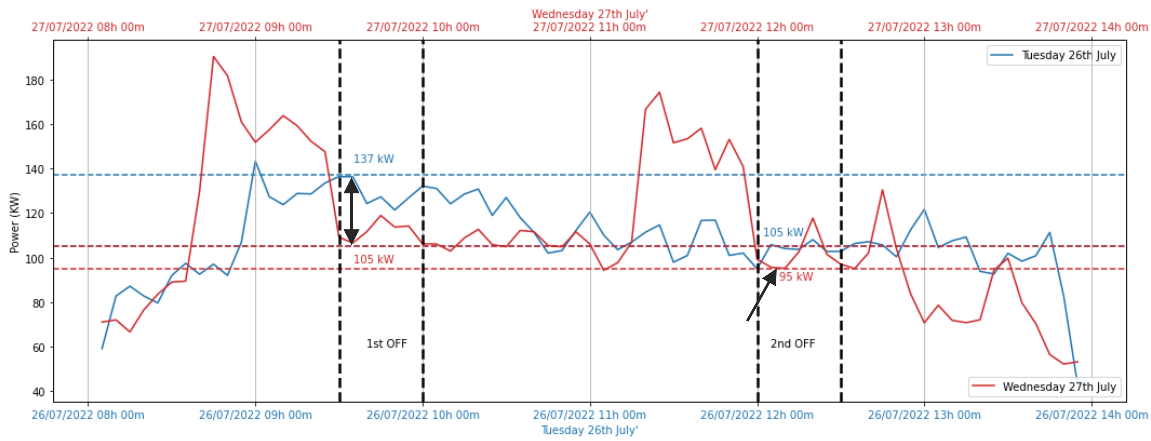


*Figure 14 – Test of July 27th / Pleiades Building - Power consumption with shutdowns vs Power consumption baseline.*

The consumption after the shutdowns, on July 28th, is smaller than the baseline. This may be largely since the occupants' energy behaviour on that day has been reduced. In the case of the previous power consumption, it is understood to be the power consumption that would have occurred daily, as it is observed that it practically coincides with the baseline consumption. In both figures, there are, previously to both shutdowns during both days, relatively flattened peak with ups and downs. This is due to the pre-cooling done in the building.

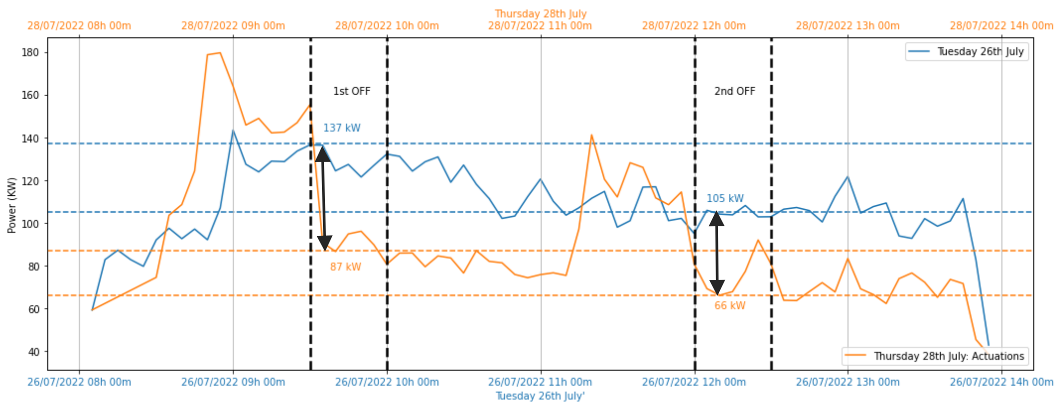


*Figure 15 – Test of July 28th / Pleiades Building - Power consumption with shutdowns vs Power consumption baseline.*

**3) Veterinary Faculty**

Both Veterinary and Chemistry buildings have rooms in which, due to the activities that are carried out inside specific rooms, such as laboratories, the power that can be reduced with respect to the maximum power of the building is reduced. The Veterinary and Chemistry buildings have rooms that make the total



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power reduction smaller. These rooms are mainly the laboratories, which have a limited available capacity to modify the internal temperature conditions due to the activities carried out there. Around 10 to 14% is the power reduced during shutdowns. The maximum power reduced was 40 kW day 27th, while 20 kW and 45 kW are approximately for July 28th.

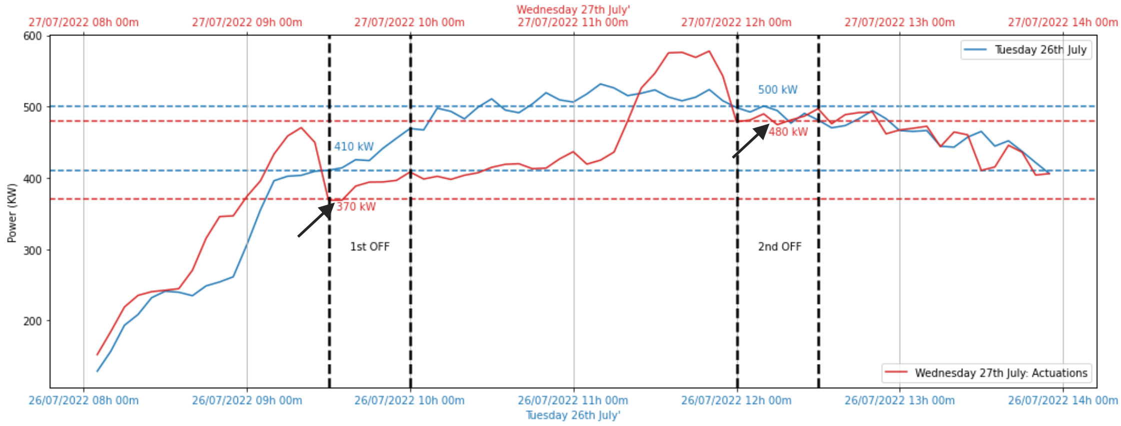


*Figure 16 – Test of July 27th / Veterinary Faculty - Power consumption with shutdowns vs Power consumption baseline.*

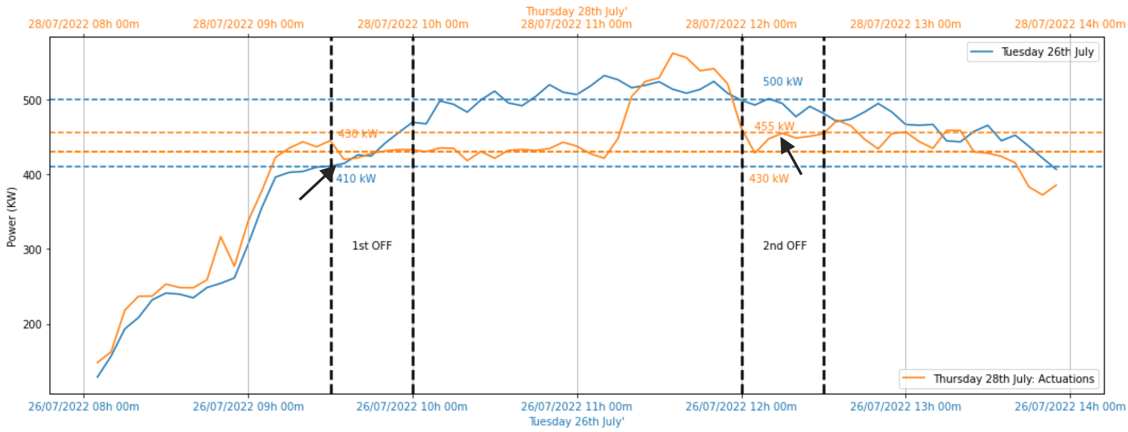


*Figure 17 – Test of July 28th / Veterinary Faculty - Power consumption with shutdowns vs Power consumption baseline.*

**4) Psychology Faculty**

The consumption on the morning of the baseline day is low compared to the consumption on the following two days. In the early morning hours on the day of the baseline there is practically no consumption. In July there is the examination period, so the consumption of the buildings is also affected on that basis. In this case of study, the activity of the building on energy terms started at 11 o'clock. It should be noted that this does not affect the calculation of the reduced power as the second shutdown is available. The power reduction is from 62% to 65% in terms of flexibility capacity magnitudes 90 and 95 kw for 2nd OFF July 27th and 28th, respectively.


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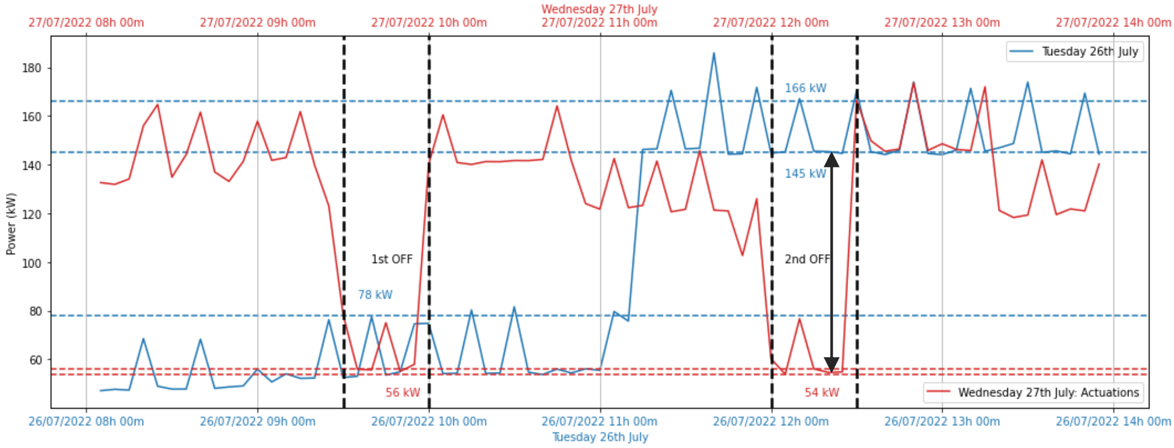


*Figure 18 – Test of July 27th/ Psychology Faculty - Power consumption with shutdowns vs Power consumption baseline.*

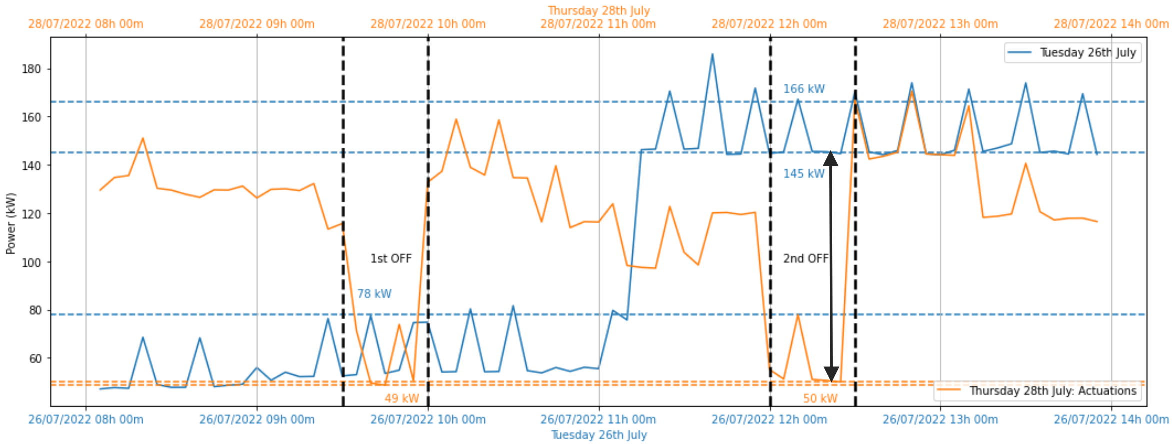


*Figure 19 – Test of July 28th / Psychology Faculty - Power consumption with shutdowns vs Power consumption baseline.*

#### 5) General Lecture Room and Mathematics Faculty

When a building has a lightweight construction, the thermal recovery of the building is high, i.e., as it does not retain heat or cold during the shutdowns. For this reason, in this building the pre-cooling method was carried out. The peak before the tests corresponds to this pre-cooling phase About the peak after the shutdowns, they are referred to power peaks which occur in response to a return to previous thermal conditions. These peaks are seen in Figure 20 and Figure 21 after the end of both shutdowns, i.e. just after 10:00 and 12:30. Moreover, it will be seen in section 2.5.2 that the same occurred in the last test of September 2nd for this building.


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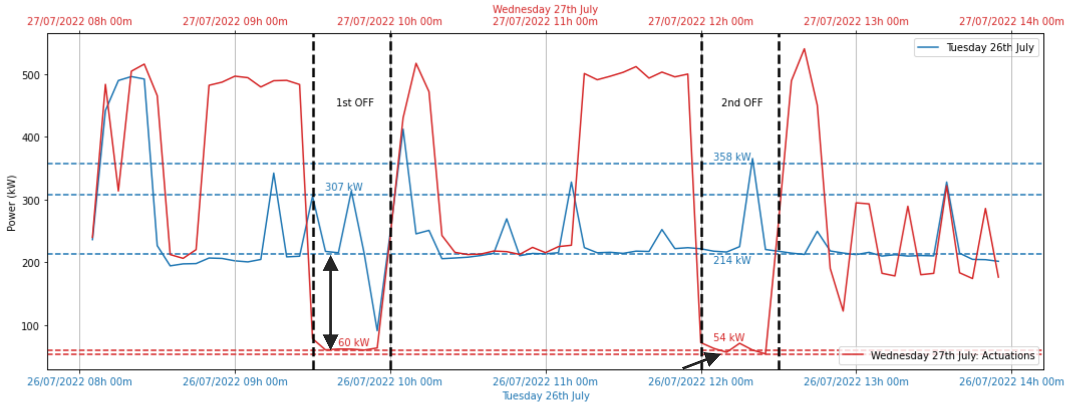


*Figure 20 – Test of July 27th / General Lecture Room and Mathematics Faculty - Power consumption with shutdowns vs Power consumption baseline.*

In addition, the reduction of power consumption achieved with the shutdowns in this building was the highest one. It was not considered for the calculations, the power peaks in the baseline day (values of 307 kW and 358 kW). From 74% to 80% of the power consumption was reduced. In terms of power reduction magnitudes, they are about 154 and 160 kW for 1st and 2nd OFF in both days.

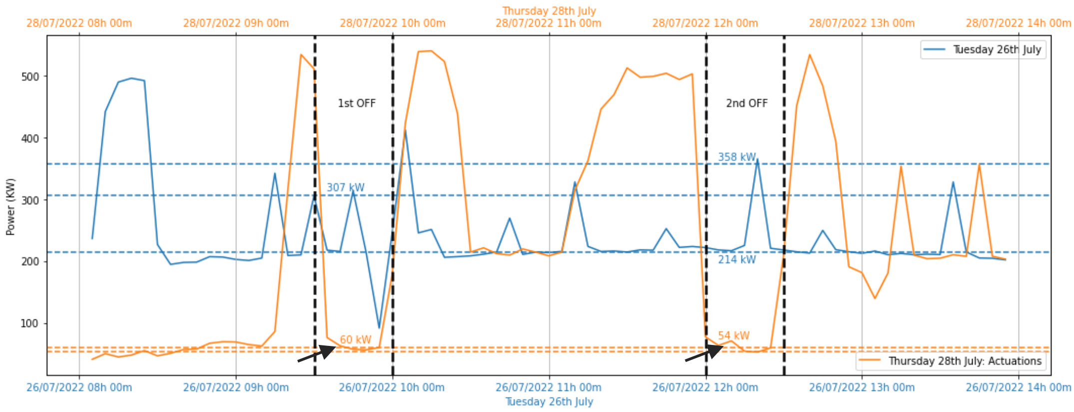


*Figure 21 – Test of July 28th / General Lecture Room and Mathematics Faculty - Power consumption with shutdowns vs Power consumption baseline.*

### 6) Work Sciences Faculty

The building holding this faculty has open entrances to the premises, and many windows, therefore heat retention is very low. HVACs systems are set to higher power to restore original thermal conditions. That could be the reason why the rebound peak power after each shutdown during both days is produced.



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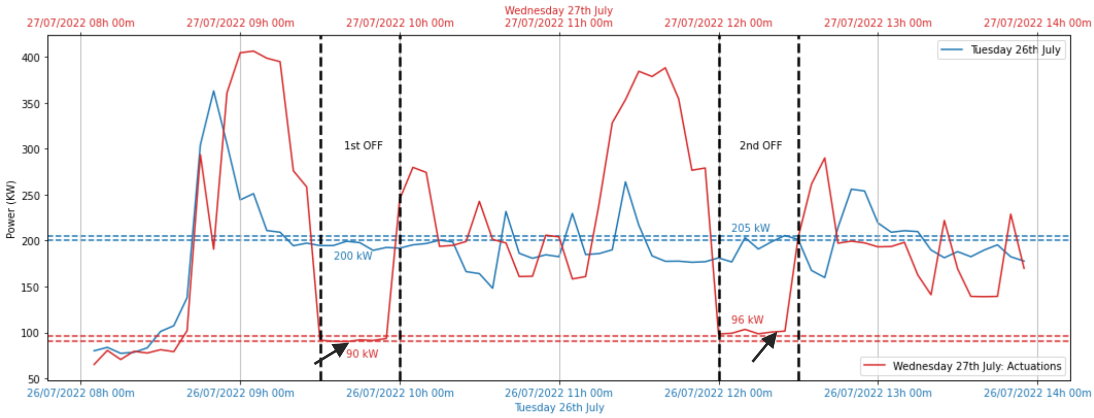


*Figure 22 – Test of July 27th / Work Sciences Faculty - Power consumption with shutdowns vs Power consumption baseline.*

In both days power reductions where similar, being approximately 110 kW of power reduction that represents a 55% of power reduction during shutdowns periods for both days.

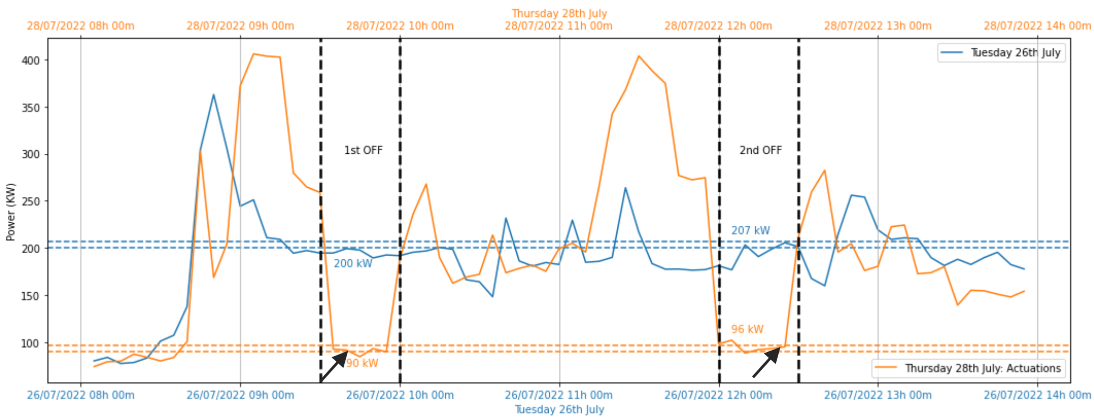


*Figure 23 – Test of July 28th / Work Sciences Faculty - Power consumption with shutdowns vs Power consumption baseline.*

**7) General Library and Documentation Faculty**

The General Library and Documentation Faculty is the most stable building of the seven studied in terms of consumption. There are no power peaks after shutdowns, nor there are power peaks throughout the day.


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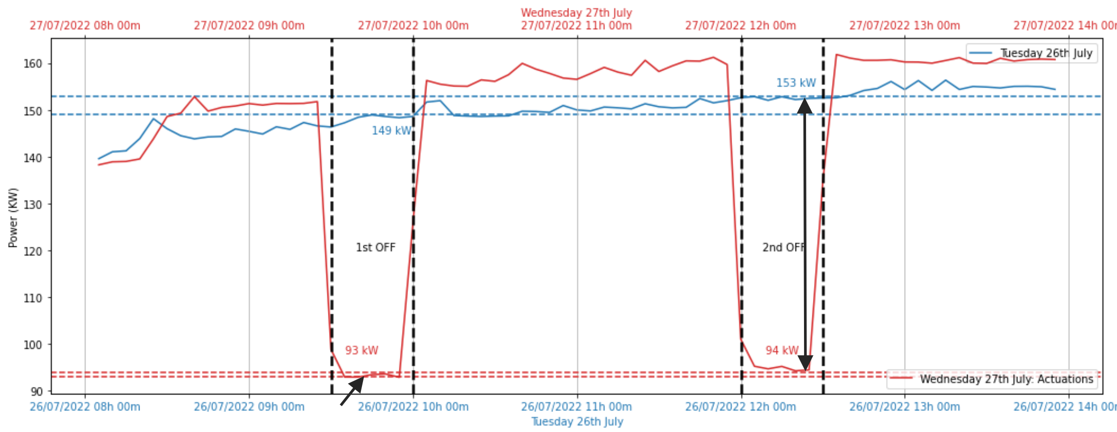


*Figure 24 – Test of July 27th / General Library and Documentation Faculty - Power consumption with shutdowns vs Power consumption baseline.*

The power consumption on July 28th, Figure 25, had higher consumption than the day of the baseline When calculating the reduced power, as always, the baseline consumption has been used. Therefore, the power reduction obtained during the four shutdowns is in the range of between 37% and 39%. The flexibility capacity was between 56 and 60 kW. The power reductions for each one of the shutdowns are detailed in Table 2.5.

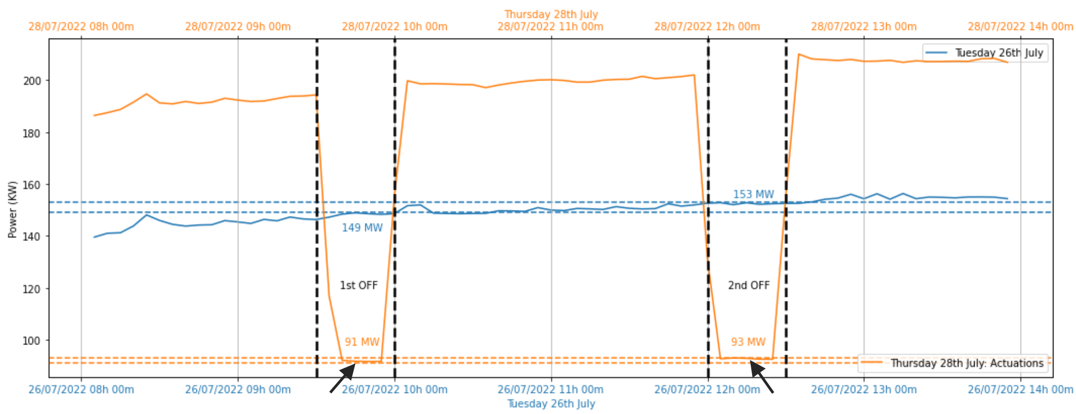


*Figure 25 – Test of July 28th / General Library and Documentation Faculty - Power consumption with shutdowns vs Power consumption baseline.*

### 2.5.2 Test of Friday, September 2nd, 2022

Final test was done on September 2nd where the daily activities of Campus of Espinardo begin and with it, the academic year 2022/2023. On the contrary of the previous tests of July, in September was done just one shutdown from 12:15 to 12:45, the activation from the long-term market agreement. In addition, some adjustments were made during the activation process based on the analysis of the previous tests which were discussed throughout the demo evaluation section.


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## 1) Chemistry Faculty

As it can be seen there was a pre-cooling phase, as well as it was in the July tests. It allowed to maintain the internal temperature of the building with a comfortable thermal comfort. This shutdown provided a power reduction of 40 - 55 kW, which represents a 15 -20% over the baseline consumption during the shutdown period.

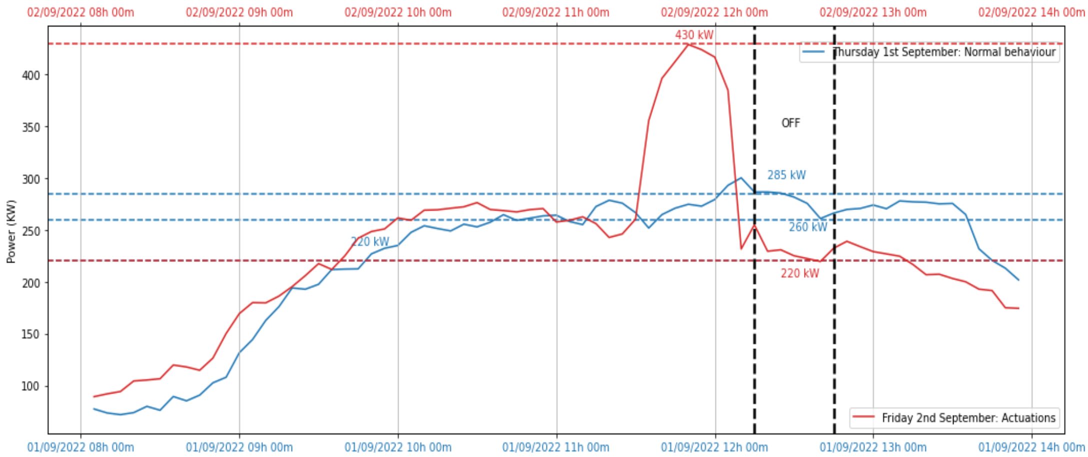


*Figure 26 – Test of September 2nd / Chemistry Faculty - Power consumption with shutdowns vs Power consumption baseline.*

## 2) Pleiades Building

In this test, pre-cooling was carried out. The power peak starting at 11:30 and lasting until the beginning of the shutdown represents the pre-cooling phase. For this reason, there were no more complaints regarding thermal comfort after the final test.

Considering the peak power of the baseline and the lower peak in the test day (black circles), both values inside the interval of the shutdown, the maximum reduced power was approximately of 35 kW. A maximum reduction of 45% was achieved.



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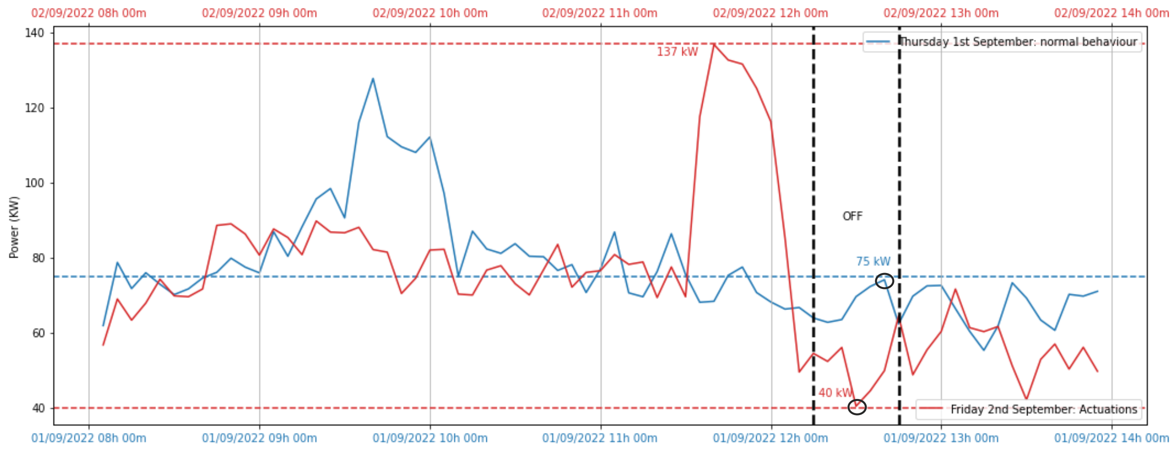


*Figure 27 – Test of September 2nd / Pleiades Building - Power consumption with shutdowns vs Power consumption baseline.*

### 3) Veterinary Faculty

The consumption of the day of the test is similar, with a slightly lower consumption, to the baseline. The peak observed previous the shutdown was as it will be the normal consumption (as it is shown with the baseline day). Once the shutdown was done, the maximum power achieved to be reduced is about 126 kW, which is a 27% reduction from baseline during the test.

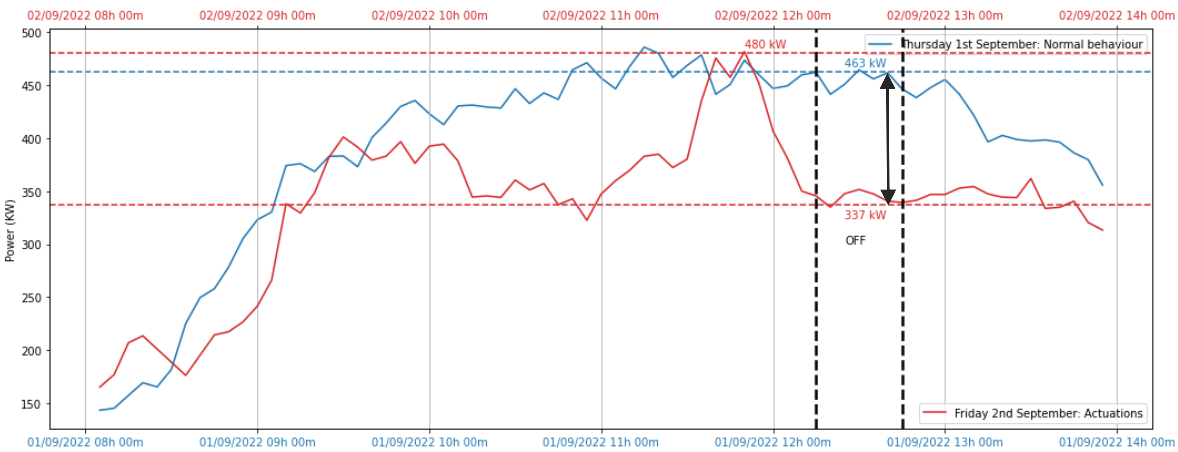


*Figure 28 – Test of September 2nd / Veterinary Faculty - Power consumption with shutdowns vs Power consumption baseline.*

### 4) Psychology Faculty

A reduction of more than 50% has been achieved. Even if there was a rebound peak after the shutdown to return to initial thermal conditions, the maximum reduction is 64 kW. Overall, it was lower than in the July tests, but it should be noted that consumption is not the same due to different factors (academic activities, work, etc.).



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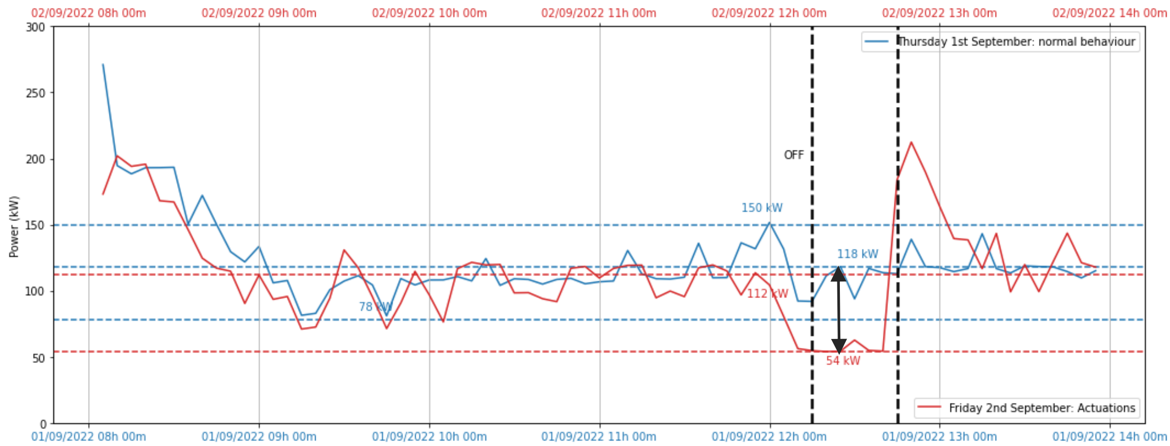


*Figure 29 – Test of September 2nd / Psychology Faculty - Power consumption with shutdowns vs Power consumption baseline.*

**5) General Lecture Room and Mathematics Faculty**

As it was commented in section 2.5.1 the consumption profile is very similar to the one in both tests of July. The 3 days of testing (July 27th, 28th and September 2nd) are characterised by having a pre-cooling phase before the shutdowns and a rebound peak that occurs just after it. This test has confirmed that it is the building with the highest power reduction. 153 kW is the maximum power that has been reduced which corresponds to a 70% of reduction compared to the baseline.

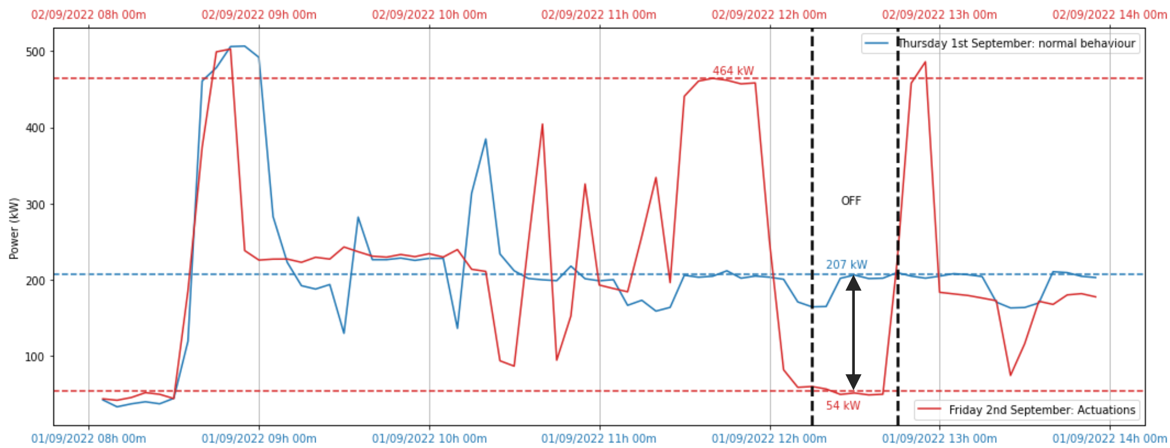


*Figure 30 – Test of September 2nd / General Lecture Room and Mathematics Faculty - Power consumption with shutdowns vs Power consumption baseline.*

**6) Work Sciences Faculty**

The first peak is identified as the start-up of the HVAC systems at the beginning of the working day. The pre-cooling phase is clearly differentiated. It corresponds to the period in which there is a higher power consumption than usual. While the power reduction is slightly lower to the power reduction during July tests, there were no more complains about thermal comfort.



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Comparing the power consumption of the day of the test with the baseline, both during shutdown period, 83 kW was calculated as the reduced power. Practically, half of the power consumption during that same period was reduced.

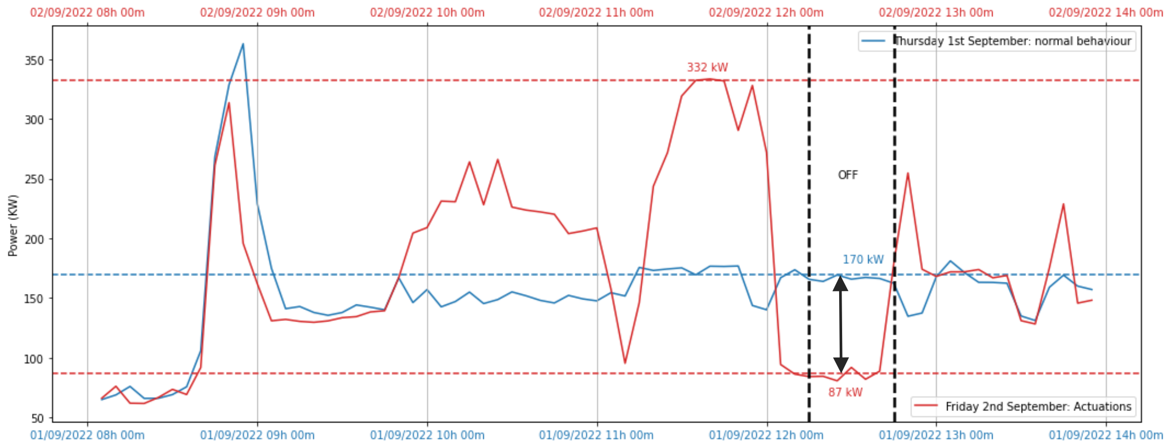


*Figure 31 – Test of September 2nd / Work Sciences Faculty - Power consumption with shutdowns vs Power consumption baseline.*

**7) General Library and Documentation Faculty**

General Library and Documentation Faculty is the most representative building in terms of consumption profile throughout the day as it is usually stable and without large changes in consumption. This last building has a power reduction of 95 kW, which corresponds to approximately 50% of the consumption of the building.

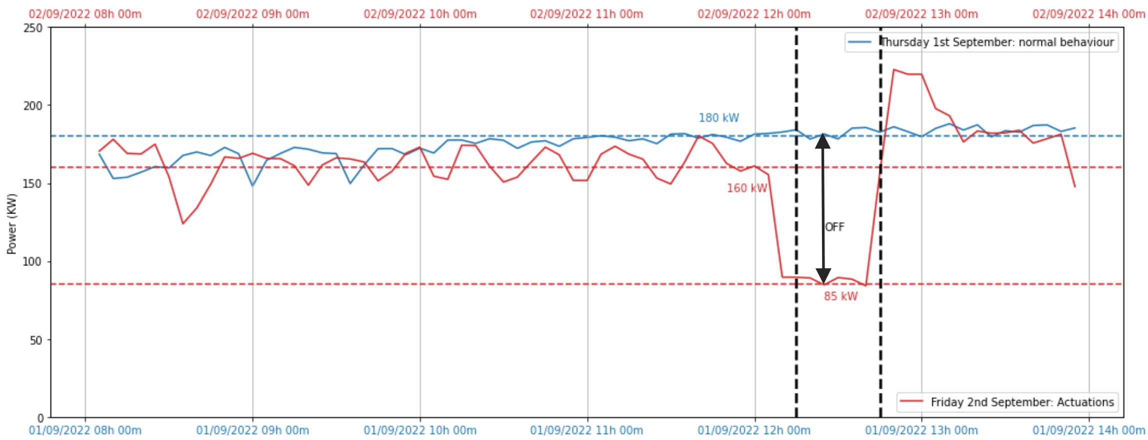


*Figure 32 – Test of September 2nd / General Library and Documentation Faculty - Power consumption with shutdowns vs Power consumption baseline.*

### 2.5.3 Global evaluations testing

The results of the total consumption of the Espinardo Campus for the activations of the three days are shown here. For the activation tests of July 27th, a reduction from 0.38 MW to 0.4 MW was achieved in both of them.



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The maximum power reductions are about 0.47 MW and 0.51 MW on July 28th for 1st OFF and 2nd OFF, respectively.

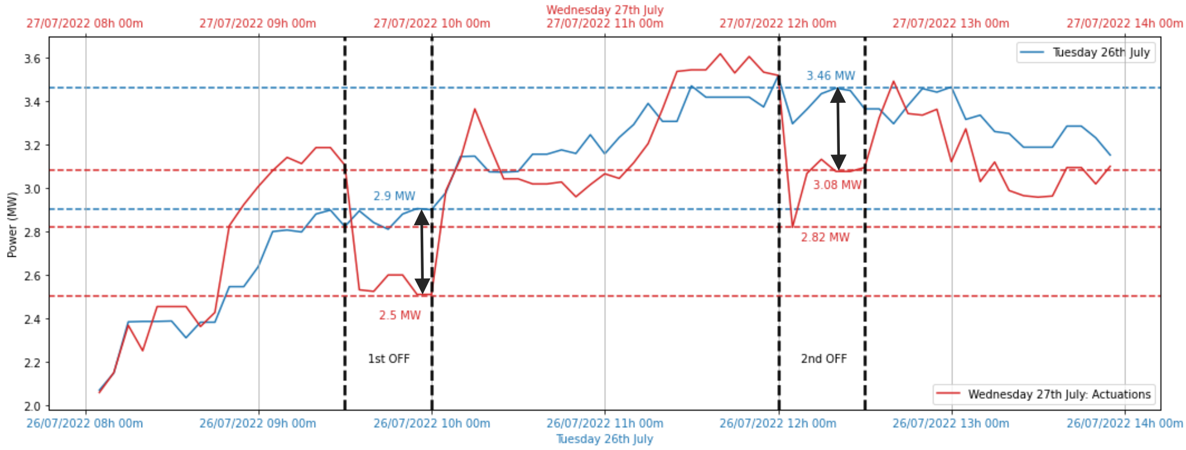


*Figure 33 – Test of July 27th / Total power consumption of Campus of Espinardo - Power consumption with shutdowns vs Power consumption baseline.*

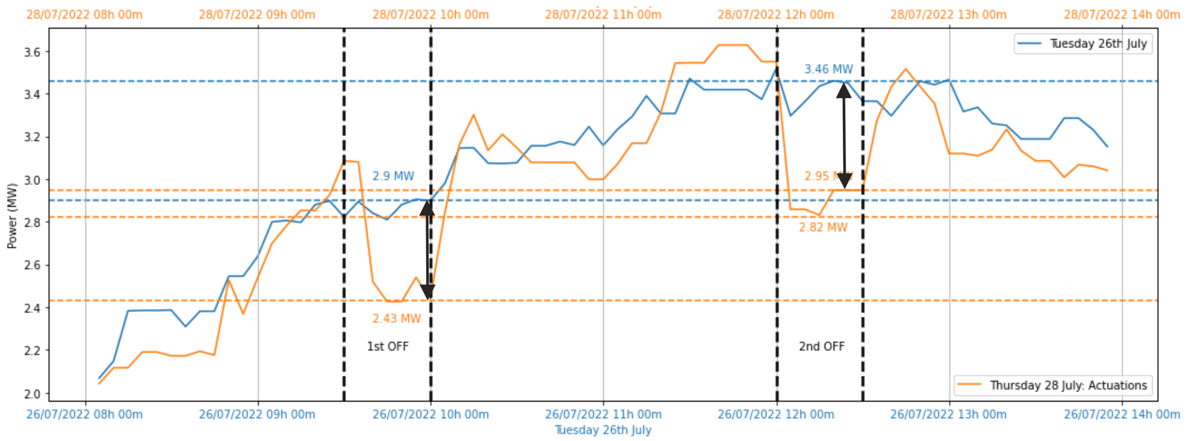


*Figure 34 – Test of July 28th / Total power consumption of Campus of Espinardo - Power consumption with shutdowns vs Power consumption baseline.*

As it was mentioned at the end of section 2.2, there was a delay when it came to actually reduce the consumption due to the moment when the shutdowns were performed and when the results of these were actually reflected in the total power consumption data at the beginning of the activation period. This happened to both tests of July, Figure 34.

In the 1st OFF of July 28th, at 09:30, the power reduction has not yet taken place. This happened a few minutes later. In the 2nd OFF, the power consumption of July 28th started to decrease at the beginning of the activation period. Approximately 5 minutes, the drop stopped, and at this moment is when the reduction of the power consumption can be observed.


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In Figure 35, the delay issue was solved by launching the activations beforehand a few minutes before the expected start of the test. The previous power peak corresponds to all the pre-cooling that have been carried out in the buildings of the test of September. On the other hand, the later peak corresponds to the thermal recovery that occurred in some buildings as mentioned in previous sections. By carrying out this test, a maximum power reduction of 0.7 MW has been achieved.

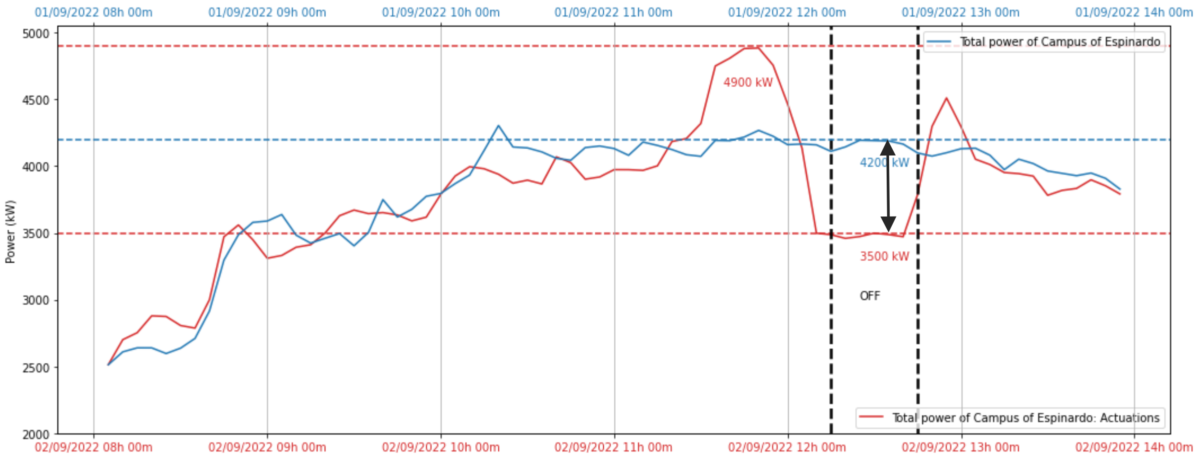


*Figure 35 – Test of September 2nd / Total power consumption of Campus of Espinardo - Power consumption with shutdowns vs Power consumption baseline.*

### 2.5.4 Summary of results

The reduced power results are summarised in two tables. Table 2.5 shows the maximum reduced power for each building for each test, including the July 27th flexibility pre-tests. Table 2.6 summarised the reduced power results obtained from the total consumption of Campus of Espinardo. Furthermore, it is detailed in which test cases and how the agreed flexibility request has been achieved.

Table 2.5 shows the maximum reduced power that each building can give as flexibility capacity based on the baseline used. These results have been collected from the power reductions calculated in Section 2.5.1 and in Section 2.5.2 for each building and test.

*Table 2.5 – Power reduction of each building from tests of July and September.*

| ID | Building name | Flexibility pre-test (without a market agreement). Maximum power reduction (MW) | Flexibility tests (with market agreements). Maximum power reduction (MW) |
|---|---|---|---|





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| | | 1st OFF of July 27th | 2nd OFF of July 27th | 1st OFF of July 28th | 2nd OFF of July 28th | September 2nd |
|---|---|---|---|---|---|---|
| **1** | Chemistry Faculty | 0.01 | 0.02 | 0.045 | 0.058 | 0.055 |
| **2** | Pleiades building | 0.032 | 0.01 | 0.050 | 0.039 | 0.035 |
| **3** | Veterinary Faculty | 0.04 | 0.02 | 0.020 | 0.045 | 0.126 |
| **4** | Psychology Faculty | 0(1) | 0.09 | 0(1) | 0.095 | 0.064 |
| **5** | General Lecture Room and Mathematics Faculty | 0.154 | 0.16 | 0.154 | 0.16 | 0.153 |
| **6** | Work Sciences Faculty | 0.11 | 0.11 | 0.11 | 0.11 | 0.083 |
| **7** | General Library and Documentation Faculty | 0.056 | 0.059 | 0.058 | 0.06 | 0.095 |
| | Total power reduction | 0.4 | 0.47 | 0.44 | 0.58 | 0.61 |

(1) There has not been power reduction in **Figure 18** and in **Figure 19** for the first shutdown with respect to the baseline, that is the reason why a null value has been considered for these two cases.

The total power reduction of the previous table, calculated by adding the reduced power of each building, is not proof of whether the agreed flexibility request has or has not been met, as the reduced power has been obtained at different moments during the activation period. However, it has allowed to know the available flexibility capacity, consumption, and thermal behavior of each building.

In parallel, the next table has been done to summarize the maximum reduced global power consumption of the Campus of Espinardo from the previous section.

*Table 2.6 – Power reduction of Campus of Espinardo from tests of July and September.*

| | Flexibility pre-test. (without a market agreement) Maximum power reduction (MW) | | Flexibility tests. (with market agreements) Maximum power reduction (MW) | | |
|---|---|---|---|---|---|
| **Campus of Espinardo** | **1st OFF of July 27th** | **2nd OFF of July 27th** | **1st OFF of July 28th** | **2nd OFF of July 28th** | **September 2nd** |



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| Power reduction requested | Not applicable | Not applicable | 0.4 | 0.5 | 1.1 |
|---|---|---|---|---|---|
| Total power reduction | 0.4 | 0.38 | 0.47 | 0.51 | 0.7 |

It is important to notice the difference between the values calculated from the consumption data of each building shown in Table 2.5 and the global values shown in Table 2.6. This is caused by the changes in consumption of other buildings in the Campus that are not being monitored individually. As a result, both results were expected to be different considering they are representing different sets of buildings.

In the first test of July 28th, the agreed flexibility capacity of 0.4 MW was achieved during the last 20 minutes of the activation period, obtaining a maximum power reduction of 0.47 MW. In the second test, the agreed 0.5 MW of flexibility request for 30 minutes was achieved approximately in the last 25 minutes of the activation period.

The delay issue of the reflection of the shutdowns in the total power consumption data at the beginning of the activation period was solved in the last test as can be seen in Figure 35. The 1.1 MW of flexibility agreed for the September test was not accomplished. However, it should be recalled that this request was specially focus on assessing if the required capacity could be reached with the buildings chosen. The maximum power reduction was 0.7 MW. This power reduction was for more than 25 minutes but less than 30 minutes of the activation period.

To summarize, the flexibility required for both tests of July was achieved during more than a half of the activation period without reaching its totality. This was approximately 66% and 83% of the activation period for the first and second test, respectively and is due to the delay of reflected power reduction in the data mentioned in previous sections.

In the test of September, the delay issue at the beginning of the activation period was solved. The flexibility agreed was not achieved. However, a high power reduction (0.7 MW) compared to the previous ones was achieved and it was maintained throughout most of the activation period.


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# 3 Dissemination

This section describes the dissemination and communication activities performed by ODINS to transmit the results of the project.

## 3.1 Online Marketing and Social Networks

In terms of media promotion, the project has been advertised through the company's web site and its social networks (Twitter and Linkedin) and the distribution of online and paper flyers.


*Figure 36 – Online promotion channels.*



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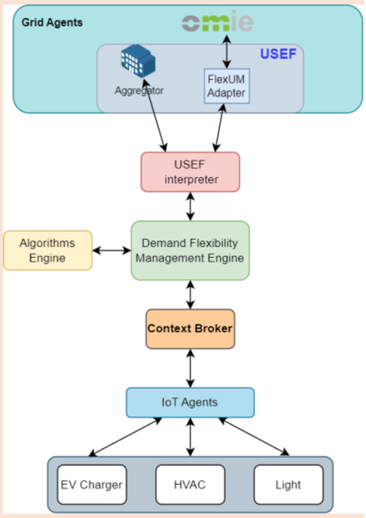
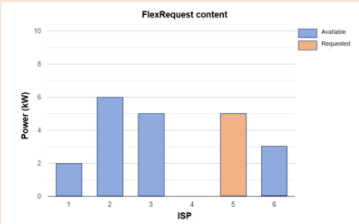
# FlexUM
# Flexibility services provision by UMU premises

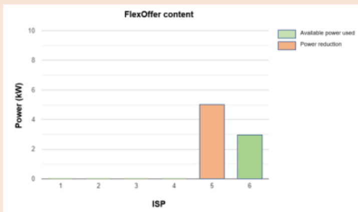
## Project Objective

FLEXUM will design, implement and evaluate a flexibility service provision (FSP) to achieve demand adjustments and responses for alleviating the network congestions at medium and low voltage network levels in the Spanish scenario located in Murcia (Espinardo). The project will benefit of a great deal of smart buildings and infrastructure already developed by OdinS and University of Murcia, that has taken part on several energy-related EU H2020 projects such as PHOENIX, ENTROPY and Smart2B. The main project results will be a FSP component, a flexibility engine and demand-response services based on a novel IoT platform developed in H2020 PHOENIX project. The engine will use artificial intelligent algorithms to quantify flexibility and will also design and suggest flexibility strategies for final consumers using a simple friendly dashboard. The flexibility engine included in the IoT platform will be compatible with communication protocols of DSOs and TSOs. We will implement a FSP component in the IoT platform to enable the bidirectional communications of congestion signals and demand events from the OMIE local market platform. Moreover, the FSP component will be design with high interoperability to be compatible with other grid systems.




FLEXUM is a funded R&I project in the first open call of the OneNet H2020 project. OneNet will provide a seamless integration of all the actors in the electricity network across Europe to create the conditions for a synergistic operation that optimizes the overall energy system while creating an open and fair market structure. The project OneNet (One Network for Europe) is funded through the EU's eighth Framework Programme Horizon 2020. It is titled "TSO – DSO Consumer: Large-scale demonstrations of innovative grid services through demand response, storage and small-scale (RES) generation" and responds to the call "Building a low-carbon, climate resilient future (LC)".




OneNet will see the participation of a consortium of over 70 partners. Key partners in the consortium include: already mentioned ENTSO-E and EDSO, Elering, E-REDES, RWTH Aachen University, University of Comillas, VITO, European Dynamics, Ubitech, Engineering, and the EUI's Florence School of Regulation (Energy).

one network for Europe

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*Figure 37 - FlexUM flyer*

## 3.2 International Congress, Workshops and Trade Events

ODINS participated in the Barcelona Smart City Expo World Congress 2022, where the solution was promoted with other products and services offered by the company.


*Figure 38 – Barcelona Smart City Expo World Congress 2022.*

Additional activities are planned. A workshop has been scheduled to show the technology and the results of the project to the participants of the PHOENIX project in the next meeting in Dublin on March 29th and 30th. Among them, there is one direct potential client for the solution, a Spanish ESCO named MIWEnergia [8]. Moreover, we plan to prepare a scientific paper to disseminate the innovation results in a high impact journal.


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# 4 Exploitation

## 4.1 Market Analysis

In the exploitation side, a market analysis was performed to identify the specific segments and locations where the solution can be profitable. Given the type of service that is being offered, the analysis was done at an international level, mostly focused on Europe.

In the next sections, information related to certain relevant aspects of the potential market are described.

### 4.1.1 Market size

As mentioned in the previous section, the preferred market for the solution is Europe.

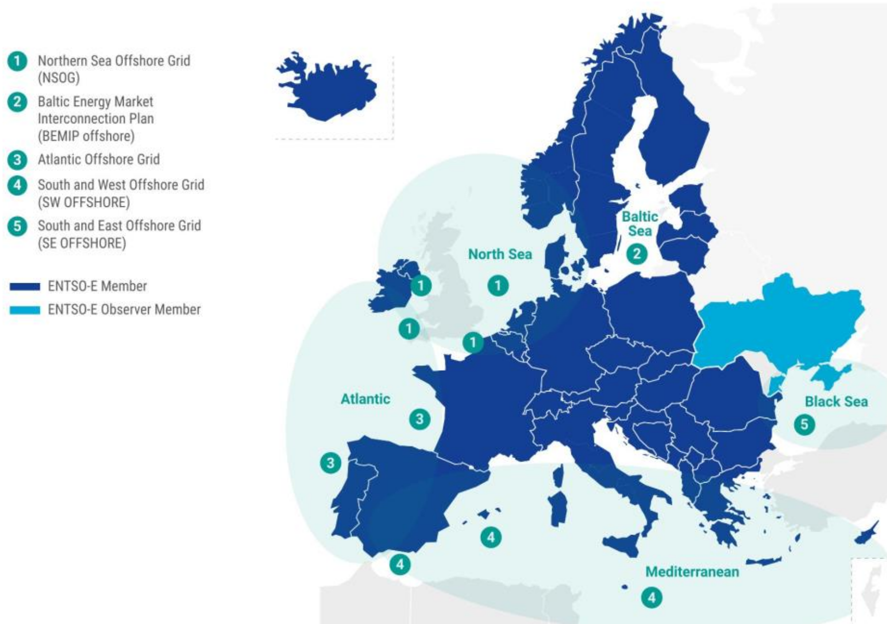


*Figure 39 – ENTSO-E context.*

The previous figure shows the European countries that participate in ENTSO-E, the European Network of Transmission System Operators for Electricity. It includes 39 Transmission System Operators (TSOs) from 35 countries which form the largest interconnected grid in the world.


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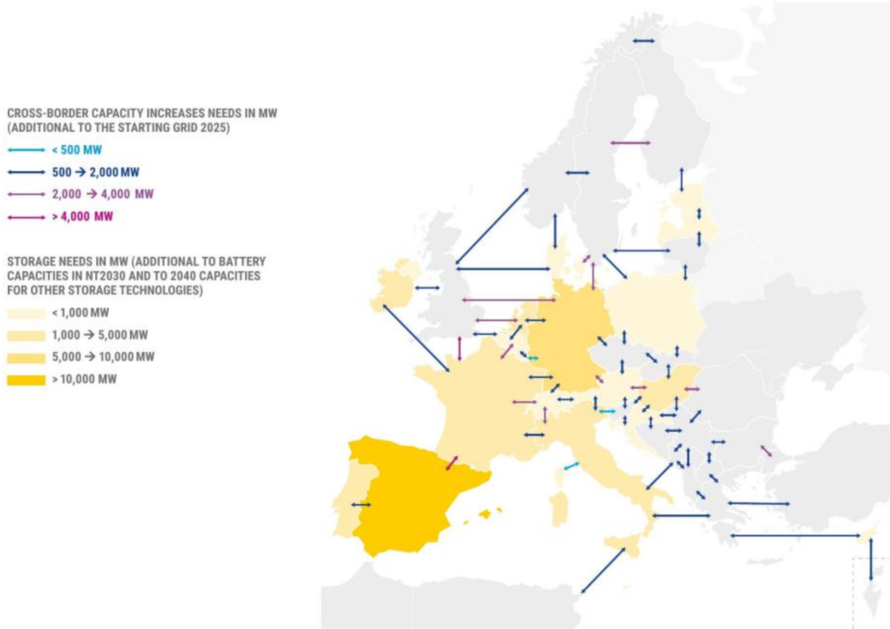


*Figure 40 – ENTSO-E projection for cross-border capacity increases (2025) and storage (2040).*

The previous figure shows a projection of the increases in the needs of cross-border capacity and storage. Considering how important is for TSOs and DSOs to maintain their networks stable and balanced, especially given the scale of the grid and knowing that all these local networks are interconnected, this aggregated network is a clear potential market for the flexibility solution developed in the project.

The other segment of potential clients (as will be described later in the *Business Model Canvas*) includes end consumers in general which want to participate as *Flexibility Service Providers* (FSP) to save money by offering load reductions on demand.

A special case of FSP is the aggregator, which can moderate the energy consumption of a group of users on demand. This actor is starting to become relevant and will most likely become one important client of the FLEXUM solution in the near future.

### 4.1.2 SWOT Analysis

A SWOT analysis has been done in the context of the market analysis which includes the 4 key points:

- **Strengths**. Characteristics of the business or project that give it an advantage over others.
- **Weaknesses**. Characteristics that place the business or project at a disadvantage relative to others.
- **Opportunities**. Elements in the environment that the business or project could exploit to its advantage.
- **Threats**. Elements in the environment that could cause trouble for the business or project.



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*Figure 41 – SWOT analysis*

And for a more detailed explanation of the SWOT analysis:

- Strengths.
    - *Innovative*. This solution offers an alternative and distributed approach to deal with congestion in networks, relaying on external agents to solve a part of the problem (the flexibility requirements can be satisfied by multiple clients). From a FSP perspective, it means being paid by reducing the consumption on demand, which is also a new paradigm in the energy market.
    - *Flexible solution in terms of exploitation models*. Customers can choose between focusing only on the results (pay per service and get a percent of the savings obtained by reducing the consumption) or also on the deployment (they finance the upgrades in the installation and own everything, which makes them more independent and allows them to get all the savings).
    - *Based on standard technologies (interoperable)*. This is critical considering the potential market is the whole continent.



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- Weaknesses.
  - *Clients potentially reluctant to invest in upgrades in their installations*. The way to get flexibility is by act on devices and upgrading some systems might be complicated and expensive.
  - *More research needed to improve forecasting algorithms*. It is important to make good quality forecasting as sending flexibility offers involves signing contracts and not fulfilling the promised reductions would involve being penalized.
  - *Not enough background to quantify the incomes obtained*. With little background knowledge, it is still complicated to quantify how much benefit can be obtained (there is not enough historical data to analyse so far).
  - *Possible comfort loss for users*. This weakness does not depend on the technology itself and may arise for example in scenarios like UMU's in which the flexibility is offered by actuating on HVAC systems.
- Opportunities.
  - *Increasing interest in flexibility solutions*. The bigger the grid, the more interesting it is to offer flexibility as an alternative way to cover the increasing energy requirements without having to do big investments in the network, especially in the generation side. This has become more relevant due to the current supply problems in Europe.
  - *Huge potential market (Europe)*. With dozens of countries interconnected in the European grid, there is a big number of DSOs which could be interested in using the technology. On the other hand, the number of aggregators is expected to increase rapidly in the following years and they are candidates for playing the role of FSPs, which means, they are also potential clients.
  - *Few stable competitors (new technology)*. With this being an emerging technology, there is no stable market yet in several countries of Europe, including Spain.
- Threats.
  - *Not stable regulations*. The constant discussions that are currently active on how to solve the supply/demand problems in Europe, there regulations are not stable at this moment.
  - *Market attractive for big companies*. Given the size of the market, big companies are likely to get interested in it by the time there is a clear path for them to develop and commercialize solutions.
  - *Penalties for not compliance*. Some potential customers could be reluctant to use the technology due to the penalties for not compliance that are normally used in the context of flexibility solutions.



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## 4.2 Business Model Canvas

A Business Model Canvas has been created for FLEXUM to identify the different elements that form the business model. It includes the 9 elements from the standard template, starting with the *Value Proposition* as the main item of the model. In the case of FLEXUM, the proposed value is in the form of a *Minimum Viable Product* (MVP).

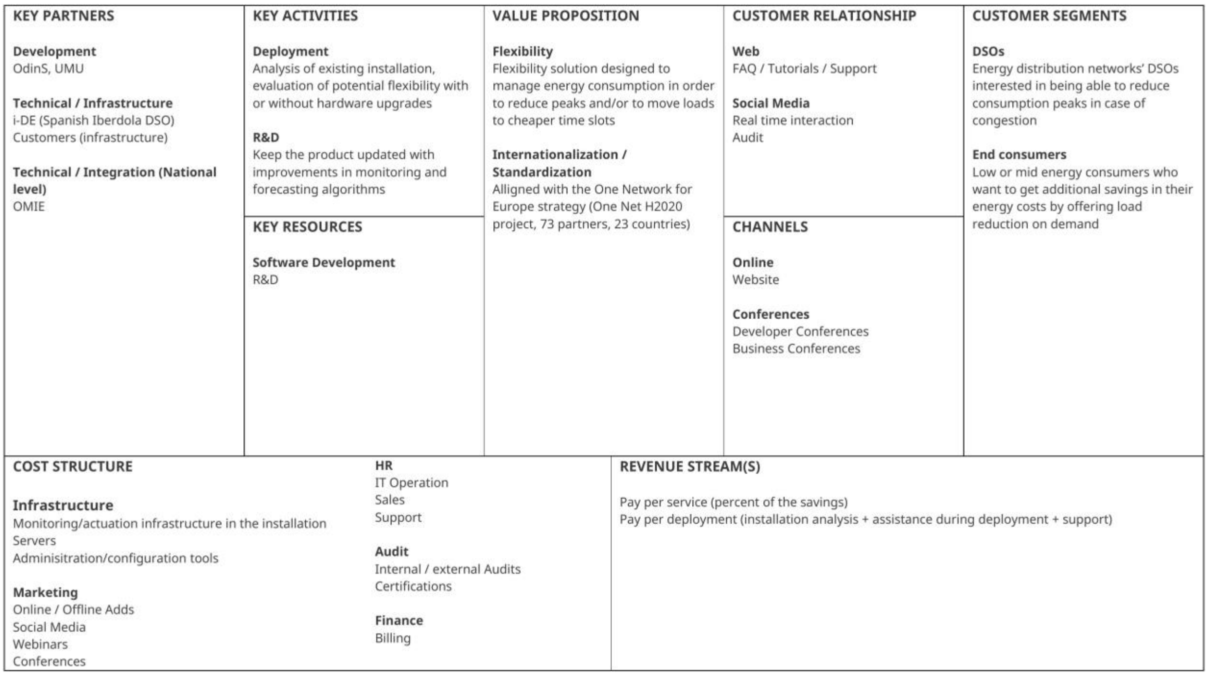


*Figure 42 – Business Model Canvas*

## 4.3 Exploitation Activities

In order to succeed in terms of exploitation, a number of activities were identified with some of them carried out during the execution of the project itself and others planned to be executed once the solution was tested and was ready to be offered to potential customers. There is a direct connection between these activities and the dissemination of the solution.

### 4.3.1 Real-World Pilot

This activity was executed during the development/testing phases of the project and is key to prove that the solution has already been tested in a real scenario. Integrating real numbers extracted from the results of the tests in the dissemination activities shall let possible customers see the potential of the solution.


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### 4.3.2 Integration with standard technologies

Another point that was considered from the beginning was the set of technologies that were going to be used as base for the development. Given the strong presence ODINS and UMU have in the EU research community, with both participating in several Horizon 2020 projects, the need of adopting standards was identified early in the definition of the project.

The most relevant standards used in FLEXUM are FIWARE, one of the reference frameworks in the IoT ecosystem, and USEF, reference framework in the context of energy and flexibility.

### 4.3.3 React to Market updates

As the energy market is in constant change due to the challenges that are arising at an international level, regulations are actively being revised and therefore it is critical to monitor the changes in the sector as they may have an important impact on the developed solution.

## 4.4 Exploitation Plan

ODINS is an ICT SME focused on developing and selling solutions and products that use the results obtained in R&D projects. In this regard, and in the context of the FLEXUM solution, both the flexibility solution itself and other IoT solutions offered by the company that include platforms, gateways and sensors, are of interest in terms of exploitation.

Based on the *Revenue Streams* defined in the *Business Model Canvas*, a direct synergy between the existing products/solutions of the company and the solution developed in FLEXUM has arisen and, as a result, part of the exploitation strategy involves including the flexibility solution as an additional innovative service offered by the company in the area of smart cities and energy management. Since the company can offer the hardware elements required to deploy the required monitoring and control system as well as the flexibility services, both *Pay per service* and *Pay per deployment* models can be used either separately, with 3rd party devices, or combined, with ODINS providing a global product that covers from the initial analysis of the installation to the deployment and maintenance of the flexibility solution with its own devices.

The *Pay per service* model is aimed at clients which do not want to get involved in the installation of devices. For them, a detailed analysis must be performed before starting the deployment in order to identify the costs derived of preparing the installation for a proper operation of the flexibility services. In addition, very clear conditions must be included in the agreement to make sure that both companies get benefits.

In the *Pay per deployment* model, the client is expected to be more independent. Once the deployment is finished, ODINS would be focused only on providing support when necessary but in general the client would be in control of the installation. This means the client would also have to fund the upgrades required in the existing


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devices and any other additional costs such as server maintenance, etc. ODINS could provide its experience and products as part of this upgrade as an additional source of income.

On the other hand, ODINS will also exploit the know-how obtained in the project to open new opportunities for collaboration in other research and development projects. In this regard, both post-doctoral and Ph.D. students will have the opportunity to participate in innovative projects in ODINS that may end up increasing the know-how of the company that might be offered to the community in conferences or journals.



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# 5 KPIs evaluation

The following KPIs have been verified through this deliverable:

**KPI2.3:** *Demonstrate more than 0.1MW of flexibility by the control of the UMU infrastructure.*

The amount of the flexibility obtained in the tests has been described in the demo evaluation section and is higher than 0.1MV.

**KPI3.1:** *Final users and stakeholders (i.e. ESCOs, aggregators) are informed and engaged with the demo results.*

This information has been provided through the website and social media of ODINS.

In terms of interest in this technology, UMU is pushing in this direction as it is also going to be validated in the MASTERPIECE project [6] and is going to send a funding request to IDAE [7] in collaboration with ODINS in the context of Demand-Response events (flexibility) with storage and generation.

**KPI3.2:** *Dissemination activities and workshops of the main innovations in cooperation with OneNet mentors.*

A workshop has already been scheduled for the next PHOENIX meeting in Dublin (March $29^{th}$ and $30^{th}$ 2023) to show the partners of the project (including one Spanish ESCO, namely MIWEnergia [8]) what has been done in FLEXUM and the results obtained with the implemented solution.

**KPI3.3:** *Identify business models and exploitation plan from which FSP can obtain revenue streams.*

This has been described in the exploitation section, which includes a market analysis, a *Business Model Canvas* and an exploitation plan. *Pay per service* and *Pay per deployment* have been identified as two business models that could be used given the nature of the solution offered, which includes hardware, services, support, etc.



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# 6 Conclusions

Throughout the document, the solution has been evaluated in the UMU demo scenario and the results show how this technology can be used for reducing energy consumption peaks on demand. More specifically, during July 28th tests, the flexibility request was achieved during the 66% of the activation period for the first test. The maximum power reduction was 0.47 MW. For the second test, the flexibility requested of 0.5 MW was satisfied with a duration of 83% of the activation period. The difficulties found in previous tests were solved in the test of September, the last one. The agreed flexibility was not satisfied but there was a significant and sustained maximum power reduction of 0.7 MW for more than 83% of the activation period.

From dissemination and exploitation points of view, a number of activities have been carried out including the promotion of the solution via online channels, a market analysis that includes a SWOT analysis and an exploitation plan. The SWOT analysis shows clearly that there is a window of opportunity for flexibility solutions right now and with this being an emerging technology, now it is the time for companies that can offer flexibility to make their move.

Overall in the project, the whole stack has been covered, from low level devices required to monitor and control devices (including metering) to the developments done at platform level, including the flexibility services and the integration with the OMIE platform. All combined, a global solution has been developed not only including the core flexibility components, but also adding the integration with 3rd party agents.

However, there is room for improvement. In terms of forecasting, more work can be done and better results can be obtained if extra information is incorporated to the algorithms, such as temperature data for installations like UMU's, in which this magnitude is relevant when it comes to combine flexibility and comfort.

Another aspect to be improved is the calculation of baselines. As described in Deliverable 1 [1], this question is quite relevant as there is a direct relation between baseline and billing/penalties.


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# 7 References


[1] D1: characterization, baseline calculation and demo definition

[2] D2: Development of flexibility and services and OneNet integration

[3] OMIE platform

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