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DELTA

Project Acronym:	**DELTA**
Project Full Title:	**Future tamper-proof Demand rEsponse framework through seLf-configured, self-opTimized and collAborative virtual distributed energy nodes**
Grant Agreement:	**773960**
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DELIVERABLE D7.6
Pilot premises energy context analysis and end-users engagement/training v2

Work Package	**WP7 – Pilot Implementation & DELTA Business Model Validation**
Task	**T7.1 Use Case Deployment Plans at Pilot Premises** **T7.2 Pilot end-users engagement and training**
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Executive Summary

The main objectives of tasks "T7.1 Use Case Deployment Plans at Pilot Premises" and "T7.2 Pilot end-users engagement and training" include the organization of the pilot demonstration plan by analyzing the pilot premises in terms of infrastructure and end-user engagement as well as the definition of the plan for deploying the DELTA framework (hardware and software) in the pilot sites and the new DELTA business models that can be demonstrated in real-life validation and through end-user satisfaction surveys.

To that end, this deliverable presents the results of the performed thorough survey of the DELTA Pilot Sites (UCY and KiWi) that aided towards identifying flexibility sources as well as Distributed Energy Resources (DER) that will validate the DELTA use cases, along with information on existing systems that could be used with the DELTA Fog Enabled Intelligent Devices (FEIDs).

This final and updated version of this deliverable expands on the methodology that has been followed for the recruitment of the pilot-participants as well as the training and engagement activities of end-users (*Section 2*). The activities that have been or are scheduled to be conducted by the pilot leaders in order to obtain public feedback and train the participants (*Section 3.2 for the Cyprus and 4.3 for UK site*) so as to promote their active participation, are also described in this final version.

Additionally, this version elaborates on the deployment plan of the DELTA solution at the Cypriot (*Section 3.3*) and UK (*Section 4.3*) pilot-site, that will transform each one of the selected buildings into a flexibility unit able to contribute to Demand Response (DR) as part of the Aggregator's portfolio.

Finally, an explicit description of the use cases that will validate the DELTA framework is presented in this version (*Sections 3.3.2 and 4.3.2 for the Cyprus and UK demonstration sites, respectively*).

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List of Acronyms and Abbreviations

Term	Description
ADM	Administration Building
AHU	Air Handling Units
BRP	Balance Responsible Party
BESS	Battery Energy Storage Systems
BEMS	Building Energy Management System
CDO	Campus Development Office
CMS	Control and Monitoring System
DVN	DELTA Virtual Node
DVNP	DELTA Virtual Node Platform
DR	Demand Response
DSR	Demand-Side-Response
DER	Distributed Energy Resources
DSO	Distribution System Operator
EV	Electric Vehicle
EAC	Electricity Authority of Cyprus
ENC	Energy Centre
EMS	Energy Management System
EEX	European Energy Exchange
FEB	Finance Economics & Business
FEID	Fog Enabled Intelligent Device
HVAC	Heating Ventilation and Cooling
HIM	Human Machine Interface
ICT	Information and communications technology
NWP	Numerical Weather Predictions
PV	Photovoltaics
PCC	Point of Common Coupling
RTU	Remote Terminal Unit
RES	Renewable Energy Resources
SMEs	Small/Medium Enterprises
SFFR	Static Fast Frequency Response
SO	System Operator
UCY	University of Cyprus
UPS	Uninterruptible Power Supplies

1. Introduction

1.1 Scope and objectives of the deliverable

Each of the pilot sites host different customers and operates under different regulatory, legal and market frameworks. This may trigger the need to treat several important aspects differently. To be fully prepared for the pilot realisation the consortium will analyse in detail the technical and socioeconomic parameters of each pilot and how these could affect the pilot activities.

The first version of this deliverable "D7.1 Pilot premises energy context analysis and end-users engagement/training v1" focused on the building requirements of each pilot-site, including the existing infrastructure, service descriptions, and energy requirements description.

The objective of this updated and final version is to present all actrivites fullfiled or planned to be performed in order to finalise the recruitment and preparation of the citizens who will participate in the pilot validation activities. Several information and awareness raising campaigns were carried out to motivate users to actively participate. The content ranges from explaining Demand Response (DR) programs and the potential benefits and risks for consumers to informing pilot participants about what to expect during the pilot activities. General demand response issues (e.g. what dynamic energy pricing means, how to interpret and take advantage of DR signals, how to alter energy consumption per carrier) as well as pilot specific aspects (e.g. what information will be monitored and collected, how it will be processed, the necessary privacy and security provisions, what to expect during pilot testing in terms of indoor environment adaptation) was presented and discussed in detail to reassure the pilot participants.
Finally, this document, presents the deployment plan for DELTA solution that is derived based on building requirements, hardware and software requirements as well as deployment strategy for the installation of the Fog Enabled Intelligent Deivces (FEIDs). The deployment plan also includes the pilot specific use-cases that will validate the innovative functionalites of the DELTA solution.

1.2 Structure of the deliverable

The rest of this deliverable is structured as follows:

Chapter 2 provides an overview of the user-engagement methodology implemented in the project, which is divided into three stages. The first stage focuses the results of previous deliverables, including the flexibility market analysis, business model and user requirments as well as current infrastructure and the energy context analysis of the pilot premises. The second stage focuses on user engagement and stakeholder involvement. It presents methods such as surveying, focus groups, workshops, monitoring and finalizes the recruitment of the participants. The plan of deploying the DELTA solution is part of the third stage.

Chapter 3 and 4 follows the methodology intoduced in the second chapter and presents the results for the Cypriot and UK pilot-sites, respectively.

A generic timeplan for the deployment of the developed DELTA solution is presented in Chapter 5, while some concluding remarks are given in the final Chapter.

1.3 Relation to Other Tasks and Deliverables

Utilizing the DR requirements of the established in D1.1, as derived from WP1, this deliverable aims to identify the lexibility sources and DERs available at the pilot-sites as well as to finalise the recruitment and training of the end-users who will participate in the pilot validation activities, while proposing a methodology for raising their awareness and motivate them to actively participate. In this scope, methodologies and best practices proposed by other similar projects were used to develop a three-stage methodology that aims to educate and prepare the end-users to actively be engaged in the deployment of DELTA solution in the pilot premises in order to be able to better evaluate and validate the project results based on end-user satisfaction assessment. Activities performed under T7.1 and T7.2 will prepare the pilot premises and the pilot participants in order to maximise the benefit of the DELTA framework deployment that will validate the buisness models and aid in assessing the Life Cycle and Life Cost of DELTA based on the performance of the solution and the end-users expericence evaluation. The activities of this deliverable and its interactions and the other tasks of WP7 are illustrated in the PERT diagram below.

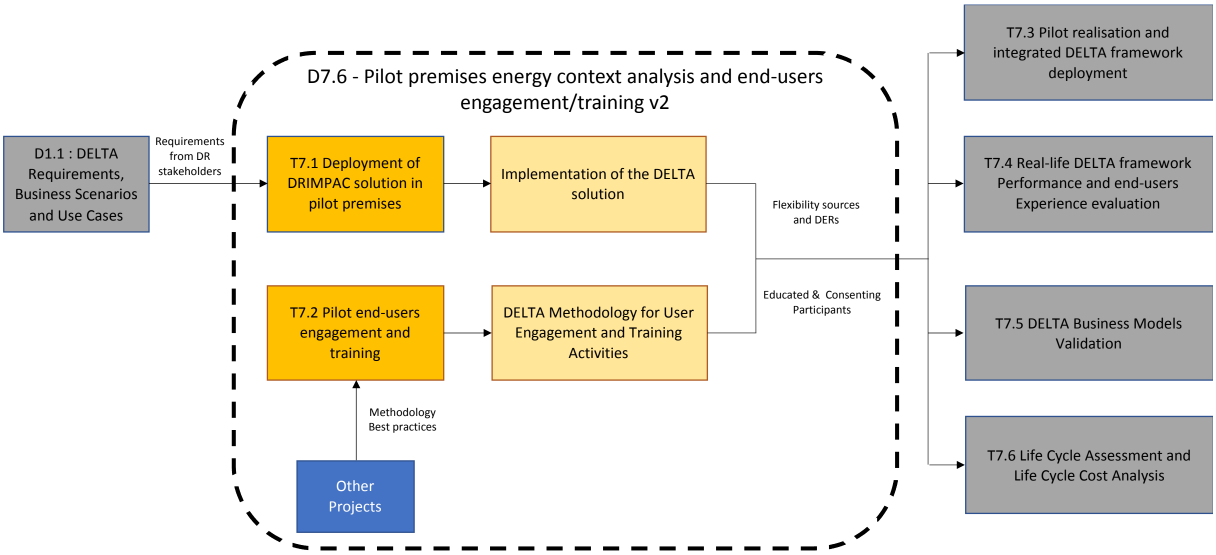

Figure 1. Relation of D7.6 with Other Tasks and Deliverables.

2. Methodology for and User Engagement Activities and DELTA Deployment

2.1 Methodology overview

Pilot – sites' end-users operate under various regulations, legal and market frameworks, which means that users' feedback have a major contribution in the DELTA project. The pilot deployment of the DELTA solution will provide experience to end-users will be analysed to evaluate the performance of the solution in terms of public acceptance. In addition, during DELTA project users' awareness on DR engagement will be improved with multiple workshops, training sessions and promotional campaigns. As shown in Figure 2, the effective achievement of these tasks relies on three stages that are proposed in order to develop and deploy the DELTA solution.

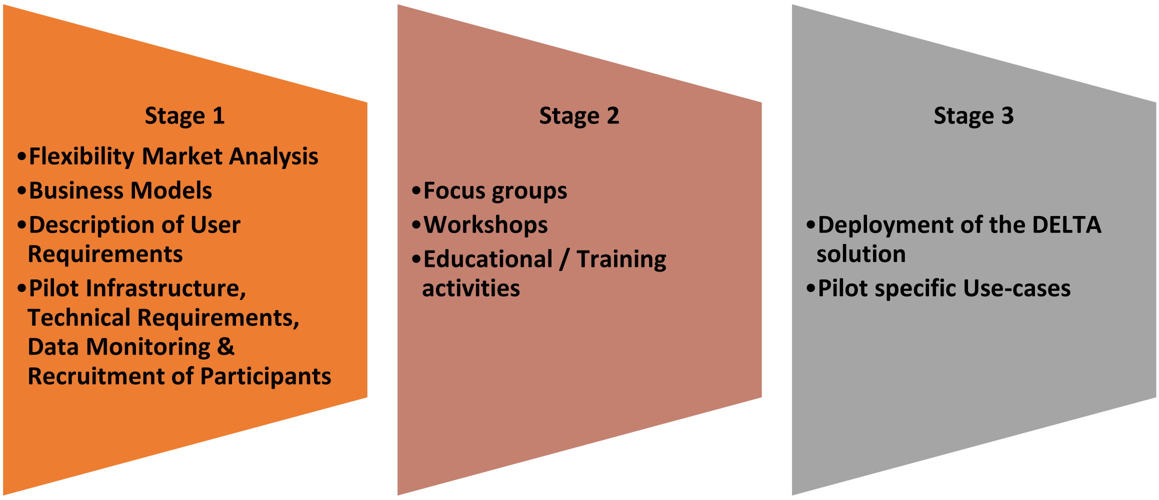

Figure 2. Methodology Overview.

Stage 1 involves the 'Flexibility Market Analysis', the 'Business Models' where the requirements and use cases are generated and analysed, and the 'Description of User Requirements' for all stakeholders. Finally, the 'Pilot Infrastructure and Recruitment of the Participants' where both UCY and KiWi infrastructures are examined and the user engagement with demand response activities is validated.
Stage 2 includes all the required activities for training and engaging the end – users at the pilot sites. Workshops, training sessions and focus groups will inform pilot – users regarding their operation for each facility, motivate them to actively participate and ensure that their feedback is included in the optimal DELTA solution. Monitoring, Data collection and Surveys will generate effective solutions, processes and strategies that will keep improving end-to-end interoperability.
The third and final stage includes the actions followed towards the deployment of the DELTA solution.

2.1.1 Stage 1 – Pilot Infrastructure Description

2.1.1.1 Flexibility Market Analysis

As a basis for the development of DR business models it is important to understand the heterogeneity of the different forms of flexibility markets, since these markets represent the sources for revenues related to the activation of DR-potential. Trading flexibility can be achieved on both production and consumption side, in various markets with different market players, reasons and problems to be solved.

This section gives an overview on different markets where flexibility is traded. All these markets have different market players involved, they follow a different reasoning and they try to solve different problems. Furthermore, they underlie different regulatory framework conditions. Some of the flexibility markets are following:

- Regulation: An electricity market can be either national end European where the market condition is set, and the liberalised area where there is a competition between the market players.
- Time resolution: The period that the market procedures are going to be activated. Future markets are those that are years or months ahead, Spots markets are for the day – ahead and intraday period and the balancing markets who is based on real time. The flexibility market prices rely on the aforementioned markets, with the future markets be the most expensive ones.
- Organisation of electricity markets: European Energy Exchange (EEX) market orients the prices for organised markets. Over – the – Counter market trade energy outside the organised markets, within the liberalised area.
- Retail and Wholesale markets: These markets differentiate the customers in two divisions based on their scale. Large entities are included into wholesale market and small consumers like residents into retail market.

All these markets have different market players involved, they follow a different reasoning and they try to solve different problems combined with demand side response and renewable energy sources. Decentralisation of the power system can be achieved with the interaction of end – users with aggregators, and the generation of different business models that include the above markets.

2.1.1.2 Business Models

The initial aims of DELTA were to provide demand response potential for both small and medium – sized electricity ‘prosumers’, those who consume and produce electricity, across Europe through a DR management platform. The platform will distribute part of the aggregator’s intelligence, in order to manage and compute efficient demand response solutions at the lower layers of its architecture. This approach includes the development of the DELTA Virtual Node (DVN) where a large number of customers (small to medium consumers, producers or prosumers) which share key common characteristics in terms of consumption, generation and available flexibility amongst others are clustered. In addition, DELTA approach was compared to similar research projects and existing products for DR Platforms, where the outcome of this analysis was that DELTA Platform is the most economic choice and the one that covers all the features and functionalities of the existing ones.
Multiple generic business models were crucial in order to establish the end – users’ interaction through the DELTA solution with distribution and transmission operators. The comparative analysis and these business models are briefly explained below and fully analysed in D2.1.
Taking into account the competitive advantages of the DVN we can develop the generic business models further by specifying the user of the DVN and the specific benefits that are based on the use of DVN in the given context.

- Explicit DR as a stand-alone service: DR Aggregator who act as a facilitator, is bundling DR potentials from different clients, which as stand-alone potentials are too small to be offered to the various flexibility markets (e.g. balancing markets). Transmission System Operator (TSO), Distribution System Operator (DSO) and Balance Responsible Party (BRP) provide the payments based on contractual agreements. Essentially, the model provides a better and cheaper incorporation of small and medium loads from the residential and tertiary sector and to higher reliability of DR potentials which are achieved by bundling of small- and medium-sized loads.
- Explicit DR combined with Energy Efficiency Service (EES): For this case the previous model is combined with Energy (Efficiency) Service Company (ESCO), known as ‘dual service’ approach. It is the functionality of price forecasting that gains increasing importance

as it supports solving the trade-off between energy efficiency and load shifting in optimised way.

- Implicit DR service for optimal use of Time Of Use – contracts: This business model relies on the ability of a Flexibility Service Company (FLESCO) that takes care of load shifts at the equipment of the client in a way that the client takes maximum benefit of an (existing) TOU tariff. The functionality of administering information about – potentially dynamic – price signals at the customers metering points would be the most crucial success factor.
- Implicit DR including power supply: In this business model the DELTA platform is applied by the retailer with the aim to bundle and manage as many DR potentials at the costumer's side as possible. The retailer will have core interest in the platform's ability to synchronise the use of DR potentials with productions patterns – if the retailer is also an electricity producer – and/or with price signals on the wholesale market.
- Microgrid Management: Microgrid manager has the authority to connect or disconnect the microgrid from the grid to enable it to operate in both grid-connected or island-mode. During island mode the manager needs to ensure that power supply is equal to power demand at each point in time. On the other hand, with grid – connected mode the microgrid manager: 1) can make use of the DR potentials available internally, and 2) offer the loads in tenders of TSO, DSO or BRP (explicit DR) of optimised the electricity cost by adapting the load profile of the microgrid to dynamic pricing (implicit DR).

2.1.1.3 Description of User Requirements

The User Requirements are based on the functional and non – functional methodology, which represent the essential subject matter of the product with the related processing actions, and the functions that must be included such as performance, usability and data security needs. In addition to that, four extra categories are included as well, that involve constraints for both project and design, project drivers and project issues. Definitions and detailed descriptions for all users (Aggregator, System Operator, Client, Prosumer, Consumer, Distributed Network Operator, Supplier, Energy Service Company, and Virtual Power Plant Energy Manager) operations, fit criterion and test cases related with software components are explicitly described in D1.1 and D1.5.

2.1.1.4 Pilot Infrastructure, Technical Requirements & Recruitments of Participants

Essentially, this section is used to describe the pilot sites infrastructures, with all the technical requirements and the recruitment of Participants as well. Based on those parameters the user engagement methods, techniques and activities might be a bit different though.

2.1.2 Stage 2 – User Engagement Activities

2.1.2.1 Focus Groups

Focus group is a market research method that usually consists 6 to 10 people in a room, where ideas, feedback, concepts and services are discussed. This method is useful especially when key stakeholders are not available during the project period, and with focus groups are able to provide their insights about what the project needs. Moderator prepare a set of questions which are designed in a way to elicit thoughtful opinions and hear their responses and ideas. These questions are categorized as: engagement questions that familirise the participants with the subject, exploration questions that the moderator ask probing and deeper questions about their ideas in order to justify their opinions, and the exit questions for any additional material that maybe should be discussed before the end of a focus group. The difference between surveys and focus groups is that surveys only collect information about people's attributes, where focus group examine their opinions in a deeper level. For each focus group, the following considerations are necessary:

- The number of participants – Ideally 10 people per session.
- How many focus groups are required and their duration? – Two focus groups is the minimum (for students and technical staff) and each session should not exceed two hours.

- How to get people to participate? – Incentives are sometimes used but many people also respond well to intrinsic motivations. Ensure that the invite makes it clear that this is part of a research project aimed at helping people understand the objectives. Also make sure that people understand what is required of them and how much it is appreciated.

2.1.2.2 Workshops

Workshop is the meeting where a group of people that are engaged with an intensive discussion for a project or a specific subject. During the workshop stakeholders can interchange information in order to promote their interest. The scope of this task is the modification of stakeholders' requirements, in order to maintain a high level of understanding of their needs. Moreover, the participants can express their own opinions with feedback contribution, which are going to improve the requirements, ways of thinking, boost the motivation and unlock new opportunities. The workshops are coordinated by a moderator who is responsible ensure the effectiveness and attractiveness of the workshop. To achieve that need to be flexible and adapt the tools to the needs of the group as well as react to participants' feedback without criticism, present clearly the project scope with the participants' roles and the ongoing progress. The moderator needs to record and document a summary of the workshop discussion, the feedback, send it to all participants and update social media / website.

2.1.2.3 Educational / Training Activities

The major role of educational and training activities is to provide consumers with relevant information about energy profiles and prices, through effective discussion and communication. Due to the fact that consumers are only paying bills for using their appliances, their knowledge about the relationship between cost and energy is very limited. Even though some markets try to change consumers' mindset, most of the markets' consumers conduct their utilities only through their monthly bills, which provide only one lump sum of kilowatt hour usage. For this reason, the correlation of quantities with usage patterns is very complicated. These activities can simplify the development of the usage patterns, as the consumers and end – users have the opportunity to express their self with ideas and opinions based on the knowledge and training that will observe from the activity. These actions are going to be perform before and during the implementation of the DELTA solution, with main objective to acquire the reflections of participants to obtain quantifiable insights on associated topics of DR participation and the effect on their electricity bills. The knowledge that participants must have after the training session includes:

- What demand is and its drivers.
- How they can participate in DR events through available solutions.
- The ability to shift and reduce demand at a site.
- The skill to identify demand costs and estimate the financial benefits of demand reduction based on the applied DR program.
- The advantages and disadvantages of selling energy directly or via aggregators
- An understanding of the emerging opportunity to manage the intermittency of their renewable energy systems.

The end – users' feedback is very crucial and the organisers of these sessions need to aim for it. The feedback will vary based on the end – user experience, and because of that the organiser need to ensure that the feedback will be supported with a proposed solution in order to modify the services/product/solution with the new requirements.

2.1.3 Stage 3 – Towards DELTA Deployment

This is the final where the deployment plann for implementing the developed DELTA solution is as well as the defined pilot specific use-cases are described.

3. Cyprus Pilot Site – The University of Cyprus Campus

3.1 Stage 1 - UCY Pilot Infrastructure Description

The campus of UCY is participating in the DELTA project taking into account its energy production and consumption mix. The campus of the UCY is located on the outskirts of east Nicosia, between Aglantzia and Athalassa and covers an area of approximately 1.2 square kilometers. Coordinates are approximately 35.15° (lat.) and 33.41° (long). The climate is one of the warmest in the European Union. Cyprus receives approximately 2 MWh/m2 of solar energy per year (global horizontal), which is approximately double that of the UK. A significant amount of energy is spent on space cooling in the summer, with a typical average daily high temperature over 30 °C for four months of the year. The UCY campus master map is shown in Figure 3.

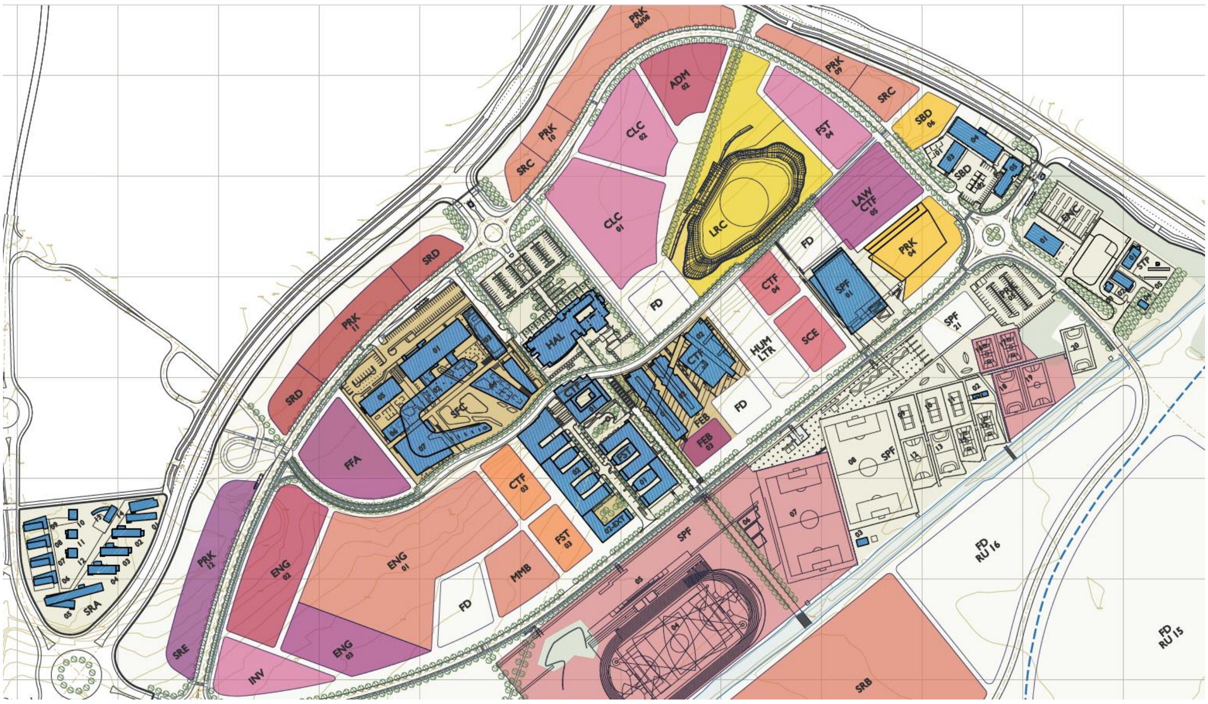

Figure 3. UCY campus master map.

The electrical connection of the university campus with the distribution grid. The voltage at the point of common coupling (PCC) of the university campus with the distribution grid is at Medium Voltage (MV) and more specifically at 11 kV. As shown in the following figure, within the university campus exist several distribution transformers, which reduces the voltage level at 400 V (three-phase voltage system). University of Cyprus has access to the data at the PCC, regarding the magnitude of the current at each feeder (two feeders totally).

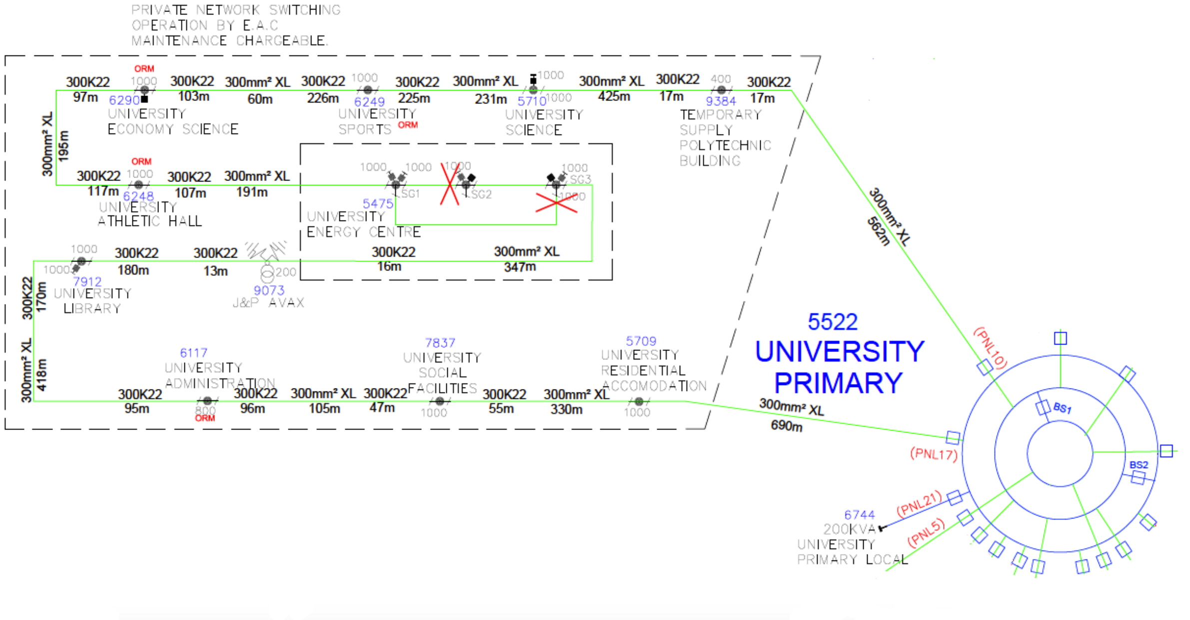

Figure 4. UCY Line Diagram.

The Campus Development Office (CDO) has overall responsibility for the administration, coordination, supervision and development of the campus regarding: both urban and architectural parameters; energy management; mechanical and electrical issues; computer networks, etc. The Technical Services of the University have expressed interest in demand response concepts and are keen to be involved with the DELTA project. The road access map to the UCY campus is shown in Figure 5.

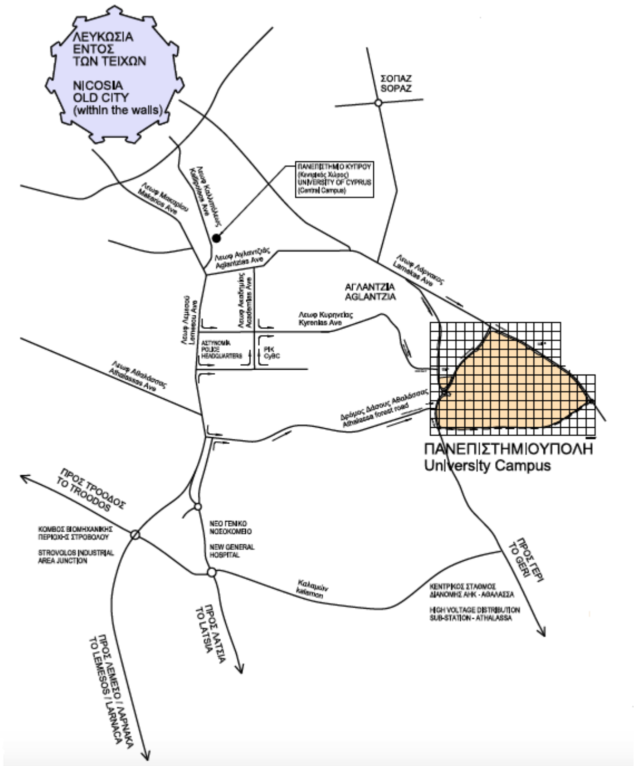

Figure 5. Road access to the University of Cyprus campus.

The UCY campus consumes approximately 12 GWh of energy per year at a cost of approximately €2.5 million and 10 $kTCO_2e$. There is currently around 400 kWp of photovoltaics (PV) installed throughout campus (approximately 225 kWp rooftop and a 175 kWp park). There are plans in the coming years to install a 5 MWp PV park on campus along with 2.35 MWh of electrochemical battery storage to aid with self-sufficiency on campus and reduce the long-term cost of energy. The campus currently comprises 17 tertiary buildings but is in the process of expanding further with polytechnic facilities currently under construction. The tertiary buildings span a broad variety of typologies and uses. They range from educational facilities (classrooms, amphitheatres), office building, restaurants, sports and health centres, etc. They are all new constructions, from 2008 onwards, and are energy efficient buildings. The total built area exceeds 80,000 sqm, the majority of which is devoted to offices and educational facilities. These buildings are used by more than 1500 personnel and many hundreds of students on a daily basis. All buildings are equipped with building management systems from various vendors, Siemens, Honeywell and Johnson Controls among others. This provides the opportunity to test the DELTA solution with BMSs' from different vendors and assess compatibility. The specifications of the BEMS are summarized in Table 1.

Table 1. BEMS specifications.

Building	BEMS type	Interfaces
Anastasios G. Leventis Building	Honeywell SymmetrE R410.2	Excel 5000 Direct, LonWorks
Building of Social Activities	Honeywell EBI R400.2	BACnet Client, LonWorks, Modicon PLC
Athletic Installations	Satchwell	Loytec, Lonworks
Faculty of Economics and Management	Siemens Desigo Insight	-
Faculty of Pure and Applied Sciences	Honeywell SymmetrE R410.2	Excel 5000 Direct, LonWorks, Modicon PLC
Faculty of Pure and Applied Sciences – Extension	Johnson Controls	-
Energy Centre	Honeywell Symmetre	BACnet Client, LonWorks, Modicon PLC, Excel 5000 Direct
Student Hall	Honeywell Symmetre R410.2	BACnet Client, Excel 5000 Direct, LonWorks

The annual energy usage of each one of the buildings along with the respective electricity cost are summarised in the table below.

Table 2. Annual energy usage and electricity cost per building.

No	Building	Type	Annual Consumption [kWh/year]	Annual Peak Consumption [kWh/year]	Annual Off-Peak Consumption [kWh/year]	Annual Peak Consumption on Weekends [kWh/year]	Annual Off-Peak Consumption on Weekends [kWh/year]	Annual Electricity cost [€/year]
1	University Administration (ADM)	Commercial - Offices	1,352,034.95	474,733.99	545,345.74	146,245.45	185,709.77	254,592.88
2	Athletic Centre Sport	Commercial - Sports Facilities	26,079.72	9,157.26	10,519.30	2,820.96	3,582.20	4,910.90
3	Athletic Hall	Commercial - Sports Facilities	317,482.14	111,476.08	128,056.99	34,341.06	43,608.00	59,782.99
4	Energy Centre – Chillers 1&2	Commercial – Heating / Cooling	997,303.07	350,178.57	402,264.00	107,875.20	136,985.31	187,795.64
5	Energy Centre – Chillers_3&4	Commercial – Heating / Cooling	1,227,904.08	431,148.47	495,277.33	132,818.59	168,659.69	231,218.61
6	Energy Centre – Chillers 5&6	Commercial – Heating / Cooling	816,722.27	286,772.04	329,426.40	88,342.33	112,181.50	153,791.64
7	Energy Centre – Chillers 7&8	Commercial – Heating / Cooling	304,947.75	107,074.94	123,001.22	32,985.26	41,886.33	57,422.72
8	Energy Centre	Commercial - Offices	1,581,973.59	555,471.32	638,091.90	171,117.20	217,293.17	297,891.13
9	Faculty of Finance Economics & Business (FEB)	Commercial - Offices	1,054,308.01	370,194.46	425,257.04	114,041.24	144,815.27	198,529.86

10	Faculty of Pure and Applied Sciences (FST 01)	Commercial - Offices/ classrooms	2,664,764.83	935,666.97	1,074,837.71	288,239.39	366,020.77	501,784.48
11	Faculty of Pure and Applied Sciences (FST 02)	Commercial - Offices	1,044,136.88	366,623.12	421,154.49	112,941.06	143,418.20	196,614.60
12	Library – Incomer 1	Commercial - Library	377,085.34	132,404.29	152,098.05	40,788.16	51,794.84	71,006.48
13	Library – Incomer 2	Commercial - Library	483,643.88	169,819.71	195,078.63	52,314.27	66,431.27	91,071.82
14	PV Lab: Chillers-Climatic	Commercial – Heating / Cooling / Offices	6,916.20	2,428.45	2,789.66	748.10	949.98	1,302.34
15	PV Lab	Commercial - Offices	26,122.34	9,172.22	10,536.49	2,825.57	3,588.05	4,918.93
16	Social Facilities Building	Commercial – Facilities	1,352,034.95	474,733.99	545,345.74	146,245.45	185,709.77	254,592.88
17	Residential Student Halls	Residential – Facilities	223,550.00	78,494.11	90,169.30	24,180.71	30,705.88	42,095.24
Total			**13,857,010.00**	**4,865,550.00**	**5,589,250.00**	**1,498,870.00**	**1,903,340.00**	**2,609,323.17**

In addition to the tertiary buildings/facilities and the chillers, the campus includes PV systems of significant capacity. : Current installations (depicted in Figure 6):

- 70.08 kWp roof-mounted grid-connected PV at UCY administration offices (ADM)
- 176.40 kWp grid-connected PV park (Phaethon) (PVP-01)
- 148.32 kWp roof-mounted grid-connected PV at UCY social facilities building (SFC-01, SFC-02, SFC-04, SFC-07)

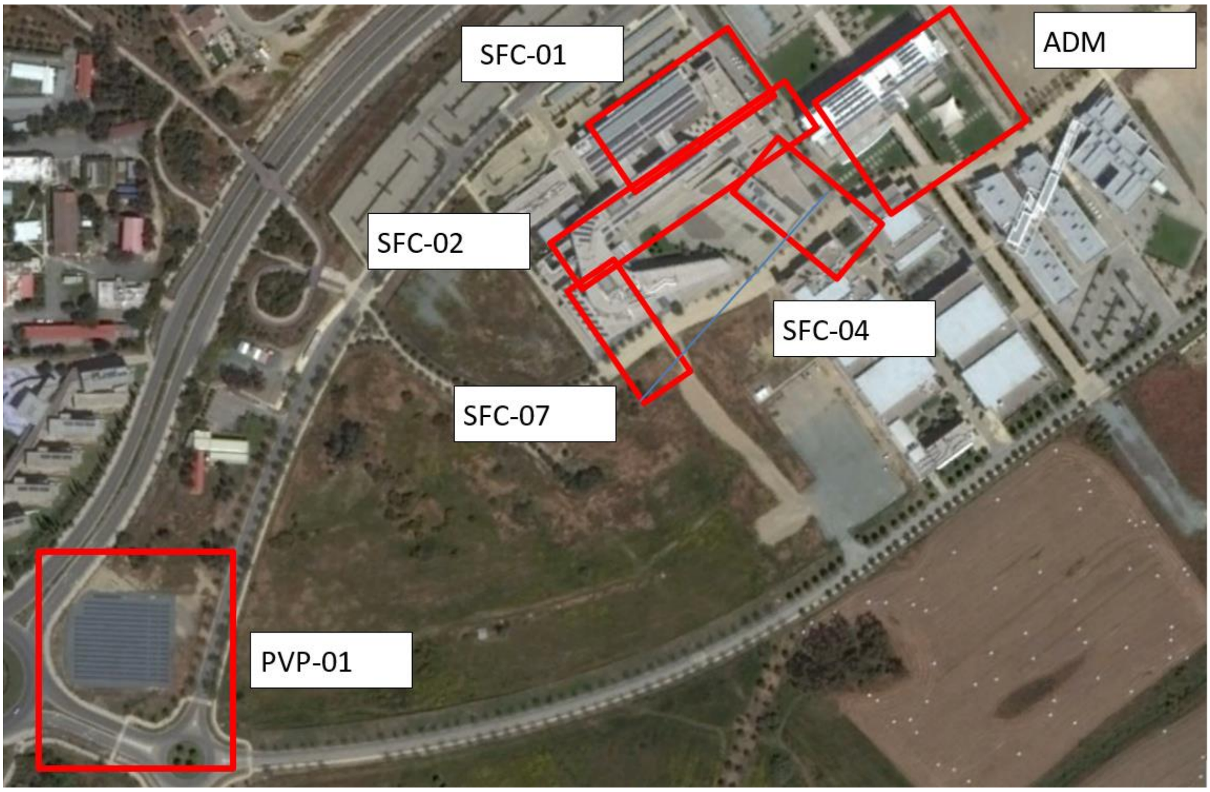

Figure 6. Current PV installations within the university campus.

The total PV installation is consisted of 23 inverters, with the following table representing each PV string per inverter and total capacity.

Table 3. Installed PV systems specifications.

Inverter	Serial Number	Location	Inverter Type	String No.	Capacity Per Inverter	System Capacity
Inverter 1	7E183F03-D8	ADM-01	SE17K	String 1.1	17.28	
Inverter 2	7E1802ED-85	ADM-01	SE16K	String 2.1	17.28	
Inverter 3	7E1802DE-76	ADM-01	SE16K	String 3.1	17.28	
Inverter 4	7E1802F1-89	ADM-01	SE16K	String 4.1	18.24	70.08
Inverter 5	7E18015A-F1	SFC-02	SE17K	String 5.1	18.24	
Inverter 6	7E1802E8-80	SFC-02	SE16K	String 6.1	18.24	
Inverter 7	7E1037E4-A9	SFC-02	SE17K	String 7.1	8.64	
Inverter 8	7E180155-EC	SFC-07	SE17K	String 8.1	17.76	
Inverter 9	7E1800F5-8B	SFC-04	SE17K	String 9.1	18.24	
Inverter 10	7E1044EC-BE	SFC-01	SE17K	String 10.1	16.80	
Inverter 11	7E18015D-F4	SFC-01	SE17K	String 11.1	16.80	
Inverter 12	7E1802F0-88	SFC-01	SE16K	String 12.1	16.80	
Inverter 13	7E1038B1-77	SFC-01	SE17K	String 13.1	16.80	148.32
Inverter 14	7E1037E0-A5	PV Phaethon	SE17K	String 14.1	17.76	
Inverter 15	7E005964-3B	PV Phaethon	SE17K	String 15.1	17.76	
Inverter 16	7E005954-2B	PV Phaethon	SE17K	String 16.1	17.76	
Inverter 17	7E1037E9-AE	PV Phaethon	SE17K	String 17.1	17.76	
Inverter 18	7E1038AB-71	PV Phaethon	SE17K	String 18.1	17.76	
Inverter 19	7E105704-E9	PV Phaethon	SE17K	String 19.1	17.76	
Inverter 20	7E180FCC-71	PV Phaethon	SE16K	String 20.1	17.76	
Inverter 21	7E180FCF-74	PV Phaethon	SE16K	String 21.1	17.76	
Inverter 22	7E180FF2-97	PV Phaethon	SE16K	String 22.1	17.76	
Inverter 23	7E180FF6-9B	PV Phaethon	SE16K	String 23.1	16.56	176.40
					394.80	394.80

The main electrical load of the university is the cooling system, which is placed centrally at the Energy Centre (ENC) building. The heating takes place by operating an oil heater, while the cooling is carried out by electrical chillers, as shown in the following figure. However, taking into consideration the climatic conditions of Cyprus, both the heating and cooling are operating for a certain period of the year. Since during summer period the temperatures are quite high, the cooling needs are significant. For this reason, flexible load can be identified that can be smartly traded through effective control of this large load.

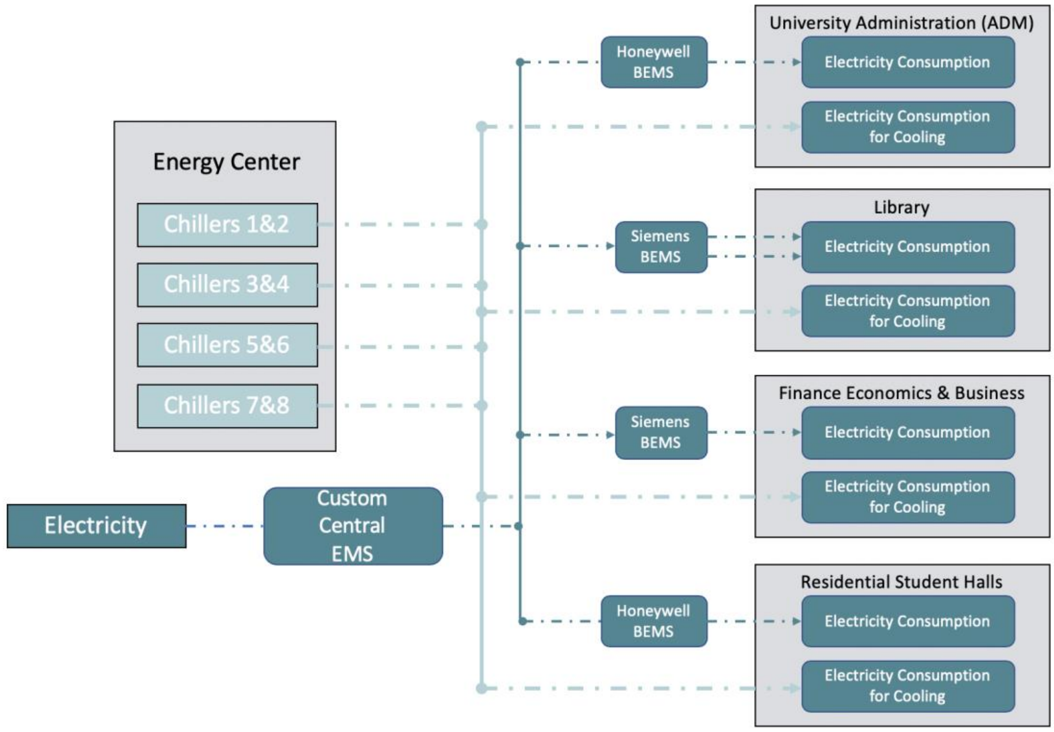

Figure 7. Energy schematic of the pilot buildings located within the UCY campus.

The control screen of the ENC. As it can be seen in Figure 8, the specific equipment parameter can be presented, regarding both the cooling (chillers) and the heating (boilers). In Figure 9, only two of the four boilers are operating. By selecting an equipment parameter, such as the ENC boiler, the specific control parameters are changed as shown below.

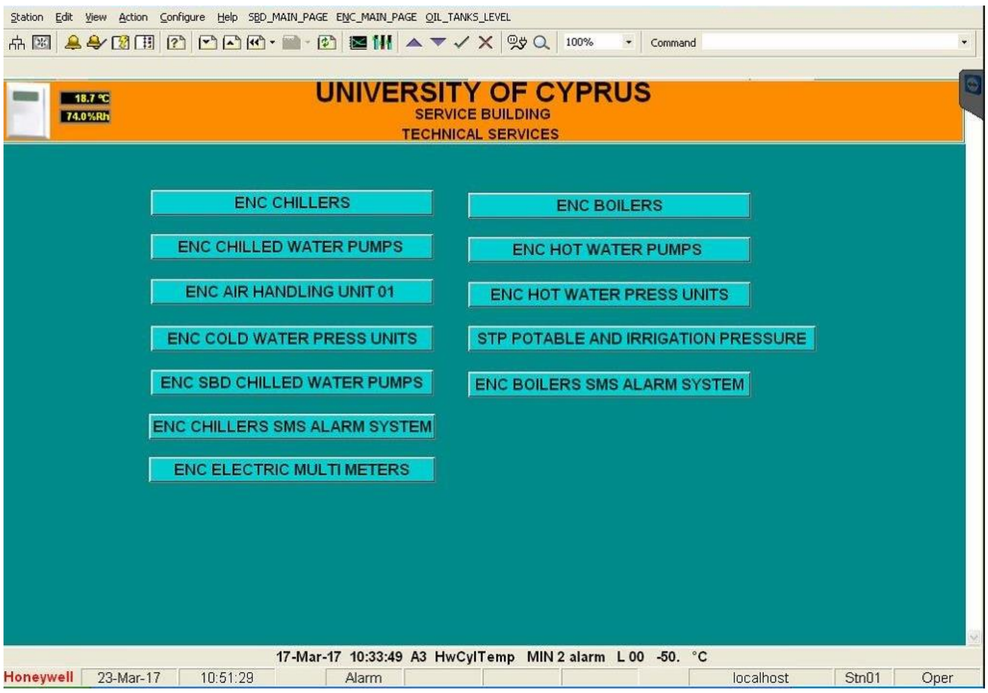

Figure 8. Display of the ENC software application.

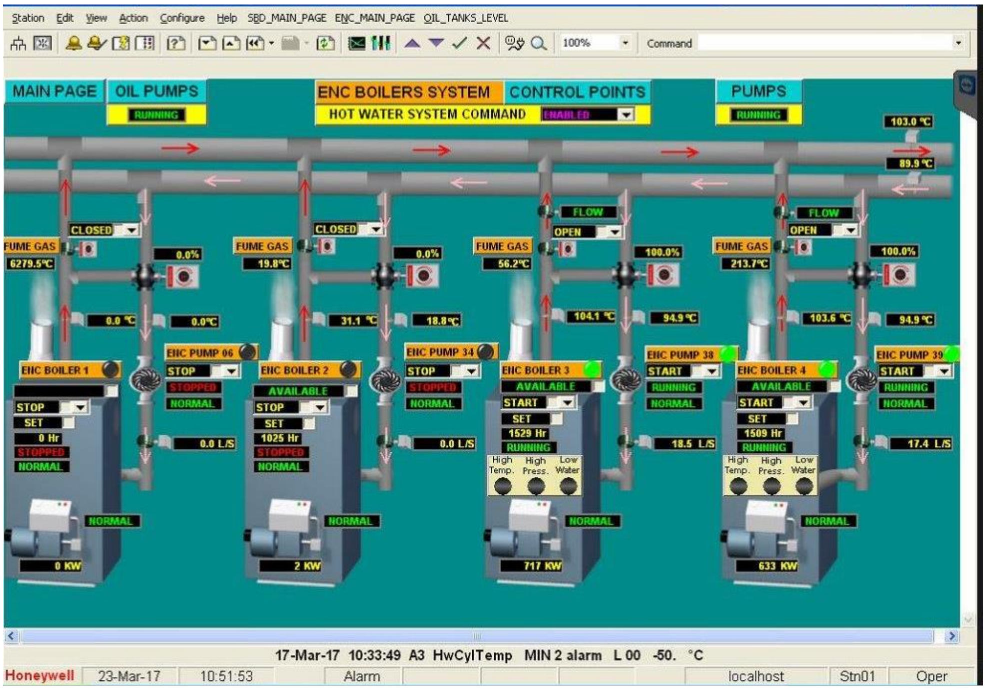

Figure 9. Display of ENC boilers.

Additionally, two electrical meters measure the electrical consumption which is analysed with multiple parameters such as voltages, currents, frequency, power, etc, as is shown in the figure below. The faulty parameters are highlighted with a red signal.

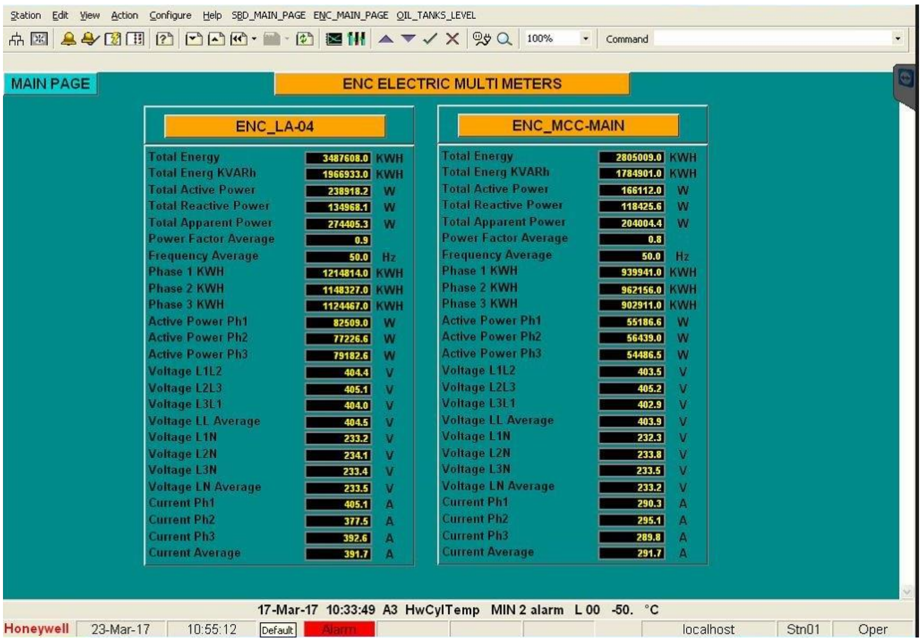

Figure 10. ENC Electric multi-meters.

Downstream of the central ENC system, central heating and cooling pipes transfer the hot/cold water to each building. As it has been already presented, each building is equipped with its own Building Energy Management System (BEMS), with the respective ICT infrastructure. A server PC gathers the data and measurements from each control point (e.g. pump, heater, boiler, chiller, etc.) of each BEMS. Consequently, the Ethernet local area network is used in order to have access to this server PC and control each parameter remotely. The controllers of the heating/cooling machine sends the information to a network adapter, which is also connected with the PC server. In case that the controller has a separate unique IP address, a remote access and control can also be implemented. However, this opportunity is not available for each BEMS. The following figures show the average monthly energy profiles of the chiller units currently installed at the UCY campus.

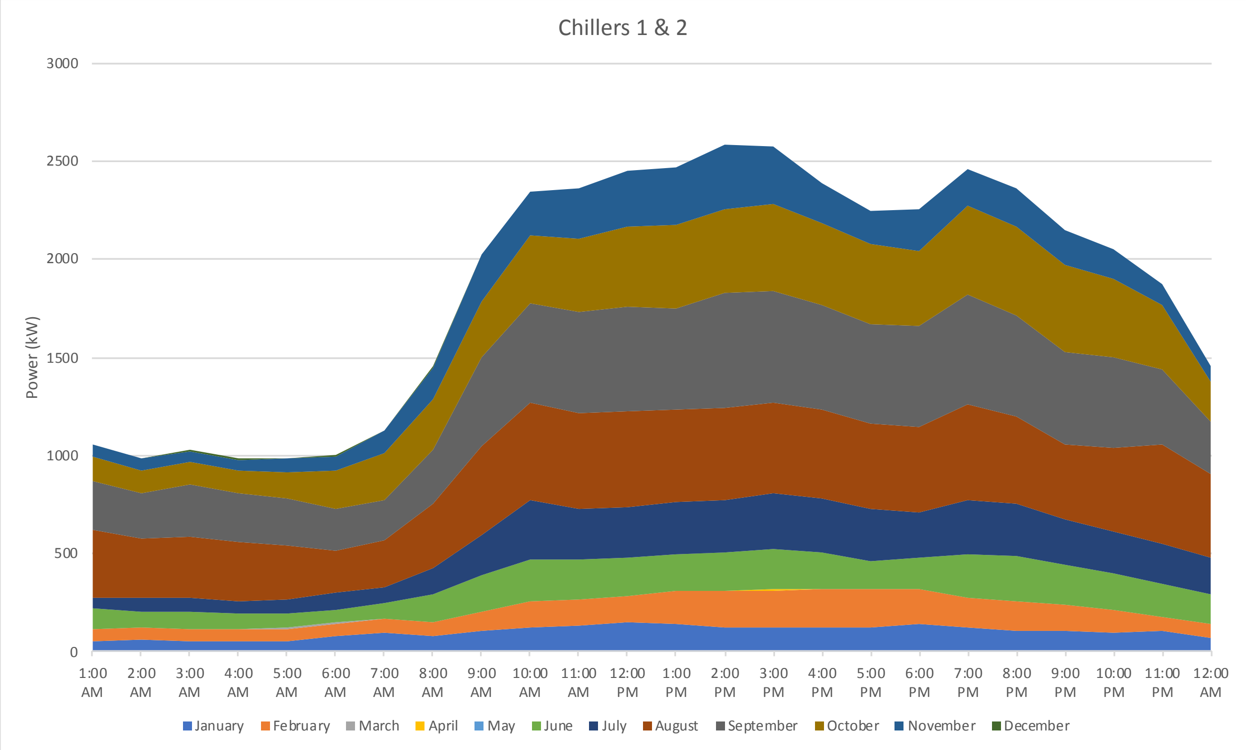

Figure 11. Average Load Profile of the chiller units 1 & 2 installed at UCY.

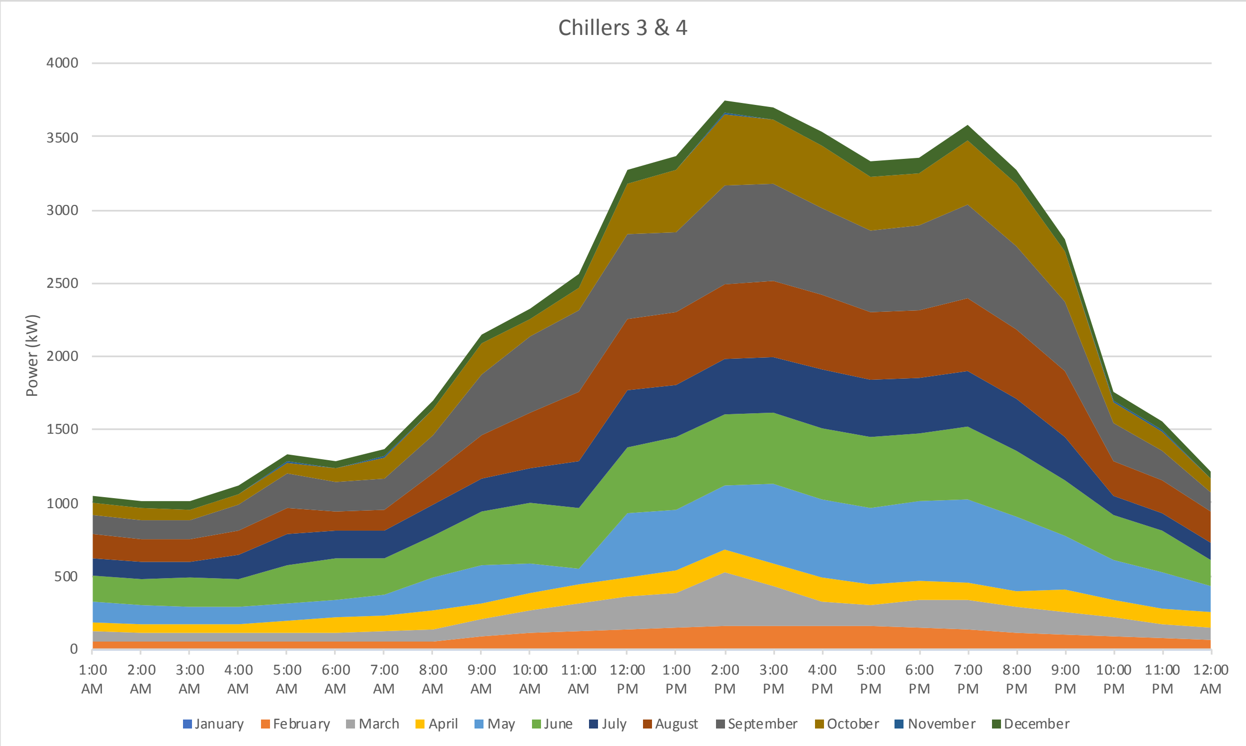

Figure 12. Average Load Profile of the chiller units 3 & 4 installed at UCY.

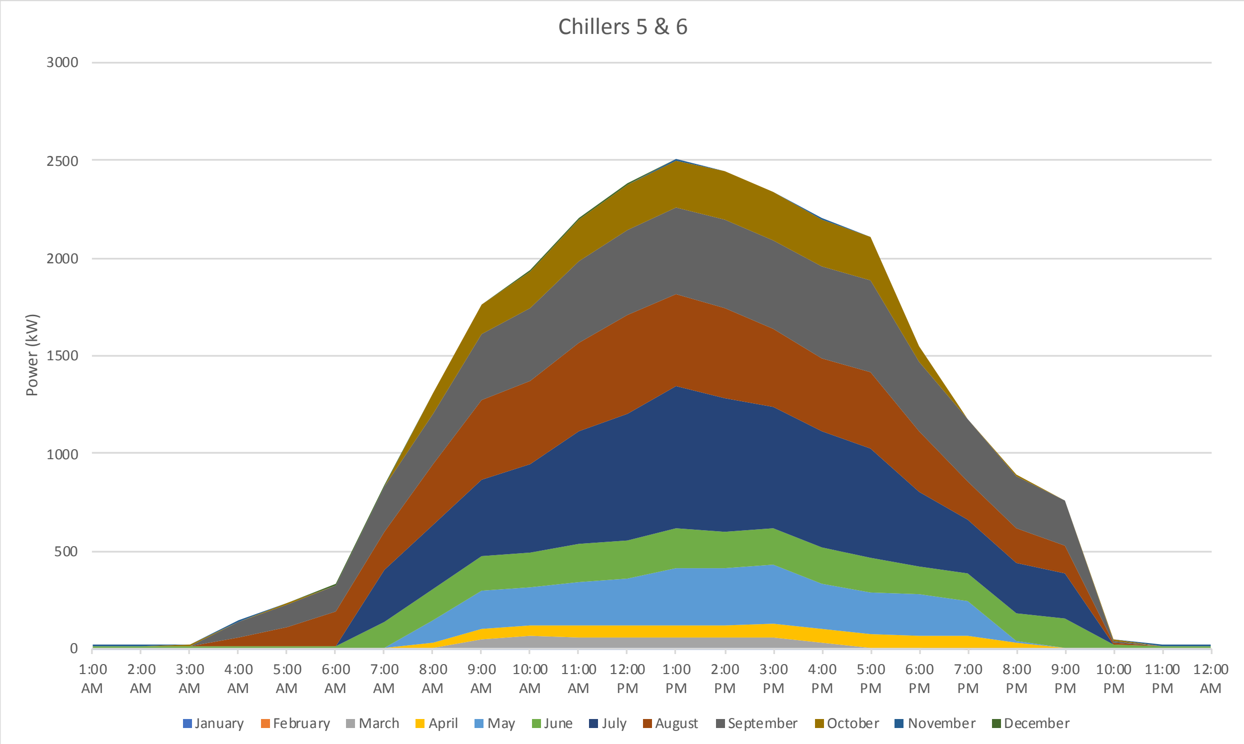

Figure 13. Average Load Profile of the chiller units 5 & 6 installed at UCY.

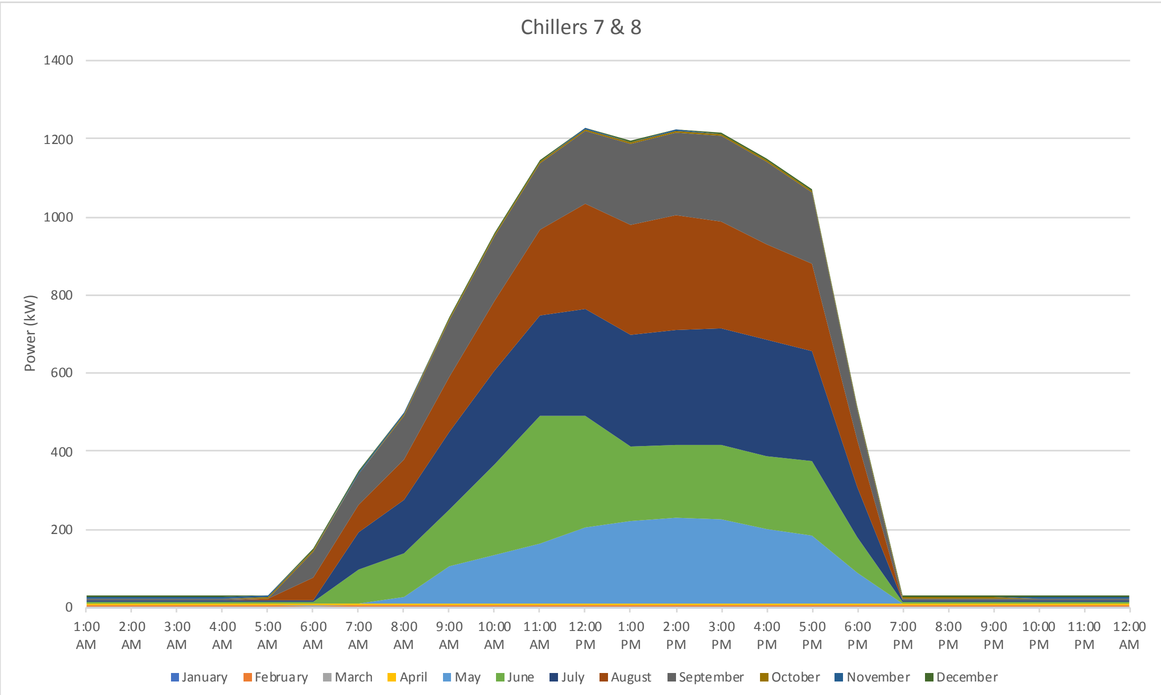

Figure 14. Average Load Profile of the chiller units 7 & 8 installed at UCY.

The following figure illustrates the average temperature levels per month for the location of the UCY campus.

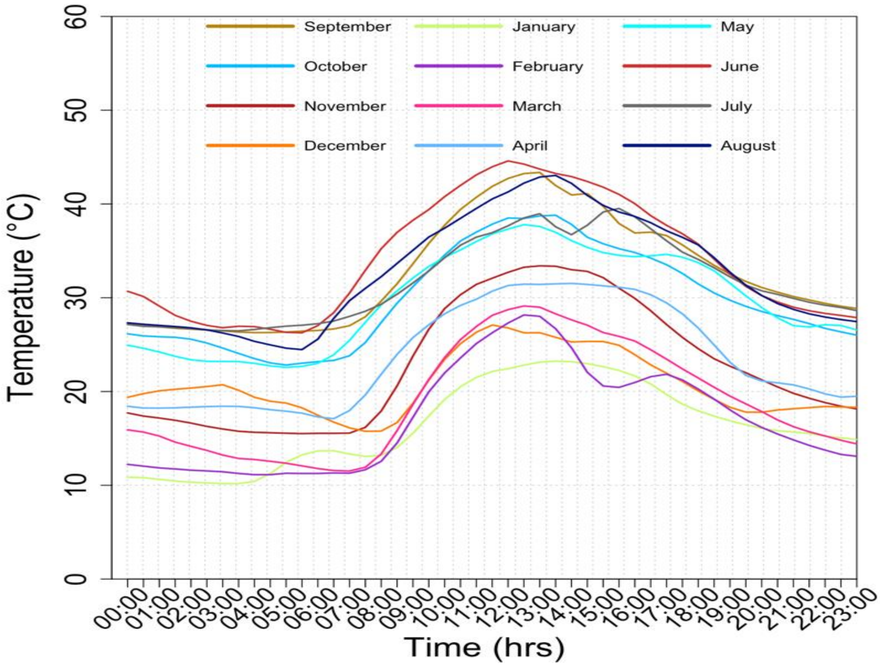

Figure 15. Average Temperature levels per month.

The whole university is operating as a microgrid with a tiered architecture. At the top tier a controller is responsible for balancing the energy demand and production by coordinating the second-tier controllers. The controllers on the second tier are the BEMS controllers of each building. Their responsibility is to coordinate the electromechanical systems of each building, in order to achieve the goals, set by the top tier controller. To achieve these goals the second-tier controllers use an array of sensors throughout each building that get information about the state of the building. In parallel to the second-tier controllers there are data acquisition devices at each substation, serving the campus and record and transmit data regarding energy consumption and quality to the main controller. An integrated BEMS solution, the inEIS platform, which is able to monitor the existing BMS systems into a singular central platform. The inEIS has been developed through extensive hardware, software and engineering work, and is used for:

- Data capturing and monitoring from different sources, such as smart meters, temperature sensors;
- Centralized monitoring and analytics of several distributed BEMS systems;
- Provision of a centralized hub for metering data exchange.

The following figures illustrate the interface of the inEIS platform used for monitoring the consumption and production of the UCY campus.

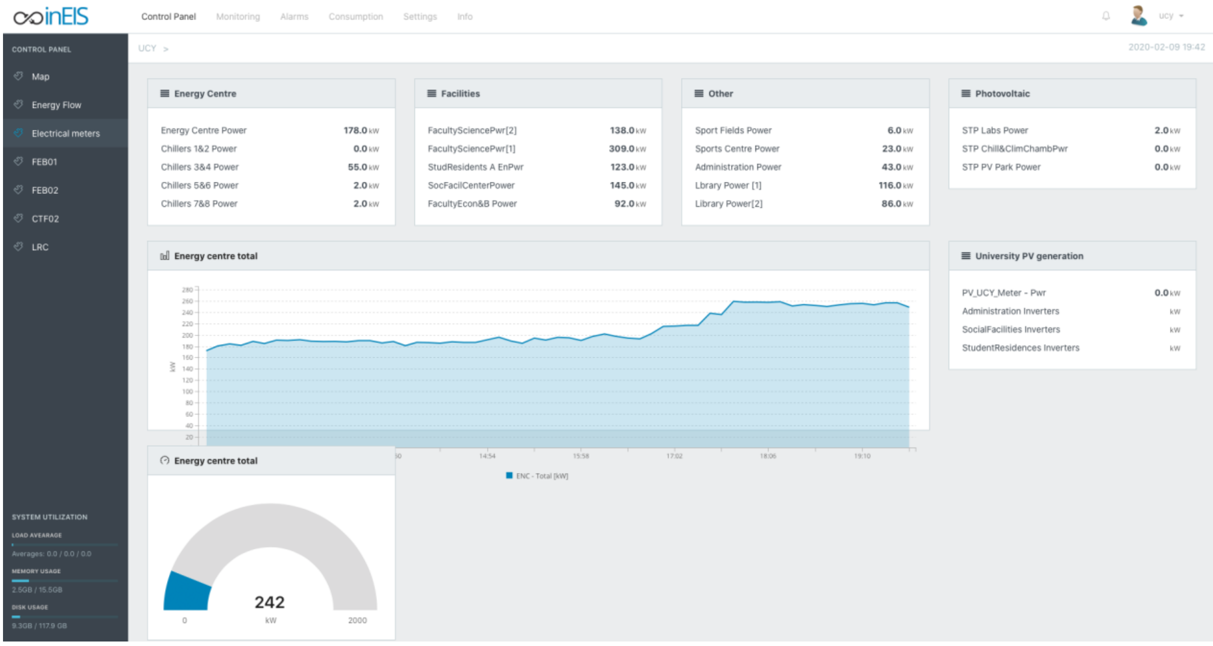

Figure 16. inEIS platform: Overview of the UCY Campus energy consumption.

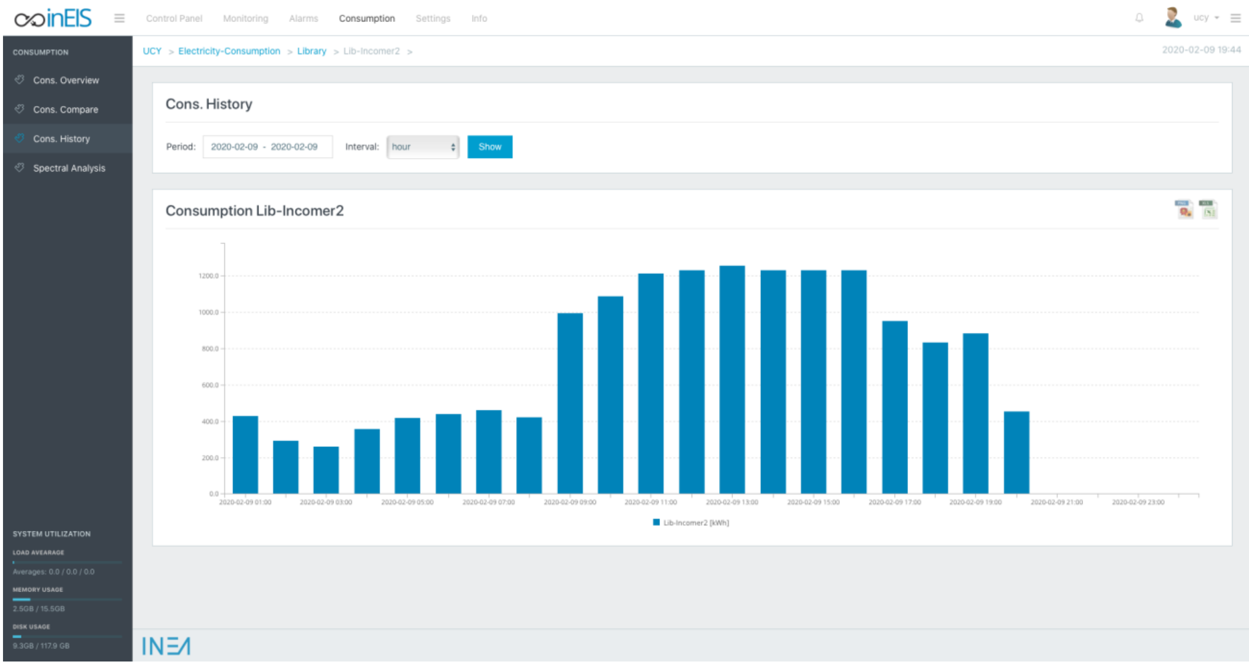

Figure 17. inEIS platform: Daily consumption of the Library building.

As depicted in Figure 18, the monitoring of the energy production from the PV installations takes place through the Solaredge website. The data are from the metering and sensor infrastructure are uploaded to the Solaredge server by using the available broadband grid of the university.

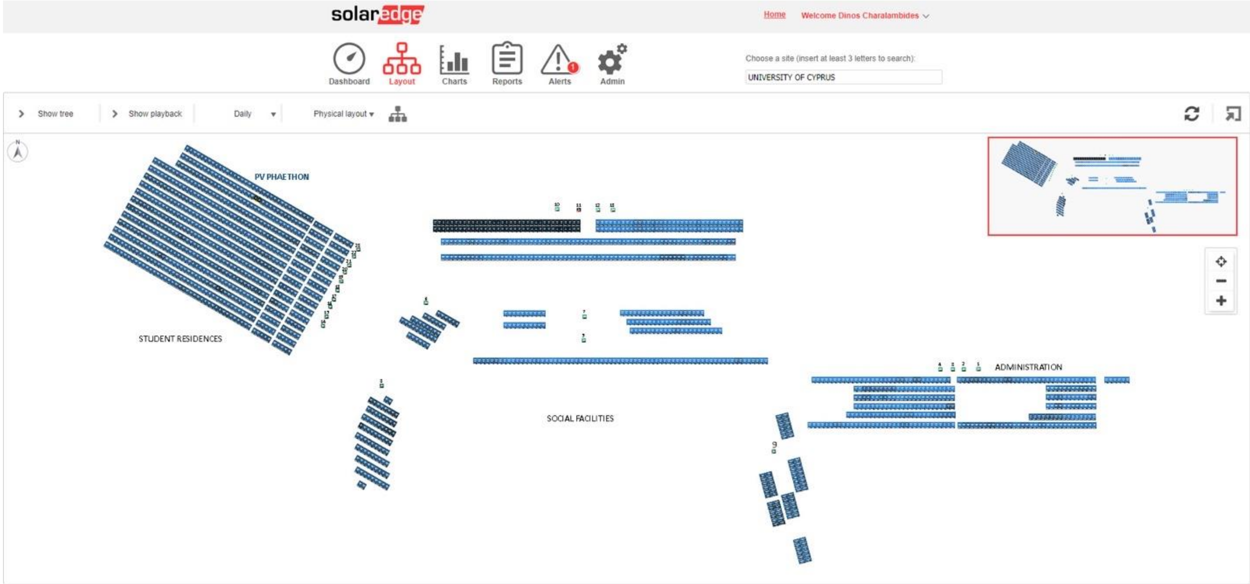

Figure 18. PV production monitoring through the Solaredge web-based platform.

Of the 17 Tertiary buildings on the University of Cyprus campus, four have been selected for participation in the DELTA project as part of the pilot deployment. The four buildings are:

- Library
- Administration
- Finance Economics & Business
- Residential

These four buildings were chosen as they represent a heterogeneous set of services, functional requirements and user experiences. In addition to the aforementioned buildings, the Photovoltaic (PV) Technology Laboratory facilities will be also utilised due to avialbality of Distributed Generation that enables testing of the DELTA solution.

3.1.1 The Library

The library at the UCY is a recent building with a modern and novel design. The building footprint is approximately 4200 m^2 (60 m by 70 m). The building plan is shown in Figure 19.

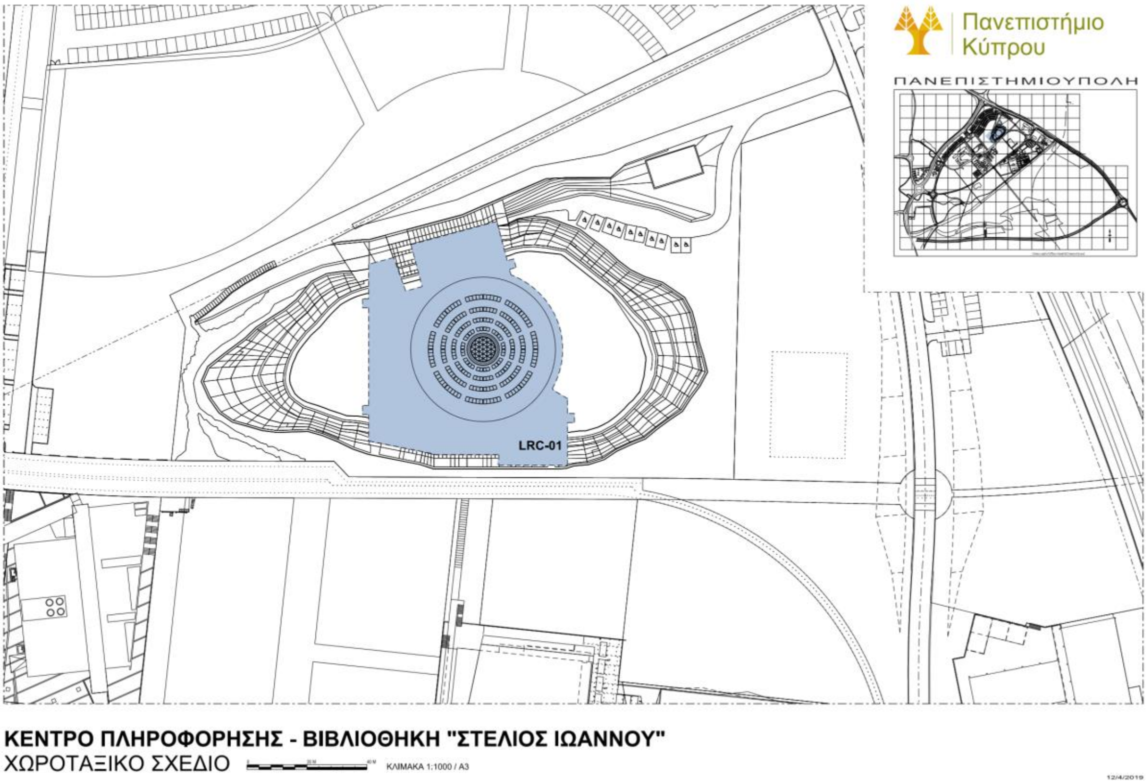

Figure 19. UCY Library building outline.

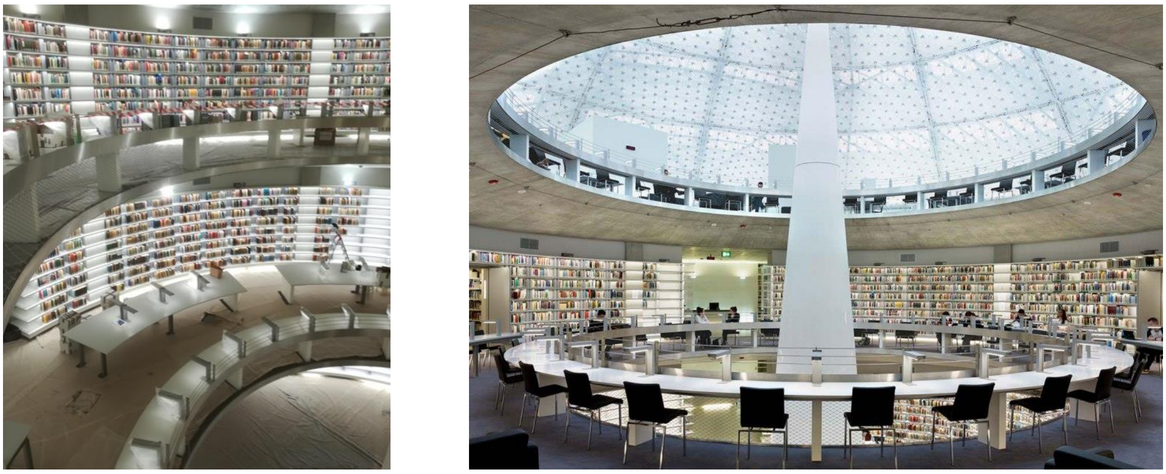

Figure 20. Internal spaces of the UCY Library building.

The Library building consists of 4 floors and comprises approximately 80 offices (mostly double occupancy, 10 m^2 with some larger communal and some single occupancy), 40 study spaces (10 of which are large open spaces and 30 of which are designed for small groups and are bookable), 10 dedicated PC labs, 10 conference/meeting rooms, 2 lecture theatres, a cafeteria, a shop and 5 kitchen spaces for staff use. There are also several facilities rooms (storage/machine rooms/communication rooms/server rooms) distributed throughout the building, most of which are situated in the basement.

There are two metering points for the library, as can be seen in the two following figures. Further investigation will be made throughout the course of the project to determine which loads are connected to which meter. The profiles of each metering point are generally similar with occasional substantial differences. For the example month, the baseline load for each meter is approximately 20 kW and the maximum load 200 kW. Weekday peak loads are around 165 kW with Saturday peaks dropping to around 140 kW and Sunday peaks to around 100 kW. The annual consumption of the library is not yet known but an approximation by extrapolation and comparison has been made at around 2 GWh.

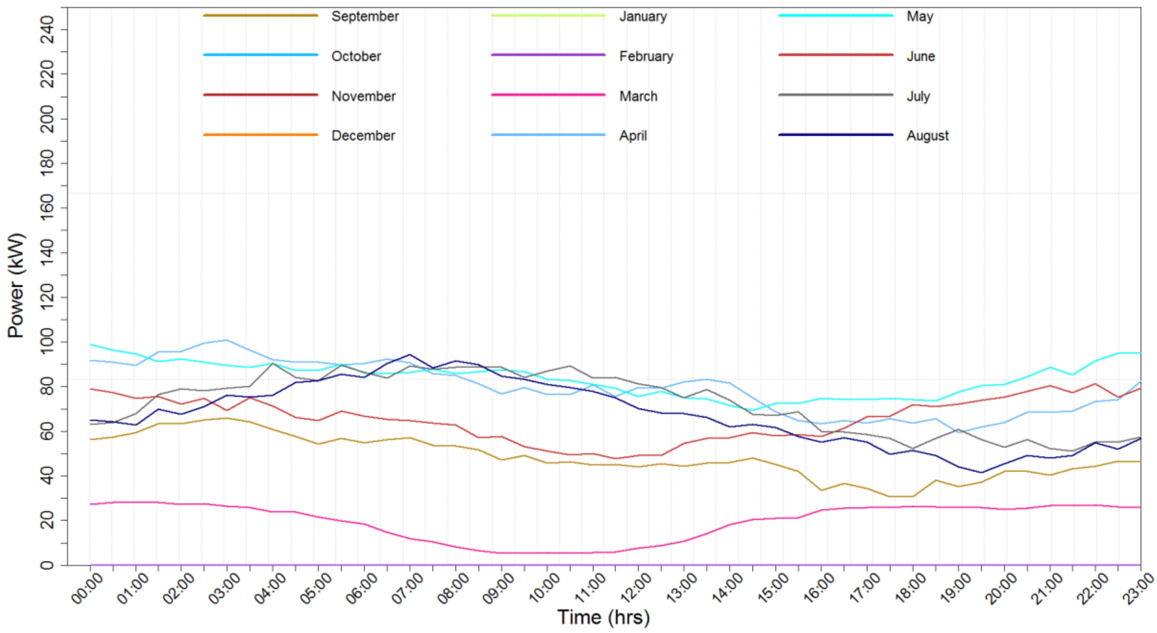

Figure 21. Average load Profile per month for the Library (Income 1) building.

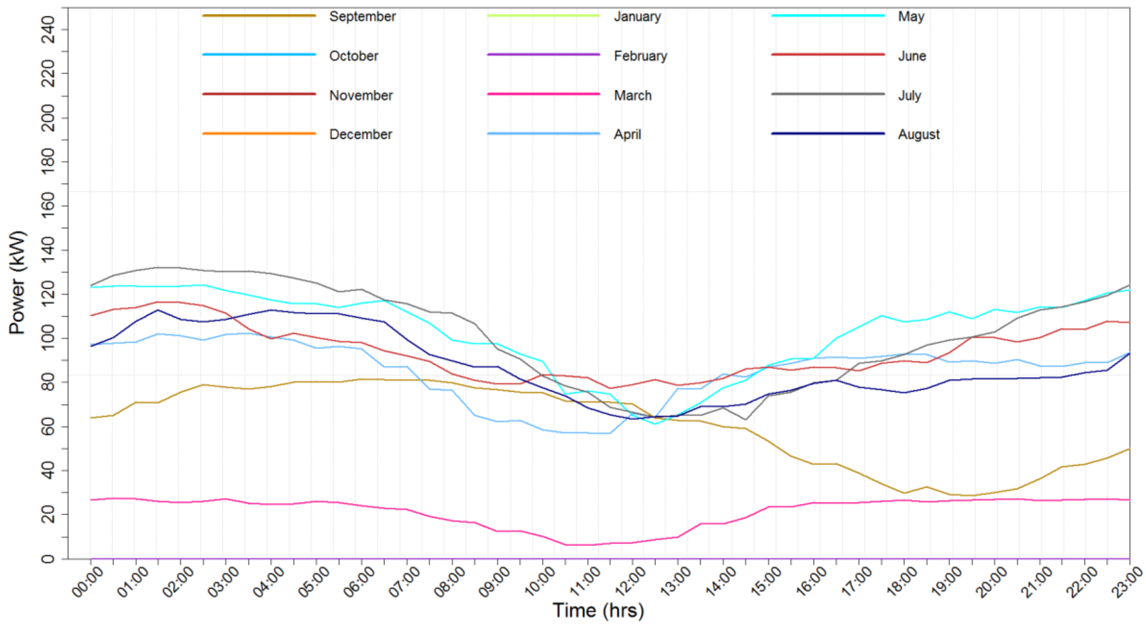

Figure 22. Average load Profile per month for the Library (Income 2) building.

3.1.2 Administration Building (ADM)

The administration building is a single building of approximately 30 m by 80 m corresponding to a footprint of approximately 2400 m^2. The building plan is shown in Figure 23, while the front view is shown in Figure 24.

Figure 23. UCY Administration building outline.

Figure 24. Front view of the UCY Administration building.

The Administration building houses the central services of the University and comprises approximately 165 offices, 10 conference/meetings rooms, 5 kitchen spaces, 1 large cafeteria (approximately 200 m^2) and 1 large lecture theatre (approximately 200 m^2) typically used for large conference events. These are distributed over 5 floors. There are also several facilities rooms (storage/machine rooms/communication rooms/server rooms) distributed throughout the building, most of which are situated in the basement. The office spaces are typically around 10 m^2, single occupancy with some communal office spaces throughout the building.

Power metering for the month of March 2019 of the Administration building is presented in Figure 25. There is a single metering point for the administration building and this metering point encompasses not only the building load but also the rooftop photovoltaic system output, which is mostly self-consumed by the building. This can be seen in Figure 25 as there are only 2 negative readings throughout the example month of March 2019. March was chosen as a representative example regarding the PV generation profile as the month of March encompasses the Spring equinox. The contribution of solar output to the profile can be expected to increase in the summer and decrease in the winter. It should be noted that heating/cooling load is not accounted for in this profile as the University campus operates a centralised district heating system. For the example month, the baseline load for the building is approximately 50 kW and the maximum weekday load 175 kW. Weekend days are approximately equivalent in terms of load, operating at around the baseline. The 70 kWp PV system on the roof of the Administration building generates approximately 100 MWh per year and the annual consumption of the building is approximately 730 MWh.

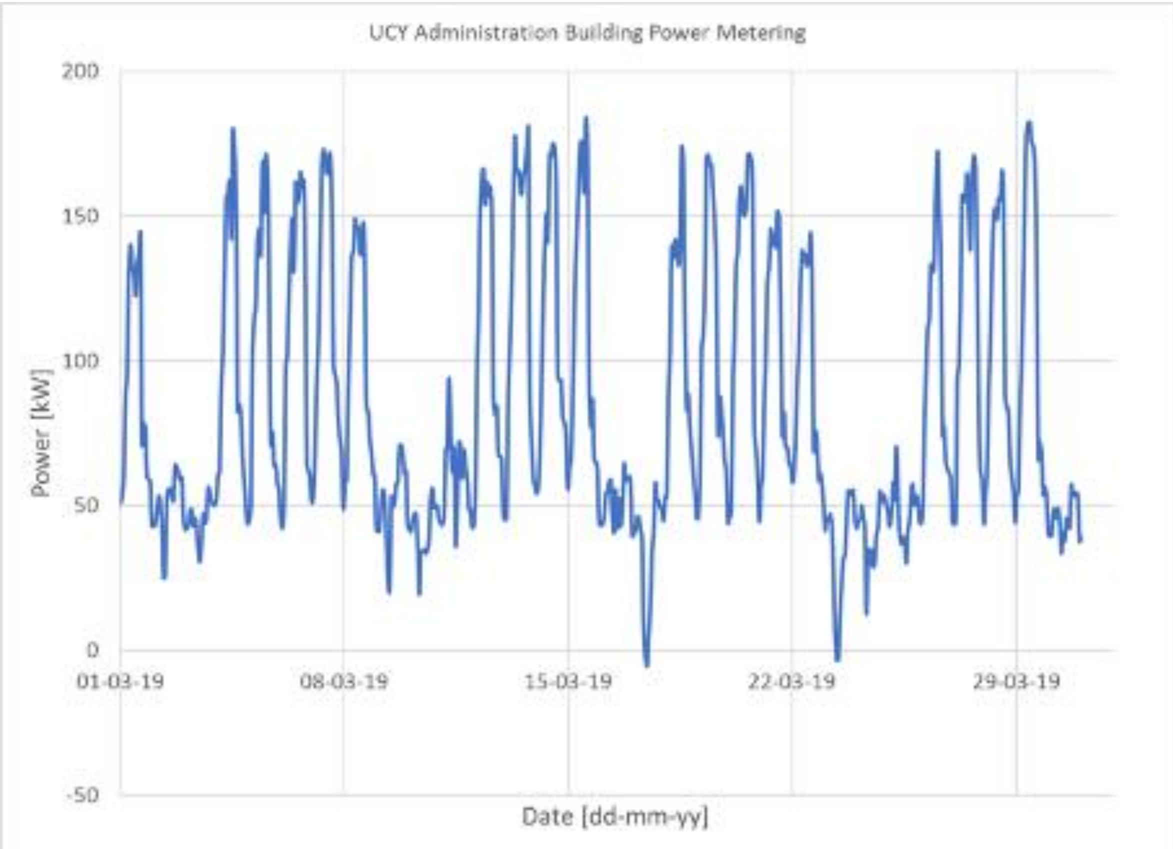

Figure 25. Power metering example for UCY Administration building, March 2019.

The average monthly load Profile for the University ADM building is illustrated in Figure 26.

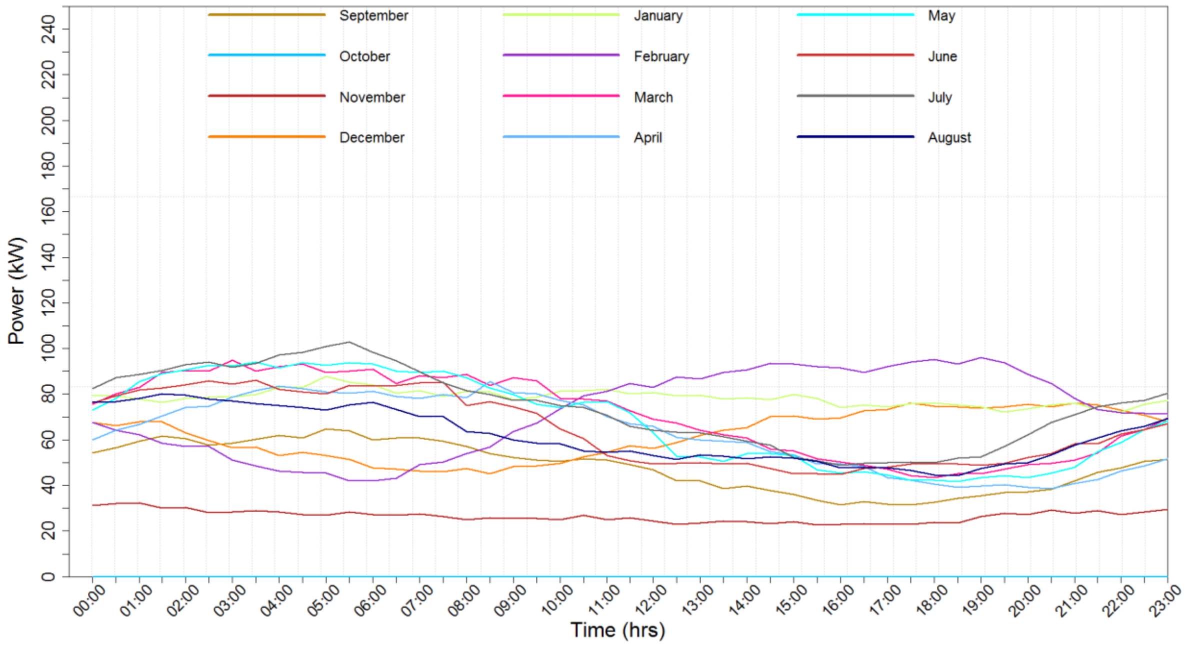

Figure 26. Average load Profile per month for the University Administration (ADM) building.

3.1.3 Finance Economics & Business (FEB)

The FEB building set comprises 2 buildings, one of 15 m by 65 m corresponding to a footprint of approximately 975 m^2 and one of 15 m by 85 m corresponding to a footprint of approximately 1125 m^2. The total footprint for the FEB building set is thus approximately 2100 m^2. The building plan is shown in Figure 27. The front view of the FEB building is shown in Figure 28.

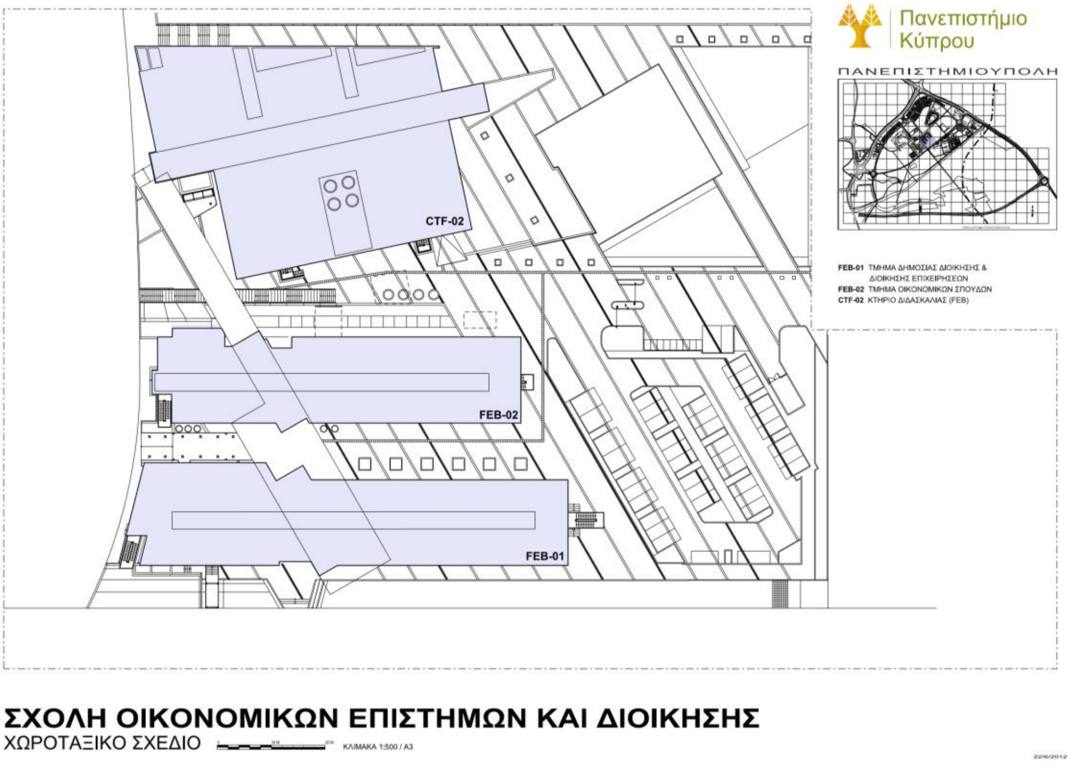

Figure 27. UCY FEB building outline.

Figure 28. Front view of the UCY Faculty of Finance Economics & Business building set.

The FEB building set comprises around 200 offices, 10 conference/meetings rooms, 10 kitchen spaces, 10 lecture theatres, 5 computer labs and a water pumping unit. These are distributed over 4 floors. There are also several facilities rooms (storage/machine rooms/communication rooms/server rooms), most of which are situated in the basement. The office spaces are typically around 15 m^2.

Power metering data for the month of March 2019 of the FEB buildings is shown in Figure 29, while the average load profine is shown in Figure 30. There is a single metering point for the FEB buildings. The FEB buildings consume approximately 1.25 GWh of electricity per year. It should be noted that heating/cooling load is not accounted for in this profile as the University campus operates a centralised district heating system to which the FEB buildings are connected. For the example month, the baseline load for the building is approximately 100 kW and the maximum weekday load 300 kW. Saturday load peaks are around 200 kW and Sunday load peaks around 150 kW.

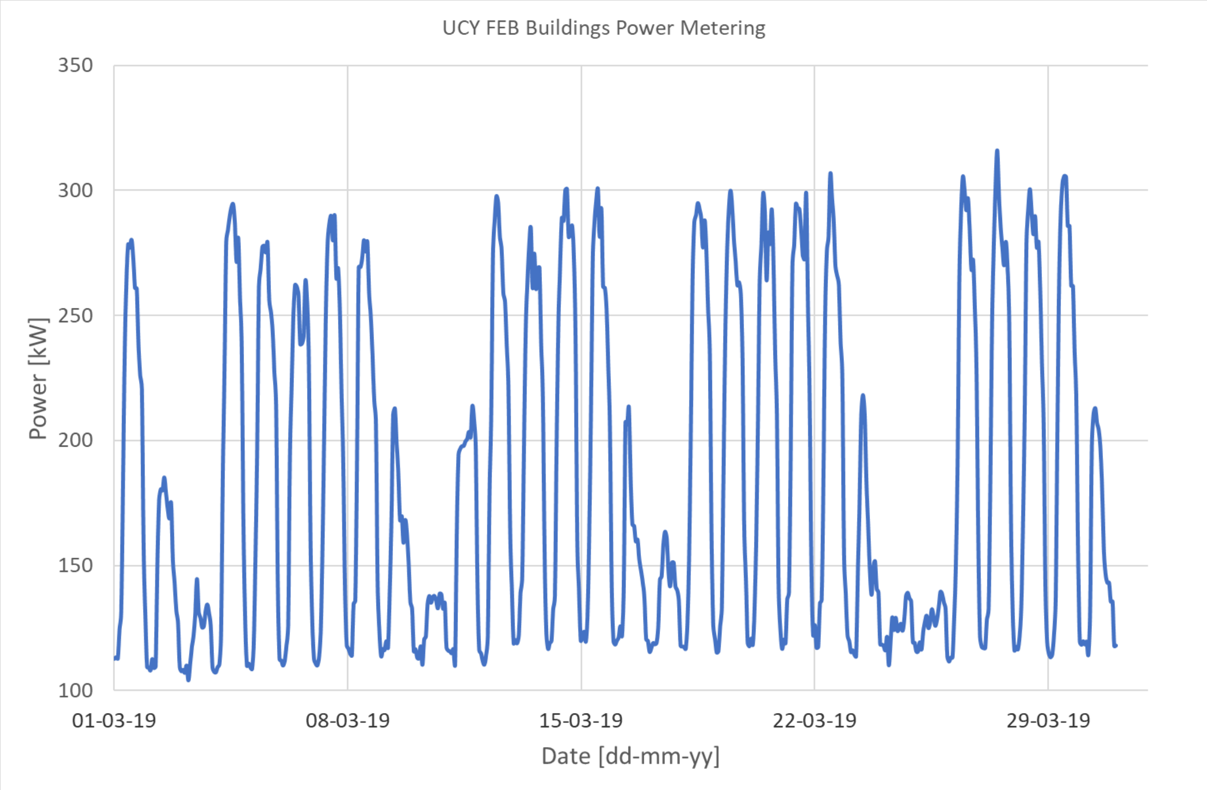

Figure 29. Power metering example for UCY FEB buildings, March 2019.

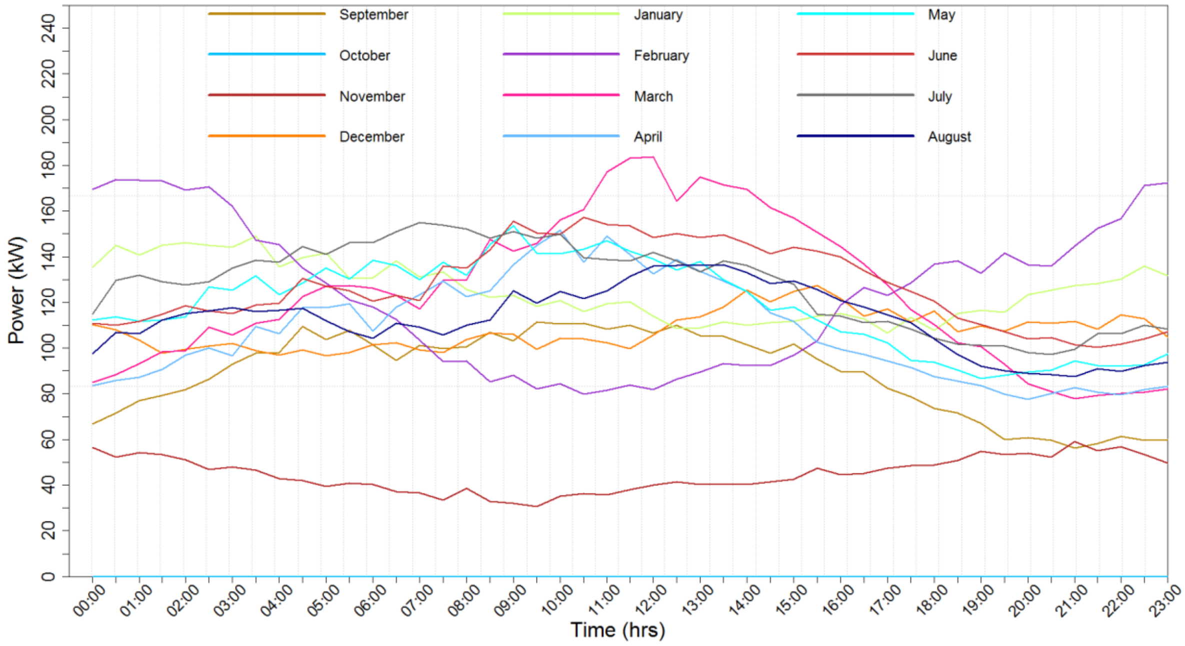

Figure 30. Average load Profile per month for the Faculty of Finance Economics & Business (FEB) building.

3.1.4 Resident Blocks

The residential blocks building set comprises 14 individual buildings each of approximately 25 m by 10 m corresponding to a footprint of 250 m^2. The total footprint of the Residential Blocks building set is thus roughly 3500 m^2. The building plan is shown in the following figure.

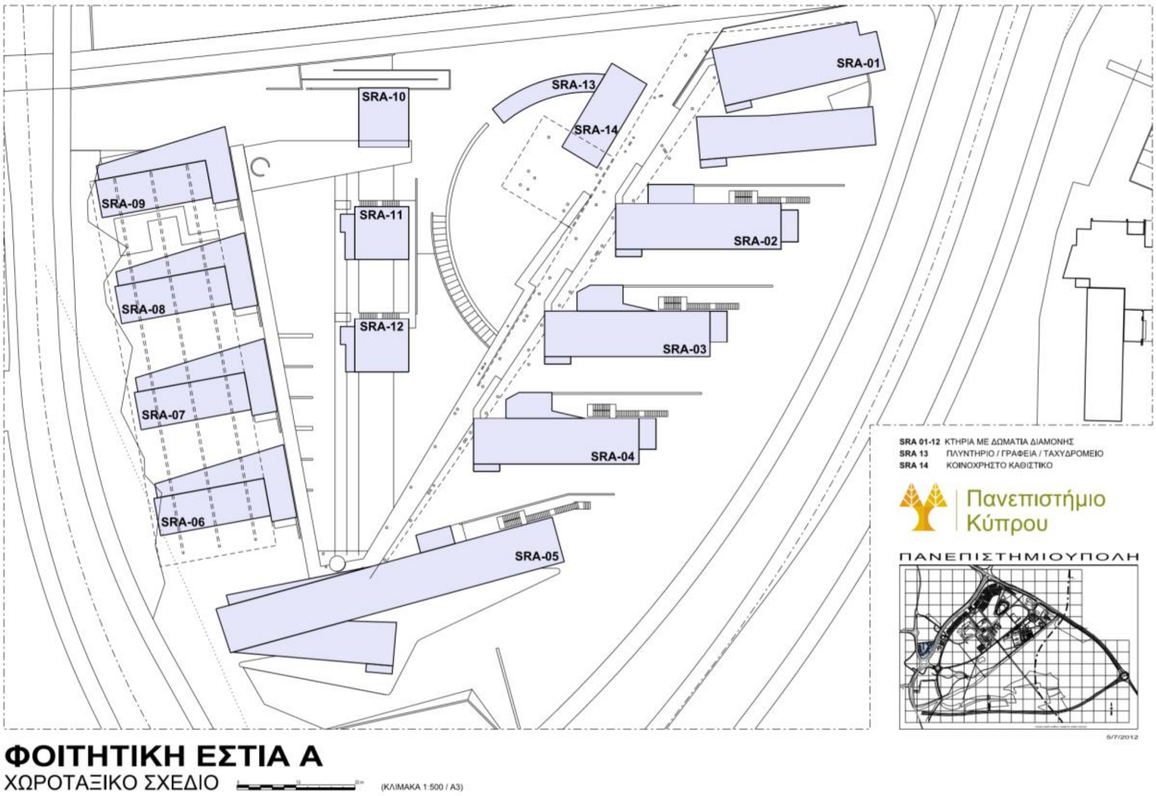

Figure 31. UCY Residential Blocks building outline.

A typical building in the Residential Blocks building set has 4 floors with facilities rooms (storage/machine rooms/communication rooms) in the lowest floor (basement level 2); and 8 individual dormitories and 1 communal kitchen on each of the 3 floors above. There is typically 1 occupant per dormitory thus approximately 25 occupants per building and around 300 residents across the building set.

Power metering data for the month of March 2019 of the Residential Blocks is presented in Figure 32. There is a single metering point for the Residential Blocks and this metering point encompasses not only the buildings load but also the nearby photovoltaic system output, which is preferentially self-consumed by the buildings. This can be seen in Figure 32 as there are significant negative readings throughout the example month of March 2019. The reason for these negative readings is that the 175 kWp PV system generates approximately 255 MWh per year whereas the Residential Blocks buildings consume approximately 185 MWh per year. March was chosen as a representative example regarding the PV generation profile as the month of March encompasses the Spring equinox. The contribution of solar output to the profile can be expected to increase in the summer and decrease in the winter. It should be noted that heating/cooling load is accounted for in this profile as the residential blocks are not controlled by the district heating system but the individual dormitories have user-controlled air conditioning systems. For the example month, the baseline load for the building is approximately 50 kW and the maximum weekday load 175 kW. There is no immediately obvious difference between weekdays and weekends in terms of load but this will be further investigated throughout the course of the project.

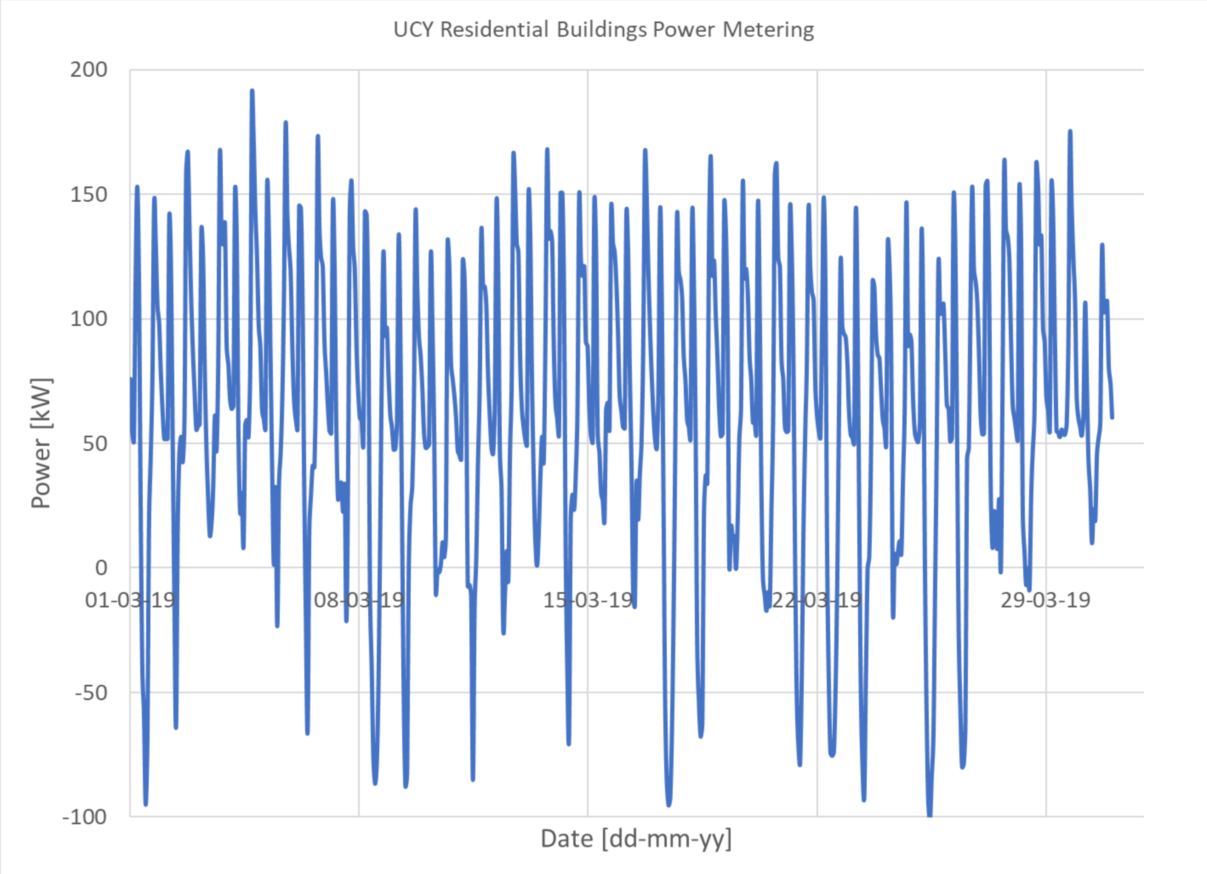

Figure 32. Power metering example for UCY Residential Blocks, March 2019.

The Average load Profile per month for the Residential Student Halls building is shown in Figure 33.

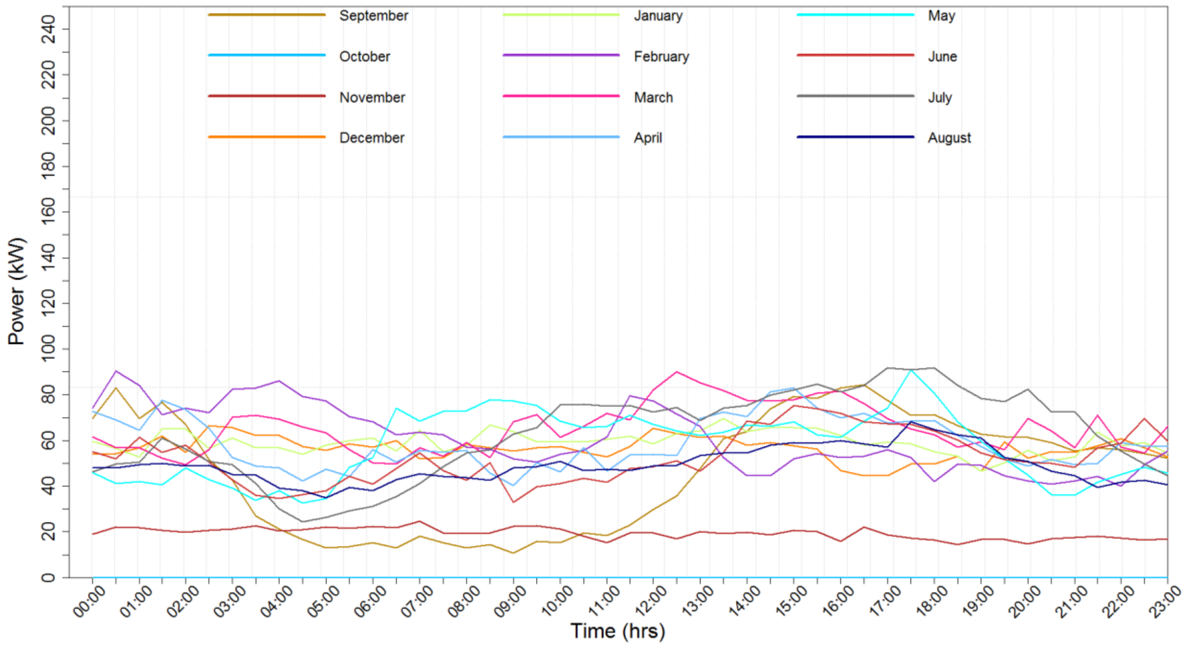

Figure 33. Average load Profile per month for the Residential Student Halls building.

Some of the Residential block buildings and the connected PV plant are shown in Figure 34.

Figure 34. UCY Residential Blocks (background) and connected PV system (foreground).

Service Description

To review, across the four buildings in the UCY pilot site described above the key services are:

- Office spaces
    - Used by staff during work hours. Most of the office spaces included in the UCY pilot are single occupancy offices although some are shared.
- Lecture theatres
- Typically used for public facing events and conferences, from 100 to 250 people
- Lecture rooms
- Mostly used to deliver course material to the students of UCY, typically host up to 50 people
- Meeting/conference rooms
- Used for internal staff and/or student meetings as well as small public facing events.
- PC labs
- Dedicated facilities with up to 50 PCs installed with various software used in course delivery to UCY students
- Study spaces
- Areas dedicated to private or group study, some open quiet spaces, many bookable rooms.
- Dormitories
- Individual living spaces
- Cafeterias
- Serving refreshments and catering for breakfast and lunch
- Kitchen spaces
- Facilitates used by staff for the preparation of hot beverages and food

An overview of the distribution of these services across the UCY pilot is given in Table 4.

Table 4. UCY Pilot services overview.

	Library	Administration	FEB	Residential	Total
Office	80	165	200		445
Lecture Theatres	2	1			3
Lecture Rooms			10		10
Meeting Rooms	10	10			20
PC Labs	10		5		15
Study Space	40				40
Dormitories				300	300
Cafeteria	1	1			2
Kitchen Spaces	5	5	2	15	27

Energy Requirements Description

The annual energy consumption and associated PV system generation for each of the 4 UCY pilot buildings are shown in Table 5.

Table 5. UCY Pilot buildings annual energy consumption and generation values.

Building	Approximate Consumption (kWh/year)	Approximate Production (kWh/year)
Administration	750,000	100,000
FEB	1,300,000	0
Residential Blocks	200,000	250,000
Library (extrapolated from 1 month of data and similarities with other campus buildings)	2,000,000	0

The total annual energy consumption across the four buildings of the UCY pilot site is thus approximately 4 GWh. The energy usage across the 4 buildings is associated with the services offered in the buildings. The energy requirements per service are described below in Table 6.

Table 6. Energy requirements for provision of services at UCY pilot site

Service	Principle Energy Requirements	Considerations for Flexibility
Office	Mostly personal computers, some printing facilities, lighting	Tied to office hours, can be predicted to some extent from calendar entries.
Lecture Theatres	Audio & Visual (AV) services, theatre lighting, local sockets often used by attendees for personal laptops	As these are linked public facing events, they would not be considered flexible, although events are booked in advance so usage is known.
Lecture Rooms	Projection, lighting	Generally booked in advance, unlikely to be considered flexible after booking due to the emphasis placed on student satisfaction. Flexible prior to booking.
Meeting Rooms	Projection, often many attendees will have personal computers, lighting	Generally booked in advance, flexible prior to booking.

PC Labs	Desktop PCs often running specific software, some of which is power intensive, lighting.	Generally booked in advance, unlikely to be considered flexible after booking due to the emphasis placed on student satisfaction. Flexible prior to booking.
Study Space	Power for personal PCs, lighting.	Generally booked in advance, unlikely to be considered flexible after booking due to the emphasis placed on student satisfaction. Flexible prior to booking.
Dormitories	Heating/cooling, local power requirements, lighting	User controlled, could be considered flexible with sufficient incentives passed to individual users, especially regarding heating/cooling.
Cafeteria	Industrial catering equipment (heating/cooling)	Tend to use energy according to service demands and thus have timeframes for operation that may be difficult to change. However, financial incentives such as time of use tariffs employed by the University may influence energy usage.
Kitchen Spaces	Appliances for cooling and heating food/beverages	Many of the heating appliances tend to be high energy devices that see a lot of use within a specific time interval (lunchtime). This interval may be spread across a few hours depending on staff preferences. It may be possible to incentivise pre/postponing the use of this equipment.

The users of these services differ in many contexts. Users of the same services may be from many different demographics and differ greatly in their comprehensions of and attitudes to demand response initiatives.

- The occupants of the Residential Blocks are all University students, some of whom reside in the dormitories for the full year and some of whom make frequent visits to families at weekends. Time spent in the dwellings is dependent on their individual schedules and influenced significantly by University timetabling of courses. The kitchen spaces in these residential blocks differ to those in the other pilot site buildings in that they are used in the evenings for food preparation.

- Office staff are a large part of the UCY pilot site as there are many offices distributed throughout the Administration, FEB and Library buildings. Office staff generally work inflexible hours and have routine set times for breaks, during which they are more likely to use the kitchen facilities and the services of the cafeterias throughout the campus.

- The lecture rooms, PC labs and study spaces will be used primarily by University students at times predetermined by timetabling. There may be some flexibility at the point of the timetabling, but these services are generally considered inflexible after this point, primarily in relation to the satisfaction of students. In this context the students are considered service users. Service users tend to utilise facilities with expectations of service provision at given times and their levels of satisfaction has commercial ramifications on the service providers. In this sense the lecture theatres and meeting rooms can be considered services provided to both internal and external persons by the University and the cafeteria can be considered similarly.

- Commercial staff responsible for the provision of services (such as the cafeteria) may have somewhat different incentives regarding demand response as companies are often tasked with energy cost reduction strategies. The timing of industrial processes may be flexible although this is not something that be dictated by the University directly – incentives must be passed to these persons through an electricity billing system which is currently simple and linked directly to the University's tariff with the electricity provider, Electricity Authority of Cyprus (EAC).

- Each of the four buildings in the UCY pilot site is managed by personnel from University technical services. These technical staff will require executive control over any settings of building energy management systems. They are tasked with the provision of services to the satisfaction of building tenants whilst minimising cost.

An overview of the service Users at the UCY pilot site is presented in Table 7.

Table 7. UCY Pilot site Service Users Overview

Technical Staff	Office Staff	Residents	Commercial Staff	Service Users (some overlap)
10	500	300	25	800

3.1.5 UCY Campus – PV Technology Laboratory, FOSS Research Centre

PV Technology Laboratory functions as a nanogrid that acts as a testbed and a subset of the UCY campus and includes PV systems, Battery Energy Storage Systems (BESS), smart meters, existing electrical loads, a controllable electric load and an Electric Vehicle (EV) charging station. The PV Technology Laboratory is consisted of two facilities used as offices for researchers, an in-door testing facility, a conference room, a storeroom and a cabinet for the BESS. The building plan and the view of the PV Technology Laboratory are shown in Figure 35 and Figure 36, respectively.

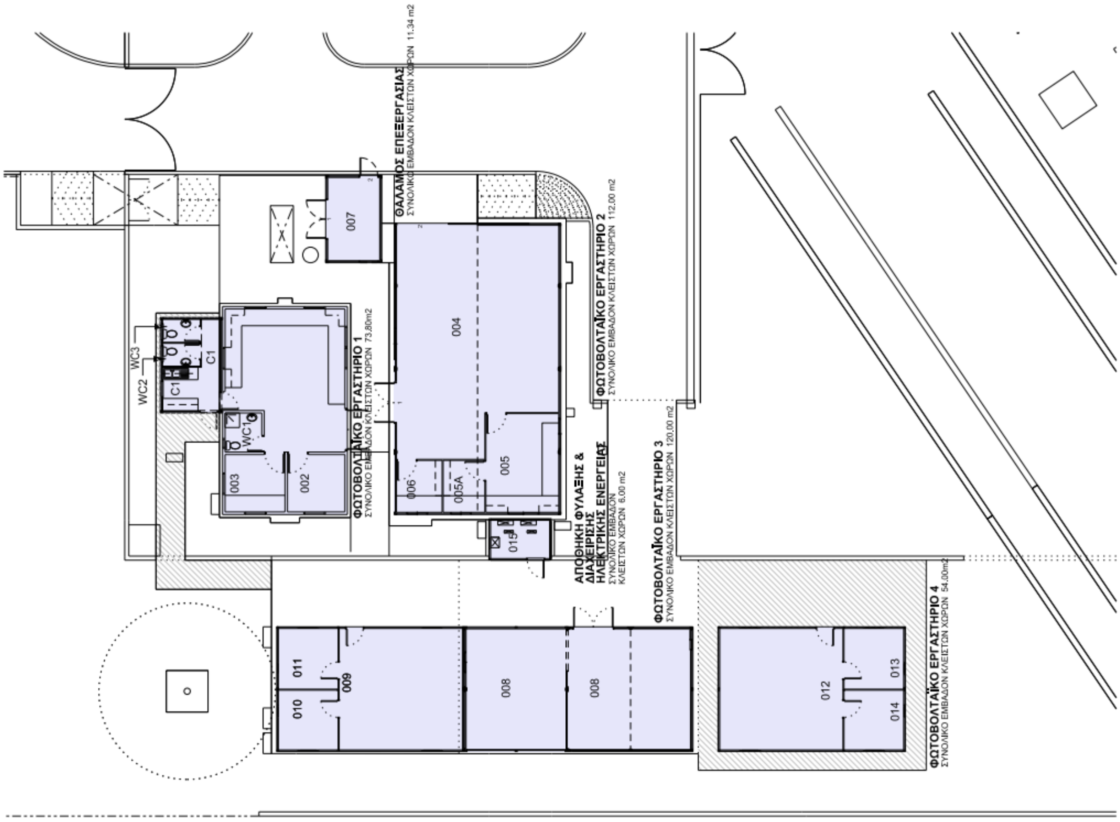

Figure 35. UCY PV Technology Laboratory building plan.

Figure 36. Top view of the PV Technology Laboratory, UCY.

The two Research facilities include the typical office appliances such as AC units, lighting and PCs, while the conference room includes the aforementioned appliances plus a projector. Currently, there no smart appliances installed at the offices. The following figure shows the researchers' offices (left) and the conference room (right).

Figure 37. Research facilities and conference room of the PV Technology Laboratory, UCY.

The PV panes are installed mainly for testing purposes and for this reason the total number is changing. The average PV and CPV installation is around 50 kWp. Furthermore, an Energy Management System (EMS) is installed, developed by Robotina, which manages a domestic size PV system (3 kWp), a small BESS (3 kWh), a controllable electric load and three smart plugs. The following figure depicts the schematic diagram of the PV Technology Lab. As shown in the diagram, two BESS are currently installed at the lab. However, only the BESS M4860 is managed by the Robotina EMS.

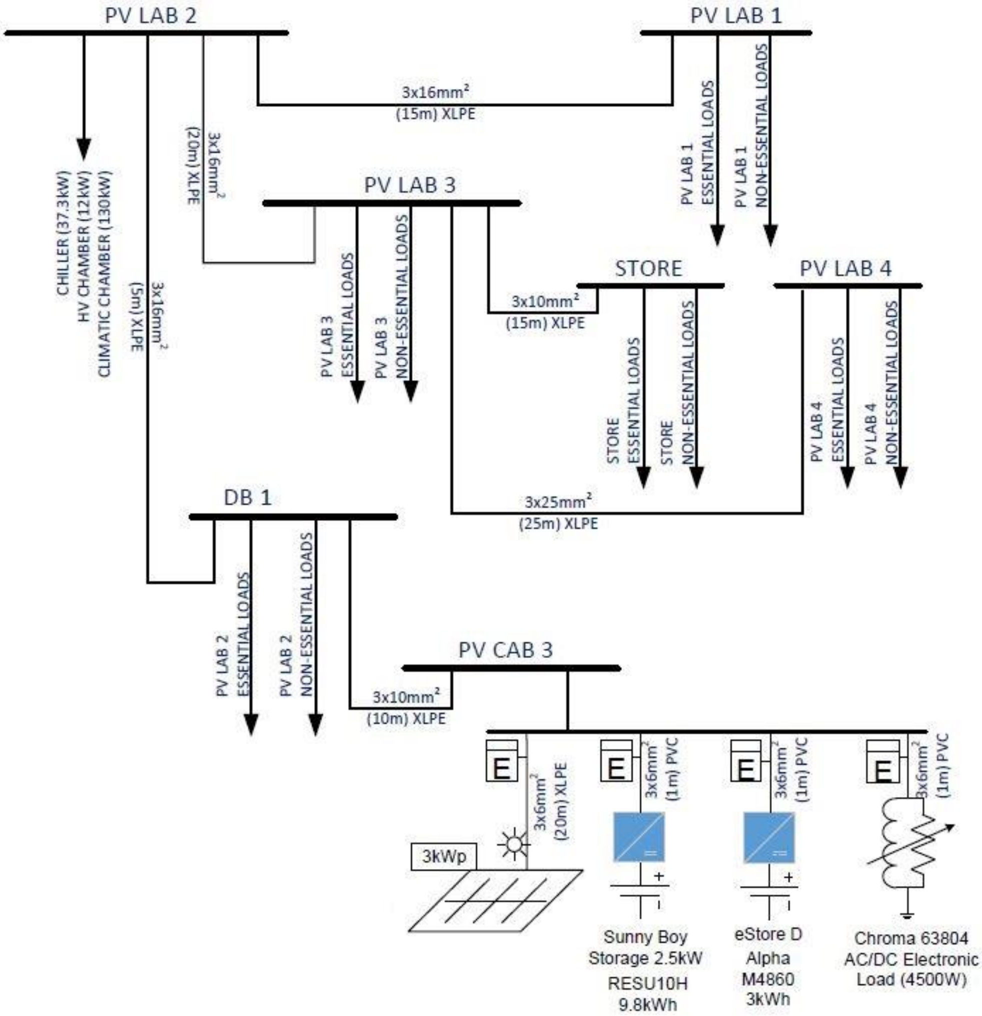

Figure 38. PV Technology Lab Schematic Diagram.

Main components of the PV Technology Laboratory:

- Smart Meter Circutor CVM-Mini: The CVM-MINI panel analyzer is a programmable measuring instrument; it offers a series of options for using it, which may be selected from configuration menus on the instrument itself. The CVM-MINI measures, calculates and displays the main electrical parameters for three-phase, balanced or unbalanced industrial systems. Measurements are taken in true effective value using the three alternating and neutral voltage inputs and three current inputs.
- A 3 kWp Poly-crystalline Si PV system is installed along with an SMA 3000TL-21 PV Inverter, as shown in the figure below.

Figure 39. PV Technology Lab: PV system connected to the EMS.

- Programmable AC & DC Electronic Load (3600W): Chroma's 63800 Series AC&DC Electronic Loads are designed for testing Uninterruptible Power Supplies (UPS), Off-Grid Inverters, AC sources and other power devices such as switches, circuit breakers, fuses and connectors. The Programmable load can simulate load conditions under high crest factor and varying power factors with real time compensation even when the voltage waveform is distorted. This special feature provides real world simulation capability and prevents over-stressing thereby gives reliable and unbiased test results. The Programmable load can simulate non-linear rectified loads with its unique RLC operation mode. This mode improves stability by detecting the impedance of the UUT and dynamically adjusting the load's control bandwidth to ensure the system's stability. The Chroma's 63800 Series AC&DC Electronic Load installed at the PV Technology Laboratory is shown in Figure 40. The specifications are summarised in the following table.

Table 8. PV Technology Laboratory Chroma's 63800 Series AC&DC Electronic Load specifications.

Model 63803	
Power	3600W
Current	0 ~ 36Arms (108 A_{peak}, continue)
Voltage	50 ~ 350Vrms (500 V_{peak})
Frequency	45 ~ 440Hz, DC
AC Section	
Range (Constant Current Mode)	0 ~ 36Arms, Programmable
Accuracy (Constant Current Mode)	0.1% + 0.2%F.S.
Resolution (Constant Current Mode)	5mA
Range (Constant Resistance Mode)	1.39Ω~2.5kΩ, Programmable

Accuracy (Constant Resistance Mode)	0.5% + 0.5%F.S.
Resolution (Constant Resistance Mode)	50µS
DC Section	
Voltage Range	7.5V ~ 500V
Current Range	0A ~ 36A
Min. operating voltage	7.5V
Rise time	75µs
Operating Mode	CC, CV, CR, CP, DC Rectified
Short Circuit Simulation	Use the CR mode loading under max. power rating
Others	Others
$V_{monitor}$	±500V / ±10V (Isolated)
$I_{monitor}$	±200A / ±10V (Isolated)
Protection	OCP : 38.4Arms ; OV alarm: 360Vrms (DC : 510VDC) OPP : 3840W ; OTP
Remote Interface	GPIB, RS-232
Input Rating	1Ø 100~115Vac ± 10% VLN, 47~63Hz ; 1Ø 200~230Vac ± 10% VLN, 47~63Hz
Dimension (H x W x D)	310 x 440 x 595 mm / 12.2 x 17.32 x 23.42 inch
Weight	66 kg / 145.5 lbs

Figure 40. PV Technology Lab: Chroma's 63800 Series AC&DC Electronic Load.

The M4860 battery pack installed at the PV Technology Laboratory is currently used only for testing purposes has the following features:

- This battery pack is designed for household photovoltaic systems;

- The battery packs built-in BMS monitors its operation and prevents the battery from operating outside design limitations;
- This battery pack can be easily expanded by adding expansion battery packs.

The following table summarises the UCY BESS specifications, while the cabinet, where the BESS M4860 is installed, is shown in Figure 41.

Table 9. PV Technology Laboratory BESS M4860 specifications.

Building	
Model	M4860
Battery Type	LiFePO4 (LFP)
Battery Manufacturer	LISHEN
System Weight	40 kg
Dimension (W x D x H)	482mm x 460mm x 156mm
IP Protection	IP20
Warranty	5 Year Product Warranty, 10 Year Performance Warranty
Electrical	
Energy Capacity	3.0kWh
Usable Capacity	2.7kWh
Depth of Discharge	90%
Nominal Voltage	51.2V
Operation Voltage Range	45 - 58V
Internal Resistance	≤50mΩ
Cycle Life	≥8000
Operation	
Max. Charge Current	30A (0.5C)
Max. Discharge Current	30A (0.5C)
Operating Temperature Range	-10°C - 50°C (*When the temperature is below 0°C or above 40°C, the performance will be limited)
Humidity	15% - 85%
BMS	
Power Consumption	<2W (Work), <100mW (Sleep)
Monitoring Parameters	System voltage, current, cell voltage, cell temperature, PCBA temperature measurement
State of Charge	Intelligent algorithm
Communication	CAN and RS485 compatible

Figure 41. PV Technology Lab BESS cabinet.

All the above-mentioned components are controlled through an EMS developed by Robotina based on Cybrotech control technology. The EMS is currently utilised to:

- maximize in-house consumption of self-generated renewable energy;
- minimize cost of electrical energy;
- contribute to local micro grid balance as a prosumer;
- assure autonomy of user connected to unstable electrical grid.

The following table summarises the Robotina EMS specifications, while the schematic operation diagram as well as the EMS installed at the PV Technology Laboratory are depicted in Figure 42.

Table 10. Technology Laboratory Robotina EMS specifications.

eStore	
hybrid inverter	3.0 kW
PV power input	4.5 kW
max DC voltage	500V DC
Max Power Point trackers	1 x 18A
battery charger	48VDC, 25A max
batteries Li-ion	3 – 9 kWh
weight	from 120kg
Relay outputs	8A/250V
Communication	Ethernet, 2x RS232, 1x RS485, IEX-2 bus
Nominal power rating	243V(100-240VAC)
Power consumption	typ. 1W (no load), 10W max
Power output	24V 200mA (IEX-2 + terminals)
Ingress protection	IP20
Operating temperature	0 – 45°C
Storage temperature	-20 – 75°C
Relative humidity	0 – 95% n/c

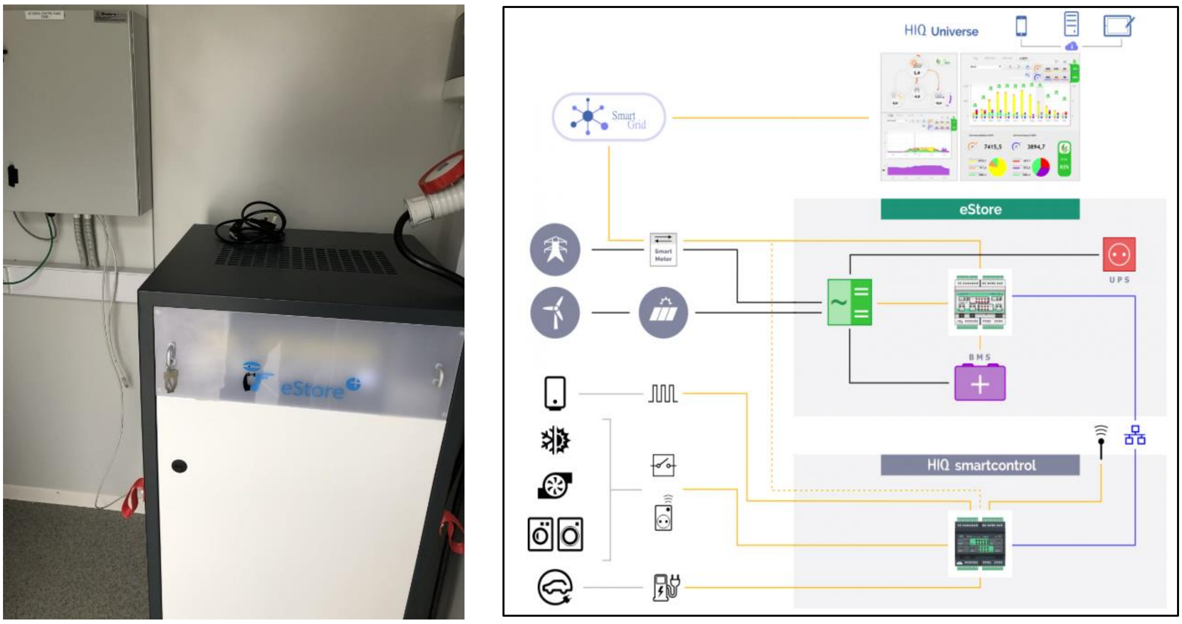

Figure 42. PV Technology Lab: Robotina EMS (left) and the schematic operation diagram (right).

3.2 Stage 2 - User Engagement Activities

The user engagement activities, as described in Section 2, conducted prior to the pilot-implementation of the DELTA framework at the UCY campus, are presented in this section.

3.2.1 Focus groups

Every new solution that is going to be implemented and tested in a pilot site requires the involvement of various groups of people. Getting users involved is the cornerstone of commitment and only by making a commitment, people will most likely act upon it. In case of DELTA project, DR events imply multiple benefits for all stakeholders and users. As it was mentioned above, focus group is the method that can provide the insights about what the project needs, raise the awareness of the participants and interchange ideas between users, technicians, partners etc.

For this reason, α Focus group was organized on the 15th of January at the premises of FOSS in UCY, where pilot site leaders had the opportunity to analyse the implementation activities of DELTA and how end-users can be engaged. The main scope of this focus group was to provide details to participants about how the DR events can be activated as well as how their active participation can yield economic benefits for them and the university community as as whole. A survey analysis that would refine the users' requirements was also conducted.

Figure 43. Focus Group conducted at the UCY.

Although the User Group of the UCY pilot is quite large, with 800 end-users in total, the conducted Focus Groups were limited to a total of 50 users as presented in Table 11. The selection of participants was based on their interaction to previous projects, and on their roles (e.g. Building Managers, students, and technical staff). In addition, questionnaires and dissemination material were sent to the end – users that are registered with UCY email addresses.

Table 11. UCY Pilot site Service Users Overview.

Technical Staff	Office Staff	Residents/Students	Commercial Staff
10	25	10	5

The following actions was included in each Focus Group section:

- Duration of the focus groups was approximately an hour and half;
- The users were provided with dissemination material and questionnaires that were completed and discussed;
- Each group was consisted with users of different ages, both genders and different educational level, to ensure an open discussion;
- Actions and activities that users are expected to engage were explained based on the objectives and the scope of the project;
- A round table – discussion was the conclusion of each focus group, user responses were kept confidential and there were no right answers to the questions posed by the Focus Group's facilitators.

Focus groups were successful with the outcome that the provision of incentives to consumers increase end – users' interest, their attractiveness to modify their energy consumption behaviours and their interaction with application of innovative pilot programmes that DELTA tries to achieve win – win scenario for all parties. However, risks and potential issues are expected, hence effective techniques and tactics that are included in DELTA solution are discussed to ensure a clear understanding for all participants. Obtaining specific insights on the different aspects of this programme helps determine themes related to the process of enrolling and participating in the programme. Flexibility, comfort, control and trust were the topics that are stood out the most, with the survey show that comfort has the highest value for the end – users over the other factors. In addition, for end – users trust was also very crucial, with some participants express concerns on the legitimacy of DELTA solution, and some of them were worried that utility will control their loads. Further concerns, such as 'what are the solution for cases where utility' control will be lagging?' and 'how these cases will affect their comfort level?' with the moderator ensures the end – users that DELTA solution has already consider these aspects. Moreover, the User Group felt that the methods that will ensure active participation from end – users' side are economic incentives and the monitoring of both energy and electricity cost. Additionally, the highest share of participants was willing to cede control for the sake of the incentive and for environmental concerns.

Below are listed several recommendations, based on the Focus Group findings.

3.2.1.1 How to Incentivise Participation

- Clear communication with an advance payment from the initial sign – up will certainly encourage active participation.
- Perceptible reasons are needed in order to provide a clear understanding why we are doing this.
- The end – users' comfort level is crucial to be unaffected.
- End – users consider essential to be able to opt – out without penalties at any time.
- The participants during the focus groups indicated that if they are in 'stand – by' mode for so long, without interacting with any DR events, they might consider to disengage with the program. For this reason, continues communication needs to be maintained throughout program.
- Participation standards might be changed when days are busy with daily activities, which results to a not significant 'DR' event.
- The presentation of the overall impact and collective reduction will be beneficial.
- Innovative Information and communications technology (ICT) solutions, advance billing methods, including blockchain technologies and distributed ledger, should be explored.
- Time – varying options and various DR programs for all customer classes (commercial, industrial or domestic) can increase the end – user participation.
- Initial investment for smart appliances and equipment cause frustration to end – users.
- Some of the focus groups participants have shown extra motivation and willingness to participate because of the environmental impact.

3.2.1.2 How the reward system should work

- Good reward system and incentive scheme are required for end – users to be interested in participation and on future engagement.
- The system is crucial to include fairness aspects especially for low energy users, provide financial benefits, as well as involve a ranking system based on end – users' efforts.
- Participants also mentioned that a competition in the reward system will be very exciting as a part of the virtual team/community.
- In addition, by upload the results on the virtual platform the neighbors will be more competitive and motivated to increase their efforts, and be involved in more 'DR' events.

3.2.1.3 Awareness of energy use is important

- The rising cost of electricity and the fact that most of the end – users cannot understand what is really happening with the energy consumption increase the concerns of the end – users.
- The majority of participants expressed that electricity bills are not user friendly and difficult to comprehend, especially consumers who have distributed energy resources.
- Participants stated that a breakdown of the energy used, and electricity costs will be very helpful and comprehensive. Moreover, customers will understand how DR rely on their behavior and what are the economic benefits to be a part in DR events.
- Feedback and visibility, reinforcement of effective action and relevant, timely advice to improve will support them to learn through their experiences in altering their energy habits.

3.2.1.4 Customers are more likely to sign up for a second year if:

- We ensure customers that will have further assistance in order to sustain and reduce more their energy consumptions.
- The DELTA solution will fine – tune and reinvent its' applied solutions and be able to sustain peoples' level of interest.
- A new reward scheme will make gamification part of the user experience and will not be based on certain events.
- The energy reduction for each customer will require less effort based on new adjustments.
- Show evidences that DELTA solution has already consider the consequences of environmental pollution and the climate change.
- Maintained their comfort levels unaffected.

The following figure illustrates the perceptions and reservations of the end-users before, during and after a DR event.

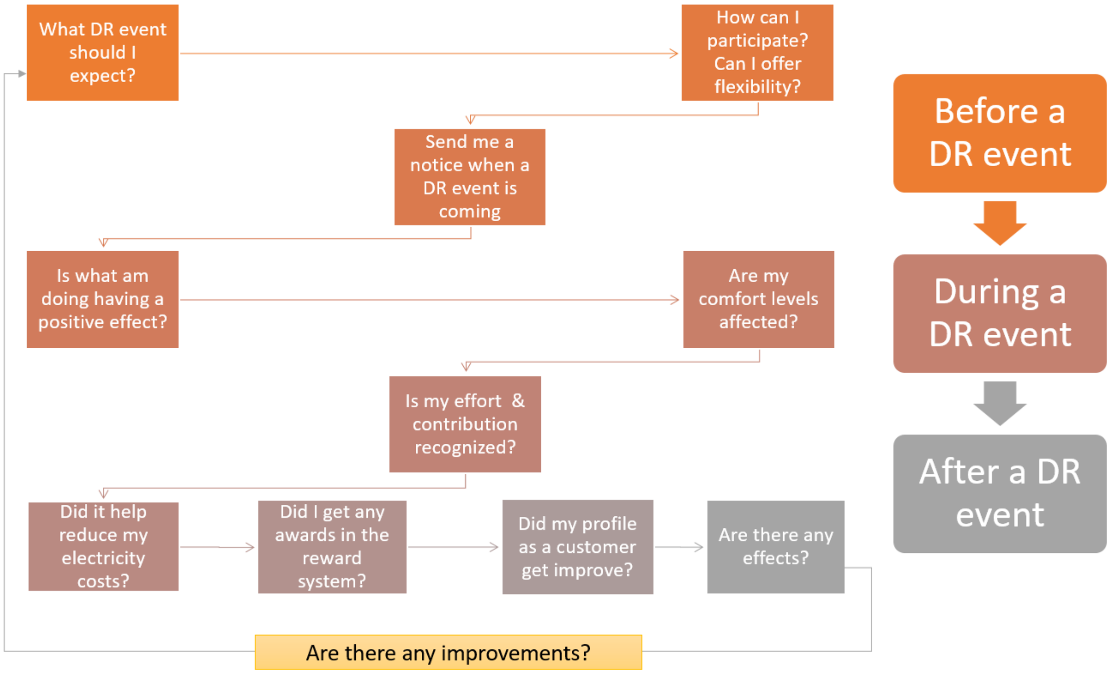

Figure 44. DR Event Perception based on Focus Group feedback.

3.2.2 Cyprus Pilot Demand Response – Demonstration Workshop

A workshop was hosted by FOSS Research Centre for Sustainable Energy of the University of Cyprus and was titled "Emerging Energy Systems & the role of DR". Addressing the evolving new electricity market and DR and focusing on the concept of the aggregator and the EU funded research and innovation project, DELTA. Invitations were sent to all those interested in smart grids and the future of energy markets to join them in discussing the latest trends in energy flexibility.

Relevant stakeholders came together to exchange views in a transparent and constructive way on the challenges ahead. Guests had the opportunity to learn about the innovative areas of research in which the projects are pioneering. The workshop emphasized on the engagement activities of end users which live or operate within the pilot sites as well as addressing their concerns. The main aim was to finalize the recruitment and preparation of the end-users as well as to motivate them so that they actively participate. Additionally, discussions on the project objectives and how they will impact the future energy markets were held, enabling guests to provide feedback which will assist in the validation of user requirements and business cases. The workshop had over 30 attendees, comprising a wide cross-section of stakeholders, while responses were analysed and classified by type of stakeholder. Four types of stakeholders were identified:

- Transmission System Operators (1)
- Distribution System Operators (3)
- Small/Medium Enterprises - SMEs (5)
- Pilot-participants / potential end-users (24)

The main conclusions drawn from the open discussion are as follows:

- The representative from TSO raised the issue of curtailment of RES due to operational instability that is affected by the intermittent nature of the resources. Detailed discussion followed revealing that the capitalization of DR activities through the use of flexible generation and other flexible loads can offer alternative operational capabilities that will alleviate the problem.

- The representative from the DSO has indicated the need for a fair operation of the flexibility market in parallel with the energy market capable of supporting the needs of the grid in managing congestion that can prevail from distributed active sources (EVs, RES, etc.). Smart control through the advance features of inverters, energy management systems etc. can play a decisive role in managing the network of the future. This operation will not violate the operation of the market since aggregators of DR / flexibilities will operate within the boundaries of say time-of-use tariffs.

- SMEs who are interested in investing in the energy market did not perceive important incomes by sharing demand flexibility at domestic level, but rather a risky and uncertain investment with low expected remunerations. They were assured that the majority of future domestic electricity customers will be populated by prosumers with storage capabilities (EVs, Battery Energy Storage Systems) and therefore the flexibility potential will be much higher.

- Pilot participants and future potential end-users of the proposed DR solutions expressed that they are well educated in energy efficiency and they know how to make energy savings by themselves with no need to use smart systems. Nevertheless, they were willing to take part in the programme. Additionally, they were in favour of monitoring and real time information by means of a web or mobile app and they showed interest in a competitive award system where the competitors can reveal their identity if they wish. Furthermore, they preferred remote external control with smart systems, but they still wanted to keep control through a smart system at their will. The majority of them expressed that the initial investment cost can be a deterring factor, while any concerns they had regarding the changes in thermal and vision comfort levels were alleviated, as the UCY partners assured the participants that the implemented solution will take comfort levels into consideration.

Figure 45. Workshop Activity at UCY (1).

Figure 46. Workshop Activity at UCY (2).

Figure 47. Workshop Activity at UCY (3).

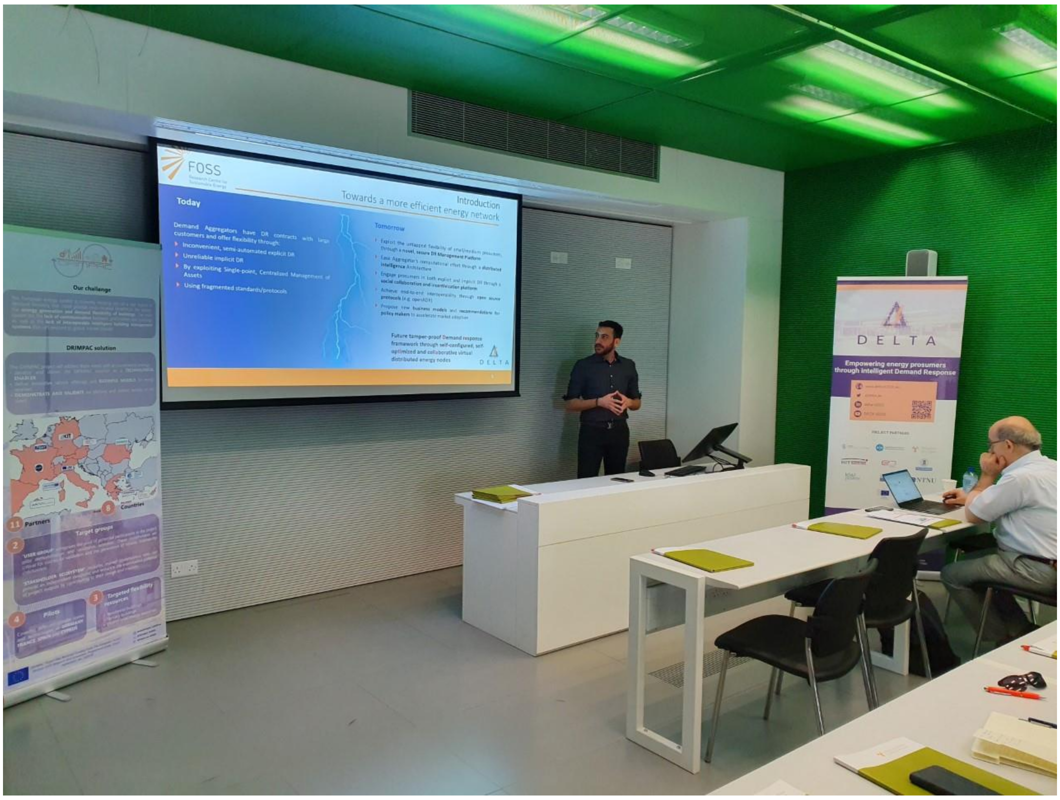

Figure 48. Workshop Activity at UCY (4).

3.2.3 Educational / Training Course

DR is one of the most customer-dependent options among “smart grid” solutions, thus successful strategies aiming to achieve effective and reliable DR participation should be developed through deep understanding of end-users’ awareness, expectations and concerns. In this scope, FOSS Research Centre for Sustainable Energy, UCY hosted an educational/training course on the 8^{th} of February 2020 at the University of Cyprus, where representatives of the pilot end-users as well as building/facility managers of the Cypriot pilot-site were invited.

The course ended with an open discussion where the 20 attendees expressed their interest on engaging with the projects as well as their concerns about the limited energy flexibility potential and the impact of DR on their comfort level. UCY partners assured the participants that the implemented solutions will take both thermal and vision comfort levels into consideration, while the flexibility potential will be maximized through the innovative decision systems introduced by the projects. Attendees also voiced their interest in engaging in a competitive award system and suggested various incentives that will motivate them to actively participate in the projects.

Figure 49. Educational / Training activity at UCY (1).

Figure 50. Educational / Training activity at UCY (2).

Figure 51. Educational / Training activity at UCY (3).

Figure 52. Educational / Training activity at UCY (4).

3.3 Stage 3 – Towards DELTA Deployment

3.3.1 UCY Deployment Plan

The technical implementation of the DELTA solution in the Cypriot pilot site requires a set of preliminary activities. In the current operation of the Campus, the potential to harvest electric flexibility is mainly identified in the cooling system of the buildings where direct load control can be applied. More specifically, explicit DR can be performed on the FEB and Library buildings. Temperature control at the FEB building can be applied separately on each floor and in three different levels:

- Economy (peak shaving/load shifting);
- Normal;
- Boost (increase consumption/valley filling).

Temperature control in the Library building is applied in a similar manner but without the floor division control as the ceiling of the building is common for all floors. It is important to note that running down of chillers on a regular basis will put strain on the mechanical parts of these assets. Since the demonstration provides no financial reward to the students and employees of the university, there will be a limit to the number of times the occupants are prepared to respond to a DR request. Additionally, it is essential for the university demonstration to not interfere with the student experience. While it is difficult to quantify the student experience, the intention is to ensure that the student life and comfort can continue to operate without undue interference from the running of the demonstration.

Implicit DR, in the form of Time-of-Use tariffs or Real Time Pricing, can be applied at the Residential Student Halls building set where no direct control on the installed BEMSs is available. Students of the UCY will be aware of the prices through web or mobile application that will be made available through the project and they will be compensated for their active participation.

In order to fully verify the functionalities and the integrated operation of the DELTA solution, the main focus of the Cypriot pilot site will be the PV Technology Laboratory, as the available PV systems, BESS and the existing central EMS will enable the testing of both implicit and explicit DR strategies.

The current lack of flexibility sources will be addressed with the purchase of various smart appliances (e.g. smart split units AC, smart lighting, smart HVAC system etc.) that will be installed at the facilities of the PV Technology lab. The operation of the aforementioned appliances will be based on multi-sensors that will ensure that the thermal and vision comfort levels of the UCY personnel will not be affected.

The DELTA interoperability framework will be verified through a Control and Monitoring System (CMS) that will be installed at the PV Technology Lab and will transform it into a fully operational nanogrid from energy management point of view. The CMS shall monitor and control the entire nanogrid installation and shall be based on IEC61850. The system is to provide interoperability between all devices. In this scope, a Remote Terminal Unit (RTU) will be purchased. The objective of the RTU is to permanently monitor itself and all subsystems and shall poll data from the bay units and I/O modules. This data will be comprised of time tagged inverter status information, system status information, alarms, measured values, metered values and fault records from IEDs. The RTU will update the real-time system database and transmit selected data to its communication processors, which will pass it on to the DSO control centre or the HMI(s). The RTU shall be capable to connect and exchange data via the communication bus with other microgrid control and monitoring systems or operator stations. Control and monitor via HMI of all substations connected to this LAN shall be possible. The operation of the CMS is illustrated in the following figure.

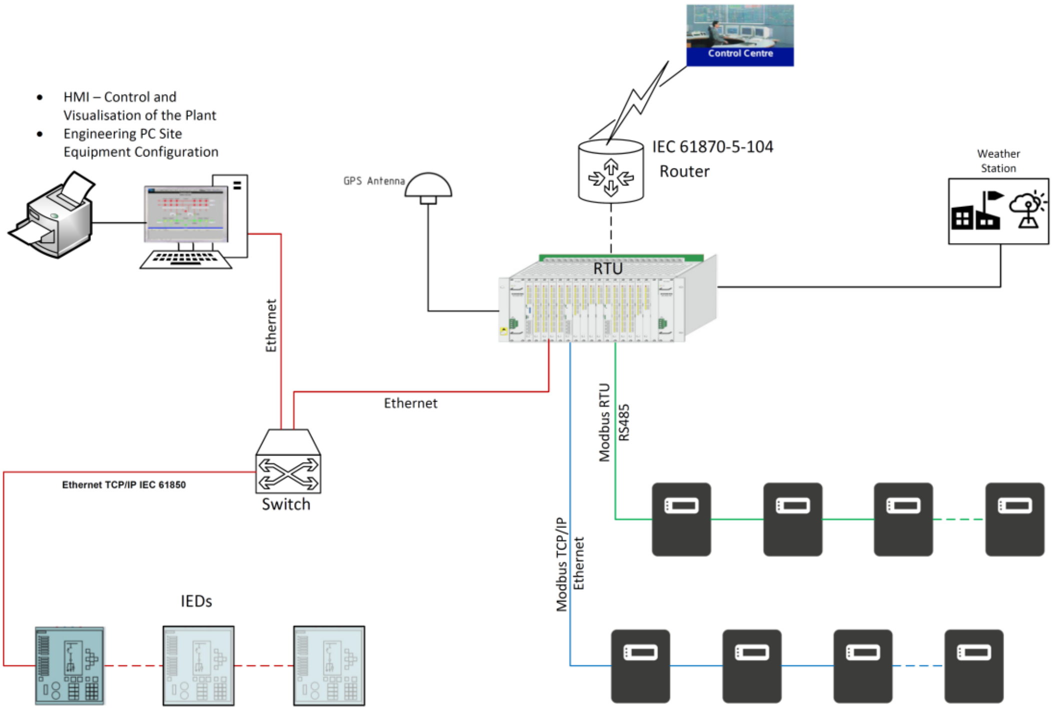

Figure 53. CMS operation Layout.

3.3.2 UCY Use-Cases

This section presents a detailed summary of the Use-Cases that will be employed at the Cypriot demonstration site for verifying the various DELTA solutions. An overview of Pilot-specific Use Cases is show in the table below.

Table 12. UCY Use-Cases.

ID	Use Case Description	Involved Partners
UC-UCY-01 [DELTA BS1-UC1]	**Flexibility forecast to improve assets availability declaration and maximise DR revenues** **Brief Description:** Accurate flexibility forecasts are produced for 2 hours / daily / weekly profiles to allow aggregators dynamic availability declaration and maximise DR revenues. **Objective:** Maximise availability and utilisation revenues from a given portfolio of turndown assets or from an existing portfolio of prosumers. **Main Course:** UCY, via the Node Flexibility Data Monitoring and Profiling (NFDM&P) component of the DELTA Virtual Node Platform (DVNP), collects data of short (one hour ahead), midterm (day ahead) flexibility forecasting, as well as power demand and supply for each building (Administration, Library, etc.). Moreover, the aforementioned data are used by the same component to readjust the availability declaration of each building based on their market programme. Those declarations are inputted to the Asset Handling Optimisation (AHO) and Self-Portfolio Energy Balancing (SPEB) both components of DVNP, which maximize revenues and improve overall reliability. Monthly performance reports will reflect the availability and utilisation based on the values forecasted by the DVNP: a) via the Demand Response & Flexibility Forecasting (DR&FF) tool and b) based on the metered values for the assets that have been dispatched. Settlements with the System Operator (SO) will be based on the availability data provided by the FEID generation, consumption, flexibility and forecasting tool.	UCY / EAC

UC-UCY-02 [DELTA BS3-UC1]	**Optimise prosumer RES self-consumption and increase flexibility** **Brief Description:** Integrate existing RES and consumption points via DVN to maximise self-consumption and reduce energy cost while maximising flexibility services. UCYs' RES includes buildings with photovoltaics, storage units, with various smart meters, inverters, and controllers. **Objective:** To maximise self-utilisation of RES generation while increasing flexibility. **Main course:** Buildings allocate RES generation capacity towards self-consumption as the main business rule on the DVNP. When RES generation capacity exceeds building, consumption need then is exported to grid, for a certain price or award that is based on agreement between UCY and DSO. When prices drop below certain threshold, the RES capacity is redirected towards self-consumption. UCYs' RES includes buildings with photovoltaics, storage units, with various smart meters, inverters, and controllers, which are able to increase flexibility through RES generation, as well as with temperature adjustments in both heating and cooling systems.	UCY / EAC

<table>
<tr>
<td>UC-UCY-03 [DELTA BS2-UC1]</td>
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Customer Admission to the Aggregator's Portfolio

Brief Description: The aggregator's personnel will be able to document the digital identity and the assets of the new customer and integrate to DELTA.

Objective: Automate as much as possible the admission of new customers to the aggregator's portfolio.

Main course:
The end-users that will interact within demand response signals for UCY case are the student residents and the staff of the PV Laboratory. End – users had complete and signed a concern form that includes:

Basic personal and contact information.
An elaborate description of the assets available on site.

The UCY's personnel examine the submitted data, contact the customer' (building) end-users to arrange an on-site inspection and verifies the building's claims, documents, any inconsistencies and other relevant information. Based on that, UCY's personnel should have all the necessary data available that will allow:

The customer's assets to be encoded and stored in the DELTA repository according to the DELTA at the buildings.
Proper configuration of the FEID that will installed at the buildings.
Determining the appropriate billing plan for the buildings.

Moreover, UCY's personnel should contact the customer and shares relevant information for the aforementioned above. When the billing plan is accepted, a second appointment is arranged for on-site installation of the FEID and other necessary equipment from UCY's personnel. Following the installation of the FEID, the UCY pulls from the DELTA repository the data pertaining to this building and employs the blockchain and smart contract tool to add the buildings' digital identity in DELTA's blockchain, which allows, among others, for the building to interface with DELTA. UCY, via the energy portfolio segmentation & classification component reruns the clustering algorithm and outputs the DVN to which the building will join.

UCY will develop a new web – application where the end-users will be able to participate in demand side response events, review their participation and check how much reduction to the billing cost they achieved and what their reward was. Furthermore, UCY will examine end-user contribution per billing period and will have the ability to remove and disengage end-users that were not active in demand response signals.
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<td>UCY</td>
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UC-UCY-04 [DELTA BS2-UC2]	**Customer Renunciation from the Aggregator's Portfolio** **Brief Description:** This use case documents the required steps to remove a customer from the aggregator's portfolio. **Objective:** Remove the customer's ability to access or interface with the aggregator's DELTA network. **Main Course:** When a customer needs to be removed, UCY must be able to disable any access or interface between customer and UCY's network. An on-site appointment will be arranged at the building, to verify the integrity and recover the equipment that was installed by the UCY personnel (this might include extra charges, e.g., damaged equipment). The contracts between building and UCY need to be physically terminated. Via the blockchain and smart contract tool the buildings' digital identity is removed from the DELTA blockchain, with an indication that is no longer an active participant, without delete the collected data, but store them in DELTA repository in order to preserve DELTA's auditability. UCY, via the energy portfolio segmentation & classification tool, issues the removal of the buildings FEID from DELTA, and inform the appropriate DVN that the prosumer is not active anymore. Finally, the DVN removes the buildings' FEID from its cluster.	CERTH, UCY
UC-UCY-05 [DELTA BS3-UC2]	**Providing localised flexibility portfolios for Distribution Network Operator to manage network constraints.** **Brief Description:** Allow flexibility clustering based on location to enable DNO to deal with specific network constraints locally. **Objective:** To enable network constraint management for DNO. **Main course:** In order to enable network management for DNO and allow flexibility clustering, UCY and EAC needs to emulate multiple scenarios and analyse them with different study cases. The following steps cover the general procedure where the scenarios will be based on. 1) EAC sends a request for flexibility to UCY for a specific geographical area (e.g. certain postcodes). 2) UCY is assessing the available flexibility in the target area via the energy portfolio segmentation and classification engine. 3) UCY sends back to the EAC an offer for flexibility including capacity, price and maximum dispatch duration for the specific area targeted by the EAC 4) EAC accepts the offer and sends UCY the agreed capacity to be dispatched and the maximum duration. 5) UCY sends dispatch signals to the buildings. 6) Flexibility is delivered over the agreed time period (initiated smart contracts are satisfied and certain flexibility capacity vs price is settled between the UCY and buildings). 7) At the end of the dispatch, performance report is issued highlighting the geographical area covered by the dispatch, the total Energy delivered over the period and the price agreed.	CERTH, UCY

UC-UCY-06 [DELTA BS3-UC1]	**Minimization of electricity operation cost of the whole campus** **Objective:** Minimization of electricity cost by optimally scheduling the consumption of end-users, the production of available RES and storage assets. **Main course:** The DR services can increase the profits in various market when the allocation of the flexibility sources rely with the best paying opportunities in close – to – real time. This will be supported by the Self – Portfolio Energy Balancing and Demand Response & Flexibility Forecasting, which are both components of the aggregator platform. The market actions (sell/buy electricity) and operation of its resources are scheduled by the aforementioned tools, based on the campus' RES technology and the ability to shift consumption/production of flexible loads, with the revenue can be maximized with the optimum selected schedule. The DELTA solution enables UCY's employees, students and residents to participate in both explicit and implicit DR that minimize the electricity costs, and maximize the revenue by participating into simulated flexibility markets. To be more precise, explicit DR services can be applied on the Finance Economics & Business (FEB) and Library buildings, by controlling temperature (heating/cooling) in three different levels: • Economy (peak shaving/load shifting); • Normal; • Boost (increase consumption/valley filling). Implicit DR can be applied at the Residential Student Halls building, with forms such as Real Time Pricing or Time-of-Use Tariffs, since there is no direct control on the installed BEMSs. A mobile application or a website can be used to inform UCY' students about the electricity prices, which are going to be developed through the project, and students will be rewarded for their active participation.	UCY, CERTH
UC-UCY-07 [DELTA BS1-UC1]	**Verification of accurate forecasting algorithms** **Objective:** Verify the accuracy of consumption and production forecasting algorithms using real data **Main course:** UCYs' large database is available for optimization and testing all the developed forecasting algorithms for both production and consumption. The database consists weather datasets (irradiance, ambient temperature), the historical data of the consumption and production, as well as the Numerical Weather Predictions (NWPs) that corresponds for campus location. The multiple categories of the tertiary buildings (lecture theaters, offices, social facilities, sports center), and the different technologies and capacities of the existing installed PV systems can classify the accuracy of the forecasting models regarding the production and consumption datasets.	UCY, CERTH

UC-UCY-08 [DELTA BS4]	**Meet DELTA targeted standardization activities** **Objective:** DELTA solution will be designed to support integration of different systems that are already present at pilot sites and future that will be deployed over the course of the project. **Main course:** The DELTA interoperability framework can be verified through communication with a Control and Monitoring System (CMS) that will be installed at the PV Technology Lab. The CMS shall monitor and control the entire nanogrid installation thorough a Remote Terminal Unit (RTU), connected with IEC61850 protocol, that will employ a combination of different communication protocols and gateways (Modbus TCP/IP, RS485) to communicate with current systems and newly deployed devices.	UCY, CERTH
UC-UCY-09 [DELTA BS3-UC1]	**Promotion of higher RES integration levels** **Objecitve:** Promotion of RES through increased self-consumption levels **Main course:** DELTA solution includes energy managements methods that are going to be deployed at the UCY pilot site by sustain the adequate levels of quality and security of supply, and with the penetration of RES production on power systems be promoted for increment. Self-consumption levels need to be analysed prior and after the DELTA deployment, to verify and investigate the percentage augmentation levels that the current PV capacity can reach without affecting the steady state of the grid. The aforementioned study will be examined with accurate modeling of the microgrid campus and the integrated PV systems.	UCY
UC-UCY-10 [DELTA BS1-UC1/UC2]	**Optimised flexibility leveraging for a connected microgrid** **Objective:** Validate the project's proposed solutions by coordinating both the demand and supply sides in a renewable-integrated, storage-augmented, DR-enabled microgrid to achieve system-wide resilient solutions. **Main course:** The validation of the solutions will be achieved through a full utility-integrated campus microgrid. The UCY campus incorporates with existing renewable technologies, BESS, infrastructure, departments and facilities, which all of them are going to be updated and reinforced with future developed technologies. UCY buildings (administration offices, sports facilities, students' dormitories, etc.) are classified as prosumers/consumers that are embedded in the microgrid, which will operate with the microgrid by integrating the current distributed RES generation through DR techniques in the most cost – effective and optimal manner. In this domain, the microgrid will operate by providing flexibility services to the local electricity market, with the energy demands of its interconnected loads. All the market activities will be emulated based on the actual measurements that will be recorded and through simulations. The use of the existing central EMS and other devices will support data acquisition, as well as to facilitate the mini market operation within the university campus.	UCY, EAC

4. UK Pilot Site – KiWi

4.1 Stage 1 - KiWi Pilot Infrastructure Description

The KiWi Power pilot site comprises focused pilots representing the commercial and residential sectors. As described on the report for D7.1 Pilot premises energy context analysis and end-users engagement/ training, KiWi Power will use Moor House (Central London, UK) but will no longer use the Ernest Dence Estate (Greenwich, UK), using instead the originally proposed Woodland Grove and Tome Close (Also known as Tom Smith Close) Estates. At the time of the D7.1 Report, KiWi were considering exploiting infrastructure and data from a current existing project, but after careful consideration and consultation with the project coordinator, it has been decided it was not a viable option and instead the pilots will switch back to the two originally proposed residential sites.

4.1.1 Moor House

Moor House is an office building located in Central London hosting approximately 4,100 employees and covering a total area of 43,300 m^2. Energy consumption is split between electricity (total annual consumption of 9,636 MWh) and gas (total annual consumption of 3,883 MWh). Each floor has a North and South zone of fan coils with individual temperature set points. KiWi Power controls the Air Handling Units (AHU) via propitiatory technology so that they can participate in the Static Fast Frequency Response (SFFR) programme, described in more detail later in this document. The front view of the Moon House is shown in the following figure.

Figure 54. Front view of the Moor House.

4.1.1.1 Demand Response at Moor House

In accordance with the requirements of the SFFR programme, whereby 1 MW of assets is required for participation, Moor House is part of a larger contract with other assets of similar technical characteristics to enable consistent availability for a 1 MW of turndown contract with the UK National Grid. Moor House gets monthly payments for availability (each month the availability payment prices are different due to the nature of the monthly procurement cycle for this product from National Grid). There are penalties that can be issued if the asset does not deliver the agreed turndown volume.

For the purpose of the pilot site, KiWi Power and partners will install the FEID alongside the existing proprietary KiWi Power technology (Fruit) that is currently managing these operations. The benefits of the FEID and the DELTA solution over the KiWi Power Fruit are detailed in the DELTA deliverable D2.1. The FEID will be preconfigured to respond to the UK National Grid Frequency and if the frequency goes above 50.2Hz then the FEID needs to give the action to the Moor House chillers to turn down to the agreed capacity. As the site is part of an existing contract under the Framework agreement of KiWi Power, any technological means to supply the necessary turndown value can be implemented without any issues around RFP regulations.

4.1.2 Woodland Grove Estate

The Woodland Grove Estate, shown in Figure 55, comprises of 110 residential units distributed over 5 low rise building hosting approximately 236 residents. Residential units were built in 1937 and they cover a total area of 7,200 m^2. Energy consumption is split between electricity (total annual consumption of 481.8 MWh) and gas (total annual consumption of 1,267 MWh). Utility charges vary based on specific supplier and tariff plans but averages for the borough for properties are 12p/kWh for electricity and 5.5p/kWh for gas, which makes the total annual cost of energy to be £57,800 for electricity and £69,700 for gas. The properties are all fitted with individual electricity and gas meters and there are gas and electricity meters in the boiler rooms supporting a district heating network.

Figure 55. Front view of the Woodland Grove Estate.

4.1.3 Tom Smith Close Estate

Tom Smith Close (also reported as Tome Close) Estate, shown in the following figure, comprises of 3 independent buildings part of the same estate. Each building is 4 stories high and hosting 20 flats, so in total 60 flats for the whole estate hosting approximately 128 residents. Residential units were built in 1965 and they cover a total area of 3,000 m2. Energy consumption is split between electricity (total annual consumption of 87.6 MWh) and gas (total annual consumption of 232 MWh). The total annual cost of energy rises to £10,500 for electricity and £12,800 for gas.

The properties are all fitted with individual electricity and gas meters and there are gas and electricity meters in the boiler rooms for the district heating network. Initial council plans for retrofitting heat meters and individual electricity smart meters and controls to each property have been postponed.

Figure 56. Front view of the Woodland Grove Estate.

4.2 Stage 2 - User Engagement Activities

The UK pilot sites fall into two categories: commercial and residential. The approach to user engagement is different giving the nature of the both types of sites, with Moor House (commercial) being a customer of KiWi Power already and the Woodland Grove and Tom Smith Close Estates being residential buildings.

For the former, KiWi follows the internal procedure within Account Management by sharing details of the project and its objectives and agrees on a process forward.

For the latter, the residential Estates, KiWi has a more curated approach as the focus is on Residential DR. The objective is to mitigate electricity disruption and power outages, by establishing a more direct form of communication between energy networks (e.g. the National Grid in the UK) and energy consumers (residents), via the DELTA aggregator. The plan within DELTA is to invite 190 households in the mentioned estates in Greenwich to join a residential community engaging with DSR.

4.2.1 Participant Recruitment

The message convened to potential users is that they will be rewarded for adapting their in-home electricity usage when demand exceeds supply from the National Grid.

KiWi Power have developed an 'Introduction to Demand Response' document that is used to explain to potential clients the need for Demand Response and how they could potentially participate in DR programmes and benefit financially for doing so:

> *"Demand Response" means reducing electricity consumption from the distribution network for short periods when the national electricity system is under stress.*
>
> *At certain times of day National Grid needs access to sources of extra power in the form of either generation or demand reduction, to be able to deal with actual demand being greater than forecast demand and/or generation unavailability.*
>
> *Traditionally, National Grid procured this requirement from peaking power stations and other, older, less efficient and more expensive power stations.*
>
> *Most of these old, inefficient, polluted power stations are in process of decommissioned for environmental reasons, and also they were too expensive to be kept operational.*
>
> *This creates the need of having DR.*

The established narrative here is that the existing methods for dealing with peak power periods are expensive and dirty power stations and that DR brings and opportunity to clean up the supply and reduce peak consumption.

As a first step, a set of materials will be distributed to the residents, introducing them to the DELTA project and showcasing the importance of the project. Subsequently additional materials might be sent as well, which could also include project breakthroughs or achievements. These could take the form of flyers and leaflets. The materials considered for circulation to potential participants include the following:

- general introduction leaflet,
- first project brochure - executive summaries of the project,
- second project brochure later on
- posters and roll-ups,

- introduction / explainer video.

The residents could also be invited to a workshop that would aim to raise awareness, engagement and acceptance. The methodology includes distribution of targeted promotion materials as well as:

- presentation of the importance of the DELTA activities,
- what are the specific outcomes of the project in an understandable and simple way,
- how can each of them benefit from the DELTA results,
- what activities are expected from each of them.

There is also a consideration for a website to be built to showcase the project and to encourage sign ups. Likewise, an explainer video could also be produced to help potential users understand the vision and purpose of app. This tool is also useful for project partners to retweet across their own social media channels and share at events.

In addition to this work, a number of options are being discussed to further engagement:

- **Social media:** Sharing relevant messages and content on social media to promote the programme and events, tagging in partners where possible and using key project hashtag.
- **Infographics:** Using digital infographics to clearly demonstrate the user journey.
- **Press Releases:** sharing a press release to announce the programme and call for participants.
- **Magazines:** Either online or printed publications distributed across the residential estates.
- **Mailing Lists:** with Residents who might sign up.
- **Community Groups:** Local community groups to help spread the word to their members.
- **Case studies:** Insights and feedback from a selection of users in order to stimulate further uptake.

4.3 Stage 3 – Towards DELTA Deployment

4.3.1 KiWi Deployment Plan

4.3.1.1 Moor House

As mentioned, Moor House is a current commercial partner of KiWi Power and so the deployment of DELTA's FEID will harmonize with the existing infrastructure at site. The KiWi Power Hardware devices are called Fruit and they have been integrated with a test FEID and now communicate via MODBUS.

Figure 57: KiWi Training Example – Equipment Description.

Once deployed the FEID will be able to monitor frequency and respond when the network is outside preset boundaries set out in the SFFR programme and described in Section 4.1 (KiWi Power Pilot Infrastructure Description). The assets available at Moor House are six 250 kW chillers (shown in Figure 58), however not all of that stated capacity will be available for demand response and so they are aggregated with other assets. In addition, given the response time of the chillers they can only participate in the Static Fast Frequency Response programme that allows full deployment of the response within 30 seconds of the dispatch signal. There are also fail safes in the programming of the Fruit that ensure the building maintains comfort levels within its operational parameters.

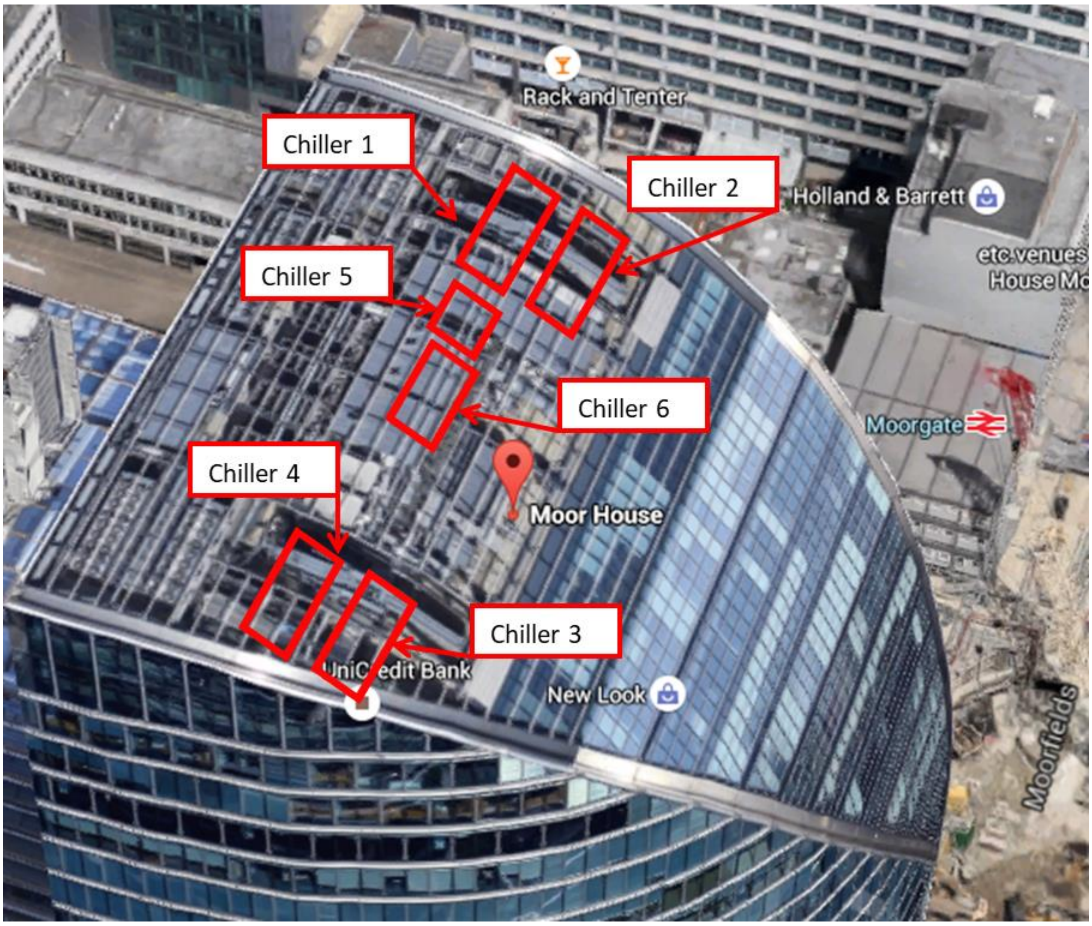

Figure 58: Layout of six chillers on the roof at Moor House.

The FEID has now been fully integrated with the FRUIT and is ready to be tested on site. The deployment to site for final testing will be completed once site access is available. Currently (April 2020) site access is restricted due to the Coronavirus lockdown.

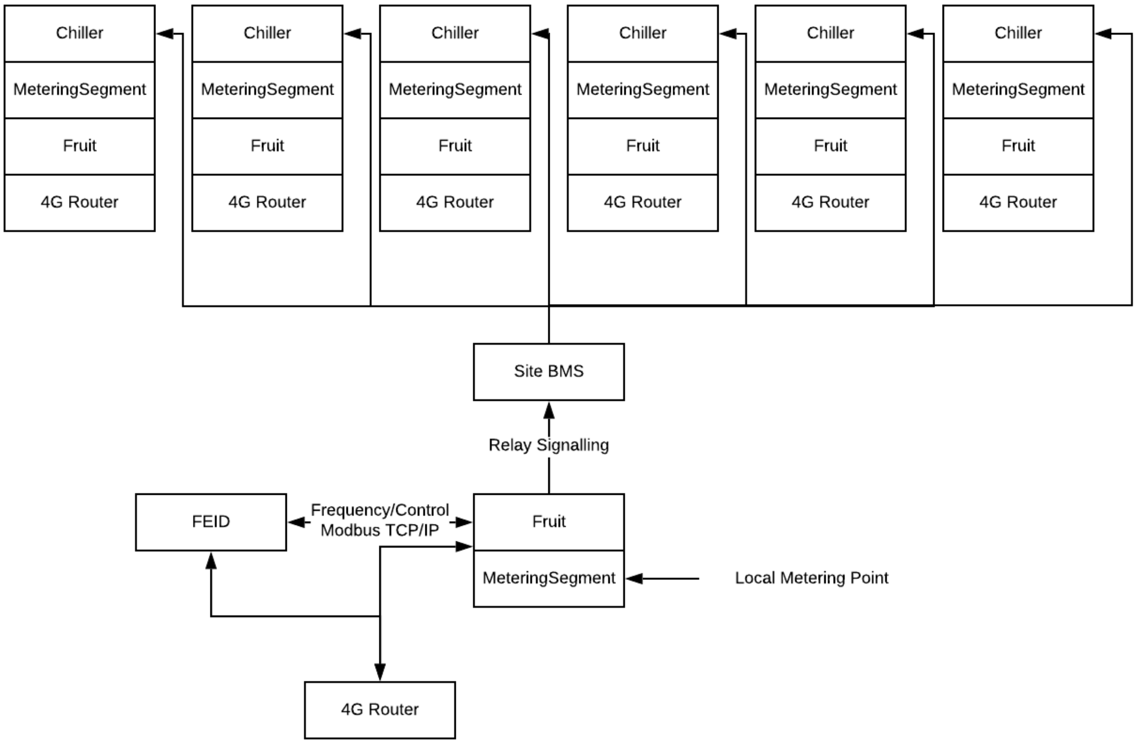

Figure 59: FEID integration with existing hardware on site at Moor House.

4.3.1.2 Residential DSR

As KiWi Power is no longer using the Ernest Dence estate as a residential Demand-Side-Response (DSR) pilot, it will take some time to engage with residents at the Woodland Grove and Tom Smith Close estates. We have already re-engaged with the Royal Borough of Greenwich Council to gain their approval to approach residents at these estates. The Council have been accommodating and have agreed to participate and support our activities where possible.

Once residents have signed up for participation in the project, they will be contacted to arrange an appointment to install a domestic electricity consumption monitoring device. At the appointment the installer will:

- Install a CT clamp on electricity meter, and connect the communication hub to broadband. These are installed in minutes, and do not require any specialist electrical knowledge.
- Install and set-up of DELTA implicit demand response app on resident's mobile or tablet.
- Provide an explanation of the scheme, including and passing on a how-to-guide.
- Administrate data privacy agreement for electricity meter data between KiWi Power and resident.

The domestic electricity consumption device will transmit data back to KiWi's central servers. This data will provide evidence of the extent of the implicit demand response triggered through DELTA's app. An overview of the architecture can be seen in Figure 60.

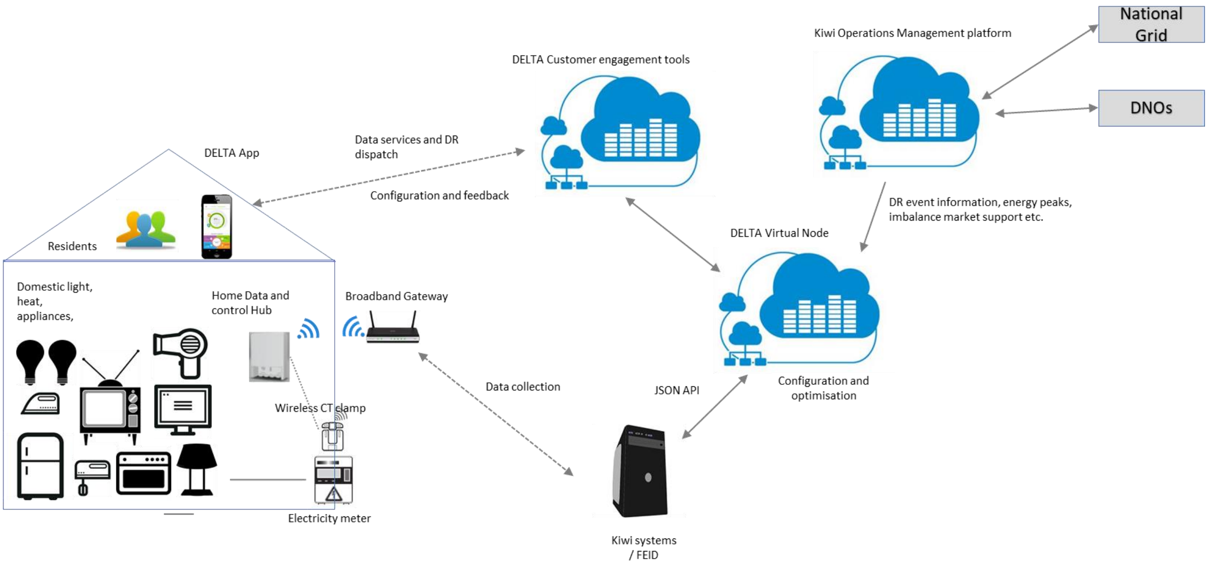

Figure 60: Residential DR deployment at pilot sites.

4.3.2 KiWi Use-Cases

The use cases that will verify the DELTA deployment solution are presented in this section.

4.3.2.1 Moor House demand response use case

Table 13. Moor House Use-Cases.

UC – KIWI - 01 [DELTA BS2-UC1/UC2/UC3 & BS3-UC2 & BS4-UC1/UC2]	
Use Case Name	Demand response through self-configured, self-optimized and collaborative virtual distributed energy nodes Static Frequency response and peak energy notifications
Pilot site	Moor House, 120 London Wall, London EC2Y 5ET
Authors	KiWi Power
Brief Description	FEID will be installed to the asset of Moor House and with KiWi Power they will response to real Static Frequency responses events
Assumptions & Preconditions	Connect FEID to the chiller of Moor House of turn-down capacity 367KW to provide a Non-dynamic response to the frequency fluctuation. KiWi Power has already installed their own technology and will be a back-up in case the FEID doesn't give the command in time. Moor House will also receive Triad warning notification to reduce the import and usage of electricity during the winter period with the heist energy peaks to relief the network constraint. FEID must comply with the Cybersecurity Act (2019/881/EU).Its important to safeguard the solidity of the Project excluding possible data breaches. Site has via the BMS cybersecurity protocols so we need to ensure that DELTA technology complies with the Act.
Objective	To prove that FEID and DVN can collect the consumption data of the asset to optimise it for DR events and also response to a real time Frequency event.
Effects/Post Conditions	Client will continue his participation to SFFR via DELTA and receive revenue from NG
Involved Actors	KiWi Power, DELTA partners, Moor House

Main course	1. A FEID device to measurement (or set of measurements). 2. The FEID as a blockchain full node checks whether this comes from a legitimate device. 3. The FEID accepts the transaction and adds it to the blockchain ledger informing the DVN Agent.
Alternate Courses	The asset fails to response to the event and no payments are made to Moor house.

4.3.2.2 Residential demand response use case

Table 14. Residential demand response Use-Cases.

UC – KIWI – 02 [DELTA BS1-UC1/UC2 & BS2-UC1/UC2/UC3 & BS3-UC2 & BS4-UC1/UC2]	
Use Case Name	Demand response through self-configured, self-optimized and collaborative virtual distributed energy nodes TRIAD warnings notifications
Pilot site	Woodland Grove and Tom Smith Close – Greenwich
Authors	KiWi Power
Brief Description	Automatic settlements via smart block chain enabled smart contracts to improve cash flows and reduce settlement period. End user will get Triad avoidance suggestions(phone app notifications) to reduce consumption
Assumptions & Preconditions	Connect FEID to the smart meters of the houses to monitor electrical consumption. During the trial period will send push notifications via the DELTA phone application to suggest to the end users to reduce the electrical consumption to avoid higher electrical tariffs
Objective	DELTA technology to improve the electrical consumption and reduce the energy bills
Effects/Post Conditions	End user will receive push notifications with valid suggestions in order to reduce the electrical bills. DELTA can only suggest the electrical turn down of the end user
Involved Actors	KiWi Power, DELTA partners, Woodland Grove and Tom Smith Close Estate – Greenwich
Main course	1. The FEID device to measure (or set of measurements). 2. The FEID as a blockchain full node checks whether this comes from a legitimate device. 3. The FEID accepts the transaction and adds it to the blockchain ledger informing the DVN Agent.
Alternate Courses	The end user doesn’t accept the suggestion of DELTA and consumptions are not reduced.

5. DELTA Deployment Timeplan

The time schedule for the DELTA deployment at the demonstration sites is depicted in the following figure.

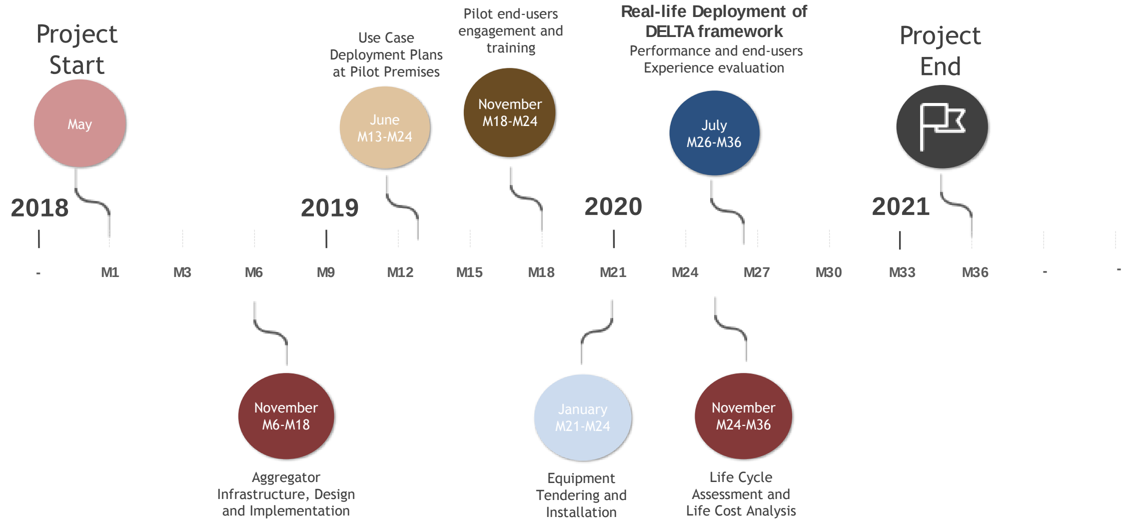

Figure 61. Timeplan of the DELTA Deployment at the pilot-sites.

The deployment plan for the pilot sites begun in January (M21) with the tendering of all required equipment as well as preliminary testing at pilot sites with the FEID 2.0, and it was expected to be finalized with the installation and set-up of the final FEIDs and ultimately the DELTA solution by the end of May. However due to the coronavirus outbreak the deployment plan has been affected, as will explained below.

Pilot-leaders follow the legal tendering procedure for installing and commissioning the required equipment and therefore the typical challengesa and delays are anticipated. Challenges related to the installation and commissioning phase commonly include:

- coordination with the financial department of the pliot-leader’s organisation;
- delays due to price negotiation process;
- delays due to out of stock products;
- long delivery periods;
- installation delays due to technical challenges.

Added to the afformentioned challenges, currently (April 2020), the coronavirus spreads around the world and its impact is increasing, thus inevitably adversely affecting the conducted research work. UCY and KiWI are facing additional unexpected equipment and services delays that slow the deployment of the DELTA solution. The purchase of the required equipment is also affected by the slow responsiveness of companies due to the current situation. Moreover, this outbreak constitutes an excusable delay under the contract’s force majeure clause extending the delivery date of services and goods that are already in line.

Given the current situation and mode of operation, the pilot-leaders estimate that the pilot activities could be delayed be for at least two-three months to ensure that all necessary activities, including the commissioning of services and installation of equipment, will be fully met for the smooth deployment of the DELTA solutions at the pilot-sites.

A more detailed pilot deployment plan for pilots will be included in D7.2 "DELTA framework deployment and pilot realisation v1" which is due M26. Hopefully, the situation related with the coronavirus outbreak will have settled, allowing a more concrete planning.

6. Conclusion

The developemnt of the pilot demonstration plan by analyzing the pilot premises in terms of infrastructure and end-user engagement as well as the definition of the plan for deploying the DELTA framework (hardware and software) in the pilot sites are documented in this deliverable.

A thorough survey of the DELTA Pilot Sites (UCY and KiWi) that aided towards identifying flexibility sources as well as Distributed Energy Resources (DER) that will validate the DELTA use cases, along with information on existing systems that could be used with the DELTA Fog Enabled Intelligent Deivces (FEIDs) is initially performed.

The two pilot sites host different end-users and operate under different regulatory, legal and market frameworks. This may trigger the need to treat several important aspects differently. To be fully prepared for the pilot realisation the pilot leaders analysed in detail the technical and socioeconomic parameters of their pilot in order to adjust the delpoyment of the DELTA solution and engange the end-users accordingly. To this end, this version also expands on the methodology that has been followed for the population of the User Group participants as well as the training and engagement activities of end-users. The activities have been or are scheduled to be conducted by the pilot partners in order to obtain public feedback and train participants so as to promote active participation.

Finally, this document, presents the deployment plan for DELTA solution that is derived based on building requirements, hardware and software requirements as well as deployment strategy for the installation of the FEIDs. The deployment plan also includes the pilot specific use-cases that will validate the innovative functionalites of the DELTA solution.