Climate and cultural-based design and market valuable technology solutions for Plus Energy Houses

Decision Tracking Report

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1	31/03/2023	Quentin Lamour (Vilogia)	Creation of the final version

Disclaimer:

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Executive summary

The CULTURAL-E project aims to define modular and replicable solutions for Plus Energy Buildings (PEBs), accounting for climate and cultural differences, to create comfortable, efficient, and affordable indoor environments. CULTURAL-E develops specific technologies and tailored solution sets suitable for different climatic and cultural contexts, which are tested in four demonstration cases (France, Germany, Italy and Norway)

The present report compiles the information gathered in the Decision Tracking Tool (DTT) by the demo owners and technical advisors along the design journey. The DTT intended to keep track of the process and decisions related to building design and integration of the Cultural-E technologies (Active window - Smart air ventilation system; Decentralised packed heat pump system; Ceiling fan - smart air movement; Cloud-based House Management System) and market-available products for building envelope, energy production, RES technologies, and storage. The information collected in the report is also available in the Excel files attached.

The report provides information for technology developers to improve their products and adapt them to their target market's cultural and climatic contexts. The information about design, installation, exploitation and maintenance processes gathered during the decision process reveals the needs and expectations of potential clients in these contexts and markets.

Moreover, the report exposes the final solution sets selected for each demo. It reveals the decision processes behind these choices, allowing the partners of the Cultural-E project and the PEB developers to better understand the cultural and climatic factors influencing the solution sets and to define suitable sets for each context.

Table of contents

List of figures

List of tables

1 Introduction

The CULTURAL-E project aims to define modular and replicable solutions for Plus Energy Buildings (PEBs), accounting for climate and cultural differences, to create comfortable, efficient, and affordable indoor environments. CULTURAL-E develops specific technologies and tailored solution sets suitable for different climatic and cultural contexts, which are tested in four demonstration cases:

1) The French demo site is in Leers in the Lille Metropolitan Area, close to the Belgian border, in a peri-urban area by the Roubaix canal, where the climate is warm and temperate. Vilogia, a private social housing company, will build and manage a 19-dwelling PEB demonstrator and a reference nZEB building.
2) The German project is located in Ostfildern in the peri-urban area of Stuttgart, with a warm and temperate climate. The company, Wohnbaustudio, will sell or rent 21 dwellings and one commercial unit.
3) The Italian demonstration building is in Castenaso near Bologna, in a rural setting close to parks and nature. The location has a humid temperate climate with hot and humid summers and cold and wet winters. The demo includes two similar residential buildings with 13 dwellings for sale by Abitcoop (a private cooperative).
4) Finally, the Norwegian site in Baerum, 11km outside Oslo city centre. The climate is subarctic; the winters are not extremely cold, and summer temperatures are fair. The building with 12 dwellings and common areas is part of the Bærum "Assisted living and welfare technology" program; the municipality financed the construction with dwellings for sale or rent. The building is managed round-the-clock by onsite staff. The construction period for the building was nearly finished as the Cultural-E project started.

The decision tracking tool aimed to support the Cultural-E Project partners towards a Participative Concept Process perspective. It kept track of the design and construction decision process for the definition and implementation of Cultural-E solution sets for Plus Energy Buildings (PEBs), including the Cultural-E developed technologies (Active window - Smart air ventilation system; Decentralised packed heat pump system; Ceiling fan - smart air movement; Cloud-based House Management System) and market available products for building envelope, energy production, RES technologies, and storage.

Most design-related decisions for implemented technologies were already made for the Norwegian demo. The focus for this demo has been on the House Management System and possible Model Predictive Control (MPC) implementations. Control of performance, correction of malfunctions, improvements, installation of complimentary sensors and meters for better operation and preparations for MPC have been in focus for the decisions.

Information and technical data about the buildings, the adopted strategies and the technologies were systematically organised and continuously updated during the project development in the DTT. They are compiled in the present report. The information collected in the report is also available in the Excel files attached.

The report aims to provide information for technology developers to improve their products and adapt them to the cultural and climatic contexts of the market they want to enter. The information gathered during the decision process reveals the needs and expectations of potential clients in these contexts and markets.

Moreover, the report exposes the final solution sets selected for each demo. It reveals the decision processes behind these choices, allowing the partners of the Cultural-E project and the PEB developers, in general, to better understand the cultural and climatic factors influencing the solution sets and to define suitable sets for each context.

2 Leers, France - Vilogia

2.1 Description of the demonstration site

2.1.1 General information

The demo case selected for the Oceanic climate is in Leers (France), in the Lille Metropolitan Area, close to the Belgian border. The property stands at an altitude of approx. 20m above sea level, in a peri-urban area, by the Roubaix canal. The climate is classified as warm and temperate. The annual average temperature in Leers is around 11 ° C. The annual rainfall is around 763 mm.

The demo owner is Vilogia, a private social housing company. Four similar buildings will be constructed on the property, next to three existing buildings and single-family houses. Building A is targeted to be the Cultural-E PEB demonstrator. Building B, with a very similar design, is planned as an nZEB building (Passivhaus label) and will be monitored to be used as a reference for comparison during the operational phase. The units in both buildings will remain the property of Vilogia and be rented as social housing. The two additional buildings (C and D) will be standard constructions (following the current RE2020 French construction legislation), and the units are intended to be sold.

Cultural-E demonstrator – Building A

- 19 appartements
- 4 floors
- Balcony
- Total living space: 1110m²
- 9 x T2 appartments (≈48m²)
- 10 x T3 appartements (≈67m²)
- Roof area 280m²

FIGURE 1 - OVERALL PLAN OF PROJECT

FIGURE 2 - PHOTO-RENDERING OF THE CULTURAL-E BUILDING

2.1.2 Reduction of energy demand

The Cultural-E demo building is designed as a passive building, focusing on the quality of the envelope and maximising the use of passive heating sources (sun, users, equipment). Therefore, the quality of the external thermal insulation and the air tightness is the central concept for the envelope conception. It will be scrutinised during the works (verification of the quality of the materials and correct installation, tests of air tightness). An active Window System with triple-glazing will be provided by the partner Eurofinestra enabling active control of the shadings to maximise the solar gains during winter and minimise them during summer. A smart all-in-one system gathering heat pump, ventilation with heat recovery and DHW will also contribute to reducing the energy demand; one unit per apartment will be installed.

Finally, the cloud-based House Management System (HMS) provided by the partner Advanticsys, coupled with a monitoring network, will reduce the energy demand, thanks to the coordination of the different systems and the exploitation of energy flexibility potential, as well as interacting with the user to foster virtuous behaviours.

2.1.3 Energy production

The objective is to reach the PEB target by producing more energy than consumed and considering: heating, DHW, lighting and ventilation; domestic consumption is not considered (electrical plug loads). Energy is produced thanks to PV panels installed on the roof. As the building is noticeably compact, PV panels will also be installed on the Passivhaus neighbour building, allowing sufficient production to reach the PEB target.

Self-consumption is foreseen in the common parts of the building; the surplus of energy production will be sold to the grid.

An e-vehicle charging station will be installed; nevertheless, the associated consumption will not count in the energy balance considered for the PEB assessment.

2.1.4 Solution sets

The envelope design minimises the energy needs of the five regulatory consumption items linked to French thermal regulations: heating, cooling, domestic hot water, lighting and auxiliaries (fans/pumps). The following systems are sized and installed in the pilot building to ensure comfort for the occupants:

- A multi-service decentralised heat pump that provides:
  - Heating via fan convectors in the rooms
  - Domestic hot water
  - Ventilation with heat recovery (double flow)
  - Cooling (passive via ventilation)

  The combined system is a commercial product, the Compact P unit by Nilan.

- Active Window System with triple-glazed windows and external Venetian blinds (Brand: Hella; model: Exterior Venetian blind AF80+) to control solar gain. The windows are produced and supplied by Eurofinestra, a partner of Cultural-E. The triple-glazed window model installed on the French demonstration site has neither mechanical ventilation nor trickle vents since the multi-service decentralised heat pump unit provides ventilation.

- The cloud-based HMS will manage and control the house systems (if desired by the occupant, who can derogate), record data related to the quality of the indoor environment and provide feedback to the occupants. The HMS acts as a central brain for controlling Indoor Environmental Quality (IEQ), considering user practices and coordinating the set of technologies to ensure the best indoor conditions and minimise energy consumption and CO_{2eq} emissions.

- Energy-efficient lighting equipment

- A 43kWp photovoltaic field, with a gross surface area of panels of around 215 m², is installed on the demonstration building's roof and the neighbouring building.

- Charging stations for electric vehicles (at least two expected)

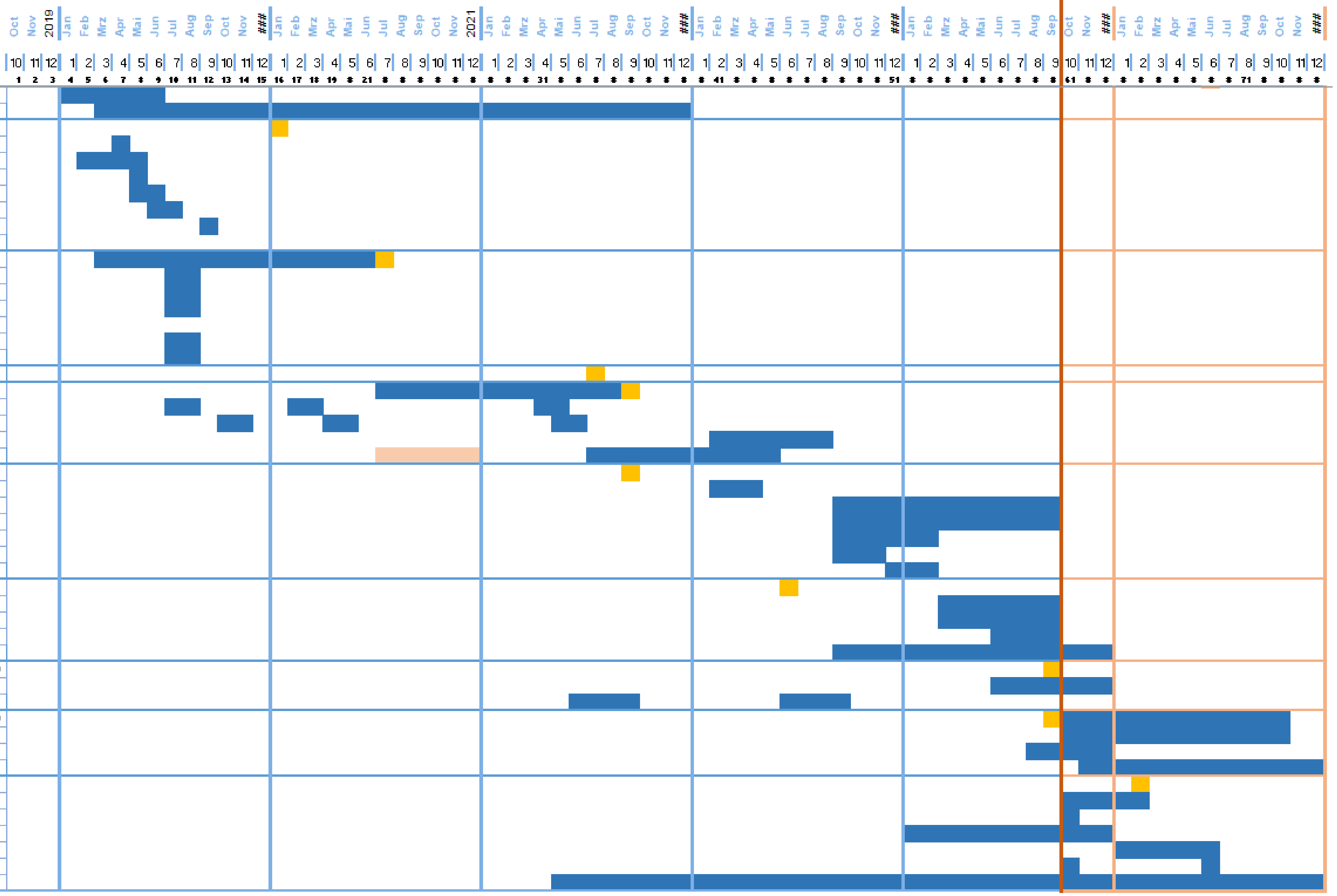
2.2 Project timeline

Last update
06/02/2023
Quentin LAMOUR, Vilogia

All Demo cases

Gantt_Main activities

		Milestones
1	Expression of project needs in Cultural-E	
2	Acquisition of Cultural-E technologies specification sheets from techno providers	
10	Establishment od LDWG following the Guidelines	MS2-**M3**
11	Internal kick-off meeting	
12	Cultural-E project concept (new project or revision of previous standard version)	
13	Sharing of 2D/3D drawings (first version)	
14	First dimensioning of PV plants by Eurac	
15	First scenarios of use of the Cultural-E technologies	
16	Consensus workshop	
17	Co-design and active engagement	
20	Preliminary Project	MS3-**M34**
21	Adaping the existing preliminary project to PEH and integrating selected technos	
22	Dimensioning of PV plants and storage by Eurac	
23	Dimensioning of heat pump and storage (with support by technology provider and Eurac)	
24	Configuration of celing fan plant (with support by technology provider and Eurac)	
25	Configuration of active window (with support by technology provider and Eurac)	
26	Configuration of HMS (with support by technology provider and Eurac)	
30	Preliminary Agreement on solution-set for the demo to launch the tenders	MS9-**M34**
40	Detailed design of the Demo	MS7-**M36**
41	Energy simulation by the design team	
42	Energy simulation by the Project advisor	
43	Executive project (arch., mech., electr., etc.)	
44	Authorizations by Local Authorities (building permit)	
50	Starting of Procurement process (only for performance-based tenders)	MS4-**M36**
51	Procurement for the works (Call for tender, analysis, negociation, and designation)	
52	Works of demo building	
53	Works of reference building (PassivHaus building)	
54	Construction of structure and walls	
55	Verification of the technical executive drawings from the Cultural-e technology providers	
56	Supply of Cultural-E technologies in area of DC building (with certifications, instruction, etc.)	
60	Planning of Commissioning	MS11-**M45**
61	Installation of Cultural-E technologies	
61	Installation of market available products (e.g. PV)	
61	Installation of monitoring system	
61	Commissioning	
70	End of Costruction works and Commissioning, production of the "As built" Design	MS13-**M60**
71	(where necessary) Adjustment/debugging of the installed technologies	
72	LCC and environmental assessment	
80	Start of the monitoring of demo building	MS14-**M60**
81	Monitoring of reference building	
82	Building labelling	
83	POE (survey: interviews, ..)	
90	Reporting of democase performance	MS16-**M65**
91	Production of User Manual by the Demo Owner	
92	Interviews with designers	
93	Production of Demo case video	
94	Production of Vademecum by ACE	
95	Organization of 2 open events for project visibility	
96	Internal and external communication	



2.3 Technologies

2.3.1 Active Window System (AWS) – Eurofinestra

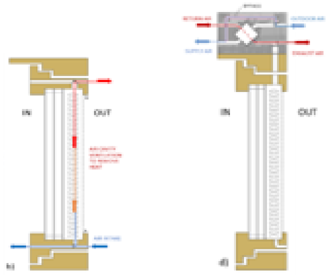
The Eurofinestra Active Window System is a multifunctional window system that enhances energy efficiency, indoor air quality and user comfort. Since trickle vents and mechanical ventilation could interfere with the functioning of the mechanical ventilation of the dwelling, the French team chose to install a simple version of the AWS, with (i) triple-glazing, (ii) a modular wood frame system, easily adaptable to different climates and design selections, and (iii) an adaptive shading system.

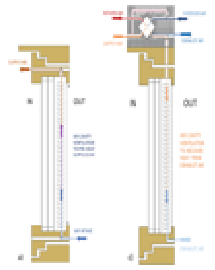
The **window block** comprises an insulating frame of extruded polystyrene and timber reinforcement. It is designed to allocate the window with integrated exterior Venitian blinds Hella AF80. The motor of the blinds is controlled directly by the occupant or the Building Management system, thanks to the algorithms developed within the Cultural-E project.

The table below describes the decision process for this equipment.

All Demo cases

Active window - Smart air ventilation system





Objective

Triple-glazed windows in the 19 apartments. Wooden frame. Durability. Easy maintenance.

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
15/06/2020	Define the options to be adopted on the windows (active system, trickle vents, shades).	Evaluate the interaction between the AWS and the mechanical ventilation (Ventive)	10/03/2020	Bilateral meeting and consensus workshop: No trickle vents, no active mechanical ventilation, only automatic shades
20/01/2021	all windows will be those of EUROFINESTRA (except the entrance hall), option without ticklevent and internal store	(Vilogia) final quantities and dimensions to be noticed to EUROFINESTRA	01/02/2021	done on 19/03/21
20/01/2021	List of test to be communicated to the control office	EUROFIN sent the list of test	01/01/2021	done
		Communicate list to the control office		done.
20/01/2021	Guide for installation	EUROFIN write a guide before going to tenders	mid 2021	received on Dec 2022
	2_Concept design			
25/03/2021	Architectural integration	Send Statigraphy to EF	Feb 21	done on 19/03/21
		EF send an architectural detail that was communicated to the design team for integration	16/04/2021	done
	3_Detailed design			
29/08/2022	Architectural integration - Wooden support installed by Vilogia - Power cable for the blinds engine should arrive in the upper part, on right or left, both are possible	VIL will confirm : - the thickness of the insulation layer - the lateral cladding of the windows - the dimensions of the windows (final list) EF must send the last U values	01/09/2022	done
16/11/2022	Need for anti-intrusion glass on the ground floor, as asked by the environmental certification body	EF will provide the technical specifications for the glass layers. Saint Gobain is the glass provider.	13/12/2022	Info received on 13/12/2022. The glass conforms to the requirements
08/12/2022	Information on the air-tightness materials and flat angle brackets. Will EF provide those?	EF send the technical characteristics of the elements	13/12/2022	EF doesn't provide flat angle brackets or air-tightness membranes. They must be included in the tenders.
	4_Manufacturing of the selected product			
22/02/2022	EF needs for information on the construction dates to prepare the manufacturing schedule	VIL provides a time line of the project	11/03/2022	done

2.3.2 Packed Heat Pump (PHP) – Ventive

Ventive has developed a compact unit integrating mechanical ventilation, a hydronic circuit for space heating and domestic hot water, and thermal storage with Phase Changing Material (PCM) into one system.

As the Ventive technology was in development, the design was constantly changing. At the beginning of the process, Ventive adapted the product to the demo owner's needs, showing interest in taking advantage of the project. Nevertheless, after this first stage of development, the demo owner needed to have a fixed design and precise information to integrate the PHP into the building design. Moreover, at the detailed design stage of the Vilogia building, the Ventive apartment PHP unit was too high to fit between the floor and ceiling slabs.
The demo owner decided to install a market-available system with comparable features. The Nilan Compact P was chosen (Figure 3). The technical characteristics will be as follows:

- Heat recovery efficiency certified by the IHP > 80%.
- Fan efficiency < 0.40 Wh/m3
- EC fans with constant airflow control
- F7 filtration on fresh air
- M5 filtration on return air
- Internal and external leakage ratio < 3%.
- Automatic summer bypass
- Frost protection by a battery connected to the heat pump
- Heating COP at +7°C outside ≥ 3.58 measured according to PHI certification
- DHW COP at +7°C outside ≥ 3.10 measured according to PHI certification
- DHW tank volume: 180 L
- Magnesium anode
- 1500W electric DHW booster heater
- R134a refrigerant
- Remote TFT control screen
- Integrated energy metering: ventilation, heating, DHW, cooling
- Data transmission and remote consultation
- Remote monitoring of machines via a dedicated application

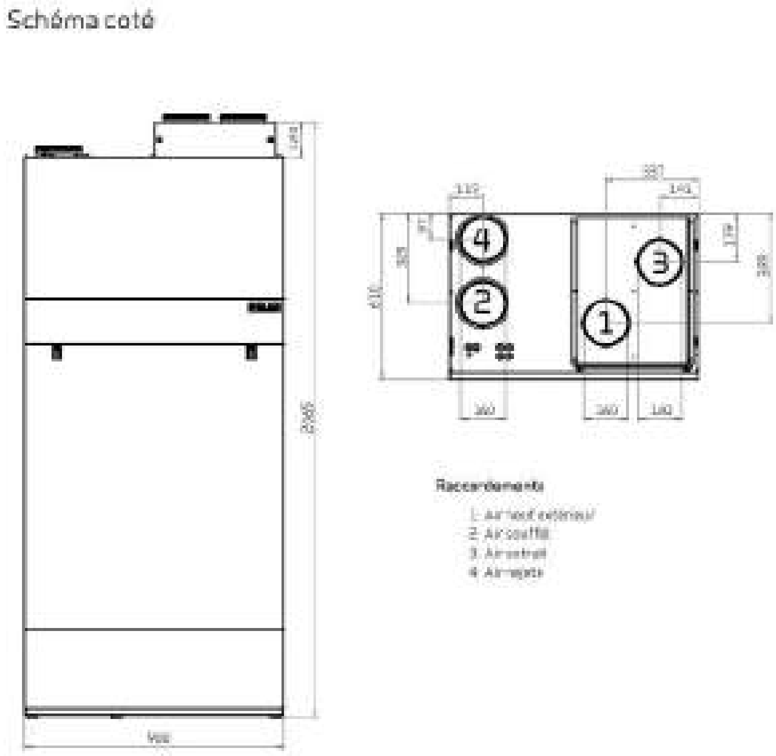


FIGURE 3 - TECHNICAL DRAWING OF THE NILAN COMPACT P

The heat pump uses the residual energy not recovered by the countercurrent exchanger to heat the supply air. The supply air temperature is increased to the desired level by means of an electric heating coil. The electric heating coil is designed for installation in the supply air duct, with the necessary sensors already in place. The heating of each coil will be regulated by the Nilan system control screen, which should be located in the living room.

Electric heating coil from Nilan or technically equivalent: D160, P = 1.2 kW.

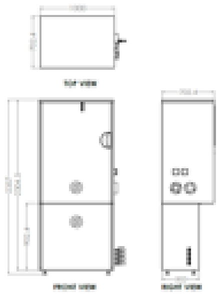
Comfort heating in the bathrooms with an Atoll SPA towel warmer with 500W round tubes from ACOVA or technically equivalent, certified NF Electricité Performance 2 stars (or Old NF Electricité Performance Mark category C or equivalent), with electronic thermostats ensuring at least the 6 orders: Comfort, Comfort -1°C, Comfort -2°C, Eco, Frost protection, Off.

For the dwellings located on the ground floor, which are more loss-making, the power of the heating coil could prove insufficient in the event of extreme cold. We, therefore, plan to use an Emotion 3 electric radiant panel from Thermor or a technically equivalent panel certified to NF Electricité Performance 2 stars (or the former NF Electricité Performance category C mark or equivalent), with electronic thermostats providing at least the following 6 settings: Comfort, Comfort -1°C, Comfort -2°C, Eco, Frost protection, Off.

The table below describes the decision process for this equipment.

All Demo cases

Decentralized Pack Heat Pump System



Objective

1 PHP / appartment to provide heating, hot water and air renewal

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
10/09/2020	Consensus Workshop The mechanical ventilation is assured by the PHP unit; any ventilation in the windows	Ventive will provide info on: - Performance - connexion to the external wall (impact on façade) - the height of the unit - access for maintenance	28/10/2020 Before 3rd GEAS	done
	2_Concept design			
05/10/2020	Define the location of the PHP : inside or outside. The design team recommends installing the PHP inside the apartments	Check the consequences of installing the PHP inside the apartments		
09/12/2021	List of test to be comunicated to control office	VENTIVE provide a list of test to be performed at Eurac	22/01/2021	done
		Send list to control office	22/01/2021	done. The control office asks for a functioning notice
		VENTIVE provide a functioning notice and flow-chart	22/01/2021	done. Tranferred to CO
	3D drawings	VENTIVE provide drawings (3D)	22/01/2021	done. Received on 19/03/21
	Agreement Ventive/Vilogia	VENTIVE will provide a draft of the agreement with Vilogia to set: - what happens after the end of the project - the responsibilities of each part - what happens in case of failure - Maintenance services	22/01/2021	Never received
		VENTIVE update the performance matrix	22/01/2021	done. Received on 19/03/21
18/03/2022	Sythesis document on technical info	VENTIVE will provide a single document gathering the info on: - geometry, weight, materials, space for maintenance and installation - list of components - Hydraulic scheme - operation flow-chart - consumption - performances - embedded CO2 - noise levels	28/03/2022	Never received. The information is released piece by piece, in several emails
	It was decided the Ventive PHP won't be installed on the French demo of Leers. A solution with equivalent features available on the market will be selected (Nilan)	Find a new pilot to be found to install one PHP in a house	July 2022	The PHP wouldn't fit because of the ceiling height. The design is constantly changing difficulting architectural integration.

2.3.3 Ceiling Fan for smart air movement – Vortice

Moving air through ceiling fans can be an effective way to provide comfortable cooling in warm environments, able to complement and/or replace the use of active cooling systems. The smart ceiling fan automatically adapts its rotational speed based on the temperature and relative humidity values measured in the room. Moreover, the ceiling fan learns from occupant's control preferences and coordinates its action with cooling and ventilation systems for an energy-efficient, comfortable and healthy indoor environment.

In France, the ceiling height is usually 2.5m. The minimum height to install the smart ceiling fan would be 2.7m, which would have strong financial consequences for the project. Moreover, the total height of the building was strongly constrained by the local urbanism rules, limiting the distance between slabs. Consequently, the design team decided not to install the system.

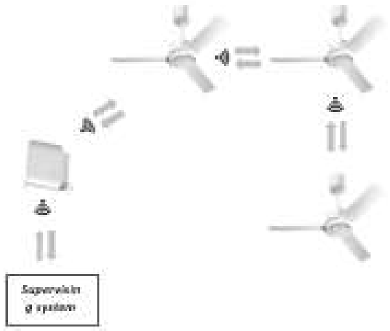
The table below describes the decision process for this equipment.

Not being installed

All Demo cases

VORTICE

Ceiling fan - smart air movement



Objective

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
16/06/2020	Discussion on technology requirements Vilogia listed questions to integrate the technology : - Minimum ceiling height? - Fixation system Vortice provided answers - minimum hight : 2,7m - The fans must be fixed on the concrete slab	Vortice will provide the technical drawings and information, as well as the user manual	26/06/2020	Done
10/09/2020	Consensus Workshop The maximum ceiling height is 2,5m. Increasing this height would have strong financial consequences for the project. Therefore, the technology won't be installed on the Leers project			

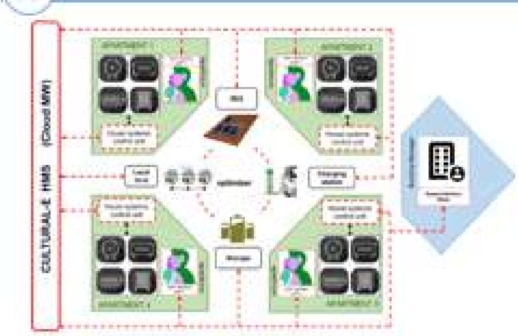
2.3.4 Cloud Base House Management System (HMS) – AdvanticSys

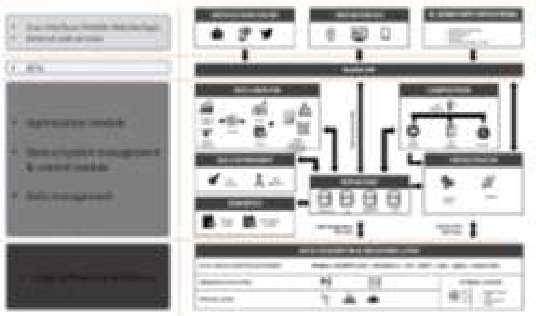
The Cloud Base House Management System (HMS) combines indoor and outdoor sensors data, RES production, common electric or thermal storages and web services to minimise and optimise energy consumption. Based on a distributed cloud infrastructure, it implements the logics to operate the different systems. The HMS behaves as a typical building management system at the apartment level with extended capabilities at the cloud level, such as advanced control strategies that run in real-time. Additionally, a user interface is developed to communicate information to all users (tenants, facility managers, building owners, etc.).

The table below describes the decision process for this equipment.

All Demo cases

Cloud-based House Magagement System





Objective

Define the architecture of a system allowing the monitoring of the building and the control of the equipment. Define the user interface and the information to be displayed to the user.

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
	2_Concept design			
30/09/2020	Definition of the space of the equipment The space occupied by the equipment depends on the type and quantity of the installed sensors and controllers	VIL/NBK must define the services and the list of sensors to be installed, and translate this into a system architecture		
	VIL held an internal workshop to define the needs related to the Monitoring system and the functionalities of the HMS.			
	Objectives of the HMS: 1) Monitor the building's performance 2) Interact with the building's technologies 3) Display information to the user			
05/01/2021	- VIL needs a system operable after Cultural-E - The occupation of he dwellings cannot be monitored (too intrusive) - The user must have The choice to run The system in automatic or manual mode			
	VIL will hire a consultant to assist VIL in 1) the definition of the monitoring system and the architecture of the HMS, 2) the implementation of the system	VIL will produce the tendering documents, will call for tenders and will select the company	May 2021 Before building permit request	Done. First tender on April 21. Delay in the building permit. 2nd and Final tender on April 22
	3_Detailed design			
Semester 2 of 22	The consultant translates the needs of Vilogia and of the Cultural-E project in a tentative system architecture	Check if this architecture is compatible with the HMS designed by AdSys	01/09/2022	Meeting with AdSys and the consultant on 31/08/22

2.3.5 Monitoring System

The Monitoring system comprises all the sensors and meters installed in the buildings (PEB and reference nZEB); it collects the data from the equipment, the dwellings and the common areas needed to feed the HMS.

Monitoring equipment in the dwellings

All 19 dwellings will be instrumented in the main room, bedroom n°1 and bedroom nº2 with:

Main room:
- A control screen showing temperature, air quality, CO2 & VOC information, control of all roller shutters, electrical consumption, hygrometry, pressure and luminosity;
- 1 sensor for temperature, CO2, hygrometry, pressure;
- 1 air quality sensor;
- Slat blind drivers with wired motors only for KNX control (4-wire: common + up + down + yellow/green earth protection)

Room 1:
- GALLERY switch 2 KNX buttons busts (1 per roller shutter);
- Sensors for temperature, CO2, hygrometry, pressure and presence;
- 1 air quality sensor;
- Slat blind drivers with wired motors only for KNX control (4wire: common + up + down + yellow/green earth protection)

Room 2:
- GALLERY switch 2 KNX buttons busts (1 per roller shutter);
- Sensors for temperature, CO2, hygrometry, pressure;
- 1 air quality measurement sensor;
- Slat blind drivers with wired motors only for KNX control (4 wires: common + up + down + yellow/green earth protection)

Technical shaft in the dwelling :
- 4 electrical counters
  - TIC Linky
  - Sockets
  - Others
  - 1 meter for backup electric battery (PAC NILAN control)
- 1 domestic cold water meter (EFS)
- 1 domestic hot water meter (DHW)
- Smartphone application in CLOUD mode (see with ADSYS).

FIGURE 4 - DESCRIPTION OF THE MONITORING SYSTEM IN THE DWELLINGS

<u>Monitoring equipment in the commons</u>

<u>Technical shaft for general services</u>

- 3 Electricity meters
  - ICT Linky
  - Sockets
- Others

<u>Technical shaft for Lifts</u>

- 1 ICT meter

<u>Technical shaft for Parking and outside</u>

- 3 electrical meters
  - TIC Linky
  - Sockets
  - Lighting

<u>Panel EVCI (Electric vehicle charging infrastructure)</u>

- 3 Electricity meters
  - Phase 1
  - Phase 2
  - Phase 3

<u>1st EVCI terminal</u>

- 1 meter
  - ICT Linky KNX radio

Façade

- 1 weather station

Lift pump

- Pump fault
- Maintenance alert

Weather station

- GPS position
- GPS time
- Multi facades
- Horizontal solar irradiation
- Temperature
- Humidity

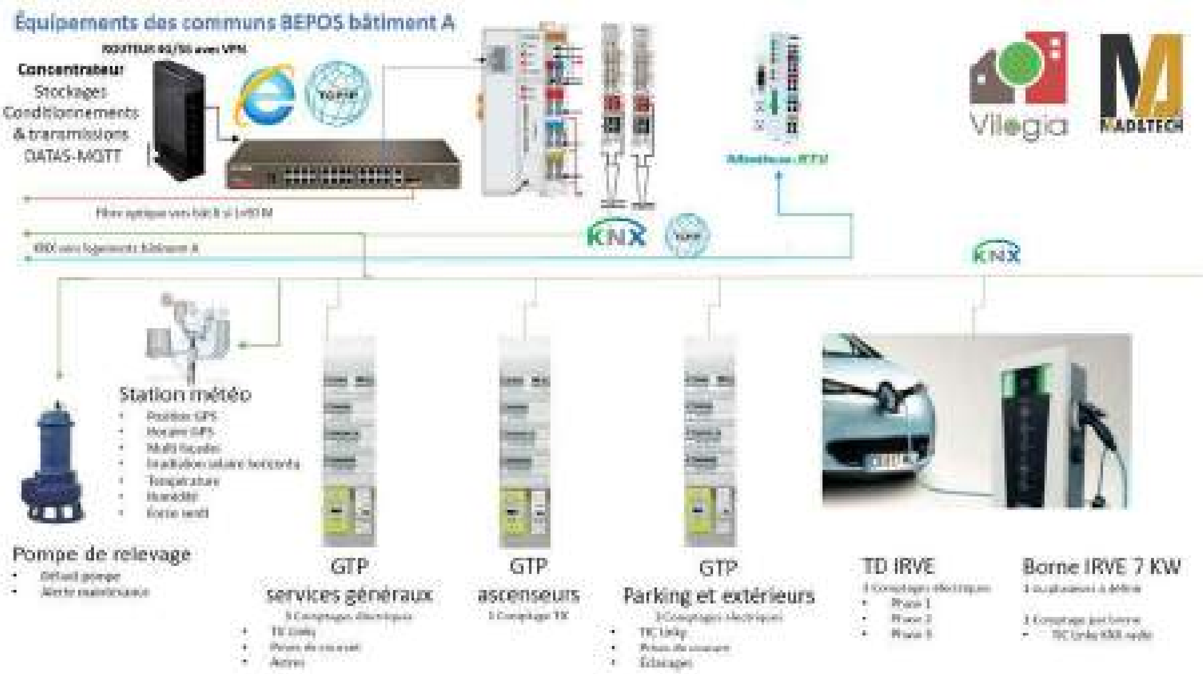


FIGURE 5 - DESCRIPTION OF THE MONITORING SYSTEM IN THE COMMON AREAS

The table below describes the decision process for this system.

Monitoring system

der

Objective

Define and install the monitoring system that will collect the data from the dwellings to feed the HMS and command the technologies

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
05/01/2021	Define the needs in terms of monitoring. VILOGIA organised internal discussions		Feb 21	Done
	Objectives of the monitoring system: 1) record and send data on the building's performance to the HMS 2) Allow the interaction between the HMS and the building's technologies			
	- VIL needs a system operable after Cultural-E - The occupation of the dwellings cannot be monitored (too intrusive) - The user must have the choice to run the system in automatic or manual mode			
	VIL will hire a consultant to assist VIL in 1) the definition of the monitoring system and the architecture of the HMS, 2) the implementation of the system	VIL will produce the tendering documents, will call for tenders and will select the company	May 2021 Before building permit request	Done. First tender on April 21. Delay in the building permit. 2nd and Final tender on April 22
26/01/2021	Define the architecture of the system	AdSys must provide a draft architecture of the system	Feb21	Done
	2_Concept design			
25/03/2021	Define the list of sensors needed for monitoring.	EURAC provides a basic list of sensors	April 21	Done
		VIL/NBK complete the list	May 21	Done A tentative list of sensors and their location in the building was produced
March 21	First tender to hire a consultant to assist VIL in 1) the definition of the monitoring system and the architecture of the HMS, 2) the implementation of the system		April 21	Tender delayed because of building permit issues
March 22	2nd tender		April 22	Company selected
	3_Detailed design			
Semester 2 of 22	The consultant translates the needs of Vilogia and of the Cultural-E project in a tentative system architecture	Check if this architecture is compatible with the HMS designed by AdSys	01/09/2022	Meeting with AdSys and the consultant on 31/08/22
		Check the compatibility with the design team project	Dec 22	done
16/09/2022	Meeting with industrials of monitoring systems to define if we can use a proprietary solution for the monitoring (cheaper) The proprietary solutions are not open and don't allow to fully implement the Cultrual-E objectives (in particular, to control the shading blinds on the windows). A KNX system will be more appropriate, although more expensive.			
10/01/2023	The consultant provided a final architecture of the monitoring system	Final check by the design team	13/01/2023	Architecture included in the tendering documents
09/02/2023	The consultant provided a final list of sensors and a detailed costing	Final check by the design team	10/02/2023	Ready to launch the tenders

2.3.6 PV and electric storage

The photovoltaic panels and associated electric systems are installed to cover the energy needs of the building, according to the PEB definition used by the demo site owner. Electric storage enables flexibility.

The French building complies with this new RE2020 thermal regulation that came into force on January 1, 2022 and incorporates the carbon impact. The RE2020 compliance verification is done based on an evaluation by the regulatory calculation engine, which imposes typical input data (scenarios) according to the type of building and a specific weather file.

The assumptions considered are given in the following table:

	REGULATION BASED INPUTS
Geometry	Exact geometry
Site (other building's impact)	Consideration of neighbouring buildings (mask)
Weather file	Weather file for the corresponding thermal zone (city of Trappes)
Walls stratigraphy and performance	Data corresponding to the final design
Windows and characteristics	Data corresponding to the final design
Solar shading	Basic control (scenarios)
Thermal bridges	Thermal bridges considered in the French RE2020 regulation
Infiltrations	Q4 = 0.55 m3/h.m²
Internal gains **(occupants' heat, lighting, and other hardware)**	Occupation 24/7 (unoccupied 2 weeks in August and one in December) Typical day : 0h - 10h / 18h – 0h Wednesday : 0h - 10h / 14h – 0h Week-end : 24h 0.02 pers/m²
Internal temperature setpoints	19 °C if occupied 16°C rest of the time
Airflow renewal	Dual flux ventilation (80% heat recovery). Power = 40W for fans Flow rate = 60 m3/h

TABLE 1- INPUTS FOR THE FRENCH THERMAL REGULATION (RE2020) SIMULATION ENGINE

The results of the regulatory study are as follows:

	Final energy		Primary energy
	MWh/y	kWh/(m²*y)	kWh/(m²*y)
heating	4,2	3,8	8,7
DHW	8,8	8	18.4
cooling	-	-	-
lighting	2	1,8	4,1
Auxiliary (pump+ventilation)	6,1	5,5	12,7
sum	21	19,1	43,9
User plug loads	27,5	25	57,5
PV-system generation	27,4	24,9	57,3
Balance without user	6,4	5,8	13,3
Balance with user	-21,1	-19,2	-44,2

TABLE 2 - EXPECTED PERFORMANCE FOR THE FRENCH DEMO

The compactness of the building and the architectural constraints related to the local urban plan do not allow the installation of solar panels on the facade. Thus, **part of the PV production is located in the neighbour building**. The solar panels that will be installed on the Leers demo site are MAXEON 3 (or technically equivalent, depending on the tenders) (Figure 6).

MAXEON 3 PUISSANCE : 390 à 400 W | RENDEMENT : jusqu'à 22,6%

Caractéristiques électriques			
	SPR-MAX3-400	SPR-MAX3-395	SPR-MAX3-390
Puissance nominale (Pnom) [2]	400 W	395 W	390 W
Tolérance (module)	+5/0%	+5/0%	+5/0%
Rendement (module)	22,6%	22,3%	22,1%
Tension à puissance maximale (Vmpp)	65,8 V	65,4 V	65,0 V
Courant à puissance maximale (Impp)	6,08 A	6,04 A	6,00 A
Tension en circuit ouvert (Voc) (+/−3)	75,6 V	75,4 V	75,3 V
Courant de court-circuit (Isc) (+/−3)	6,58 A	6,57 A	6,56 A
Tension maximale du système		1000 V IEC	
Calibre des fusibles série		20 A	
Coef. Temp. Puissance (Pmpp)		−0,27% / °C	
Coef. Temp. Tension (Voc)		−0,236% / °C	
Coef. Temp. Courant (Isc)		0,058% / °C	

Garanties, certifications et conformité	
Tests Standards [3]	IEC 61215, IEC 61730
Certification Qualité management	ISO 9001:2015, ISO 14001:2015
Test à l'ammoniaque	IEC 62716
Test au sable	IEC 60068-2-68, MIL-STD-810G
Test aux environnements salins	IEC 61701 (Sévérité maximum)
Test PID	1000 V : IEC 62804
Autres Tests	TUV
Écolabellisation Declare (ILFI)	Premier panneau solaire labellisé pour sa transparence quant aux matériaux et sa conformité aux normes LBC [4]
Cradle to Cradle Certified™ niveau Bronze	Première gamme de panneaux solaires à avoir été certifiée pour l'innocuité et la réutilisation de ses matériaux, la consommation d'énergie renouvelable, la gestion du carbone, l'utilisation de l'eau et l'équité sociale [5]
Contribution à la certification Green Building	Panneaux permettant l'obtention de points supplémentaires aux fins de l'obtention des certifications LEED et BREEAM
Conforme aux règles HSE	RoHS, OHSAS 18001:2007, sans plomb, recyclage au PV Cycle, REACH SVHC-163

Conditions de test et caractéristiques mécaniques	
Température	−40°C à +85°C
Résistance à l'impact	25 mm de diamètre à 23 m/s
Cellules	104 Cellules monocristallines Maxeon Gén. 3
Verre trempé	Verre trempé haute transmission avec couche antireflet
Boîtier de connexion	Classé IP-68, Stäubli (MC4), 3 diodes de dérivation (bypass)
Poids	19 kg
Charge maximale [1]	Vent : 2400 Pa, 244 kg/m² avant et arrière Neige : 5400 Pa, 550 kg/m² avant
Cadre	Anodisé noir de classe 1

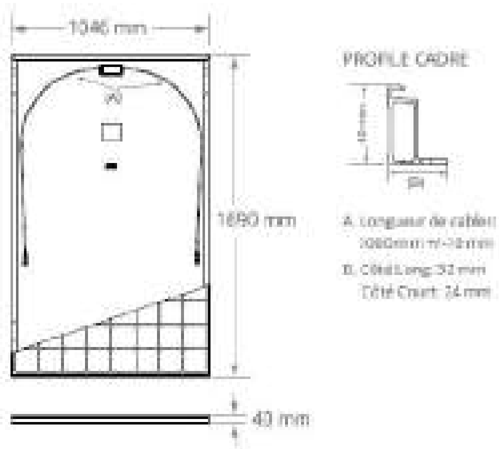


FIGURE 6 - TECHNICAL DESCRIPTION OF THE PV PANELS MAXEON 3

Load matching and grid interaction

In the particular case of collective housing, PV marketing is complex (in the case of an individual house, the producer and the consumer are the same person/entity, simplifying things). It is difficult for a social housing company like Vilogia to "sell" electricity directly to its tenants. Still, such a company can, on the other hand, self-consume in the common areas only or at the level of the dwellings, but the second case is complicated to implement. Self-consumption is possible without batteries/storage (self-consumption with free injection on the grid) or with a battery, knowing that its presence is a sensitive subject from the point of view of insurance and generates additional premiums.

Also, from a financial point of view, self-consumption lowers tenants' charges and reduces incomes because the volume injected into the network is lower, and the price is less interesting /kWh than choosing the "Total sale" option.

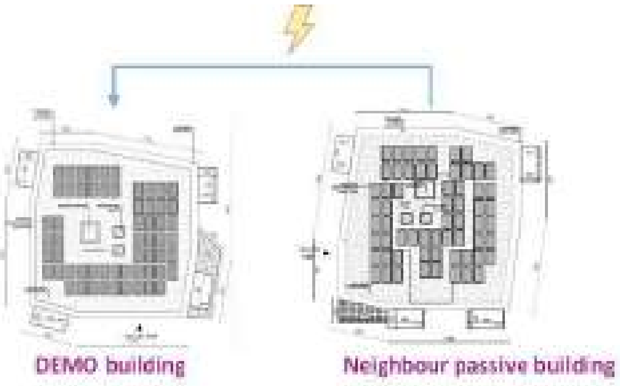
Even if it is theoretically possible, the list of obstacles to overcome makes it simpler to sell the entire production. The choice was to auto-consume only in the common areas (when needed) and inject the rest on the grid. This explains the low rate of self-consumption but a higher rate of self-production: the production compensates for the five uses, representing 50% of consumption (the remaining 50% corresponds to plug loads).

KPI	Estimated value
self-generation (load cover factor)	50 %
self-consumption (supply cover factor)	10 %
Peak export	43 kW
Peak import	57 kW

TABLE 3 - KPIS OF PV

The table below describes the decision process for this equipment.

BIPV & electric storage



Objective

Date	Phase and decisions	To dos	Deadline	Remarks
	E			
July 2020	Definition of the typo of PV to be installed BIPV or common PV pannels. Based on previous experiences (PVSite project), VIL would prefer common PV, which are simpler to install and maintain.	Check with the objectives of the Cultural-E project	End of July 20	
24/07/2020	VIL will install common PV			
	2_Concept design			
26/02/2020	The design team estimated the consumption of the building and the PV needs	Confirm the estimation through a detailed study of the consumption of the building. Depends on the objectives set by the architect		
30/09/2020	The design team provided a detailed calculation of the consumption of the building			
06/11/2020	Self-consumption on the common parts of the building, at least. Self-consumption in the dwellings is to be decided. In that case, the business model is not favourable for Vilogia, since the company bears the investment, but no ROI is possible because the law doesn't allow to sell electricity to the tenant.	VIL checks internally if there is an interest in implementing self-consumption with the tenants		
05/02/2021	The building roof area is not enough to install all the needed PV	Check the possibility of installing PV on the reference building's roof. Check the compatibility with the Cultural-E PEB definition		
30/03/2022	Part of the PV on the roof of the neighbour building is compatible with the Cultural-E PEB definition			
02/05/2022	Only self-consumption in the common parts and not with the tenants. Since the consumption volume in the common parts is low, the interest in installing batteries is minimal. Therefore, no battery will be installed.			
	3_Detailed design			
11/07/2022	The design team provided the description of the PV system to be included in the tenders			
16/12/2022	Final tendering documents sent by the design team with the final PV system's description			

2.3.7 E-Mobility charging stations

It comprises the e-mobility charging stations and the associated electric system.

The car park will be served using a twisted main cable on which MICHAUD GE003/GE004 single-phase or GE005/GE006 three-phase Electrical vehicle charging infrastructure (EVCI) connectors (or equivalent) will be placed at each delivery point to provide individual derivations (Figure 7).

A MICHAUD GE001 (or equivalent) switch/disconnector box will be placed at the origin of the EVCI outgoing feeder. Each branch will lead to a MICHAUD GE020 metering cabinet (single-phase) integrating the individual main circuit breaker, the control panel for the LINKY meter and the connection circuit breaker, and a modular box designed to receive the charging station's protection equipment.

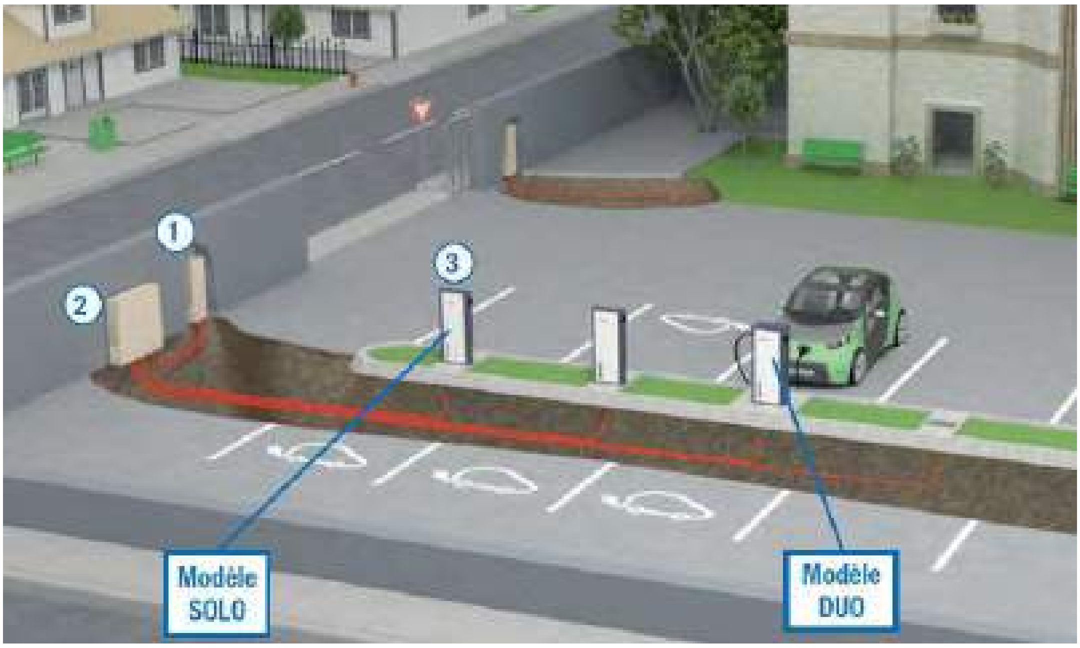


FIGURE 7 - ILLUSTRATION OF THE ELECTRIC VEHICLE CHARGING INFRASTRUCTURE (EVCI)

The table below describes the decision process for this equipment.

E - mobility charging station				
Objective				
Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
mars-21	The French regulation obliges to pre-equip 100% of the parking lots with a local power grid for e-vehicles. The tenant can then easily install a charging station. Local DSO is responsible for charging the electricity consumed. Grants are available to finance this pre-equipment. The installation of at least one charging station is mandatory to receive such a grant. At least one station will be installed	Meet suppliers to define a suitable solution and include it in the tendering documents		
	2_Concept design			
sept-22	A suitable solution was identified and included in the tendering documents			
	3_Detailed design			
16/12/2022	Final tendering documents sent by the design team with a description of the e-vehicle charging system			

3 Ostfildern, Germany – Wohnbau Studio

3.1 Description of the demonstration site

The project is located in Ostfildern near Stuttgart. At an altitude of approx. 410m above sea level, the climate is classified as warm and temperate. The annual average temperature in Ostfildern is around 10 ° C. The yearly rainfall is about 877 mm.

With a mix of different floor plans and sizes, an attempt is made to appeal to a wide range of prospective tenants. The residential units will be realised as rental apartments. A large part of the lighting design will be pre-installed on site to ensure energy-efficient lighting. The household appliances are also made available to future tenants.

Number of floors: 4 Floors - A ground floor, two upper floors and an attic.

Number of dwellings: 21 + 1 commercial unit

Surface areas:

- Residential units, 1^{st} - 2^{nd} floor and attic: 1679 m² (NRF), average approx. 80 m²/apartment
- Commercial unit, ground floor: 778 m^2 (NRF)
- Underground: car parking, storage, technical cabinets: 1173 m²

Outdoors and common areas: green open spaces around the building, potentially partially green terraces.

FIGURE 8 - SITE LOCATION OF THE GERMAN DEMONSTRATION SITE

FIGURE 9 - RENDERING OF THE GERMAN DEMONSTRATION BUILDING

3.1.1 General information

The energy concept is based on a three-step strategy. The first step is reducing energy demand in the building through passive measures related to the envelope and through the targeted choice of generation and supply technologies. On the one hand, this concerns energy demand for heating, DHW, lighting and ventilation. On the other hand, since user electricity accounts for about half of the total energy demand, this share is also included in our strategy. In this context, the user with his behaviour is part of the concept. The user is involved thanks to the feedback from the cloud system, which provides information and data from the monitoring system. The cloud connection module provided by the partner Advanticsys is part of the House Management System (HMS).

In the second step, we increase energy production on site. As the energy concept is fully based on electricity, the only generation system is photovoltaics (PV). From the beginning, the architects (partner Wohnbau Studio) focused on maximising the roof area to maximise the area for BIPV. In total 80 kWp will be installed. The total electricity production is calculated to be 74 MWh/a.

The third step focuses on the share of self-consumption of produced electricity and the integration of e-mobility. Here a 2nd –life battery system with a capacity of 66 kWh is planned.

Concerning the heat and DHW supply systems, the building is separated into two parts. A central air-to-water heat pump is used from the ground floor to the 2nd floor. A separate storage tank is installed for each temperature level (heating, DHW). In the attic (penthouse), it is planned to install the Packed Heat Pump (PHP) units from the partner Ventive.

Also, the ventilation system is different in the different building sections. Controlled mechanical ventilation, including heat recovery, is planned in the attic and the commercial area on the ground floor. In the 1st and 2nd storeys with residential use, an exhaust ventilation system with trickle vents in the facade (windows) is planned.

3.1.2 Penthouse

The solution set in the penthouse (attic) consists of the following:

- Efficiency House 40 (EH40) envelope insulation standard
- PHP unit for heating, DHW and controlled mechanical ventilation (Ventive)
- Low-temperature under-floor heating system
- Active window system (AWS) with integrated shading (Eurofinestra)
- High-efficiency user appliances
- LED lighting system
- HMS and cloud feedback system for users (Advanticsys)
- Connection to the PV – Battery system
- E-vehicle charger

3.1.3 Ground floor, 1st and 2nd floor

There are different solution sets for the residential floors and the commercial unit. A central air-to-water heat pump heats both areas.

The solution set consists of the following:

- Efficiency House 40 (EH40) envelope insulation standard
- Central air to water HP for heating and DHW
- Low-temperature under-floor heating system
- Fresh water stations in the apartments for DHW
- Exhaust ventilation system
- Active window system (AWS) with integrated shading and trickle vents (Eurofinestra)
- High-efficiency user appliances
- LED lighting system
- HMS and Cloud feedback system for users (Advanticsys)
- Connection to the PV – Battery system
- E-vehicle charger

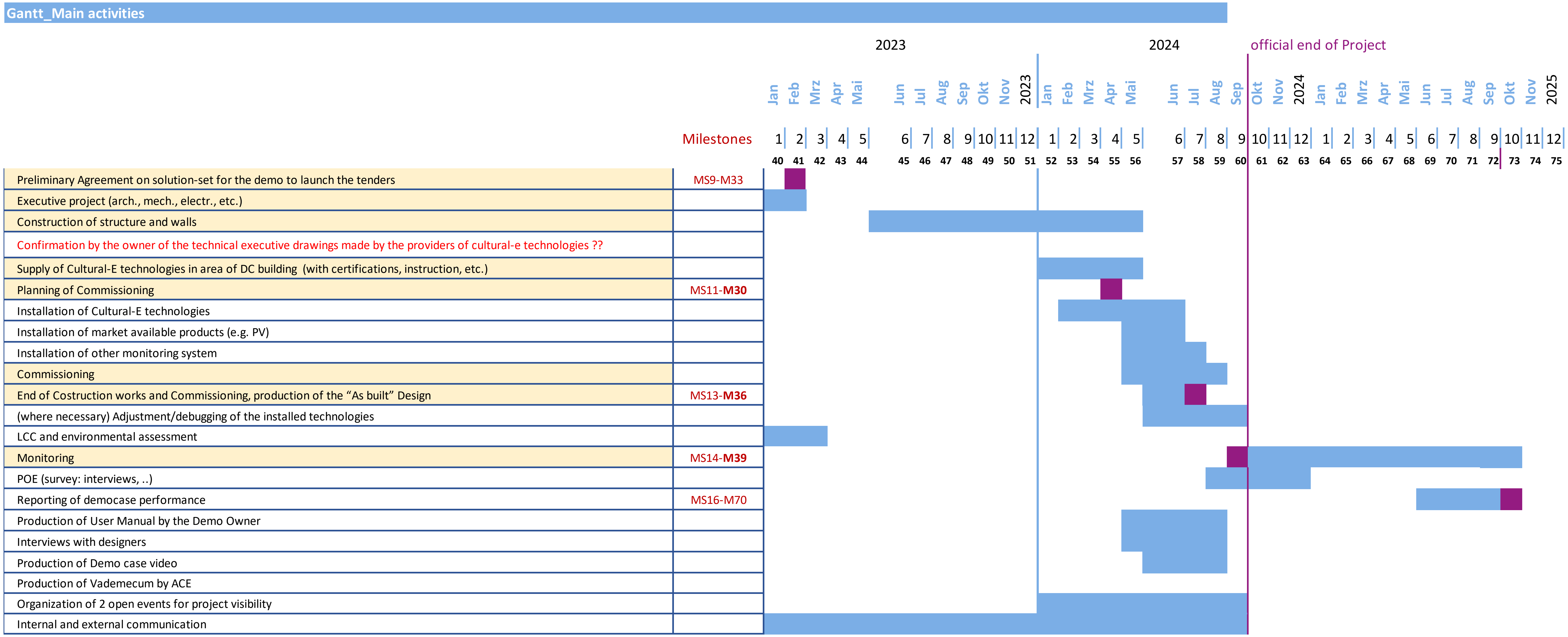
3.1.4 Commercial area on the ground floor

The solution set consists of the following:

- Efficiency House 40 (EH40) envelope insulation standard
- Central air to water HP for heating
- Under-floor heating system
- Electric instantaneous water heaters for DHW
- Controlled ventilation system, including heat recovery
- Ceiling fans for improvement of thermal comfort in summer (Vortice)
- LED lighting system
- HMS and cloud feedback system for users (Advanticsys)
- Connection to the PV – Battery system
- E-vehicle charger

The central heat pump can switch operation into cooling mode, which is used for the ventilation units in the commercial area and a certain basic cooling by the chilled cooling and heating system. In the residential areas, the cooling mode is not available.

3.2 Project timeline



3.3 Technologies

3.3.1 Active Window System (AWS) – Eurofinestra

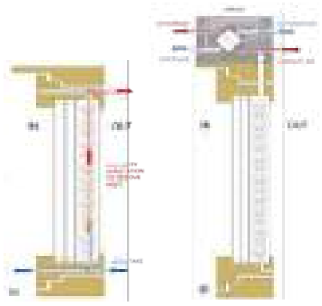
The Eurofinestra Active Window System is a multifunctional window system that enhances energy efficiency, indoor air quality and user comfort. The AWS is based on (i) a modular wood frame system, easily adaptable to different climates and design selections, (ii) adaptive shading systems, (iii) integrated decentralised ventilation devices, and (iv) the possibility to exploit the shading semi ventilated cavity through its interaction with the decentralised ventilation devices.

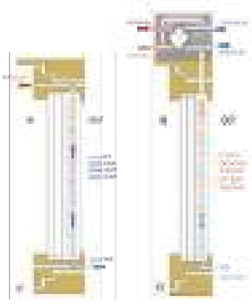
The ventilation concept in the German demo is based on trickle vents in the windows combined with exhaust fans in the bathroom. The German team chose, therefore, a version of the AWS with (i) triple-glazing, (ii) a modular wood frame system, (iii) adaptive shading systems and (iv) integrated trickle vents.

The window block comprises an insulating frame of extruded polystyrene and timber reinforcement. It is designed to allocate the window with integrated exterior Venitian blinds of Hella. The motor of the blinds is controlled directly by the occupants or the Building Management system, where algorithms developed within the cultural-E project can be integrated. Also, the thermally broken, noise-reducing, self-regulating trickle vents are integrated into the timber reinforcement.

The table below describes the decision process for this equipment.

Active window - Smart air ventilation system





Objective

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
11.08.2021	Wohnbaustudio gives a presentation of the building with its hybrit construction and floor-to ceiling glazing with sliding doors. It seems possible to install the AWS System at 8-12 classic windows in the building.	Wohnbaustudio provides plans and sketch of vertical section of the facades to check by Eurofinestra if AWS can be adapted to floor-to ceiling- windows.	16.08.21	ventilation concetp requires trickle vents and shading => Selected technology: tilt and pivot wood window with integrated exterior sun shade and trickle vents.
29.09.2021	Decision to work on the 11 "classc" windows with the AWS System	Wohnbaustudio will get back to Eurofinestra with more specific technical questions during design development phase, presumably in the next 1-2 months.	01.12.21	The other windows are part of curtain wall and they required specific desing; they cant be implemented from our cultural-e product.
	2_Final design			
31.01.2022	technical requirements for the glazing are specified	more info needed from Eurofinestra for better undertanding of the AWS system. Data sheets of trickle vents and shading system including KNX-readiness. Deeper analysis which windows are possible for AWS-System	26.05.22	U-value, g-value, LT, Sound rating
24.06.2022	32 AWS windows can be intgrated in the Demo			
	3_Execution design			
24.10.2022	coordination of AWS construction for 1/5 details started by Wohnbaustudio	Feedback needed from Eurofinestra	15.11.22	
25.01.2023	repeadted request for purchasing more details of AWS Windows for detailed integration in the plans of Wohnbaustudio	Feedback needed from Eurofinestra	15.11.22	still waiting for answer of Eurofinestra

3.3.2 Packed heat pump (PHP) from Ventive

Ventive has developed a compact unit integrating mechanical ventilation, a hydronic circuit for space heating and domestic hot water, and thermal storage with Phase Changing Material (PCM) into one system.

The table below describes the decision process for this equipment.

Decentralized Pack Heat Pump System

Objective

Heating of the apartment, DHW preparation and storage and controlled ventilation system with heat recovery system.

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
	Kick off meeting with WS as new Demo case Partner	Ventive compiles requested technical data and drawings of the presented new version	14.09.2021, done	Ventive showed a new version of the PHP, that can be installed in an apartment.
19.09.2021	decision to install PHP units in the penthouse apartments in the Demo Case	all performance data are missing. Tests are planned at EURAC. Open questions to be solved by the initiative of Ventive: what warranty gives ventive?, how can the installation and maintenance work without trained craftsmen in Germany?	16.09.2021, done	On the Penthouse level, there is the possibility to installl the PHP units outside the apartments on the balconies/ terrasses. In the other floorplans no adequate place could be found. Furthermore, the risk to install a heating-ventilation unit that is still in a early phase of development in the whole building is to high, even if the units are provided for free. The advantage of the decentralised system is not clear for the team, especially in a new building. The energy concept does not require a controlled ventilation, this function is accepted as add on even if the installation of the ducting means more effort.
	3_Final design			
	drawings, schematic of new PHP and some technical data provided by Ventive	still some questions open about technical data. SIZ asks, why the french PHP-Version cannot be used in the german demo	22.10.21, done	
	new drawings and further technical information provided by Ventive	integration of PHP units in floorplan by WS	22.11.2021, done	
	WohnbauStudio provides floorplans with PHP units installed at outside walls of each apartment in the 5 penthouse apartments	providing data about sound emission and outdoor air flow of PHP units installed on balconies. Check if the french version could be used.	03.12.2021, done	
31.01.2022	first technical and performance data were presented by Ventive, also possibility of control by screen and app	Sound level issue is still open and measurements are missing. planned at EURAC during performance tests.	open, demppends on capacity of EURAC	Sound emissions of the units are crucial because the units will be installed on the balconies and their position is near by spaces with sound level requirements due to German law.
	4_Execution design			
04.08.2022	SIZ lounches a cloud platform for exchange of documents and data.	preparation of 3d-drawings of the unit for the German demo by ventive	08.09.2022, done	the colud platform should fascilitate the data exchange and accelerate the planning of the integretion in the building and development at Ventive.
08.09.2022	Presentation of drawinngs	Set up of test program ant EURAC by Roberto Fedrizzi, confirmation of thests by SIZ	30.09.22, done	schedule for the tests is: shipping to Eurac in Jan. 2023, tests at EURAC in Feb 2023
03.11.2022	discussion about warranty, service and maintenance of the units in the demo after end of EU-Project	Set up of a draft contract for service by Ventive	01.04.2023	Current situation is: during EU-Project, all support and maintenance by Ventive is guaranteed. After end of project, owner of units is WohnbauStudio and Ventive gives no more warranty. In Germany, it is commmon that the manufacturer of the units give a warranty of 2 years (also EU-law?). As the project ends with the commissioning of the building, all risk is transferred to WohnbauStudio from that point on. Ventive offers supervision of the units by their cloud service as well as installation of software backups. The price for this service is open, see to dos.

Each dwelling on the 3rd floor (penthouse) will be equipped with the PHP system from Ventive, providing the following functions:

1. High-efficiency dual-flow ventilation with heat recovery;
2. Heating source for under-floor heating;
3. DHW production;
4. Thermal storage system;
5. Additional cooling by ventilation system during loading of the thermal storage system.

The units will be installed outside the apartments on the balcony. Final drawings are not yet available because the units are still in development. The technical characteristics will be determined in May 2023 at the EURAC-test labs in Bolzano.

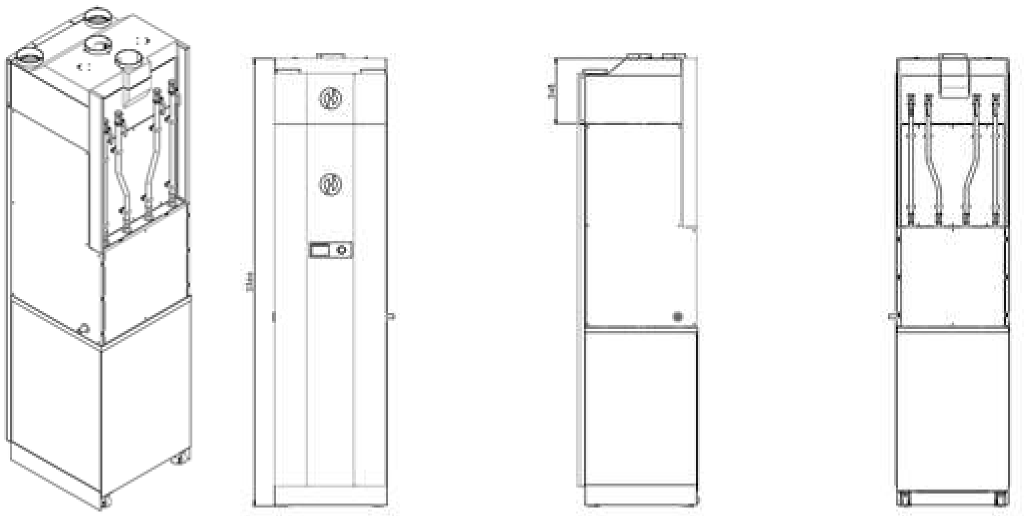


FIGURE 10 - PRE-CONSTRUCTION DRAWING OF PHP UNITS ON 3RD-FLOOR APARTMENTS

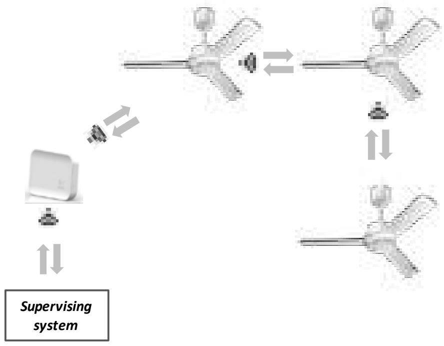
FIGURE 11 - POSITION OF THE PHP UNITS ON THE BALCONIES ON THE 3RD FLOOR

3.3.3 Ceiling Fan for smart air movement – Vortice

Moving air through ceiling fans can be an effective way to provide comfortable cooling in warm environments, able to complement and/or replace the use of active cooling systems. The smart ceiling fan automatically adapts its rotational speed based on the temperature and relative humidity values measured in the room. Moreover, the ceiling fan learns from occupant's control preferences and coordinates its action with cooling and ventilation systems for an energy-efficient, comfortable and healthy indoor environment.

The table below describes the decision process for this equipment.

Ceiling fan - smart air movement



Objective

generate air movement to increase thermal comfort during summer in order to avoid active cooling

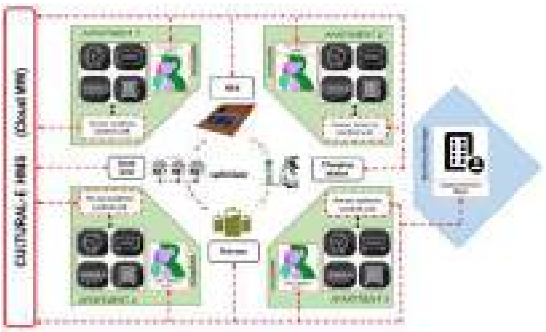
Date	Phase and decisions	To dos	Deadline	Remarks
	1_2_Selection of technology/ Preliminary design			
	investiage possible locations for ceiling fans	discuss minimum spatial requirements		Room height must be higher than 2,70 m
	room height in residential areas are at 2,50 and therefore to low for dhe ceiling fans. Since office work is very similar to residential situations like sitting and reading a book or watching TV, we think that the installation in the comercial area is acceptable for the Cultural E project goals.	to be confirmed by EURAC, Roberto Lollini	15.09.2021	confirmation by email from Roberto Lollini (15.09.2021)
	3_Final design			
	finalize locations, quantity and sizes of ceiling fans	develop office layout and different office types	01.02.2022	
	4_Execution design			
26.10.2022	detailing of integration of ceiling fans in the rooms but behind the wood lamellas in the ceiling. Also detailing of position in floor plans.	feedback from Vortice needed.	02.11.2022	
02.11.2022	ceiling fan needs a niche in the seiling of 500x500 mm due to the minimal height	Check whether acoustic requirements can be met.	06.12.2022	sound protection between the floors.

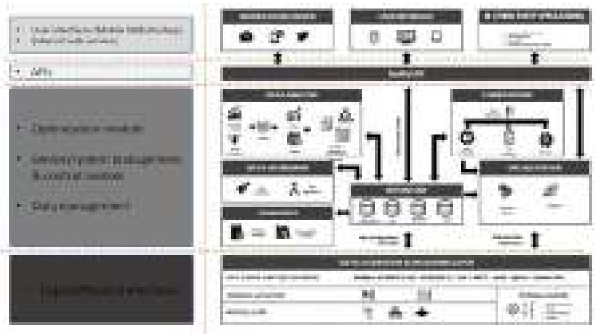
3.3.4 Cloud-based House Management System (HMS) and Monitoring – AdvanticSys

The Cloud Based House Management System (HMS) combines indoor and outdoor sensors data, RES production, common electric or thermal storages and web services to minimise and optimise energy consumption. Based on a distributed cloud infrastructure, it implements the logics to operate the different systems. The HMS behaves as a typical building management system at the apartment level with extended capabilities at the cloud level, such as advanced control strategies that run in real-time. Additionally, a user interface is developed to communicate information to all users (tenants, facility managers, building owners, etc.).

The table below describes the decision process for this equipment.

Cloud-based House Magagement System





Objective

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
18.10.2021	coordination meeting with Advanticsys for IT-Architecture of HMS	cost estimation of sensor and room automation and monitoring system, including realisation of setpoint adjustment by cloud	dec. 2021	cost estimation showed too high cost for suggested architecture
	3_Final design			
02.12.2021	it is agreed: typical installation and control architecture for room automation in the demo advanticsys adds data aquisition device for data collection and set-point changes, communication by bus	development of new new IT architecture and cost estimation	february 2022	Requirement of Wohnbaustudio for building automation is to work independently of the Advanticsys systems.
08.02.2022	IT architecture developed and agreed with Advanticsys. All the control routines will be running in Wohnbau Studio KNX system, advanticsys device will only be a gateway itself, logging data, pushing it to the cloud and sending set point data		08.02.2022	Roomautomation in apartments by KNX, control in central heating station and other central units by own Modbus system, advanticsys communication by MQTT gateway.

The dwellings are equipped with a comfort monitoring system and a metering system, shown in Figure 12 to Figure 14. The sensors and actors for heating and shading control, the window contacts, the presence button and a user interface screen are planned in KNX technology. All meters are connected to the HMS by Modbus. Light control is in the conventional technology.

The communication in the central heating is accomplished by the BMS using Modbus. Here the PHP units of the penthouse are included. The communication between the KNX system and the BMS is accomplished by a KNX-Modbus gateway.

The control algorithms in stand-alone operation without cloud connection are located as follows:

- Room temperature, shading => KNX system in each dwelling
- PHP unit independent
- Central heating station => BMS (building management system)

The IT architecture (Figure 15) allows a bi-directional cloud connection by MQTT protocol. This allows to collect the monitoring data in the AdvanticSys cloud and change set points in the BMS and the KNX system via cloud control. With this, it is possible to test control strategies and algorithms developed within the Cultural-E project in the real demo case building.

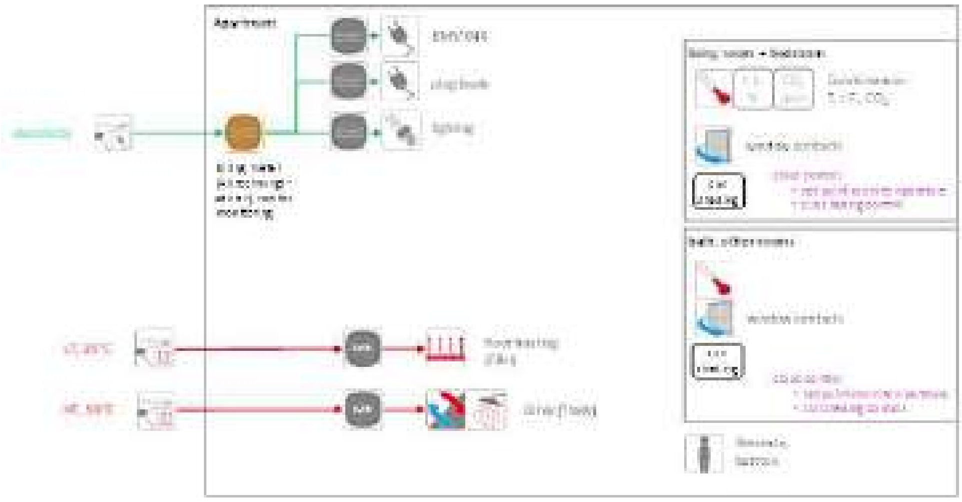


FIGURE 12 - METERING AND MONITORING IN THE APARTMENTS ON THE 1ST FLOOR.

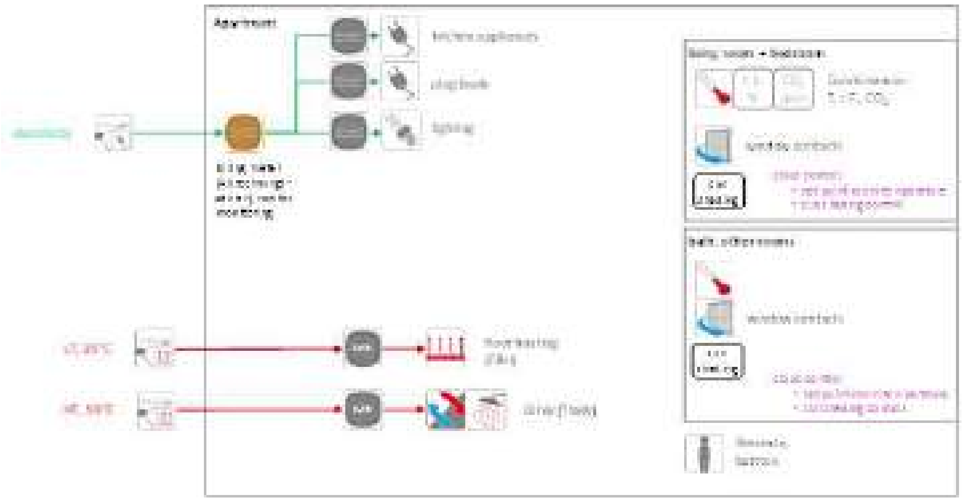


FIGURE 13 - METERING AND MONITORING IN THE APARTMENTS ON THE 2ND FLOOR.

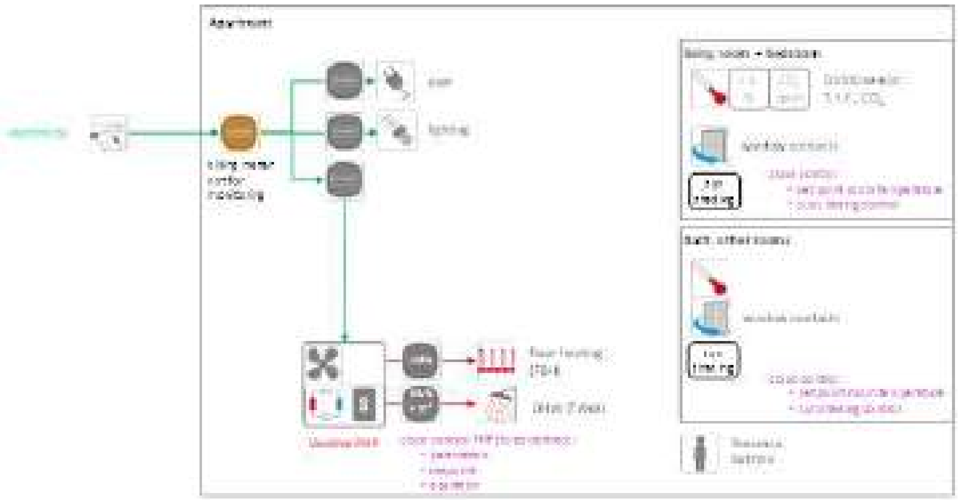


FIGURE 14 – METERING AND MONITORING IN THE APARTMENTS OF THE PENTHOUSE.

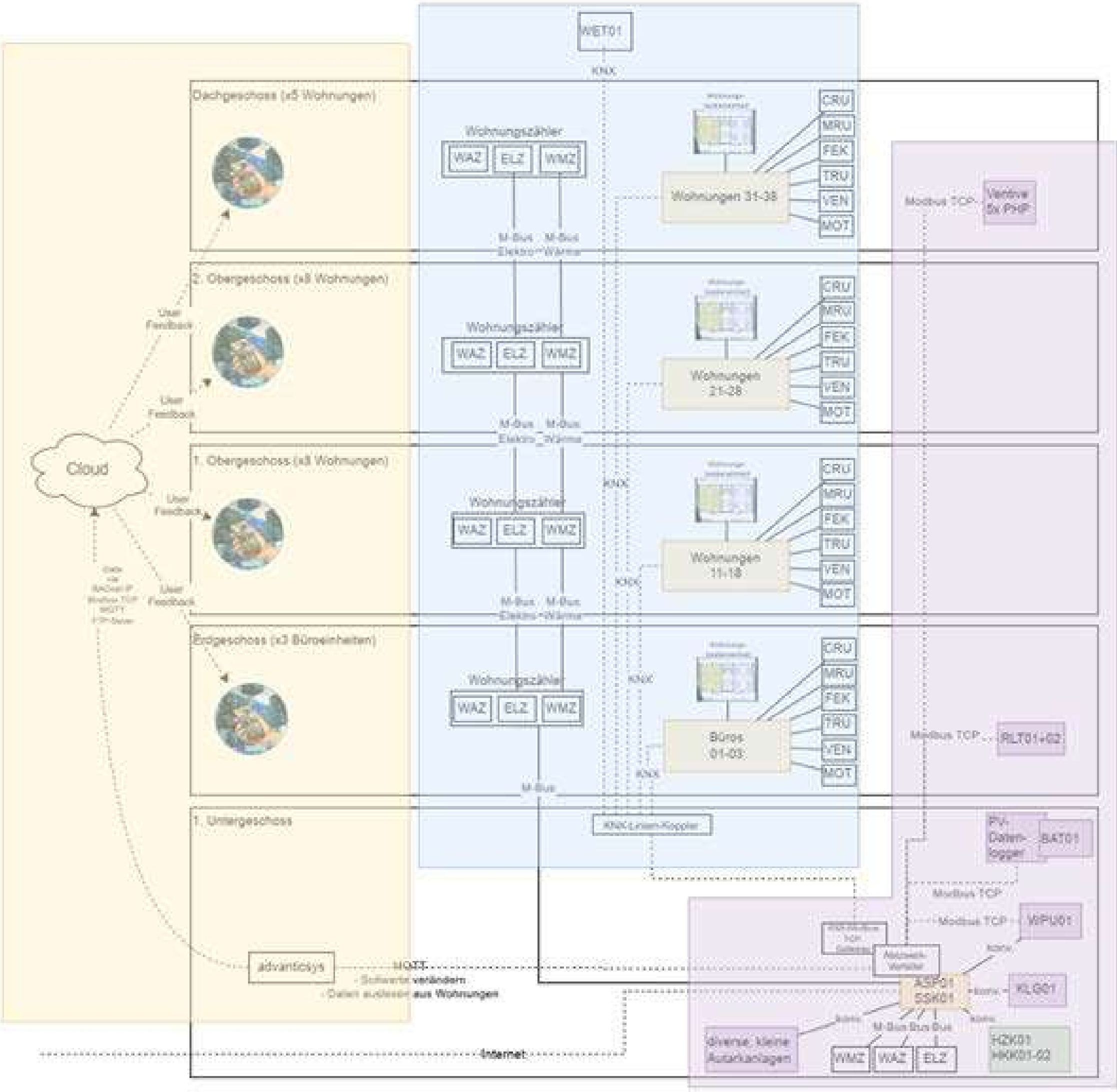
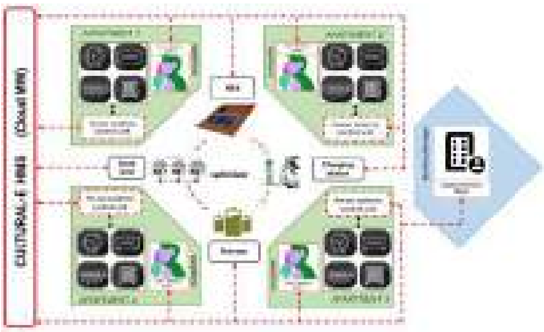
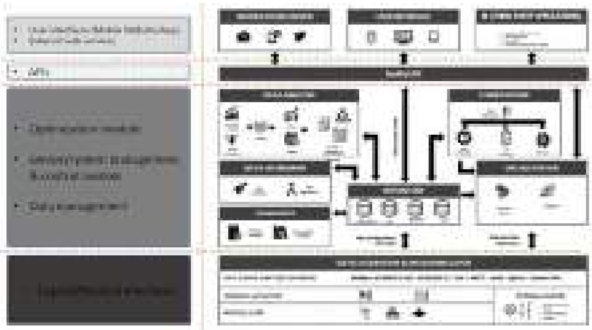


FIGURE 15 - TOPOLOGY OF HMS AND COMMUNICATION WITH THE CLOUD SYSTEM OF ADVANTICSYS.

Cloud-based House Magagement System





Objective

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
18.10.2021	coordination meeting with Advanticsys for IT-Architecture of HMS	cost estimation of sensor and room automation and monitoring system, including realisation of setpoint adjustment by cloud	dec. 2021	cost estimation showed too high cost for suggested architecture
	3_Final design			
02.12.2021	it is agreed: typical installation and control architecture for room automation in the demo advanticsys adds data aquisition device for data collection and set-point changes, communication by bus	development of new new IT architecture and cost estimation	february 2022	Requirement of Wohnbaustudio for building automation is to work independently of the Advanticsys systems.
08.02.2022	IT architecture developed and agreed with Advanticsys. All the control routines will be running in Wohnbau Studio KNX system, advanticsys device will only be a gateway itself, logging data, pushing it to the cloud and sending set point data		08.02.2022	Roomautomation in apartments by KNX, control in central heating station and other central units by own Modbus system, advanticsys communication by MQTT gateway.

3.3.5 BIPV and electric storage

The photovoltaic panels and associated electric systems are installed to cover the energy needs of the building, according to the PEB definition used by the demo site owner. Electric storage enables flexibility.

In total, 202 PV-Panels are planned with 80.4 kWp installed: 190 are AC-410MH/108V with 410 Wp/Module; 12 PV-Panels are semi-transparent with 210 WP/panel. The total calculated electricity production is 74 MWh/a.

FIGURE 16 - INSTALLATION OF THE 190 PV-PANELS ON THE ROOF TYPE AC-410MH/108V. 12 SEMI-TRANSPARENT MODULES WITH 210 WP/MODULE.

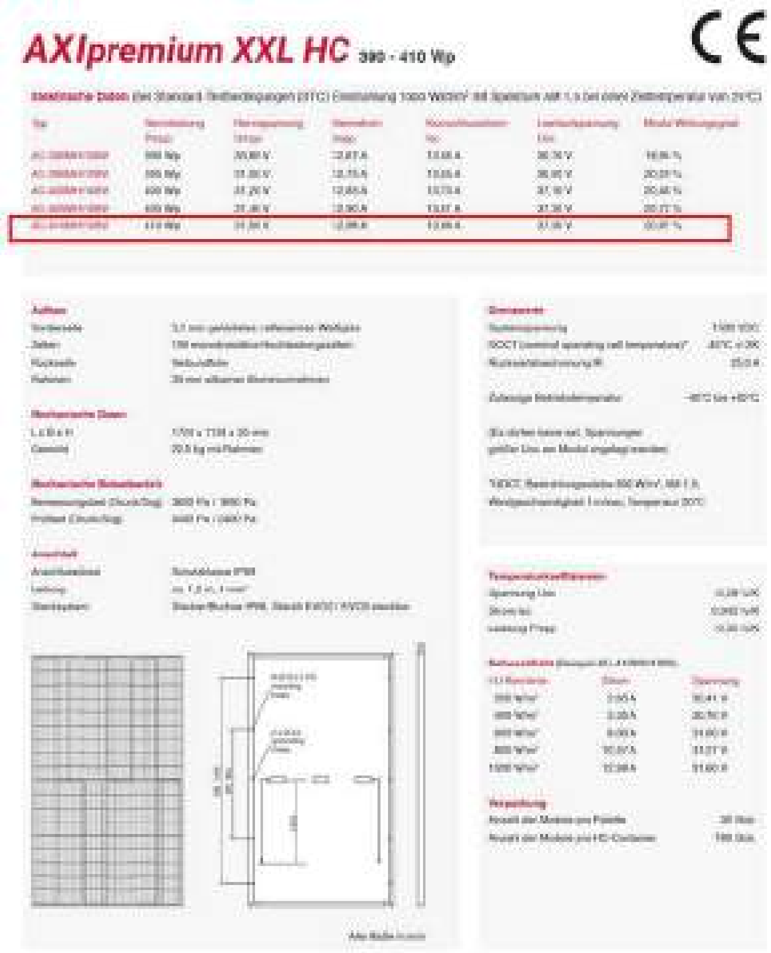


FIGURE 17 - TECHNICAL DESCRIPTION OF THE PV PANELS AC-410MH/108V OR SIMILAR

The table below describes the decision process for this equipment.

BIPV & electric storage

Objective				
maximisation of energy production and self consumption				
Date	**Phase and decisions**	**To dos**	**Deadline**	**Remarks**
	1_Selection of technology			
18.08.2021	beginning of PV optimisation by EURAC on the basis of the 3d-model of the demo.	Identification of possible PV surfaces on roof(s) and facades	15.09.2021, done	
14.09.2021	SIZ-EGS presented the results of different possibilities to reach the PEH target by using PV-Systems only on the roof.	discussionon the possible surfaces for BIPV in architectural point of view.	30.09.2021, done	from the beginning, the roof was enlarged to maximize area for PV instead of using facade PV with less yield.
	3_execution design			
20.01.2022	decision to search for a **2nd life battery** system for sustainability reasons.	search for manufacturer, capacity and cost estimation.	20.02.2022	
24.02.2022	decisison to install 66 kWh battery on the basis of economical investigation between 100 kWh and 66 kWh capacity.	manufacturer: Voltfang	24.02.2022	calculation basis: PV=90 kWp, consumer: heating and DHW, user of 24 apartments, 25 cars à 18250 km/a.

3.3.6 2nd life battery system

There are no efficient and widespread recycling options for current batteries from electric mobility. The 2nd-life use of electric vehicle batteries offers the opportunity to reduce the ecological footprint. Discarded batteries usually have an age-related residual capacity of over 80%. They are, therefore, ideal for further use in stationary storage systems, which are an essential component of the sustainable energy transition. A 66 kWh Voltfang industrial-type battery system is used in the project (Figure 18).

Voltfang Industrial 66 kWh	
Garantie:	
Systemgarantie:	5 Jahre
Kapazitätsgarantie:	siehe Battery Flat
Batteriespeichersystem bestehend aus:	
Voltfang Industrial - Lithium-Ionen Batteriespeicher:	
Hersteller:	Voltfang GmbH
Nutzbare Kapazität:	66 kWh
Max. Leistungsabgabe:	50 kW
Anzahl an Rack:	2
Maße (H/ B/ T) in mm pro Rack:	2000 / 800 / 600
Batteriewechselrichter	
Bidirektionaler Batteriewechselrichter:	
Hersteller:	KACO
Typ:	gridsave 50.0 TL3-M

FIGURE 18 - SPECIFICATION OF VOLTFANG BATTERY SYSTEM.

4 Castenaso, Italy - Abitcoop

4.1 Description of the demonstration site

4.1.1 General information

The Italian demonstration building is located in Castenaso, near Bologna (Italy), in a rural setting crossed by the river Idice and close to parks and nature. The location has a humid temperate climate with hot and humid summers and relatively cold and wet winters. Average rainfall in the town ranges from 600 to 900 mm/y and usually concentrates in spring and autumn. In winter, snowfalls can occur and are sometimes very abundant, with frequent night frosts. The modest windiness contributes to fogs and mists and the permanence of high air pollution. Strong winds blow occasionally.

The demo includes two similar residential buildings with dwellings of different sizes, built by Abitcoop (a private cooperative, meaning they get an agreement for using public soil for 99 years) for selling. Both buildings are equipped with photovoltaic panels on the roof, divided into systems connected to each apartment. Technical boxes on the balconies host each apartment's heat pump and other technical services. A technical room hosts the inverter and batteries. Cabinets on each floor host vertical distribution of electricity and water.

Pilot A: 3 floors, 6 dwellings

Pilot B: 3 floors, 7 dwellings

Surface area: approximately 80 - 100 m2/dwelling

Outdoor area: green area, parking

FIGURE 19 - ILLUSTRATION OF DEMO BUILDINGS

FIGURE 20 – WORK IN PROGRESS 9/2022

FIGURE 21 - WORK IN PROGRESS 10/2022

4.1.2 Solution set

The solution sets for the dwellings:

- CasaClima "A" envelope insulation standard
- Compact HP for heating, cooling and DHW
- Air distribution for heating/cooling and ventilation with heat recovery
- Active window system (AWS) with integrated external shading
- High-efficiency user appliances (suggested to new owners)
- LED lighting system
- HMS system
- PV – Battery system
- E-vehicle charger (predisposed)

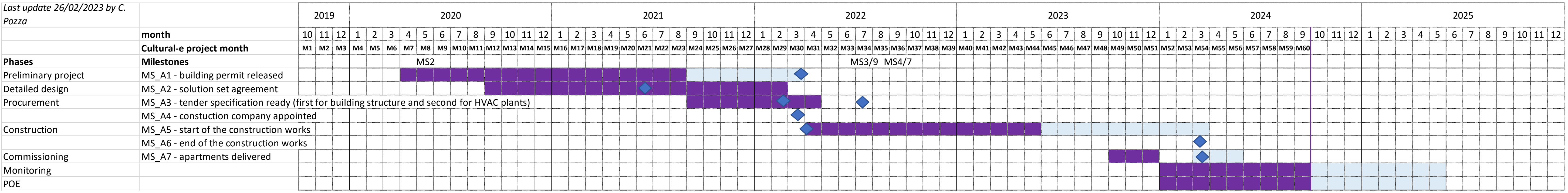
In particular, the design process led to the definition of the following characteristics for building components and systems:

TYPE			Notes
Insulation/air infiltration	External walls	Materials: (inside) plaster, poroton, EPS , plaster (outside) U = 0.172 W/m2K	The values refer to most relevant stratigraphy. Others are present, i.e., wall to staircase

	Roof	Materials: (outside) high reflective waterproofing membrane, bitumen, polyurethane foam panels, vapour barrier, concrete slab, floor brick–cement, internal plaster (inside) U = 0.107 W/m2K	The values refer to most relevant stratigraphy. Others are present, i.e., terraces
	Floor-ground	Materials: (inside) ceramic floor, screed, underfloor heating package - EPS , EPS , vapour barrier, screed with EPS, reinforced concrete slab (ground) U = 0.227 W/m2K	The values refer to most relevant stratigraphy. Others are present, i.e., floor-garage
Windows	AWS	Triple glazing, minimal air infiltration, external shadings (control of height and tilt angle).	
	Traditional	Materials: PVC, glass, ext. solar shading U = 1.05 W/m2K, Ug =1 W/m2K, Uw = 1.15 W/m2K, Ggl = 0.55	
HVAC	NILAN Compact P w. Air distribution	Active/passive H&C and DHW production. Air/air heat pump with mechanical ventilation with recovery. Thermal power approx. 2kW. DHW storage 180l.	Inlet: living room, bedrooms Outlet: kitchen, bathroom
	Ducted split unit system, w. air distribution	Active H&C Thermal power approx. 2-4 kW.	This is a backup system/covering peaks. Input: living room, bedrooms. Output: where the unit is installed, usually corridor
	Pre-tempering system	Heat exchanger, solar thermal panels & storage, passive ground probe, circulation pump.	External air is preheated in winter and pre-cooled in summer before the HR.
	Ceiling fans	Fans are activated depending on user activity measured by a specific activity sensor in the living room. In bedrooms, fans are activated by user preferences overnight.	These fans operate in summer only to avoid active cooling as much as possible and help in some instances, i.e., the user is back home or the temperature is within 25-27°C.
Lighting	LED	Proper lighting is installed in every room. Manual control, not dimmed.	Consumption of lighting is monitored. Lights are not controlled automatically, i.e., based on presence after cost-

			benefit evaluation, and also because of the reliability of presence detection.
Plug loads	User appliances		AbitCoop does not provide end users with specific appliances. Users will be encouraged to choose energy-efficient appliances and informed about consumption trends.
E-vehicle	Charging wall box	Ducting to garage.	Only predisposition. Users will decide if/which product to install.
BEMS	Local BMS	Controllers/Actuators installed for connecting to subsystems (HVAC, shading), sensors and essential user interfaces	Wired/bus
	Cloud-based HMS	Includes a field gateway to local BMS and an app (tablet) for user interaction.	Requires Internet connectivity
Monitoring	Room sensors	In the living room and bedrooms, to measure T/RH/CO2	Light is not measured because the high cost of sensors is not motivated by expected benefits. Despite the supply temperature for H&C being managed at the dwelling level, it is important to get room temperature for comfort reasons (driving room) and for shading control/avoid overheating
	Outdoor sensors	On the roof/facades, to measure actual T/RH/irradiance/wind	Wind sensors are required for safety reasons, i.e., to recover blinds if the wind is strong. Some measures are conveniently acquired by subsystems. Outdoor conditions are also fetched by cloud services, which are increasing reliability.
	Power, energy consumption	Light/force lines are monitored.	Relevant subsystems are also monitored because built-in power/energy consumption measurement is not available/precise
	PV-electric energy storage	Energy production, battery charge status and energy exchange with the power grid are monitored.	This is done by the PV-inverter-battery subsystem, which is connected by a standard interface to the HMS

4.2 Project timeline



4.3 Technologies

4.3.1 Active Window System – Eurofinestra

The Eurofinestra Active Window System is a multifunctional window system that enhances energy efficiency, indoor air quality and user comfort. The AWS is based on (i) a modular wood frame system, easily adaptable to different climates and design selections, (ii) adaptive shading systems, (iii) integrated decentralised ventilation devices, and (iv) the possibility to exploit the shading semi ventilated cavity through its interaction with the decentralised ventilation devices.

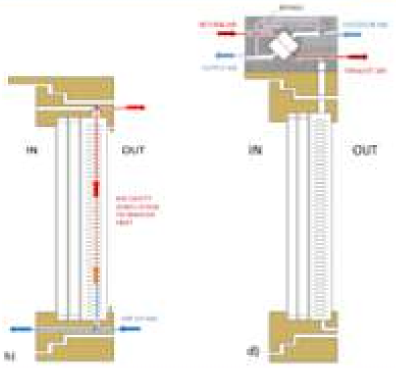
The table below describes the decision process for this equipment.

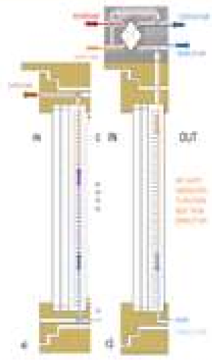
Last update
27/02/2023
Cristian Pozza

Technology provider: EUROFINESTRA

All Demo cases

Active window - Smart air ventilation system





Objective

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
27/08/2020	Confiuguration option 4 with advanced automated shading was selected as the most suitable one since ventilation will be fully managed by the PHP system. Proposed variant for the building B: with traditional heating system and advanced ventilation and window system (option 1-2 with decentralized ventilation).	(EUROFINESTRA) to perform cost estimation according to budget available and provide a proposal for the IT demo (EURAC) to check feasiblity of application of AWS configuration 1-2 in building B	15/09/2020	done 31/3/2021: building A and B will have same setup (no variants)
29/09/2020	Some limitations came out on the application of AWS on wide openings. Having integrated shadings is hard on wide windows, both for condensation issues within the glazings and for shading dimension itself. AWS cannot be configured as sliding doors.			
	2_Concept design			
27/01/2021	Sliding window replaced by casement window to allow for better shadowing and to stay within the budget.			
	3_Detailed design			
	4_Manufacturing of the selected product			
01/10/2022		Small changes to EUROFINESTRA product to adapt better to structures. Sealing with silicone is the only option (instead of metal)		
	5_Delivery			
27/02/2023	Conditions agreed			

At first, all 4 potential setups were discussed by the LDWG and the technology developer. The option (external shading system, integrated mechanical ventilation, no trickle vents/air pre-tempering) was then selected based on uncertainties on the feasibility and reliability of more complex solutions. The same setup was chosen for both A-B pilots to ease the commissioning phase. Double-glazing windows were selected based on considerations of the local climate.

In particular, a specific need emerged during the design phase, as usually new owners are allowed to choose the type of windows. Wide windows have been chosen by default instead of sliding windows, which are unavailable under the AWS concept. Also, scaling the AWS concept to wide windows posed some issues with condensation within glazings in more complex configurations, and the shading size implied a higher distance between glazings.

During the finalisation of the design, some potential issues were discussed on how different materials and sealing types could be compatible with wall insulation layers and still durable to avoid fissuring/water infiltration. Silicone sealing was chosen because a metal layer (the common practice) could not be used. Also, anti-theft bars on the ground floor would compromise the thermal efficiency of the component (thermal bridges). The window frame was specifically shaped. Minor changes to the original design were necessary to reduce the potential air infiltration caused by imprecise commissioning.

4.3.2 Packed Heat Pump (PHP) – Ventive

Ventive has developed a compact unit integrating mechanical ventilation, a hydronic circuit for space heating and domestic hot water, and thermal storage with Phase Changing Material (PCM) into one system.

During the preliminary design, some decisions were taken:

- Preliminary estimations raised an issue related to the original concept of PHP. Indeed, the unit can cool recirculating air while recovering heat from exhaust/air extraction, and the process can happen until DHW storage is tapped. In the Mediterranean climate, the unit would stop cooling on many summer days. A secondary heat sink was proposed to overcome the issue, which would have eliminated excess heat outside.
- The compact unit should be positioned outside, in a technical box on the balcony. It was not feasible to make a large hole in the façade to host the unit exhaust/inlet and a second heat sink. This was due to visual impact and potential noise emission from the façade.
- Underfloor heating was planned. The unit did not have the capability to regulate outflow temperature, and a mixing valve/extra components were needed.
- The size prescribed for ducting was minimal for the nominal flow, thus, a silencer was foreseen.
- The air inlet in rooms was expected to be colder and move faster than from usual systems. Then, special care was needed to choose suitable diffusers to avoid bedroom discomfort.

The Packed Heat Pump system development did not fit the demo timelines and the requirements for support during installation and commissioning. An Mk2 model shown in 2022 differed significantly from the one shared earlier; therefore, integrating the new layout would have implied design changes that could not be considered as they impacted structural design and seismic risk evaluations and would oblige a new building permit request, with consequent delays. Relevant documentation (technical information and drawings, user manuals, and installer instructions) was also unavailable and offered remote commissioning and assistance service unsuitable for Abitcoop's business, which required a local assistance/dealer. These conditions did not allow the LDWG to implement the PHP in the Italian demo, despite the product being considered very interesting for the application. LDWG run the process of selecting an alternative technology.

From a climate perspective, both heating degree day (HDD) and cooling degree day (CDD) are relatively high, and humidity can reach high levels in summer. This means that heating, cooling and ventilation are essential and must work smoothly. Despite heating and cooling need peaks that could be mitigated by proper design and control of envelope components, the HVAC system should be selected carefully to provide good performance in both summer and winter without penalising comfort and user expectations.

From a cultural perspective, Italian owners have specific expectations regarding indoor comfort, targeting comfortable temperature and humidity conditions. It is also common praxis to adopt flexible and modular systems so that customisation and additional systems can still be opted-in when selling the dwellings.

Abitcoop also has specific needs as a company. By their statute, Abitcoop continues to assist the dwelling owners after sales, not only because of legal constraints and because Abitcoop brand is renowned locally for quality and high customer satisfaction but also because the owners are cooperative associates first. On these premises, introducing a component that is not tested and ready for installation in the dwellings for sale is impossible.

Different alternatives have been evaluated based on the above considerations while preserving the project goals of positive energy balance, cost affordability and user acceptance.

The selection of alternatives has been made:

Firstly, considering the impact of different alternatives on the project objectives and the innovation level.

- multi-split system based on reversible air-air heat pump;
- based on replacing Ventive's compact unit with separate components (air-water HP, mechanical ventilation with HR, dehumidifier, heat storage), then performing both heating and cooling by an underfloor system;
- based on a compact unit (high efficiency, i.e. PassivHaus compliant).

This step outputs specifications (qualitative criteria) as:

- Minimum functionalities required: Heating, Cooling, DHW, and Ventilation;
- Suitable for installation in a dwelling (50-150 m2);
- Compliance with national and local regulations;
- High manufacturing quality, CE marked, accompanying documentation in Italian (datasheet, manuals, installation instructions), aftersales support;
- Installers/local retailers should be available for prompt repair and maintenance services;
- Compatible with Cultural-E project requirements

- Possibility to connect and control from supervisory/BMS system to allow for cooperation with other project technologies and interaction with users;
- Proven very low energy consumption;
- Be an innovative solution for PEB (at the component level or system level);
- Standard interfaces and connections/ducting;
- Flexibility and energy storage capabilities;
- Cost affordability.

Secondly, considering the quality criteria above, a list of suppliers has been contacted. The solution with a compact unit providing HVAC/R by air distribution, supplemented by ducted split AC units, has been selected.

A pre-tempering water supply to HVAC/R units has been applied using a passive ground probe under the parking lot to increase heating and cooling efficiency.

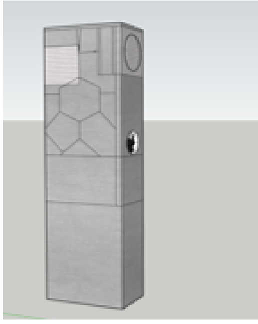
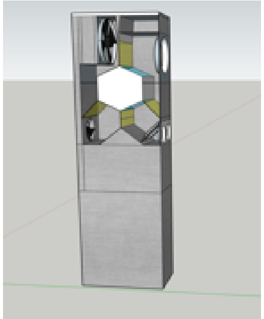
Further, the larger dwellings are connected to a centralised heat storage fed by solar thermal panels to increase the dwelling's efficiency in heating mode and reduce the need for active heating.

The table below describes the decision process for this equipment.

All Demo cases

ventive

Decentralized Pack Heat Pump System

Objective

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
27/08/2020	According to the preliminary analysis (dynamic energy simulations) on predicted heating and cooling loads of the building, the PHP is considered suitable for the application. Eurac proposed a scheme for aeraulic distribution.	(EURAC) to check with Ventive if possible to include a backup electrical resistance (ABITCOOP) to define ductwork system for all the apartments and share it with ventive and eurac	29/09/2020	
29/09/2020	PHP will be installed in a dedicated shelf on the balcony of each apartment. Heating system distribution is a radiant floor system under specific request from abitcoop.	(ABITCOOP) to send specifications for space heating (mass flow, pressure head and supply temperature) to Eurac and Ventive	10/06/2020	checked on 31/3/2021: specification for space heating and cooling shared. AbitCoop will need to provide interface (hyd. separator, mixing valve, circulator, actuators at the manifold).
31/03/2021	PHP does not provide control of UFH (mix valve, circulator, actuators). Eurac proposed that HMS could control these devices instead of purchasing a commercially available control and room sensors.	[Eurac] share the information with AdSys and AbitCoop. To consider before defining electrical plants/provisioning		
	2_Concept design			
31/03/2021	PHP cannot manage UFH directly Also, hydraulic separator is needed		31/03/2021	
31/03/2021	noise insulation arount PHP and along air ducts needed		31/03/2021	
	3_Detailed design			
31/03/2021	obtained tech specs for demo designer on 19/3/2021 and 29/3/2021. AbitCoop can continue/Review design steps	Eurac and NBK check information AbitCoop can review architectural, electric plant, HVAC plant design AbitCoop can apply for permission to build	31/03/2021	
27/05/2021	integrated in electrical design			
	4_Manufacturing of the selected product			
	5_Delivery			
01/06/2022	HP cannot be delivered on time for testing and finalization of units. First prototypes not working properly. Needed guarantees missing (i.e. docs, maintenance agreement) for finalizing desing	NILAN Compact P unit chosen	01/06/2022	

4.3.3 Ceiling Fan for smart air movement – Vortice

Ceiling fans can effectively provide comfortable cooling in warm environments, complementing and/or replacing active cooling systems. The smart ceiling fan automatically adapts its rotational speed based on the temperature and relative humidity values measured in the room. Moreover, the ceiling fan coordinates its action with cooling and ventilation systems for an energy-efficient, comfortable, healthy indoor environment.

Since the initial stage, LDWG recognised that ceiling fans could be an excellent option to reduce cooling loads, especially in the living rooms and kitchens. As the benefit to the user relies on the increased evaporation from the skin, their usage in bedrooms was not foreseen initially.

It was also agreed that user preference had to be considered a priority while the ceiling fan could operate autonomously.

The positioning of the ceiling fans was not trivial to define. They had to be positioned in the room's centre, but lighting had similar requirements. Putting rotating blades close to lights would cause light flickering; thus, the positioning and type of lighting had to be defined carefully.

The minimum height for the rotating blades posed an issue at a later stage, once the ceiling height had to be reduced to allow for enough space for running air distribution, and a plasterboard layer was added. The LDWG and technology provider co-designed a new solution that allowed for shortening the stem length (bearing the blades) and reducing the footprint of the product's base. The updated version also hosts light on the stem, which solves the flickering issue.

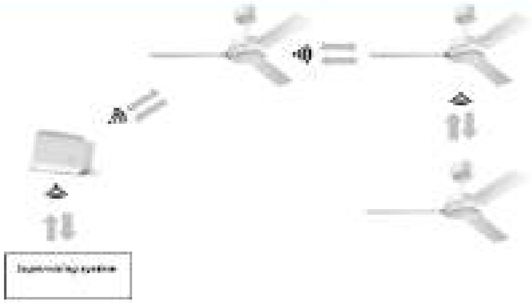
The table below describes the decision process for this equipment.

Last update
27/02/2023
Cristian Pozza

All Demo cases

Technology provider:

Ceiling fan - smart air movement



Objective

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
27/08/2020	Ceiling fan installation can be a good option to reduce cooling loads and abitcoop is definitely interested. Installation is feasible in the living rooms and kitchens: 2 ceiling fans/apartment.	(ABITCOOP) to prepare a proposal prepares for the location of ceiling fans on the apartment internal layout. To be discussed with eurac, unive and vortice (EURAC) to verify if installation in bedrooms is feasible	29/08/2020	
29/09/2020	High level of control for ceiling fan activation will be done through the HMS according to PHP control. Users will always keep the option for manual control.	(EURAC) to organize a meeting between ABITCOOP, ADSYS and VORTICE to define architectural integration of fans and other design/existing conditions	31/10/2020	done
12/04/2020	Demo owner requirements: - ceiling fan installed in both living and bedroom zone (ca 3-4 ceiling fan/apartment) - control based on presence of occupants - ceiling fan shall provide support to the cooling system during peak loads HMS shall supervise the ceiling fan and cooling system control prioritizing comfort when the apartement is occupied and energy savings when it is not occupied	VORTICE does a proposal for the installation and make a first budget estimation	12/11/2020	done
27/01/2021	Demo owner and Vortice decided to reduce the number of fans to meet the budget constraints (one in the living room and one in the two bedrooms, not foreseen in the kitchen and in the third bedroom).	[VORTICE] Vortice will produce more simulations to support this decision.	TBD	
	2_Concept design			
	3_Detailed design			
27/05/2021	integrated in electrical design		27/05/2021	
	4_Manufacturing of the selected product			
01/10/2022	Issues with heights and aestetics.	[VORTICE] Vortice will apply changes to base/anchors.		
	5_Delivery			
27/02/2023	Conditions agreed			

4.3.4 Cloud Based House Management System (HMS) – AdvanticSys

The Cloud Base House Management System (HMS) combines indoor and outdoor sensors data, RES production, common electric or thermal storages and web services to minimise and optimise energy consumption. Based on a distributed cloud infrastructure, it implements the logics to operate the different systems. The HMS behaves as a typical building management system at the apartment level with extended capabilities at the cloud level, such as advanced control strategies that run in real-time. Additionally, a user interface is developed to communicate information to all users (tenants, facility managers, building owners, etc.) in an open, standardised way.

As a first step, the LDWG and technology partner cooperated in drafting a proper architecture for the field devices and connections to each subsystem. The LDWG outlined a specific requirement about the system’s reliability in case of connectivity loss. In this case, the user should be allowed to get minimal information and operate key actions on the technical building systems through the HMS components in the dwelling.

A second decision was taken about the monitoring. As 1) most of the information foreseen for demonstration purposes (metering and IEQ monitoring) could be conveniently collected on the cloud by the HMS instead of introducing invasive redundant systems, and 2) the HMS could provide the end user with the resulting KPIs, it was decided to connect all sensors and metering to the HMS.

At the building level, a technical vane hosting PV’s inverters and batteries was dedicated to hosting the HMS hardware. At the dwelling level, most HMS hardware was positioned in electrical boxes facing stairwells. As Abitcoop requires a local dealer/assistance for installed systems, a local installer will provide hardware for managing field-bus connectivity and minimal control of devices and subsystems. The technology provider will remotely configure a field gateway to communicate and control Sensors, devices, subsystems and the HMS.

A building field controller will connect to building common spaces and systems. Each dwelling field controller will connect to the dwelling’s sensors, devices and subsystems. The overall system is designed to allow at least minimal interaction/control for the user.

Advanced information from HMS is provided by a user app on a tablet. This directly connects to HMS and requires an active connection to the cloud.

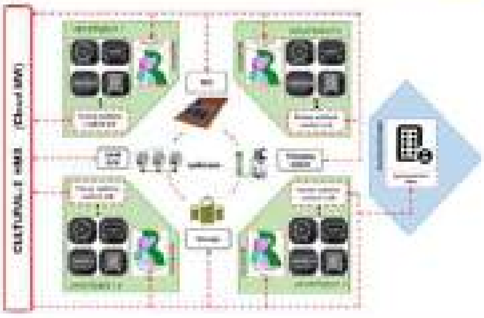
The table below describes the decision process for this equipment.

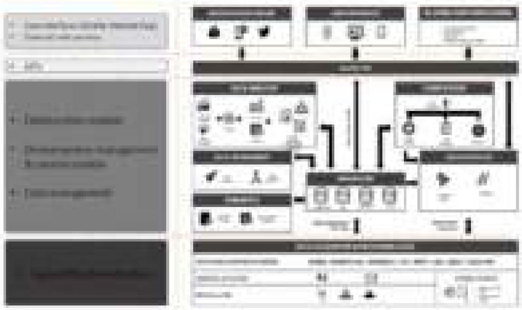
Last update
27/02/2023
Cristian Pozza

Technology provider:

All Demo cases

Cloud-based House Management System





Objective

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
29/09/2020	need to define a general system architecture for building monitoring and integrated technology control.	(ADSYS + PP involved) to define general system architecture and sensors to be installed for building monitoring and technology control.	30/11/2020	
	2_Concept design			
01/02/2021	Monitoring of pilot building requires a draft before proceeding with electrical plant design	[Eurac] share first draft of required sensors and metering for reference building	28/02/2021	
27/05/2021	Architecture agreed. Tech room will host a local server for exposing metering and weather station as service on LAN. Each dwelling server deal with local metering and sensors, gathers data from tech room server, connects to HELLA local gateway, connects to cloud as a single entity.			
	3_Detailed design			
01/09/2022	Important to get info from WP4 logics asap.			
26/02/2023	Field components not to be supplied by Adsys.	[ADSYS] to provide field gateway		

4.3.5 Monitoring system

The Monitoring system comprises:

- All the sensors and meters installed as fixed in the buildings (PEB and reference nZEB); it collects the data from the equipment, the dwellings and the common areas needed to feed the HMS (temperature, relative humidity, CO2).
- All the sensors and meters installed temporarily in the buildings for running a specific measurement (noise, lux, particulate)

It was decided to avoid redundant sensors (sensors for the project scope and sensors for the HMS); therefore, most IEQ sensors (temperature, relative humidity, CO2) have been installed and connected to the HMS for nearly real-time data collection. The status of subsystems and devices (i.e. dwelling mode, windows contacts) and energy metering (lighting, appliances, HVAC, PV production, energy exchanged with grid) are also tracked.

Both the quality of the measurement and the appearance of the sensor had to be considered.

The table below describes the decision process for this equipment.

Last update 27/05/2021 Cristian Pozza	*Last update*			Technology provider:

All Demo cases

Monitoring system				
Objective				
Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
28/09/2020	We will monitor also building C as reference building. EURAC did a first budget estimation.	(EURAC) to include in the 2nd amendment the budget shift request for the monitoring of the reference building	31/10/2020	2nd amendment not submitted yet
	2_Concept design			
01/02/2021	Monitoring of ref building will include HMS backbone	[Eurac] share first draft of required sensors and metering for reference building [Eurac] ask green light to [AdSys]	28/02/2021	

4.3.6 BIPV and electric storage

The photovoltaic panels and associated electric systems are installed to cover the energy needs of the building, according to the PEB definition used by the demo site owner. Electric storage enables flexibility.

LDWG evaluated the optimal size for PV and batteries based on energy simulations and considering different scenarios, including:

- Each dwelling is connected to its own PV system and batteries.
- All dwellings share the same PV plant and batteries, joining an energy community.

A techno-economical analysis showed that lower capacity for PV plants was needed in the case of PV shared across buildings and in an energy community.

At design, installing batteries was not economically convenient based on Italian-specific energy market rules and rewarding. Also, management costs for an energy community were unclear and likely too high/risky for AbitCoop, as no precise regulation was established on the benefits repartition between users. Finally, based on the existing regulation, sharing a PV plant of relevant peak power across different users would have implied sizing all the dwellings' electrical systems as a 3-phase system, raising costs and complexity without generating a comparable benefit.

It was decided to install PV systems serving the individual dwellings, oversize the PV system and electrical installations in the dwellings (still in the 1-phase range), and design it for future adaptation of connections and/or join all the apartments in an energy community. The battery size meets self-sufficiency targets based on estimated load profiles, including user appliances and HVAC.

The same PV and battery size (5.5 kWp, 6 kWh, respectively) were adopted for all the apartments to ease management with suppliers and the energy supplier (while remaining below the 6kW threshold).

A technical room hosting inverters and batteries was foreseen on the ground floor. DC cabling runs from the roof to the ground floor in insulated ducts.

The table below describes the decision process for this equipment.

Last update: 27/02/2023
Cristian Pozza

Technology provider:

All Demo cases

BIPV & electric storage

Objective

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
27/08/2020	EURAC presented the results of optimization analysis in the case of shared PV plant for all building apartments (energy community) and single small PV plants for each apartment. Lower capacity is needed for the PV system (ca 35 kWp) in the case of energy community compared to the overall capacity installed in the case of single PV plants (ca 50 kWp). Battery installation is not convenient economically for the specific case in the present electricity power market in Italy. However, management costs for energy community are too high for abitcoop and there are still no clear rules on how to share benefits among the users. abitcoop agreed to keep PV-battery plants separated for each apartment but to oversize them in order to face future increase of electricity consumption, changes in energy fees and have the option to switch to energy community in case the users want to do that in the future.	(ABITCOOP) sends detailed roof plans with useful surface of PV and potential increase of roof surface possible (EURAC) run simulations with positive energy balance option and batteries	30/09/2020	
26/10/2020	ABITCOOP and EURAC agreed to have same PV plat size for each apartment < 6kW because it is easier to manage contracts with the energy supplier. Therefore, the production of the PV plant need to be maximized. Technical room for inverters and batteries can be placed at ground floor. DC cables run from roof to ground floor through insulated ducts.	(ABITCOOP) to check with the architect if possible to have a pitched roof instead of a flat one and provides input needed for the economic analysis (EURAC) to run again simulations with 6 kW PV plant/apartment installed on a pitched roof (10° inclination) and batteries (EURAC) to provide suggestions on PV module types to maximize efficiency and on battery requirements	18/02/2021	5 kW PV. 6 kWh battery
	2_Concept design			
27/06/2021	ADSYS suggests specs for inverter (Communication)			

4.3.7 E-Mobility charging stations

It comprises the e-mobility charging stations and the associated electric system.

At an early stage, it was foreseen to install a 3 kW wall box EV charging station in each garage. The installation cost was too high regarding the benefit, as many new owners are likely not to own an electric vehicle soon. Therefore, it was planned to run ducting as a predisposition, thus leaving the new owner the choice for customisation.

The table below describes the decision process for this equipment.

Last update 27/02/2023 Cristian Pozza | *Last update* | Technology provider:

All Demo cases

E - mobility charging station

Objective

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
26/10/2020	3 kW wall box to be installed in each garage for EV charging stations.			
	2_Concept design			
01/02/2021	charging station predisposed (not installed). Add metering.			

5 Baerum, Norway – Baerum Municipality

5.1 Description of the demonstration site

5.1.1 General information

The Norwegian demo owner is Bærum Municipality, and the building is located just outside (11 km) Oslo City Centre. The climate can be classified as subarctic, but due to proximity to the coast, the winters are not extremely cold, and summer temperatures are fair. The mean temperature in January is -3 °C and 18 °C in July. There are about 2400 sun hours a year, and precipitation is about 700 mm per year (snow in the winter and rain in the summer).

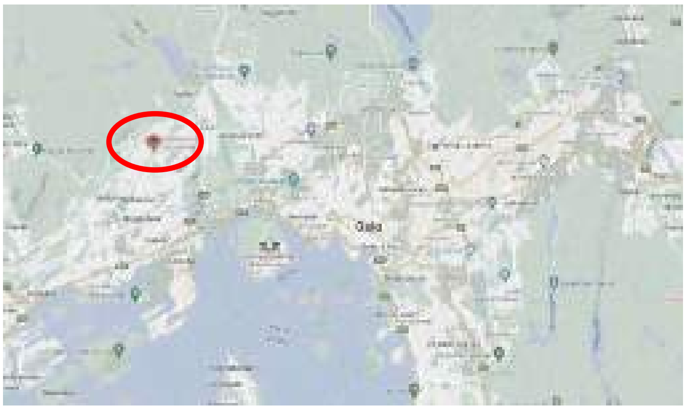


FIGURE 22 - MAP: EIKSVEIEN 116 IS LOCATED JUST OUTSIDE NORWAY'S CAPITAL, OSLO.

Eiksveien 116 was included in the project during the construction phase (end phase). The building is still "run-in" phase, which will be over in May 2023.

The decisions regarding solutions and technologies implemented in this building were taken before the Cultural-E project started. These technologies and solutions sets were aligned with the Cultural-E project and, with minor new additions, the demo would provide information and data. Bærum Municipality was therefore invited to join the Cultural-E project.

The Norwegian building code describes the minimum requirements for any new building. However, Bærum Municipality wanted to go further in environmental impact and clever climate solutions, cooperating closely with residents and commercial and academic interests. By 2050, Bærum municipality should be a low-carbon emission community, and this building should be part of the solutions. Bærum Municipality and its design team had certain building criteria they wanted to reach and implement. The building should be a Futurebuilt project and should achieve BREAM-Nor Excellent. The following requirements had to be met to reach this goal:

- Zero-emission construction site;
- Circular economy/construction requirements;
- Universal design;
- Local headwater management and climate adaptation;

- The building should be near zero energy standard (Futurebuilit);
- Plus Energy building solutions and local energy storage should be assessed;
- Energy solutions (electrical consumption and heating) should be from a renewable source;
- Heating should be provided by heat pumps with energy wells;
- Passive measures should be implemented to provide cooling (blinds);
- Photovoltaic panels on the roof must be installed;
- Low-energy bulbs for lighting should be used;
- Materials used should be low-carbon emission materials;
- Innovative use of wood elements and use of precut wood elements, modules of solid wood. The use of solid wood will give flexibility at assembly and disassembly;
- The materials must also tolerate high stress, have long maintenance intervals and contribute to low total carbon emissions. Materials with a low carbon footprint must be used;
- The material in the building should also facilitate a healthy indoor climate.

During the run-in phase, the contractor operates and tests the building. Bærum Municipality planned to take over all the responsibilities, including technical systems, in august 2022, but troubles in the run-in phase have postponed the takeover. At takeover, the official logging period will start.

The building is part of the "Assisted living and welfare technology" program. Bærum municipality financed the construction, but users can buy or rent their apartments. The building is managed round-the-clock by onsite staff, three workers at night and about 12 during the day. There are 12 units with one occupant per unit, and the building's total floor area is 1350m^2.

FIGURE 23 - PHOTO OF THE FINISHED BUILDING (COURTESY BÆRUM MUNICIPALITY).

The area per apartment is about 60 m^2. The building has three floors, with apartments on the second and third floors. The staff areas are on the ground floor, consisting of offices, meeting rooms and restrooms. The common areas on the 1st and 2nd floor are common living rooms with a kitchen and a hallway. Outside, there are parking areas with EVs and E-bike charging possibilities.

5.1.2 Solution set

5.1.2.1 Building level

Some of the solutions used are at the building level, and offices, common areas and apartments utilise them:

- The building envelope and windows are highly insulated;
- The centralised electric boiler heats the floor and preheats domestic water in the whole building;
- Limited floor heating control (±3 °C) in all rooms;
- The boiler is connected to the 20kW heat pump;
- The geothermal wells provide energy to the heat pump;
- Advanced HMS (control of offices and common areas and metering in the apartments);
- PV panels on the roof (20kWp) (energy input at building level);
- Battery pack (7kWh);
- Centralised demand-controlled ventilation system (DCV) (common areas and offices);
- Charge points for wheelchairs in the hallway;
- 4 charge points for EV outside;
- Motion detection light system in offices and common areas;
- An AMS meter registers all electric usage in offices and common areas.

These areas have the following solution sets (in addition to the above):

5.1.2.2 Apartments

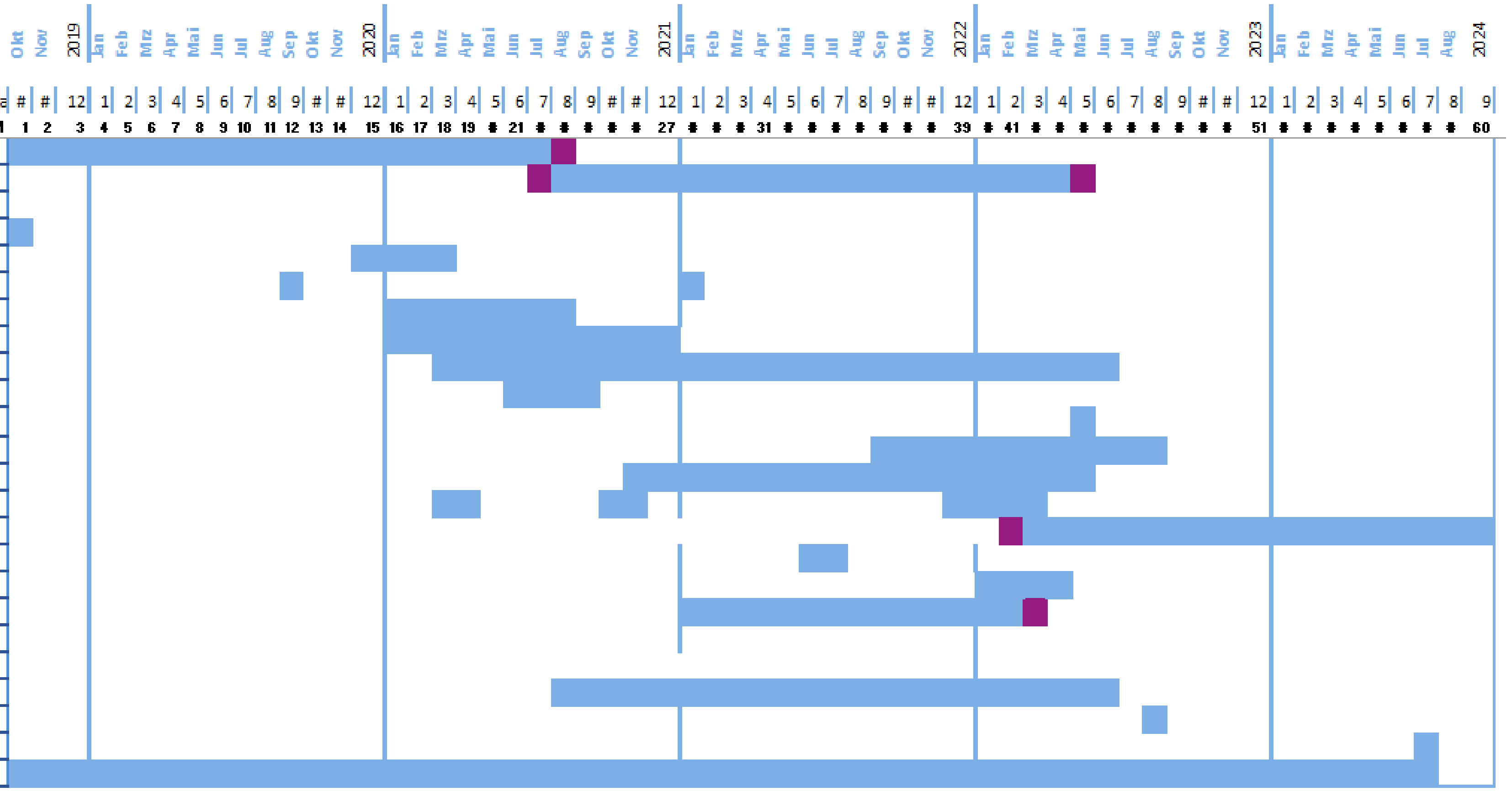
Some of the solutions above are also utilised by the apartments, while others are in apartments only:

- Automatic window blinds;
- Balanced mechanical ventilation with heat recovery;
- Electric floor heating bathroom (thermostat);
- A private AMS meter registers electricity usage for each apartment;
- Energy meters for each apartment measure hot water usage and heating.

5.2 Project timeline

Gantt_Main activities

	Milestones	Expected start date	Expected end date
Ongoing project (pre-Cultural-E)			16.08.2021
Commissioning / test period		16.07.2021	16.07.2022
Cultural-E Activities			
KOM		08.10.2019	09.10.2019
Establishment of LDWG following the Guidelines	MS2	01.12.2020	31.03.2021
Sharing of 2D/3D drawings (first version)		01.09.2020	01.09.2020
Expression of project needs in Cultural-E		01.01.2021	31.08.2021
Cultural-E project concept (new project or revision of previous standard version)		01.01.2021	31.08.2021
Configuration of HMS (with support by technology provider and Eurac)		01.03.2021	01.09.2021
(Updated) Energy simulation by Cultural-E project advisor		June 2021	
Confirmation by owner of the technical executive drawings made by the providers of cultural-e technologies			30.04.2023
Installation of Cultural-E technologies (HMS, complemental technologies)	MS11	01.09.2021	30.04.2023
(where necessary) Adjustment/debugging of the installed technologies		30.11.2021	30.04.2023
LCC and environmental assessment	Ongoing		30.04.2023
Monitoring	MS14-**M39**	01.11.2021	30.10.2022
Building labelling		15.06.2022	31.07.2022
POE (survey: interviews, ...)		01.08.2022	30.04.2023
Reporting of democase performance	MS16-**M54**	01.01.2022	31.03.2023
Production of User Manual by the Demo Owner	Not planned		
Interviews with designers	Not planned		
Production of Demo case video		16.08.2021	30.06.2023
Production of Vademecum by ACE		20.08.2023	20.08.2023
Organization of 1 open events for project visibility		30.06.2023	31.07.2023
Internal and external communication		01.10.2019	03.07.2024



Run in phase is still in progress. This phase has been extended several times and is now set to May 2023. In January 2023, the contractor responsible for the run-in phase paused his work and terminated his contract with Bærum Municipality, causing delays in the delivery and instalment of several Cultural-E components. Bærum Municipality took over the run-in phase in conjunction with external advisors in February 2023.

5.3 Technologies

Most of the solution sets and technologies implemented in the building were requirements from Bærum municipality and were included in the original tender documents. The requirements and decisions for the solutions at Eiksveien 116 were taken before the construction phase and before the building was included in the Cultural-E project. The original tender documents are, therefore, currently unavailable.

Building design and materials, window system and HVAC system were defined before the building was included in the Cultural-E project. However, the technologies have been evaluated from a local context perspective.

The active window system is not considered a relevant test object for the Norwegian demo. According to Building codes in Norway, energy-efficient balanced ventilation with 80% heat recovery and 0.8 W/(m^2 K) or better u-value for windows is expected for energy-efficient buildings. Separate ventilation units are installed in each dwelling, and a centralised demand-controlled ventilation system is installed in common areas.

A packed heat pump system would not be a relevant choice for the Norwegian demo. The building has a centralised heat pump and domestic hot water system for the whole building. Generally, for the Norwegian market, the preferable solution is one balanced ventilation system per apartment or a centralised balanced ventilation system for several apartments connected to the same staircase. Domestic hot water systems are often centralised for all flats, with an electrical heater in each apartment. The Scandinavian market is quite fragmented, and preferable solutions and practices differ. Packed heat pump systems are more relevant for the Swedish market, where Flexit is a competitor with similar solutions.

The ceiling height in Norwegian dwellings usually is 2.4 m. This is not fulfilling the needed height for the safe operation of ceiling fans. Some projects might have up to 2.7m ceiling height. However, up to now, cooling is not a standard solution for Norwegian dwellings. If used, cooling by air-to-air heat pumps is a standard solution in single-family houses. Cooling in the demo building can be done by a lower setpoint for water-based floor heating systems and cooling by ventilation in common areas. Prototypes for increased air movement are developed for office buildings; they are included in the ventilation system as personally controlled nozzles in the ceiling.

5.3.1 Installed Monitoring system and control

The demo building already had an advanced cloud-based BMS (or HMS) system through GK cloud and the Niagara system at the Municipality level. The building has advanced real-time control strategies for sensor-based demand-controlled ventilation (DCV) in common areas, optimal control of the heat pump and electrical boiler, sensor-based floor heating system, etc.

Setpoints, real measured values and historical data can be read at room level in real-time. Currently, the total signals/values possible to log are several hundred, but we do not need all of them for Cultural-E purposes. We are presently logging and sending 4 signals to Advanticsys and looking into about 250 other signals in the Cultural-E context. Due to restrictions from Bærum municipality, we cannot send all of the values. Only a few carefully selected values can be transmitted abroad and used in the Cultural-E project.

The Cloud-based House Management System (HMS) combines indoor and outdoor sensors data, RES production, common electric or thermal storages and web services to minimise and optimise energy consumption. Based on a distributed cloud infrastructure, it implements the logics to operate the different systems. The HMS behaves as a typical building management system at the apartment level with extended capabilities at the cloud level, such as advanced control strategies that run in real-time. Additionally, a user interface is developed to communicate information to all users (tenants, facility managers, building owners, etc.).

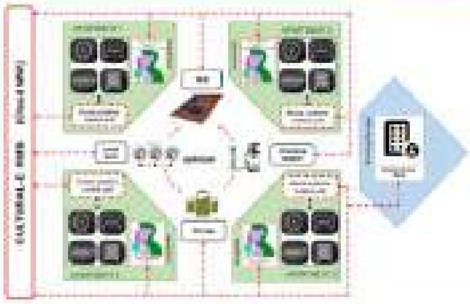
The Monitoring system comprises all the sensors and meters installed in the buildings (PEB and reference nZEB); it collects the data from the equipment, the dwellings and the common areas needed to feed the HMS.

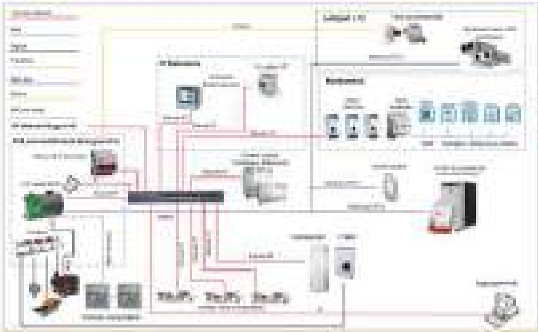
Monitoring system

Objective				
analysis of energy consumption in the apartments and the comercial units to show which level of plus energy building is reached. Giving				

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
Q1 2020	Bærum Municipality uses NIAGARA in several of their buildings	Technbology provider is GK inneklima		)
	2_Concept design			
	Data collection, and datatransfers possible			
	3_Detailed design			
	4_Manufacturing of the selected product			
	5_Delivery			
	Installed during building phase			
	6_Installation			
2020	Installed during building phase			
	7_Commissioning			
Q4 2022	Data collection and datatransfer		01.06.2023	Tested in Q4 2022. Selected data need to be sent to
	8_Monitoring			
Q1 2023	Testing until delivery	Ongoing run in phase	01.06.2023	removing errors and debugging
	9_Evaluation			
Q1 2023	Data not selected		01.09.2023	Some data are protected (privacy)
	Final solution			
Q1 2023	NIAGARA	Data collecting can be done by the HMS-System.		Automatic sending and sent to Advant of selected data

Cloud-based House Management System





Objective

Accesible control system in cloud.

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
2020	Solution in original tender documents. HMS to be controlled by Bærum municipality			System is cloud based. Magero , see Monit system
	2_Concept design			
	Bærum Municipality will not allow outside company control			Can implement some changes suggested by cultural E partners

5.3.2 Ventilation systems

Control in common areas

The air-handling unit for common areas and offices is a DCV, or Demand Controlled Ventilation system. It is installed in the technical room on the ground floor. A Variable Airflow Valve (VAV) regulates the airflow in each room, which controls heat, cooling and CO2. Setpoints for the parameters are set in the HMS. In each room, a sensor regulates the VAV in sequence with the floor heating. With increased temperature or CO2 over setpoint, the air volume will increase, and floor heat will decrease, and vice versa.

Control in apartments

Each apartment has one air handling unit (placed in the storage room). This unit is a balanced mechanical ventilation system with heat recovery (84 – 86 %). It is a CAV or Constant air volume unit. The residents locally control it. The controls are limited to only a few settings. They should be used mainly in winter or summertime. The unit is connected to the HMS by Modbus RTU, but the unit cannot be controlled. Temperature and air volume can be monitored in the HMS.

HVAC

Objective

Required ventilation and heat recovery

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
2020	Solution in original tender documents. Separate airhandlingunits for each appartments. One larger ventilastion system for common areas and offices.			Separate unit locally controlled in appartments by residents. Temeprature can be monitored in HMS. Ventiltion in common areas and offices are controlled in cloud based HMS.
	2_Concept design			
	The norwegian building code demands air handling units with heat recovery.			
	3_Detailed design			
	n/a			

Sensors

Several sensors are necessary for the HMS operation. For instance, the CO2 and temperature sensors give input to the ventilation system. In addition, there are energy meters on technical units like the heat pump and boiler. Temperature meters are installed on the domestic water inlet and the water-based floor heating system.

A true occupancy detector activates some indoor lights in the common areas/offices. The window blinds are controlled by a sun detector mounted outside the building.

Information on airing habits (windows open/closed) and door opening/closing is required to optimise energy conservation and understand the usage of the building (habits of the residents). Therefore, part of the Cultural-E procurements will include wireless sensors on doors and windows in some apartments. This is a separate system which is not connected to the HMS system.

5.3.3 Window blinds and windows used for airing

The window blinds are controlled by daylight detectors and provide shade when solar radiations are too intense, enabling indoor temperature control.

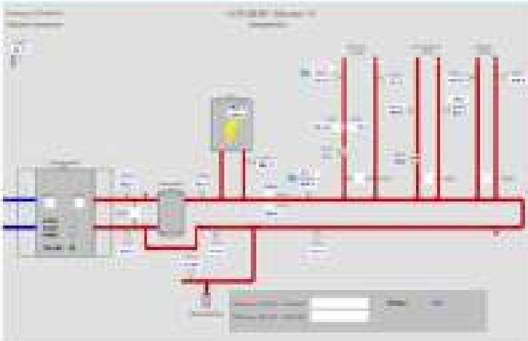
A daylight detector automatically controls the blinds, which may also be controlled manually from within each apartment. Blinds are also used for visual protection while caring for the users; they should not open during care activities. The blind position is not registered in the original BMS system.

Blinds are not mounted for all apartments. Detailed simulations showed a possible need for more shading. These apartments will be under detailed monitoring. Simulations also showed window airing can be crucial for indoor summer temperatures. Extra wireless sensors will be installed in apartments to monitor airing habits and the use of closed blinds.

5.3.4 Centralised heat pump system

The 20kW heat pump is designed to cover about 85% of the energy used by the ventilation, transmission/infiltration heat and hot water. The peak loads and backup heat will be provided with a 36-kW electric boiler. The system collects energy from the energy wells, and the energy is distributed around the building according to the scheme below. The table below describes the decision process for this equipment.

Centralized heat pump system



Objective

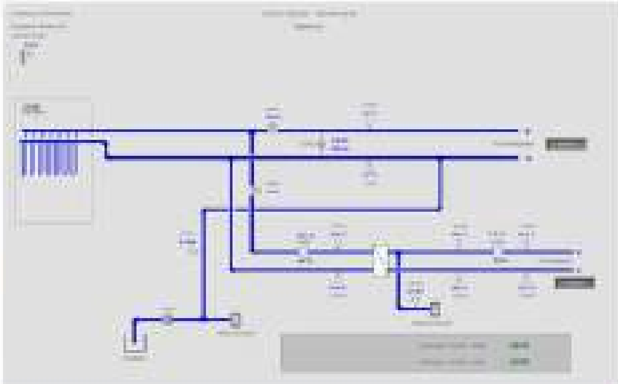
Heatpump (in combination with eletric boiler) delivers waterbased floor heating and preheats domestic water

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
2019	20 kW Heatpump in combination with electric boiler			Heatpumps are required in order to reach the low energy demands requiremtnt in BREEAM and
	2_Concept design			
2019	Heatpump chosen in prestudy and "BREEAM Ene 4" memorandum			to be included in tender documents
	3_Detailed design			
	4_Manufacturing of the selected product			
	5_Delivery			
	6_Installation			
Q1 2021	Connection between heatpump and energy well established			
	7_Commissioning			
01.04.2022	2 months after start, one pump shut down			new pump orderer, and installed in august 2022
	8_Monitoring			
Q1 2023	Monitoring temperature data			
	9_Evaluation			
Q1 2023	in progress		01.05.2023	
	Final solution			
Q1 2023	As described			operational

5.3.5 Thermal storage

The requirements for a renewable energy source were met by adding geothermal energy wells outside of the building. These energy wells are 250m deep and provide energy to the heat pump. The table below describes the decision process for this equipment.

Thermal storage



Objective

Energysource for heatpump and heatstorage

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
01.11.2018	Requirement to have thermal storage described in common "functional description-Bok.2" from Bærum municipality			Decission taken early. Included in original tender documents and before Cultural E
	2_Concept design			
	Need to install enough enerywells to give energy to heatpump.			
	3_Detailed design			
	3 energy wells at 250m depth			
	4_Manufacturing of the selected product			
	n/a			
	5_Delivery			
Q4 2019	Placement of wells			
	6_Installation			
Q4 2019	Drilling of wells			
	7_Commissioning			
	8_Monitoring			
Q1 2021	Connection between heatpump and well established			
	9_Evaluation			
	n/a			
	Final solution			
Q1 2023	3 Energy wells connected to heatpump			operational

5.3.6 PV panels on the roof

The photovoltaic panels and associated electric systems are installed to cover the energy needs of the building, according to the PEB definition used by the demo site owner. The roof should have an optimal ratio between PV and Bluegreen roofing system to reach level Excellent in BREEAM-Nor. About half of the roof comprises green plants with water absorption abilities.

The PV system does not communicate with the HMS because the communication equipment between the HMS and PV is not yet installed. The installation process is, however, underway. The PV is connected to the building's energy system, so solar radiation will provide extra energy. During most of the months, this energy will be used locally in the building (net import of energy), but during hot days in the summer, there will probably be energy export to the electrical grid. Currently, the only way to see the energy production from the PV is on the control unit in the technical room. Real-time (current status) energy production is shown on display.

We have done several simulations with an increased PV area on the roof to see if we can reach PEB requirements. We now have a PV panel area of about 137 m^2 generating about 20 053 kWh. The simulation predicts we will reach PEB target with a 180m^2 area. In addition to the simulation, an LCA calculation was performed on additional PV. When using the Norwegian electric mix as a reference, the results show a beneficial outcome of more PV. In any case, this increase in the PV area is expensive and must be evaluated before the procurement as an additional Cultural-E solution.

The table below describes the decision process for the PV panels.

PV panels roof

Objective

Provide additional energy to building. Sell energy back to grid when sun gives energy surplus.

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
25.05.2020	Described in document "functional description" from Bluetec			Requirements from Bærum Municipality in original tender documents before CulturalE
	2_Concept design			
18.08.2020	Discussion of size and incline. 137m2, 23 kWp PV.			
	3_Detailed design			
18.08.2020	Connection to HMS voted down. Investigating M-Bus option			Result: No decision. No HMS connection and No m-Bus
	4_Manufacturing of the selected product			
	ZNShine PV-Tech Co.ltd are manufacturer			
	5_Delivery			
	6_Installation			
	Bluetec installed the PV systems.		01.08.2022	
	7_Commissioning			
15.09.2020	PV installed, but not connected to HMS.			Energy production from PV not available on HMS, but system produces energy
	8_Monitoring			
Q3 2022	Monitoring of PV not available	Must be integrated in HMS	01.05.2023	Monitoring was originally part of contract. Contractor responsible for the run in phase did not follow up on this. Also there are noe connection beetween HMS and PV panels. Energy from panels goes directly into building grid.
	9_Evaluation			
01.07.2022	Procuring more PV to reach PEB status	Simulated PV production vs energy consumation in IDA ICE	01.05.2023	Energy production generate about 20 053 kWh from 137 m2. Eikseveien 116 has passive house standard, but we want PEB standard. With the current PV solution we are about 25 663 kWh short of compliant PEB level 1. The PV production was not scaled with PEB in mind in design stage. Now less than 50% of available surface space on roof is utilized with PV. We have been looked at the possibilities to increase the PV area with additional panels. The increase would be 180 m2. With This would give 26 381
	Final solution			
01.02.2023	More PV panels.	Evaluate real life energy consumation and PV panel production. Re-estimate increase	01.05.2023	Need approval from Eurac
01.02.2023	Connect to HMS	Install equipemnt for HMS communication	01.02.2023	Bluetect difficult to reach and time-consuming procurement process in Bærum municipality

5.3.7 E-mobility charging stations

The building has 4 EV charging stations and associated electrical systems. The tenants of the building are not capable of driving; the charging is relevant for the employees. Charging patterns were expected to derive from a typical apartment building with main charging in the evening and night, but since the user (employees) is different than expected, the patterns may differ. The charge stations are currently "plug-and-play, " meaning they charge when an e-vehicle is connected. Currently, the only way to control charge speed and time is through the e-vehicles onboard charging app.

Since the charging system is limited in size, it doesn't have an advanced control system for delayed charging as relevant for MPC control. A separate energy meter connected to the BMS is installed for Cultural-E purposes. Monitoring is crucial and will generate new knowledge of charging patterns for this type of buildings.

E - mobility charging station

Objective				
EV chargingstation for residents/employes				

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
Q4 2018	Futurebuilt requirments: Chargestations in combination with battery and PV			Described Bærum municipality FutureBuilt quality program
	2_Concept design			
Q4 2020	Described solution in "energirapport"			Decission taken early. Included in original tender documents
	3_Detailed design			
	described and decide in buildingguide and later tender documents			
	4_Manufacturing of the selected product			
	Eeasee Charge points			Off shelf product
	5_Delivery			
	n/a			
	6_Installation			
	n/a			
	7_Commissioning			
	n/a			
	8_Monitoring			
Q1 2023	No monitoring			
	9_Evaluation			
Q1 2023	evalutated during run in phase	Need to power consumtion. Meter need to be inst	30.04.2023	Used daily by staff, but there is no logging of power usage
	Final solution			
Q1 2023	4 Easee Chargepoint	Need to install meter for logging. One meter for all 4 chargers.	30.04.2023	Chargers also have possibility to be controlled by App, but this technology is not planned used.

5.3.8 Electrical storage

Electric storage enables flexibility, storing the energy produced by the PV panels, which becomes available when energy is consumed in the building. The demo site has a 7.2kWh battery pack installed on an outdoor shelf. The batteries have limited storage capacity compared to production, and a trial option for storage is included. The control system for the batteries needs further product development to be fully optimised for MPC use. Ongoing dialogue for battery control development is slow due to the heavy demand for PV and storage systems in Norway. The current order of Bærum municipality to a contractor is only for the battery to be connected to the HMS.

Battery control options are, however, several. The vendor can supply a control option which regulates the battery input/output according to the electricity price. Another option is based on the vendors' system, but we can create control algorithms based on setpoints or threshold values according to our specifications. The latter is more complicated and requires additional procurements in the form of working hours programming the algorithm. The table below describes the decision process for this equipment.

Electric storage

Objective				
Provide energy when energy prices are high and/or to counteract energy peaks (peak shaving)				
Date	**Phase and decisions**	**To dos**	**Deadline**	**Remarks**
	1_Selection of technology			
26.10.2018	Requirement to have battery in the building is described in the zoning plan from Bærum municipality			Decision taken early. Included in original tender documents and before Cultural E.
	2_Concept design			
########	Suggested control solutions for battery described in document "functional description" (Bluetec).			Several control options suggested: 1. Peakshaving-setpoint adjustable. 2. Storing energy in daytime-Release nighttime. 3. Backup power if power failure/loss.
	3_Detailed design			
	Battery is "off shelf" product.			Batterypack has limited capacity
	4_Manufacturing of the selected product			
	Pixii is battery supplier			
	5_Delivery			
	Bluetec installed the systems.			
	6_Installation			
	Installed during building phase. 7,2 kWh Battery			
	7_Commissioning			
Q3 2022	Battery installed but without control unit			No control over battery. Unclear how function is.
	8_Monitoring			
Q4 2022	No control unit in battery. No option for control and monitoring of power.	to be integrated in HMS with control options		Control option was originally planned. But it was not implemented.
	9_Evaluation			
Q1 2023	Unable to evaluate			Do not know if or how it works
	Final solution			
Q1 2023	Battery control unit to be connected	Must be installed before run in phase is finished	30.04.2023	Procurement in progress. Several options possible: 1-Battery control intergated with AMS- Control by pixii system (e.g price). 2. Control integrated in HMS- Parameters for control must be programmed.

<u>Improvements, data transfer and MPC possibilities</u>

Several errors have been detected (and corrected) in the run-in phase. Mostly, addressing errors occurred between the room number and meter address (wrong room number on the meter/valve). Also, some values on temperature/energy use are too high or too low. For instance, one room has a high floor temperature because the air in the ventilation system is low. This increases unnecessary energy usage from this floor circuit. Fixing the errors will result in better energy use (and a better indoor climate), and the building will behave according to the simulated model.

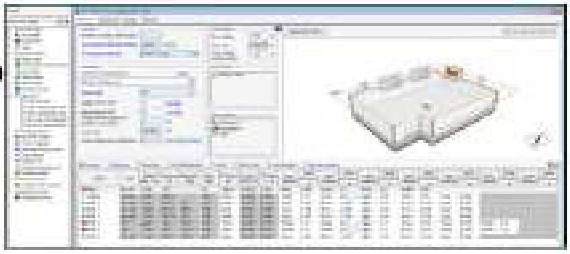
5.3.9 Simulation

The energy and indoor environment calculations were performed with dynamic simulations via the IDA Indoor Climate and Energy (IDA-ICE) software. The platform offers a good balance between solid mathematical modelling and a user-friendly graphical interface, making it possible to model all the systems of the building.

The overall energy usage was calculated to be 45 715 kWh, and the PV to produce 20 052 kWh. With the current PV solution, we are about 25 663 kWh short of the "compliant" PEB target. The building is classified as BREEAM Excellent, meaning the building's performance is within the top 10% and reaches a Passivhaus standard., even if the PV production was not scaled with the PEB target in mind in the design stage.

Simulation

Simulation of building with IDA-ICA 4.8



Objective

Evaluate energy consumption and thermal comfort. Study Cultural-E changes before implementing in building

Date	Phase and decisions	To dos	Deadline	Remarks
	1_Selection of technology			
Q3 2022	Building technology in place before Cultural E			Requirements from Bærum Municipality in original tender documents before part of Cultural E
	2_Concept design			
	Simulation for selcting additional Cultural-E components			
	3_Detailed design			
	4_Manufacturing of the selected products			
	5_Delivery			
	6_Installation			
	7_Commissioning			
	8_Monitoring			
Q3 2022	Simulation of building with IDA-ICA 4.8			Findings: 25 863 kWh short of compliant PEB The building is extremely energy efficient, however PV production was not scaled with PEB in mind in design stage Less than 50% of available surface space on roof is utilized
Q1 2023	Simulation vs real building	Evaluated after takeover	01.06.2023	
	9_Evaluation			
Q2 2023	Use tool to justify more PV/Battery		01.06.2023	If PV area is extended with 180 m2, net energy balance (over a year) is positiv. Building can then be categorized as PEB1
	Final solution			

6 Conclusion

The present report compiles the information gathered in the Decision Tracking Tool (DTT) by the demo owners and technical advisors along the design journey. The intent of the DTT was to keep track of the process and decisions related to building design and Cultural-E technologies' integration.

CULTURAL-E develops specific technologies and tailored solution sets suitable for different climatic and cultural contexts. The report shows that some technologies were not installed in all four demonstration sites because of technical and/or cultural reasons. For instance, the limited ceiling height didn't allow the installation of smart ceiling fans in France, Germany (installation only in the commercial area), or Norway.

Consequently, the technology developers must adapt their products to a selected market segment and be competitive. For that purpose, they need feedback from the stakeholders involved in the design, installation, exploitation and maintenance process to adapt their product to the climatic and cultural contexts of the markets they want to enter. Moreover, the technology developers must also identify the information their customers need for architectural and technical integration at the different stages of the real-estate project development (preliminary project, detailed design, tenders, construction/installation, commissioning, monitoring). Tracking the design process helps in such tasks.

In conclusion, since it helps the technology providers refine and adapt their products and identify the needs of potential customers, a tracking method is profitable for a project integrating technologies in development. The present report and the information gathered hereabove are a guide for the technology developers to access their target market.

Finally, the report exposes the decision processes that led to the final solution sets selected for each demo. It helps the partners of the Cultural-E project and the PEB developers analyse the cultural and climatic factors influencing the choices of solution sets and define suitable solution sets for each context.