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Sun coupled innovative Heat pumps

D6.4 – First Report on SunHorizon monitoring activities

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Organisation name of lead contractor for this deliverable: CARTIF

Participants : CEA, RINA-C, ITAE, SE, RTU, EMVS, FAHR, AJSCV, IVL, IES, VEO

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Project Contractual Details

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Summary

SunHorizon (SH) will demonstrate up to TRL 7 innovative, reliable, cost-effective coupling of solar and HP technologies. SunHorizon addresses three main research pillars that interact each other towards project objectives achievement, demonstration and replication: i) optimized design, engineering and manufacturing of SunHorizon technologies, ii) smart functional monitoring for H&C, iii) Key Performance Indicators (KPI) driven management and demonstration.

T2.4 established a list of indicators to assess the performances of SunHorizon standalone technology and combined packages during their operational phase and for the simulation scenarios to achieve project objectives. In order to calculate these KPIs, within WP4 a proactive KPI-based tool has been developed. The KPI-based maintenance tool will automatically calculate the KPIs of each demo site. T6.4 aims at demonstrating that the actual KPIs are being achieved, and what are the deviations from the grant agreement. The first deliverable is deliverable D6.4, in which the following main activities have been conducted:

- Establish the way of working within T6.4 and the associated deliverables (D6.4, D6.5, D6.6)
- General methodology for the monitoring data production, collection and operation summary report of the SunHorizon installed TPs (supported by SE, CARTIF), establishing:
  - How the dashboard of the KPIs will look like (IES, CARTIF)
  - How the KPIs should be demonstrated and reported (CARTIF)
  - How the data work flow will be (SE, IES, CARTIF)
- Pre-monitoring methodology (CARTIF) establishing:
  - What will be done with these data: Riga Sunisi and Sant Cugat pre-monitoring summary data (RTU, AJSCV, CARTIF, IES)
  - SE web database server: detailed ‘raw data ’(SE)
  - Calibration of energy models (RINA, IES, CARTIF)
- Communication with specific demo responsible and demo support partners to introduce the monitoring and operation summary (KPIs) tools (deployment in T6.3, use in T6.4).

As the installation of technologies are aimed to be finished in M36 (September 2021) and D6.4 is due in the same date, D6.4 just aims to establishing the methodology that will be followed in the following reports: D6.5 and D6.6, where the achievement of KPIs will be demonstrated.

Keywords

Key performance indicators, monitoring campaign, project demonstration, project results, project impacts

List of acronyms and abbreviations

Abbreviation	Meaning
KPI	Key Performance Indicators
DHW	Domestic Hot Water
SH	Space heating
SC	Space cooling
RES	Renewable energy sources
TP	Technology Packages

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1 Introduction

SunHorizon project aims to demonstrate that a proper combination of technologies, also known in the project as Technology Packages (TP), can avoid wasting energy, identifying malfunctioning of equipment, maximizing energy coming from renewables, increasing self-consumption, reducing local energy bills and cut of CO_2 emissions. These TPs include technologies such as solar panels (PV, hybrid, thermal) and heat pumps (thermal compression, adsorption, reversible), managed by a controller with predictive and pro-active maintenance (among other capabilities).The assessment of the TPs deployed in the demo sites will come from the estimate of the energy baseline[1] for each demo site (before SunHorizon was installed) and the analysis of the Key Performance Indicators (KPIs) during the monitoring period, following the methodology described in Work Package (WP)2. At the demonstration campaign and monitoring campaign (in principle from M37 to M48[2]), KPIs will be regularly checked at the monitoring database and evaluated to get insights and lessons learnt from the different demonstration cases (that will feed Task 6.5). This document will also report specific guidelines for the TPs derived from the experience gained during the monitoring period.

The first goal of this task is to select, install on site and validate the monitoring instrumentation with regard to task T6.1 and the requirements for measuring KPIs, following the methodology and definitions from WP2. The second goal is to set the main methodology to be followed during the monitoring campaign, including responsible partner, frequency or necessary actions. This methodology will be explained within D6.4. Later, within D6.5 and D6.6, the different demo responsible and demo site supervisors (CEA, RINA-C, CARTIF, ITAE) will regularly check the monitoring database and KPI based evaluation of the demo cases, and report it. Schneider and IES, will ensure and supervise the actual data acquisition by the monitoring systems and the integration into the IES data base, respectively, during demonstration campaign. Furthermore, SE will support the definition of the on-site communication infrastructure, and will provide monitoring hardware, as has been done within WP4, and WP6. The task objectives and responsibilities of partners are summarized in Figure 1.

Detected failures or performance deviations will be diagnosed and subsequently solved by each demo site responsible partner with the assistance of the respective demo site supervisors (CEA, RINA-C, CARTIF, ITAE) and the technology manufacturers involved in the demo site's TP.

The maintenance tool that will be provided by CARTIF will set automatic alarms and warnings, which will be integrated within the Tool and iSCAN. Some alarms will be calculated every 15 min (depending on the granularity of iSCAN data) and some will be obtained on a daily basis. In case an alarm is generated, iSCAN will automatically send an email to the demo responsible and supervisors. Alarms will not occur frequently, but warnings can appear more often (e.g. the efficiency of some heat pump is decreasing compared to its nominal value). The KPIs will be calculated automatically every day. Only when an alarm or warning is generated, the demo site responsible partner will need to check the SunHorizon system status (online) and the KPIs. As previously said, the diagnosis and resolution of warnings and alarms will be performed with the assistance of the respective demo site supervisors (CEA, RINA-C, CARTIF, ITAE; as dode in the scope of WP2). Besides that, the demo site responsible and supervisor partners will check the KPI evolution at least once a month to report the monthly project results. In case a danger alarm which requires the assistance from the technology providers, they will collaborate to diagnose and solve the problem. D4.2 gathers the main alarms from each technology and the corresponding action to be taken in each case.

Lastly, according to the Description of Action (DoA), performance of TP will be monitored via dedicated KPI panel, which will be provided by IES (through iDashboard tool) and CW (through the App), and thanks to the demo tracking Tool (from WP1). IVL will monitor the aspects related to emissions.

[1] Baseline refers to the final energy consumption (gas and electricity) of the demo sites before SunHorizon was installed. In WP2 this baseline was already estimated: final energy consumption, (in some) the efficiencies of the existing systems (before SunHorizon) and the thermal demand (domestic hot water, space heating, space cooling, electricity consumption of the building).

[2] The dates of the monitoring campaign for each demo will vary depending on when the system is commissioned. At least one year of reporting will be needed.

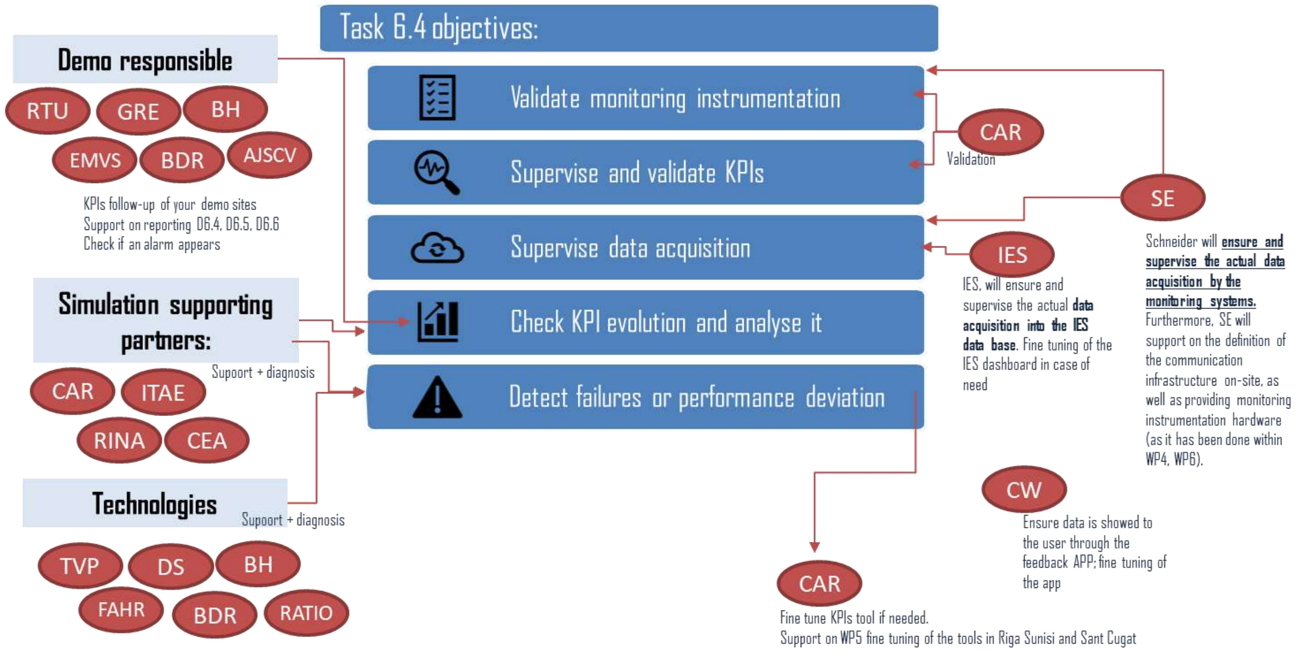

Figure 1- Task 6.4 overview: objectives and responsibilities of partners.

1.1 Task structure

The first task to be conducted within T6.4, is to establish the way of working within T6.4 and the associated deliverables (D6.4, D6.5, D6.6). Table 1 shows the associated deliverables, expected content, when are due and who leads it. More specifically, Table 2 shows the expected content for the next two deliverables D6.5 and D6.6, in which the evolution of KPIs and developments and updates of the monitoring campaign of each demo should be explained.

Table 1- Deliverables from T6.4

	Content	Due in	Lead beneficiary
D6.4	Establish the common methodology for the demonstration of project KPIs	30/09/2021	CARTIF
D6.5	Report the first 6 months (M36-M42) achievements of project KPIs	31/03/2022	AJSCV
D6.6	Report the last 6 months (M42-M48) achievements of project KPIs	30/09/2022	BDR

Table 2- Table of contents of deliverables D6.5 and D6.6

Enumeration	Contents
1. Introduction of the deliverable	Introduction to the deliverable
2. Demo #Number	1-Berlin, 2-Nunberg, 3-Sant Cugat, 4-Madrid, 5-Piera~~,6.- Verviers Sport Centre~~, 7-Swimming Pool, 8- Riga Imanta, 9- Riga Sunisi
2.1. Status update of the demo site	Any demo update related to: tendering procedure, installation progress, commissioning progress, any new potential risk, etc.
2.2. Status update of the monitoring system	News on variables, installation progress, commissioning progress, any new potential risk, data collection progress and relevant events (any disconnection of communication, for how long, how it was detected and solved, etc.), so we can later have a table of lessons learnt, and develop guidelines for using properly the tools
2.3. KPIs main summary	Copy Table 7 and fill it with monthly values. Describe contingency plans (e.g. Why some KPI is not being achieved)

2.4. KPI and PIs screenshots from iSCAN	Every month, demo site responsible does screenshots of the IES dashboard, including the monthly main 12 KPIs. and with the support of the simulation supporting partner an analysis will be performed. At least monthly analysis is needed. But you can go also to analyse some specific day →(if you think is interesting, or an alarm appeared that day and might be worth mentioning it
2.4.1. Month 37 **2.4.2. Month 38** **2.4.3. Month 39** **2.4.4. Month 40** **2.4.5. Month 41** **2.4.6. Month 42** *In case of D6.6, reporting will start from M43 to M48	
2.5. Alarms logging	Alarms will be reported here. An automatic e-mail will be sent to the building staff (if needed), demo responsible, and the simulation supporting partner. In iSCAN the alarm log can be also shown Describe what was the alarm, how it was solved, by the demo responsible (With the help of technology providers if needed)

The collection of data for the KPIs demonstration is described in the following figure:

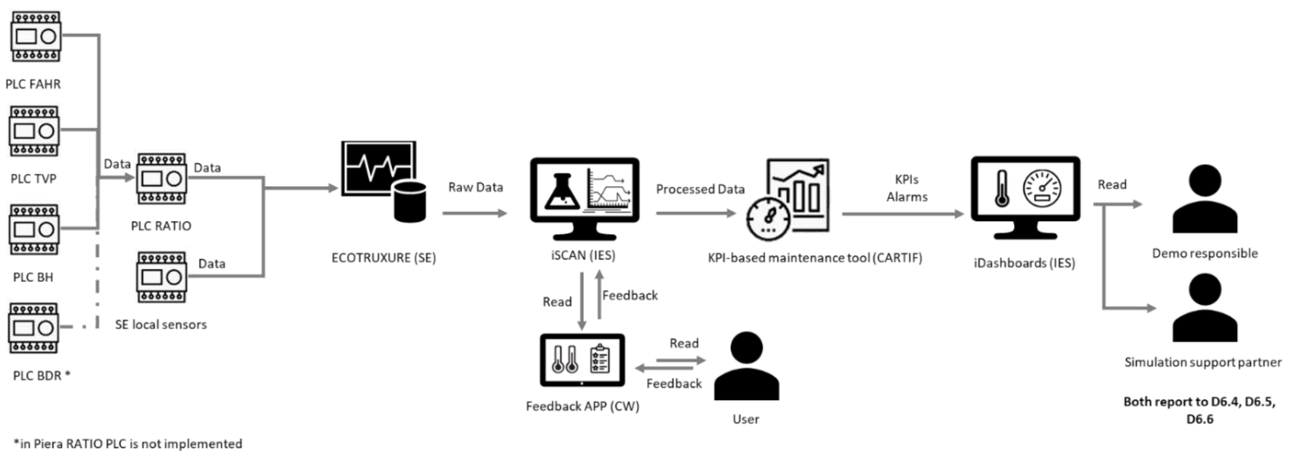

Figure 2- Data collection flow. Demos communicate feedback through the feedback APP and download data from the iDashboard of IES

Generally, in all demo sites the different PLC from the technologies will communicate with RATIO's PLC. RATIO will then communicate the data to the EcoStruxure server[3] from Schneider (SE). In parallel, SE is also testing direct communication with BH (not implemented in any demo). In Piera, RATIO's PLC is not implemented, but in this case all the variables are collected from BDR's PLC, and will be communicated from this one to EcoStruxure.

Once the data is gathered by EcoStruxure, iSCAN will get it and process it (filling data gaps, for example). The processed data will be used by the KPI-based maintenance tool to calculate KPIs and alarms, that will be shown: 1) in the dashboard for the demo site responsible and simulation supporting partners; 2) to the user through the feedback App from CW to read and provide feedback. The Dashboard will be used for reporting the project achievements in D6.5 and D6.6

Thus, the responsibilities of each partner will be:

[3] BH's PLC is also testing the direct communication with EcoStruxure. But it is still unclear.

Table 3- Responsibilities within T6.4 of the monitoring campaign and KPIs demonstration

Partner	Main responsibility	Frequency
CARTIF	Lead T6.4. Establish methodology of KPIs gathering and reporting Support on KPIs follow-up of the following demo sites: Riga Sunisi, Madrid Fine tune KPIs tool if needed. Support on WP5 fine tuning of the tools in Riga Sunisi and Sant Cugat	Check if an alarm appears in one of the following demo sites: Verviers SC, Verviers SP, Madrid. Help to diagnose it Support demo sites in KPIs reporting (every month) Lead reporting D6.4, and support D6.5 and D6.6
ITAE	Support on KPIs follow-up of Sant Cugat Support on reporting D6.4, D6.5, D6.6 when is due Check if an alarm appears Help to diagnose it	Support demo sites in KPIs reporting (every month) Deliverables when are due Alarms when are raised up
CEA	Support on KPIs follow-up of Berlin, Nunberg, Piera Support on reporting D6.4, D6.5, D6.6 when is due Check if an alarm appears Help to diagnose it	Support demo sites in KPIs reporting (every month) Deliverables when are due Alarms when are raised up
RINA-C	Support on KPIs follow-up of Verviers SP and Riga Imanta Support on reporting D6.4, D6.5, D6.6 when is due Check if an alarm appears Help to diagnose it	Support demo sites in KPIs reporting (every month) Deliverables when are due Alarms when are raised up
GRELIEGE	KPIs follow-up of Verviers SC, Verviers SP Support on reporting D6.4, D6.5, D6.6 Check if an alarm appears	KPIs reporting (every month) Deliverables when are due Alarms when are raised up
RTU	KPIs follow-up of Riga-Sunisi and Riga Imanta Support on reporting D6.4, D6.5, D6.6 Check if an alarm appears	KPIs reporting (every month) Deliverables when are due Alarms when are raised up
EMVS	KPIs follow-up of Madrid Support on reporting D6.4, D6.5, D6.6 Check if an alarm appears	KPIs reporting (every month) Deliverables when are due Alarms when are raised up
BDR	KPIs follow-up of Piera Support on reporting D6.4, D6.5, D6.6 Check if an alarm appears	KPIs reporting (every month) Deliverables when are due Alarms when are raised up
BH	KPIs follow-up of Berlin and Nürnberg Support on reporting D6.4, D6.5, D6.6 Check if an alarm appears	KPIs reporting (every month) Deliverables when are due Alarms when are raised up
AJSCV + VEOLIA	KPIs follow-up of Sant Cugat Support on reporting D6.4, D6.5, D6.6 Check if an alarm appears	KPIs reporting (every month) Deliverables when are due Alarms when are raised up

SE	Schneider will ensure and supervise the actual data acquisition by the monitoring systems. Furthermore, SE will support on the definition of the communication infrastructure on-site, as well as providing monitoring instrumentation hardware (as it has been done within WP4, WP6).	Every time that data flow is broken
IES	IES, will ensure and supervise the actual data acquisition into the IES data base. Fine tuning of the IES dashboard in case of need	Every time that data flow is broken
Technologies: FAHR, BDR, TVP, DS, BH, RATIO	Demonstrate PIs evolution	Help to explain alarms and PIs reporting (Every month) Operation of their technologies goes smoothly (in case of any fault, help demo sites to identify/solve it).
IVL	Ensure the monthly gas consumption and electricity consumption is gathered for LCA	Every 6-month

The monitoring and operation summary (KPIs) tools will be communicated with specific demo responsible and demo support partners in dedicated calls.

As Riga-Sunisi and Sant Cugat are Type A demo sites (i.e. where WP5 tools will be fully demonstrated), pre-monitoring data has been obtained to feed the calibration of the building models and existing energy systems (such as radiators, ground floor heating or the existing heat pumps in Sant Cugat). In D6.4, the pre-monitoring methodology will be clarified, and what will be done with these data, and how the calibration of energy models is done, will be explained.

As a reminder of D4.2 codification of the demos is listed below:

- [TP1] Berlin #1
- [TP2] Nürnberg #2
- [TP3] Sant Cugat #3
- [TP4] Madrid #4
- [TP4] Piera #5
- [TP1] Verviers public Sport Centre #6
- [TP2] Verviers Swimming Pool #7
- [TP2] Riga Imanta #8
- [TP2] Riga Sunisi #9

As Verviers public sport centre (demo 6) withdraws from the project, it will not be included in the present deliverable. **Nevertheless, the codification will remain this way to be consistent with the past deliverables.**

2 Methodology

General methodology for the monitoring data production, collection and operation summary report of the SunHorizon installed TPs is explained in this section. Operation summary means to state:

- What will be reported
- How to report it
- How it feeds other tasks

2.1 Monitoring and control workflow concept update

In Figure 8 a collaborative tool (MURAL) was used to discuss with partners the different data work flows and time frequency of data collection within the project. The workflow to be implemented will be:

1- PLCs from technologies will collect data from sensors (located in their technologies and/or the entire system). PLCs will generally send data to RATIO's PLC, so as to communicate the data to EcoStruxure software. Only Boostheat PLC will connect directly to EcoStruxure

2- Enterprise Server collects data from sensors and meters and makes available all data in real time via EcoStruxure and SmartConnector API

3- Data from sensors and meters are pulled and stored to iSCAN every 15 minutes via Smartconnector API and Micorosft Azure web hook. It includes data from sensors and meters installed within the building and equipment consisting of the SunHorizon Technology Packages.

4- The data is processed by the various tools and services (self-learning, calibration of building model, hybrid controller, KPI-based maintenance proactive tool and predictive maintenance for Fault Detection).
   a. The KPI-based maintenance proactive tool will calculate KPIs, PIs and Is for each demo site. The KPIs are the basis of the proactive maintenance strategy, where a rule-based fault detection identifies and triggers alerts. According to these KPIs recommended maintenance actions are included in D4.2, and can be diagnosed by demo site responsible and supervisor.
   b. Building demand prediction:
      i. environmental sensor measurements (such as internal temperature, relative humidity, lux levels, etc.) and occupant related information (such as comfort feedback, activity, clothing level, etc.) as well as the user-feedback, will allow to train a machine learning model to predict the comfort of the users, calibrate the model, and help the in-advance controller to follow different strategies to meet comfort requirements.
      ii. iSCAN platform, provided by IES, will provide prediction of the energy demand/needs of the building according to the expected weather and use patterns for the next prediction horizon (48h).
   c. Hybrid controller will receive as input the building energy demand to be supplied in each targeted time period and will allow the predictive control algorithms to find the optimal control strategy (the best combination of TPs operation setpoints).
   d. Furthermore, the predictive maintenance tool will have rule-based fault detection algorithms to identify and predict faults
   e. Engineer user performs DUU assessment and decides for the best design of the technology package (offline)

5- The results are displayed to the building's facility/energy manager and demo site responsible via KPIs, alerts, warnings in the iDashboard of IES.

6- Additionally, the Feedback app is collecting comfort feedback by the occupant and also display energy data to the user

7- Furthermore, there will be a data gap filling service, that whenever a gap is found in recorded data, an algorithm is able to be trained on historic data and fill in the gap. iSCAN will also manage the connection to the weather forecast service.

Table 4 shows a summary of where the tools from WP4 and WP5 are applied.

Table 4- WP4 and WP5 application tools

	Monitoring (SE)	Maintenance tool (proactive)	CW app	iSCAN platform	Maintenance tool (predictive)	Hybrid controller demonstration	Self-learning services + calibrated building model (prediction of demand)
[TP1] Berlin #1	X	X	X	X			
[TP2] Nürnberg #2	X	X	X	X			
[TP3] Sant Cugat #3	X	X	X	X	X	X	X
[TP4] Madrid #4	X	X	X	X			
[TP4] Piera #5	X	X	X	X			
[TP1] Verviers public Sport Centre #6	X	X	X	X			
[TP2] Verviers Swimming Pool #7	X	X	X	X			
[TP2] Riga Imanta #8	X	X	X	X			
[TP2] Riga Sunisi #9	X	X	X	X	X	X	X

2.2 Proactive maintenance tool (KPIs calculation and alarm triggering)

KPIs are calculated for each demo site. Some KPIs, such as non-renewable primary energy savings (PESnren) compares the actual consumption of SunHorizon system with the consumption in the baseline conditions. The baseline of the TPs deployed in the demo sites will come from the estimate of the energy baseline for each demo site and the analysis of the KPIs during the monitoring period. The energy baseline was already calculated in WP2 and as the models were developed by each partner in WP2, every demo site supervisor (CEA, RINA-C, CARTIF, ITAE) will send an hourly baseline of the demos to be integrated within CARTIF's maintenance tool. Still, as the building demand can change from year to year (due to weather and consumer patterns variation), the energy baseline are recalculated per demo assuming the efficiencies from WP2 (for the existing systems) and estimating that way the energy that would have been consumed if SunHorizon was not installed in the demo to meet the same heating, cooling and electricity demand[4].

The proactive maintenance tool will have a set of algorithms working that, starting from the measured and available data of the demos, will conduct the calculation of indicators related to fault detection, will declare faults according to those indicator values and will provide useful KPIs for the evaluation of maintenance strategy**. The components included under this tool are described in D4.2 but a small summary is listed hereafter:**

- Indicators calculator: this service will calculate numerical indicators that have a direct relation with the defined failure modes and that will change their values as the fault that cause that failure evolve during time. There are two types of indicators:
  - KPI and PI: defined in D2.4
  - KPI and PI Model-based residuals: using the monitored conditions (temperature, pumps on/off, etc.) of the SunHorizon system, a model is run to estimate the ideal KPI and PI in those conditions. As model outputs, Type A cases will use TRNSYS models, whereas Type B cases will use regression models from the outputs of WP2 work. The model-based KPI/PI are used for condition-based alarms (see below).

[4] SunHorizon monitoring system will measure the heat, cooling and electricity consumed/supply by SunHorizon system. Therefore, the demand can be derived from it

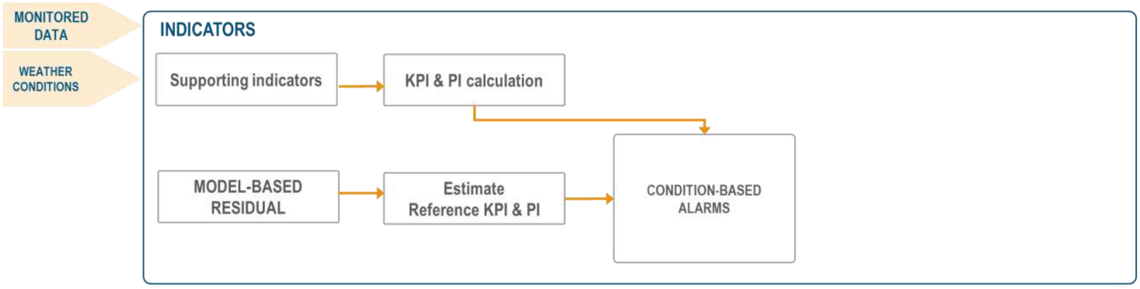

Figure 3 – indicators calculator: KPI and PI from real monitored values and KPI and PI model-based residuals calculation (Source: D4.2). Both feed the condition-based alarms

- Alarms management: there exist three sources of alarms in SunHorizon:
  - Equipment alarms: generated by the proprietary control system of the equipment or its internal logic of malfunction detection. This could be read from the equipment and integrated in the tool, but the communication limitations do not allow to integrate them. This is due to the fact that RATIO's PLC reads from other PLCs and has a limitation of 64 variables within its PLC.
  - Sensors alarms: generated by comparison of sensors measurements with predefined thresholds in order to detect that operating condition are out of bounds. For example, temperature of the solar thermal panels cannot exceed 90ºC. The thresholds are set by CARTIF following the manual of the technical providers of SunHorizon, but can be updated afterwards in case of need.

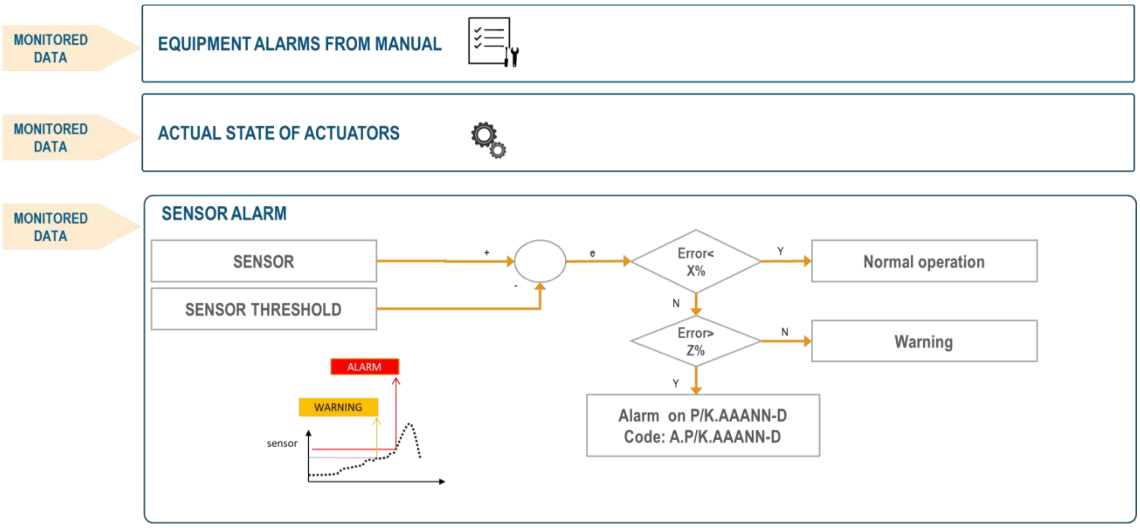

Figure 4 – Type of alarms (Source: D4.2)

  - Condition based alarms: comparison between actual measurements and model outputs is carried out following the model-based fault detection theory. The size of the error of these residuals is an indicator of faults in the system. After evaluating the complexity of all the KPIs, RER and HCI are used for this purpose. Predefined thresholds are 50% for "warning alarm" and 80% for "danger alarm", as the way of detecting that operation condition in the equipment and/or system are changing. The threshold will be fine-tuned during the monitoring campaign.

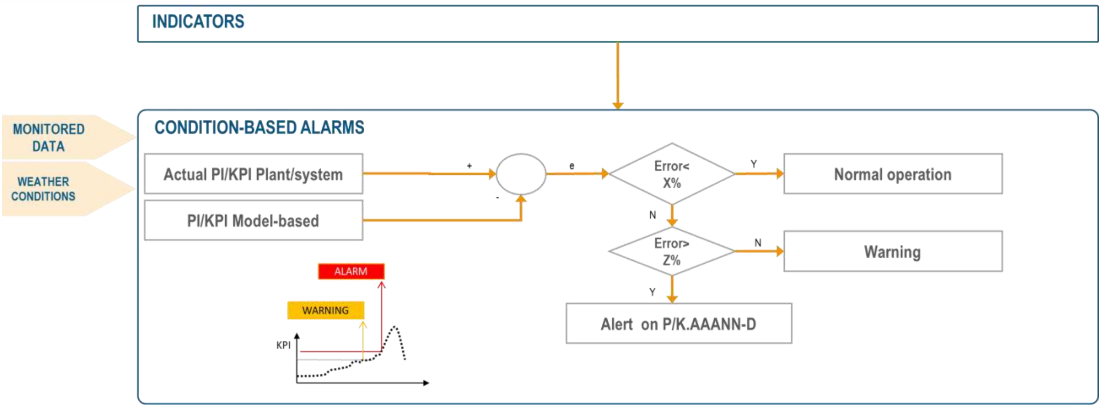

Figure 5 – condition-based alarms (Source: D4.2).

- Fault detection logic: this decision-making module will identify if any fault situation is occurring in the system according to the alarms combination and will associate it with any of the defined failure modes included in the FMECA reports. A list of faults is included in D4.2. Numerous faults need the combination of condition-based alarms + sensor alarms + actual state of actuators to detect the specific fault. Some equipment alarms could be useful to improve the detection logic. Nevertheless, it is not possible to integrate them due to limitations of RATIO's PLC. Plus, these alarms (equipment alarms) will already be shown in the technology panel (e.g. Boostheat technology), so it is not essential to include them.

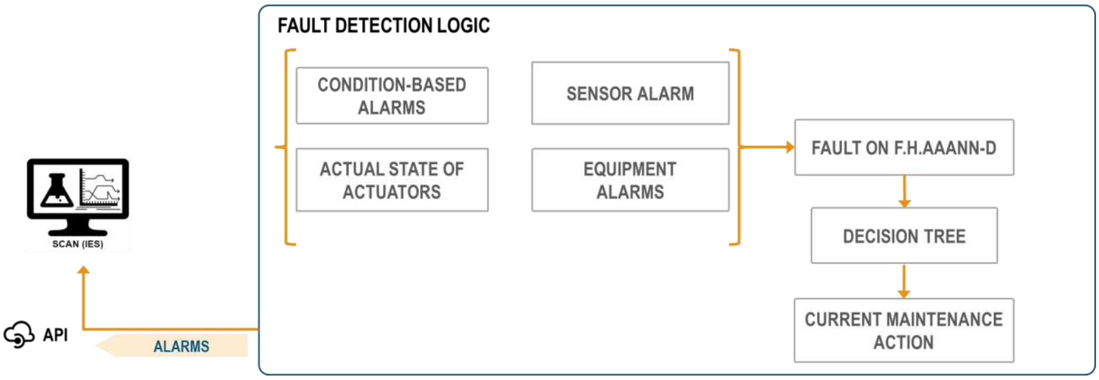

Figure 6 – fault detection logic (using condition-based alarms + sensor alarms + actual state of actuators) (Source: D4.2).

- Maintenance KPIs calculator: based on the detected faults of the equipment in the demos, maintenance KPIs are calculated to assess the maintenance strategy's performance, especially when new maintenance tasks are defined.

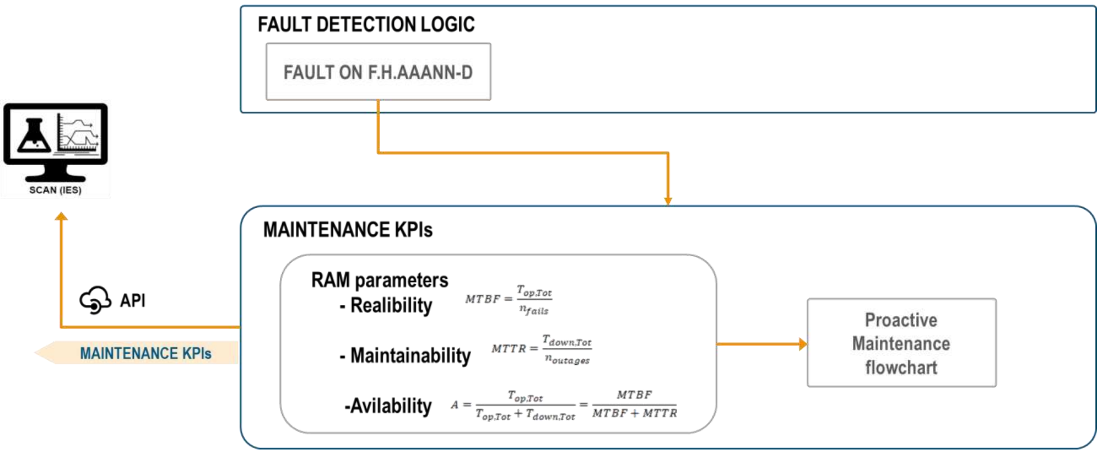

Figure 7 – RAM parameters calculation (Source: D4.2).

The sensor alarms and conditioned-based alarms are programmed within iSCAN. This will allow to send an automatic email to the demo responsible and demo supporting partner, to diagnose the problem.

Data flow diagram obtained from Mural exercise:

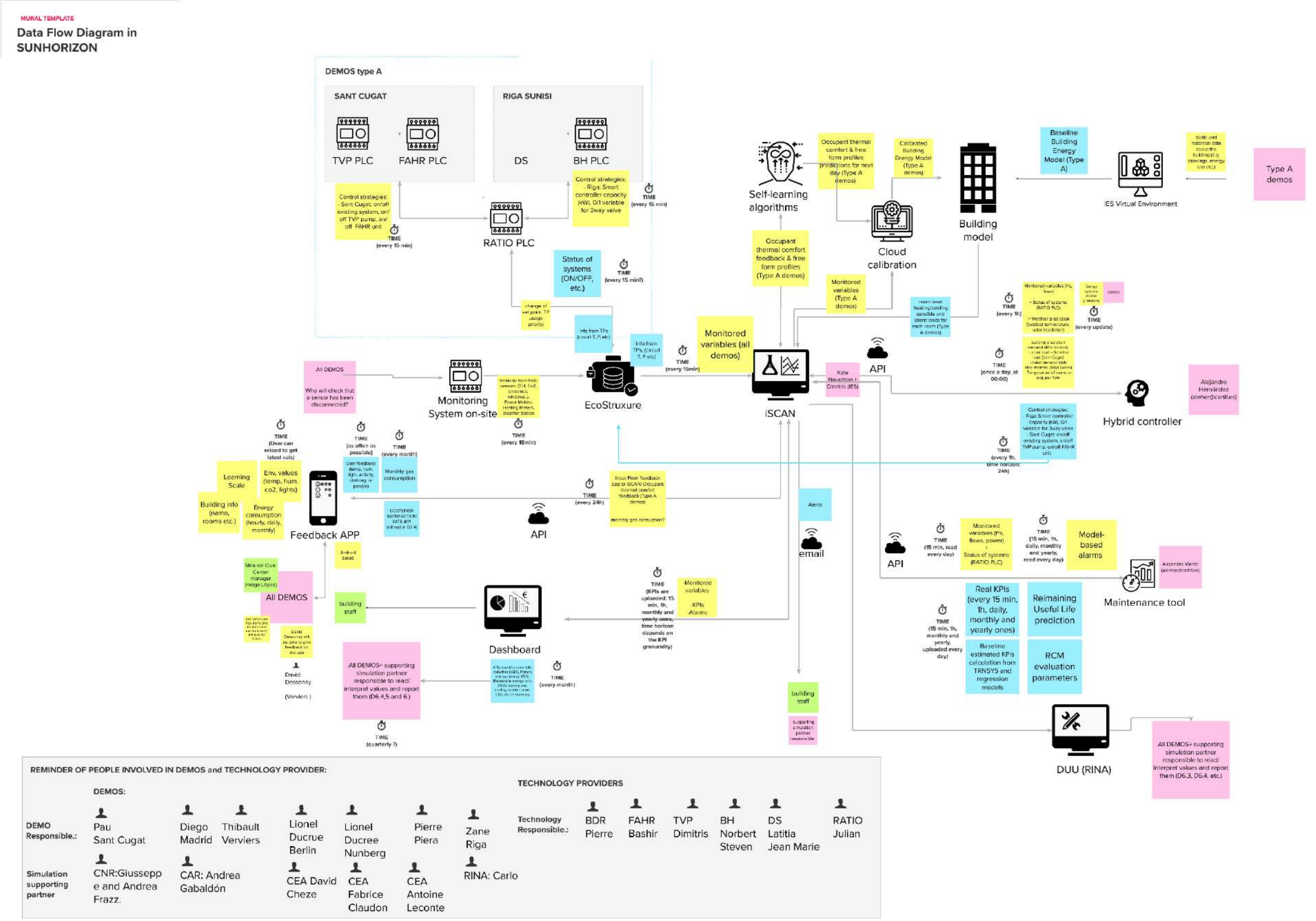

Figure 8- Mural exercise

2.3 Summary of what will be reported during the monitoring campaign

WP2 defined a list of KPIs and PIs within Task 2.3. An estimation of the expected achievements for each KPI was calculated as well. This is known in D2.4 as "threshold". The demo responsible and demo supporting partners will determine whether the KPIs of their demo are within the threshold or not, and will diagnose the reason.

Project KPIs (project level)

Table 5- Summary of KPIs: description, code (to know what to download), frequency of acquisition and threshold from WP2. The "Nº" indicates the number of the demo site

KPI	Description	Code in iSCAN	Frequency	Threshold
CAPEX	Capital expenditure	K.CAPex-Nº	One-off	reduction from 5 to 10%
CBR	Costumer's bills reduction	K.CBRsy-Nº-mon	Monthly (and yearly)	up to 60%.
CSAT*	Customer's satisfaction rate	K.CSAtu-Nº	Unknown	No threshold
GHG savings	GHG emissions reduction	K.GHGsa-Nº-mon	Monthly (and yearly)	40 to 60% (expressed in relative values)
HCI	Heating comfort index (building level)	K.HCIsy-Nº-mon	Monthly (and yearly)	7 to 15 ºC·h
CCI	Cooling comfort index (building level)	K.HCIsy-Nº-mon	Monthly (and yearly)	7 to 15 ºC·h
LCOH	Levelized cost of heat	K.LCOhs-Nº	Yearly	from 2 to 4 cts€/kWh
OPEX	Operational expenditure	K.OPExs-Nº	Yearly	a reduction from 10 to 20% of the OPEX
PESnren (absolute) And relative: $f_{sav,PE_{nren}}$	Non-renewable primary energy savings	K.PESnr-Nº-mon	Monthly (and yearly)	50 to 70% (expressed in relative values)
RER	Renewable energy ratio	K.RERsy-Nº-mon	Monthly (and yearly)	40 to 70% (expressed in relative values)
SCR	Electricity self-consumption fraction	K.SCRsy-Nº-mon	Monthly (and yearly)	up to 80% of self-consumption ratio
SPB	Simple pay back	K.SPBsy-Nº	One-off	10 years

*CSAT frequency will depend on the amount of feedback received from the user.

Besides the threshold, the direct impact of the eight SunHorizon demonstration cases is:

- Primary energy savings: 107 kWh/m²/yr
- Reduction of thermal energy bill: 5.9 €/m²/yr
- GHG emission savings: 23 kg-CO_2/m²/yr
- Share of energy consumption from RES for H&C: 58%
- Investment: 721,510 €

Project PIs (Technologies)

SunHorizon will demonstrate at TRL7 modular, high-performance, integrated, affordable **components** to provide low-carbon heating and cooling in residential and commercial buildings. The solutions will rely on renewable,

local energy sources to promote feasible alternatives to traditional fossil fuel-based solutions, as well as on energy storage to match the thermal energy supply to the demand.

Particularly, each technology aims to improve their components (within WP3) to:

- *TVP aims to achieve an instantaneous solar thermal efficiency of 70% (at 90ºC). Furthermore, TVP aims to achieve an energy output increase of 20% 2 ,*
- *BoostHeat aims to achieve up to 200% of SGUE values (PI BH01). OPEX reduction of 20%3*
- *Fahrenheit aims to increase COP by 20-30% and an OPEX and CAPEX reduction of 10-15% and 20%, respectively*
- *BDR aims to increase the COP of the systems in 15%. It will result in 15% electricity savings and 20% of OPEX reduction.*
- *Dual Sun aims to increase of 25% the instantaneous efficiency for low temperature applications and an increase of 60% for DHW preparation. Reduce the CAPEX in 10%.*
- *RATIO aims to increase annual solar energy capture by 20% and O&M cost reduction in 15%.*

The objective is not to achieve the improvements in real time operation (and at a system level), but at component level (in test labs in WP3). Nevertheless, using PIs calculation, it could be analysed if at system level some of these objectives are also achieved.

Table 6- Summary of PIs: description, code (to know what to download), frequency of acquisition and threshold from WP2

PI	Description	Frequency	Technology
$\eta^{gross}_{TVP,at\,T_{supply}}$	Instantaneous thermal efficiency	Monthly	TVP
$f_{sol,th}$	Solar Thermal Fraction	Monthly	TVP
$SGUE$	Seasonal Gas Utilization Efficiency	Monthly	BH
SPF_{BH}	Seasonal Performance Factor	Monthly	BH
$(S)EER$	Seasonal electric EER (cooling)	Monthly	FAHR
SPF_{FAHR}	Seasonal Performance Factor of FAHR unit	Monthly	FAHR
$(S)COP_{BDR}$	Seasonal electric COP (heating)	Monthly	BDR
$(S)EER_{BDR}$	Seasonal electric EER (cooling)	Monthly	BDR
SPF_{BDR}	Seasonal Performance Factor of BDR unit	Monthly	BDR
$\eta^{gross}_{BDRcol,th}$	Instantaneous thermal efficiency	Monthly	BDR- PIERA
$f_{sol,th}$	Solar thermal fraction	Monthly	BDR- PIERA
$\eta^{gross}_{BDRcol,el}$	Solar Electric efficiency	Monthly	BDR- PIERA
$\eta^{gross}_{DS,th}$	Instantaneous thermal efficiency:	Monthly	DS
$f_{sol,th}$	Solar thermal fraction	Monthly	DS
$\eta^{gross}_{DS,el}$	Solar Electric efficiency	Monthly	DS
TER	Thermal-electric Ratio	Monthly	DS
dT	Stratification Efficiency		RATIO

Alarms

An automatic email will be sent by iSCAN to the demo site supervisors

The status of the alarm can be warning or danger.

It is responsibility of demo site supervisors to assess if there is actually something damaged (e.g. the KPI of RER is decreasing from the reference value, due to the decrease of performance of PVT panels, maybe they are not clean) or alarms are being raised very often for no reason (in that case CARTIF revises and fine tunes the tool).

Every time there is an alarm, the alarm needs to be included in table of subsection B of the Annex, indicating when it was raised, what was the problem and if any action was taken/needed to solve the issue.

Current alarms at 2021-06-16 08:51 UTC:

Category	Alarm	Timestamp	Raised at	State	Details
D.K.RERsy-9-15m	*K.RERsy-9-15m*	2021-06-15 00:00	2021-06-16 08:47	Danger	K.RERsy-9-15m

Unsubscribe from these emails

Figure 9- Example of a typical alarm email. The image was obtained from testing the proactive maintenance tool and communication with iSCAN platform

2.4 How to report the monitoring campaign

Every month, demo site responsible does screenshots of the IES dashboard, including the monthly main 12 KPIs. Figure 11 shows an example of the dashboard. The time frame can be change according to the needs (last month, last 7 days, etc.) and the KPIs and PIs of previous tables will be there. Screenshots will be taken every month by the demo responsible, and with the support of the simulation supporting partner an analysis will be performed.

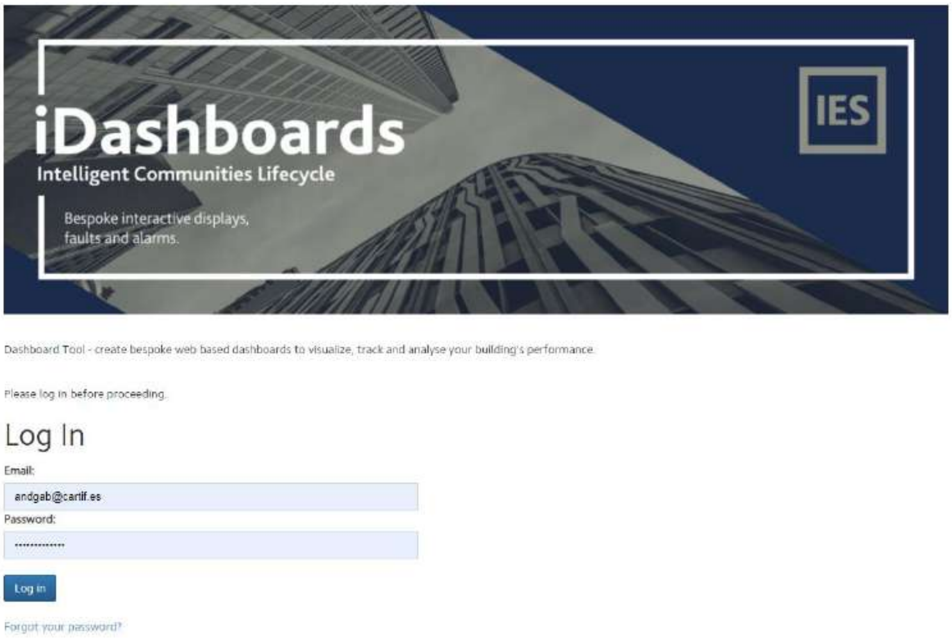

Figure 10 - iDashboard log in

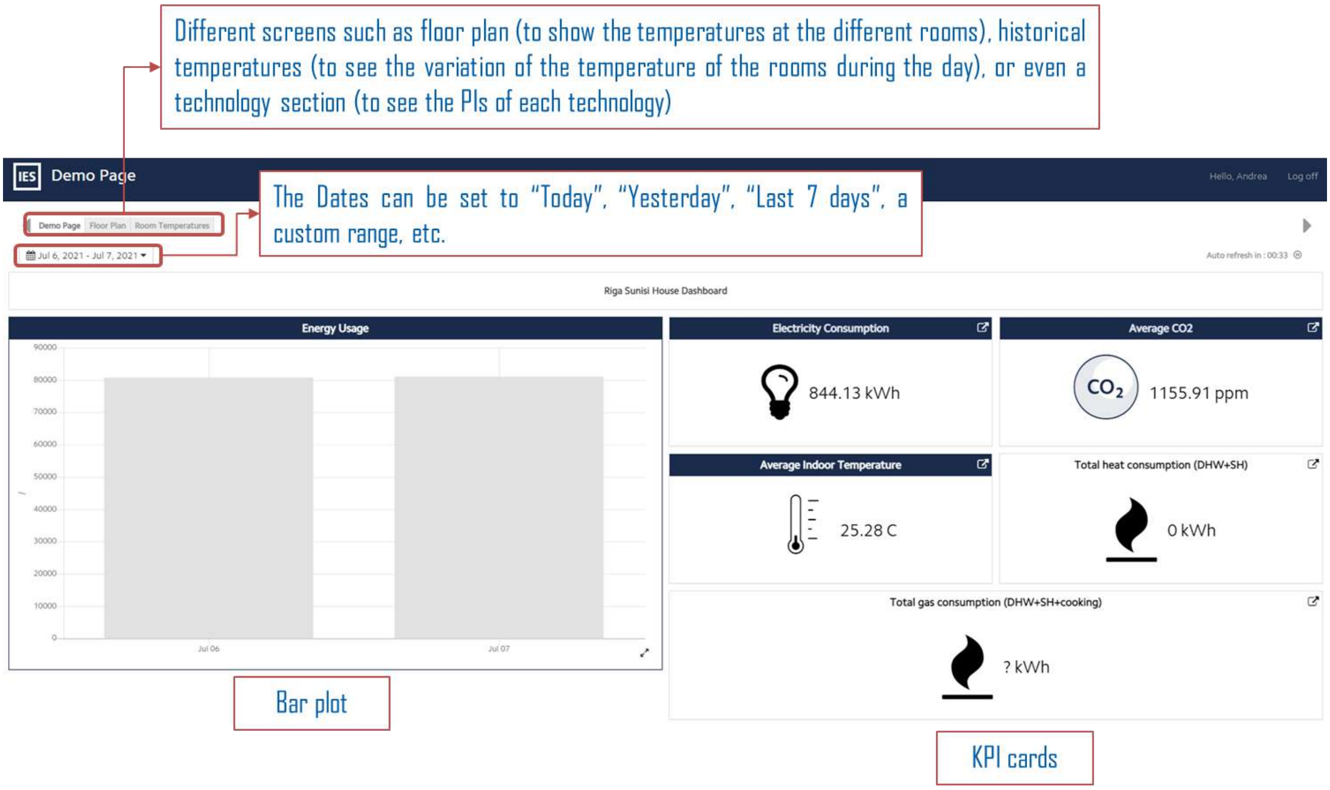

Figure 11 - IES Dashboard example. The Dates can be set to "Today", "Yesterday", "Last 7 days", etc. There will be different screens such as floor plan (to show the temperatures at the different rooms), historical temperatures (to see the variation of the temperature of the rooms during the day), or even a technology section (to see the PIs of each technology)

Then, the monthly 12 KPIs in a 6-month period is obtained (for D6.5 from September 2021 to February 2022, for D6.6 from March 2022 to August 2022). The 6-month average of the main KPIs is obtained from the Dashboard and included in table

7. In the table if the actual value is compared with the threshold of the KPI and any deviation from the threshold is explained below the table. For example, if it has an impact on scope, and the contingency plan.

It must be considered that some KPIs will be very affected by seasonal variability, and the threshold is an annual value. Therefore, in D6.6 an average within the 12-month monitoring campaign should be also calculated.

Table 7- KPIs summary template for demonstration campaign

KPI name	Threshold	Actual value	Deviation	Impact on scope
			Yes/No	

Contingency plan of deviations can be described afterwards (e.g., set a different control strategy, refine the KPI calculation or alarm notification, etc.).

3 Berlin #1

3.1 Status update of the demo site

The tender was launched in May 21 and the contract will be signed in September 21 with the installer (company Werkstück) and the owner. The installation starting date is planned by April 22. The TVP panels have been replaced by Ratiotherm panels and the renovation of the roof will be performed by the owner.

3.2 Status update of the monitoring system

The future monitoring system architecture is shown in the following figure.

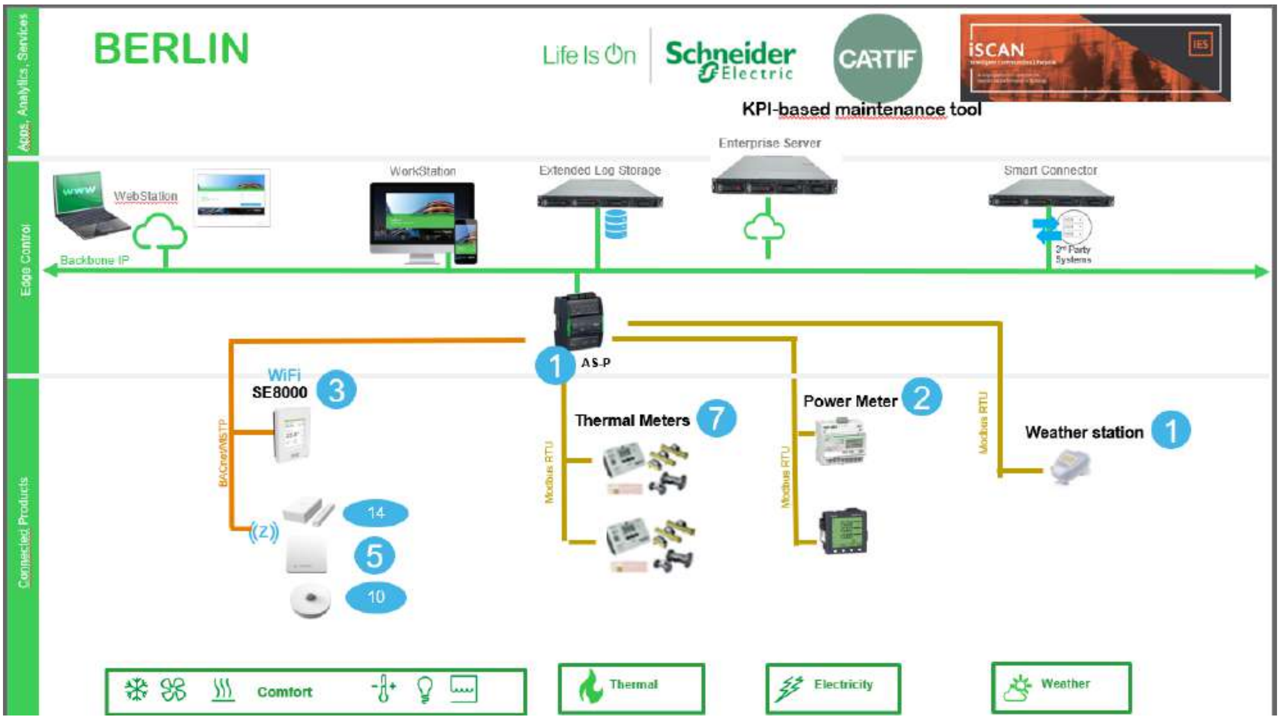

Figure 12 - Monitoring Architecture (Berlin)

The sensors that have been already provided are listed below. Only two sensors are missing.

Table 8 – Status update of the monitoring sensors (Berlin)

Article	Description	Qty	Delivered	
SE8350U5B00P	Fancoil Controller + Sensor (T, H, CO2) (wireless, zigbee comunication) - 24V AC		Yes	SE 8000
SED-CO2-G-5045	Zigbee Sensor (T, H, CO2)	5	Yes	T H CO2
SED-MTH-G-5045	Zigbee Sensor (T, H, motion) - Battery	10	Yes	P
SED-WDC-G-5045	Zigbee Window/door Sensor	14	Yes	W
AS-P	Automation Server	1	Yes	C BOX
PS-24V	24V PS for thermal meters and controllers	1	Yes	
TB-PS-W1	Terminal Block for PS24	1	Yes	
TB-ASP-W1	Terminal Block for AS-P	1	Yes	
ABLM1A24012	Power transformer	1	Yes	
A9MEM2155	Electricity meter iEM2155 1P+N direct ins. 63A display comm Modbus MID	2	Yes	EM
		1	Yes	
KDK00R	Ultrasonic Thermal Meter for DHW and heating	4	Yes	TM
KAMODR	Modbus communication module	6	Yes	TM FM
KDF00F	Flow meter	2	Yes	FM
	Weather Station	1	Yes	WS
	Thermal Meter ((DN12 / 10 m / 0.02 l/s))	1	**No**	TM
	Thermal meter -Glycol	1	**to be defined**	

3.3 KPIs summary

In next steps, tables from the Annex, subsection A, B and C, will be filled in with monthly values. In case the KPIs values are not within the thresholds, contingency plans will be described to solve the issues (if possible) or provide insights for future installations of the TPs.

3.4 KPI and PIs screenshots from iSCAN

The installation of technologies has not finished. Thus, the sensors from the technologies and the SunHorizon system have not been installed and no data is being collected from the demo site. Therefore, the iDashboard is not available as KPIs cannot be calculated neither the channels can be connected with the sensors (as they are not installed yet).

When the installation is commissioned, **screenshots from the iDashboard will be taken every month**: from every screen. There will be a screen with the main 12 KPIs (see Table 5), another with room temperatures, another one with evolution of temperatures and lastly one with the PIs at technology level. The time frame can be changed according to the needs (last month, last 7 days, etc.). The time frame should be at least set for obtaining the KPIs from the previous month. If there is an alarm then screenshots from that day can be taken to diagnose what happened. Based on the screenshots, the demo site responsible, with the support of the simulation supporting partner, will perform an analysis on a monthly basis.

3.4.1 Month 36

Data from the pre-monitoring period (prior M36) is not being collected in demo Type B.

D6.5 will include reporting from M37 to M42, and D6.6 from M43 to M48.

3.5 Alarms logging

Alarms will be reported here. An automatic email will be sent to the building staff (to be confirmed), demo responsible, and the simulation supporting partner. No alarm notification has been set yet for this demo site.

Table 9 – Alarm receivers (Berlin)

ROLE IN THE PROJECT	PROJECT PARTNER
Building Staff	Not registered yet
Demo Responsible	BH/Lionel Ducree
Simulation Supporting partner	CEA/David Cheze

4 Nürnberg #2

4.1 Status update of the demo site

The tender was launched in May 21 but we are searching for a new installer from October to mid-December 2021. The installation starting date is planned by May 22. In parallel, BH is searching for a carpenter for the roof reinforcement.

4.2 Status update of the monitoring system

The future monitoring system architecture is shown in the following figure.

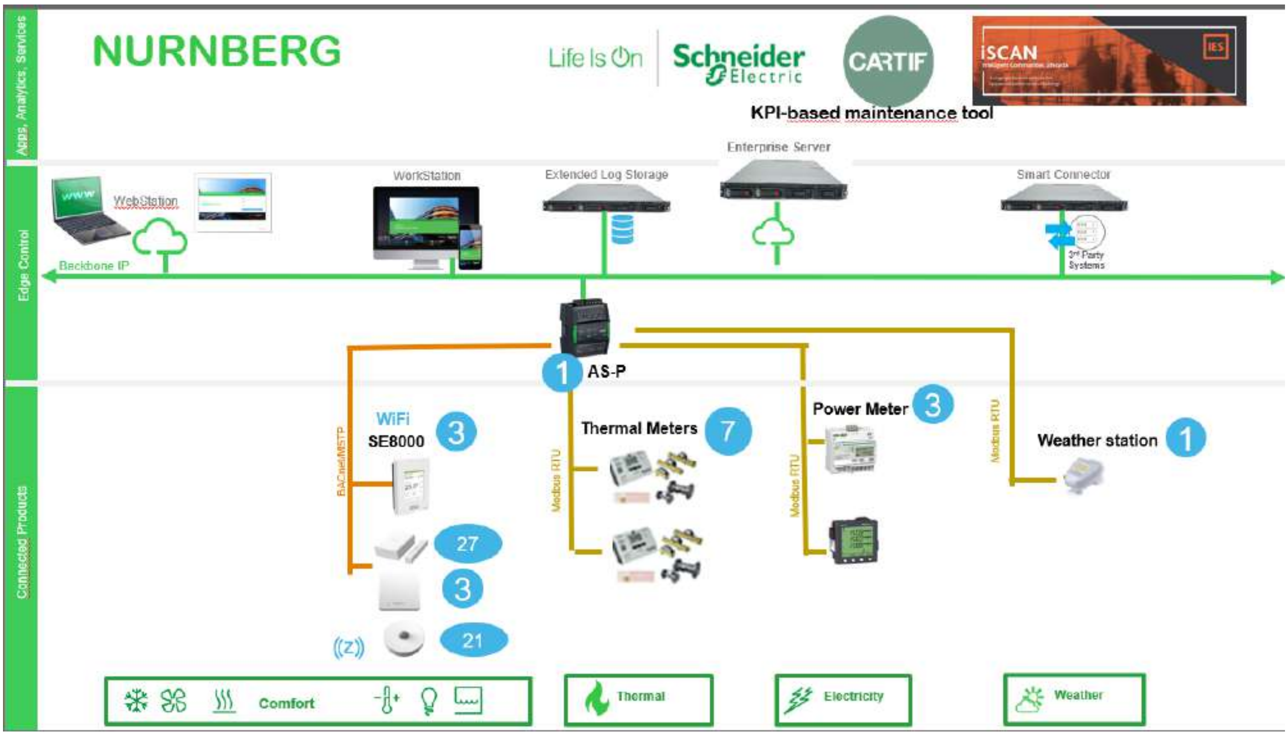

Figure 13 - Monitoring Architecture (Nürnberg)

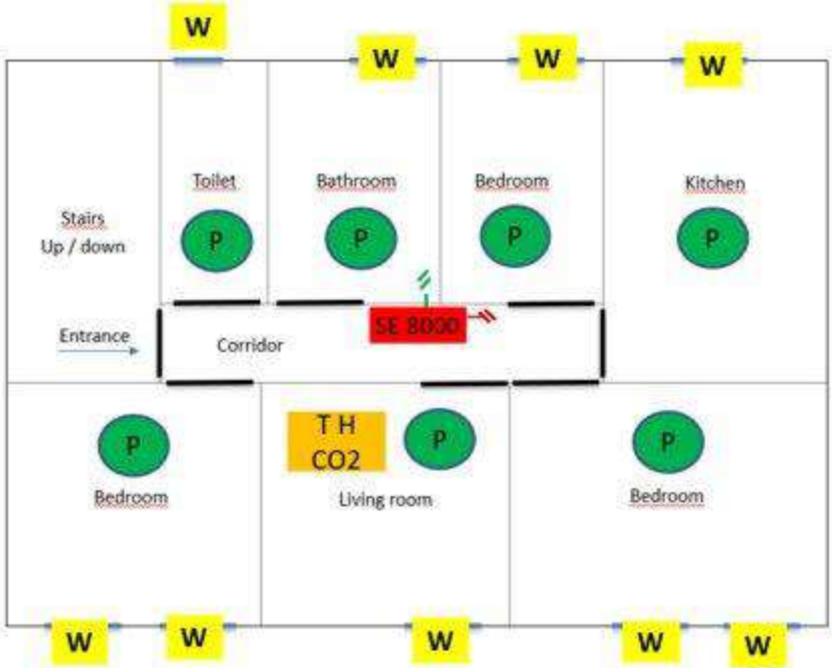

Figure 14 - Monitoring Architecture: Map of room sensors (Nürnberg)

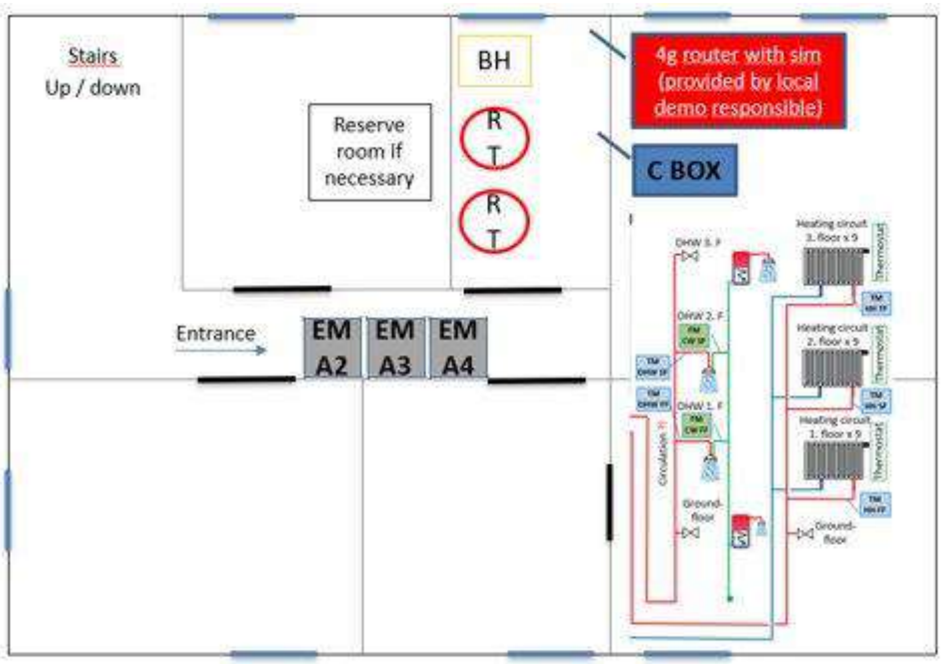

Figure 15 - Monitoring Architecture: Map of thermal meters (Nürnberg)

The sensors that will be provided are listed below.

Table 10 - Status update of the monitoring sensors (Nürnberg)

Article	Description	Qty	Delivered	
SE8350U5B00P	Fancoil Controller + Sensor (T, H, CO2) (wireless, zigbee comunication) - 24V AC	3	No (Ready for shipment)	SE 8000
SED-CO2-G-5045	Zigbee Sensor (T, H, CO2)	3	No (Ready for shipment)	T H CO2
SED-MTH-G-5045	Zigbee Sensor (T, H, motion) - Battery	21	No (Ready for shipment)	P
SED-WDC-G-5045	Zigbee Window/door Sensor	27	No (Ready for shipment)	W
AS-P-NL	Automation Server	1	No (Ready for shipment)	C BOX
PS-24V	24V PS for thermal meters and controllers	1	No (Ready for shipment)	
TB-PS-W1	Terminal Block for PS24	1	No (Ready for shipment)	
TB-ASP-W1	Terminal Block for AS-P	1	No (Ready for shipment)	
ABLM1A24012	Power transformer	1	No (Ready for shipment)	
	Power transformer for KD	1	No (Ready for shipment)	
	Box	1	No (Ready for shipment)	
	PS for SE8000	5	No (Ready for shipment)	C BOX
	Weather Station	1	No (Ready for shipment)	SE 8000
	Electricity meter	3	No (Ready for shipment)	WS
	Thermal meter	7	No (Ready for shipment)	EM
				TM

4.3 KPIs summary

For the future, tables from the Annex, subsection A, B and C, will be filled in with monthly values. If the values of the KPIs are not within the thresholds, contingency plans will be described to solve the issues (if possible) or provide insights for future installations of the TPs.

4.4 KPI and PIs screenshots from iSCAN

The installation of technologies has not finished. Thus, the sensors from the technologies and the SunHorizon system have not been installed and no data is being collected from the demo site. Therefore, the iDashboard is not available as KPIs cannot be calculated neither the channels can be connected with the sensors (as they are not installed yet).

When the installation is commissioned, **screenshots from the iDashboard will be taken every month**: from every screen. There will be a screen with the main 12 KPIs (see Table 5Table 5), another with room temperatures, another one with evolution of temperatures and lastly one with the PIs at technology level. The time frame can be changed according to the needs (last month, last 7 days, etc.). The time frame should be at least set for obtaining the KPIs from the previous month. If there is an alarm then screenshots from that day can be taken to diagnose what happened. Based on the screenshots, the demo site responsible, with the support of the simulation supporting partner, will perform an analysis on a monthly basis.

4.4.1 Month 36

Data from the pre-monitoring period (prior M36) is not being collected in demo Type B.

In case of D6.5, reporting will start from M37 to M42 and, in case of D6.6, from M43 to M48.

4.5 Alarms logging

Alarms will be reported here. An automatic email will be sent to the building staff (to be confirmed), demo responsible, and the simulation supporting partner. No alarm notification has been set yet for this demo site.

Table 11 - Alarm receivers (Nürnberg)

ROLE IN THE PROJECT	PROJECT PARTNER
Building Staff	Not registered yet
Demo Responsible	BH/Lionel Ducree
Simulation Supporting partner	CEA/Fabrice Claudon

5 Sant Cugat #3

5.1 Status update of the demo site

The courtyard reinforcement has been done in May 21. The installation by VEO started in June 21 and, currently, only the technical room, the interconnections with the re-coolers and the current system are finished. The hybrid chiller is being delivered soon. The commissioning and start up should be postponed by end-September to mid-October.

5.2 Status update of the monitoring system

The future monitoring system architecture is shown in the following figure.

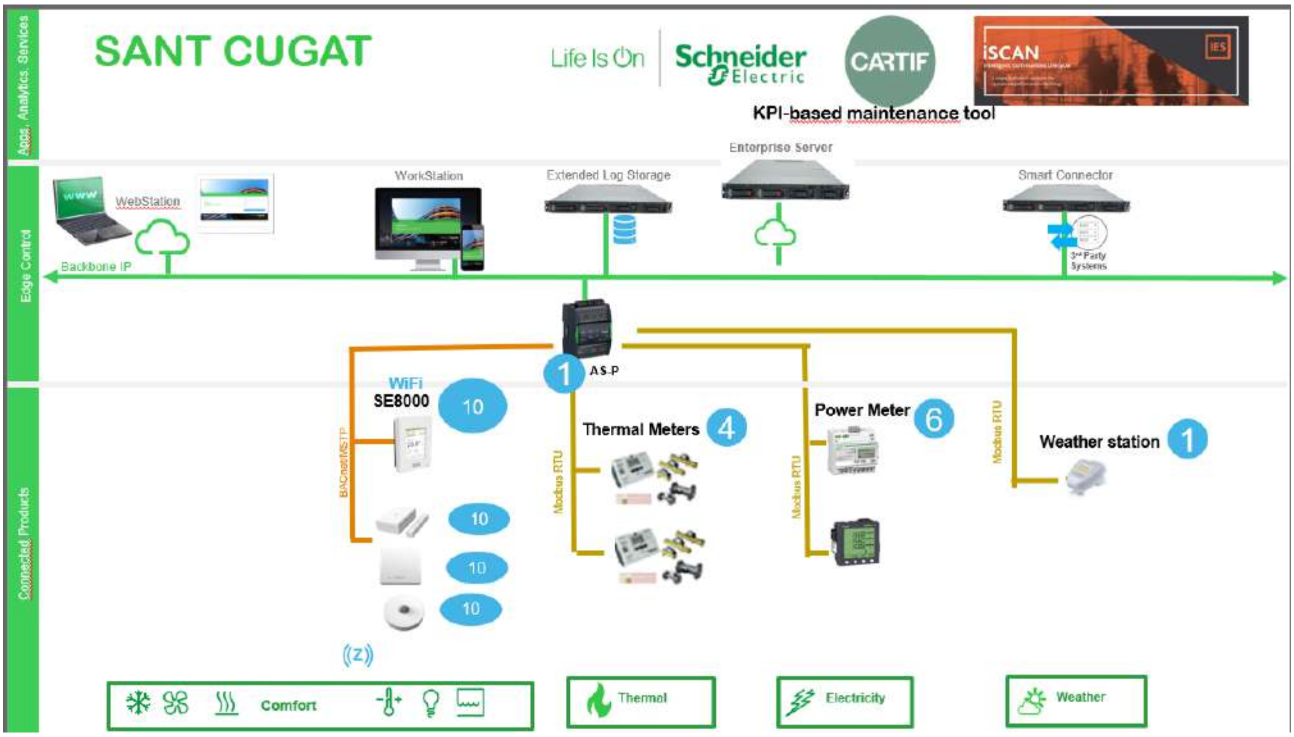

Figure 16 - Monitoring Architecture (Sant Cugat)

The sensors that have been already provided are listed below. Only one Electricity meter is missing.

Table 12 - Status update of the monitoring sensors (Sant Cugat)

Article	Description	Qty	Delivered	
SE8350U5B11P	Fancoil Controller + Sensor (T, H, CO2) (wireless, zigbee comunication) - 24V AC	10	Yes	SE 8000
SED-CO2-G-5045	Zigbee Sensor (T, H, CO2)	10	Yes	T H CO2
SED-WDC-G-5045	Zigbee Window/door Sensor	10	Yes	W
SED-MTH-G-5045	Zigbee Sensor (T, H, motion) - Battery	10	Yes	P
AS-P	Automation Server	1	Yes	C BOX
PS-24V	24V PS for thermal meters and controllers	1	Yes	
TB-PS-W1	Terminal Block for PS24	1	Yes	
TB-ASP-W1	Terminal Block for AS-P	1	Yes	
ABL8MEM24012	Power transformer	1	Yes	
MKCLCGFRBM000_K	Thermal meter	1	Yes	TM
MAMODBASE-603	Modbus communication card	1	Yes	TM
A9MEM3155	Electricity meter	2	Yes	EM
----	PS24V for SE8000	10	Yes	SE 8000
----	Weather station	1	Yes	WS
----	Box	1	Yes	C BOX
A9MEM3155	Electricity meter	4	No	EM
	Thermal meter	3	Yes	TM

The exact variables that will be communicated are:

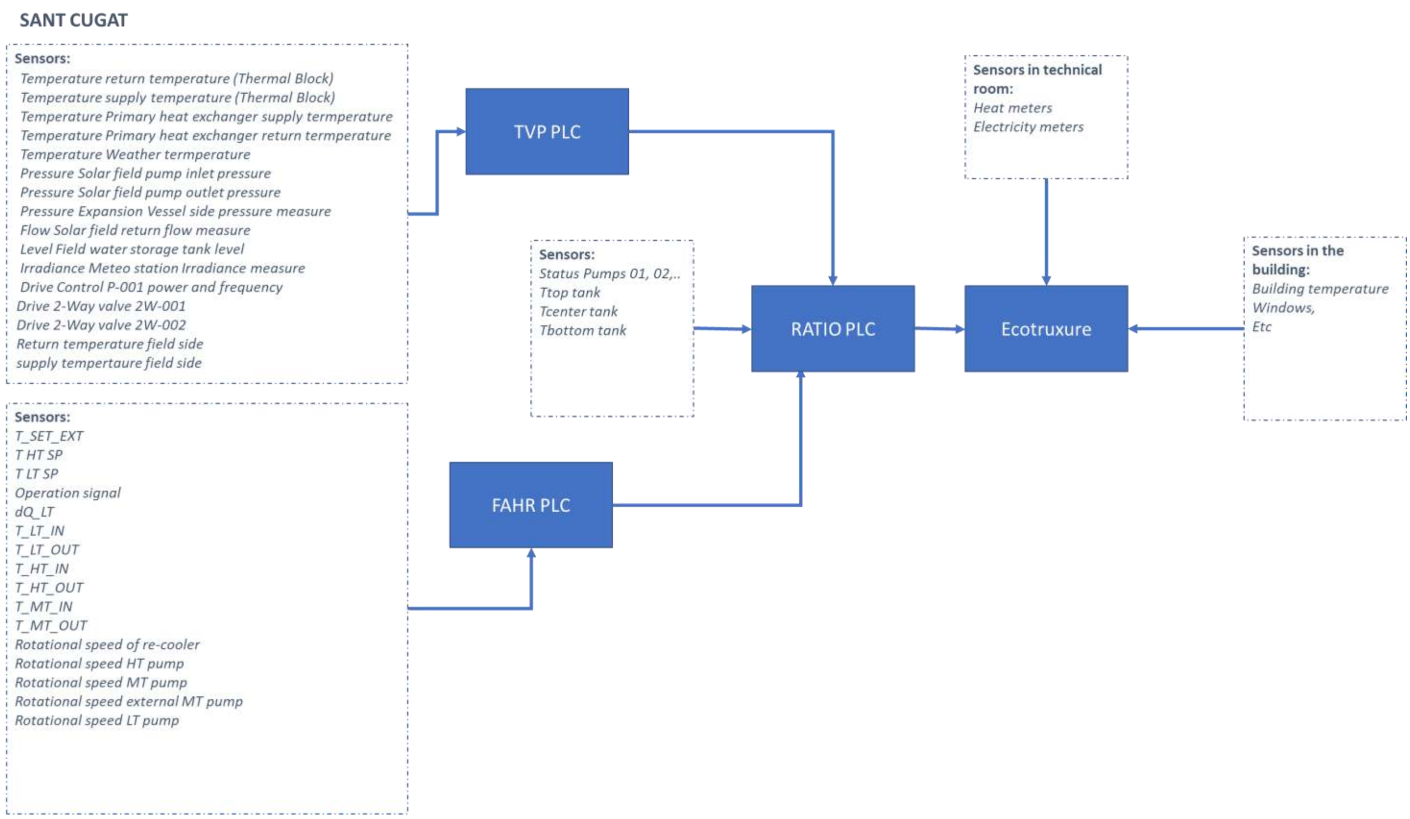

Figure 17 - Monitoring data production flow (Sant Cugat)

The data collection progress and relevant events are included in Table 13.

Table 13 - Data collection progress (Sant Cugat)

Relevant events	Date when discovered	Action taken	Mitigation plan	Date when solved
No internet access in the demo due to internal VPN	July 2020	Schneider bought a new router with internet connection	No need	August 2020
Weather station in Sant Cugat does not work (from XX/2021)	From the beginning of the monitoring period (July?)	SE contacted the WS producer in order to understand which are the problems and how to fix them	The technicians are going to solve the problem in the next month	Ongoing
Data gathering stopped (from 8th of July)	error in the Schneider server appear on 19/08/2021 11:23	Demo site responsible checks if there is some connection problem in the demo site. Demo site responsible checks if the router is connected, or if there is any other problem with the Automation Server. If everything seems fine, Demo site responsible reboots the router and the system. Schneider checks connection of the Automation Server. If everything seems fine, contacts the router provider	Include an alarm in iSCAN to automatic notification to the demo responsible Schneider has a talk with the router provider to deliver a troubleshooting guide. It seems there is also an error with the modbus configuration	Ongoing

5.3 KPIs summary

For the future, tables from the Annex, subsection A, B and C, will be filled in with monthly values. If the values of the KPIs are not within the thresholds, contingency plans will be described to solve the issues (if possible) or provide insights for future installations of the TPs.

5.4 KPI and PIs screenshots from iSCAN

The installation of technologies has not finished. Thus, the sensors from the technologies and the SunHorizon system have not been installed and no data is being collected from the demo site. Therefore, the iDashboard is not available as KPIs cannot be calculated neither the channels can be connected with the sensors (as they are not installed yet).

When the installation is commissioned, **screenshots from the iDashboard will be taken every month**: from every screen. There will be a screen with the main 12 KPIs (see Table 5Table 5), another with room temperatures, another one with evolution of temperatures and lastly one with the PIs at technology level. The time frame can be changed according to the needs (last month, last 7 days, etc.). The time frame should be at least set for obtaining the KPIs from the previous month. If there is an alarm then screenshots from that day can be taken to diagnose what happened. Based on the screenshots, the demo site responsible, with the support of the simulation supporting partner, will perform an analysis on a monthly basis.

5.4.1 Month 36

Data from the pre-monitoring period (prior M36) is being collected in demo Type A.

The pre-monitoring started in August 2020 in Sant Cugat (for room temperatures).

There is no data for winter time yet, but in May, one week of heating supply was measured. As it can be seen, the heating system starts at 4:30 am, and it supplies heating up to 8 am. The temperature supply and return are in average around 38º, and 36 respectively, but even though the power is 0, the flowrate is still on until 43ºC on the return temperature is achieved.

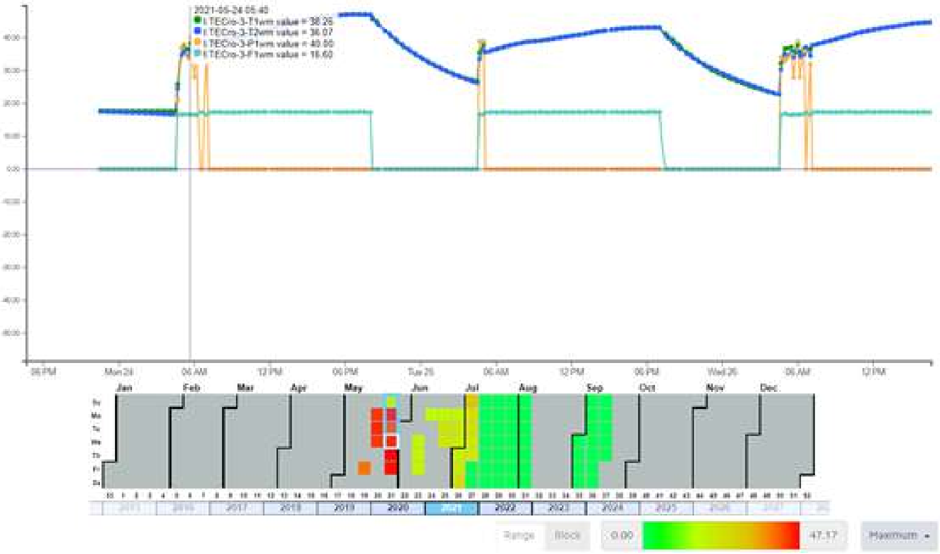

Figure 18- I.TECro-3-T1wm (Water meter return temperature), I.TECro-3-T2wm (Water meter supply temperature), I.TECro-3-F1wm (Water meter flow rate), and I.TECro-3-P1wm (Water meter power supplied) on May 24th,25th and 26th. Sant Cugat demo site

In the next figure it can be seen that the cooling system has a constant schedule, usually from 6 am to 7 pm. Although ion Saturday it seems the system can be switched off during some hours (in that day from 11:40 – 14:10). The temperatures are very constant when the cooling system is on: return temperature around 12 ºC, supply temperature around 10 ºC.

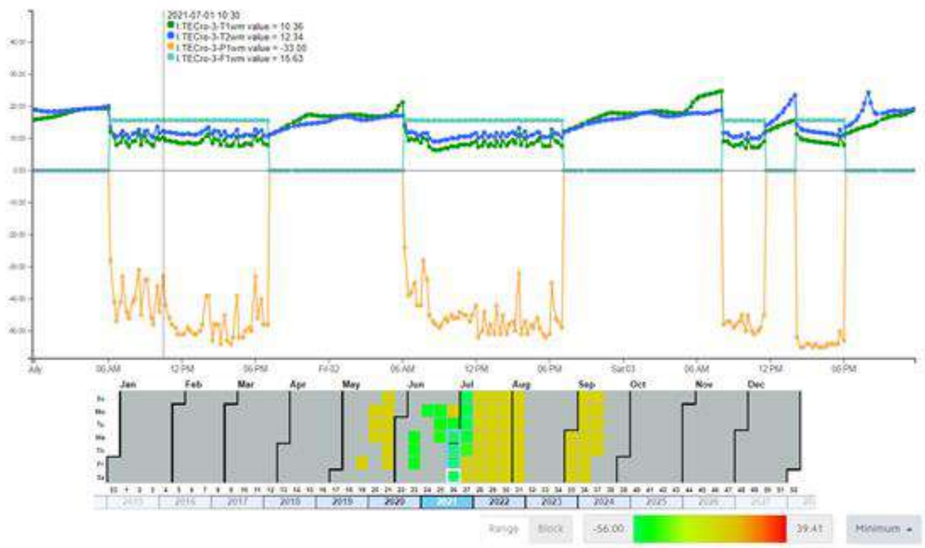

Figure 19- I.TECro-3-T1wm (Water meter return temperature), I.TECro-3-T2wm (Water meter supply temperature), I.TECro-3-F1wm (Water meter flow rate), and I.TECro-3-P1wm (Water meter power supplied) on July 1st, 2nd and 3rd. Sant Cugat demo site

There is a data loss from the 2nd week of August until the 1st week of September. This issue was diagnosed by SE and CARTIF the 3rd week of August, and it was fixed by SE (see data progress table). Nevertheless, it can be seen that from the 8th of July the Civic centre measures zero power and zero temperatures in the heat meter. It has been confirmed by the demo site responsible, that the building was closed during that time. Thus, there is some problem still with the communication with this sensor.

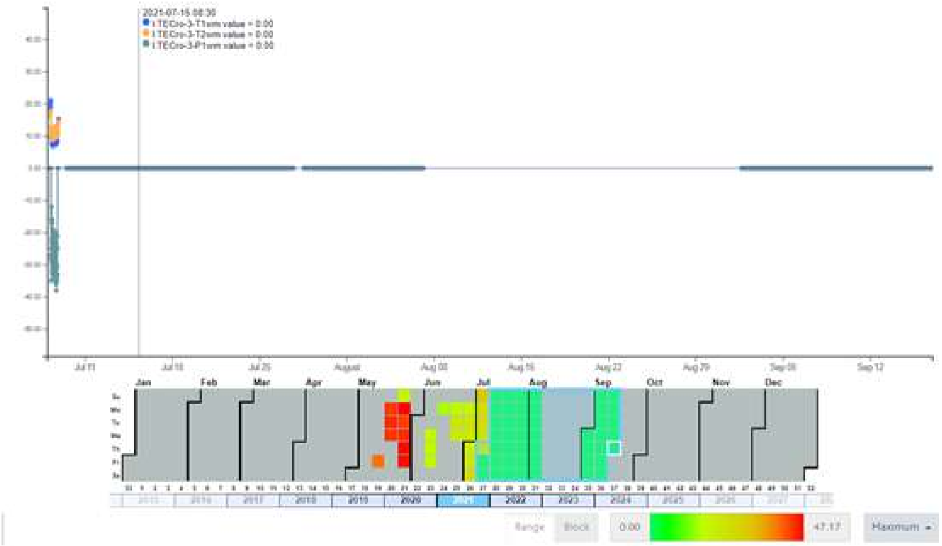

Figure 20- I.TECro-3-T1wm (Water meter return temperature), I.TECro-3-T2wm (Water meter supply temperature), I.TECro-3-F1wm (Water meter flow rate), and I.TECro-3-P1wm (Water meter power supplied) from July 8th until today (20-09-2021). Sant Cugat demo site

In the electricity meter no data is found:

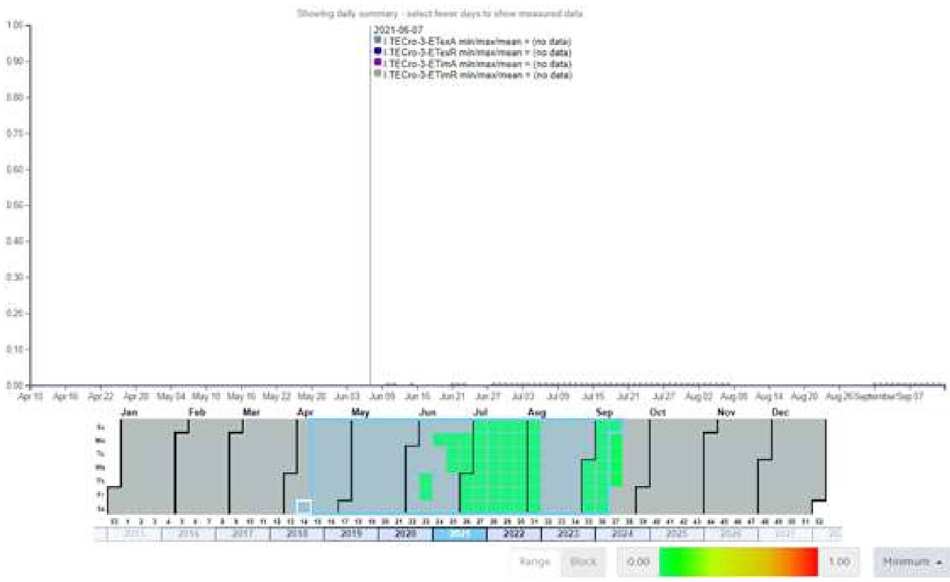

Figure 21- I.TECro-3-ETimA (Technical room active energy total import), I.TECro-3-ETexA(Technical room active energy total export), I.TECro-3-ETimR (Technical room reactive energy total import) and I.TECro-3-ETexR(Technical room reactive energy total export) from April to September. Sant Cugat demo site

In case of D6.5, reporting will start from M37 to M42 and, in case of D6.6, from M43 to M48.

5.5 Alarms logging

Alarms will be reported here. An automatic email will be sent to the building staff (to be confirmed), demo responsible, and the simulation supporting partner. No alarm notification has been set yet for this demo site.

Table 14 - Alarm receivers (Sant Cugat)

ROLE IN THE PROJECT	PROJECT PARTNER
Building Staff	VEOLIA/Silvia Jané
Demo Responsible	AJVSC/ Gerard Riba and Anna Mundet
Simulation Supporting partner	CNR-ITAE/Andrea Frazzica CARTIF/Alejandro Hernández

5.6 Pre-monitoring data analysis

5.6.1 Calibration of the building model

The calibration of the building model has not started at the time of writing this deliverable. This was a delay carried over from the delay of the commissioning of the pre-monitoring equipment. The baseline building model has been developed in IES-VE software and presented in Annex B in Deliverable 5.3. Once we gather enough pre-monitoring data we will start the calibration of the building model.

5.6.2 Calibration of the energy system model

The power consumed by the heat pump has not been measured. The building electricity consumption sensor has not worked. Therefore, it is not possible to estimate the COP of the existing heat pump and calibrate the energy system model.

Nevertheless, the power, temperature supply and return, and flow rate of the existing heat pump has been measured: for one week in May (therefore, heating supply is partially characterised), and for some period in summer. The apparent temperature from the weather file of iSCAN is used, and the following relationships are obtained for the 1st-3rd of July.

There is no clear relationship between power and outdoor apparent temperature. The range goes from -24 to -55.

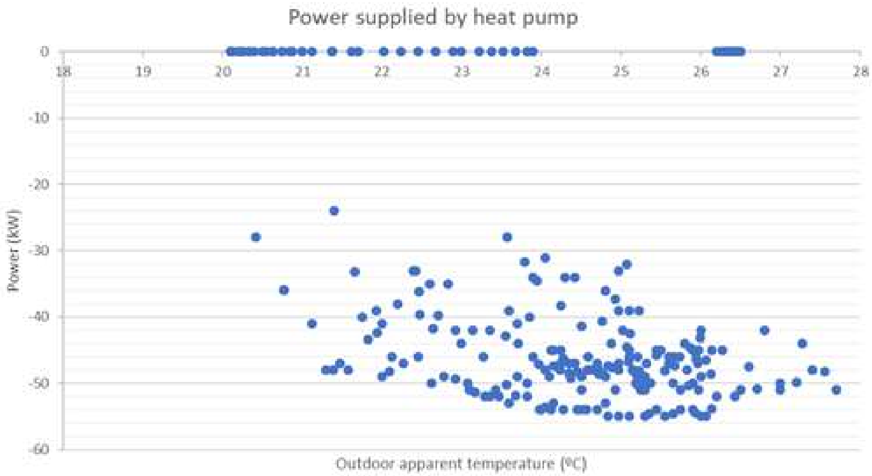

Figure 22 – Power supplied by heat pump versus outdoor apparent temperature for Sant Cugat (In summer)

There is no clear relationship between temperatures supply/return and outdoor apparent temperature. But the supply temperature is within the range of 6-14ºC, whereas the return temperature goes from 9 to 14.4 (with an average dT of 3ºC).

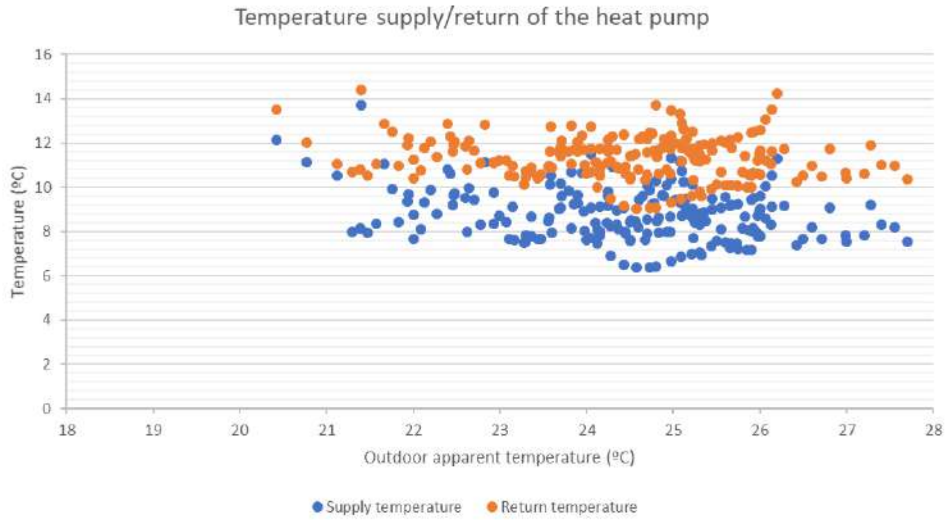

Figure 23 – return and supply temperature versus outdoor apparent temperature for Sant Cugat

6 Madrid #4

6.1 Status update of the demo site

The tender was launched in May 21 and the resolution took place in June 21 with Umavial, the same company that performed the retrofitting of the buildings. The installation started end of July 21 and currently only the technical room and the interconnections with the current system have to be performed. The commissioning and start up should be postpone until beginning of October.

6.2 Status update of the monitoring system

The future monitoring system architecture is shown in the following figure.

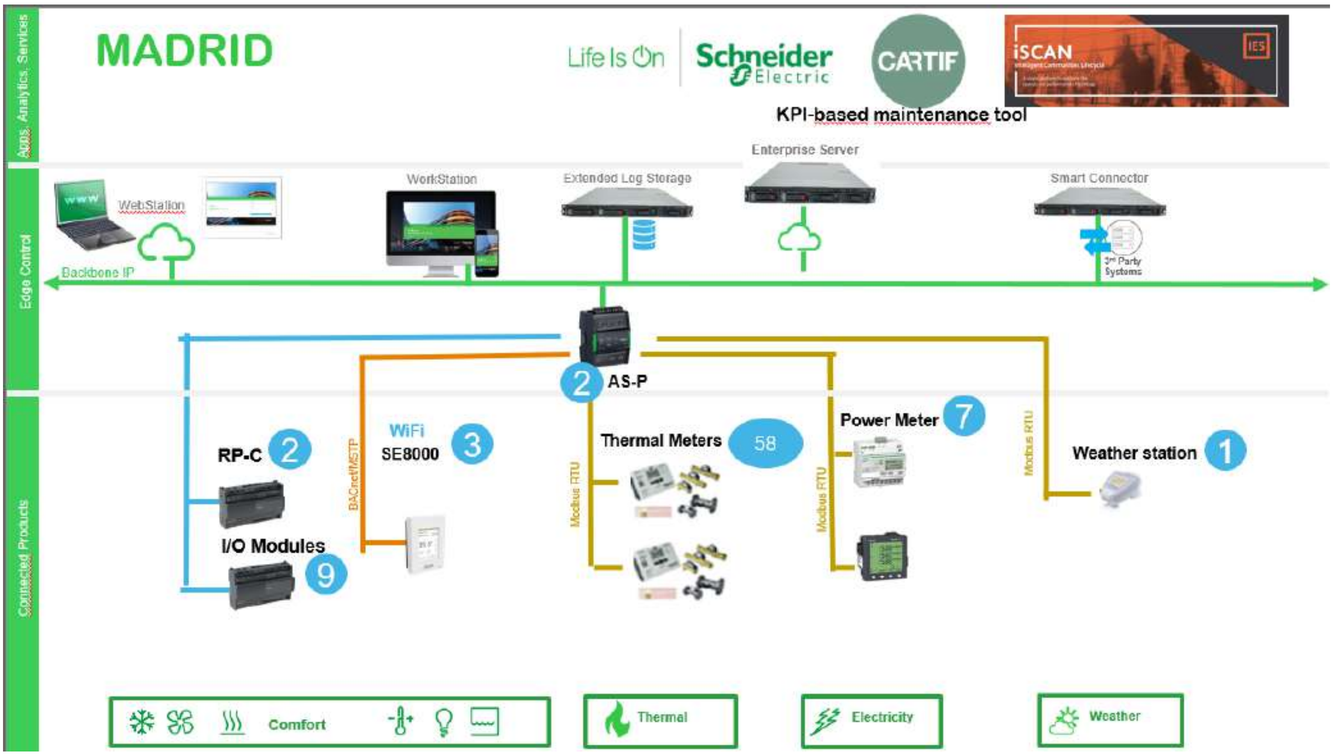

Figure 24 – Monitoring architecture (Madrid)

The sensors that have been already provided are listed below.

Table 15 - Status update of the monitoring sensors (Madrid)

Article	Description	Qty	Delivered	
METSEPM5320	Electricity meters	6	Yes	EM
	Weather station	1	Yes	WS
AS-P	Automation Server	2	Yes	C BOX
TB-ASP-W1	Terminal Block for AS-P	2	Yes	
PS-24V	24V PS for thermal meters and controllers	2	Yes	
TB-PS-W1	Terminal Block for PS24V	2	Yes	
SHO100-T	Outdoor Humidity sensor	1	Yes	TM
STP200-400	Immersion T sensor	6	Yes	TM
STP200-200	Immersion T sensor	2	Yes	TM
STP200-100	Immersion T sensor	20	Yes	TM
STP400-ot	Pocket for sensor	6	Yes	TM
STP200-ot	Pocket for sensor	2	Yes	TM
STP100-ot	Pocket for sensor	20	Yes	TM
SPW106	Differential Pressure Transmitters	2	Yes	TM
SPP110-600	Pressure Water Transmitters	5	Yes	TM
KDK30F	Thermal meter	2	Yes	TM
VF208W-50NS	Butterfly valve	14	Yes	TM
MF20-230F	Actuator for butterfly valve	14	Yes	TM
MD-S2	Auxiliary switch	14	Yes	
UI-16	Universal I/O module	4	Yes	
AO-8	Analogic I/O module for SmartX Server AS-P	2	Yes	
DO-FA-12	Digital I/O module for SmartX Server AS-P	3	Yes	
TB-IO-W1	Terminal block for I/O module	9	Yes	
S-CABLE-L2	Cable	2	Yes	
RP-C-16A-F-230V	RP-C	2	Yes	
	Flow 3,0 m³/h, Pipe DN40, Glycol (40% monopropylene glycol), Heat/Cool	1	Yes	
	Flow 1-1.5 m³/h, Pipe 40x42 Cooper, Glycol (40% monopropylene glycol), Heat/Cool	1	Yes	
KABACN	Modbus communication module	4	Yes	TM
KAD230V	PS for Multical	6	Yes	TM
STX120-400	Immersion T sensor	6	Yes	TM
METSEPM5320	Electricity meters	1	Yes	EM
STX520-400	Thermal meter	1	Yes	TM

6.3 KPIs summary

For the future, tables from the Annex, subsection A, B and C, will be filled in with monthly values. If the values of the KPIs are not within the thresholds, contingency plans will be described to solve the issues (if possible) or provide insights for future installations of the TPs.

6.4 KPI and PIs screenshots from iSCAN

The installation of technologies has not finished. Thus, the sensors from the technologies and the SunHorizon system have not been installed and no data is being collected from the demo site. Therefore, the iDashboard is not available as KPIs cannot be calculated neither the channels can be connected with the sensors (as they are not installed yet).

When the installation is commissioned, **screenshots from the iDashboard will be taken every month**: from every screen. There will be a screen with the main 12 KPIs (see Table 5Table 5), another with room temperatures, another one with evolution of temperatures and lastly one with the PIs at technology level. The time frame can be changed according to the needs (last month, last 7 days, etc.). The time frame should be at least set for obtaining the KPIs from the previous month. If there is an alarm then screenshots from that day can be taken to diagnose what happened. Based on the screenshots, the demo site responsible, with the support of the simulation supporting partner, will perform an analysis on a monthly basis.

6.4.1 Month 36

Data from the pre-monitoring period (prior M36) is not being collected in demo Type B.

In case of D6.5, reporting will start from M37 to M42 and, in case of D6.6, from M43 to M48.

6.5 Alarms logging

Alarms will be reported here. An automatic email will be sent to the building staff (to be confirmed), demo responsible, and the simulation supporting partner. No alarm notification has been set yet for this demo site.

Table 16 - Alarm receivers (Madrid)

ROLE IN THE PROJECT	PROJECT PARTNER
Building Staff	EMVS
Demo Responsible	EMVS/Diego Romera
Simulation Supporting partner	CARTIF/Andrea Gabaldón

7 Piera #5

7.1 Status update of the demo site

The demo requested a quotation and only one offer have been received (June 21). The offer is already validated and currently we are working on the agreement between BDR and the owner of Piera house, with the help of legal experts. The installation starting date is expected by September 21.

7.2 Status update of the monitoring system

The future monitoring system architecture is shown in the following figure.

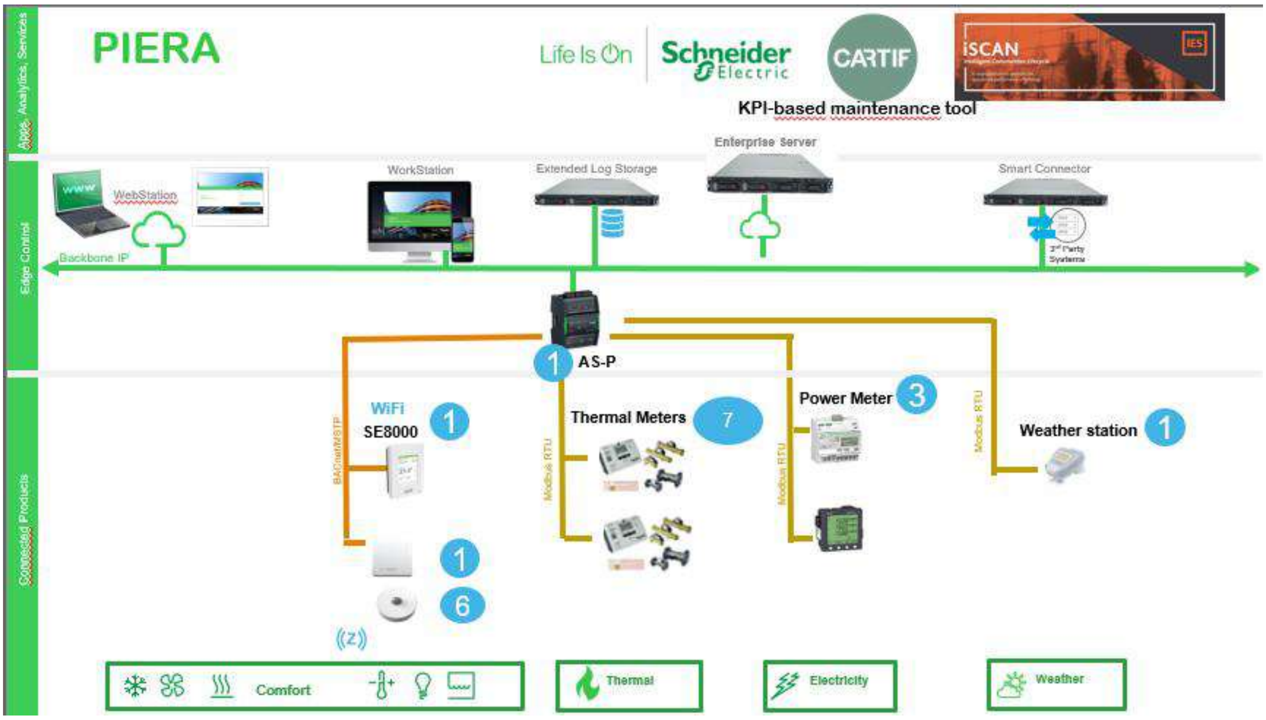

Figure 25 - Monitoring Architecture (Piera)

The sensors that have been already provided are listed below. Only one thermal meter is missing

Table 17 - Status update of the monitoring sensors (Piera)

Article	Description	Qty	Delivered	
KAMODR	Modbus communication card	4	Yes	TM
KDK05F	Thermal meter	1	Yes	TM
KDK10R	Thermal meter	3	Yes	TM
SE8350U5B00P	Fancoil Controller + Sensor (T, H, CO2) (wireless, zigbee comunication) - 24V AC	1	Yes	SE 8000
SED-CO2-G-5045	Zigbee Sensor (T, H, CO2)	1	Yes	T H CO2
SED-MTH-G-5045	Zigbee Sensor (T, H, motion) - Battery	6	Yes	P
AS-P	Automation server	1	Yes	C BOX
PS-24V	24V PS for thermal meters and controllers	1	Yes	
TB-ASP-W1	Terminal Block for AS-P	1	Yes	
TB-PS-W1	Terminal Block for PS24	1	Yes	
ABLM1A24012	Power transformer	1	Yes	
A9MEM2155	Electricity meter	3	Yes	EM
	Weather station	1	Yes	WS
	PS24V for SE8000	1	Yes	SE 8000
	Box	1	Yes	C BOX
	Thermal meter	1	Yes	TM
	Thermal meter	2	No	TM

7.3 KPIs summary

For the future, tables from the Annex, subsection A, B and C, will be filled in with monthly values. If the values of the KPIs are not within the thresholds, contingency plans will be described to solve the issues (if possible) or provide insights for future installations of the TPs.

7.4 KPI and PIs screenshots from iSCAN

The installation of technologies has not finished. Thus, the sensors from the technologies and the SunHorizon system have not been installed and no data is being collected from the demo site. Therefore, the iDashboard is not available as KPIs cannot be calculated neither the channels can be connected with the sensors (as they are not installed yet).

When the installation is commissioned, **screenshots from the iDashboard will be taken every month**: from every screen. There will be a screen with the main 12 KPIs (see Table 5Table 5), another with room temperatures, another one with evolution of temperatures and lastly one with the PIs at technology level. The time frame can be changed according to the needs (last month, last 7 days, etc.). The time frame should be at least set for obtaining the KPIs from the previous month. If there is an alarm then screenshots from that day can be taken to diagnose what happened. Based on the screenshots, the demo site responsible, with the support of the simulation supporting partner, will perform an analysis on a monthly basis.

7.4.1 Month 36

Data from the pre-monitoring period (prior M36) is not being collected in demo Type B.

In case of D6.5, reporting will start from M37 to M42 and, in case of D6.6, from M43 to M48.

7.5 Alarms logging

Alarms will be reported here. An automatic email will be sent to the building staff (to be confirmed), demo responsible, and the simulation supporting partner. No alarm notification has been set yet for this demo site.

Table 18 - Alarm receivers (Piera)

ROLE IN THE PROJECT	PROJECT PARTNER
Building Staff	Not registered yet
Demo Responsible	BDR/Pierre Koenig
Simulation Supporting partner	CEA/Antoine Leconte

8 Verviers Swimming Pool #7

8.1 Status update of the demo site

No company has responded to the tender publication and after request, 2 offers have been received. But no decision has been taken since the 2 offers (Nesca and Balteau) have to be detailed and discussed. The installation activities have not therefore been planned.

8.2 Status update of the monitoring system

The future monitoring system architecture is shown in the following figure.

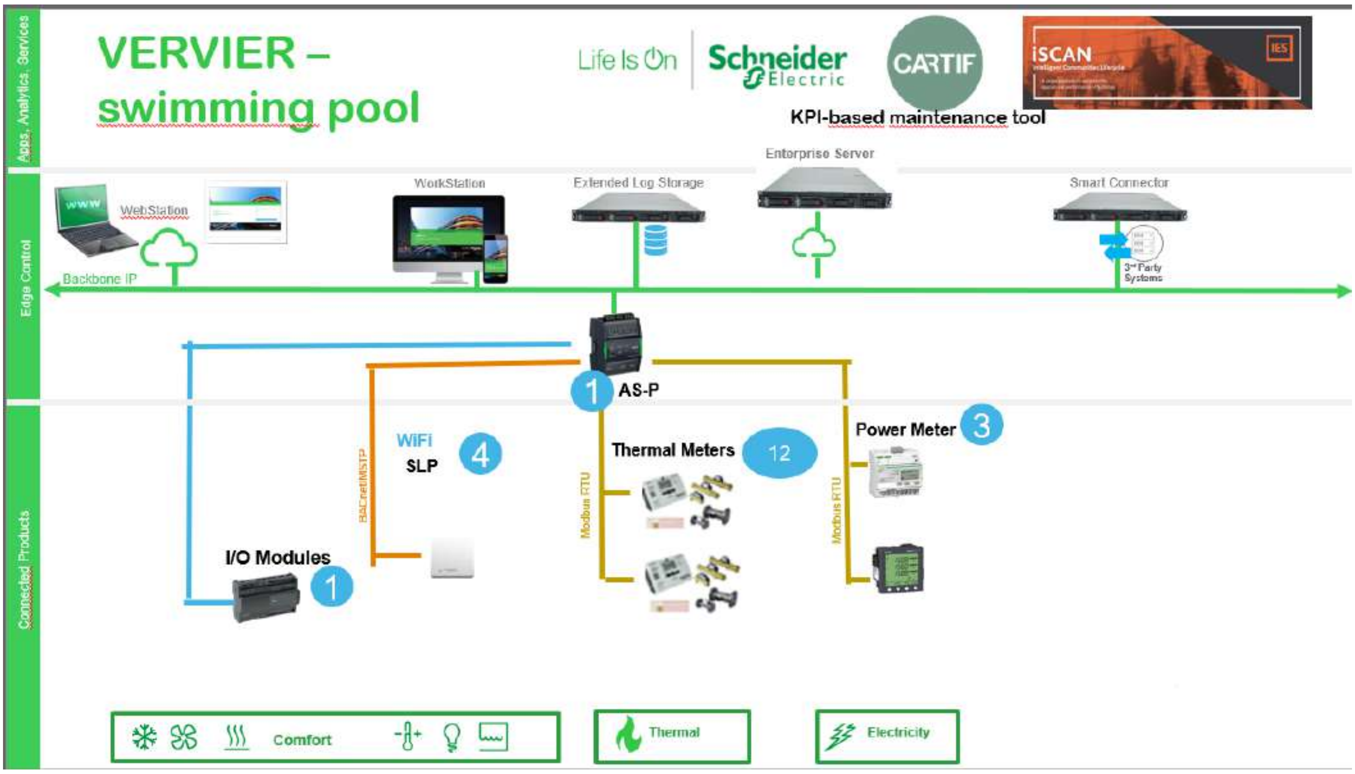

Figure 26 - Monitoring Architecture (Verviers Swimming Pool)

The sensors that will be provided are listed below.

Table 19 - Status update of the monitoring sensors (Verviers Swimming Pool)

Article	Description	Qty	Delivered	
KDK65R	Heat meter	2	No	TM
	Heat meter - Modbus RTU	1	No (to be defined)	TM
	Thermal meter	1	No (to be defined)	TM
A9MEM3155	Electricity meter MID iEM3155 3P e 3P+N direct ins.63A, Modbus RS485, 1DI+1DO	3	No	EM
STP100-50	Temperature sensor (intrusive) con guaina separata NTC 1,8K L=50mm pressacavo	7	No	TM
STP50-ac	Pozzetto in acciaio inossidabile per STP300 Lunghezza 50mm	7	No	TM
SLPWXCV2	SpaceLogic - air quality sensor -CO2, VOC, Humidity, Temperature	4	No	SLP
	Escluso dalla nostra fornitura Misuratore Gas naturale (Isoil)	1	No (to be defined)	TM
AS-P-NL	Automation Server	1	No	C BOX
TB-ASP-W1	Terminal Block for AS-P	1	No	
PS-24V	24V PS for thermal meters and controllers	1	No	
TB-ASP-W1	Terminal Block for AS-P	1	No	
TB-IO-W1	Terminal Block for AS-P and expansion modules	1	No	
UI-16	Universal I/O module. No.16 input	1	No	
	power transformer 230V-24Vac for KD	1	No	
ABLM1A24012	Power transformer	1	No	
	Box	1	No	
KAMODR	Modbus communication module	3	No	
				TM

8.3 KPIs summary

For the future, tables from Annex A, B and C will be filled with monthly values. If the values of the KPIs are not within the thresholds, contingency plans will be described to solve the issues (if possible) or provide insights for future installations of the TPs

8.4 KPI and PIs screenshots from iSCAN

The installation of technologies has not finished. Thus, the sensors from the technologies and the SunHorizon system have not been installed and no data is being collected from the demo site. Therefore, the iDashboard is not available as KPIs cannot be calculated neither the channels can be connected with the sensors (as they are not installed yet).

When the installation is commissioned, **screenshots from the iDashboard will be taken every month**: from every screen. There will be a screen with the main 12 KPIs (see Table 5Table 5), another with room temperatures, another one with evolution of temperatures and lastly one with the PIs at technology level. The time frame can be changed according to the needs (last month, last 7 days, etc.). The time frame should be at least set for obtaining the KPIs from the previous month. If there is an alarm then screenshots from that day can be taken to diagnose what happened. Based on the screenshots, the demo site responsible, with the support of the simulation supporting partner, will perform an analysis on a monthly basis.

8.4.1 Month 36

Data from the pre-monitoring period (prior M36) is not being collected in demo Type B.
In case of D6.5, reporting will start from M37 to M42 and, in case of D6.6, from M43 to M48.

8.5 Alarms logging

Alarms will be reported here. An automatic email will be sent to the building staff (to be confirmed), demo responsible, and the simulation supporting partner. No alarm notification has been set yet for this demo site.

Table 20 - Alarm receivers (Swimming Pool)

ROLE IN THE PROJECT	PROJECT PARTNER
Building Staff	SYNERGIS/ David Desonnay
Demo Responsible	GRE/Thibault Vanderhauwart
Simulation Supporting partner	RINA/Diego Ratazzi

9 Riga Imanta #8

9.1 Status update of the demo site

The tender was launched in May 21 and only one company submitted their offer which was acceptable both from the technical and financial point of view. The contract with the installer was signed in June 2021. The installation of RATIO equipment started in Imanta; detailed design almost completed (final corrections ongoing). The installation and commissioning might be completed in October/November (subject to the gas design approval time).

9.2 Status update of the monitoring system

The future monitoring system architecture is shown in the following figure.

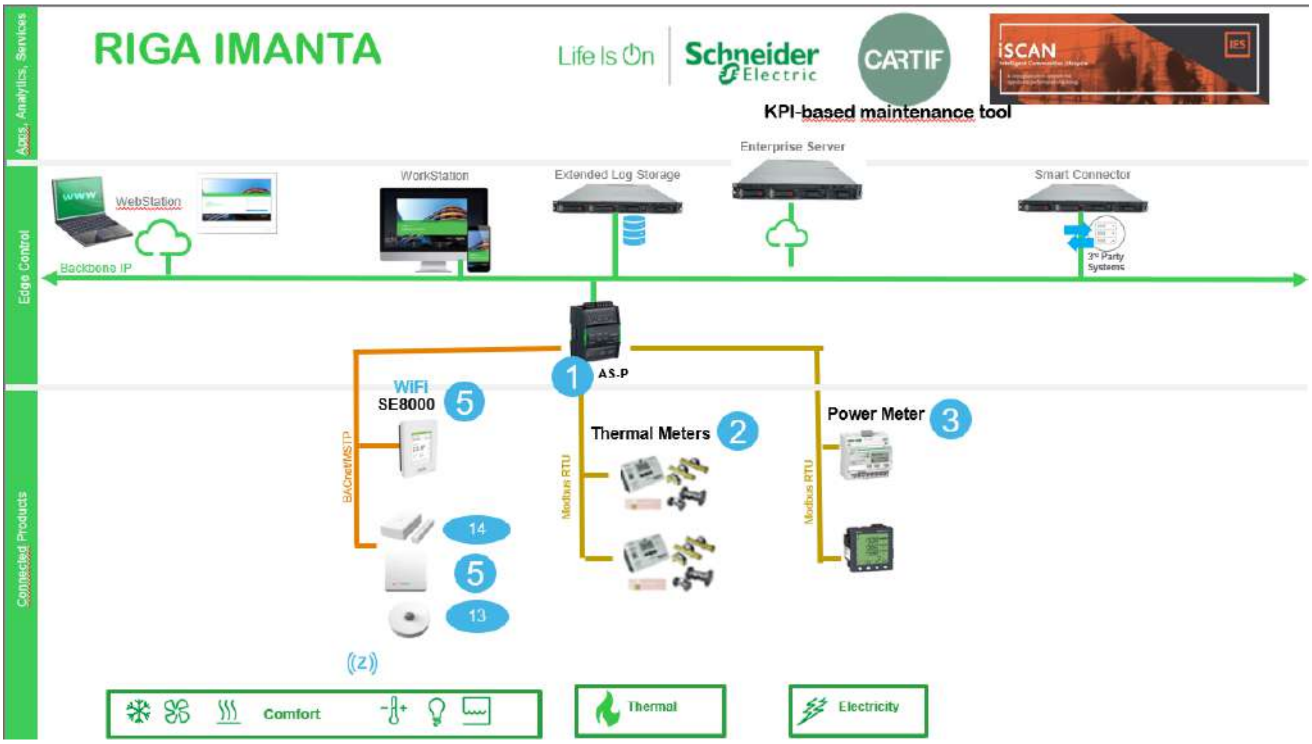

Figure 27 - Monitoring Architecture (Riga Imanta)

The sensors that have been already provided are listed below.

Table 21 - Status update of the monitoring sensors (Riga Imanta)

Article	Description	Qty	Delivered	
SE8350U5B00P	Fancoil Controller + Sensor (T, H, CO2) (wireless, zigbee comunication) - 24V AC	5	Yes	SE 8000
VCM8002V5031	WiFi Comunication card for SE8000	5	Yes	SE 8000
SED-CO2-G-5045	Zigbee Sensor (T, H, CO2)	5	Yes	T H CO2
SED-MTH-G-5045	Zigbee Sensor (T, H, motion) - Battery	13	Yes	P
SED-WDC-G-5045	Zigbee Window/door Sensor	14	Yes	W
AS-P	Automation server	1	Yes	C BOX
PS-24V	24V PS for thermal meters and controllers	1	Yes	C BOX
TB-PS-W1	Terminal Block for PS24	1	Yes	C BOX
TB-ASP-W1	Terminal Block for AS-P	1	Yes	C BOX
ABLM1A24012	Power transformer	1	Yes	C BOX
A9MEM3155	Electricity meter	1	Yes	EM
	Power transformer for KD	1	Yes	TM
	Box	1	Yes	C BOX
	PS24V for SE8000	5	Yes	SE 8000
KDK00R	Thermal meter	1	Yes	TM
KDK05R	Thermal meter	1	Yes	TM
KAMODR	Modbus communication module	2	Yes	TM
A9MEM3155	Electricity meter	2	No	EM

Data collection progress and relevant events is shown hereafter.

Table 22 - Data collection progress (Riga Imanta)

Relevant events	Date when discovered	Action taken	Mitigation plan	Date when solved
Room controllers SE8000 do not display the CO2 level on the screen **(data is collected but not visible to the residents)**	September 2021	In progress. SE needs to reprogram the display.	Since SE8000 can display only one set of indoor climate data, the most representative/accurate values from the sensors installed in the specific room should be selected for the display.	**Still ongoing (in progress)**
For some of the wireless sensors delivered to Imanta batteries were not connected	June 2021	Solved by RTU during installation	N/A	June 2021
One SE8000 is offline and some sensors are not connected to SE8000	September 2021	In progress. Some sensors are not communicating with SE8000. The sensors and SE might not be properly paired due to the initially unplugged battery. SE8000 will be reconfigured.	N/A	**Still ongoing (in progress)**

9.3 KPIs summary

For the future, tables from Annex A, B and C will be filled with monthly values. If the values of the KPIs are not within the thresholds, contingency plans will be described to solve the issues (if possible) or provide insights for future installations of the TPs.

9.4 KPI and PIs screenshots from iSCAN

The installation of technologies has not finished. Thus, the sensors from the technologies and the SunHorizon system have not been installed and no data is being collected from the demo site. Therefore, the iDashboard is not available as KPIs cannot be calculated neither the channels can be connected with the sensors (as they are not installed yet).

When the installation is commissioned, **screenshots from the iDashboard will be taken every month**: from every screen. There will be a screen with the main 12 KPIs (see Table 5Table 5), another with room temperatures, another one with evolution of temperatures and lastly one with the PIs at technology level. The time frame can be changed according to the needs (last month, last 7 days, etc.). The time frame should be at least set for obtaining the KPIs from the previous month. If there is an alarm then screenshots from that day can be taken to diagnose what happened. Based on the screenshots, the demo site responsible, with the support of the simulation supporting partner, will perform an analysis on a monthly basis.

9.4.1 Month 36

Data from the pre-monitoring period (prior M36) is not being collected in demo Type B.

In case of D6.5, reporting will start from M37 to M42 and, in case of D6.6, from M43 to M48.

9.5 Alarms logging

Alarms will be reported here. An automatic email will be sent to the building staff (to be confirmed), demo responsible, and the simulation supporting partner. No alarm notification has been set yet for this demo site.

Table 23 - Alarm receivers (Riga Imanta)

ROLE IN THE PROJECT	PROJECT PARTNER
Building Staff	Not registered yet
Demo Responsible	RTU/Zane Broka
Simulation Supporting partner	RINA/Carlo Maccio

10 Riga Sunisi #9

10.1 Status update of the demo site

The tender was launched in May 21 and only one company submitted their offer which was acceptable both from the technical and financial point of view. The contract with the installer was signed in June 2021. Detailed design almost completed (final corrections ongoing). The installation and commissioning might be completed in October/November (subject to the gas design approval time).

10.2 Status update of the monitoring system

News on variables, installation progress, commissioning progress, any new potential risk, etc.

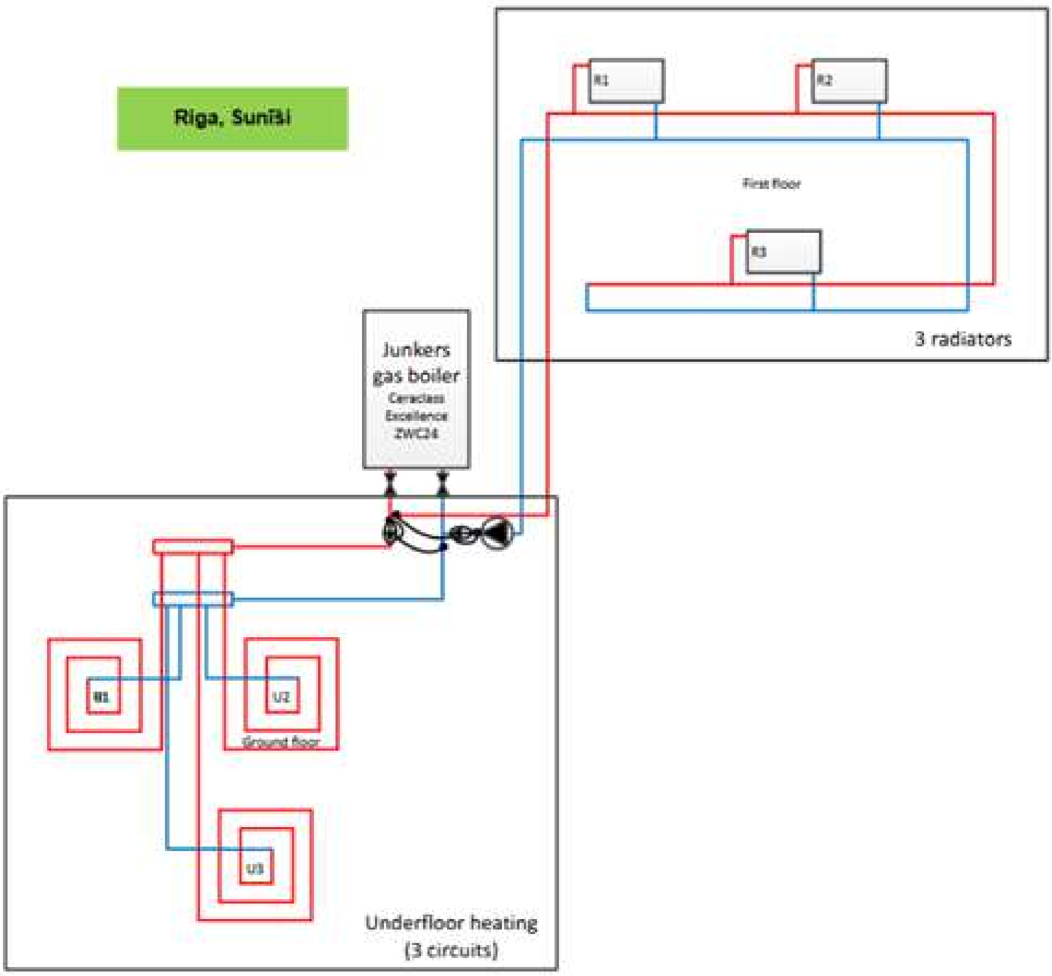

Figure 28 – Pre-monitoring thermal meters location (Riga Sunisi)

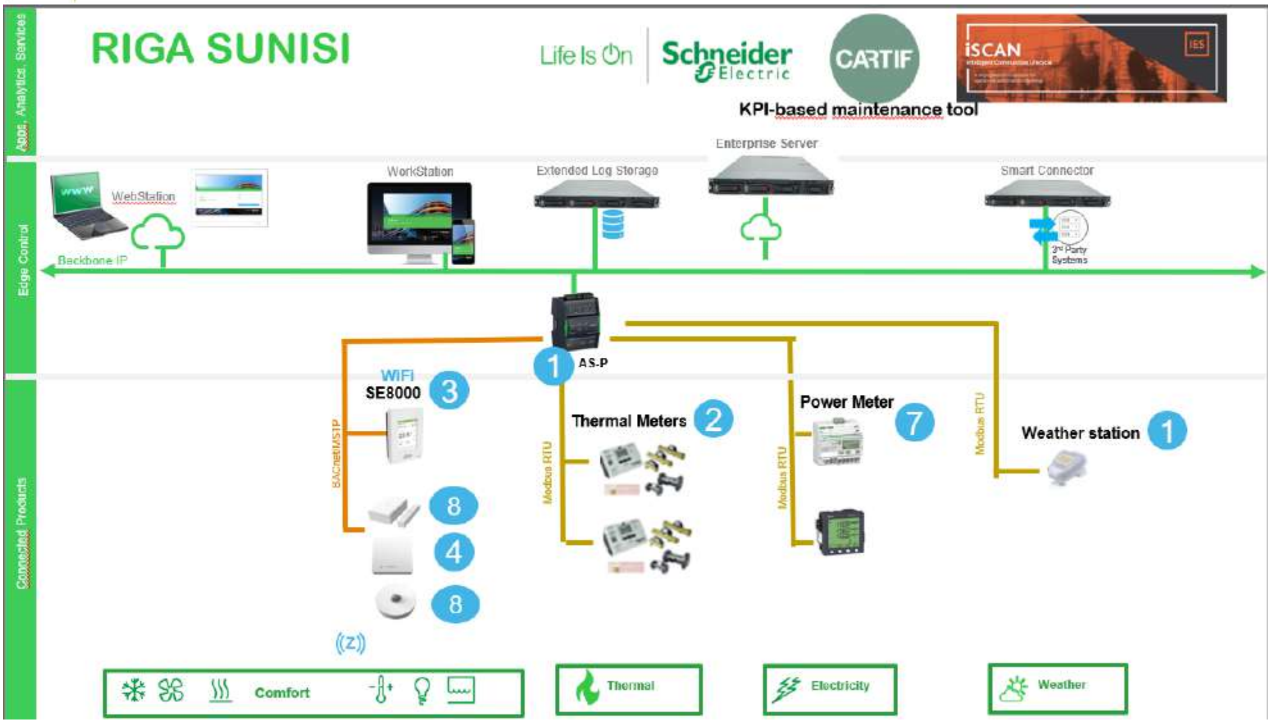

Figure 29 – Monitoring architecture (Riga Sunisi)

For each room: motion, temperature, co2 and humidity sensors were installed. In the living room and each bedroom there are at least three different sensors for temperature and humidity: “room controller”, motion sensor and CO2 sensor. Since the room controllers, especially for Sunisi, are quite bulky and their fixing to the wall would require drilling holes or other irreversible interventions, they were not placed against the wall and are instead located on some furniture (e.g. table, windowsill or even on the floor) depending on what was available in the specific room considering they also require a power outlet. In contrast, the motion and CO2 sensors were placed on the wall (upper part, close to ceiling). Consequently, the data from room controllers are in general much less reliable. Their temperature might be affected by additional objects nearby (incl. heat sources/equipment/furniture/windows/radiators etc.), and it is also possible that the residents might slightly relocate the controller. So, in general for data display, data analysis and modelling purposes we should rather use the temperature from the wireless sensors instead of the room controller.

In some rooms also, window sensors were installed. In already existing electrical cabinet for monitoring of total energy and single circuits. Three intrusive thermal-energy meters (Multical with Modbus) were installed to measure separately: space heating (underfloor, and radiators heating) and domestic hot water consumption.

Table 24 - Status update of the monitoring sensors (Riga Sunisi)

Article	Description	Qty	Delivered	
SE8350U5B00P	Fancoil Controller + Sensor (T, H, CO2) (wireless, zigbee comunication) - 24V AC	2	Yes	SE 8000
SE8350U5B11P	Fancoil Controller + Sensor (T, H, CO2) (wireless, zigbee comunication) - 24V AC	2	Yes	SE 8000
VCM8002V5031	WiFi communication card	4	Yes	SE 8000
SED-CO2-G-5045	Zigbee Sensor (T, H, CO2)	4	Yes	T H CO2
SED-WDC-G-5045	Zigbee Window/door Sensor	8	Yes	W
SED-MTH-G-5045	Zigbee Sensor (T, H, motion) - Battery	8	Yes	P
AS-P	Automation Server	1	Yes	C BOX
PS-24V	24V PS for thermal meters and controllers	1	Yes	
TB-PS-W1	Terminal Block for PS24	1	Yes	
TB-ASP-W1	Terminal Block for AS-P	1	Yes	
ABL8MEM24012	Power transformer	1	Yes	
MHCEHFTFBM000	Thermal Meter	1	Yes	TM
MHCDHATFBM000	Thermal Meter	1	Yes	TM
MAMODBASE-603	Modbus communication card	2	Yes	TM
A9MEM3155	Electricity meter	1	Yes	EM
----	PS for SE8000	4	Yes	SE 8000
----	Weather station	1	Yes	WS
----	Box	1	Yes	C BOX
A9MEM3155	Electricity meter	3	No	EM
SED-CO2-G-5045	Electricity meter	3	Yes	EM

Data collection progress and relevant events is shown hereafter.

Table 25 - Data collection progress (Riga Sunisi)

Relevant events	Date when discovered	Action taken	Mitigation plan	Date when solved
During installation: some of the monitoring components delivered by SE were equipped with Italian plugs	September 2020	RTU replaced those plugs with suitable ones	n/a	September 2020
During installation: the flanged heat meter sent by SE for upper floor space heating turned out to be too large for the desired location	September 2020	SE sent a smaller thermal meter as a replacement	n/a	October 2020
Data collection process from the demo site was very slow initially	October 2020	SE technicians did some corrections on their end which solved the issue. Additionally,	A separate internet router was installed also in Imanta.	November 2020

		RTU replaced the existing internet router with a separate 4G router for monitoring.		
The heat meter for the first floor and ground floor occasionally gives a negative temperature difference between the supply and return flow	November 2020	Negative values set to zero during data pre-processing	RTU to check during TP2 installation if repositioning of the sensors might help to improve data accuracy	**Solved partially (in progress)**
Room controllers SE8000 do not display the CO2 level on the screen (data is collected but not visible to the residents)	October 2020	In progress. SE needs to reprogram the display.	Since SE8000 can display only one set of indoor climate data, the most representative/accurate values from the sensors installed in the specific room should be selected for the display.	**Solved partially (in progress)**

10.3 KPIs summary

For the future, tables from the Annex, subsection A, B and C, will be filled in with monthly values. If the values of the KPIs are not within the thresholds, contingency plans will be described to solve the issues (if possible) or provide insights for future installations of the TPs

10.4 KPI and PIs screenshots from iSCAN

The installation of technologies has not finished. Thus, the sensors from the technologies and the SunHorizon system have not been installed and no data is being collected from the demo site. Therefore, the iDashboard is not available as KPIs cannot be calculated neither the channels can be connected with the sensors (as they are not installed yet).

When the installation is commissioned, **screenshots from the iDashboard will be taken every month**: from every screen. There will be a screen with the main 12 KPIs (see Table 5Table 5), another with room temperatures, another one with evolution of temperatures and lastly one with the PIs at technology level. The time frame can be changed according to the needs (last month, last 7 days, etc.). The time frame should be at least set for obtaining the KPIs from the previous month. If there is an alarm then screenshots from that day can be taken to diagnose what happened. Based on the screenshots, the demo site responsible, with the support of the simulation supporting partner, will perform an analysis on a monthly basis.

10.4.1 Month 36

Data from the pre-monitoring period (prior M36) is being collected in demo Type A. The room sensors were placed in Sunisi in September, whereas the final meters were installed in late October. Thus, the full pre-monitoring is ongoing since November 2020.

Figure 30 shows when there is data gaps from January 2021 until today (18/08/2021) of the heat consumption from the DHW sensor (named as I.TECro-9-P1-dhw-Energy[5]), the ground floor heating (I.TECro-9-P2-Energy), and the radiators heating (I.TECro-9-P3-Energy). The orange-yellowish areas indicate that there are data gaps, which will be fixed in the

[5] Appears in the graph as “Manual_P1dhw-Energy”, “Manual_P2-Energy” and “Manual_P3-Energy” because there was an issue of communication between iSCAN and SE

future with the “data gaps filling” service from iSCAN. From June, the power from radiators and ground floor heating measures 0, as the heating system is off.

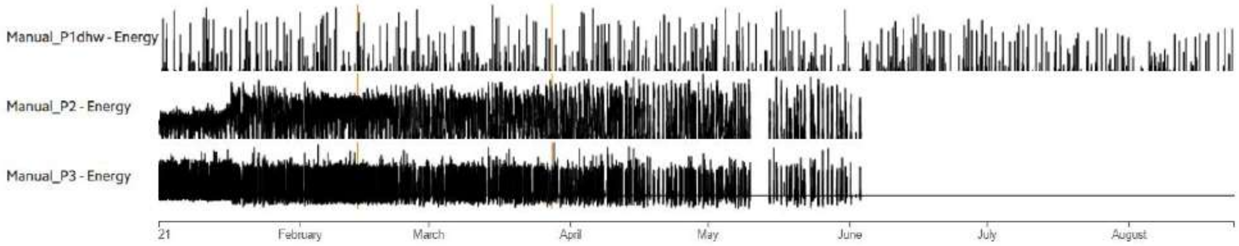

Figure 30 - Heat consumption from the DHW sensor (usually named as I.TECro-9-P1-dhw-Energy → Manual_P1dhw), the ground floor heating (usually named as I.TECro-9-P2-Energy → Manual_P2-Energy), and the radiators heating (usually named as I.TECro-9-P3-Energy→ Manual_P3-Energy).).

Figure 31 shows more details from the weather station (daily average of each variable). The hourly precipitation is low (< 20 cm), and slightly concentrated in spring (March to June). The diffuse horizontal radiation is very low (almost null) until March, and it increases from March to August. In the case of the direct normal radiation, it increases with the same trend as the diffuse horizontal radiation, but it is mostly zero in January, and starts increasing in February. The apparent outdoor temperature goes from the minimum of -20ºC (Achieved in February) to the maximum of 35ºC.

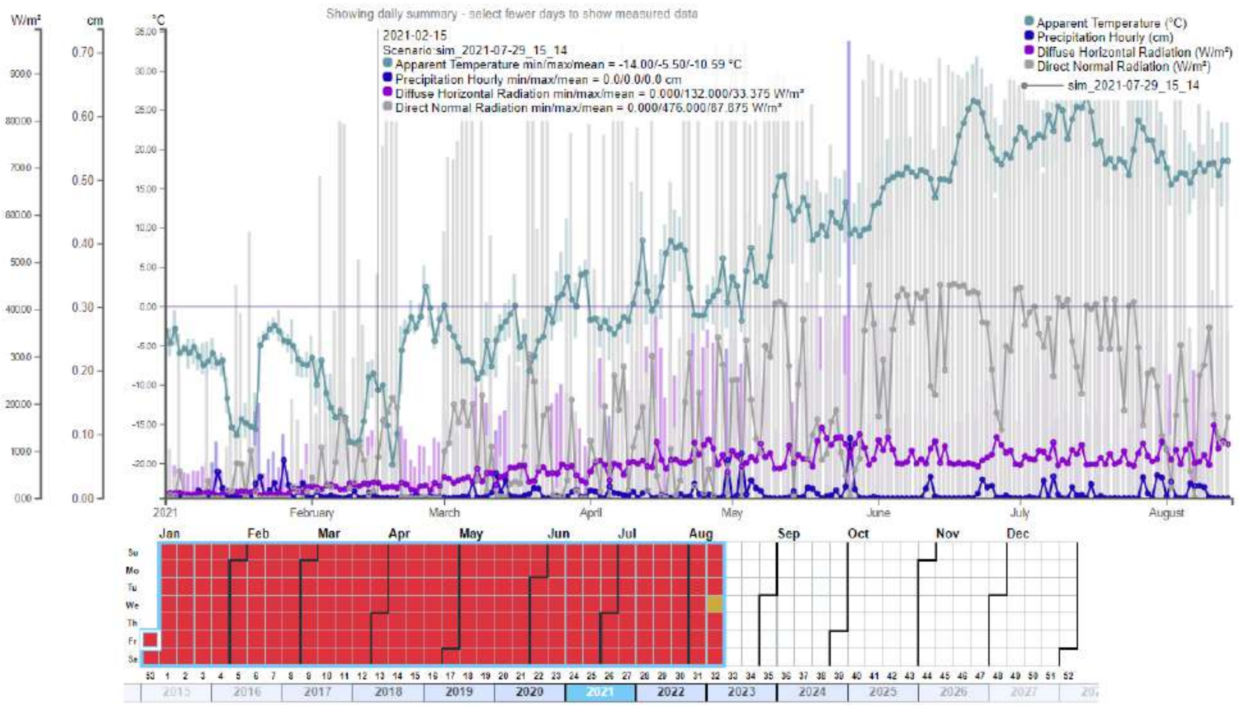

Figure 31 - Weather station variables: apparent temperature (ºC), hourly precipitation (cm), diffuse horizontal radiation (W/m²) and direct normal radiation (W/m²). Riga Sunisi demo site

The thermal energy from the heat meters (the ground floor heating (I.TECro-9-P2-Energy), and the radiators heating (I.TECro-9-P3-Energy)) are used from the whole pre-monitoring period (December to June). In July only DHW consumption is found.

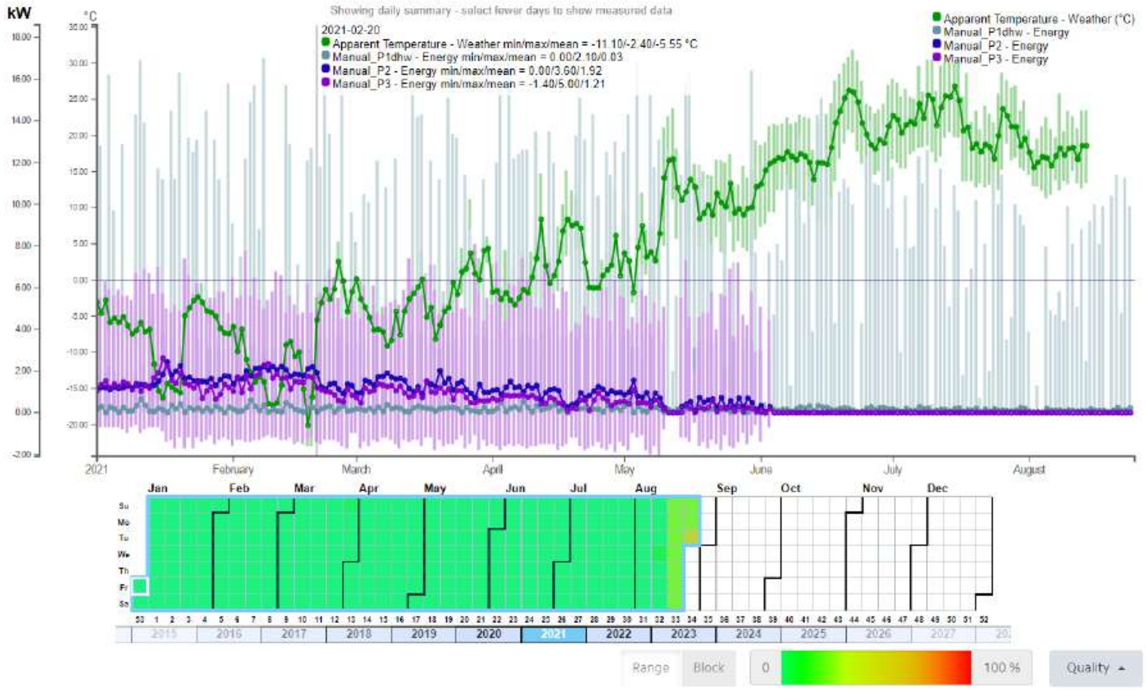

Figure 32- Average values for the whole pre-monitoring period from Apparent temperature (from Weather station), heat consumption from the DHWsensor (I.TECro-9-P1-dhw-Energy), the ground floor heating (I.TECro-9-P2-Energy), and the radiators heating (I.TECro-9-P3-Energy). Riga Sunisi demo site

Selecting two days of winter (20 and 21 of January), DHW is used mainly during the morning (around 8 am), but other peaks are found from 15:30 to 17:45. We could assume that all the demand is consumed for the shower and sinks, but perhaps it also provides water for cooking. DHW peaks vary from 0 to 18.10 kW. Regarding the space heating consumption, peaks are higher for the radiators (0 to 10.9 kW), whereas for ground floor heating varies from 0 to 5.40. Ground floor heating is usually always on during winter time (January, for example) whereas in March to May, it is turned off during some hours (usually from 7 am to 9 am, sometimes until 3 pm). In both some negative values are found. The negative values could be due to the recirculation of water or the thermostatic valves of the radiators, or due to the possibility of some "non-operating" heating pipes to heat up from the other heating loop which is providing heat at that moment. RTU will check the sensor positions to potentially improve the data quality during installation of TP2.

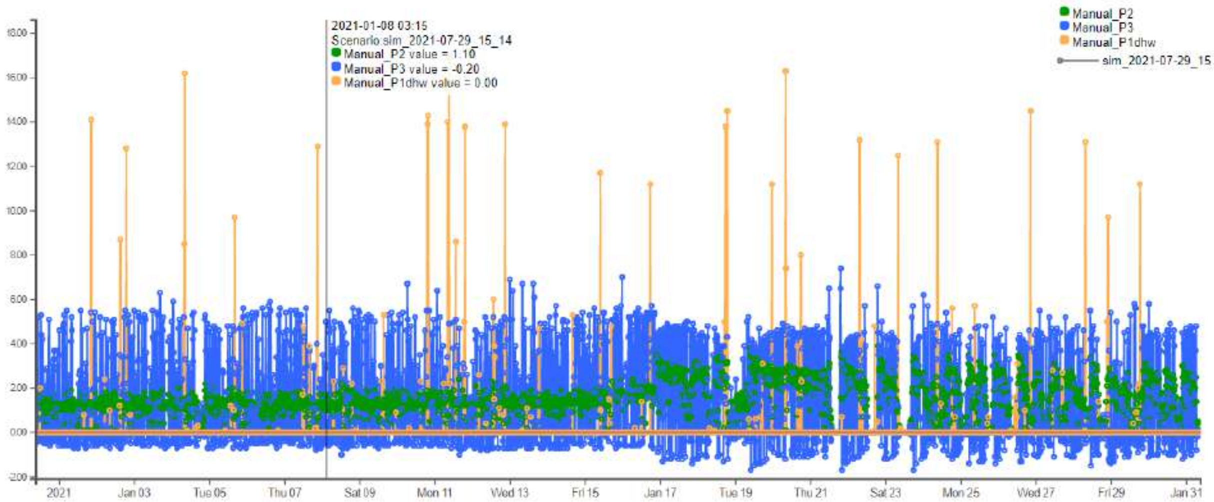

Figure 33 - Average values of January from heat consumption from the DHW sensor (I.TECro-9-P1-dhw-Energy), the ground floor heating (I.TECro-9-P2-Energy), and the radiators heating (I.TECro-9-P3-Energy). Riga Sunisi demo site (Units: kW)

In case of D6.5, reporting will start from M37 to M42 and, in case of D6.6, from M43 to M48.

10.5 Alarms logging

Alarms will be reported here. An automatic email will be sent to the building staff (to be confirmed), demo responsible, and the simulation supporting partner. No alarm notification has been set yet for this demo site.

Table 26 - Alarm receivers (Riga Sunisi)

ROLE IN THE PROJECT	PROJECT PARTNER
Building Staff	Not registered yet
Demo Responsible	RTU/Zane Broka
Simulation Supporting partner	CARTIF/Andrea Gabaldón and Alejandro Hernández

10.6 Pre-monitoring data analysis

10.6.1 Calibration of the building model

The energy modelling activities for this building have started as part of WP5 where a baseline model of the building was developed in IES-VE software, and a full modelling report is found in Annex A in Deliverable 5.3. During that period, data inputs were collected including bills and drawings of the building. This lead to the development of the 3D geometry of the building and populated with the data collected, and complemented with assumptions. As seen in the figure below, the requirement to improve accuracy of the model is to develop an operational model via calibration based on pre-monitoring data.

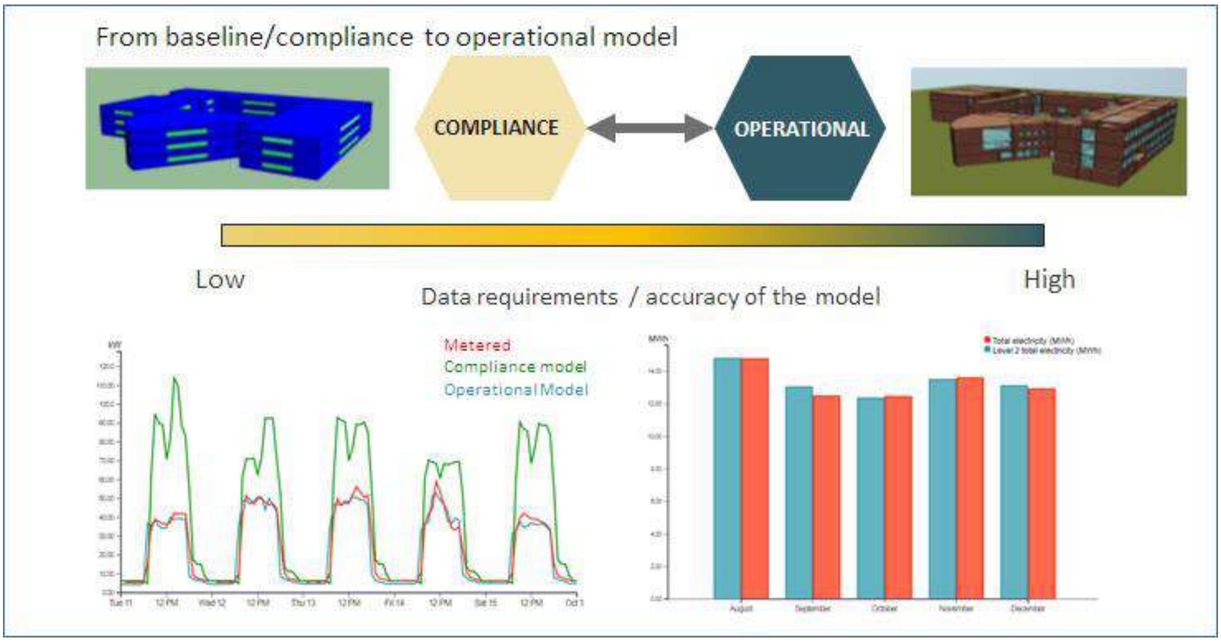

Figure 34 – IESVE approach from a compliance model (based on assumptions) to an operational model (calibrated one). Riga Sunisi demo site

To develop an operational model, the existing building model is calibrated for energy demand and indoor environmental conditions. At the time of writing this deliverable, the model was updated based on data collected from the pre-monitoring period of Dec 2020 to July 2021. This included the replacement of the assumptions with accurate building use and environmental condition profiles, as well as accurate weather data.

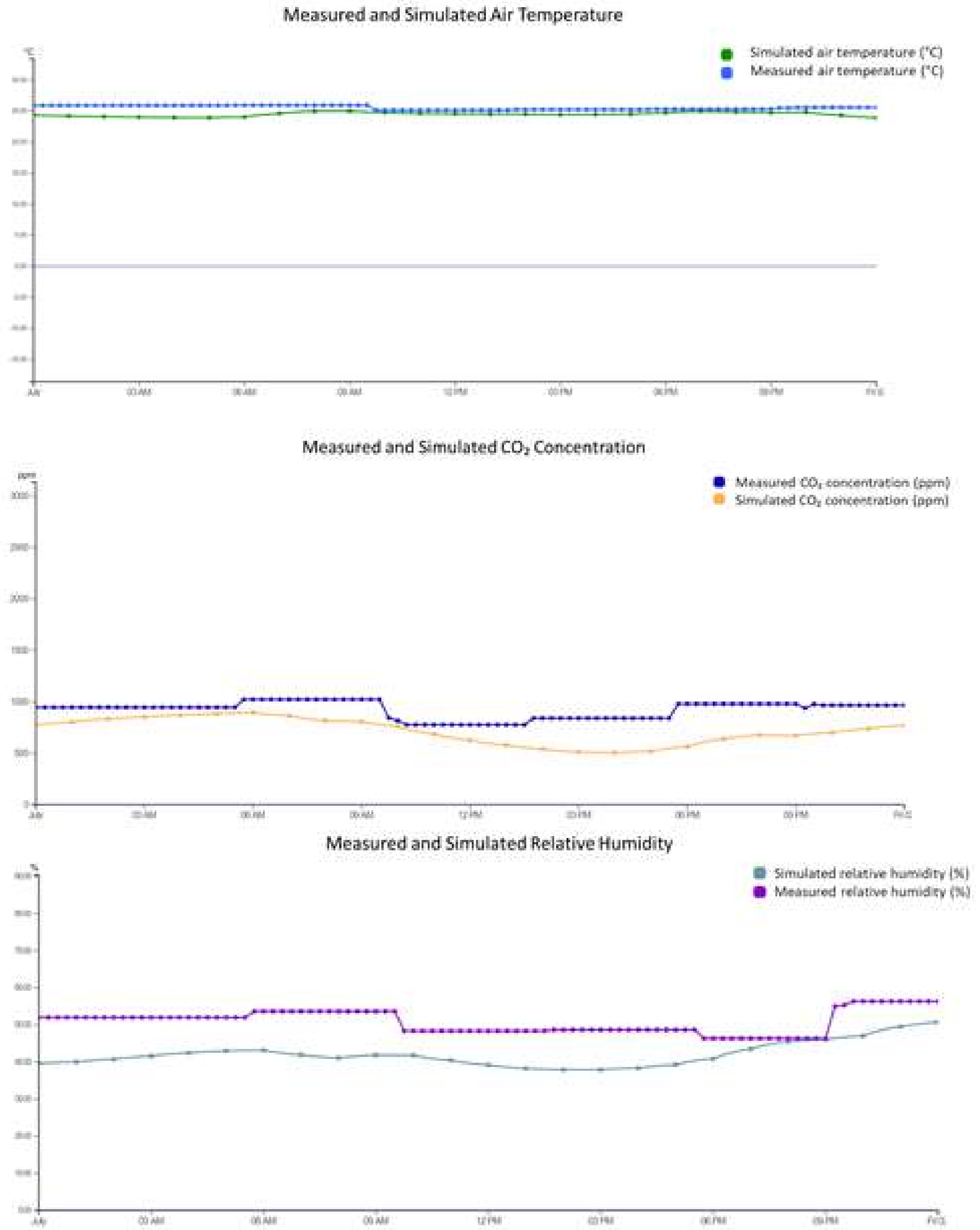

Figure 35 – Simulated versus measured air, co2 concentration and relative humidity for a week of July 2021. Riga Sunisi demo site

The first results were obtained for the summer season. The figure above shows the comparison between simulated and metered data for a week in July 2021 and for indoor air temperature, CO2 concentration and relative humidity for the living room. The results show good overlap between the simulated and measured values. The next steps are to calibrate for the winter season and optimise calibration to remove the performance gap as much as possible.

10.6.2 Calibration of the energy system model

The pre-intervention monitored data have been used as input for validating the TRNSYS Radiator components used in the SUNISI TRNSYS model.

The monitored Flow Rate, Supply temperature and ambient temperature has been used as Radiator input in the TRNSYS model.

CV(RMSE) and NMBE parameters have been calculated comparing the output parameter of the radiator component 'Radiator Injected power' and the power coming from the monitored data.

It has been noted that sometimes the heat meters installed in the demo provide some negative power value. In order to obtain more reliable results of the analysis, the input flow rate have been put equal to 0 when the heat meter indicated negative power.

In addition, the data gathered presented several missing information. Since the algorithm that fills the data gaps were not active at the time of performing this analysis, the missing time steps data have been considered equal to 0. In order to reduce the impact of this assumption the simulation period for the ground floor and the first floor have been chosen depending on the completeness of the set of data.

The ground floor simulation last from 01 Jan 2021 at 0:00:00 to 28 Feb 2021 at 23:45:00. The first-floor simulation last from 02 Feb 2021 at 16:31:00 to 28 Feb 2021 at 23:45:00.

In the following table the results of the simulation are presented, providing the following output:

- CV(RMSE) and NMBE value, calculated considering time step of 15 minutes.
- CV(RMSE)_hr and NMBE_hr , calculated considering the hourly mean value.
- CV(RMSE)_day and NMBE_day, calculated considering the daily value.

The column 'a' compare the parameter or the radiator component 'Power injected in radiator' and the monitored power value provided directly by the heat meter. The column 'b' compares the 'Power injected in radiator' and the power calculated considering the monitored values of flow rates, supplied temperatures and outlet temperatures of the Heat meter.

The main input parameters of the TRNSYS Radiator component and their respective value considered in each simulation are reported for each configuration. The initial values of the parameters have been set equal to the ones used in the simulations performed in WP2.

Regarding the validation of the emission system of the first floor (Radiators), first the Thermal capacitance parameter has been varied, with the best results obtained with a value of 200 kJ/K. Then the nominal power has been varied with the best results obtained in configuration 9 with nominal power set at 5400 W.

The results shown that the CV(RMSE) value have very high value when calculated considering the 15-minute time step, while considering the daily value the CV(RMSE value is below the ASHRAE threshold in almost all the configuration. The NMBE value present lower value, and is below the ASHRAE threshold in configuration 8, 9 and 10.

Regarding the validation of the emission system of the ground floor (underfloor heating), only the nominal power of the Radiator component has been varied, with configuration 9 which obtained the bests results with a power of 8000W. The thermal capacity, that was estimated for the simulations performed in WP2, has been considered fixed.

The results shown that the CV(RMSE) is below the ASRAHE threshold in each configuration, while the NMBE is below the threshold in configuration 4, 8 and 9.

Table 27 - Radiator Validation_First Floor - 1 (variation of the Radiator thermal capacitance) All have: Radiative fraction of total emitted power at nominal conditions (DT=60) = 0.35; - Nominal power (DT=60) = 6300 W; - Radiator exponent (convection + radiation) = 1.3; Configuration 1: - Radiator thermal capacitance = 100 kJ/K; Configuration 2: - Radiator thermal capacitance = 50 kJ/K; Configuration 3: - Radiator thermal capacitance = 150 kJ/K; Configuration 4: - Radiator thermal capacitance = 200 kJ/K; Configuration 5: - Radiator thermal capacitance = 250 kJ/K, Configuration 5: - Radiator thermal capacitance = 300 kJ/K. Riga Sunisi demo site

	1		**2**		**3**		**4**		**5**		**6**	
	a	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**
CV(RMSE)	85%	81%	112%	104%	82%	77%	80%	75%	79%	74%	79%	74%
NMBE	-16%	-11%	-29%	-23%	-15%	-9%	-15%	-9%	-15%	-10%	-16%	-10%

CV(RMSE) hr	42%	43%	57%	55%	40%	41%	39%	40%	40%	40%	41%	41%
NMBE hr	-16%	-11%	-29%	-24%	-15%	-9%	-15%	-9%	-15%	-10%	-16%	-10%
CV(RMSE) day	20%	17%	33%	28%	19%	16%	**19%**	**15%**	19%	16%	20%	16%
NMBE day	-16%	-11%	-29%	-23%	-15%	-9%	**-14%**	**-9%**	-15%	-10%	-16%	-10%

Table 28 - Radiator Validation_First Floor - 2: Variation of nominal power of radiator (DT=60). All have: Radiative fraction of total emitted power at nominal conditions (DT=60) = 0.35; - Radiator exponent (convection + radiation) = 1.3; Radiator thermal capacitance = 200 kJ/K; Configuration 7: - Nominal power of radiator (DT=60) = 6000 W; Configuration 8: Nominal power (DT=60) = 5700 W ; Configuration 9: Nominal power (DT=60) = 5400 W; Configuration 10: Nominal power of radiator (DT=60) = 5100 W. Riga Sunisi demo site

	7		**8**		**9**		**10**	
	a	**b**	**a**	**b**	**a**	**b**	**a**	**b**
CV(RMSE)	77%	74%	76%	73%	74%	72%	74%	72%
NMBE	-10%	-5%	-6%	-1%	-1%	4%	4%	8%
CV(RMSE) hr	38%	39%	36%	39%	36%	39%	36%	40%
NMBE hr	-10%	-5%	-6%	-1%	-1%	3%	4%	8%
CV(RMSE) day	15%	13%	13%	12%	**12%**	**13%**	13%	15%
NMBE day	-10%	-5%	-6%	-1%	**-1%**	**4%**	4%	8%

Table 29 - Radiator Validation_Ground Floor -1. All have: Radiative fraction of total emitted power at nominal conditions (DT=60) = 0.35; - Radiator exponent (convection + radiation) = 1.1; Radiator thermal capacitance = 2811 kJ/K; Configuration 1: - Nominal power of radiator (DT=60) = 22300 W; Configuration 2: Nominal power (DT=60) = 15000 W ; Configuration 3: Nominal power (DT=60) = 10000 W; Configuration 4: Nominal power of radiator (DT=60) = 9000 W; Configuration 5: Nominal power of radiator (DT=60) = 6000 W. Riga Sunisi demo site

	1		**2**		**3**		**4**		**5**	
	a	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**
CV(RMSE)	45%	35%	37%	27%	28%	18%	26%	17%	29%	25%
NMBE	-29%	-23%	-21%	-15%	-8%	-2%	-4%	1%	14%	18%
CV(RMSE) hr	40%	33%	31%	25%	21%	16%	19%	15%	22%	23%
NMBE hr	-29%	-23%	-21%	-15%	-8%	-2%	-4%	1%	14%	18%

CV(RMSE) day	34%	28%	26%	21%	15%	12%	12%	11%	18%	21%
NMBE day	-29%	-23%	-21%	-15%	-8%	-2%	-4%	1%	14%	18%

Table 30 - Radiator Validation_Ground Floor – 2. All have: Radiative fraction of total emitted power at nominal conditions (DT=60) = 0.35; - Radiator exponent (convection + radiation) = 1.1; Radiator thermal capacitance = 2811 kJ/K; Configuration 6: - Nominal power of radiator (DT=60) = 6500 W; Configuration 7: Nominal power (DT=60) = 7000 W ; Configuration 8: Nominal power (DT=60) = 7500 W; Configuration 9: Nominal power of radiator (DT=60) = 8000 W. Riga Sunisi demo site

	6		**7**		**8**		**9**	
	a	**b**	**a**	**b**	**a**	**b**	**a**	**b**
CV(RMSE)	27%	23%	26%	21%	26%	19%	26%	18%
NMBE	10%	15%	7%	11%	4%	9%	1%	6%
CV(RMSE) hr	20%	20%	19%	18%	18%	17%	18%	16%
NMBE hr	10%	15%	7%	11%	4%	9%	1%	6%
CV(RMSE) day	15%	18%	13%	15%	12%	14%	**11%**	**12%**
NMBE day	10%	15%	7%	11%	4%	9%	**1%**	**6%**

11 Conclusion

The achievement of project objectives needs to be recorded, supervised and assessed during the monitoring campaign of any project. The direct impact of the 8 SunHorizon demonstration cases was estimated in 107 kWh/m²/year of primary energy savings, reduction of thermal energy bills in 5.9 €/m²/yr, and GHG emission savings of about 23 kg-CO2/m²/yr, that will result in a renewable energy ratio of 58% and an investment of 721,510 €.

As the installation of technologies are intended to be finished in M36 (September 2021) and D6.4 is due in the same date, D6.4 just aims to establishing the methodology that will be followed in the following reports: D6.5 and D6.6, where the achievement of KPIs will be demonstrated. This document establishes the responsibilities of each partner, and how the KPIs will be reported. Within WP4 a proactive KPI-based tool has been developed that will help to calculate the KPIs and PIs, and set proactive and predictive alarms. The different partners will access the iDashboard to see the evolution of KPIs, and the iSCAN platform to see the processed data in more details.

Furthermore, a pre-monitoring campaign was designed for Type A demo sites in order to calibrate TRNSYS and IESVE models from WP5. These models will be used within WP5 to predict demand and the best control strategies to be followed. The calibration of the TRNSYS model in Riga Sunisi has been achieved, whereas for Sant Cugat there is insufficient data. The calibration of the building model is still ongoing.

At the appendixes, Table A, B and C will be used by each demo site to monitor the KPI evolution, data collection progress (to monitor the relevant events that might appear) and follow-up on alarms notification.

A. ANNEXES

A. KPI table every 6 months

Table A: KPIs summary template for demonstration campaign

KPI name	Threshold	Actual value	Deviation	Impact on scope
			Yes/No	

B. Alarm table

Table B: Alarm summary template for demonstration campaign

Alarm code	Raised at	State	Explanation
		Danger/warning	

C. Data collection problems and progress

Table C: Data collection progress

Relevant events	Date when discovered	Action taken	Mitigation plan	Date when solved

D. Project KPIs summary (at the conclusion section of D6.5 and D6.6)

Table D: Summary of KPIs

KPI	Berlin #1	Nunberg #2	Sant Cugat #3	Madrid #4	Sant Cugat#5	Verviers SP #7	Riga Imanta #8	Riga Sunisi #9
CAPEX								
CBR								
CSAT								
GHG savings								
HCI								
CCI								
LCOH								
OPEX								
PESnren (absolute)								

And relative: $f_{sav,PE_{nren}}$								
RER								
SCR								
SPB								

E. Project PIs (Technologies)

Table E: Summary of PIs

PI	Berlin #1	Nunberg #2	Sant Cugat #3	Madrid #4	Sant Cugat #5	Verviers SP #7	Riga Imanta #8	Riga Sunisi #9
$\eta^{gross}_{TVP,at\,T_{supply}}$								
$f_{sol,th}$								
$SGUE$								
SPF_{BH}								
$(S)EER$								
SPF_{FAHR}								
$(S)COP_{BDR}$								
$(S)EER_{BDR}$								
SPF_{BDR}								
$\eta^{gross}_{BDRcol,th}$								
$f_{sol,th}$								
$\eta^{gross}_{BDRcol,el}$								
$\eta^{gross}_{DS,th}$								
$f_{sol,th}$								
$\eta^{gross}_{DS,el}$								
TER								
dT								