D5.3 Web-monitor system of BEM performance

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CONTENTS

TERMINOLOGY AND ABBREVIATIONS

BEMO	Building Energy Management system Optimizer = overall S4ECoB system
BMS	Building Management System
BEMO server	Central component of each BEMO installation (usually 1 BEMO server per building / site); consists of several software components (e.g. data base, data fusioning module, GUI and BMS interface, gateway to occupancy sensor network, internet remote access) running on a dedicated PC / server or on PC / server which is already part of the BMS
BEMO Control and Management Platform	a web application running on the BEMO server, accessible through internet connection and a web browser, that comprises the communication platform, the optimization unit, a messaging system and four software communication modules
AHU	Air Handling Unit

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EXECUTIVE SUMMARY

This deliverable is associated to T5.5, consisting of a web based monitoring system for benchmarking the energy performance of the building air conditioning systems before and after the implementation of the S4ECoB system optimization as support to the decision making.

The software monitoring system has been integrated directly into the BEMO Control and Management Platform and provides direct information to the current BMS through the optimization unit.

Unfortunately it was not possible to implement a complete and fully functional monitoring system. The difficulties encountered in the accessibility of the Building Management System (BMS) in the three project pilots delayed and/or made the successful implementation of the optimization logic developed in WP5 impossible. For this reason a detailed analysis of the energy performance before and after the optimization was not possible.

In the Linate airport, Honeywell has not granted the right to access their BMS installed physically on the pilot site, therefore no direct interaction between BEMO and BMS was established and no real-time optimization could be performed. Due to these restrictions and based on the optimization strategies specifically developed in the context of D5.2 "BEM performance quantification, verification and cost-benefit analysis", in Linate a comparative table of the optimization model with real historical energy data was implemented along with energy saving calculations in order to accomplish the task goal described above.
The only implemented facility monitoring functionalities in the Linate pilot site was the graphical representation of charts plotting the available historical data from the boxes composing the Air Handling Unit (AHU) system.

In Principe Pio shopping centre, the technical difficulties encountered during the implementation of the BACnet communication, along with the reluctance of Siemens in enabling the read and write communication between the BMS physically installed on the pilot and the S4ECoB System, have not led to the successful connection with the desired controllers that would have been necessary to perform the monitoring and optimization goals. However, the optimization controlling interface has been implemented in the optimization unit module and it is ready to be used anytime Siemens will provide the required access to the BMS.

In Maremagnum shopping centre, the connection between the S4ECoB System and the BMS was successfully established allowing the end user to access the controlling interface and energy data monitoring dashboard that have been implemented.

1 INTRODUCTION

1.1 Purpose of this document

The purpose of this deliverable is to describe the web monitoring system for the visualization of the BMS performance according to the optimization provided by the BEMO.

The document presents the optimization unit software module, detailing the general optimization routine and the optimization logic that has been implemented for the three pilot sites.
Further, the web monitoring system is presented, explaining the web pages to control and monitor the BMS.
Finally a recap of the work that has been done and the solutions developed concludes the deliverable.

1.2 Structure of the deliverable

This document is structured as follows:

- Chapter 2 presents the optimization unit software module that is integrated into the BEMO Control and Management Platform, describing the general optimization routine and the optimization logic implemented for each pilot site.

- Chapter 3 is the main chapter of this document and it presents the implemented web monitoring system. Section 3.1 is dedicated to the BMS controlling interfaces web pages, while section 3.2 for BMS monitoring web pages.

- Chapter 4 reports some key conclusions about the achieved results.

1.3 Relationship to the project objectives

This deliverable describes the optimization unit and the web monitoring system that are integrated into the BEMO Control and Management Platform running on the BEMO server, installed on the three operative demonstrators (Objective 7), and composing the BEMO system (Objective 5). The optimization is performed based on the occupancy levels recorded by the Occupancy Sensor (Objective 2) composed by the APU (Objective 1).

1.4 Relationship to other deliverables and tasks

The presented deliverable takes inputs from T4.2, T4.4, T5.2 and T5.3 and the associated deliverables. From D4.2 this deliverable takes the nomenclature and the consolidated architecture of the BEMO system. From D4.3 it uses the definition of the BEMO Control and Management platform in which the software modules are integrated. From D5.1 and D5.2 it obtains the optimization models developed during the project.

1.5 Contributions of Partners

DAPP had the main responsibility to prepare this document.

2   OPTIMIZATION UNIT

The optimization unit, consisting of
-   i)   optimization logic and algorithms,
-   ii)   energy system monitoring tables and charts,
-   iii)   BMS control web interfaces and,
-   iv)   energy data stored in the database,

is not an external module of the BEMO system, but is developed within the BEMO Control and Management Platform Web Application that is described in details in Deliverable 4.3 "BEMO control and management platform".

The logical workflow of the main optimization routine performed by the optimization unit, presented in Figure 1, is subdivided in five main steps:
1.   Connection to the Building Management System (BMS)
2.   Read current value of energy data to optimize from the BMS
3.   Application of the optimization logic developed in the context of the present WP5
4.   Write optimized energy data values to the BMS
5.   Insertion of a new optimization record into the database

If an error occurred or a step fails, a specific error record is inserted in the database and the procedure skips the following phases except the insertion of a new optimization record comprehensive of the transaction status, which reports eventual errors.

Only the user Administrator can manage the error records through the Administration pages of the BEMO Control and Management Platform, but the Optimization Manager can monitor the transaction status through view access to the optimization records in the database.
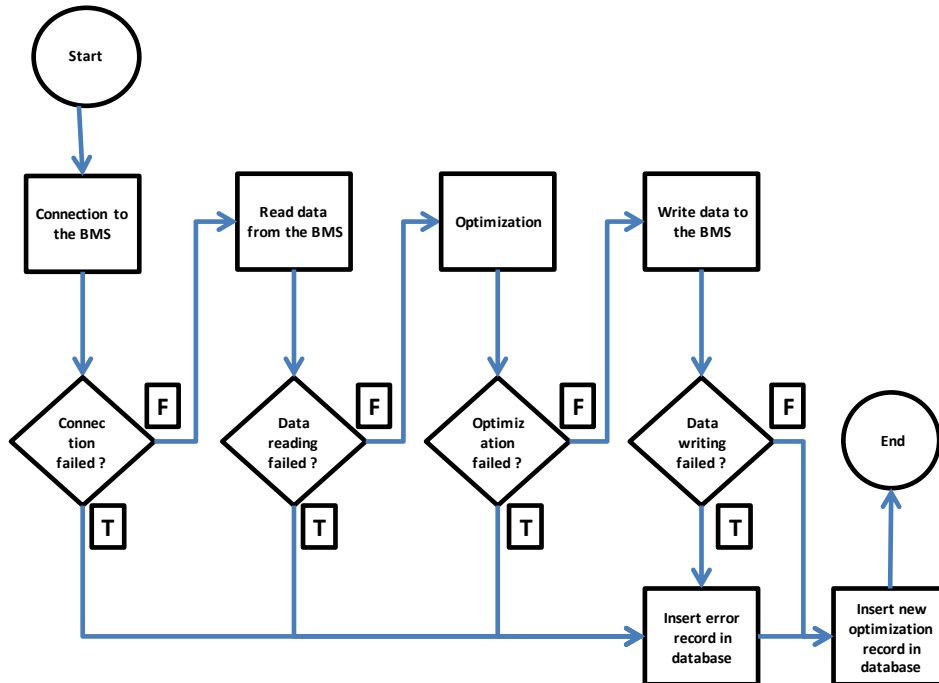
Figure 1- Optimization routine workflow

2.1 Linate

According to the operating context introduced in the previous chapter, the optimization logic implemented in Linate suggests optimized values for minimum ventilation rate, hot flow, and cold flow in heating and cooling mode. Those optimized values are based on the occupancy level detected by the S4ECoB system in the airport, see D5.2.

Table 1 shows the implemented optimization logic. The potential energy saving at different occupancy levels in the heating and cooling season can roughly be calculated by putting the average measured flow per gate into relation with the proposed occupancy-derived flow per gate.

This model assumes that the reduction in flow is linearly linked to the energy reduction, so the reduction in flow is a good estimate for energy savings.

Occupancy Level		0	1	2	3
Minimum Ventilation Rate [m3/h]		336	450	1500	2400
Hot Flow [m3/h]	**Heating Mode**	1500	1000	1200	1900
	Cooling Mode	150	150	300	400
Cold Flow [m3/h]	**Heating Mode**	0	200	300	500

	Cooling Mode	200	300	1200	2000
Energy Saving [%]	**Heating Mode**	50	60	50	20
	Cooling Mode	88	85	50	20

Table 1 - Potential energy savings in Linate

For further details on the optimization model developed in Linate please refer to Deliverable 5.1 "Calibrated and optimized building models and energy consumption" and Deliverable 5.2 "BEM performance quantification, verification and cost-benefit analysis".

The logical workflow of the implemented optimization comparative algorithm used by the comparative table described in subsection 3.1.1 in the present document is shown in Figure 2.

For each record in the analysis, the corresponding BMS ventilation rate, hot flow and cold flow, are taken, then according to the associated occupancy level detected by S4ECoB system, the corresponding values listed in Table 1 are selected for cooling or heating mode. The optimized values listed in Table 1 are shortened in Figure 2 as Opt. Value. Then the BMS values are checked with optimized value related to the occupancy and eventually set to correct. When the analysis stops, the average energy saving is calculated over the period analysed.
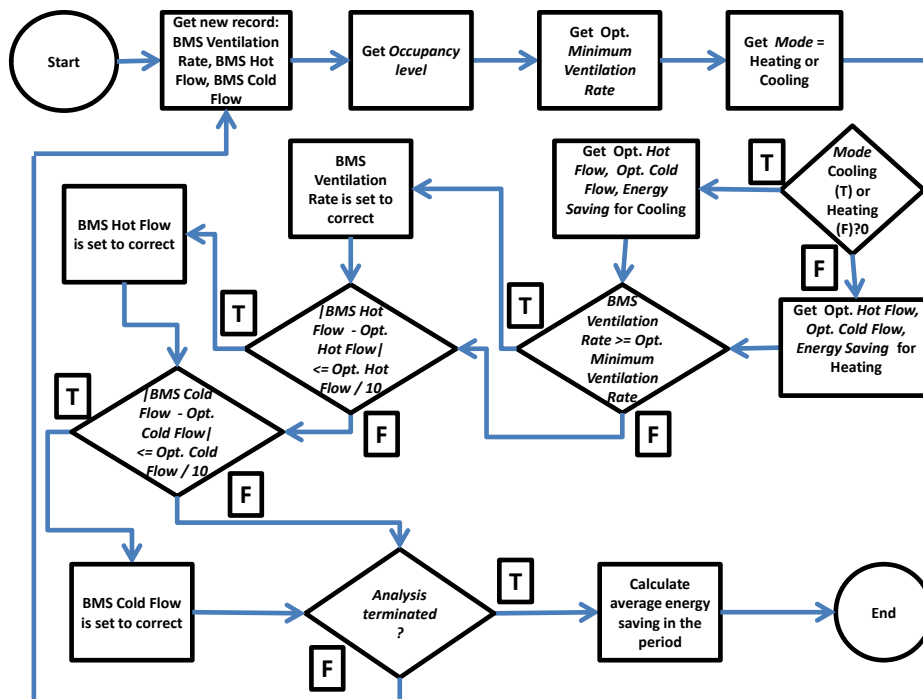
Figure 2 - Linate optimization logic workflow

2.2 Principe Pio

In Principe Pio shopping centre the optimization routine implements a strategy to optimize the set point temperature of the two rooftop units. The strategy runs with a frequency of 15 minutes.

Figure 3 presents the logical workflow for the implemented optimization strategy based on the following seven parameters:

1. Optimization planning schedule: calendar input with hourly granularity specifying which days the strategy is going to work.
2. Heating and cooling mode periods: start and end date for the two periods in which respectively cooling and heating strategy (and appropriate matrix) has to be applied.
3. Maximum occupancy estimated for the day: calendar input with daily granularity specifying the maximum occupancy level expected for the day.
4. Last occupancy detected: the occupancy level associated to the last record of tb_audio_metadata stored in the database.
5. Maximum occupancy detected for the day: the maximum occupancy level associated to all the record of tb_audio_metadata stored in the database during the current day.
6. Cooling matrix of set points: the elements of this matrix are the optimised set points temperature values for the cooling period.
7. Heating matrix of set points: the elements of this matrix are the optimised set points temperature values for the heating period.

The two matrixes implemented by the strategy are provided manually by the Optimization Manager in the web control interface described in subsection 3.1.2 and are structured as follows in Table 2:

Current occupancy level	0 (has the daily maximum occupancy been reached yet?) No	1 (has the daily maximum occupancy been reached yet?) Yes
0	Set Point[0,0]	Set Point[0,1]
1	Set Point[1,0]	Set Point[1,1]
2	Set Point[2,0]	Set Point[2,1]
3	Set Point[3,0]	Set Point[3,1]

Table 2 - Principe Pio matrix of set points temperature

First of all the Boolean flag in the optimization planning schedule is read in order to know if in the current hour of the current day, the optimization strategy has to be performed. If not, the algorithm terminates. Otherwise, the heating or cooling mode is identified, then the estimated maximum occupancy level of the current day is read, the last occupancy level is detected, and the maximum occupancy level detected in the current day is calculated. The matrix of set points is chosen according to heating or cooling mode identification: in the case of heating mode, the heating matrix is chosen, otherwise if cooling mode, the cooling matrix is chosen. Then the optimized set point is selected in the chosen matrix substituting to the rows the last occupancy level detected and to the columns a Boolean flag which indicates if the maximum estimated occupancy level has been reached during the day.
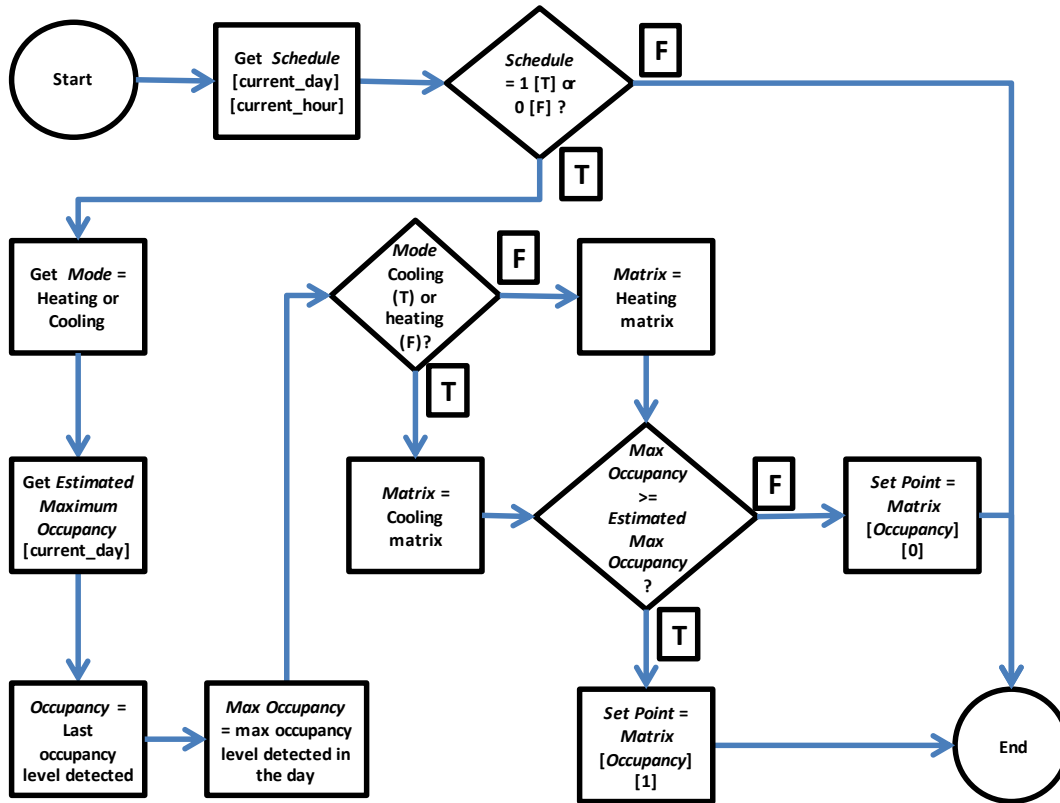
Figure 3 - Principe Pio optimization strategy logical workflow

2.3 Maremagnum

In Maremagnum shopping centre the optimization routine implements a ventilation control strategy to optimize the frequency (Hz) of the fan engine. The strategy runs with a frequency of 15 minutes.
The strategy implements an optimization formula for ventilation as follows:

$$Frequency = A * Occupancy + B$$

Figure 4 presents the logical workflow for the implemented optimization strategy based on the following seven parameters:

1. Optimization planning schedule: calendar input with hourly granularity specifying which days the strategy is going to work.
2. Constant frequency value: this value will be applied to the frequency in the case the optimization is not planned.
3. A parameter value: the A parameter in the optimization formula for ventilation.
4. B parameter value: the B parameter in the optimization formula for ventilation.
5. Frequency lower bound: lower bound that defines the minimum value the optimized frequency can take and be sent to the BMS.
6. Frequency upper bound: upper bound that defines the maximum value the optimized frequency can take and be sent to the BMS.

7. Last occupancy detected: the occupancy level associated to the last record of tb_audio_metadata stored in the database.

First of all the Boolean flag in the optimization planning schedule is read in order to know if in the current hour of the current day, the optimization strategy has to be performed. If not, the constant frequency value is applied as the optimized frequency to be written into the BMS and the algorithm terminates. Otherwise, A and B parameter of the optimization formula for ventilation are set together with lower and upper bound for the optimized frequency value, and the last occupancy level is detected. Then the optimized frequency value is calculated through the already presented optimization formula for ventilation and the resulting value is checked to be between lower and upper bound. If the value is over the upper bound, the upper bound is selected as the final frequency to be written into the BMS, instead the lower bound is selected if the value is below the lower bound. This control permits to avoid bad frequency value to be written into the BMS.
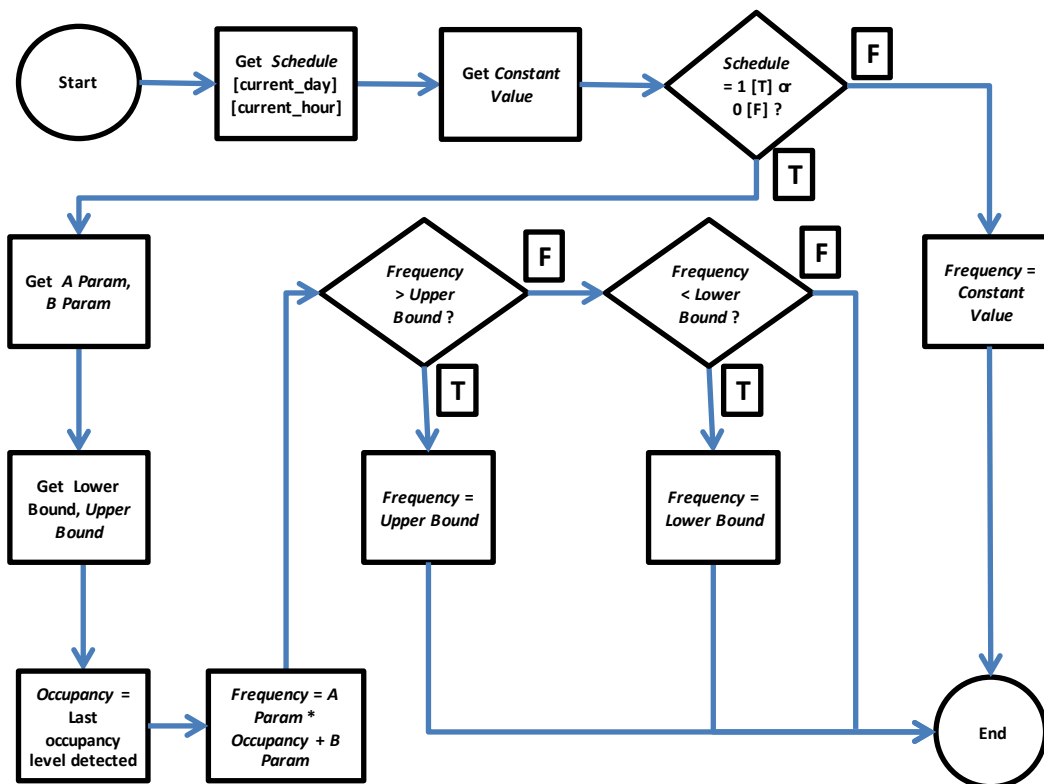
Figure 4 - Maremagnum optimization strategy logical workflow

3 WEB MONITORING SYSTEM

The structure of the web pages for the web-monitoring system of the BEMO Control and Management Platform (fully treated in Deliverable 4.3 "BEMO Control and Management Platform") are treated in excerpts with a focus on the visualisation of the optimisation results and on the control of the optimization routine.

For general layout and functional details of the BEMO Control and Management Platform please refer to Deliverable 4.4 "BEMO Manual".

3.1 BMS Controlling Interfaces

In order to control, manipulate and tune the optimization algorithms developed for the three pilot sites, a web page customized for each pilot site has been implemented.

3.1.1 Linate

Figure 5 presents the comparative table and energy savings calculation web page implemented for Linate airport. The controlling interface could not be implemented because it was not possible to access the BMS.

The user should perform six actions in order to compare the energy consumption with and without the S4ECoB optimization and calculate potential energy savings:

1. **APU selection**: clicking the "Choose one APU" button, a selection list will open for choosing the APU for the analysis.
2. **AHU selection**: clicking the "Choose one AHU" button, a selection list will open for choosing the AHU for the analysis.
3. **Start date selection**: clicking the starting date button, a calendar will open in order to help the user choosing a starting date for the analysis.
4. **End date selection**: clicking the starting date button, a calendar will open in order to help the user choosing a starting date for the analysis.
5. **Gate selection**: clicking the "Choose one Gate" button, a selection list will open for choosing the Gate for the analysis.
6. **Start the analysis**: After the selection of an APU, AHU, start date, end date, gate, clicking the "ShowData" button, the analysis will start showing the comparative table and the average potential energy saving.
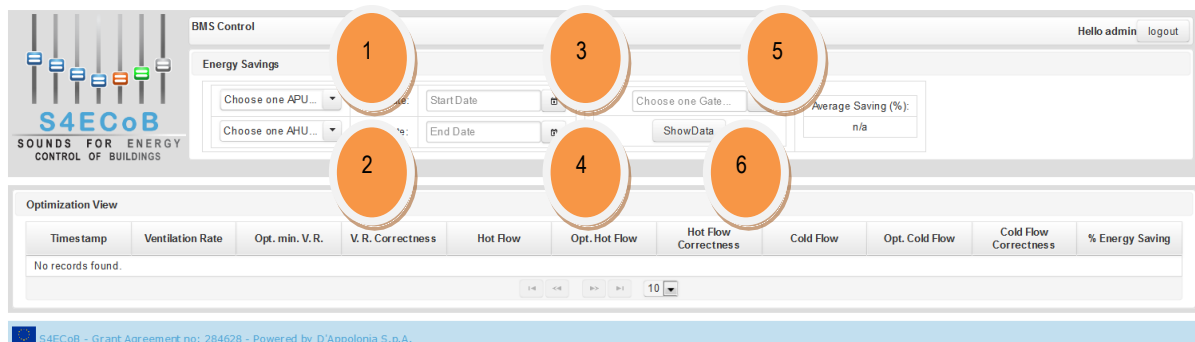
Figure 5 - Linate comparative table and energy savings web page: analysis selection

Once the selection was performed and the "ShowData" button is pressed, the retrieved energy data stored in the database together with the optimized values proposed by the optimization model according to the recorded occupancy level will be shown in the main content area of the page (point 2 in Figure 6). On the header of the page, on the right, the average potentials energy savings calculated in the analysed period will be shown (point 1 in Figure 6).

The main content area of the page (point 2 in Figure 6) shows 11 columns. The first column to the left is the timestamp of the record on the database. For each record the table presents the real BMS ventilation rate, the hot flow and the cold flow for the selected gate. To the right of this value, two columns indicates the corresponding optimized value and a Boolean flag suggesting if the real BMS value is in line with the optimized value or not. The last column states the potential energy saving percentage provided by turning S4ECoB system ON. For details on how optimized values, Boolean flags and potential energy savings percentage are provided please refer to section 2.1 of the present document.
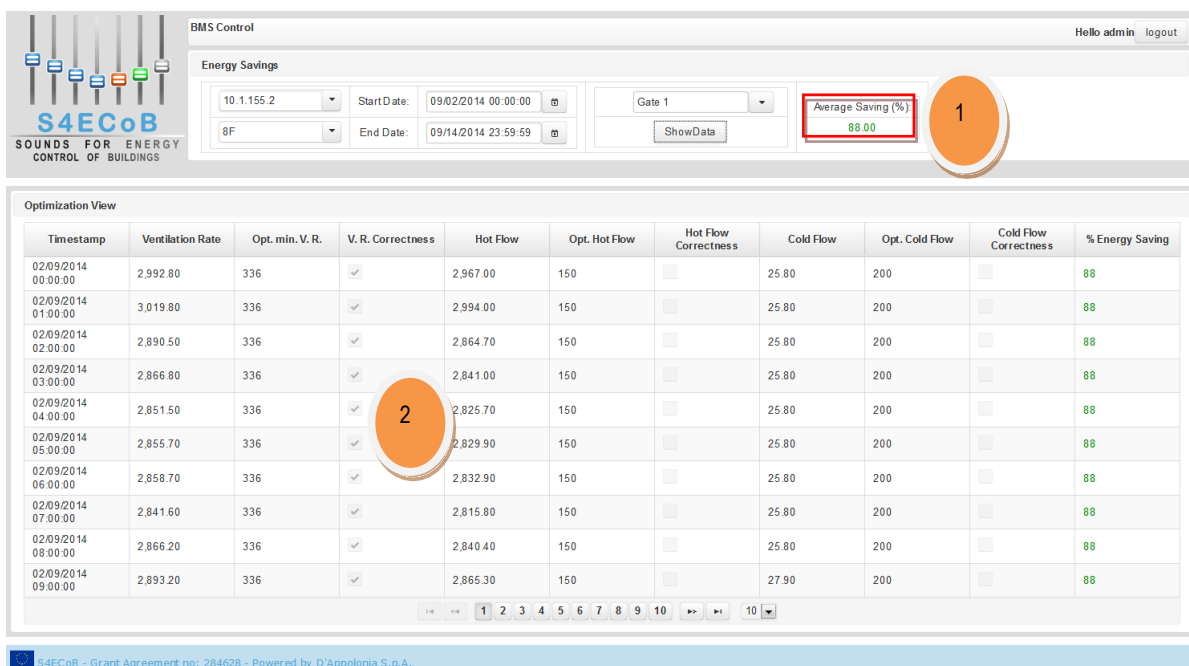
Figure 6 - Linate comparative table and energy saving web page analysis started

3.1.2   Principe Pio

Figure 7 presents the BMS control interface for the optimization procedure developed for Principe Pio shopping centre. This interface enables the Optimization Manager the setting of the AHU set points values, cooling and heating periods, a reference week, and an annual schedule for the optimization planning, and a reference week and an annual schedule for the estimated maximum occupancy level for the day.
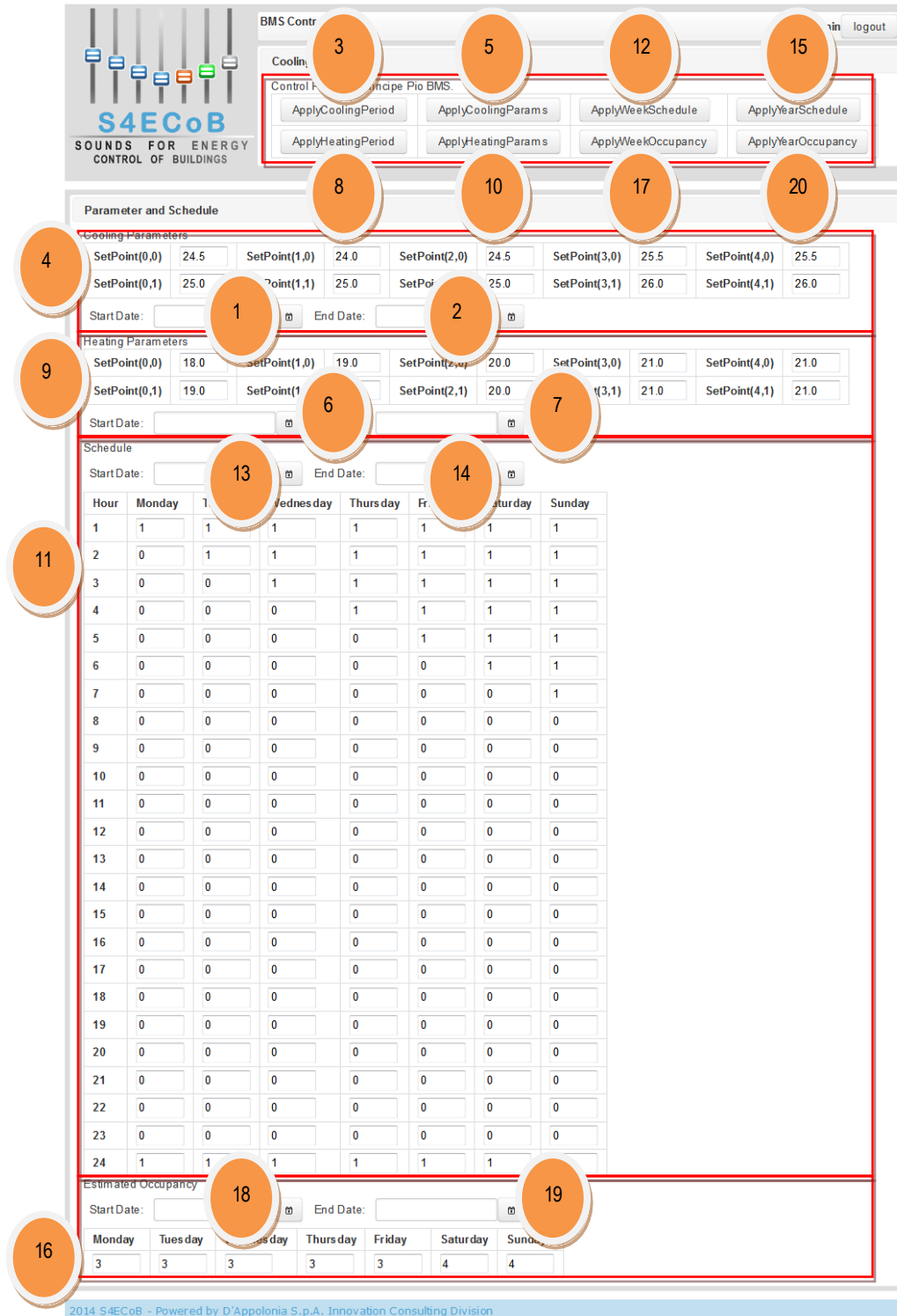
The web interface is composed by five sections marked with red rectangles in Figure 7, here listed from top to bottom:

1. **Application buttons**: in the header section of the page, six buttons are presented in order to apply the information provided by the user in the main content area of the page.
2. **Cooling parameters**: on top of the main content area the user can enter the values for the cooling matrix of set points and define the cooling period.
3. **Heating parameters**: below the user can enter the values for the heating matrix of set points and define the heating period.
4. **Optimization planning**: the bigger area of the main content is reserved to the compilation of the optimization planning (reference weeks and schedule).
5. **Estimated maximum occupancy per day**: on the bottom of the main content area the user can enter the values for the estimated maximum occupancy per day.

The Optimization Manager can perform twenty actions in order to configure the optimization strategy in Principe Pio:

1. **Cooling period start date selection**: clicking the starting date button, a calendar will open in order to help the user choosing a starting date for the cooling period.
2. **Cooling period end date selection**: clicking the starting date button, a calendar will open in order to help the user choosing an ending date for the cooling period.
3. **Cooling period application**: clicking the "ApplyCoolingPeriod" button, the start and end date for the strategy cooling period will be applied.
4. **Cooling set points matrix compilation**: in this area of the page, the Optimization Manager can compile the cooling matrix of set point temperatures.
5. **Cooling set points matrix application**: clicking the "ApplyCoolingParams" button, the cooling matrix of set point temperatures compiled in point 4, will be applied.
6. **Heating period start date selection**: clicking the starting date button, a calendar will open in order to help the user choosing a starting date for the schedule.
7. **Heating period end date selection**: clicking the ending date button, a calendar will open in order to help the user choosing an ending date for the schedule.
8. **Heating period application**: clicking the "ApplyHeatingPeriod" button, the start and end date for the strategy heating period, will be applied.
9. **Heating set points matrix compilation**: in this area of the page, the Optimization Manager can compile the heating matrix of set point temperatures.
10. **Heating set points matrix application**: clicking the "ApplyHeatingParams" button, the heating matrix of set point temperatures compiled in point 9, will be applied.
11. **Planning reference week compilation**: in this area of the page, the Optimization Manager can compile the reference week for optimization planning by entering Boolean flags with an hourly granularity for each day in the week.
12. **Planning reference week application**: clicking the "ApplyWeekSchedule" button, the reference week for optimization planning compiled in point 11 will be applied.
13. **Planning start date selection**: clicking the starting date button, a calendar will open in order to help the user choosing a start date for the schedule.
14. **Planning end date selection**: clicking the ending date button, a calendar will open in order to help the user choosing an end date for the schedule.
15. **Planning schedule application**: clicking the "ApplyYearSchedule" button, the schedule for optimization planning duplicating the compiled reference week of point 11 on the period selected in points 13 and 14, will be applied.

16. **Estimated maximum occupancy per day reference week compilation**: in this area of the page, the Optimization Manager can compile the reference week for estimated maximum occupancy inserting Boolean flags with a daily granularity.
17. **Estimated maximum occupancy per day reference week application**: clicking the "ApplyWeekOccupancy" button, the reference week for estimated maximum occupancy compiled on point 16, will be applied.
18. **Estimated maximum occupancy per day start date selection**: clicking the starting date button, a calendar will open in order to help the user choosing a starting date for the schedule.
19. **Estimated maximum occupancy per day end date selection**: clicking the starting date button, a calendar will open in order to help the user choosing a starting date for the schedule.
20. **Estimated maximum occupancy per day schedule application**: clicking the "ApplyYearOccupancy" button, the schedule for estimated maximum occupancy duplicating the compiled reference week on point 16 on the period selected on points 13 and 14, will be applied.

Figure 7 - Principe Pio BMS control interface web page

3.1.3 Maremagnum
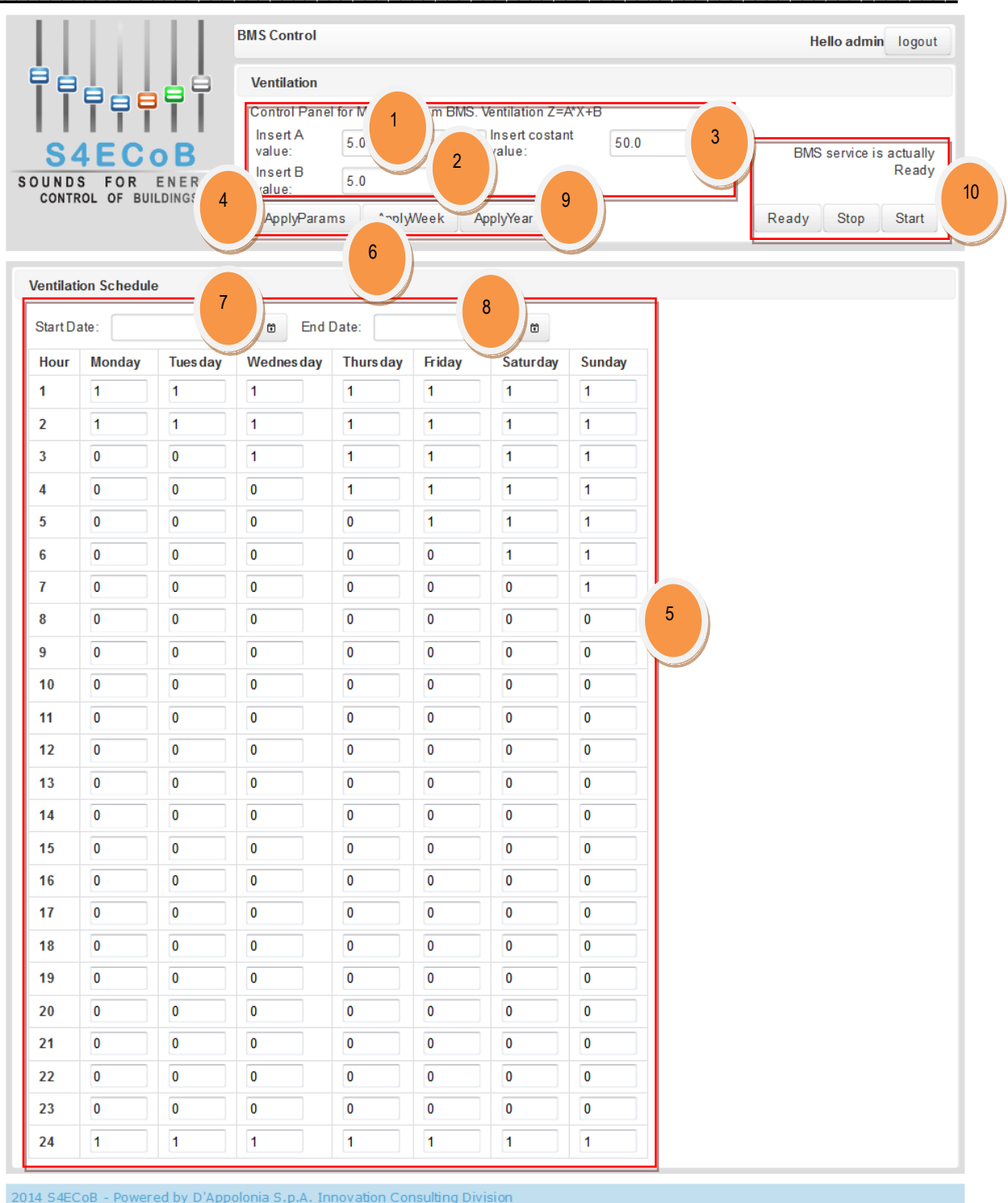
Figure 8 presents the BMS control interface for the optimization routine implemented and running in Maremagnum shopping centre. This interface permits to the Optimization Manager the setting of the parameters for the optimization formula related to the frequency of the fan, and the setting of a reference week and an annual schedule for the optimization planning.

The web interface is composed by four sections marked with red rectangles in Figure 8, here listed from top to bottom and from left to right:

1. **Ventilation formula parameters**: on the top right of the header section of the page the user can insert the values for A and B parameters in the optimization formula for ventilation and the constant value to use for the frequency of the fan, in the case the optimization is not planned.
2. **Application buttons**: on the bottom right of the header section of the page, three buttons are presented in order to apply the information provided by the user in sections 1 and 3 of the page.
3. **Optimization routine management**: on the left of the header section of the page, the Optimization Manager can monitor the optimization routine status and Ready, Start and Stop the BMS optimization service.
4. **Optimization planning**: the main content area is reserved to the compilation of the optimization planning reference weeks and schedule.

The Optimization Manager can perform ten actions in order to control optimization procedure on the Maremagnum BMS:

1. **A parameter insertion**: here the Optimization Manager can provide the value for the A parameter in the optimization formula for ventilation.
2. **B parameter insertion**: here the Optimization Manager can provide the value for the B parameter in the optimization formula for ventilation.
3. **Constant value insertion**: here the Optimization Manager can provide the constant value for the frequency of the fan in the case the optimization was not planned for a given hour or the ventilation formula provided a value of the frequency that was outside the given boundary limits.
4. **Parameters application**: clicking the "ApplyParams" button, the three inserted parameters in points 1,2,3 for ventilation formula, will be applied.
5. **Reference week compilation**: in the main content area of the page, the Optimization Manager can compile the reference week for optimization planning inserting Boolean flags with an hourly granularity for each day in the week.
6. **Reference week application**: clicking the "ApplyWeek" button, the reference week for optimization planning compiled on point 5, will be applied.
7. **Start date selection**: clicking the starting date button, a calendar will open in order to help the user choosing a starting date for the schedule.
8. **End date selection**: clicking the ending date button, a calendar will open in order to help the user choosing an ending date for the schedule.
9. **Schedule application**: clicking the "ApplyYear" button, the schedule for optimization planning duplicating the compiled reference week on point 5 on the period selected on points 7 and 8, will be applied.
10. **BMS controlling routine monitoring and management**: on the right of the header, the Optimization Manager can monitor and manage the BMS optimization routine. The management capabilities of the optimization service are limited to putting the service to ready, stopped and running status (buttons from left to right).

Figure 8 - Maremagnum BMS control interface web page

3.2 BMS Monitoring

In this section the web pages developed for the web monitoring system are described in detail.

3.2.1   Linate

Figure 9 presents the facility monitoring web page implemented for Linate airport where the AHU boxes variables can be plotted as line charts.

The user should perform seven actions in order to compare the energy consumption with and without S4ECoB optimization and calculate potential energy savings:

1. **Pilot selection**: clicking the "Choose one Pilot" button, a selection list will open for choosing the pilot for the analysis.
2. **AHU selection**: clicking the "Choose one AHU" button, a selection list will open for choosing the AHU for the analysis.
3. **APU selection**: clicking the "Choose one APU" button, a selection list will open for choosing the APU for the analysis.
4. **Field selection**: clicking the "Choose one Field" button, a selection list will open for choosing the AHU boxes variable to be plotted for the analysis. The variables are seven:
   a.   tempAmb: ambient temperature measured by the box sensors.
   b.   portTot: air flow measured by the box sensors.
   c.   portFrd: cold air flow measured by the box sensors.
   d.   regVlvCld: hot valve regulation measured by the box sensors.
   e.   regVlvFrd: cold valve regulation measured by the box sensors.
   f.   spTAmb: the ambient zone temperature set point.
   g.   spEffAmb: zone ambient effective temperature measured by the box sensors.
5. **Start date selection**: clicking the starting date button, a calendar will open in order to help the user choosing a start date for the analysis.
6. **End date selection**: clicking the end date button, a calendar will open in order to help the user choosing a end date for the analysis.
7. **Start the analysis**: After the selection of a pilot, AHU, APU, field start date, and end date, clicking the "ShowCharts" button, the analysis will start showing the line charts for the selected field in the selected period. These charts will be presented in Figure 10.

Figure 9 - Linate BMS monitoring web page: analysis selection

Once the selection was performed and the "ShowCharts" button pressed, the retrieved data stored in the database will be plotted in the main content area of the page in three different charts divided by ASU. Figure 10 presents these charts showing the ambient temperature.

The AHU boxes are divided in the three charts according to the area covered by the three ASU:

1. The first chart (point 1 in Figure 10) plots the series belonging to the eight boxes in the area covered by ASU 1, namely the CPV13, CPV14, CPV15, CPV16, CPV17, CPV18, CPV30, and CPV32 boxes.

2. The second chart (point 2 in Figure 10) plots the time series belonging to the six boxes in the area covered by ASU 0, namely the CPV19, CPV20, CPV21, CPV22, CPV23, and CPV24 boxes.

3. The third chart (point 3 in Figure 10) plots the time series belonging to the six boxes in the area covered by ASU 2, namely the CPV25, CPV26, CPV27, CPV28, CPV29, and CPV31 boxes.

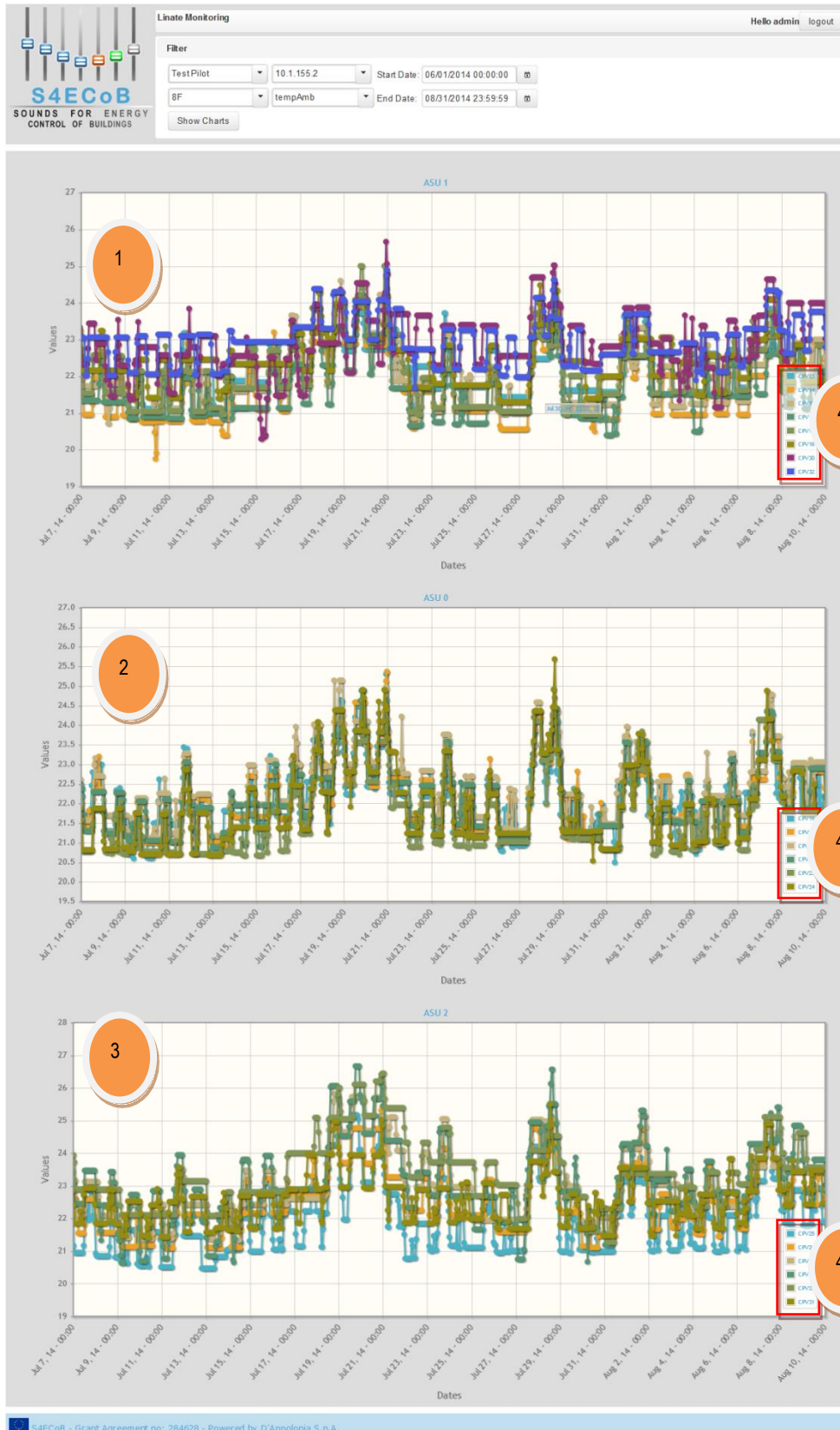The charts are zoomable through mouse dragging and it is possible to return to default resolution with a double click of the mouse.

Figure 10 - Linate BMS monitoring web page: analysis started

Point 4 in Figure 10 and Figure 11 is the legend for the chart. In this legend the series plotted in the corresponding chart are listed as couples of colour and box name. It's possible to hide a series from the chart by simply clicking on his entry in the legend, and clicking a second time the series will show again. In Figure 11 a screenshot of the first chart, corresponding to ASU1, is presented in order to show only one series (CPV13) that has been isolated from the others in order to better analyse it.

Moving the mouse over a sample in the series, a label will appear as in point 5 in Figure 11, showing the timestamp and value for the sample.
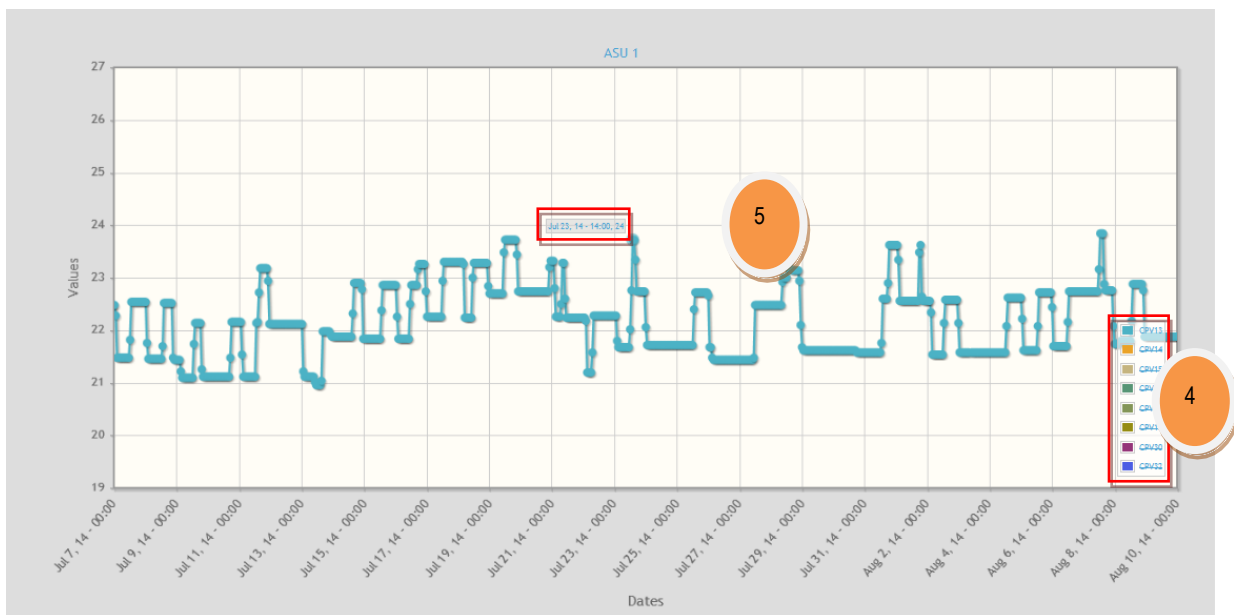
Figure 11 - Linate BMS monitoring chart: series and samples selection

3.2.2 Maremagnum

Figure 12 presents the optimized energy data monitoring web page implemented for Maremagnum shopping centre where the optimization routine for ventilation was successfully implemented and validated on the pilot BMS.

The user should perform three actions in order to monitor optimization energy data stored in the database by the optimization routine performed by the optimization unit and described in Chapter 2 "Optimization Unit" in the present document:

1. **Start date selection**: clicking the starting date button, a calendar will open in order to help the user choosing a start date to filter the table entries (see D4.4 "BEMO manual").
2. **End date selection**: clicking the ending date button, a calendar will open in order to help the user choosing an end date to filter the table entries.
3. **Filters application**: After the selection of a start date and end date, clicking the "Search" button, the Sound Manager applies the filters to the table view.
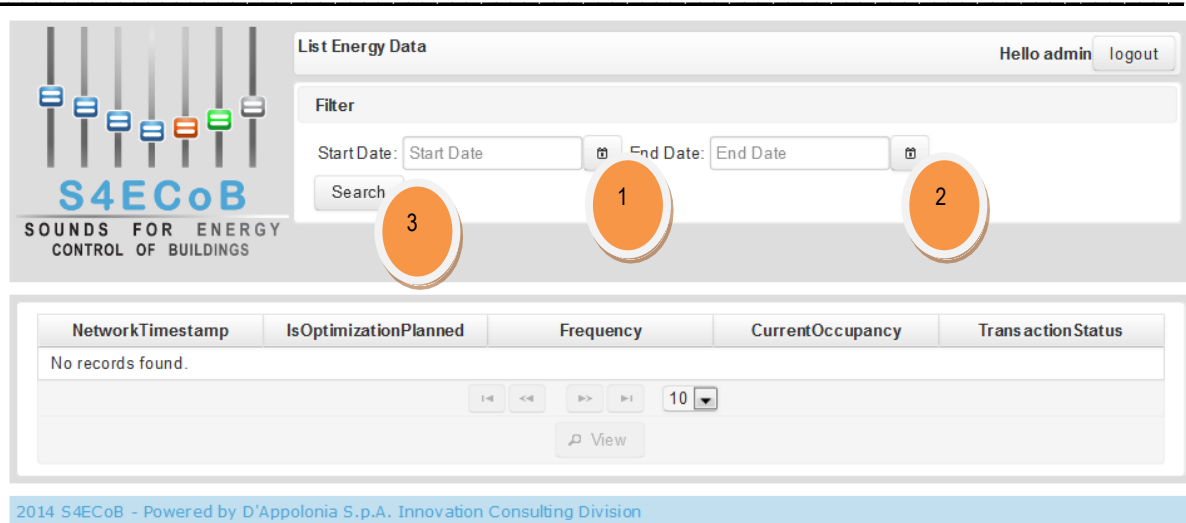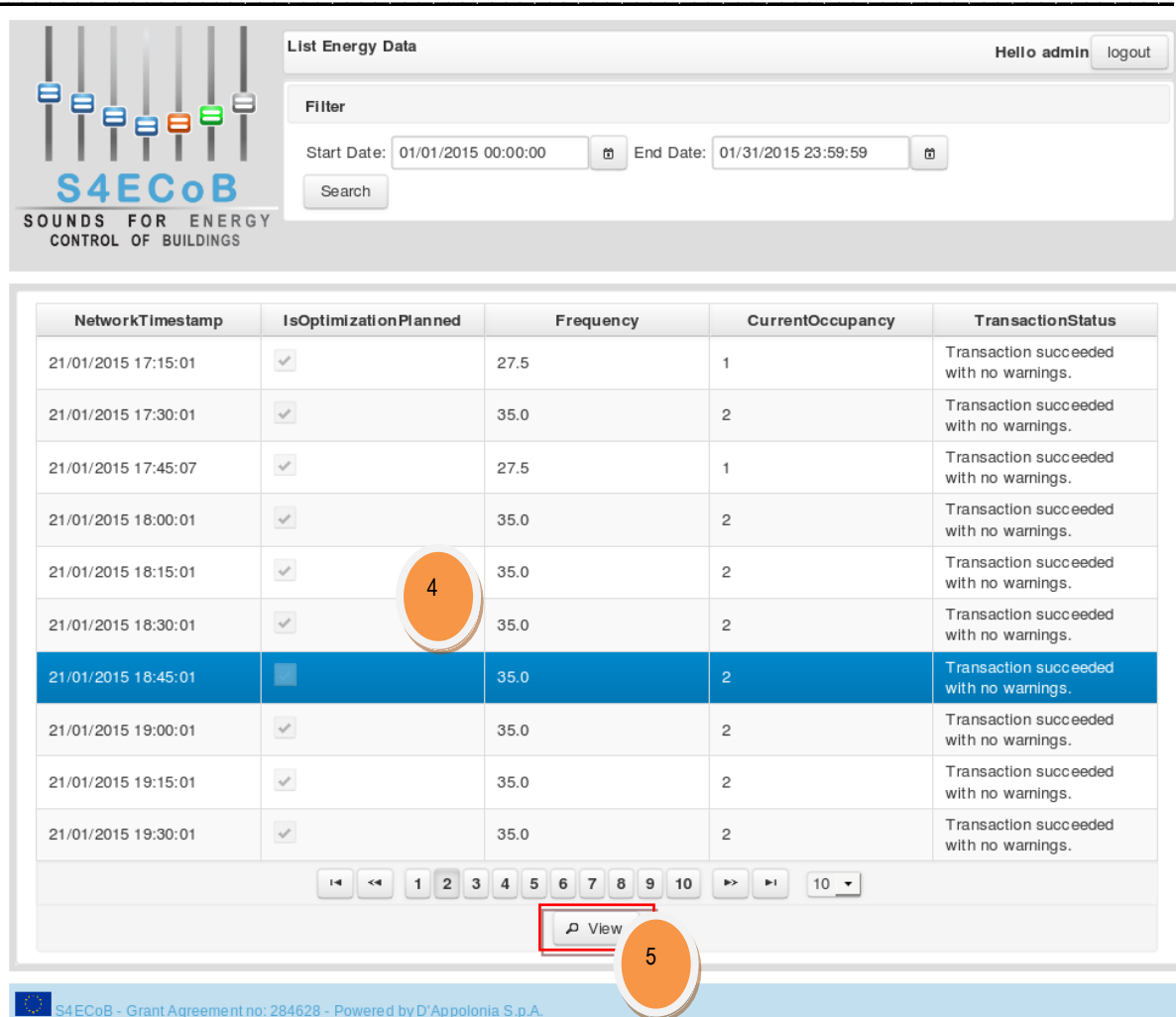
Figure 12 - Maremagnum optimized energy data monitoring: analysis selection

Once the selection was performed and the "Search" button pressed, the retrieved optimized energy data stored in the database will be shown in the main content area of the page. Now the user can navigate through the records, select one record (point 4 in Figure 13) and view all the attributes associated to the record selected by clicking the "View" button (point 5 in Figure 13).

Figure 13 - Maremagnum optimized energy data monitoring: analysis started

Figure 14 presents the View element that appears when the user pressed the "View" button. By clicking the "x" on the top right or the "Close" button on the bottom left, the View element will be closed.
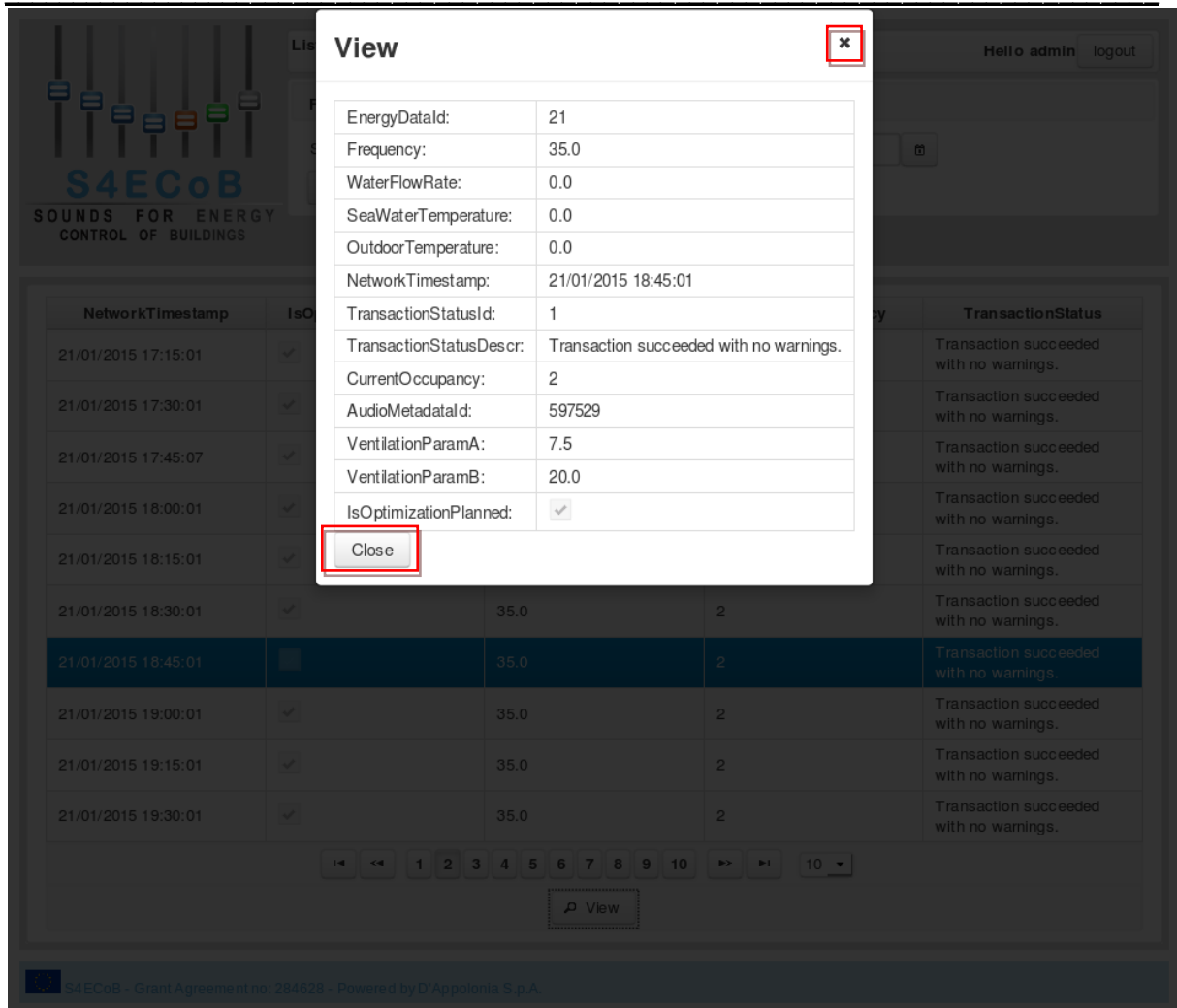
Figure 14 - Maremagnum optimized energy data monitoring: view single entry

Figure 15 presents the facility monitoring web page implemented for Maremagnum shopping centre where the optimized value of the frequency of the fan can be plotted as a line chart.
The three actions that the user can perform are the same already presented for the Linate optimized energy data monitoring web page in Figure 12.
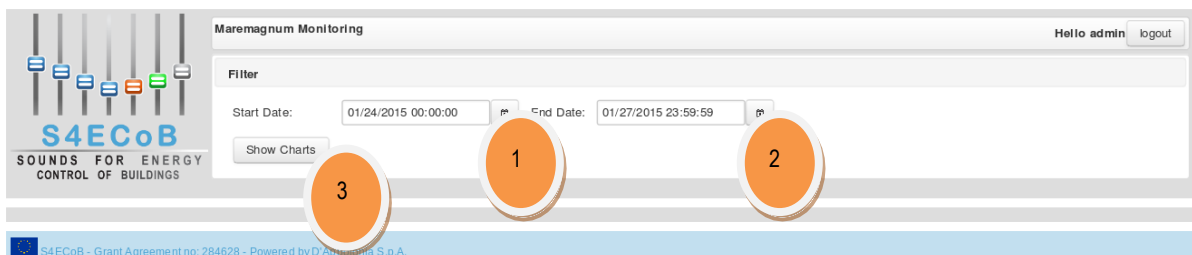

Figure 15 - Maremagnum BMS monitoring web page: analysis selection

Once the selection was performed and the "Show Charts" button pressed, the retrieved data stored in the database will be plotted in the main content area of the page as shown in point 4 in Figure 16. The chart functionalities are the same already described for Linate in Figure 11.
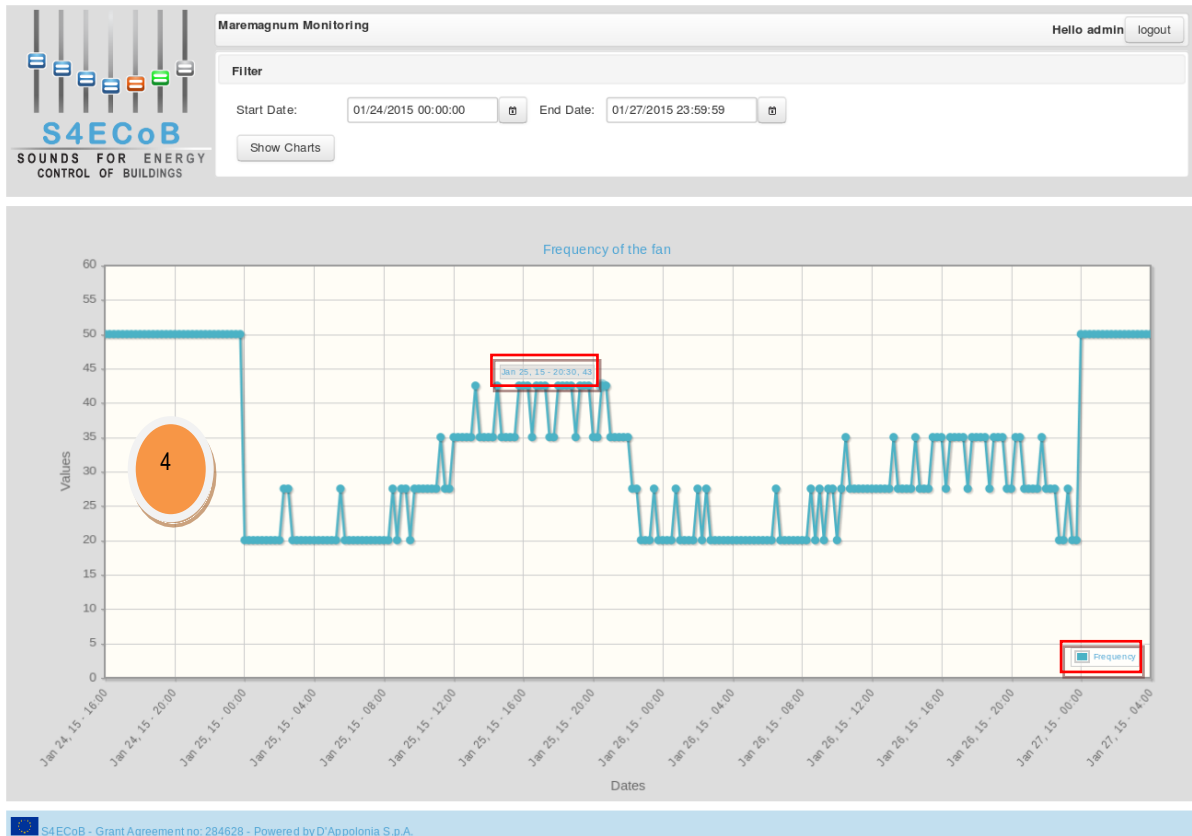

Figure 16 - Maremagnum BMS monitoring web page: analysis started

4   CONCLUSIONS

The objective of T5.5 associated to this deliverable is to design and develop a web-based monitoring system of the energy performance of the building air conditioning systems. It should be integrated directly into the BEMO Control and Management platform, and, thanks to the optimization unit, writing optimized energy data into the BMS that was already installed at the demo sites.

For Linate it was not possible to access the BMS and so to implement the optimization procedure. A comparative table of the optimization model was developed and has been implemented together with the potential average savings calculation over a given period including the visualisation of time series plots. This will enable the Facility Manager to better decision making and optimal building control by using the monitoring system and benchmarking the historical energy data from the AHU boxes.

For Principe Pio the optimization unit has been implemented following the optimization logic developed, together with a controlling interface web page for manually inserting the parameters needed by the heating and cooling strategy to optimize the set point temperature of the two rooftops units.

For Maremagnum the optimization unit has been implemented following the optimization logic developed and the optimization routine successfully managed to read and write values from/to the Schneider BMS. A controlling interface web page has been implemented in order to manage the optimization routine and insert the parameters needed by the ventilation strategy to optimize the frequency of the fan engine. An optimized energy monitor web page has been implemented in order to let the Optimization Manager monitor historical optimized frequency set point as well as the optimization procedure.

A general optimization routine has been developed and integrated into the BEMO Control and Management Platform through a service as described in D4.3. Full control of the optimization service is reserved to Administrator users, but also the Optimization Manager can start and stop the optimization procedure. A full control panel is accessible through web pages for controlling the parameters of the procedure, and other web pages enable the monitoring of BMS performance.