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Sun coupled innovative Heat pumps

D6.5 – Second Report on SunHorizon monitoring activities

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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 methodology to report KPIs and PIs were reported.

Now in D6.5 the following activities have been conducted:

- Review of monitoring data production, collection and operation summary report of the SunHorizon installed TPs
- Reporting monitoring and operation summary (KPIs)

The present document will report the operation summary of the demos over the past months (summer period) and detect ways to improve the data collection and control of the TPs.

As the installation of technologies are aimed to be finished in September 2022 and not all demo sites have achieved this milestone only the work done in Madrid, Riga Sunisi, Riga Imanta, and Sant Cugat is presented.

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.

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. Nevertheless, at the time of the development of this deliverable the iDashboard tool was not available, so the KPIs have been calculated manually using the data from Schneider (SE) platform.

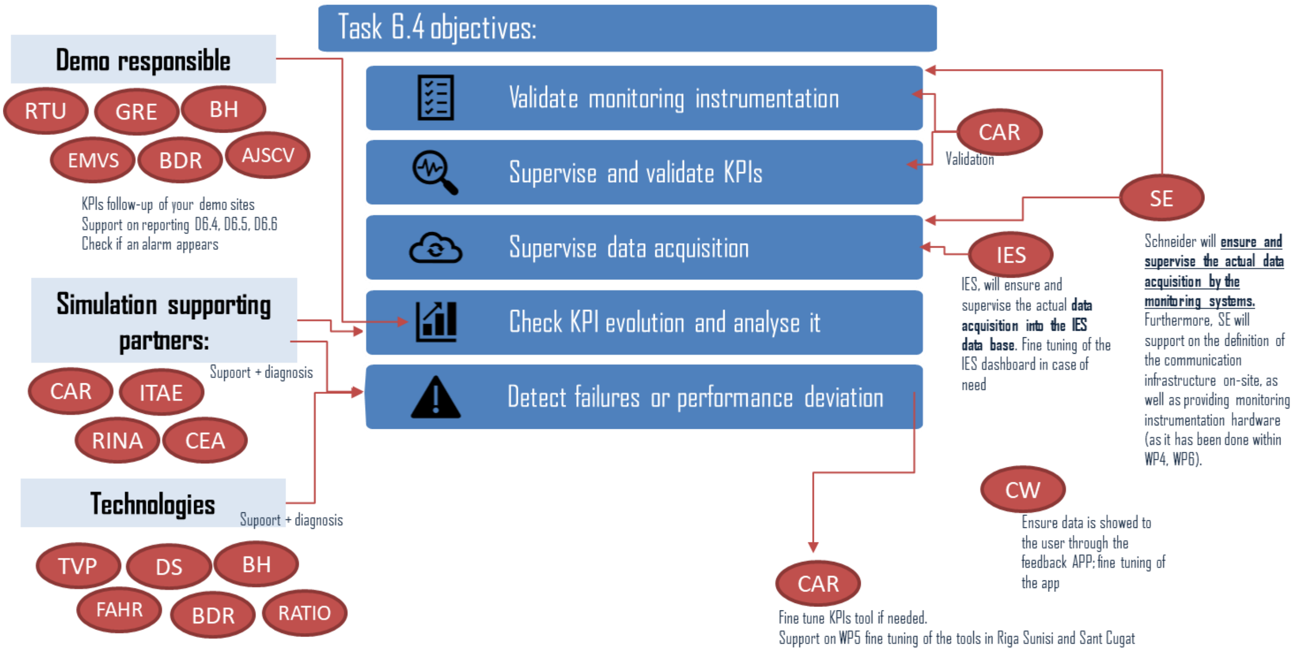


Figure 1: Task 6.4 overview: objectives and responsibilities of partners.

1.1 Overall summary of demos

The commissioning data, monitoring progress (on room comfort and TP performance), as well as the integration of the data into the Schneider platform and iSCAN platform is shown in Table 1. The legend (Figure 2) indicates whether the progress is smoothly running (as expected in time and objectives indicated in green), if there are aspects to be followed up (in yellow, e.g. communication problems), or if there are aspects that are critical or that has not been done/commissioned yet (in red).

[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).

Table 1: Overall summary progress on monitoring and commissioning

Demo	Commissioning date	Monitoring room comfort	Monitoring TP (heat and el. Meters)	Schneider platform	iSCAN integration
Riga Sunisi	January 2022 (PVT electrical), April 2022(BH)	🟢	Inconsistencies 🟡	🟢	🟡
Riga Imanta	December 2021	🟢	Inconsistencies 🟡	🟢	🟡
Sant Cugat	March 2022 (heat). June 2022 cooling	🟢	Inconsistencies 🟡	🟢	🟡
Madrid	Sept 2022 (Except PVT). Fully Oct 2022	🟢	Missing data 🟡	Still to be done 🟡	🟡
Cluj Napoka	Tendering delay (change of Heat pump type)	N/A	N/A	N/A	N/A
German demos	Bankruptcy of BH	N/A	N/A	N/A	N/A

Legend of actions' progress:	
🟢	smoothly running
🟡	aspects to be solved – communications errors
🔴	No commissioning yet

Figure 2: Legend

1.2 Task structure

The first task to be conducted within T6.4 is to continue the way of working established within D6.4. Table 2 shows the associated deliverables, expected content, when are due and who leads it. D6.5 (i.e. the present document) and D6.6 are related to the evolution of KPIs and developments and updates of the monitoring campaign of each demo that should be explained.

Table 2: Deliverables from T6.4

	Content	Due in	Lead beneficiary
D6.4	Establish the common methodology for the demonstration of project KPIs	30/09/2021 - submitted	CARTIF
D6.5	Report the first 6 months (M42-M48) achievements of project KPIs	31/10/2022	AJSCV
D6.6	Report the last 6 months (M48-M55) achievements of project KPIs	30/09/2023	BDR

The expected collection of data for the KPIs demonstration is described in the following figure. 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[2] from Schneider (SE). In parallel, SE has direct communication with BH (Riga sunisi and Imanta). Once the data is gathered by EcoStruxure, iSCAN will get it through an API and process it (filling data gaps, for example).

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

But, at the time of the development of this deliverable not all variables have been integrated in iSCAN (due to a refinement of SE APIs), breaking the communication in that point. Thus, the KPI-based maintenance tool to calculate KPIs and alarms cannot be used, neither the iDashboard.

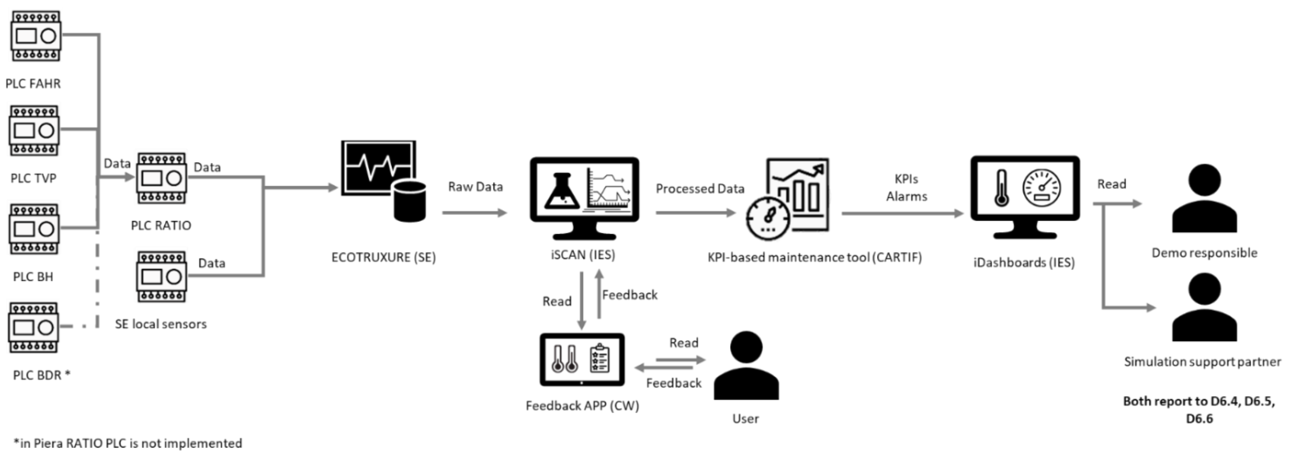


Figure 3: Data collection flow. Demos communicate feedback through the feedback APP and download data from the iDashboard of IES

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

- [TP1] Berlin #1
- [TP2] Nuremberg #2
- [TP3] Sant Cugat #3
- [TP4] Madrid #4
- [TP1] Cluj Napoka #6
- [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. Also, Berlin, Nuremberg and Cluj Napoka will not be included as the commissioning phase of the technology packages has not started. **Nevertheless, the codification will remain this way to be consistent with the past deliverables.**

The responsibilities within task 6.4 of each partner, are shown in Table 3.

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, Nuremberg 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 Cluj Napoca 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
CLUJ NAPOKA	KPIs follow-up of CLUJ NAPOKA Support on reporting 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 Nuremberg 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

2 Methodology

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 4: 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%*
- *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 5: 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

At the time of writing this deliverable the alarms integration within iSCAN have not been completed. Thus, the alarms won't be reported.

How to report the monitoring campaign

Every month, demo site responsible does screenshots of the IES dashboard, including the monthly main 12 KPIs. At the time of writing this deliverable the dashboard integration within iSCAN have not been completed, so screenshots won't be added. Instead, an analysis has been performed for each demo site based on the monitored data calculating the main KPIs.

3 Sant Cugat #3

3.1 Status update of the demo site

The courtyard reinforcement has been done in May 21. The installation by VEO started in June 21 and, finished in December 2021. The commissioning works took place on January 2022 and currently the only pending point is the iScan visualization (however the system is collecting data). Commissioning of the hybrid chiller was done in 15/03/2022 (without heat), on-site check of the machine on 09/06/2022. Operating of the hybrid chiller with heat from 10/05/2022 to 15/11/2022. Adjustments between the master and slave connections (the chillers are running during the night) were needed.

Since 01/09/2022 some periods where the system is offline but there is no explanation for this. We still looking for answers to this situation.

3.2 Status update of the monitoring system

The monitoring system was updated and it is summarized in the following diagram.

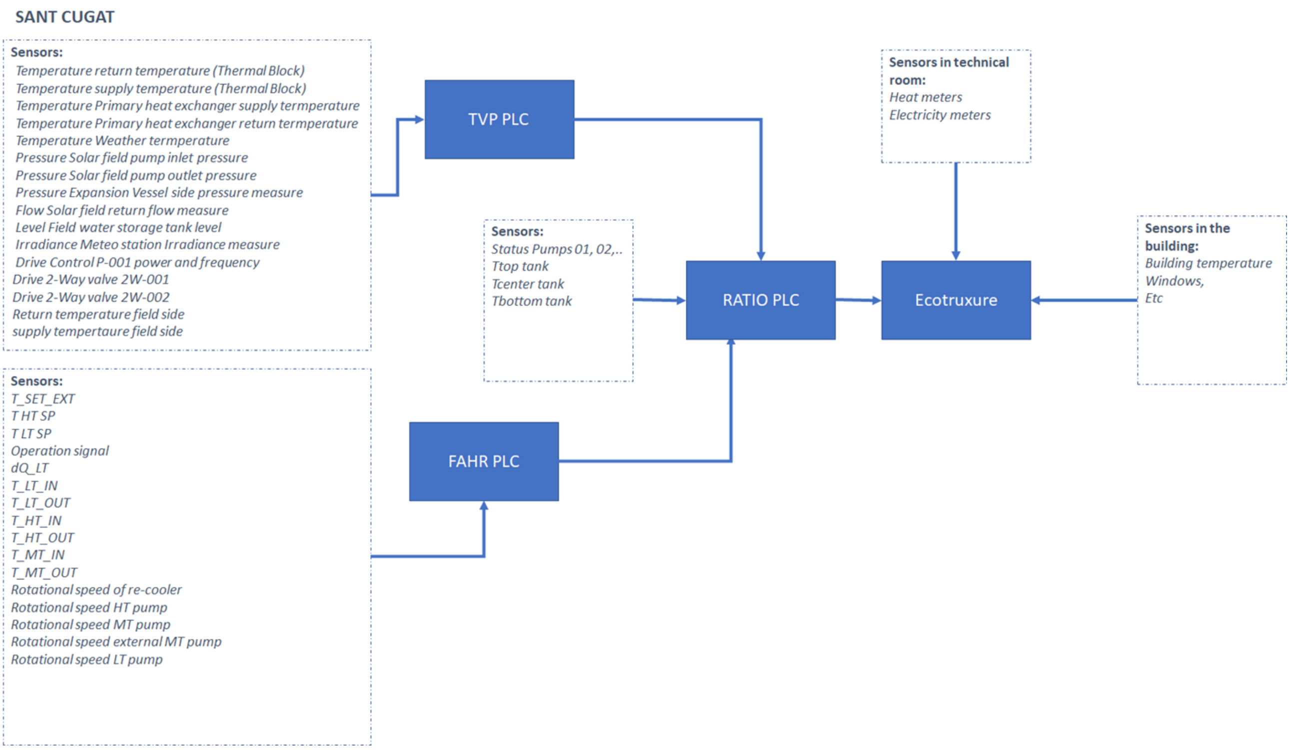


Figure 4 - Monitoring data (Sant Cugat)

Flow meters were added to measure in each point of the schematics:

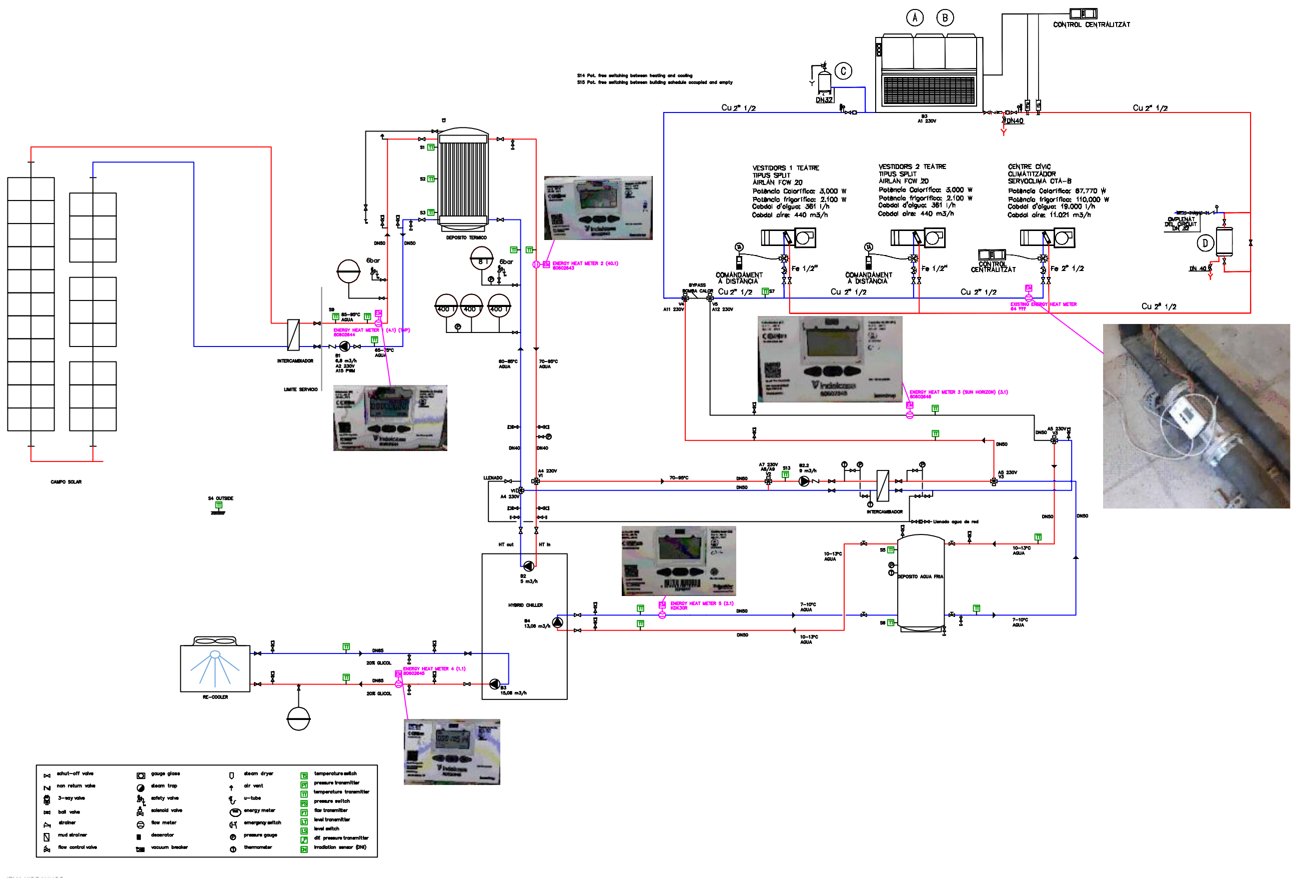


Figure 5: Monitoring heat meters (Sant Cugat)

The data collection progress and relevant events are included in Table 6.

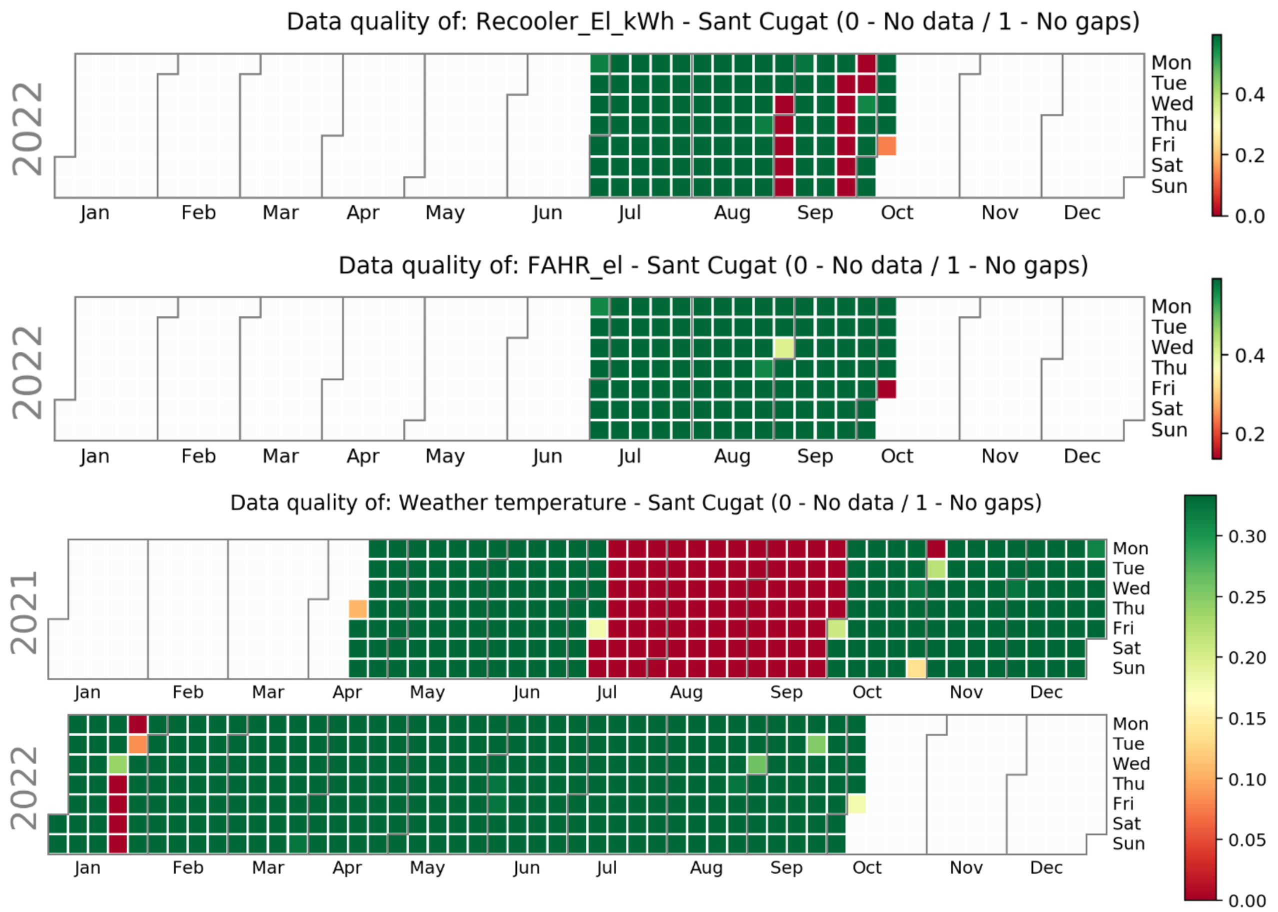
Table 6: Data collection progress (Sant Cugat)

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 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.	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.	Ongoing

		Schneider checks connection of the Automation Server. If everything seems fine, contacts the router provider	It seems there is also an error with the modbus configuration	
Connection of the TVP installation to the modem	September 2022	Connection of TVP is working with modem	Next step is SCADA integration of data	Ongoing
Alarm notification	2022	There is no remote control of the system	Next step is SCADA integration of alarms	Ongoing

3.3 Data quality

The data analysed for the TP (electricity consumption, etc) is only available for the summer period, mainly, as the whole commissioning of the TP finished in June 2022. There are some data gaps but it is not critical. The weather data is the one with higher disconnections.



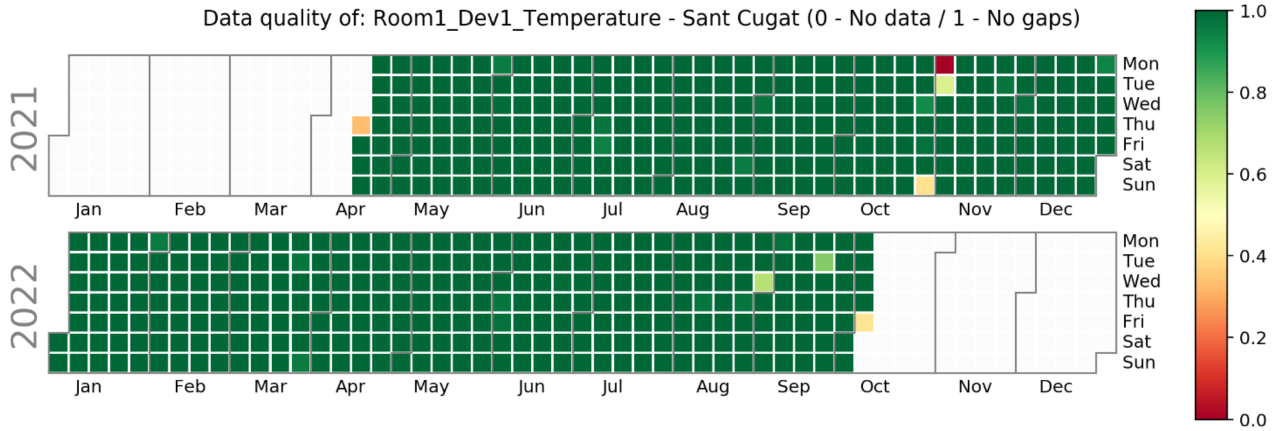
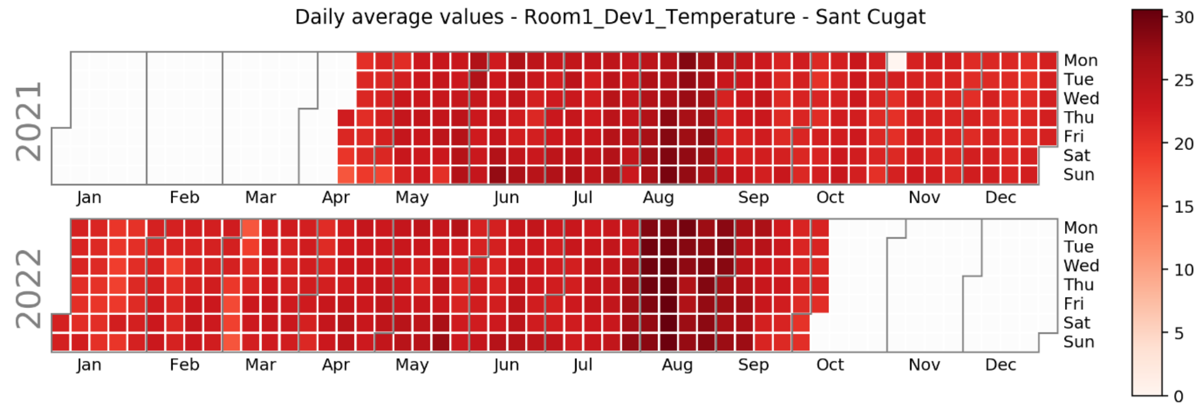
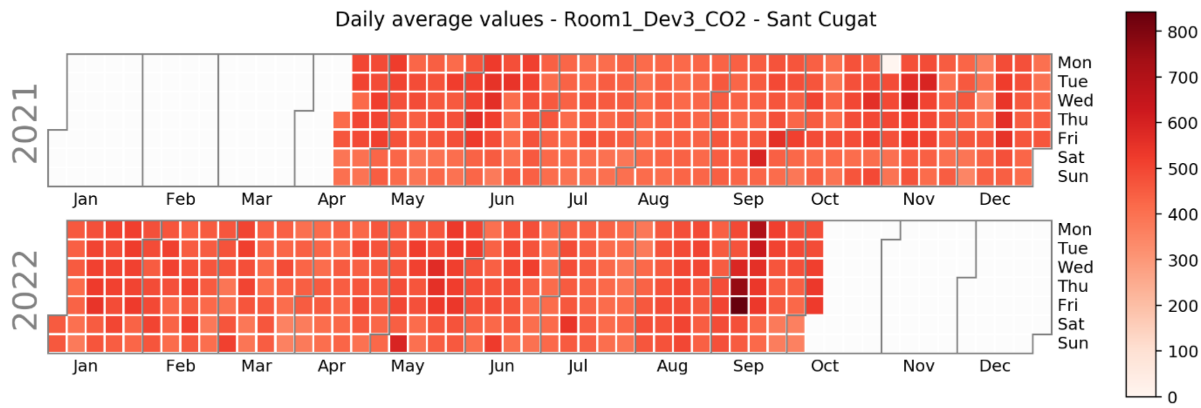


Figure 6: Data quality of electricity meters in Sant Cugat (red means no data, green that there is no data gaps).

The following diagram provides information about the temperature and CO_2 daily average values for room 1 and room 10. The overall picture shows that CO_2 daily average values are within the expected comfort values (<600 ppm) and temperature levels are within the range of 20ºC-24ºC.





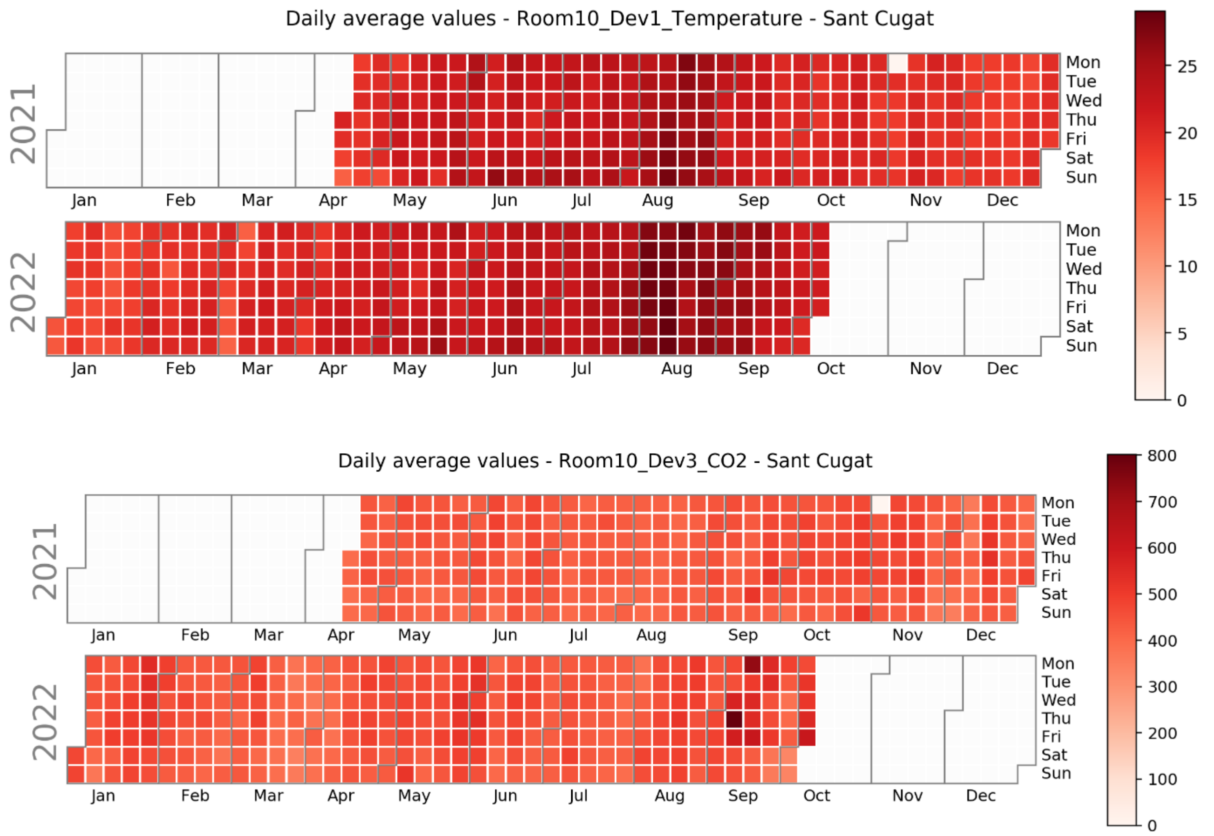


Figure 7: Daily average values for room 1 and 10 in Sant Cugat (temperature and CO_2 levels)

3.4 Issues and observations during TP operation

From a check of the monitoring data available for the summer period 2022 (July, August, September), several critical anomalies were underlined. Five representative operation days were selected in order to underline the anomalies in the controls and correct functioning of the system. Then, the PIs, calculated on a monthly base, are reported.

TVP loop. In Figure 8 the total solar energy rate calculated for 180 m^2, the TVP heat meter data (retrieved from "TVP meter" page on SE interface, field named "ExtLogActual Power") and the primary heat exchanger supply and return temperature retrieved from RATIO PLC are reported. Data show that the temperature of the flow on primary HX rise up to the upper set-point and the energy production is arrested.

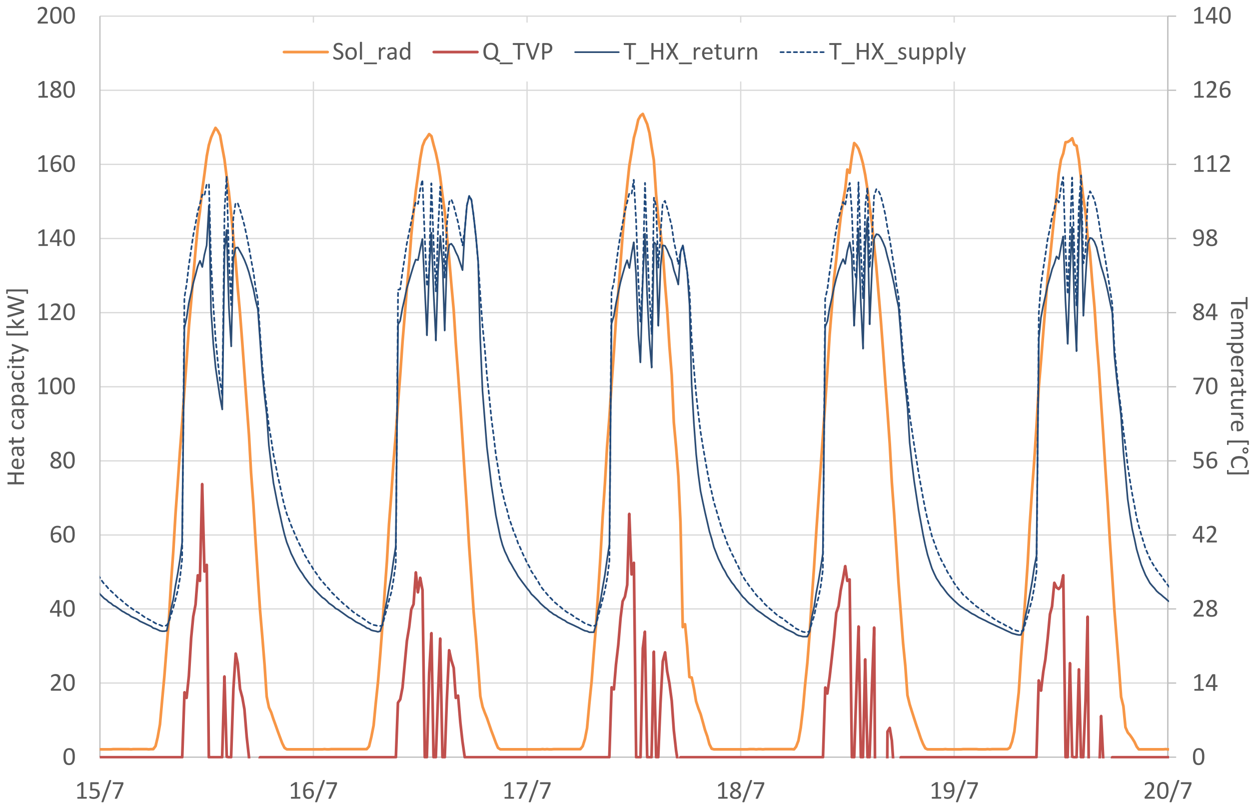


Figure 8: Focus on TVP operation data related to the 5 reference days

In Table 7 the monthly performance indicators, related to the summer period, are reported. It's possible to notice that the efficiency is achieved by TVP solar panels is lower than the expected one and simulated one (ranging between 50% and 60%). This is due to the operation control that lead to the dynamic trend showed in Figure 8, there is no heat request on the secondary side of the heat exchanger that connect the TVP loop and the RATIO loop. For this reason, the upper temperature set-point is reached and the flow is delivered to the dry-cooler in order to avoid over-heating as showed in Figure 9 where the heat capacity output and the electrical power is supply are reported. The electrical power measurement includes the circulation pumps and the dry-cooler electrical supply. In Figure 9 it's possible to notice the frequent activations of the dry-cooler due to the over-heating set-point temperature reached in the TVP loop.

Table 7: TVP monthly performance indicator referred to the summer season

	July	August	September
Q_TVP [MWh] **(TVP thermal power output "I.QFTvp-3")**	4.28	3.53	1.61
Solar radiation [MWh]	15.9	21.9	9.5
Efficiency **(TVP solar thermal efficiency "P.EFTtv-3")**	27.0%	16.1%	17.0%

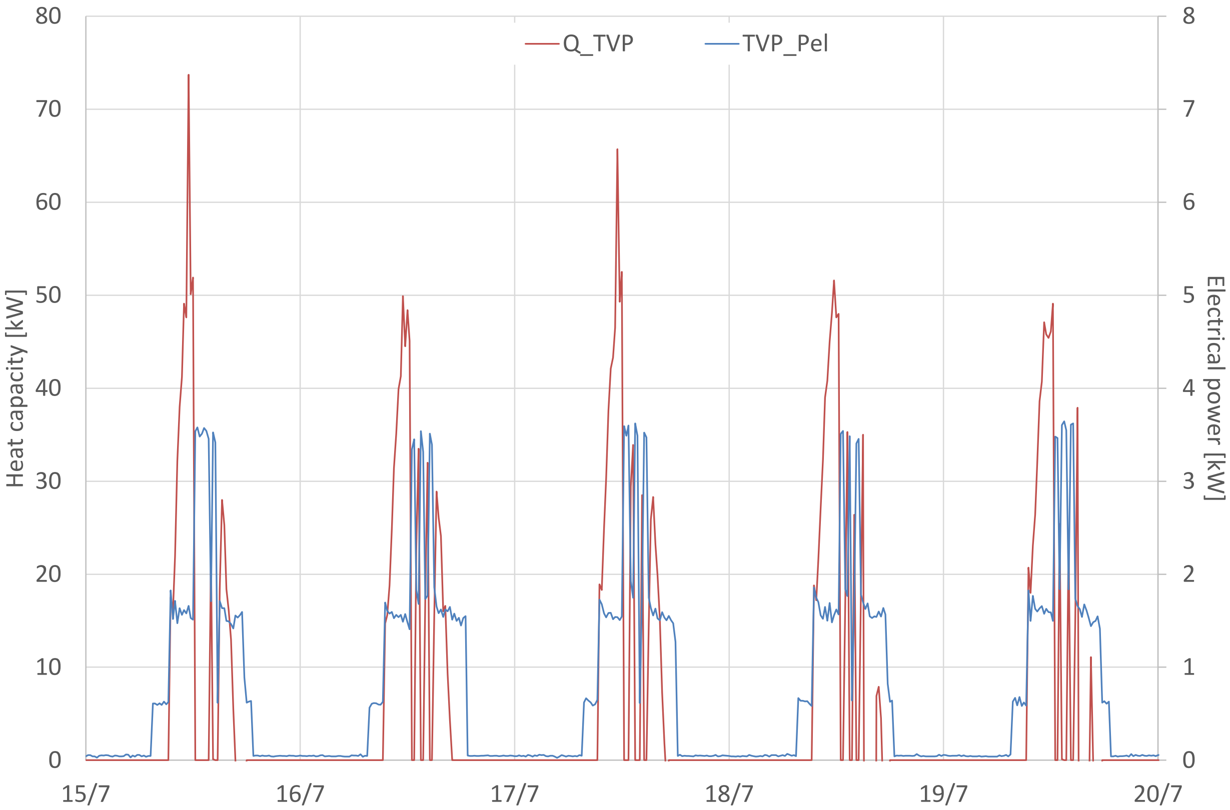


Figure 9: TVP heat capacity output and electrical power supply

From the comparison between the TVP energy supply (Q_TVP) and FAHR hot temperature energy demand (Q_HT) there is a mismatch that is physically unacceptable since the HT demand is higher than the TVP production (there are no other heat sources), this is possible signal of an anomaly in the monitoring system. The ratio between Q_HT and Q_TVP is approximately constant for the three summer months (Table 8). For FAHR energy and heat capacity data, data were retrieved from "Fahrenheit meter" – "Hybrid Chiller meter" and "Thermal tank energy meter" pages on SE interface, fields named "ExtLogActual Power" – "ExtLogCooling energy E3" and "ExtLogHeat energy E1". In Figure 10 it's possible to notice the mismatch in terms of heat capacity, since there is more heating demand than supply, right now is not clear why the temperature in the TVP primary loop rises up to the upper set-point.

Table 8: Comparison between TVP heating energy production and FAHR heating energy demand

	July	August	September
Q_TVP [MWh] (TVP thermal power output "I.QFTvp-3")	4.28	3.53	1.61
Q_HT [MWh]	10.74	8.70	3.96
Ratio HT/TVP	251%	247%	249%

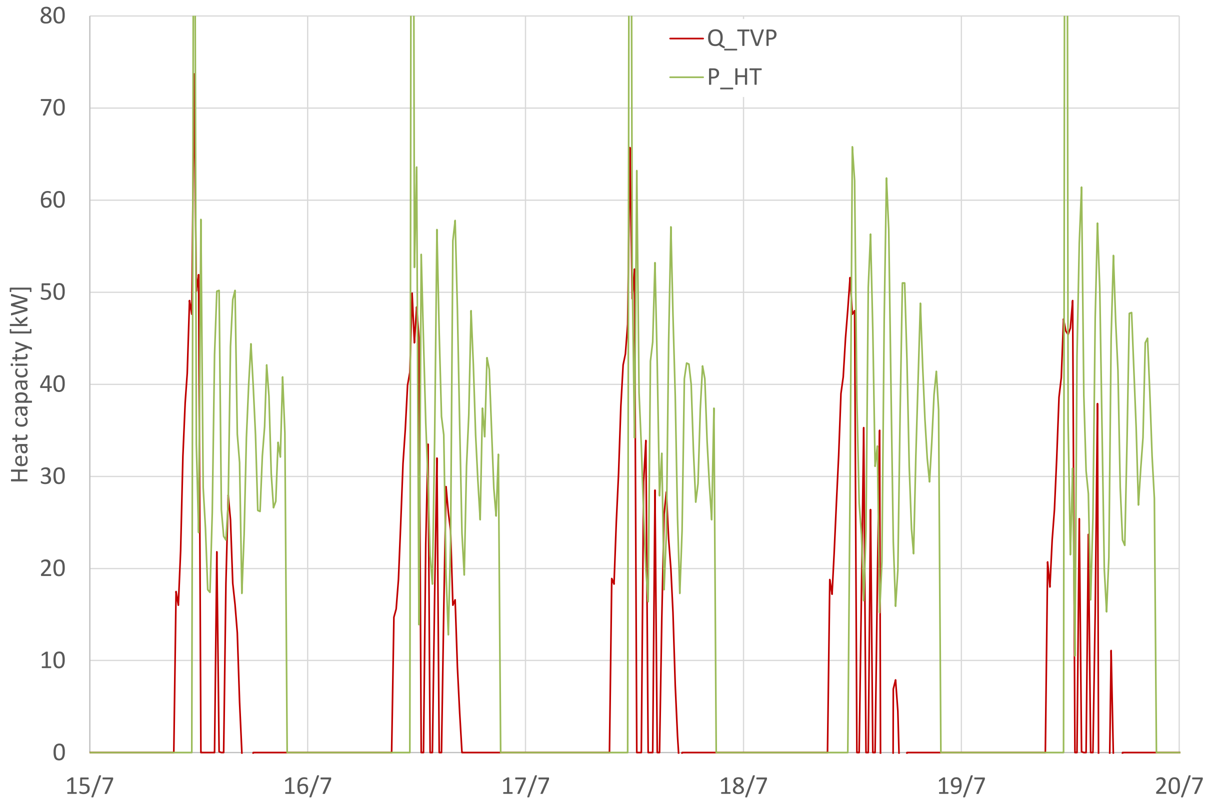


Figure 10: TVP heat supply and FAHR HT heat demand

The FAHR HT-MT-LT energy balance and electrical energy demand is reported in the Table 9. It's important to underline that the cooling (LT), recooling (MT) and electrical energy (E_el) data is related to the hybrid chiller (adsorption and compression), while HT is related only to the adsorption cycle (Figure 4)

Table 9: FAHR energy balance

	July	August	September
Q_HT [MWh]	10.74	8.70	3.96
Q_MT [MWh]	27.03	7.96	11.48
Q_LT [MWh]	15.4	2.83	6.28
E_el [MWh]	5.1	4.0	2.2

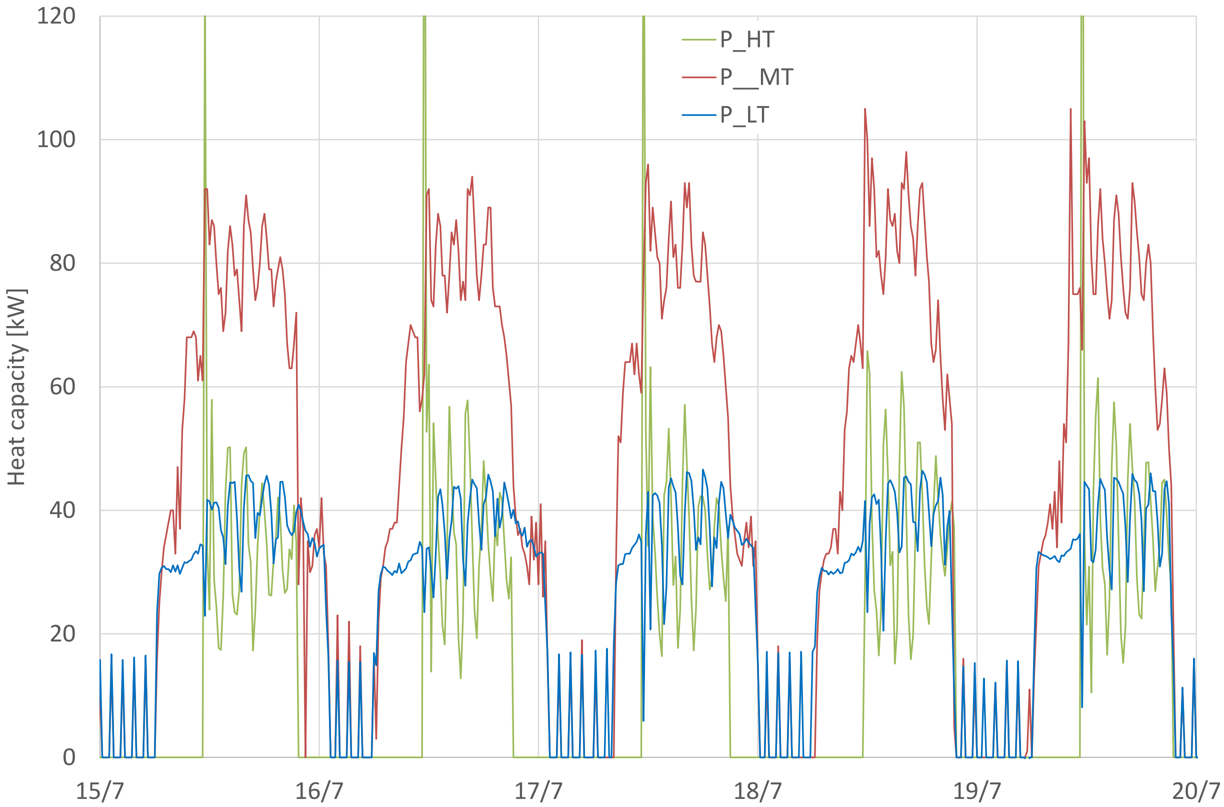


Figure 11: FAHR dynamic operation trend

Finally, the LT data retrieved from “Hybrid Chiller meter” page on SE interface were compared with ones retrieved from RATIO plc page: “ExtLogCalculated cooling power last half cycle 1” – “ExtLogCalculated cooling power last half cycle 2” – “ExtLogCalculated cooling power of the compr. chiller”. Theoretically, the sum of the last three values should be equal to the value called “ExtLog Actual Power” contained on “Hybrid Chiller meter” page (the overall LT cooling capacity). Data show a mismatch (Figure 11) which makes impossible to understand which is the correct one (figure 5).

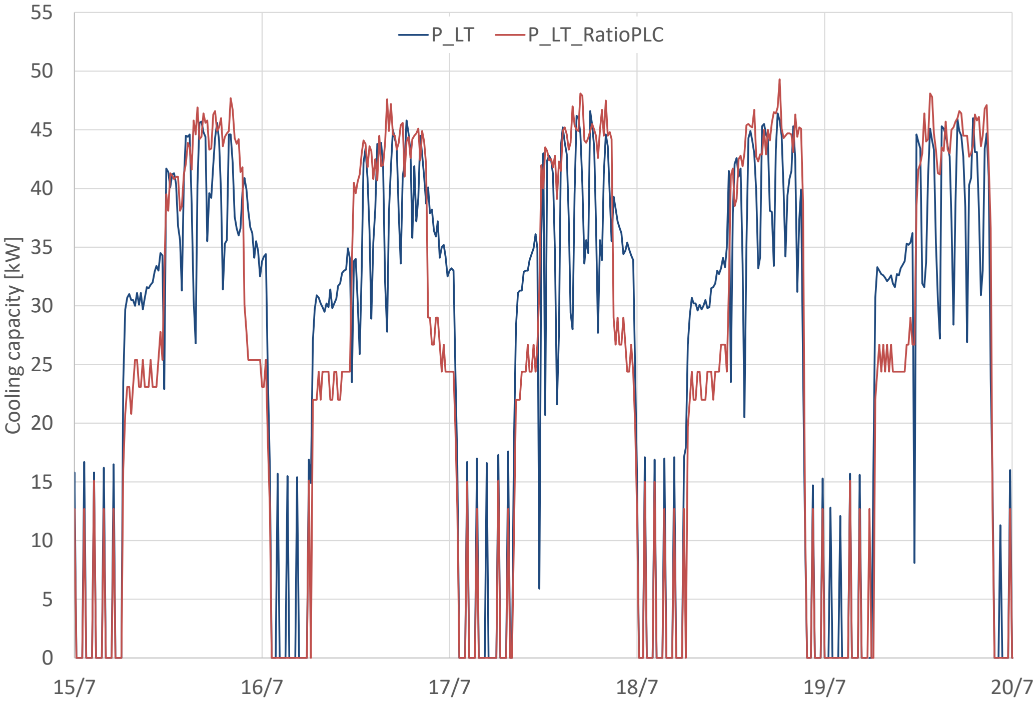


Figure 12: Comparison of monitoring data referred to the FAHR cooling capacity retrieved from two different pages of SE web interface

Due to these uncertainties the calculation of the KPIs is not possible. This first evaluation of the monitoring system and operating trends will lead to a revision of the system in order to have a good quality monitoring campaign for winter 2022/2023 and summer 2023.

3.4.1 Fahrenheit details

Temperatures of the solar field fit the needs of the adsorption chiller, according to Fahrenheit analyses. The graphs below show the accumulated frequency of the temperatures:

- Driving temperture for adsorption chiller (between 82 to 92 ºC mostly)
- Re-cooling temperature adsorption (varies from 30ºC to 37ºC)
- Chilled water temperature from cold water tank (varies from 11 to 12 ºC).

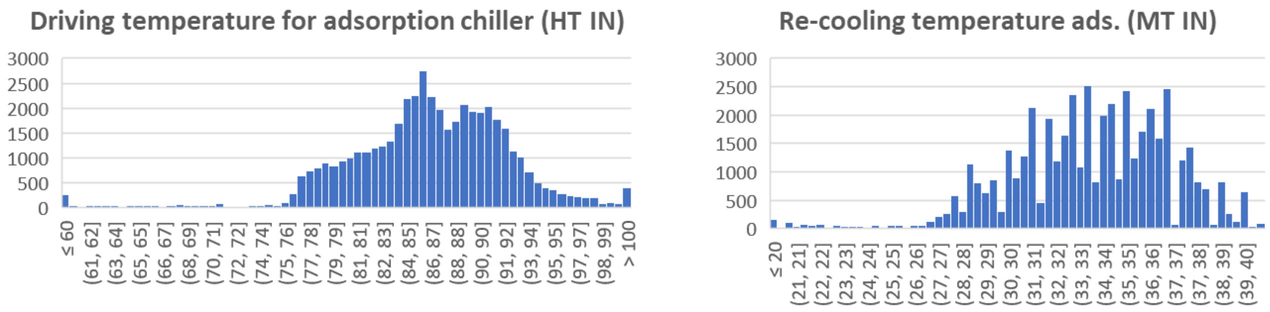


Figure 13: Temperature frequency for the driving temperature of the adsorption chiller (HT IN), the re-cooling temperature (MT IN)

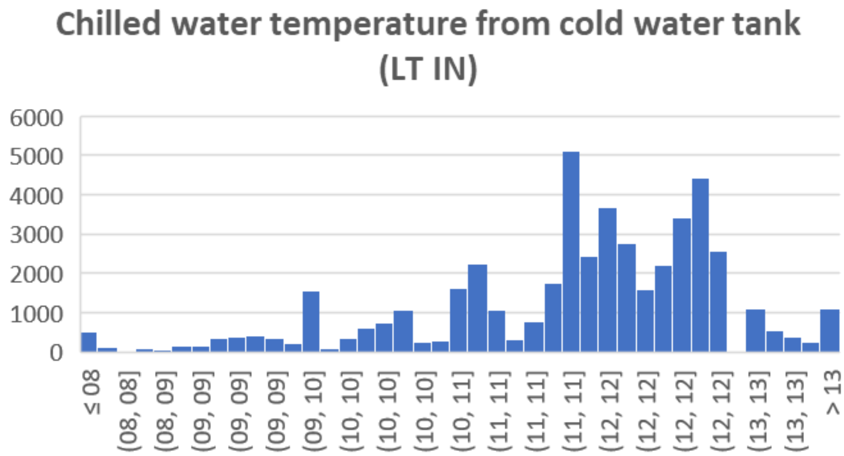


Figure 14: Temperature frequency of the cold water tank (supply temperature of the fahrenheit unit).

3.4.2 Electricity balance

Electricity bills are collected since June 2021 until September 2022. The summary can be seen below. As the weather temperatures for the whole period are not available (it has data gaps during many periods) the electricity consumption prior the commissioning of SunHorizon cannot be comparable. In fact, if July 2021 consumption is compared with July 2022 consumption, there is an increase of electricity consumption but it cannot be concluded that this is caused by SunHorizon or by more severe climatic conditions (heat waves that occurred in Spain during the summer of 2022).

Table 10: Energy consumed per period (period 1, 2, 3, 4, 5 and 6) in Sant Cugat buildings (all)

	P1 [kWh]	P2 [kWh]	P3 [kWh]	P4 [kWh]	P5 [kWh]	P6 [kWh]	TOT [kWh]
jun.-21	0.0	0.0	6278.0	3907.0	0.0	3861.0	14046.0
jul.-21	6601.0	4395.0	0.0	0.0	0.0	5545.0	16541.0
ago.-21	0.0	0.0	799.0	628.0	0.0	1472.0	2899.0
sep.-21	0.0	0.0	5265.0	3383.0	0.0	3134.0	11782.0
oct.-21	0.0	0.0	0.0	3488.0	2049.0	4594.0	10131.0
nov.-21	0.0	7023.0	4030.0	0.0	0.0	8777.0	19830.0
dic.-21	7956.0	4362.0	0.0	0.0	0.0	10367.0	22685.0
ene.-22	7866.0	4643.0	0.0	0.0	0.0	11726.0	24235.0
feb.-22	6352.0	3681.0	0.0	0.0	0.0	8696.0	18729.0
mar.-22	0.0	7234.0	4287.0	0.0	0.0	7764.0	19285.0
abr.-22	0.0	0.0	0.0	4861.0	3008.0	6706.0	14575.0
may.-22	0.0	0.0	0.0	4647.0	3011.0	4623.0	12281.0
jun.-22	0.0	0.0	6878.0	4355.0	0.0	6490.0	17723.0
jul.-22	6283.0	4287.0	0.0	0.0	0.0	8236.0	18806.0
ago.-22	0.0	0.0	2159.0	1828.0	0.0	3255.0	7242.0
sep.-22	0.0	0.0	4610.0	3286.0	0.0	4470.0	12366.0
oct.-22	0.0	0.0	0.0	3403.0	2240.0	5012.0	10655.0

The energy cost (in €/kWh) associated to each period is presented below:

Table 11: Energy cost per period (period 1, 2, 3, 4, 5 and 6) in Sant Cugat buildings (all)

	P1 [€/kWh]	P2 [€/kWh]	P3 [€/kWh]	P4 [€/kWh]	P5 [€/kWh]	P6 [€/kWh]
jun.-21			0.10350	0.08866		0.06727
jul.-21	0.14758	0.12788				0.06361
ago.-21			0.09988	0.08504		0.06361
sep.-21			0,099883/0,07	0,085044/0,073716		0,06309/0,059077
oct.-21				0.07372	0.06629	0.05908
nov.-21		0.08594	0.07723			0.05908
dic.-21	0.09094	0.08594				0.05908
ene.-22	0.12804	0.11301				0.06212
feb.-22	0.12804	0.11301				0.06212
mar.-22		0,113005/0,10213	0,091843/0,085968			0,062124/0,060949
abr.-22				0.07806	0.06919	0.06095
may.-22				0.07806	0.06919	0.06095
jun.-22			0.08597	0.07806		0.06095
jul.-22	0.24499	0.23377				0.19259
ago.-22			0.21761	0.20970		0.19259
sep.-22			0.21761	0.20970		0.19259
oct.-22				0.27175	0.26287	0.25464

The energy cost has increased overtime. All periods are more expensive in 2022 than in 2021. Taken as an example July the cost of the period 1 increased from 0.14758 in 2021 to 0.24499.

Analysing the data of the electricity meters installed in Sant Cuga-t, that measure the TVP consumption (from the dry coolers), the Fahrenheit consumption, pumps consumption, re-cooler consumption and the general consumption, it can be seen that there are inconsistencies among the meters. The "Pgeneral" should be the sum of all consumption of the SunHorizon meters, but it does not match with the consumption of the individual meters. This could be due to a wrong labelling of the meter or a wrong position of them (maybe it's measuring only the existing heat pump consumption). The same happens with the Fahrenheit electricity meter, which measures just a few kWh over the past months. Thus, either is wrong labelled or the unit of measure is different (maybe MWh). Due to these inconsistencies, the data cannot be trustworthy to continue calculating the KPIs of the demosite. As next steps, further revisions will be made to amend these issues.

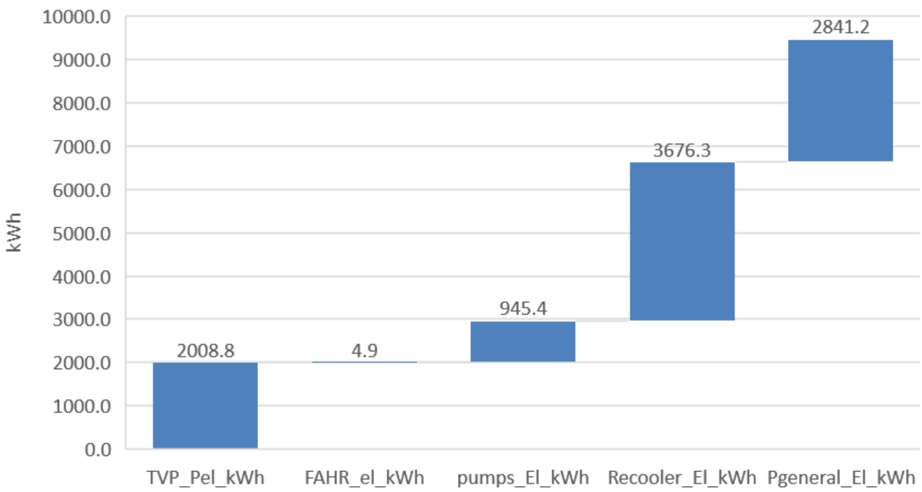


Figure 15: Overview of electricity meters in Sant Cugat (kWh) in July 2022

3.5 KPIs summary

Heating comfort index and cooling comfort index is calculated for each room.

Table 12: Heating comfort index (HCI) for each room

Room	Value for 2021	Value for 2022	Deviation	Impact on scope
Room 1	125	100	No major deviation	No impact
Room 2	293	434	No major deviation	No impact
Room 3	140	314	No major deviation	No impact
Room 4	2649	1644	No major deviation	No impact
Room 5	167	265	No major deviation	No impact
Room 6	245	367	No major deviation	No impact
Room 7	125	220	No major deviation	No impact
Room 8	55	54	No major deviation	No impact
Room 9	78	62	No major deviation	No impact
Room 10	481	831	No major deviation	No impact

Table 13: Cooling comfort index (CCI) for each room

Room	Value for 2021	Value for 2022	Deviation	Impact on scope
Room 1	441	711	No major deviation	No impact
Room 2	444	490	No major deviation	No impact
Room 3	975	1215	No major deviation	No impact
Room 4	550	732	No major deviation	No impact
Room 5	440	583	No major deviation	No impact
Room 6	802	1882	No major deviation	No impact

Room 7	393	645	No major deviation	No impact
Room 8	172	347	No major deviation	No impact
Room 9	169	359	No major deviation	No impact
Room 10	115	384	No major deviation	No impact

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 Madrid #4

4.1 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 finished in April 2022, but the commissioning was done in September 2022 (when the installation was approved by the industrial organism) and the PV installation was commissioned in October 2022. During the last 6 months (from March 2022 to October 2022) the following actions have been done:

- Finish electric legalization process: Contract increase of electric power in the building (34kW).
- 1st Phase of Commissioning: Heat Pumps
- Finish Legalization of PV system
- Finish verification process of the monitoring points and communications
- Definition of the monitoring variables to be imported by iSCAN
- Validation of the methodology to access to the monitoring data by SCHNEIDER
- Contract of the self-consumption in the building
- 2nd Phase of Commissioning: Distribution System and Dwellings

The main difficulties have been:

- Generalized material supply delays.
- Main Contractor Issues: Lack of experience and knowledge in executing high complexity systems, specially associated to hydraulics and communication and controls.

This has impacted the installation works timing, especially due to the legalization of the electric system and therefore the process of Contracting an increase of power required for the commissioning.

4.2 Status update of the monitoring system

The monitoring system architecture is shown in the following figure.

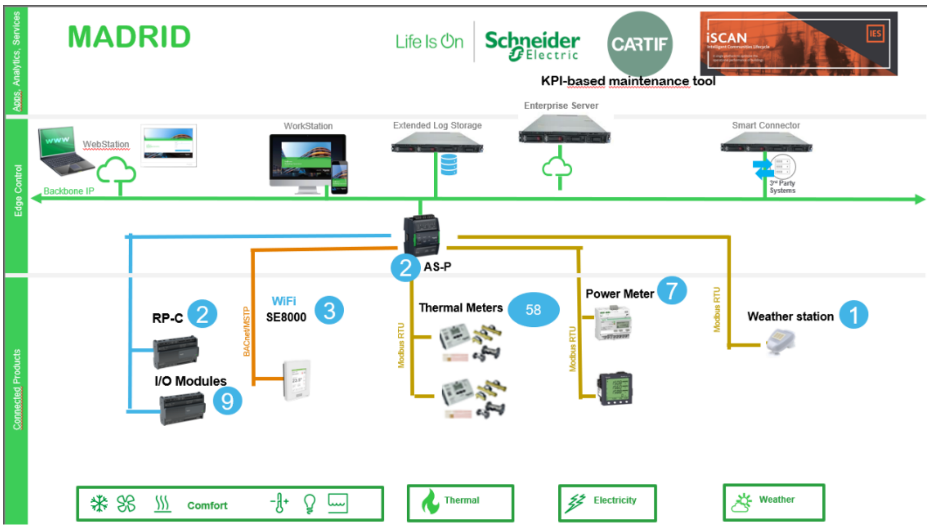


Figure 16: Monitoring architecture (Madrid)

The sensors that have been already provided are listed below.

Table 14: Status update of the variables that will be used in Madrid

Code	Description	Variables included in the sensor
T1	solar module temperature	Temperature
T8	Top solar tank temperature	Temperature
T10	top dhw tank Temperature	Temperature
T12	bottom dhw tank Temperature	Temperature
T13	top sh tank Temperature	Temperature
T15	bottom sh tank Temperature	Temperature
C1	general shc heat meter	Heat Energy C1, T1, T2
C2	general dhw heat meter	Heat Energy C2, T1, T2
C3	aw heat pump heat meter	Heat Energy C3, T1, T2
C4	ww heat pump consumption side heat meter	Heat Energy C4, T1, T2
C5	ww heat pump source sid heat meter	Heat Energy C5, T1, T2
C6	solar heat meter	Heat Energy C6, T1, T2
C7-C15	dwelling dhw heat meter	Heat Energy C7-C15, and from each T1, T2
C16-C24	dwelling shc heat meter	Heat Energy C16-C24, and from each T1, T2
DW1-DW9	dwlling interior temperature	temperature (one per dwelling)
EM1	SHC and DHW general board elec. Meter	Active energy total import
EM2	FV generation electric meter	Active energy total import, Active energy total export
EM3	AWHP elec. meter	Active energy total import
EM4	Electric resistor wW HP elec. Meter	Active energy total import
EM5	Electric resistor AW HP elec. Meter	Active energy total import
EM6	Electric resistor wW HP elec. Meter	Active energy total import
MS	Meteorological station	Temperature, wind velocity

4.3 Data quality

There will be just two monthly KPIs shown, since data started being collected by the 23th of September 2022 until the 30th of October 2022, and the commissioning of the whole monitoring installation is being done step-by-step. For now, only data at building level (temperature) is being collected.

The heat and electricity meters measure zero for all the period, probably because there is a problem on the communication or the data is not being collected (the meters are somehow disconnected), so from 107 variables that could be gathered from the meters, we are only receiving 80 of them.

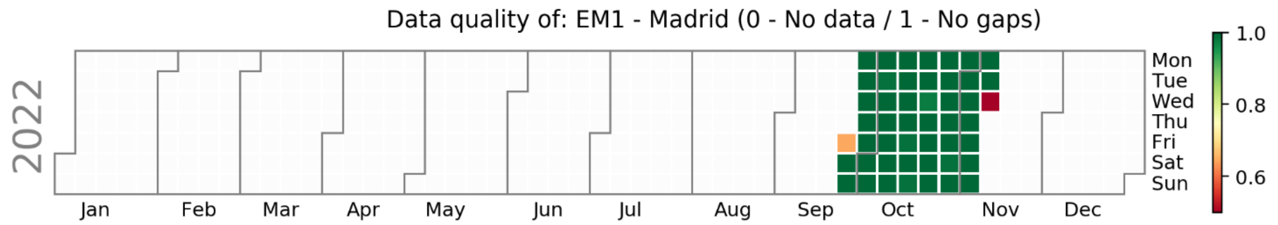
In the tables below, there is a list of the variables that only measure zero, and from the ones that only measure two values (mainly 0 and 0.1).

Meters that shows two values only	Description
C4_Heat energy	ww heat pump consumption side heat meter
C19_Heat energy	dwelling shc heat meter
C20_Heat energy	dwelling shc heat meter
C21_Heat energy	dwelling shc heat meter
C22_Heat energy	dwelling shc heat meter
C24_Heat energy	dwelling shc heat meter

Meters with no data	Description
C5_Heat energy	ww heat pump source sid heat meter
C6_Heat energy	solar heat meter
C15_Heat energy	dwelling dhw heat meter
C16_Cool energy	dwelling shc heat meter
C17_Cool energy	dwelling shc heat meter
C18_Cool energy	dwelling shc heat meter
C19_Cool energy	dwelling shc heat meter
C19_Cool energy	dwelling shc heat meter
C20_Cool energy	dwelling shc heat meter
C21_Cool energy	dwelling shc heat meter
C22_Cool energy	dwelling shc heat meter
C23_Cool energy	dwelling shc heat meter
C23_Heat energy	dwelling shc heat meter
C24_Cool energy	dwelling shc heat meter
DW9	dwelling interior temperature
EM1	SHC and D_HW general board elec. Meter
EM2_export	FV export electric meter
EM2_import	FV import electric meter
EM3	AW HP elec. meter
EM4	Electric resistor wW HP elec. Meter
EM5	Electric resistor AW HP elec. Meter
EM6	Electric resistor wW HP elec. Meter

Figure 17: Overview of data gaps

A detail analysis of data gaps can be found using python. As an example, only the meters of C4, C5, C23 and EM1 are shown below. As it can be seen although it seems there is no data gaps in the variables, the values inside the meter are always zero, which can also mean that the meter is disconnected or not working properly. This has been confirmed with the demo site leader. The meters transformers (toroidal) are missing in the meters and will be connected within December 2022.



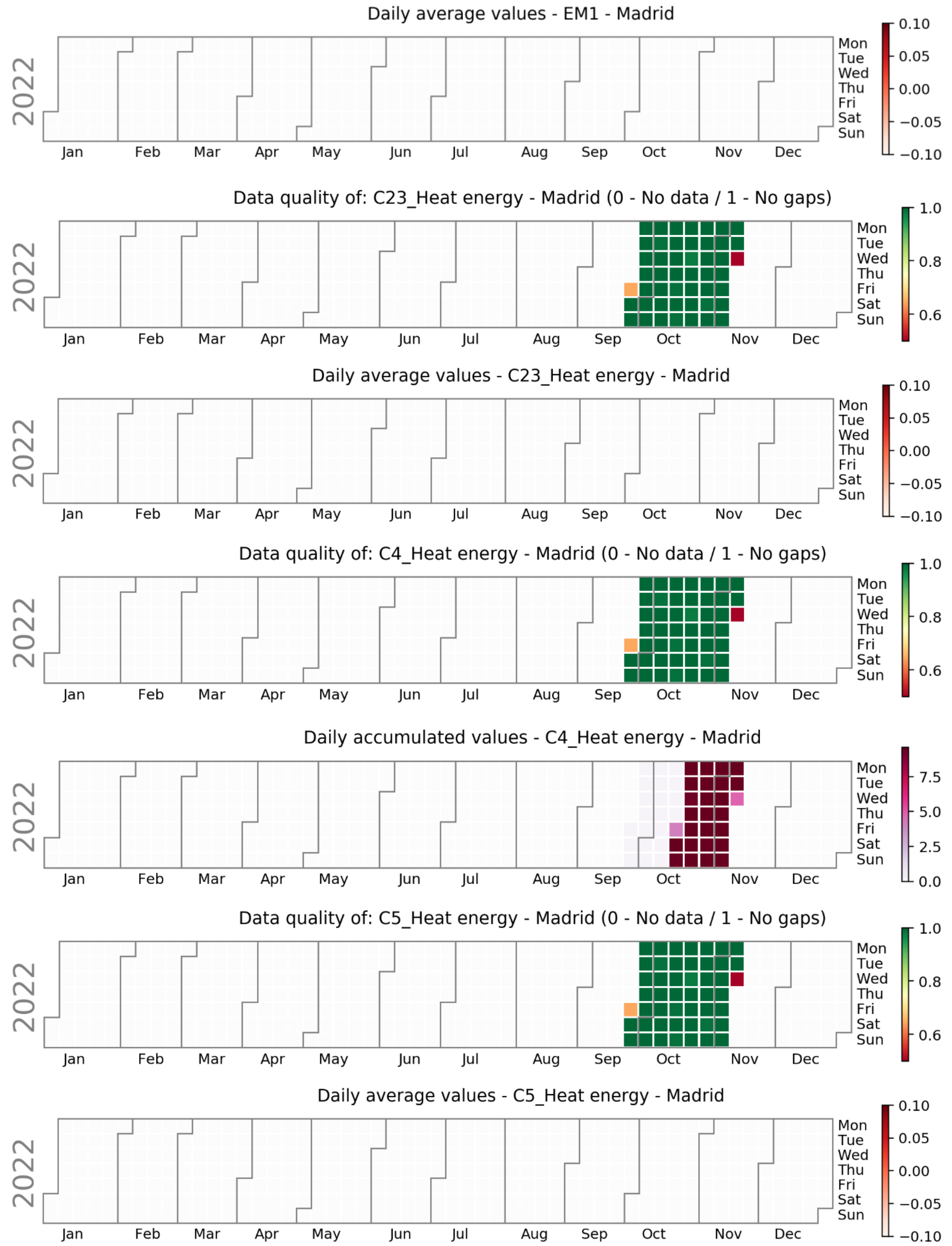


Figure 18: Data quality (0=red no data, 1= no gaps), and average daily values

For the temperature of the dwellings (D1 to D9 variables) it can be seen that DW1 is within the comfort range (around 20ºC), while DW9 is not measuring data. Building mean temperature is within the range of 22 to 25ºC.

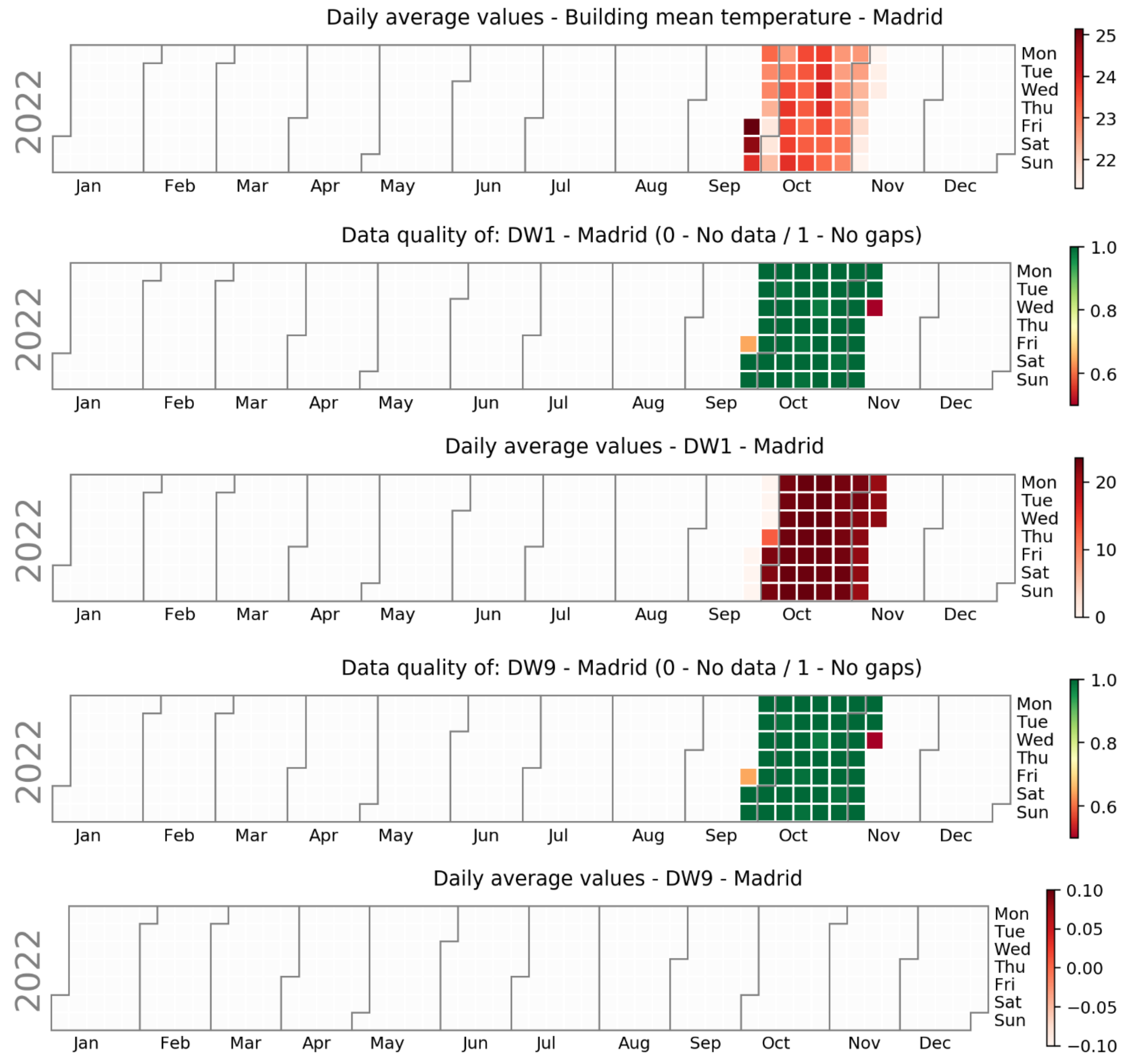


Figure 19: Data quality (0=red no data, 1= no gaps), and average daily values of dwelling temperatures

4.4 Issues and observations during TP operation

No major issues observed, besides the data gaps in some variables.

4.5 KPIs summary

For the future, tables from the Annex, subsection A, B and C, will be filled in with monthly values. For now, only temperatures in the dwellings are available, so the Heating and Cooling Comfort Index (HCI and CCI) are the only ones showed.

Table 15: CCI and HCI summary for September to October

KPI name	Description	Actual value	Deviation	Impact on scope
K.CCIsy-4-mon	Cooling comfort index (building level)	12.23	No deviation	No impact
K.HCIsy-4-mon	Heating comfort index (building level)	0.00	No deviation	No impact

Alarm table won't be added as at the time of the submission of this deliverable the iSCAN platform was not fully integrated.

4.5.1 Heating and cooling comfort index

The KPIs shown reflect the Heating and Cooling Comfort Index (HCI and CCI) of the dwelling, being calculated at building level and for each floor of the building with the average temperature of the houses of each floor. The codification in D4.2 was the following:

- K.CCIgr-4-mon, as Cooling comfort index (ground floor) calculated monthly
- K.CCIff-4-mon, as Cooling comfort index (first floor) calculated monthly
- K.CCIsf-4-mon, as Cooling comfort index (second floor)calculated monthly
- K.CCItf-4-mon, as Cooling comfort index (third floor) calculated monthly
- K.CCIlf-4-mon, as Cooling comfort index (last floor) calculated monthly
- K.HCIgr-4-mon, as Heating comfort index (ground floor) calculated monthly
- K.HCIff-4-mon, as Heating comfort index (first floor) calculated monthly
- K.HCIsf-4-mon, as Heating comfort index (second floor) calculated monthly
- K.HCItf-4-mon, as Heating comfort index (third floor) calculated monthly
- K.HCIlf-4-mon, as Heating comfort index (Last floor) calculated monthly

Data gaps are excluded from the calculation as the iSCAN service to fill the data gaps was not possible. Once iSCAN is totally integrated the KPIs will be re-calculated for this period filling the missing data.

For all dwellings there is data, except for dwelling 9 which corresponds to the 4th floor apartment B dwelling. The average temperature for each building floor is shown in Figure 20 for the complete measuring period, as there is only enough data to calculate the monthly KPIs for October. The higher temperatures registered belong to the second floor, this could be due to their space heating consumption (shown in Figure 21) and to reduced thermal losses; the third floor presents more variation that could be due to having higher thermal losses.

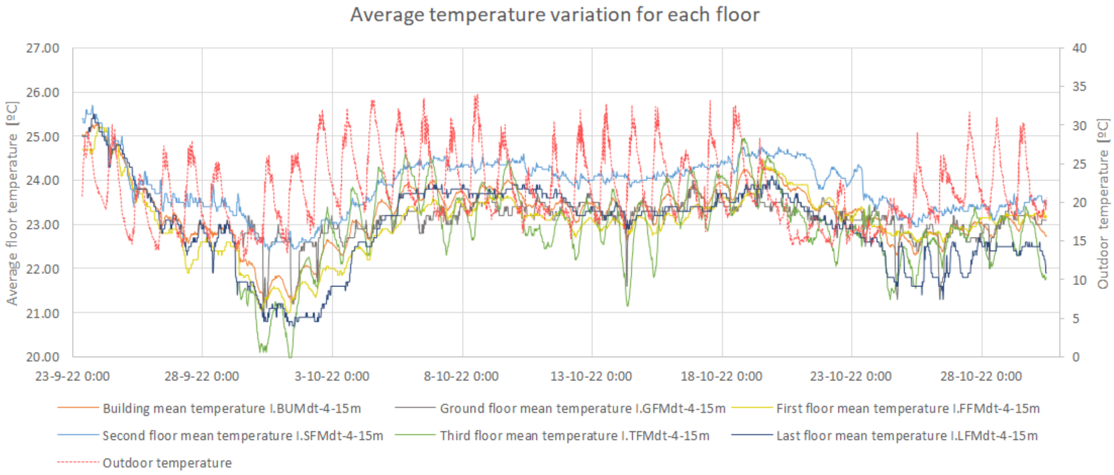
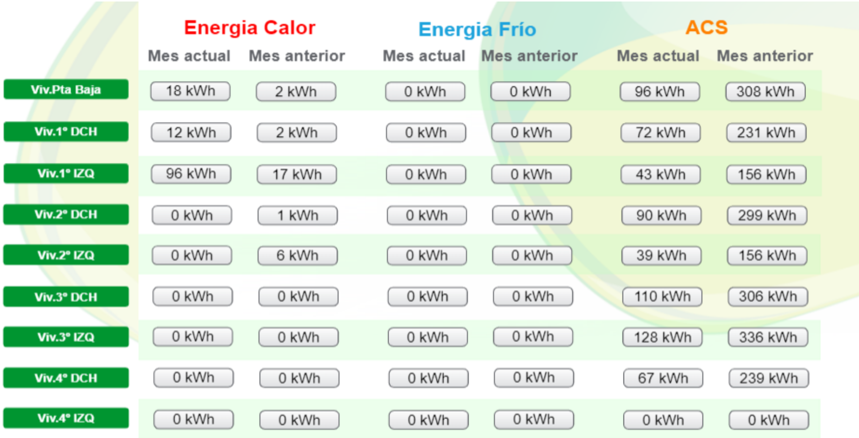


Figure 20: Average temperature variation for each floor in Madrid demosite



	Energia Calor		Energia Frío		ACS	
	Mes actual	Mes anterior	Mes actual	Mes anterior	Mes actual	Mes anterior
Viv.Pta Baja	18 kWh	2 kWh	0 kWh	0 kWh	96 kWh	308 kWh
Viv.1º DCH	12 kWh	2 kWh	0 kWh	0 kWh	72 kWh	231 kWh
Viv.1º IZQ	96 kWh	17 kWh	0 kWh	0 kWh	43 kWh	156 kWh
Viv.2º DCH	0 kWh	1 kWh	0 kWh	0 kWh	90 kWh	299 kWh
Viv.2º IZQ	0 kWh	6 kWh	0 kWh	0 kWh	39 kWh	156 kWh
Viv.3º DCH	0 kWh	0 kWh	0 kWh	0 kWh	110 kWh	306 kWh
Viv.3º IZQ	0 kWh	0 kWh	0 kWh	0 kWh	128 kWh	336 kWh
Viv.4º DCH	0 kWh	0 kWh	0 kWh	0 kWh	67 kWh	239 kWh
Viv.4º IZQ	0 kWh	0 kWh	0 kWh	0 kWh	0 kWh	0 kWh

Figure 21: Energy metering for SH, SC and DHW consumption per dwelling (screenshot from 9/11/2022). Mes anteriorl=October, mes actual=November, Energia calor = heating, energia frio= cooling, ACS = DHW.

In the Figure 22 it can be seen that the temperature has been dropping since the start of the monitoring campaign. This is due to the fact that the ambient temperature in Madrid has been decreasing and the space heating supply has not been switched on.

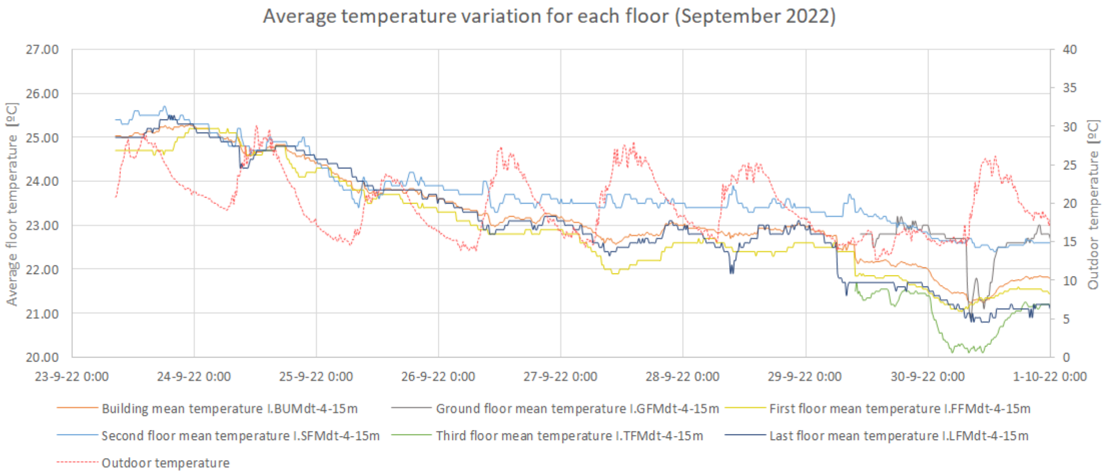


Figure 22: Average temperature variation for each floor in Madrid demosite (September 2022)

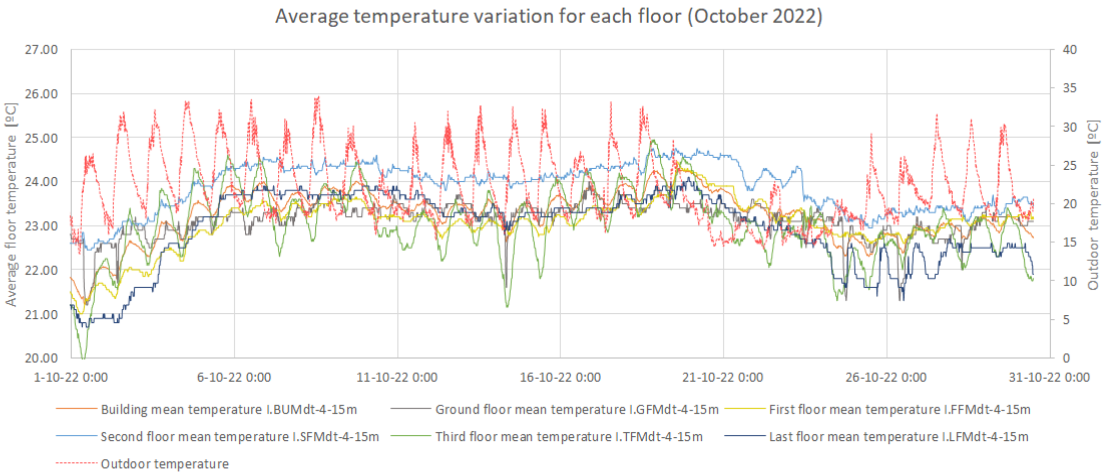


Figure 23: Average temperature variation for each floor in Madrid demosite (October 2022)

The calculated values are gathered in Table 16 with the sum of hours of discomfort for each month per floor. The highest discomfort is obtained in the second floor. In Figure 5 there is a graph showing the hourly values of the Cooling Comfort Index; where we can see that these values are related to the first days of measuring (between 23rd and 25th of September) where the outdoor temperature was still above 24ºC and there was no cooling supply in the building. The CCI started to decrease once the outdoor temperature dropped, and the indoor temperature was within the comfort range (below 25ºC in summer and above 18ºC in winter).

Table 16: Madrid summary of CCI and HCI

	Cooling comfort index					
	Building level	Ground floor	First floor	Second floor	Third floor	Last floor
Month	K.CCIsy-4-mon	K.CCIgr-4-mon	K.CCIff-4-mon	K.CCIsf-4-mon	K.CCItf-4-mon	K.CCIlf-4-mon
September	12.23	0.00	6.60	33.30	0.00	13.30
October	0.00	0.00	0.00	0.00	0.00	0.00

	Heating comfort index					
	Building level	Ground floor	First floor	Second floor	Third floor	Last floor
Month	K.HCIsy-4-mon	K.HCIgr-4-mon	K.HCIff-4-mon	K.HCIsf-4-mon	K.HCItf-4-mon	K.HCIlf-4-mon
September	0.00	0.00	0.00	0.00	0.00	0.00
October	0.00	0.00	0.00	0.00	0.00	0.00

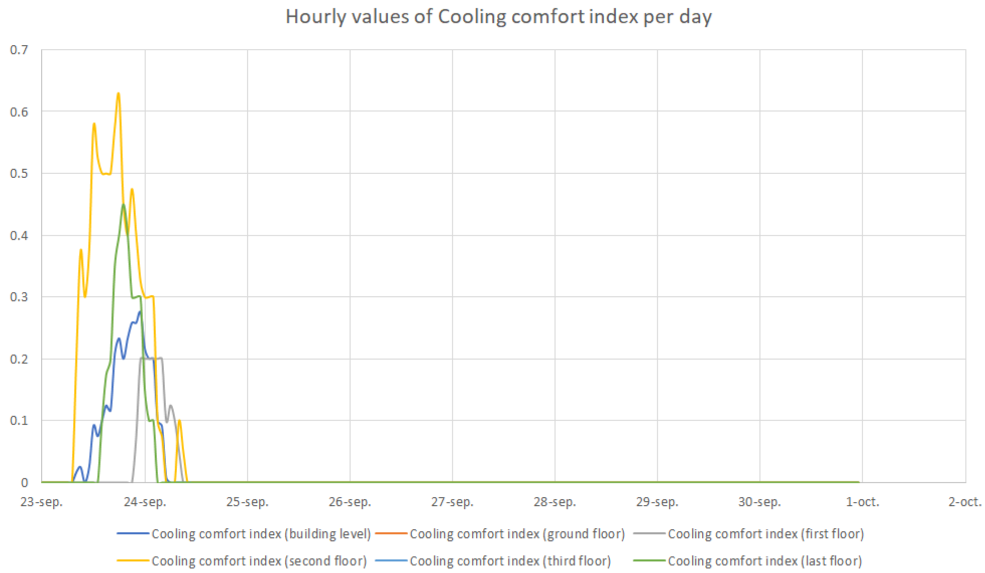


Figure 24: Hourly values of Cooling comfort index per day

5 Riga Imanta #8

5.1 Status update of the demo site

The tender for TP2 installation (Imanta and Sunisi together) was launched in May 2021, 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 was completed in September 2021, after approval of all technology providers and other involved SunHorizon partners. The installation and commissioning were completed for Imanta on 20 December 2021. The physical connection between RATIO–SE technologies in Imanta demo site was also established in December; however, connection between BH–SE took longer as the technology providers were still developing and needed to agree on the ICT architecture to enable data exchange. It was completed, commissioned and tested in the first half of ’22, hence enabling SE to collect data also from BH and RATIO equipment.

Since commissioning of the TP2, overall, numerous and frequent demo site visits have been required and carried out by the demo manager (RTU) for troubleshooting (mostly for Boostheat hardware and connection issues, but also for SE (e.g. monitoring issues) and RATIO).

5.2 Status update of the monitoring system

The monitoring system architecture is shown in the following figure. Furthermore, there is data being collected from RATIO and from BOOSTHEAT PLCs.

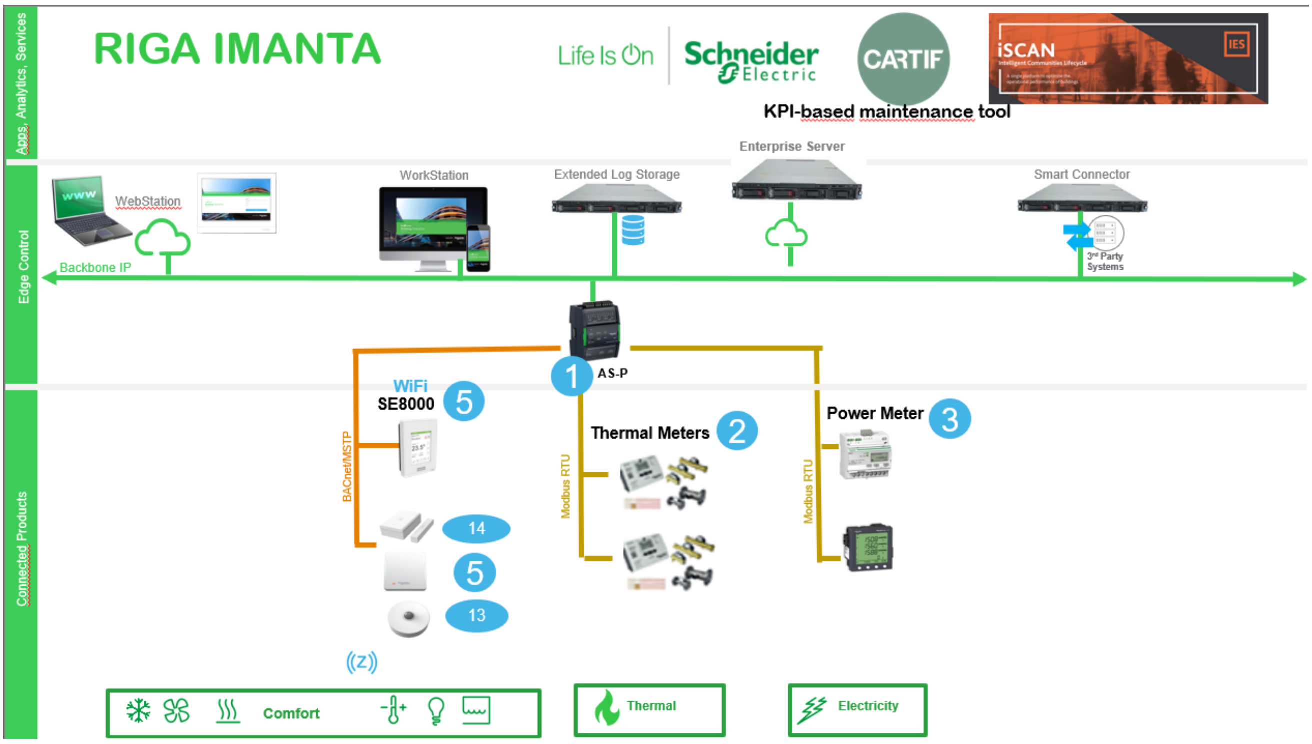
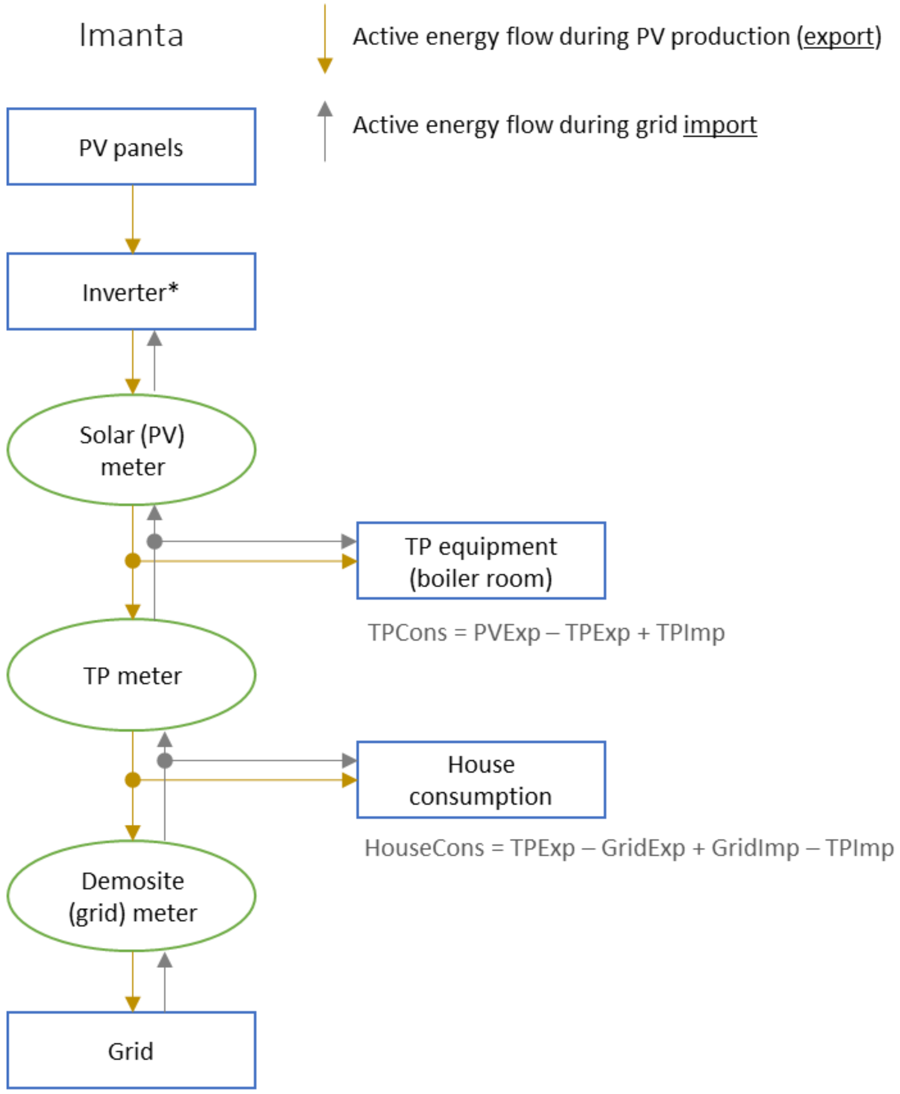
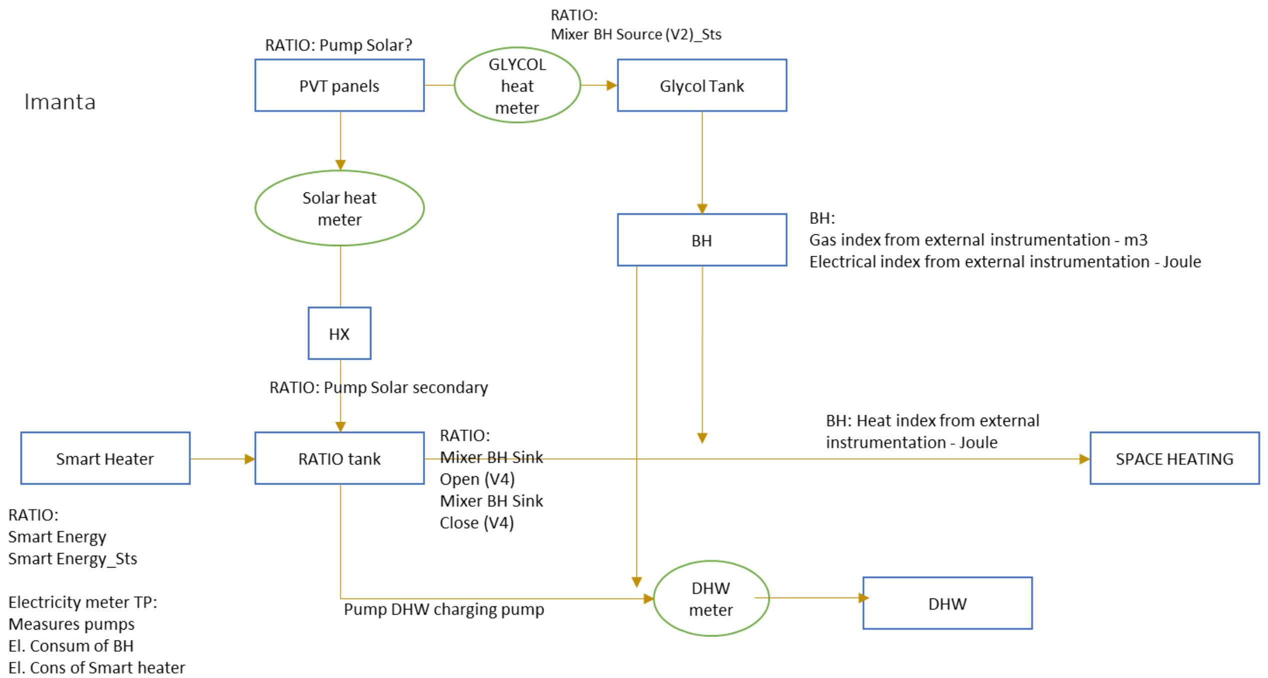


Figure 25 - Monitoring Architecture (Riga Imanta)

To calculate the KPIs the electricity and thermal balance is performed taken into account the different variables from the meters (heat, electricity meters) and variables coming from RATIO and BOOSTHEAT:



* There is a small inverter self-consumption when PV doesn’t produce.



Data collection progress and relevant events is shown hereafter.

Table 17: 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. Since data is collected, this is not a monitoring issue, but the display can be adjusted according to user needs.	n/a
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	A number of room sensors and controllers were reset and SE central box moved closer to improve the coverage. Still, some SE8000 controllers were failing even with a signal strength of ~30%.	Since the room sensors and controllers are connected via WiFi and the house is spacious, it was found that to improve the wireless signal strength, especially on the upper floor, a WiFi repeater should be installed.	WiFi repeater and replacement SE8000 controller delivered to the demo site on Dec. 2021,

				installed on January 2022
Communication issues with the room sensors located further away from the SE central box	March 2022	SE suggested installing an additional WiFi repeater to improve the signal strength.	RTU purchased and installed another WiFi repeater.	May 2022
No data on the flow from two glycol meters	April 2022	After identifying too high concentration of glycol by BH, the heat carrier was diluted in May. The concentration can impact the measurements as the meters are specified for a pre-defined concentration.	Some faults in wiring of meter data connection were found. After rewiring, data collection is ongoing. Further validation of data to be performed during KPI assessment.	June 2022
Some **SE8000** controllers are going offline and data is intermittent	June 2022	Restart of devices as needed, which can often solve at least part of the issues.	Even with two WiFi repeaters per house, data collection from some SE8000 controllers is still intermittent. Since the demo site is a residential house and the monitoring equipment already installed takes a lot of space and is intrusive for the demo residents, it is not feasible to install additional ICT devices.	Continuous activity in progress (the failing devices need to be restarted if offline)
Some monitoring devices offline	June 2022	Network switch replaced with a new one, which fixed the issue.	Network switches might need to be replaced from time to time (especially if using non-industrial grade devices with lower reliability).	June 2022
iSCAN to be updated	October 2022	New APIs and change of names in variables in SE platform in 14/10/2022	Set alarms that if there is a data gap of more than 24h, it informs the demo group to be able to react more quickly	Ongoing

5.3 Issues and observations during TP operation

From the first months of operation, Boostheat heat pump experienced a number of internal technical issues: some issues emerged from the preventive maintenance / monitoring by BH (e.g., low pressure of glycol network, a lack of CO2 refrigerant etc.), some were displayed as alarms on BH screen to the end-users e.g.:

- "C078 too low heating water flow";
- "C024 Compressor 3 motor blockage";
- "C019 Overheat of heat pump heater 2 temperature".

During the following months of TP2 operation, a number of additional issues, mostly related to Boostheat, were solved or identified:

- In Imanta a replacement of the Boostheat internal heat pump unit due to "deteriorated behaviour" in Apr '22.

- Dilution of the glycol heat carrier up to ~57% in May ’22 (M44) after BH discovered it was too concentrated (close to 100%).
- A leak in the glycol pipes behind DualSun panels was found and fixed in Sept ’22 (M48).
- In early Oct ’22, after trying to turn on space heating, BH informed that the CO2 refrigerant has leaked from the heat pump in Imanta, and due to the severity of this leak it cannot be fixed by refilling. Consequently, the heat pump in Imanta is not operating and only the condensing gas boiler operation of Boostheat is possible. BH has informed that the heat pump failure is permanent and they cannot fix it.
- During summer 2022, there were large glycol pressure variations observed: pressure was dropping too low for heat pump operation. While BH heat pump and DS panels are in the same glycol circuit, the required pressure for the heat pump is 1…3 bar (pref. 1.5), but the pressure of PVT panels can drop down to 0 bar (at 0 m height) or H / 10 [bar], max is 1.5 bar. DS explained that these pressure variations are normal for the panels due to the expansion of their polypropylene heat exchanger: the pressure stabilises at the atmospheric pressure after ~ 1 month or so after installation so that the resulting pressure will be just the height between the panels and the pump. BH also suggested checking the expansion tank volume and pressure, which, according to the installer, is fine (40 L / 1.3…1.5 bar). Thus, the only feasible solution for both sites and esp. for Imanta (panels on ground, so the same height as the heat pump) is adding a heat exchanger and a circulation pump. BH was not in favour of this solution as it would lower the system's efficiency and suggests changing the volume of the expansion tanks and adapting the inflation pressure correctly. Solving of this issue was still in progress, and the solution should have been selected considering also the uncertainties around BH participation in the project and the potential eventual decommissioning of the Boostheat heat pump in the demosites. Since, as of October 2022, the heat pump has failed permanently, the issue of glycol pressure variations has become irrelevant.

Furthermore, the following insights have been obtained observing the monitoring. The DHW temperature setting of Boostheat is too high and the option to adjust is has been disabled since summer 2022 (was user-selectable previously). The internal DHW tank top temperature is set to 65 °C. However, to save energy, the users would prefer a lower temperature e.g., 50 °C, which would also allow to more rely on the solar heat during the summer. Since the DHW temperature received by BH from the RATIO Oskar tank is usually lower, with this high temperature setting, BH gas boiler is often operating and consuming gas for heating the DHW up to 65 °C even during summer.

Previously, RATIO had devised a specific control strategy for the Smart Energy electric heater to be aligned with the net metering arrangements in Latvia in order to enable “storing” in the grid the surplus electricity from PV production up to the amount of the annual electricity consumption. It was supposed that, with this strategy, the electric heater would only consume that part of PV production which exceeds the annual consumption. However, it turned out that there was an error in the program and the above (rather complicated) strategy was not implemented, so eventually RATIO had switched to their standard control rules (as for Germany e.g.). This can be cost-inefficient as it does not allow the household to “store” their produced electricity from the summer months to be consumed in the winter. RATIO is still open to correct the program and adjust it so that it works properly in Latvia. Improvements should be devised based on the actual data analysis from the demo monitoring and RATIO measurements. Initial analysis shows that the German strategy can be still applied for Imanta because the household electricity consumption is rather low, so the residents indeed benefit from converting the surplus PV electricity into the heat by the Smart Energy heater while still being able to store enough electricity in the grid.

After several months of operation, it can be concluded that the Boostheat unit in Imanta has never been continuously operating in the heat pump mode (even with the replaced thermodynamic unit), so only the condensing gas boiler mode has been possible. Hence, demonstration of fully integrated TP2 operation, including the heat pump, has not been possible so far. At the beginning of October 2022, BH informed RTU that they’ve observed a huge loss of the CO2 refrigerant which cannot be fixed easily on-site by refilling. Boostheat has not been able to find a solution for the heat pump in Imanta.

Moreover, even operation of the gas boiler has not been error-free and continuous. E.g. the gas boiler failed in Imanta in October 2022 and was out of order for ~1 day, hence DHW and space heating was discontinued. BH was able to assist remotely but could not solve it immediately. Eventually they clarified that they “had a bug in settings” and managed to fix it. Such issues clearly show that continuous operation of the Boostheat unit even in the gas boiler mode is not feasible if BH limits or discontinues their technical support. It can lead to sudden interruption of the heat supply causing a lot of discomfort to the residents. If the Boostheat unit is not replaced by a reliable alternative heat pump technology, the demo owner in Imanta will need to revert to their old conventional gas boiler. So TP2 becomes nonoperational and only producing electricity by PVT panels would be possible.

5.4 KPIs summary

5.4.1 Electricity balance

Eight months data is shown in the following table. The period of data starts in March 2022, and finished end of October. Data gaps are excluded from the calculation as the iSCAN service to fill the data gaps was not possible. Once iSCAN is totally integrated the KPIs will be re-calculated for this period filling the missing data.

For each month, the electricity balance is calculated as shown in Figure 26.

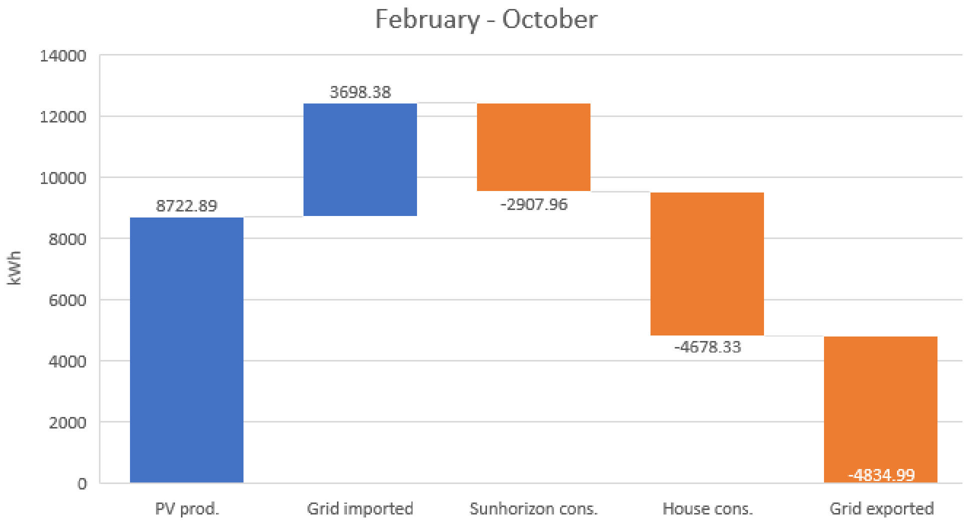


Figure 26: Electricity Balance: February - October

The highest electricity consumption from SunHorizon occurred in the months of May and June, due to RATIO's controller settings that were programmed according to Germany's rules (to increase self-consumption) instead of Latvian rules (export energy and "save" it for winter time).

The electricity consumption of the house is very similar in every month with an average consumption of 584.8 kWh per month. It seems the data for March is inconsistent as the value is too high (probably measures the consumption of February too). The self-consumption ratio varies from 10 to 56%, remaining around 50% in the months of May to October.

2022	PV production	Grid imported	SunHorizon cons.	House cons.	Grid exported	PV self-cons.	Self-cons. Ratio	Gas savings
2								
3	1048.8	1712.8	192.3	1629.2	940.2	108.7	10.4%	-575.80
4	1269.7	293.7	413.8	396.3	753.4	516.3	40.7%	-389.10
5	1310.9	226.0	609.6	360.6	**566.6**	**744.3**	56.8%	891.80
6	1390.0	160.9	534.3	354.8	**661.7**	**728.2**	52.4%	-329.10
7	1383.5	165.6	438.7	372.8	**737.7**	645.8	46.7%	-111.10
8	1228.2	196.5	397.6	401.9	625.2	603.0	49.1%	525.50
9	791.0	379.2	221.5	530.9	417.8	373.3	47.2%	not meas.
10	300.8	563.741	100.178	631.875	132.454	168.312	56.0%	not meas.

Figure 27: Electricity balance results from February 2022 to October 2022. For February 2022 Grid Exported data was not available so the value obtained for the balance is not reliable

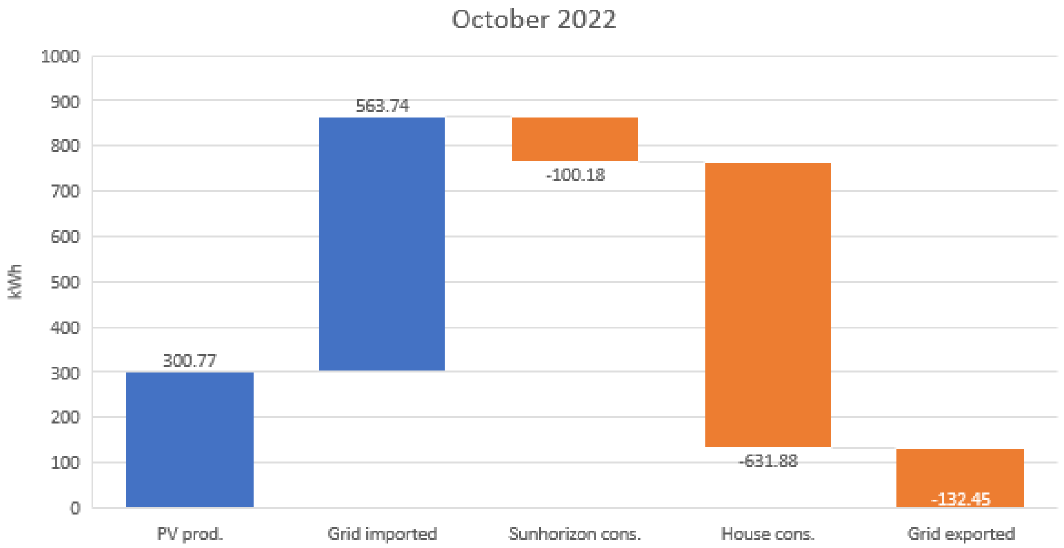


Figure 28: Electricity Balance October

If the solar electric efficiency is calculated for the PVT panel, the result is as follows:

2022	10	9	8	7	6	5	4	3
PV Energy Exported	300.8	791.0	1228.2	1383.5	1390.0	1310.9	1269.7	1048.8
Solar Eff.	18%	17%	17%	16%	15%	14%	19%	24%

Figure 29: PVT solar efficiency

The PVT solar efficiency ranges from 14 to 24% which is within the expected range (nominal efficiency 19%).

Regarding data gaps, no major data gaps are observed:

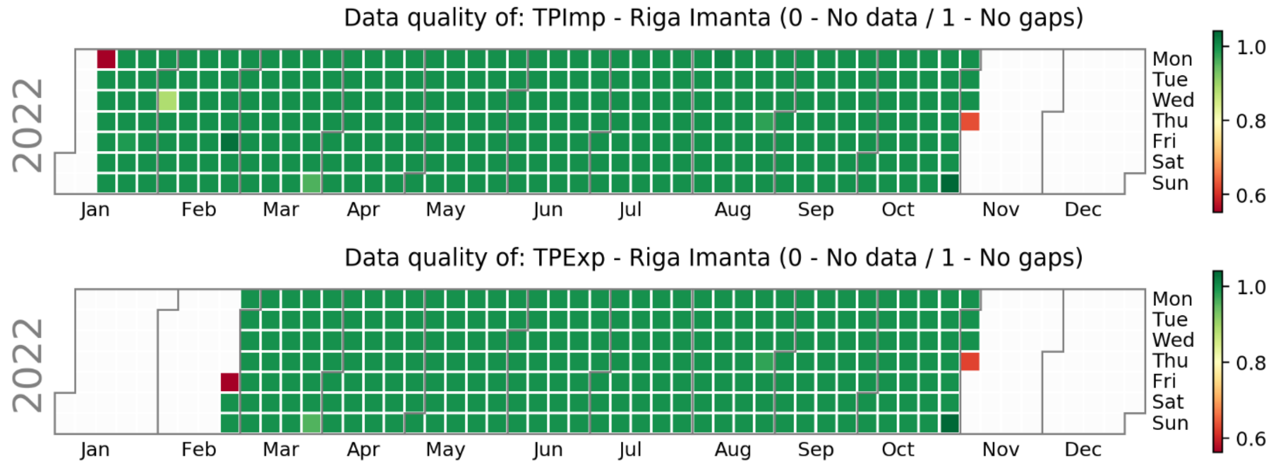


Figure 30: Data quality for TP meter in Imanta

5.4.2 Thermal balance

Space heating is not measured, only DHW is measured.

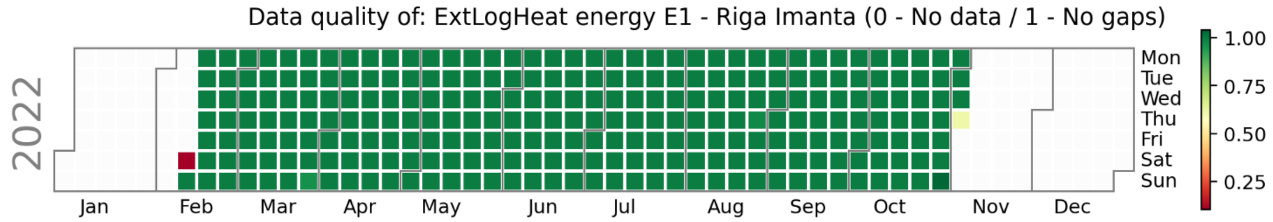


Figure 31: DHW energy meter gaps for Imanta

Table 18: monthly DHW consumption

2022	Oct	Sep	Aug	Jul	Jun	May	Apr	Mar	Feb
DHW Consumption [kWh]	151	217	238	221	218	229	373	238	231

Inconsistencies in the data do not allow to perform the thermal balance. As seen, the thermal energy measured on the production side of the PVT panels does not match the one measured on the glycol side.

The mentioned difference is reported in the figure below, where the error between the two variables is above 50%.

Table 19: Thermal PVT Production vs Glycol Thermal Energy

2022	Oct	Sep	Aug	Jul	Jun	May	Apr	Mar	Feb
Heat PVT [kWh]	0.00	9.00	11.00	28.00	23.00	0.00	0.00	0.00	0.00
Glycol Thermal Energy [kWh]	5.00	11.00	21.00	67.00	60.00	0.00	0.00	0.00	0.00
Error	100%	18%	48%	58%	62%	#¡DIV/0!	#¡DIV/0!	#¡DIV/0!	#¡DIV/0!

Therefore, it will be necessary to properly verify the sensors trying to solve this issue, allowing the collection of reliable data from the demosite.

The same inconsistencies can be observed if the data quality and daily average values are obtained for the PVT meter and glycol meter:

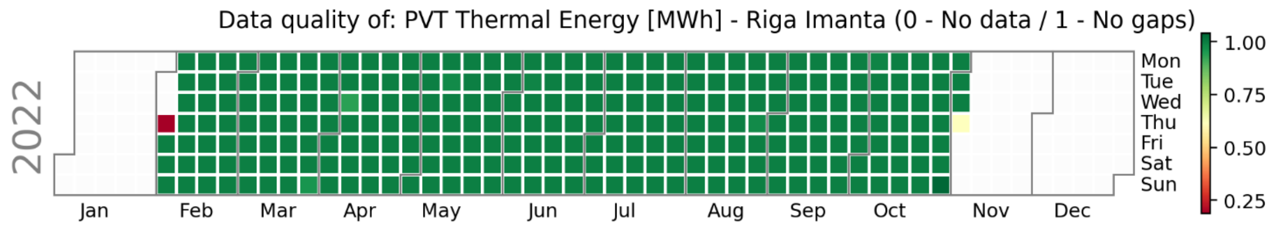


Figure 32: Solar energy meter gaps for Imanta

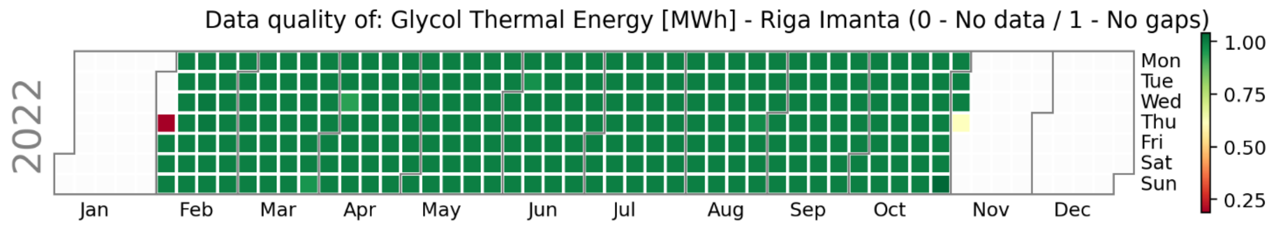


Figure 33: Glycol energy meter gaps for Imanta

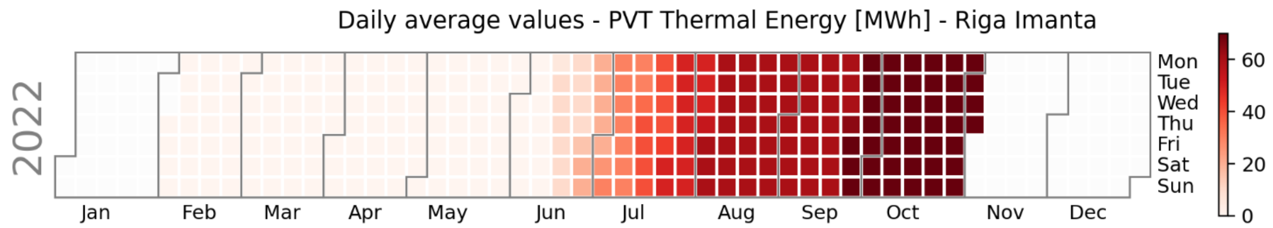


Figure 34: Solar energy daily average values for Imanta

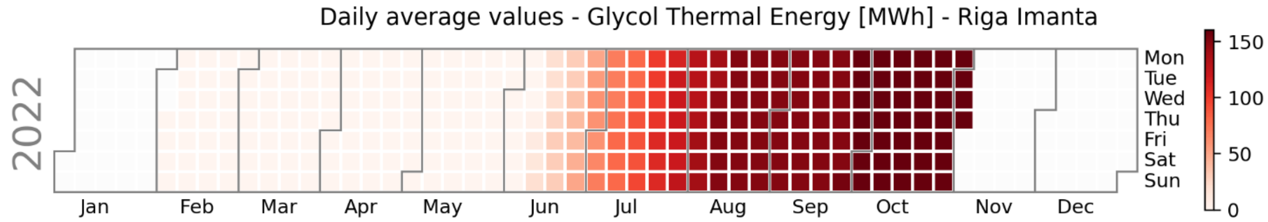


Figure 35: Glycol energy daily average values for Imanta

5.4.3 Gas consumption

To compare 2021 and 2022, a regression is performed to adjust values of 2021 to climatic conditions of 2022 (and create and adjusted reference model of the baseline).

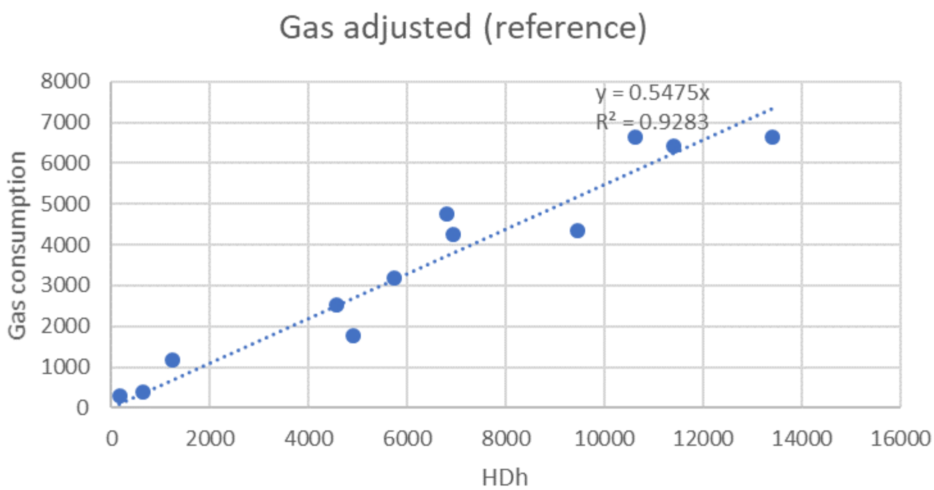


Figure 36: Gas consumption of 2021 compared to heating degree hours to obtain the "gas consumption adjusted reference model"

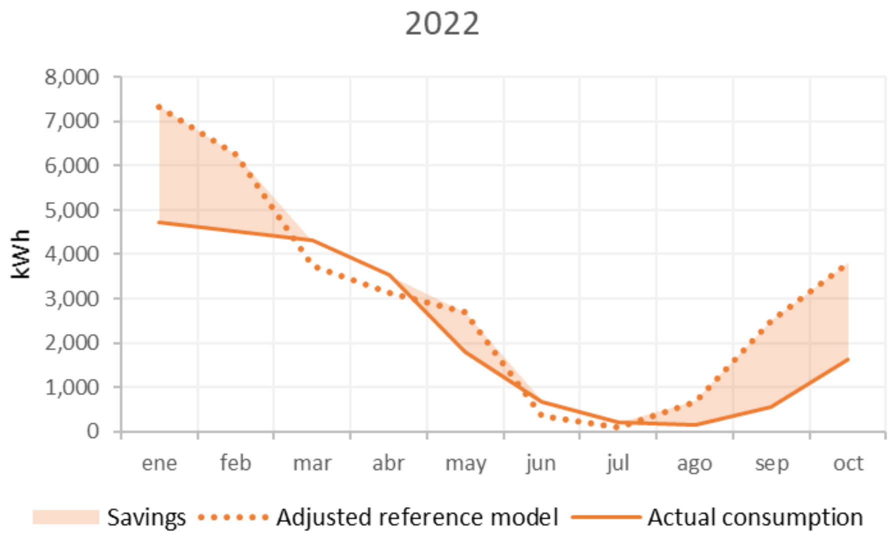


Figure 37: Comparison of actual gas consumption of 2022 with the "gas consumption adjusted reference model"

There are some gas cons. Savings [4383.9 kWh], but the increase of the gas bill (a factor of 2.4 €/kWh more[3]) has caused greater operating costs (excluding monthly fees).

Table 20: Gas consumption comparison (2022 VS adjusted reference model) in terms of energy (kWh) and costs (energy costs €). .

2022	Gas cons. 2022 [kWh]	Gas costs 2022 [€]	Gas cons. [kWh] Adjusted ref. model	Gas costs adj. [€]	Gas savings [kWh]	Gas costs savings [€]
1	4716.0	186.1	7343.8	209.7	2627.8	23.6
2	4508.6	177.9	6253.1	178.5	1744.5	0.6
3	4304.6	169.8	3728.7	106.4	-575.8	-63.4
4	3529.9	139.3	3140.8	89.7	-389.1	-49.6
5	1795.8	137.0	2687.7	76.7	891.8	-60.3
6	676.7	51.6	347.0	9.9	-329.7	-41.7
7	203.5	22.1	92.4	3.7	-111.1	-18.4
8	150.5	16.3	676.0	26.7	525.5	10.4
Total	**19885.6**	**900.2**	**24269.5**	**701.3**	**4383.9**	**-198.9**

Furthermore, potentially the gas savings could be higher if Boostheat could operate in heat pump mode.

[3] From 01/01/21 to 30/06/21 the cost is of 0.0285479€/kWh
From 01/07/21 to 31/12/21 the cost is of 0.03954€/kWh
From 01/01/22 to 30/04/22 the cost is of 0.0394548€/kWh (including state support)
From 01/05/22 to 30/06/22 the cost is of 0.0762993€/kWh
From 01/07/22 to 31/12/22 the cost is of 0.1086184€/kWh (including state support)

6 Riga Sunisi #9

6.1 Status update of the demo site

The tender for TP2 installation (Imanta and Sunisi together) was launched in May 2021, 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 was completed in September 2021, after approval of all technology providers and other involved SunHorizon partners. The installation and commissioning were completed for Sunisi in early April 2022 (M43). All the required physical data connections between different technologies (BH–SE and RATIO–SE) were established in the first half of '22 apart from the last one – RATIO–SE in Sunisi, which was commissioned in Sept '22. SE has confirmed that all the connections are operational and data collection is ongoing.

Since commissioning of the TP2, overall, numerous and frequent demo site visits have been required and carried out by the demo manager (RTU) for troubleshooting (mostly for Boostheat hardware and connection issues, but also for SE (e.g. monitoring issues esp. in Imanta) and RATIO).

6.2 Status update of the monitoring system

The Monitoring architecture was updated including RATIO PLC data and BOOSTheat PLC Data.

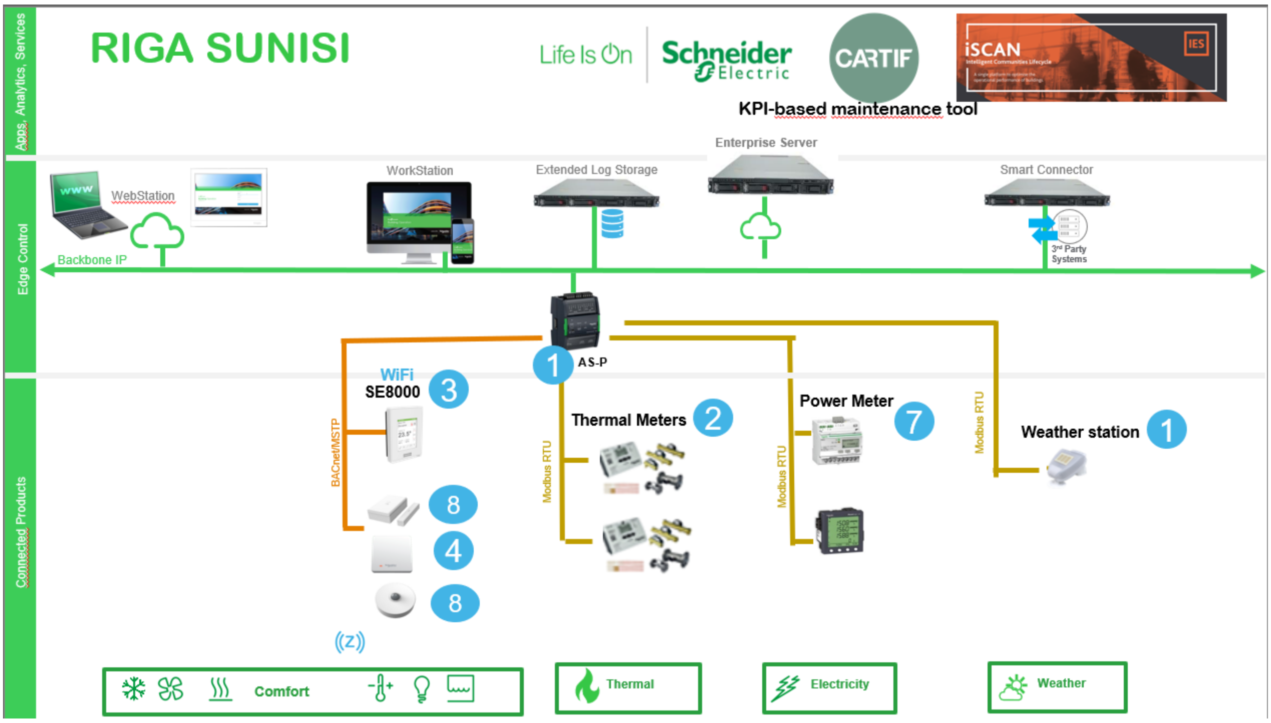


Figure 38: Monitoring architecture (Riga Sunisi)

Based on the electricity meters the electric balance can be done as follows:

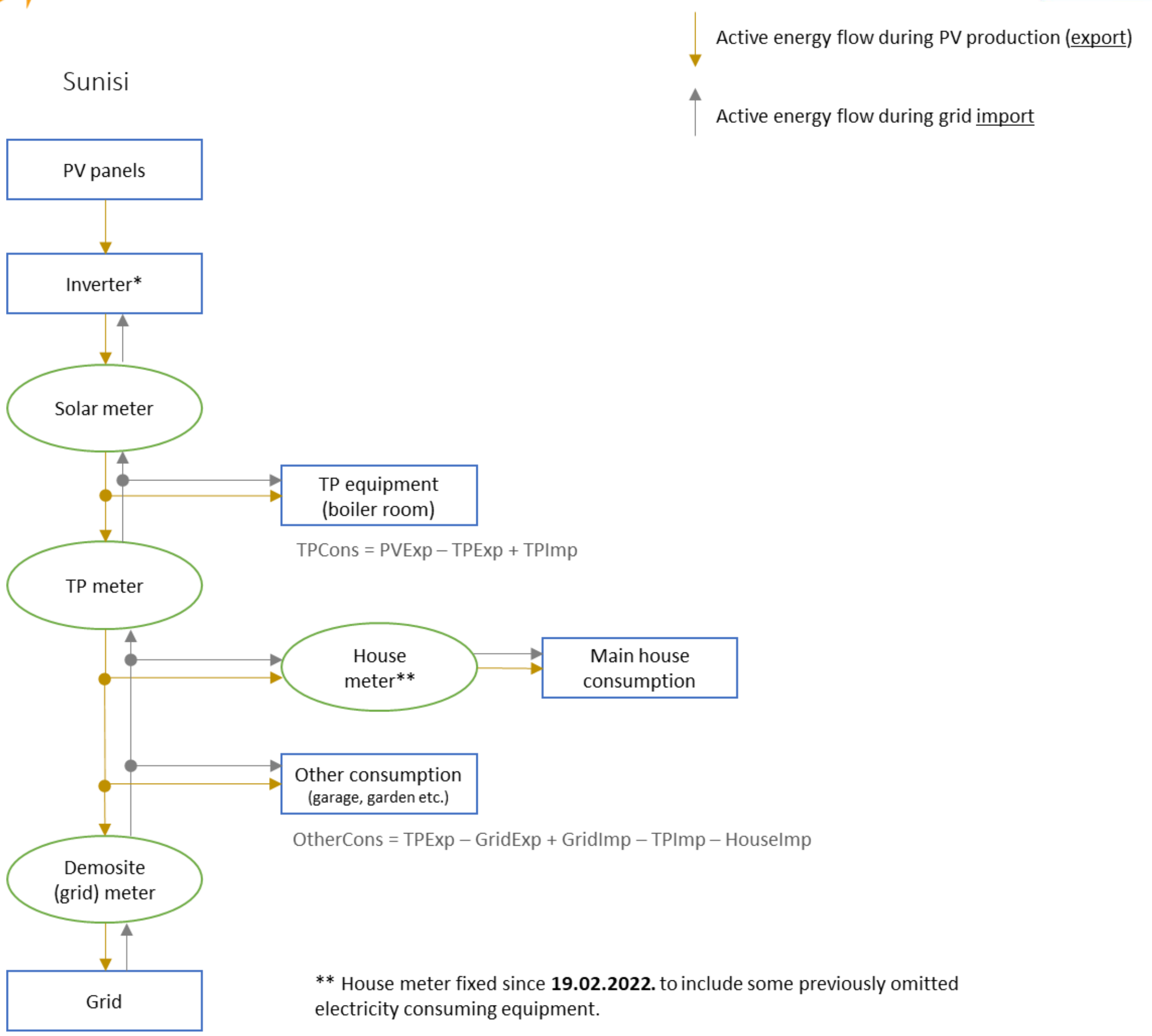


Figure 39: Electricity balance (Riga Sunisi)

Furthermore, for the thermal balance the following variables will be considered:

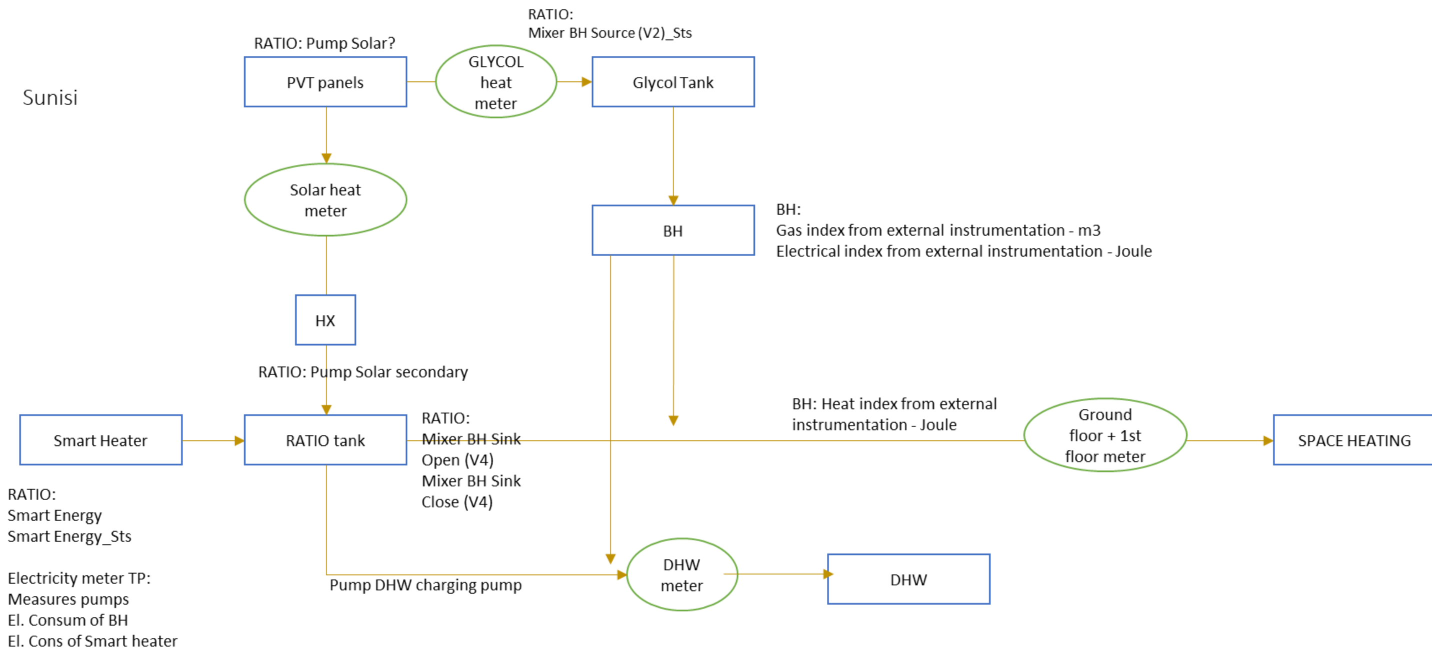


Figure 40: Thermal balance (Riga Sunisi)

Data collection progress and relevant events is shown hereafter.

Table 21: Data collection progress since the beginning (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, RTU replaced the existing internet router with a separate 4G router for monitoring.	A separate internet router was installed also in Imanta.	November 2020
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	n/a

			values from the sensors installed in the specific room should be selected for the display. Since data is collected, this is not a monitoring issue, but the display can be adjusted according to user needs.	
The heat meter for the first floor and ground floor occasionally gives a negative temperature difference between the supply and return flow	September 2021	Negative values need to be set to zero during data pre-processing	n/a (repositioning of the sensors not feasible due to space restrictions because the pipes have been installed very close to each other)	October 2021
Data gaps noticed in iSCAN	Data gaps since mid-2021 discovered in August 2022	New APIs and change of names in variables in SE platform in 14/10/2022	Set alarms that if there is a data gap of more than 24h, it informs the demo group to be able to react more quickly	Solved partially (in progress)
House electricity meter not measuring all the electricity consumption	January 2022	After installation of all the electricity meters and their data analysis, it was found that the pre-monitoring meter has not been including the whole house consumption (wiring issue).	After rewiring, it was verified that the data from all electricity meters is consistent. Additionally, electricity balance is verified during KPI assessment.	Meter connection rewired in February 2022
No data on the flow from two glycol meters	April 2022	After identifying too high concentration of glycol by BH, the heat carrier was diluted in May. The concentration can impact the measurements as the meters are specified for a pre-defined concentration. However, it did not solve the issue with missing flow data.	Some faults in wiring of meter data connection were eventually found. After rewiring, data collection is ongoing. Further validation of data to be performed during KPI assessment.	June 2022
Premonitoring DHW meter not providing correct data since April 2022	June 2022	The issue was not identified at once because on SE portal data of another heat meter was displayed instead. After correcting that, it was concluded that the DHW meter needs to be	DHW meter was relocated to the correct spot. Further validation of data to be performed during KPI assessment.	October 2022

		relocated following the TP2 upgrade since the system configuration had changed and the premonitoring meter was not able to measure the DHW flow anymore.		

6.3 Issues and observations during the operation of the TP

During the first months of operation (April–November 2022) a number of issues, mostly related to Boostheat, were solved or identified:

- Dilution of the glycol heat carrier up to ~57% in May '22 (M44) after BH discovered it was too concentrated (close to 100%)
- Large glycol pressure variations: pressure drops too low for heat pump operation, dropping down to ~0.25 bar
- Refilling of the CO2 refrigerant in the heat pump in Apr '22 (M43): even though the heat pump had not been operating, BH observed continuous small leakage of CO2 (about 0.3 kg/year out of total volume of 4.2 kg). Hence, a local refrigeration engineer, certified to handle the CO2 refrigerant, was subcontracted to refill the CO2 in the heat pump. BH suggested at that time that annual refilling of the CO2 would be necessary and that the recurrent refilling cost would be covered by BH.
- During summer 2022, there were large glycol pressure variations observed: pressure was dropping too low for heat pump operation. While BH heat pump and DS panels are in the same glycol circuit, the required pressure for the heat pump is 1…3 bar (pref. 1.5), but the pressure of PVT panels can drop down to 0 bar (at 0 m height) or H / 10 [bar], max is 1.5 bar. DS explained that these pressure variations are normal for the panels due to the expansion of their polypropylene heat exchanger: the pressure stabilises at the atmospheric pressure after ~ 1 month or so after installation so that the resulting pressure will be just the height between the panels and the pump. BH also suggested checking the expansion tank volume and pressure, which, according to the installer, is fine (40 L / 1.3…1.5 bar). Thus, the only feasible solution is adding a heat exchanger and a circulation pump. BH was not in favour of this solution as it would lower the system's efficiency and suggests changing the volume of the expansion tanks and adapting the inflation pressure correctly.
- Furthermore, the following insights have been obtained observing the monitoring. Similar to imanta, the DHW temperature setting of Boostheat is too high and the option to adjust is has been disabled (was user-selectable previously). The internal DHW tank top temperature is set to 65 °C. However, to save energy, the users would prefer a lower temperature e.g. 50 °C, which would also allow to more rely on the solar heat during the summer. Since the DHW temperature received by BH from the RATIO Oskar tank is usually lower, with this high temperature setting, BH gas boiler is often operating and consuming gas for heating the DHW up to 65 °C even during summer.

Previously, RATIO had devised a specific control strategy for the Smart Energy electric heater to be aligned with the net metering arrangements in Latvia in order to enable "storing" in the grid the surplus electricity from PV production up to the amount of the annual electricity consumption. It was supposed that, with this strategy, the electric heater would only consume that part of PV production which exceeds the annual consumption. However, it turns out that there was an error in the program and the above (rather complicated) strategy was not implemented, so eventually RATIO switched to their standard control rules (as for Germany e.g.). This is cost-inefficient as it does not allow the household to "store" their produced electricity from the summer months to be consumed in the winter. Eventually, the house owner in Sunisi decided to turn off the electric heater at all since ~ July '22 to save electricity for the winter. RATIO is still open to correct the program and adjust it so that it works properly in Latvia. Improvements should be devised based on the actual data analysis from the demo monitoring and RATIO measurements.

During troubleshooting of the BH glycol pressure issue and refilling of glycol in October 2022, the PVT glycol loop was disconnected from the BH unit. Following that, it was found that, with this configuration, the glycol pressure is stable and heat pump is able to operate, albeit without the solar glycol loop. Thus, since end of October until ~12 November the BH heat pump was operating in this mode, however with some faults and not continuously (restarting required after the faults).

BH explained that the faults might be due to small leaks of the CO_2 refrigerant. Nevertheless, only after ~2 weeks of operation the BH heat pump failed permanently. In November 2022 BH informed RTU that the heat pump won't be able to operate anymore (they observed some "blocked motor" error messages, and there was not enough CO_2 refrigerant, which is the same issue as previously found already in Imanta). So, the Boostheat can operate as a condensing boiler only.

Moreover, even operation of the gas boiler has not been error-free and continuous. For example, in Sunisi there were even many faults for the BH unit when trying to turn on the space heating several times in October 2022. Eventually, the machine stopped providing heat during night-time even in the gas boiler mode and displayed many errors. The issues observed so far clearly show that continuous operation of the Boostheat unit even in the gas boiler mode is not feasible if BH limits or discontinues their technical support. It can lead to sudden interruption of the heat supply causing a lot of discomfort to the residents. If the Boostheat unit is not replaced by a reliable alternative heat pump technology, the demo owner in Sunisi will need to revert to their old conventional gas boiler. So TP2 becomes nonoperational and only producing electricity by PVT panels would be possible.

6.4 KPIs summary

6.4.1 Electricity balance

Eight months data is shown in the following table. The period of data starts in February 2022, and finished end of September. Data from October is not included. Data gaps are excluded from the calculation as the iSCAN service to fill the data gaps was not possible. Once iSCAN is totally integrated the KPIs will be re-calculated for this period filling the missing data.

For each month, the electricity balance is calculated as shown in Figure 39. The highest electricity consumption from SunHorizon occurred in the months of May and June, due to RATIO's controller settings that were programmed according to Germany's rules (to increase self-consumption) instead of Latvian rules (export energy and "save" it for winter time). Due to this, the owner switched off the electricity heater during summer, reducing significantly the SunHorizon consumption and, the self-consumption ratio. The electricity consumption of the house is very similar in every month with an average consumption of 338.13 kWh per month. The detail balances of June and September shows that consumption is reduced significantly without electric heater (switched off manually by the owner in July), which reduces the electricity consumption of SunHorizon significantly.

Table 22: Electricity balance results from February 2022 to September 2022. For February 2022 Grid Exported data was not available so the value obtained for the balance is not reliable.

2022	PV production	Grid imported	SunHorizon cons.	Other cons	House cons.	Grid exported	PV self-cons.	Self-cons. Ratio	Gas savings
2	166.7	463.9	25.6	160.1	232.4	-7.8	174.5	104.7%	135.50
3	990.0	316.6	31.1	177.7	386.3	711.4	278.6	28.1%	409.70
4	1146.8	267.9	265.0	51.1	337.1	761.4	385.3	33.6%	454.70
5	1333.1	619.7	496.6	499.5	352.1	**604.6**	**728.5**	**54.6%**	468.30
6	1380.2	464.0	414.5	516.8	363.1	**549.8**	**830.5**	**60.2%**	9.80
7	1345.4	368.6	110.3	395.5	385.3	**822.9**	522.5	38.8%	68.10
8	1251.5	273.0	32.3	207.3	334.6	950.5	301.0	24.1%	18.70
9	844.0	237.6	38.2	63.6	317.0	662.8	181.2	21.5%	not meas.
10	393.2	334.602	72.184	89.015	304.334	262.247	130.931	33%	not meas.

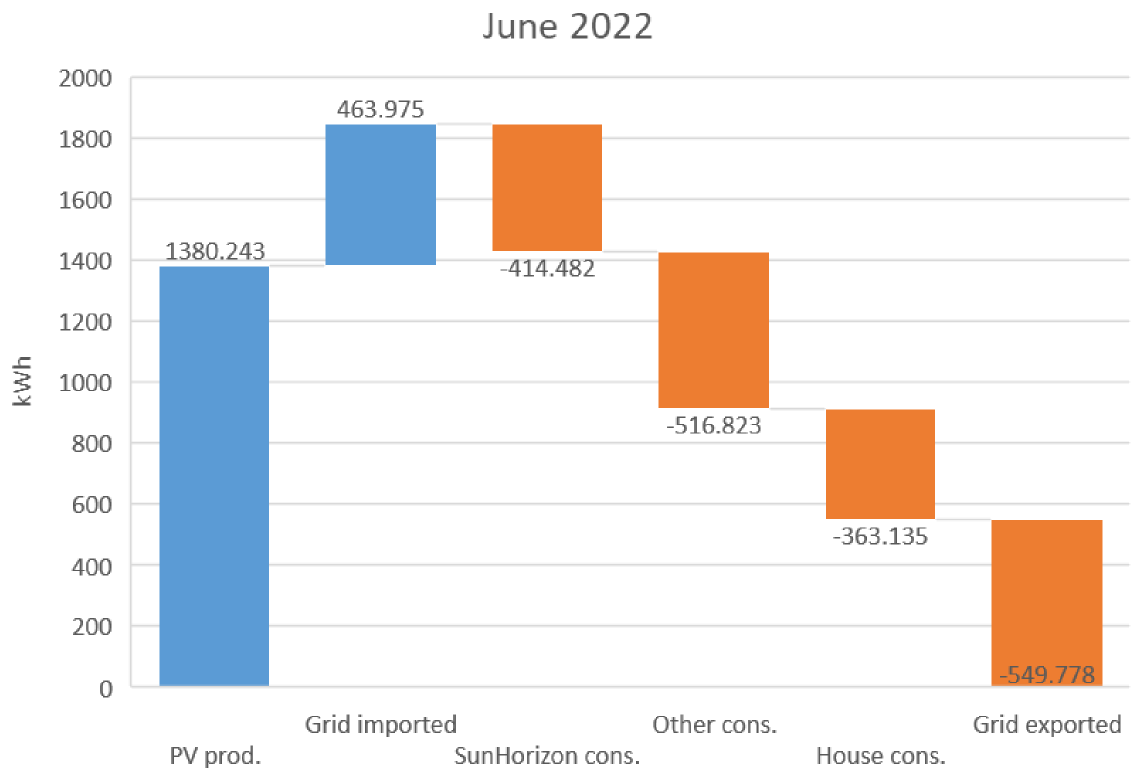


Figure 41: Electricity Balance June

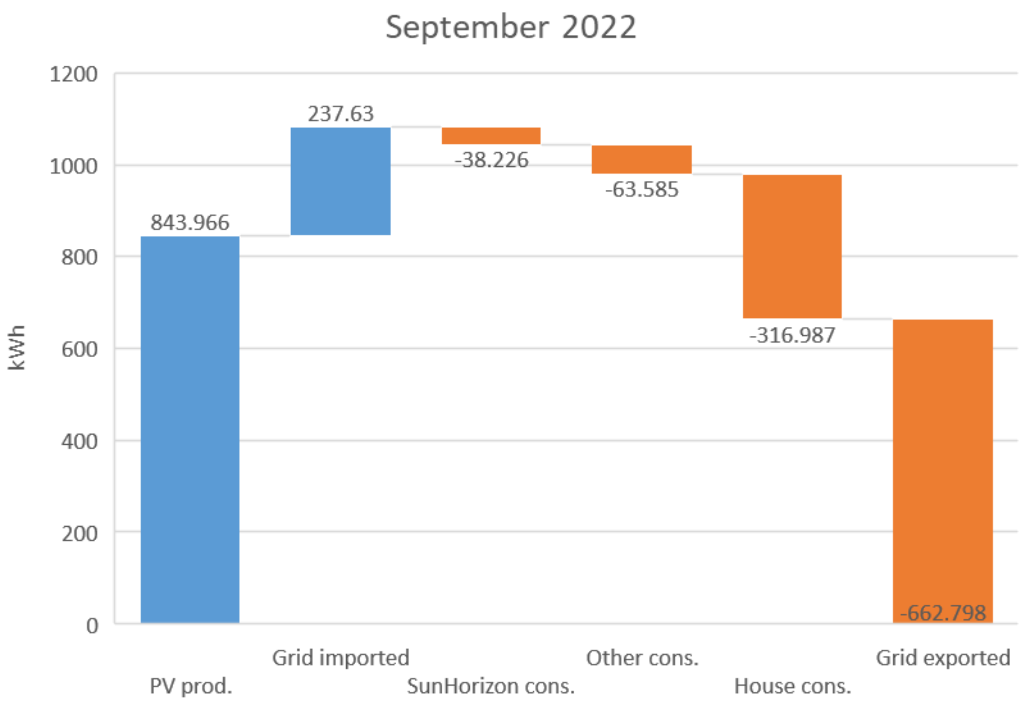


Figure 42: Electricity Balance September

The variable Smart Energy (in volts) provided by Ratiotherm PLC showed that there is consumption until end of June. From July 2022 and henceforth Smart Energy signal variable for Sunisi should not be used because even though the control signal is provided, the heater has been turned off manually with a switch and does not consume any electricity.

If the solar electric efficiency is calculated for the PVT panel, the result is as follows:

2022	2	3	4	5	6	7	8	9	10	11
PV prod.	166.7	990.0	1146.8	1333.1	1380.2	1345.4	1251.5	844.0	393.2	49.2
Solar eff.	12%	24%	18%	16%	16%	17%	18%	20%	25%	23%

Figure 43: Electricity Balance June

The PVT solar efficiency ranges from 12 to 24% which is within the expected range (nominal efficiency 19%).

6.4.2 Thermal balance

Some inconsistencies have been found when doing the thermal balance. DHW meter measures zero during a lot of months (March to Sept 2022). This was confirmed with the demo site leader and it seems the meter stopped collecting data when TP2 was commissioned (within March).

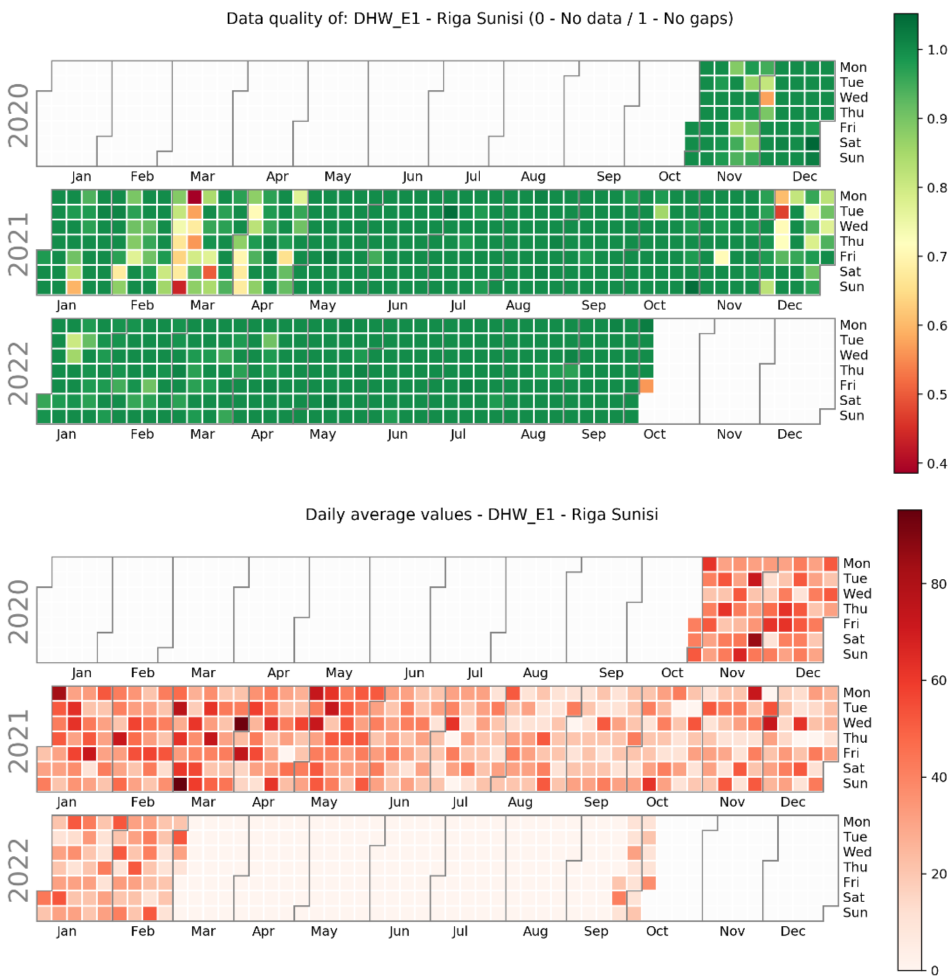


Figure 44: Data quality (0=red no data, 1= no gaps), and average daily values of DHW meter (energy; kWh)

If DHW daily energy of 2022 is compared with the daily energy 2021, there is consumption during the whole year.

For the space heating it can be seen that there is similar consumption in 2021 and 2022. The grounfloor in 2022 shows higher consumption during the months of March and April compared to the same months in 2021. This can be explained if weather temperatures are checked, which shows lower average temperatures during March and April of 2022 compared to the ones in 2021.

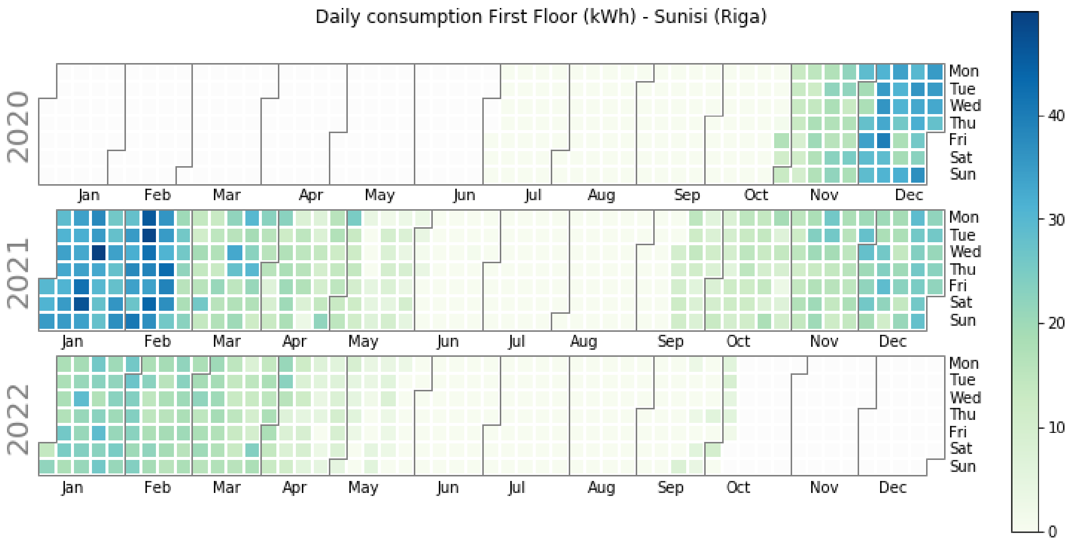


Figure 45. First floor daily energy in Sunisi

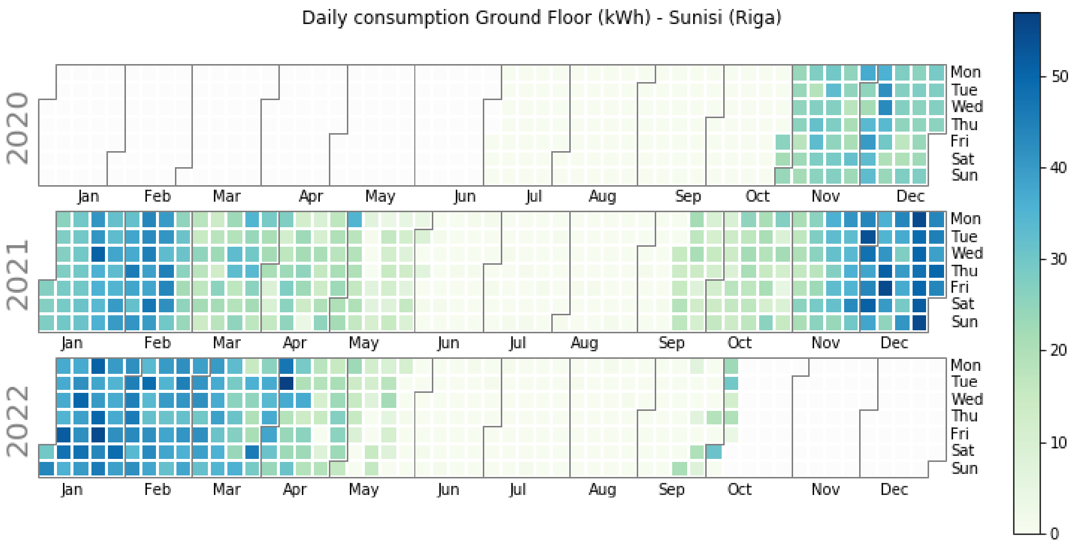
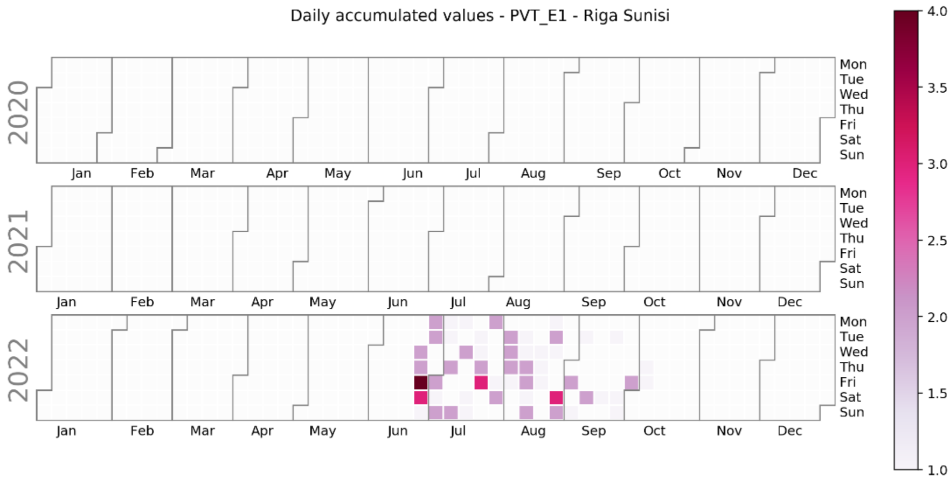


Figure 46. Ground floor daily energy in Sunisi

Regarding the meters of the solar field, there is a mistmatch between the PVT production and how much is stored from the PVT thermal production in the glycol tank (PVT thermal production≠glycol thermal meter; glycol > 0 when PVT is 0).



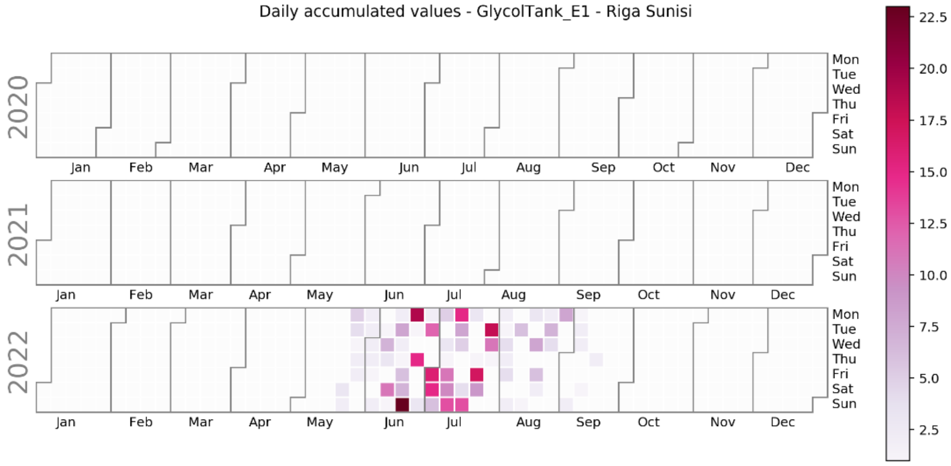


Figure 47: Mismatch of data in Glycol tank and PVT

If the overall thermal balance is assessed, considering the gas consumption from the bills to calculate the thermal production of BH (by the time of writing the deliverable the Boostheat variables were missing more most of the months) by assuming a 96% performance efficiency, the value of thermal production does not match with the total consumption (space heating + dhw meters). Also, in this balance it can be seen that the DHW consumption is too low. During May the electric heater was switched off, so the groundfloor and first floor thermal consumption should not be coming only from Boostheat (and the gas consumption is too high to be coming from both: Boostheat and the electric heater).

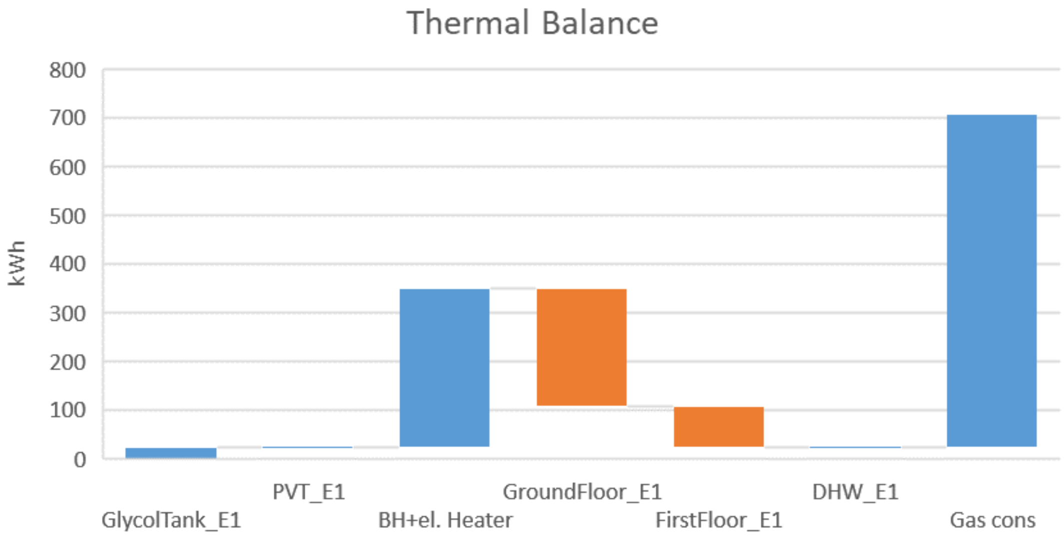


Figure 48: Thermal balance for May 2022.

These inconsistencies cause that the performance of the technologies cannot be calculated for the period of assessment.

Besides that, weather data is being collected since November 2020. The variation of outdoor temperatures can be seen in Figure 49 specially in August, where higher temperatures are reached in 2022 compared to 2021.

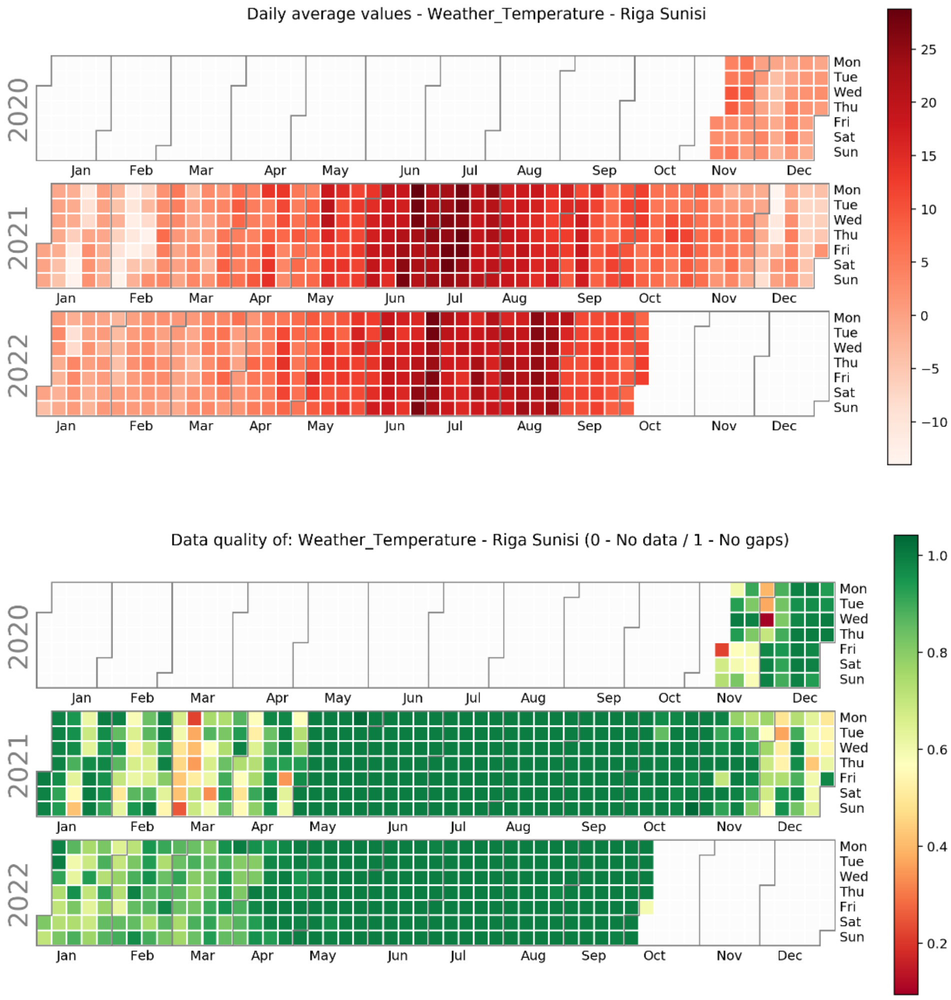


Figure 49: Outdoor temperature in Riga Sunisi

6.4.3 Gas consumption

To compare 2021 and 2022, a regression is performed to adjust values of 2021 to climatic conditions of 2022 (and create and adjusted reference model of the baseline).

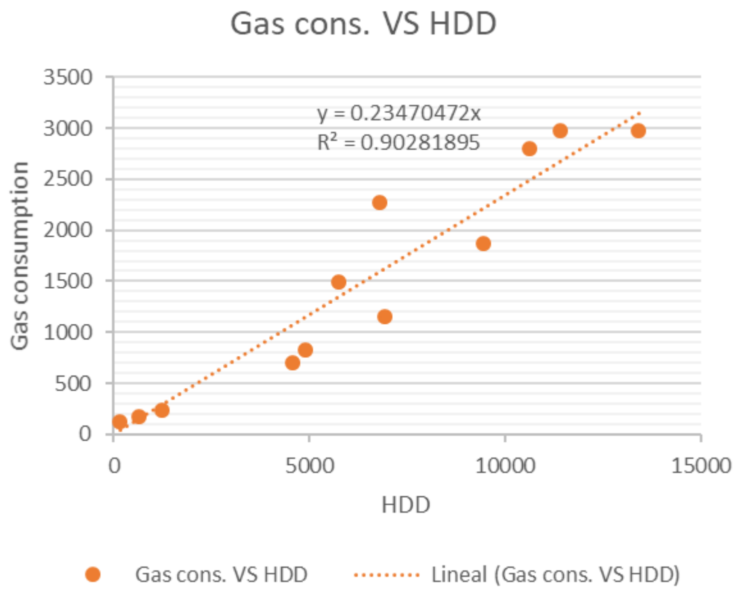


Figure 50: Gas consumption of 2021 compared to heating degree hours to obtain the "gas consumption adjusted reference model"

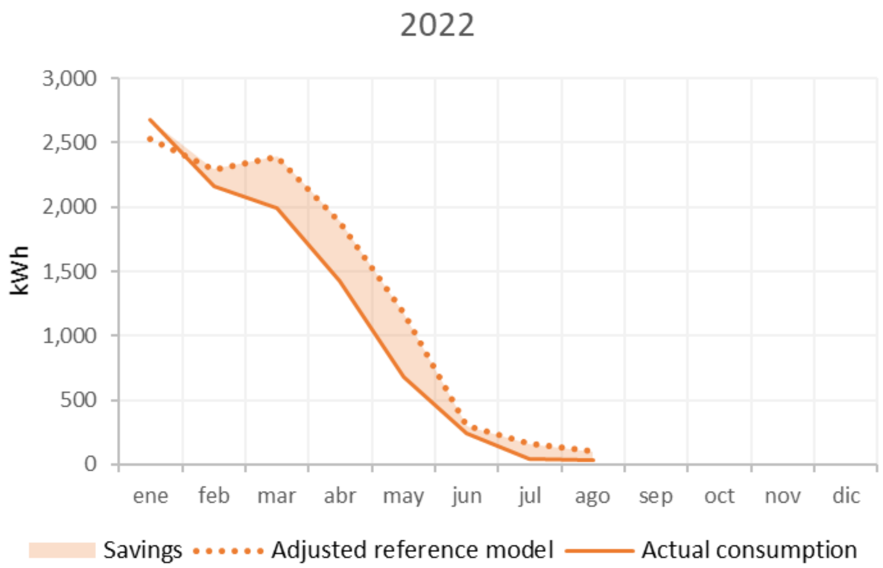


Figure 51: Comparison of actual gas consumption of 2022 with the "gas consumption adjusted reference model"

There are some gas cons. Savings [1564.7 kWh], but the increase of the gas bill (a factor of 2.4 €/kWh more[4]) has caused greater operating costs (excluding monthly fees).

[4] From 01/01/21 to 30/06/21 the cost is of 0.0285479€/kWh
From 01/07/21 to 31/12/21 the cost is of 0.03954€/kWh
From 01/01/22 to 30/04/22 the cost is of 0.0394548€/kWh (including state support)
From 01/05/22 to 30/06/22 the cost is of 0.0762993€/kWh
From 01/07/22 to 31/12/22 the cost is of 0.1086184€/kWh (including state support)

	Gas cons. 2022 [kWh]	Gas costs 2022 [€]	Gas cons. [kWh] Adjusted ref. model	Gas costs adj. [€]	Gas savings [kWh]	Gas costs savings [€]
2	2160.3	85.2	2295.8	65.4	135.5	-19.8
3	1991.7	78.6	2401.4	68.3	409.7	-10.2
4	1422.6	56.1	1877.3	53.8	454.7	-2.4
5	685.0	52.3	1153.2	33.6	468.3	-18.6
6	242.4	18.5	252.2	8.5	9.8	-9.9
7	42.2	4.6	110.2	6.4	68.1	1.8
8	31.6	3.4	50.3	4.1	18.7	0.6
Total	6575.7	298.7	8140.4	240.1	1564.7	-58.6

Table 23: Gas consumption comparison (2022 VS adjusted reference model) in terms of energy (kWh) and costs (energy costs €).

Furthermore, potentially the gas savings could be higher if Boostheat could operate in heat pump mode.

6.4.4 Heating comfort index

The HCI is calculated for 2022 in Sunisi. Some discomfort can be found in the months of June and October, probably due to cold spells, but the value of the indicator is anyway low (around 0.1 to 1ºC·15min). This happens specially in the bathroom.

Some hours of discomfort can be found from 8am to 10 pm in the bedrooms. But again, the value of the indicator is low.

Furthermore, June and October should not be considered as relevant as they are not part of the "heating season".

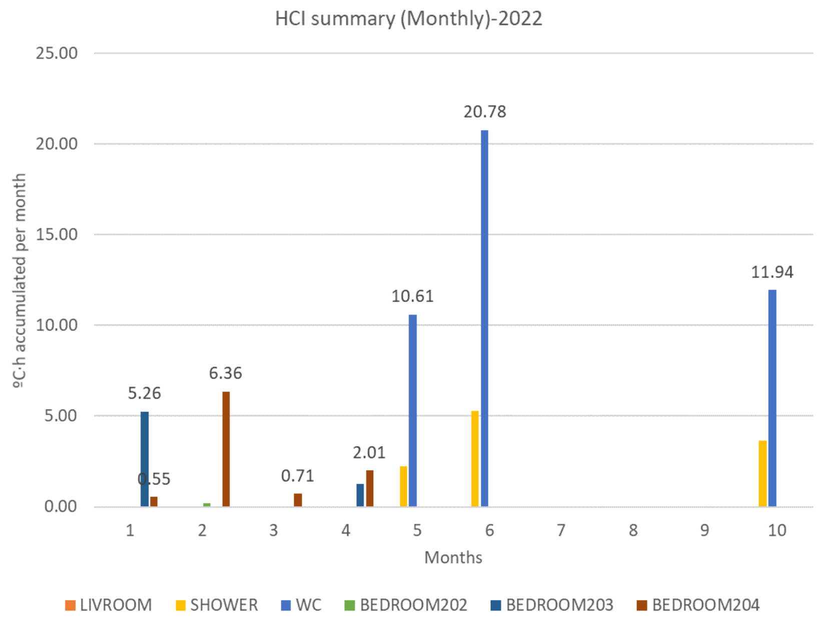


Figure 52: HCI for each room and per month

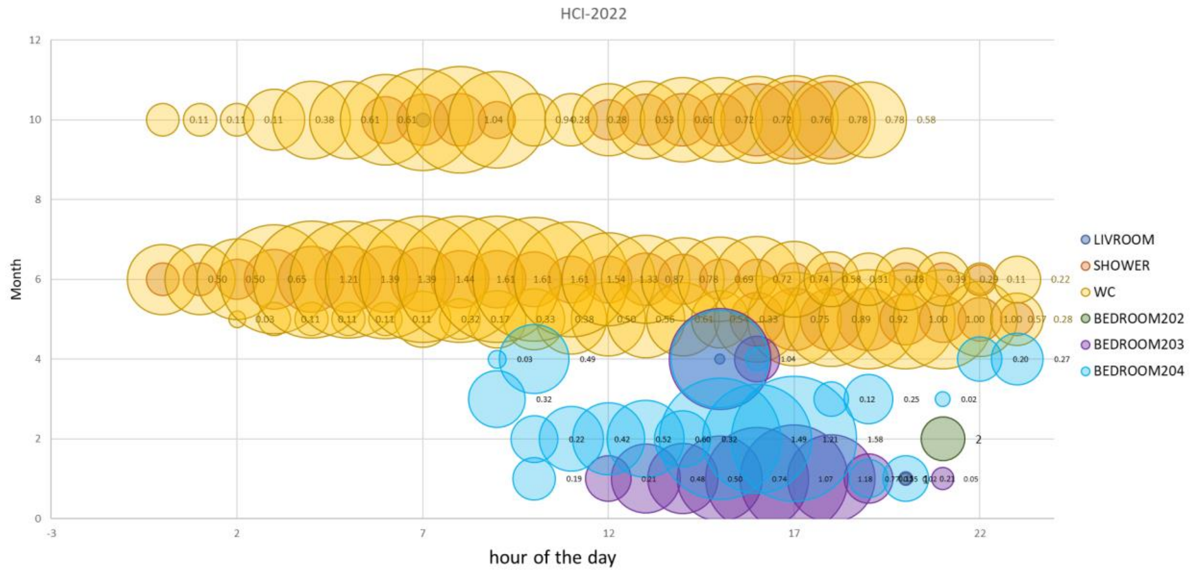


Figure 53: HCI for each room and month and depending on the hour of the day.

7 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 have been delayed for various reasons, only 4 demo sites (which have commissioned the TP) are being reported in the present document.

D6.4 methodology was supposed to be followed, but at the time of writing this deliverable the iSCAN integration of data was not performed (Due to a loss of data and change of APIs in Schneider platform). Also, the iDashboard of IES was not elaborated for the demo sites.

Thus, simulation supporting partners (CNR, CARTIF and RINA) have performed manually the KPIs for Sant Cugat, Madrid, Riga Sunisi and Riga Imanta. Inconsistencies on the data obtained have been highlighted, and not all KPIs (e.g. primary energy consumption) have been possible to calculate due to lack of data and the inconsistencies. In general, the comfort KPIs are being met. The electricity balance shows promising results for Riga Sunisi, whereas the thermal balance needs to be improved (Boostheat has not operated as heat pump in the whole period) to achieve gas savings objectives. In Madrid the comfort has being met, but the KPIs were not possible to calculate them due to lack of connection of the electricity and heat meters.

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								