COLLECTiEF

ACTION PLAN OF IMPLEMENTATION ACTIVITIES

Project acronym: COLLECTiEF

Project title: Collective Intelligence for Energy Flexibility

Call: H2020-LC-SC3-EE-2020-2

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Disclaimer

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Name	Organization
Runar Solli	EM SYSTEMER AS, EM
Italo Aldo Campodonico Avendano Mohammadreza Aghaei	NORGES TEKNISKNATURVITENSKAPELIGEUNIVERSITET, NTNU
Panayiotis Papadopoulos	CyI
Marco Pietrobon	R2M
Peter Riederer	CSTB

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Executive Summary

Deliverable 4.2 describes the status of the pilot buildings, using the SRI assessment, both before and after deployment of the COLLECTiEF solution. The deliverable identifies and describes the field devices needed in order to deploy the solution, including a description of the BMS system in the Norwegian pilots and how the interfacing with the COLLECTiEF solution will be performed. Lastly the deliverable contains a timeline of activities for deployment of the COLLECTiEF solution on all the pilot buildings, with a discussion on foreseen risks and mitigation strategies.

Chapter 2 describes the characteristics of the legacy equipment for all the pilot buildings based on the SRI assessment. The chapter break down the SRI score in detail, showing the impact scores and the domain scores respectively for each pilot building in the project.

Chapter 3 contains an introduction to BMS systems, and a thorough description of the BMS system residing in the Norwegian pilot buildings. It describes the different REST API calls that will be used within the COLLECTiEF solution.

Chapter 4 show the result of an SRI assessment based on the deployment of the COLLECTiEF and comparing the scores with pre-COLLECTiEF assessment performed in chapter 2, and information on what domains the COLLECTiEF solution will impact.

Chapter 5 identifies and describes the legacy equipment chosen for the COLLECTiEF solution to be implemented and deployed on the pilot sites.

Chapter 6 contains an action plan of activities and a timeframe to carry them out for deployment of the COLLECTiEF solution on all the pilot sites and topics of potential risks during deployment and monitoring/assessment phase of the project that should be considered.

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List of Acronyms

AMS	Advanced Measurement Systems
API	Application Programming Interface
BACnet	Building Automation and Control Networks
BACS	Building Automation and Control System
BAS	Building Automation System
BMS	Building Management System
BRiG	Border Router + iGateway (Edge Node)
CETMA	Centro Di Ricerche Europeo Di Tecnologie Design E Materiali
COLLECTiEF	Collective Intelligence for Energy Flexibility
CO_2	Carbon Dioxide
CyI	The Cyprus Institute
D	Deliverable
DCS	Distributed Control System
EV	Electric Vehicle
FCU	Fan Coil Unit
GOB	Guy Ourisson Building
GS	Graduate School
HVAC	Heating, Ventilation and Air Conditioning
HAN	Home Area Network
HMI	Human Machine Interface
IAQ	Indoor Air Quality
IEQ	Indoor Environmental Quality
IoT	Internet of Things
JSON	JavaScript Object Notation
KPI	Key Performance Indicators
kWh	Kilowatt Hour
MQTT(S)	Message Queuing Telemetry Transport (Secure)
MWh	Megawatt Hour
NTL	Novel Technologies Laboratories
PLC	Programmable Logic Controller
POE	Post-Occupancy Evaluation
PV	Photovoltaic
REST	REpresentational State Transfer
RH	Relative Humidity
SCADA	Supervisor Control and Data Acquisition
SRI	Smart Readiness Indicator
WP	Work Package
ÅKE	Ålesund Kommunale Eiendomsforetak

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1 Introduction

The COLLECTiEF project aims to enhance, implement, test, and evaluate an interoperable and scalable energy management system based on Collective Intelligence (CI) that allows easy and seamless integration of legacy equipment into a collaborative network within and between existing buildings and urban energy systems with reduced installation cost, data transfer and computational power while increasing data security, energy flexibility and climate resilience.

The COLLECTiEF system is expected to reach the technology readiness level (TRL) 8, which implies that the system needs to be complete and qualified.

This deliverable aims to evaluate the existing building mass included in the project portfolio based on the SRI methodology and to compare with the new SRI level achieved after the COLLECTiEF solution has been deployed. This will show that the SRI level will be increased for all pilot buildings included in the project.

Further, the deliverable identifies the field devices needed for a successful implementation of the COLLECTiEF solution as well as a discussion on interfacing with the local BMS system found on the Norwegian pilot buildings through its REST API. The deliverable also explains how necessary data is made available for the COLLECTiEF algorithms and evaluation of the solution.

An implementation plan is presented, and a discussion and identification of the implementation timeframe is included.

Lastly, foreseen risks and challenges are discussed, and mitigation actions are presented.

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2 Description of characteristics of legacy equipment and their functionality level in each demonstration building

The Smart Readiness Indicator (SRI) was born due to the need for new tools to speed up the building renovation investments and the integration of cutting-edge ICT-based technology to optimize energy efficiency, demand flexibility and improvement of user comfort in the buildings.

In this work, the SRI has been assessed considering at the beginning of this project version 4.4, but the final assessment presented in this report is using the current version 4.5 of the SRI spreadsheet. Currently, the SRI assessment has been performed in all the Cypriot, French, Italian and Norwegian pilots that are part of the COLLECTiEF project, considering a common standard for its application, that includes the use of all the services present in Method B, with final goal of obtain an improvement of at least one category in all of the pilot buildings.

2.1 General Methodology

In the present section, a brief explanation of the methodology used in the SRI framework will be explained. For further information, it is recommended to read the support documentation to the Excel spreadsheet calculation: ‘Practical Guide Sri Calculation Framework V 4.5’.

2.1.1 Assessment Information

As a basic consideration, each assessment is expected to have in first instance the information on the assessor. The European Commission Services and the technical support team may use this information to contact assessors for collecting feedback on the SRI testing and implementation.

Table 1 Sample assessment information.

Version SRI	4.5
Assessor Name	-
Email address	-
Telephone number	-
Assessment date	08-04-2023

2.1.2 General Information

The selected building type and usage will be used to select the appropriate weighting factors, which can for example reflect the differences in relative importance of domains such as domestic hot water or cooling depending on the use of the building.

In the current version 4.5, no differentiation has been made in the default weighting factors within a building type (all non-residential buildings currently use the same weighting factors) but exists an important difference in the energy-related weights depending on the location of the building.

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Table 2 Sample general information of the building.

Building Name	Eidet *Omsorgssenter*
Building type	non-residential
Building usage	non-residential - healthcare
Location	Norway
Climate zone	*North Europe*
Total useful floor area of the building²	1.000 - 10.000 m²
Year of construction	> 2010
Building state	Original
Description	-
Address	-

2.1.3 Methodology Selection

In the present section, the user can specify the weighting method for the services and the present domains used for the calculation. In some instances, these inputs might be predefined (e.g., the weights), having two main options: i) catalogue A and ii) catalogue B. Catalogue A is a simplified version of the assessment that includes 27 services, while catalogue B, which is the one used in this work, contemplate the use of 54 services.

Table 3 Selected common methodology for the SRI assessment.

Preferred weightings	Default
Preferred services catalogue	B

The domains may be '*Present*', '*Absent-mandatory'* and '*Absent- not mandatory'*.

Table 4 Sample technical systems that could be present in the building.

Domain	Present?
Heating	Present
Domestic hot water	Present
Cooling	Absent – not mandatory
Ventilation	Present
Lighting	Present
Dynamic building envelope	Present
Electricity	Present
Electric vehicle charging	Absent – not mandatory
Monitoring and control	Present

2.1.4 Calculation Sheet

In this part, each domain is broken down into different services where the assessment takes place. The methodology considered for the assessment, considering each service, is the following:

- Define if the service is applicable to the building.
- Define the functionality level (most of the cases values between 0 to 4, where 0 represents no no-smartness and 4 represents the maximum achievable level).
- Specify if a service considers a shared functionality level (in percentage).
- Define the functionality level of the shared service.

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2.1.5 Scale For Results

In order to follow a common standard in the results of the SRI assessment, the Total SRI Score is presented in the range between 0% and 100%, as well the impact scores, the domain scores and the detailed scores. From version 4.5, the SRI Class is no longer presented in letters from A to E (where A is the maximum level of smartness and E is the lower achievable level); thus, SRI class is provided in 7 numerical ranges, presented in the following table:

Table 5 SRI range and SRI class used for assessment categorization.

#	SRI Range	SRI Class (V4.4)
1	90%-100%	A
2	80%-90%	B
3	65%-80%	C
4	50%-65%	D
5	35%-50%	E
6	20%-35%	F
7	0%-20%	G

2.2 Overall Results - Current Status

The application of the SRI was first performed on the current status of the pilot buildings, based on factors such as their HVAC legacy equipment, grid interaction, and other factors that represent their current level of smartness.

The final SRI score is represented by the weighted sum of the aggregated scores. Similarly, the “Building” aggregated score is the weighted sum of the “Energy Efficiency”, and “Maintenance and Fault Prediction” impact scores; the “User” aggregated score is the weighted sum of the “Convenience”, “Comfort”, and “Health, Well-being and Accessibility” impact scores; and the “Grid” score is represented only by the “Energy Flexibility and Storage” impact score.

The results for the current SRI and Aggregated scores are presented in Table 6:

Table 6 Overall results of the SRI assement for the pilot’s part of COLLECTiEF.

Building	SRI Range	SRI Class	SRI Score	Aggregated Score		
				Building	User	Grid
Cypriot Pilots						
Guy Ourisson Building	*0%-20%*	*G*	*5.8 %*	*6.6 %*	*10.9 %*	*0.0 %*
Graduate School	*0%-20%*	*G*	*5.7 %*	*6.4 %*	*10.6 %*	*0.0 %*
Novel Technologies Laboratory	*0%-20%*	*G*	*19.1 %*	*24.3 %*	*22.2 %*	*10.7 %*
French Pilots						
G2Elab	*50%-65%*	*D*	*50.6 %*	*65.2 %*	*64.0 %*	*22.5 %*
Italian Pilots						
Valsesia C2	*0%-20%*	*G*	*12.2 %*	*19.6 %*	*13.7 %*	*3.2 %*
Valsesia C3	*0%-20%*	*G*	*12.2 %*	*19.6 %*	*13.7 %*	*3.2 %*
Valsesia C4	*0%-20%*	*G*	*12.2 %*	*19.6 %*	*13.7 %*	*3.2 %*
Norwegian Pilots						
Eidet Omsorgssenter	*35%-50%*	*E*	*36.9 %*	*48.9 %*	*48.3 %*	*13.4 %*
Ellingsoy Idrettshall	*20%-35%*	*F*	*33.9 %*	*45.0 %*	*43.0 %*	*13.9 %*
Flisnes Barneskole	*20%-35%*	*F*	*27.9 %*	*43.9 %*	*34.3 %*	*5.5 %*
Hatlane Omsorgssenter	*20%-35%*	*F*	*32.5 %*	*46.2 %*	*39.3 %*	*12.1 %*

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Moa Helsehus	*20%-35%*	*F*	*25.9 %*	*39.2 %*	*34.5 %*	*3.9 %*
Spjelkavik Ungdomsskole	*20%-35%*	*F*	*30.8 %*	*44.8 %*	*41.6 %*	*6.0 %*
Tennfjord Barneskole	*20%-35%*	*F*	*27.9 %*	*42.4 %*	*36.2 %*	*5.1 %*

Building	SRI Range	SRI Class	SRI Score	Aggregated Score		
				Building	User	Grid
Cypriot Pilots						
Guy Ourisson Building	*0%-20%*	*G*	*5,80%*	*6,60%*	*10,90%*	*0,00%*
Graduate School	*0%-20%*	*G*	*5,70%*	*6,40%*	*10,60%*	*0,00%*
Novel Technologies Laboratory	*0%-20%*	*G*	*19,10%*	*24,30%*	*22,20%*	*10,70%*
French Pilots						
G2Elab	*50%-65%*	*D*	*50,60%*	*65,20%*	*64,00%*	*22,50%*
Italian Pilots						
Valsesia C2	*0%-20%*	*G*	*12,20%*	*19,60%*	*13,70%*	*3,20%*
Valsesia C3	*0%-20%*	*G*	*12,20%*	*19,60%*	*13,70%*	*3,20%*
Valsesia C4	*0%-20%*	*G*	*12,20%*	*19,60%*	*13,70%*	*3,20%*
Norwegian Pilots						
Eidet Omsorgssenter	*35%-50%*	*E*	*36,90%*	*48,90%*	*48,30%*	*13,40%*
Ellingsoy Idrettshall	*20%-35%*	*F*	*33,90%*	*45,00%*	*43,00%*	*13,90%*
Flisnes Barneskole	*20%-35%*	*F*	*27,90%*	*43,90%*	*34,30%*	*5,50%*
Hatlane Omsorgssenter	*20%-35%*	*F*	*32,50%*	*46,20%*	*39,30%*	*12,10%*
Moa Helsehus	*20%-35%*	*F*	*25,90%*	*39,20%*	*34,50%*	*3,90%*
Spjelkavik Ungdomsskole	*20%-35%*	*F*	*30,80%*	*44,80%*	*41,60%*	*6,00%*
Tennfjord Barneskole	*20%-35%*	*F*	*27,90%*	*42,40%*	*36,20%*	*5,10%*

Among the pilots, Cypriot and Italian pilots have the lowest overall SRI score, which are part of the lowest SRI range (0%-20%). In case of the Norwegian pilots, there are 6 in the second lowest category (20%-35%) but with three of the with a score over 30%, and one building in the range 35% to 50%. In the case of the French pilot, it has the current highest level of smartness of all the pilots.

The “Building” and “User” scores are stably higher for the Norwegian and French Pilots, but low for the Cypriot and Italian. In all these cases, “Grid” aggregated score represents the lowest aggregated score but offers an opportunity where COLLECTiEF can take an advantage to improve the overall score of these buildings.

In the following sections, all pilot buildings are presented in detail.

2.3 Cyprian Pilots

The Cyprian pilots are represented by the following three non-residential buildings.

2.3.1 Guy Ourisson Building

The Guy Ourisson Building corresponds to an educational building with an overall score of 5.8%, in being the lower SRI range, between 0% and 20%. The domains present in the building, and used for the SRI assessment, are presented in the following table:

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Table 7 Domains present in the Guy Ourisson building.

Domain	Present?
Heating	Present
Domestic hot water	Present
Cooling	Present
Ventilation	Present
Lighting	Present
Dynamic building envelope	Present
Electricity	Present
Electric vehicle charging	Absent – not mandatory
Monitoring and control	Present

2.3.1.1 Impact Scores

Considering the impact scores of the building, exits room for improvement, in terms of smartness, in all the categories, but it is especially noticeable the low score in "Energy flexibility and storage" and "Information to occupants", where the COLLECTiEF Project can act to improve the smartness of the building.

Table 8 Impact scores of the current status of the building Guy Ourisson Building.

Impact	Score
Energy efficiency	13.3%
Energy flexibility and storage	0.0%
Comfort	14.4%
Convenience	9.9%
Health, well-being, and accessibility	19.2%
Maintenance and fault prediction	0.0%
Information to occupants	0.0%

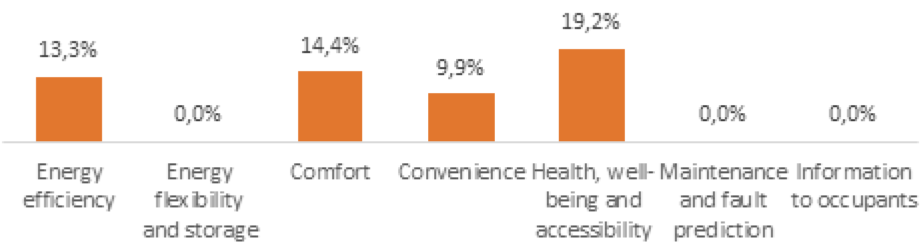

Figure 1 Impact scores of the current status of the building Guy Ourisson Building

2.3.1.2 Domain Scores

Accordingly, the domain scores show low smartness levels in all the present domains, "Heating" being the one with a higher score. In specific, an improvement is expected to be seen in the categories of "Ventilation" and "Monitoring and control".

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Table 9 Domain scores of the current status of the building Guy Ourisson Building.

Domain	Score
Heating	14.5%
Domestic hot water [3]	5.3%
Cooling	10.6%
Ventilation	10.0%
Lighting	0.0%
Dynamic building envelope	9.6%
Electricity	0.0%
Electric vehicle charging	0.0%
Monitoring and control	0.0%

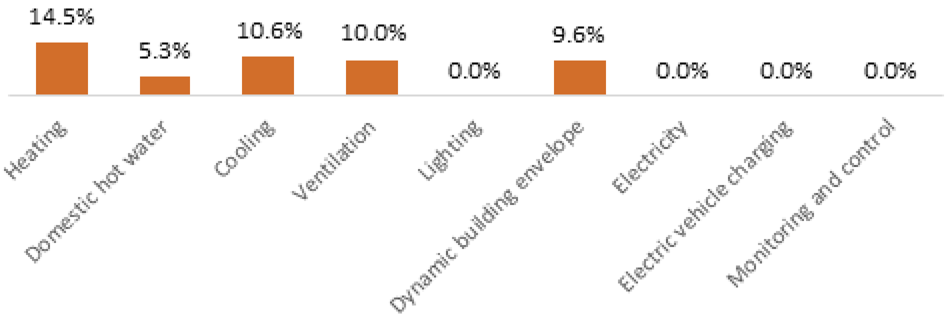

Figure 2 Domain scores of the current status of the building Guy Ourisson Building.

2.3.2 Graduate School

The Graduate School corresponds to an educational building with an overall score of 5.7%, being in the lower SRI range, between 0% and 20%. The domains present in the building, and used for the SRI assessment, are presented in the following table:

Table 10 Domains present in the Graduate School building.

Domain	Present?
Heating	Present
Domestic hot water	Present
Cooling	Present
Ventilation	Present
Lighting	Present
Dynamic building envelope	Present
Electricity	Present
Electric vehicle charging	Absent – not mandatory
Monitoring and control	Present

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2.3.2.1 Impact Scores

Similarly, to Guy Ourisson Building, exists space to improve in impacts such as “Energy Flexibility and Storage” and “Information to occupants”. In this case, the impact scores that are related to the User use, as it is the case of “Comfort” and “Health, well-being and accessibility” have the higher level of smartness in the building.

Table 11 Impact scores of the current status of the Graduate School building.

Impact	Score
Energy efficiency	12.8%
Energy flexibility and storage	0.0%
Comfort	13.9%
Convenience	7.7%
Health, well-being, and accessibility	20.8%
Maintenance and fault prediction	0.0%
Information to occupants	0.0%

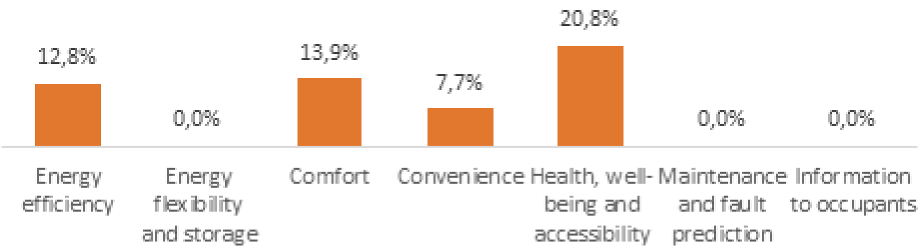

Figure 3 Impact scores of the current status of the Graduate School building.

2.3.2.2 Domain Scores

Accordingly, the domain scores show a higher smartness level in domains as ventilation and heating than others, but with space to only improve in “Monitoring and control” and “Electricity”.

Table 12 Domain scores of the current status of the Graduate School building.

Domain	Score
Heating	16.8%
Domestic hot water	0.0%
Cooling	10.6%
Ventilation	18.8%
Lighting	0.0%
Dynamic building envelope	0.0%
Electricity	0.0%
Electric vehicle charging	0.0%
Monitoring and control	0.0%

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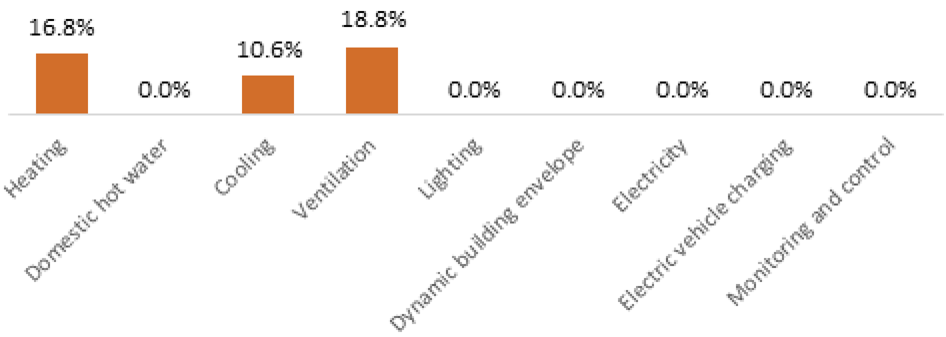

Figure 4 Domain scores of the current status of the Graduate School building.

2.3.3 Novel Technologies Laboratory

The Novel Technologies Laboratory corresponds to an educational building with an overall score of 19.1%, being in the lower SRI range, between 0% and 20%. The domains present in the building, and used for the SRI assessment, are presented in the following table:

Table 13 Domains present in the Novel Technologies Laboratory building.

Domain	Present?
Heating	Present
Domestic hot water	Present
Cooling	Present
Ventilation	Present
Lighting	Present
Dynamic building envelope	Present
Electricity	Present
Electric vehicle charging	Absent – not mandatory
Monitoring and control	Present

2.3.3.1 Impact Scores

Novel Technologies Laboratory shows better impact scores than the other two Cypriot pilots, especially in the impact areas related to "Building" behavior, as it is the case of "Energy efficiency" and "Maintenance and fault prediction". Additionally, it also presents a higher score in the "Energy flexibility and storage".

Table 14 Impact scores of the current status of the building Novel Technologies Laboratory.

Impact	Score
Energy efficiency	27.7%
Energy flexibility and storage	10.7%
Comfort	35.2%
Convenience	21.4%
Health, well-being, and accessibility	22.2%
Maintenance and fault prediction	20.9%
Information to occupants	10.1%

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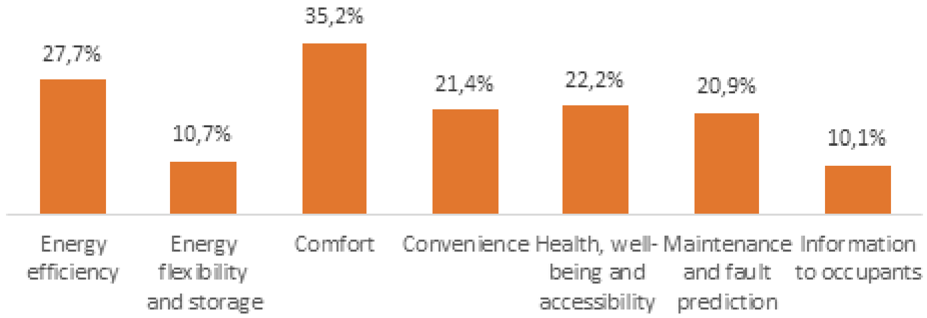

Figure 5 Impact scores of the current status of the building Novel Technologies Laboratory.

2.3.3.2 Domain Scores

The impact in energy efficiency and energy flexibility is given in part for the improvements shown in the areas of “Heating”, “Cooling”, and “Electricity”, showing all scores over 30%, but with lower scores in domestic hot water and monitoring and control.

Table 15 Domain scores of the current status of the building Novel Technologies Laboratory.

Domain	Score
Heating	37.5%
Domestic hot water	5.3%
Cooling	36.1%
Ventilation	19.6%
Lighting	14.7%
Dynamic building envelope	9.6%
Electricity	31.3%
Electric vehicle charging	0.0%
Monitoring and control	0.0%

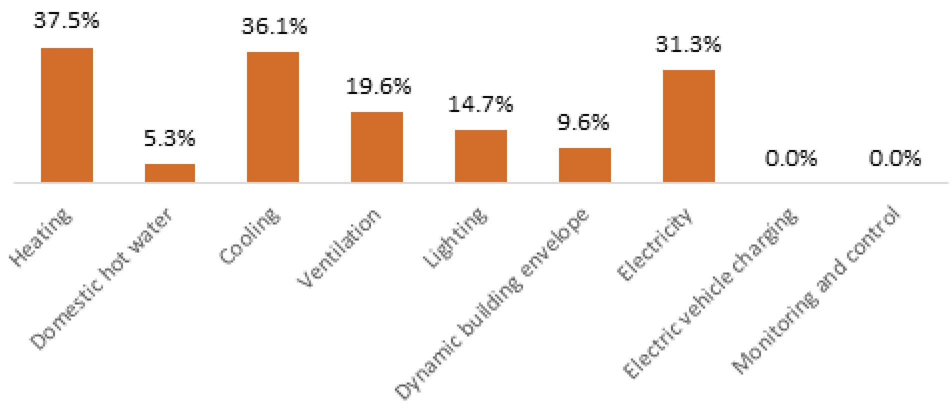

Figure 6 Domain scores of the current status of the building Novel Technologies Laboratory.

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2.4 French Pilots

In the present section, the French Pilot's SRI assessments for their current status are presented in detail.

2.4.1 G2Elab

The G2Elab corresponds to an office/educational/laboratory building with an overall score of 50.6%, in being the SRI range between 50% and 65%, the highest among the studied pilots. The domains present in the building, and used for the SRI assessment, are presented in the following table:

Table 16 Domains present in the G2Elab building.

Domain	Present?
Heating	Present
Domestic hot water	Absent – not mandatory
Cooling	Present
Ventilation	Present
Lighting	Present
Dynamic building envelope	Present
Electricity	Present
Electric vehicle charging	Present
Monitoring and control	Present

2.4.1.1 Impact Scores

For this pilot, high levels of smartness in the different scores are present, which is expected, given the functionality of the building. Here, COLLECTiEF can work mainly in improve the "Energy flexibility and storage" impact score, which is by far the lowest score for this pilot.

Table 17 Impact scores of the current status of the building G2Elab.

Impact	Score
Energy efficiency	68.9%
Energy flexibility and storage	22.5%
Comfort	63.9%
Convenience	62.2%
Health, well-being, and accessibility	55.8%
Maintenance and fault prediction	61.6%
Information to occupants	74.1%

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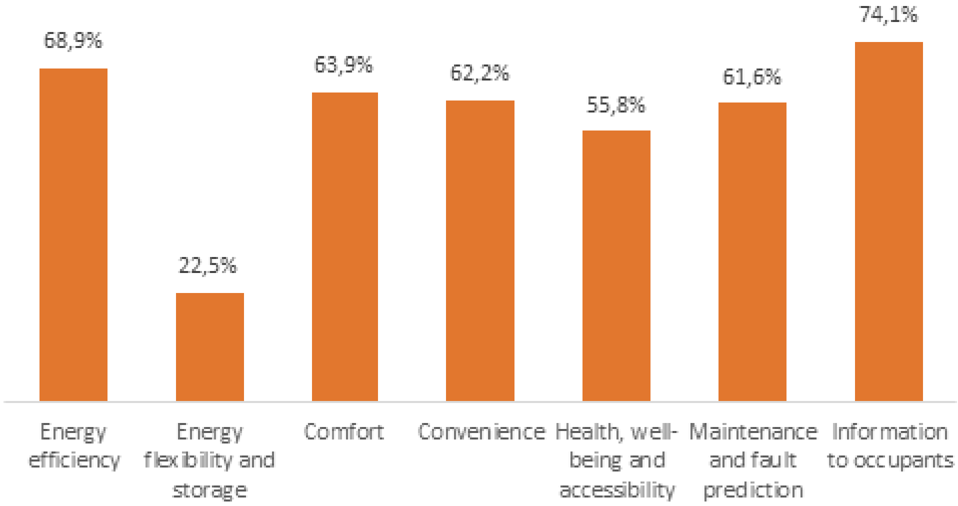

Figure 7 Impact scores of the current status of the building G2Elab.

2.4.1.2 Domain Scores

The low score in "Energy flexibility and storage" is a direct consequence of the inclusion of non-smart electric charging since it is the only score that is present in a negative value. The other domains that are present in this pilot show values higher than 40% (except for "Dynamic building envelope").

Table 18 Domain scores of the current status of the building G2Elab.

Domain	Score
Heating	41.0%
Domestic hot water	0.0%
Cooling	51.3%
Ventilation	77.0%
Lighting	44.0%
Dynamic building envelope	16.0%
Electricity	55.7%
Electric vehicle charging	-27.8%
Monitoring and control	59.9%

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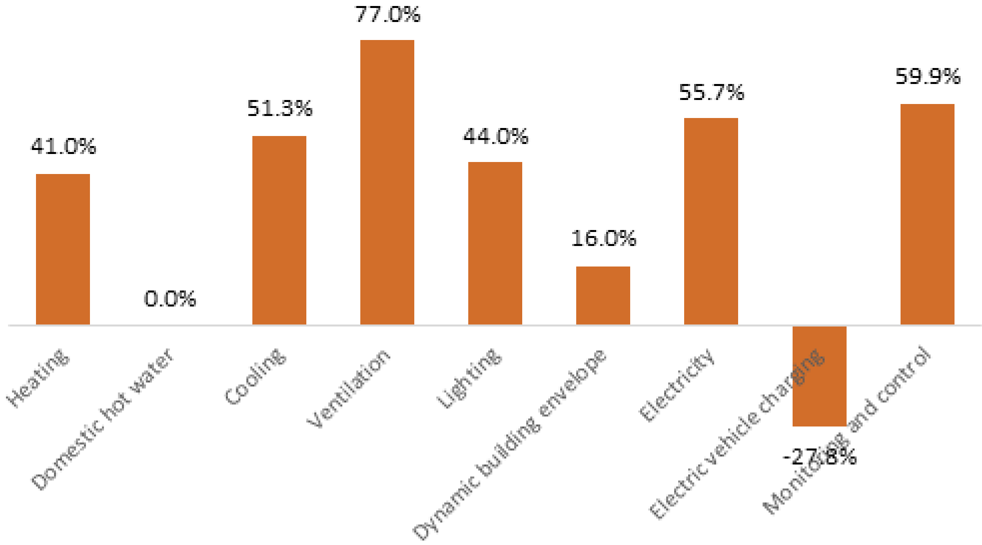

Figure 8 Domain scores of the current status of the building G2Elab.

2.5 Italian Pilots

In the present section, the Italian Pilot's SRI assessments, for their current status, are presented in detail.

2.5.1 Valsesia C2

The Valsesia C2 building corresponds to a residential building block with an overall score of 12.2%, being the lower SRI range, between 0% and 20%. The domains present in the building, and used for the SRI assessment, are presented in the following table:

Table 19 Domains present in the Valsesia C2 building.

Domain	Present?
Heating	Present
Domestic hot water	Present
Cooling	Present
Ventilation	Absent – not mandatory
Lighting	Present
Dynamic building envelope	Present
Electricity	Present
Electric vehicle charging	Absent – not mandatory
Monitoring and control	Present

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2.5.1.1 Impact Scores

Considering the impact scores of the buildings, exits room for improvement, in terms of smartness, in all the categories, but it is especially noticeable the low score in “Energy flexibility and storage” and the “Information to occupants”, where the COLLECTiEF Project is targeting its work.

Table 20 Impact scores of the current status of the building Valsesia C2.

Impact	Score
Energy efficiency	32.6%
Energy flexibility and storage	3.2%
Comfort	28.0%
Convenience	10.1%
Health, well-being, and accessibility	13.9%
Maintenance and fault prediction	6.5%
Information to occupants	2.7%

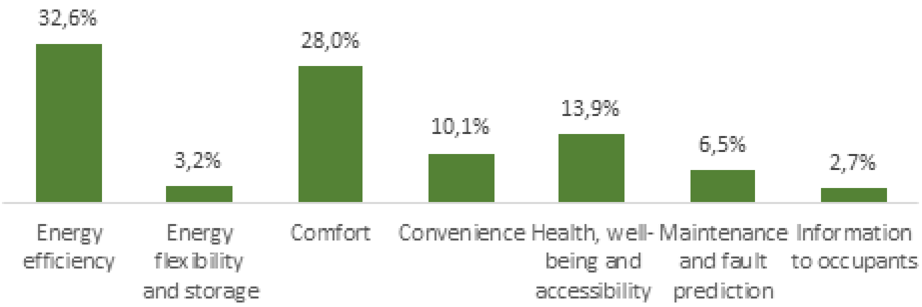

Figure 9 Domain scores of the current status of the building G2Elab.

2.5.1.2 Domain Scores

Accordingly, the domain scores show relatively good smartness levels in the heating domain but low level in domains such as “Monitoring and control” and “Electricity”. These last two mentioned domains, which are directly related to the energy flexibility impact score, are where COLLECTiEF can improve with the development of its work.

Table 21 Domain scores of the current status of the building Valsesia C2.

Domain	Score
Heating	30.8%
Domestic hot water	0.0%
Cooling	9.3%
Ventilation	0.0%
Lighting	0.7%
Dynamic building envelope	0.0%
Electricity	0.0%
Electric vehicle charging	0.0%
Monitoring and control	9.1%

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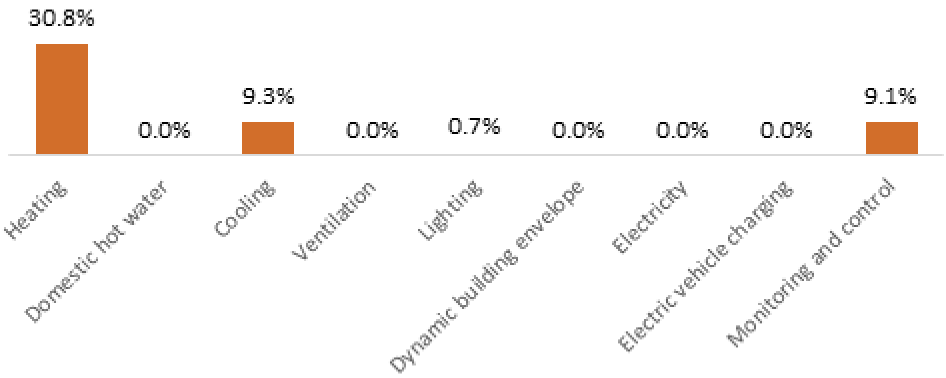

Figure 10 Domain scores of the current status of the building Valsesia C2.

2.5.2 Valsesia C3

The Valsesia C3 building corresponds to a residential building block with an overall score of 12.2%, being the lower SRI range, between 0% and 20%. The domains present in the building, and used for the SRI assessment, are presented in the following table:

Table 22 Domains present in the Valsesia C3 building.

Domain	Present?
Heating	Present
Domestic hot water	Present
Cooling	Present
Ventilation	Absent – not mandatory
Lighting	Present
Dynamic building envelope	Present
Electricity	Present
Electric vehicle charging	Absent – not mandatory
Monitoring and control	Present

2.5.2.1 Impact Scores

Considering the impact scores of the buildings, exits room for improvement, in terms of smartness, in all the categories, but it is especially noticeable the low score in “Energy flexibility and storage” and the “Information to occupants”, where the COLLECTiEF Project is targeting its work.

Table 23 Impact scores of the current status of the building Valsesia C3.

Impact	Score
Energy efficiency	32.6%
Energy flexibility and storage	3.2%
Comfort	28.0%
Convenience	10.1%
Health, well-being, and accessibility	13.9%
Maintenance and fault prediction	6.5%
Information to occupants	2.7%

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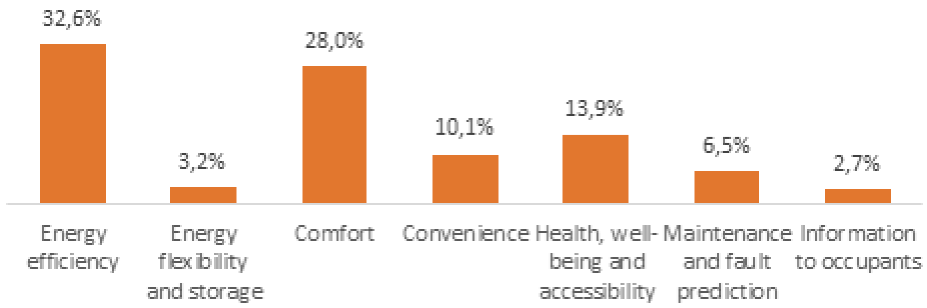

Figure 11 Impact scores of the current status of the building Valsesia C3.

2.5.2.2 Domain Scores

Accordingly, the domain scores show relatively good smartness levels in the heating domain but low level in domains such as "Monitoring and control" and "Electricity". These last two mentioned domains, which are directly related to the energy flexibility impact score, are where COLLECTiEF can improve with the development of its work.

Table 24 Domain scores of the current status of the building Valsesia C3.

Domain	Score
Heating	30.8%
Domestic hot water	0.0%
Cooling	9.3%
Ventilation	0.0%
Lighting	0.7%
Dynamic building envelope	0.0%
Electricity	0.0%
Electric vehicle charging	0.0%
Monitoring and control	9.1%

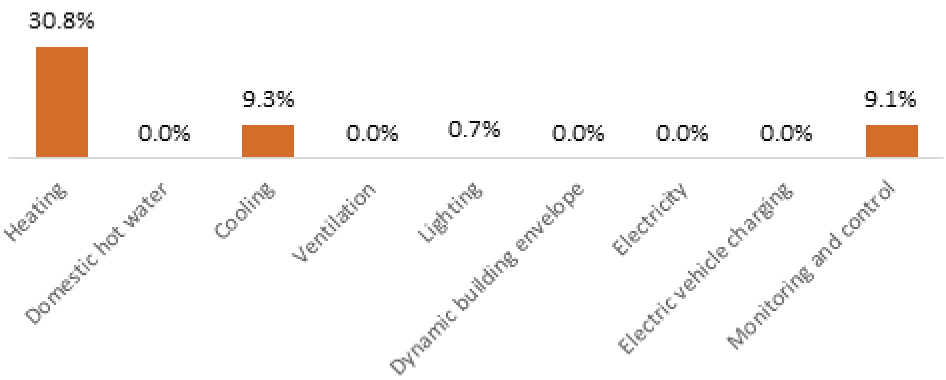

Figure 12 Domain scores of the current status of the building Valsesia C3.

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2.5.3 Valsesia C4

The Valsesia C4 building corresponds to a residential building block with an overall score of 12.2%, being the lower SRI range, between 0% and 20%. The domains present in the building, and used for the SRI assessment, are presented in the following table:

Table 25 Domains present in the Valsesia C4 building.

Domain	Present?
Heating	Present
Domestic hot water	Present
Cooling	Present
Ventilation	Absent – not mandatory
Lighting	Present
Dynamic building envelope	Present
Electricity	Present
Electric vehicle charging	Absent – not mandatory
Monitoring and control	Present

2.5.3.1 Impact Scores

Considering the impact scores of the buildings, exits room for improvement, in terms of smartness, in all the categories, but it is especially noticeable the low score in "Energy flexibility and storage" and the "Information to occupants", where the COLLECTiEF Project is targeting its work.

Table 26 Impact scores of the current status of the building Valsesia C4.

Impact	Score
Energy efficiency	32.6%
Energy flexibility and storage	3.2%
Comfort	28.0%
Convenience	10.1%
Health, well-being, and accessibility	13.9%
Maintenance and fault prediction	6.5%
Information to occupants	2.7%

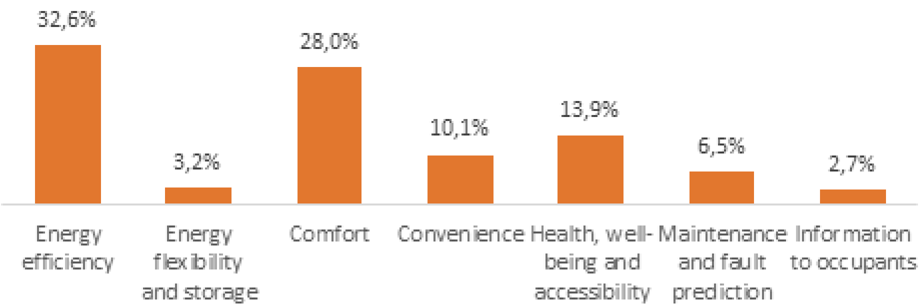

Figure 13 Impact scores of the current status of the building Valsesia C4.

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2.5.3.2 Domain Scores

Accordingly, the domain scores show relatively good smartness levels in the heating domain but low level in domains such as “Monitoring and control” and “Electricity”. These last two mentioned domains, which are directly related to the energy flexibility impact score, are where COLLECTiEF can improve with the development of its work.

Table 27 Domain scores of the current status of the building Valsesia C4.

Domain	Score
Heating	30.8%
Domestic hot water	0.0%
Cooling	9.3%
Ventilation	0.0%
Lighting	0.7%
Dynamic building envelope	0.0%
Electricity	0.0%
Electric vehicle charging	0.0%
Monitoring and control	9.1%

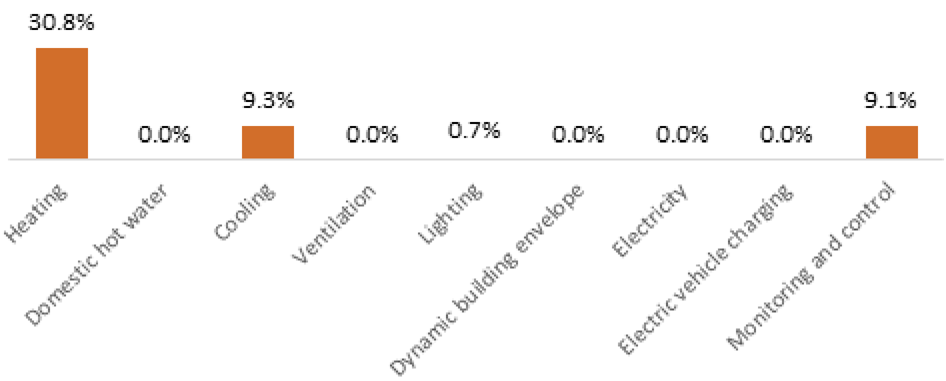

Figure 14 Domain scores of the current status of the building Valsesia C4.

2.6 Norwegian Pilots

In the present section, the Norwegian Pilot’s SRI assessments for their current status are presented in detail.

2.6.1 Eidet Omsorgssenter

The present building, Eidet Omsorgssenter, corresponds to a health care center with an overall score of 36.9%, being the higher SRI range score among the Norwegian pilots, with a score between 35% and 50%. The domains present in the building, and used for the SRI assessment, are presented in the following table:

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Table 28 Domains present in Eidet Omsorgssenter building.

Domain	Present?
Heating	Present
Domestic hot water	Present
Cooling	Absent – not mandatory
Ventilation	Present
Lighting	Present
Dynamic building envelope	Present
Electricity	Present
Electric vehicle charging	Absent – not mandatory
Monitoring and control	Present

2.6.1.1 Impact Scores

Considering the impact scores of the Eidet Omsorgssenter, exits room for improvement, in terms of smartness, in all the categories, but it is especially noticeable the low score in “Energy flexibility and storage”, where the COLLECTiEF Project is targeting its work.

Table 29 Impact scores of the current status of the building Eidet Omsorgssenter.

Impact	Score
Energy efficiency	55.4%
Energy flexibility and storage	13.4%
Comfort	64.3%
Convenience	43.3%
Health, well-being, and accessibility	51.3%
Maintenance and fault prediction	42.5%
Information to occupants	34.1%

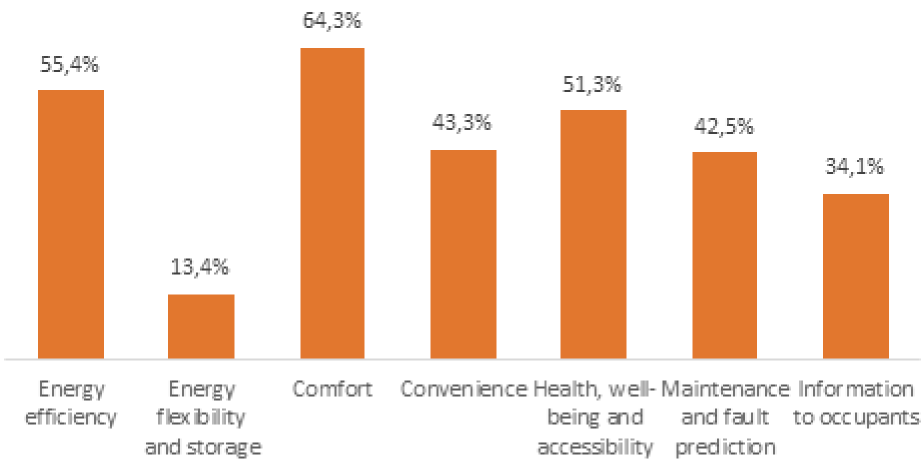

Figure 15 Impact scores of the current status of the building Eidet Omsorgssenter.

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2.6.1.2 Domain Scores

Accordingly, the domain scores show relatively good smartness levels in domains such as “Ventilation” and “Lighting” but low level in domains as “Heating”, “Monitoring and control” and “Electricity”. A special case is Monitoring and Control, which is directly related to the energy flexibility impact score, where COLLECTiEF can improve with the development of its work.

Table 30 Domain scores of the current status of the building Eidet Omsorgssenter.

Domain	Score
Heating	37.6%
Domestic hot water	45.4%
Cooling	0.0%
Ventilation	68.2%
Lighting	29.3%
Dynamic building envelope	0.0%
Electricity	21.7%
Electric vehicle charging	0.0%
Monitoring and control	30.5%

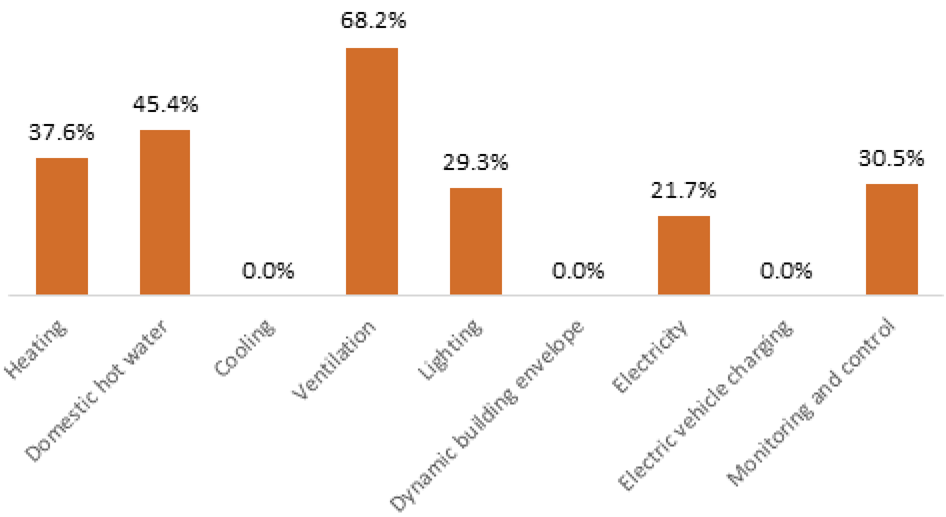

Figure 16 Domain scores of the current status of the building Eidet Omsorgssenter.

2.6.2 Ellingsøy Idrettshall

The present building, Ellingsøy Idrettshall, corresponds to a sport hall with an overall score of 33.9%, with the score in the range between 20% and 35%. The domains present in the building, and used for the SRI assessment, are presented in the following table:

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Table 31 Domains present in Ellingsoy Idrettshall building.

Domain	Present?
Heating	Present
Domestic hot water	Present
Cooling	Absent – not mandatory
Ventilation	Present
Lighting	Present
Dynamic building envelope	Present
Electricity	Present
Electric vehicle charging	Absent – not mandatory
Monitoring and control	Present

2.6.2.1 Impact Scores

The impact scores of Ellingsøy Idrettshall show good scores in the "Energy efficiency" and "Comfort" impacts. In the case of "Energy flexibility and storage" and "Information to occupants" the scores are not high but the application of the COLLECTiEF project can help to improve these specific scores.

Table 32 Impact scores of the current status of the building Ellingsøy Idrettshall.

Impact	Score
Energy efficiency	52.0%
Energy flexibility and storage	13.9%
Comfort	61.5%
Convenience	44.2%
Health, well-being, and accessibility	38.7%
Maintenance and fault prediction	38.0%
Information to occupants	27.6%

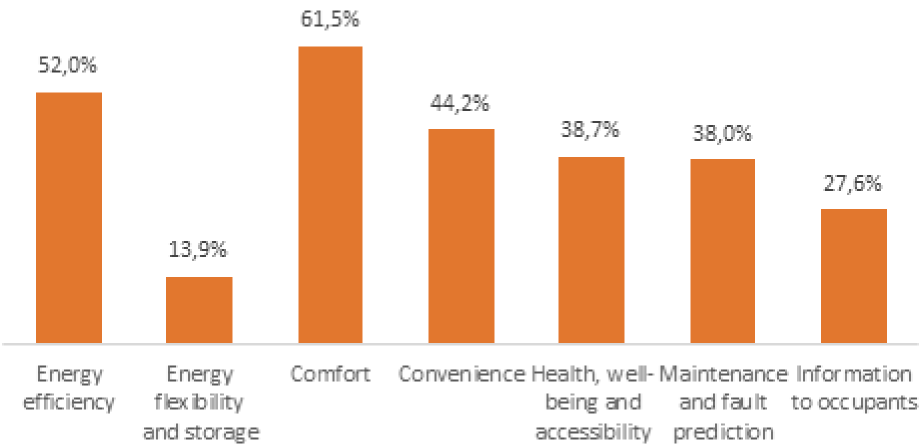

Figure 17 Impact scores of the current status of the building Ellingsøy Idrettshall.

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2.6.2.2 Domain Scores

Accordingly, the domain scores with higher results are "Domestic hot water" and "Ventilation". Like other buildings, COLLECTiEF could help to improve the scores of the electricity and monitoring and control domains.

Table 33 Domain scores of the current status of the building Ellingsøy Idrettshall.

Domain	Score
Heating	35.0%
Domestic hot water	61.1%
Cooling	0.0%
Ventilation	45.7%
Lighting	29.3%
Dynamic building envelope	0.0%
Electricity	13.3%
Electric vehicle charging	0.0%
Monitoring and control	31.6%

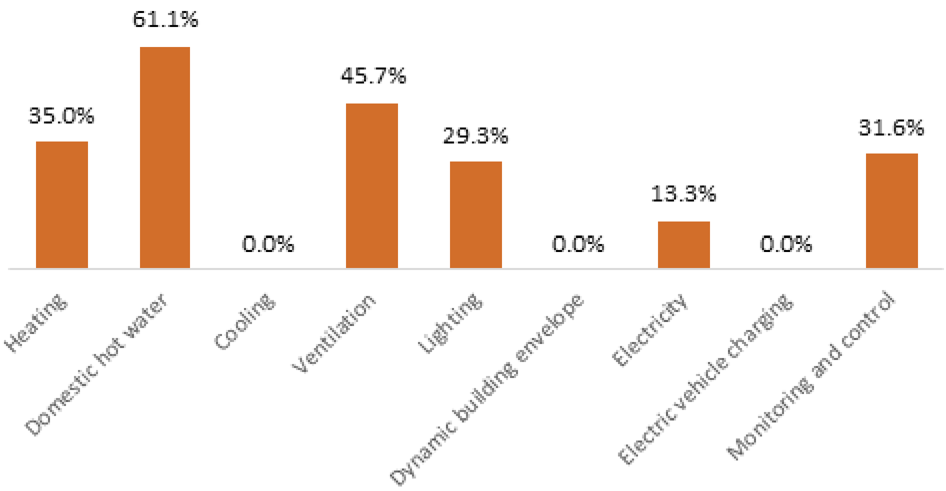

Figure 18 Domain scores of the current status of the building Ellingsøy Idrettshall.

2.6.3 Flisnes Barneskole

The present building, Flisnes Barneskole, corresponds to an education building with an overall score of 27.9%, with the score in the range between 20% and 35%. The domains present in the building, and used for the SRI assessment, are presented in the following table:

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Table 34 Domains present in the Flisnes Barneskole building.

Domain	Present?
Heating	Present
Domestic hot water	Present
Cooling	Absent – not mandatory
Ventilation	Present
Lighting	Present
Dynamic building envelope	Absent – not mandatory
Electricity	Present
Electric vehicle charging	Absent – not mandatory
Monitoring and control	Present

2.6.3.1 Impact Scores

Considering the impact scores of the building there is room for improvement, in terms of smartness, in all the categories, but it is especially noticeable the low score in "Energy flexibility and storage", where the COLLECTiEF Project is targeting its work.

Table 35 Impact scores of the current status of the building Flisnes Barneskole.

Impact	Score
Energy efficiency	50.6%
Energy flexibility and storage	5.5%
Comfort	48.8%
Convenience	35.1%
Health, well-being, and accessibility	22.8%
Maintenance and fault prediction	37.2%
Information to occupants	30.6%

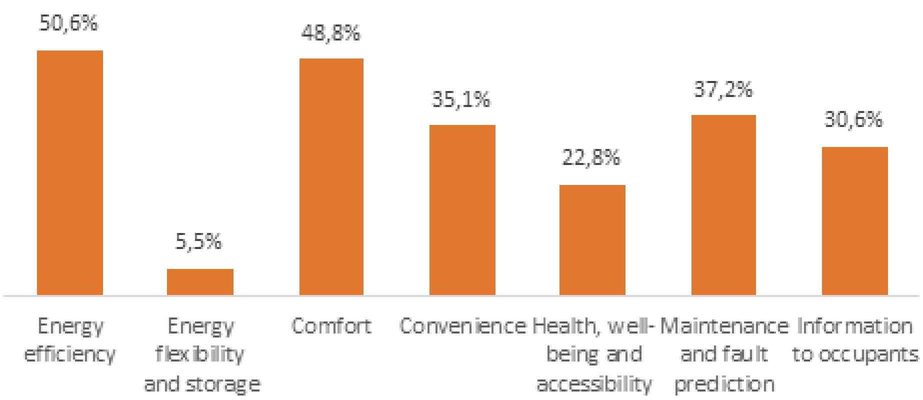

Figure 19 Impact scores of the current status of the building Flisnes Barneskole.

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2.6.3.2 Domain Scores

Accordingly, the domain scores show relatively good smartness levels in the “Heating” and “Monitoring and control” domains, but a low level in the “Electricity” domain.

Table 36 Domain scores of the current status of the building Flisnes Barneskole.

Domain	Score
Heating	37.4%
Domestic hot water	20.0%
Cooling	0.0%
Ventilation	25.3%
Lighting	29.3%
Dynamic building envelope	0.0%
Electricity	13.3%
Electric vehicle charging	0.0%
Monitoring and control	30.5%

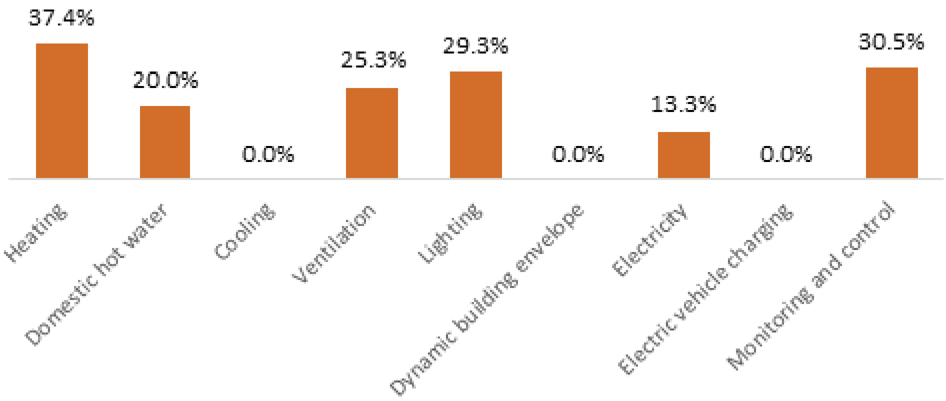

Figure 20 Domain scores of the current status of the building Flisnes Barneskole.

2.6.4 Hatlane Omsorgssenter

The present building, Hatlane Omsorgssenter, corresponds to a care center with an overall score of 32.5%, with the score in the range between 20% and 35%. The domains present in the building, and used for the SRI assessment, are presented in the following table:

Table 37 Domains present in Hatlane Omsorgssenter building.

Domain	Present?
Heating	Present
Domestic hot water	Present
Cooling	Present
Ventilation	Present
Lighting	Present
Dynamic building envelope	Absent – not mandatory
Electricity	Present
Electric vehicle charging	Absent – not mandatory
Monitoring and control	Present

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2.6.4.1 Impact Scores

Considering the impact scores of Hatlane Omsorgssenter, “Energy flexibility and storage”, and the “Information to occupants” can be improved given the low scores of the current SRI assessment.

Table 38 Impact scores of the current status of the building Hatlane Omsorgssenter.

Impact	Score
Energy efficiency	56.1%
Energy flexibility and storage	12.1%
Comfort	50.3%
Convenience	41.9%
Health, well-being, and accessibility	37.7%
Maintenance and fault prediction	36.3%
Information to occupants	27.2%

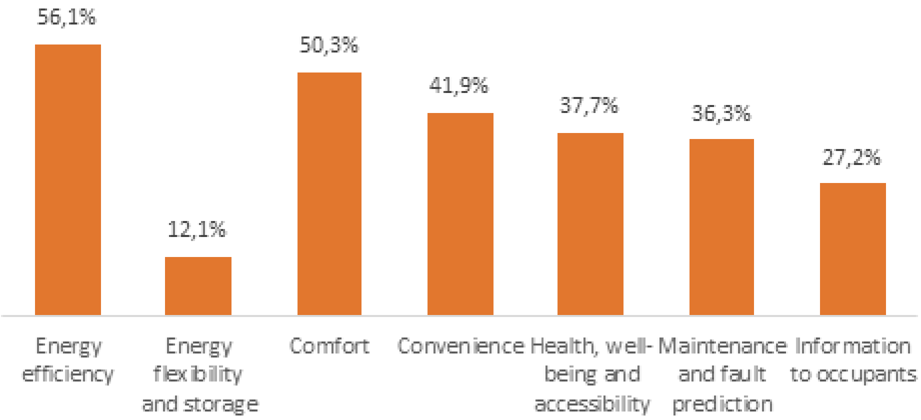

Figure 21 Impact scores of the current status of the building Hatlane Omsorgssenter.

2.6.4.2 Domain Scores

Accordingly, the domain scores show relatively good smartness levels in domains as “Domestic hot water”, and relatively good smartness levels in domains as “Heating”, “Ventilation”, “Monitoring and control”, and “Lighting”. In the case of electricity domain, which is directly related with the “Energy flexibility” impact score, the score obtained is low, but it is possible to improve with the application of the solutions given by the project.

Table 39 Domain scores of the current status of the building Hatlane Omsorgssenter.

Domain	Score
Heating	36.7%
Domestic hot water	61.1%
Cooling	33.9%
Ventilation	31.9%
Lighting	29.3%
Dynamic building envelope	0.0%
Electricity	13.3%
Electric vehicle charging	0.0%
Monitoring and control	31.6%

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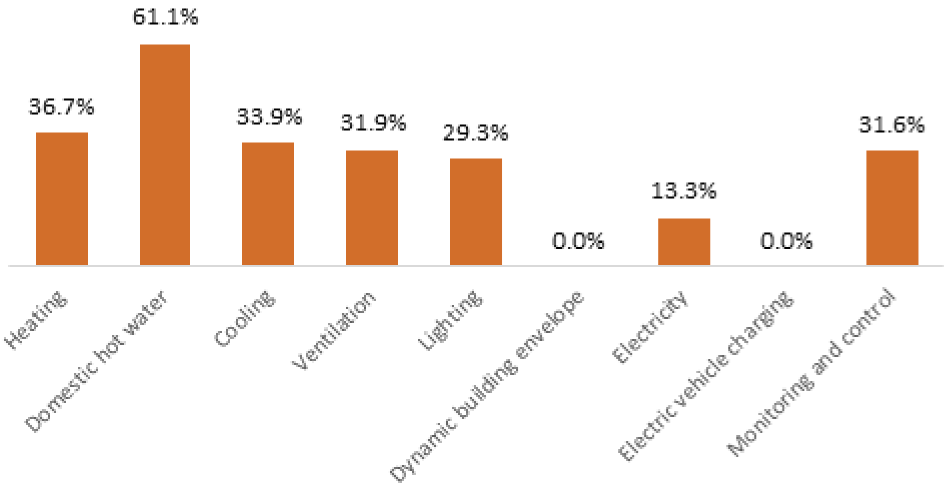

Figure 22 Domain scores of the current status of the building Hatlane Omsorgssenter.

2.6.5 Moa Helsehus

The present building, Moa Helsehus, corresponds to a health center with an overall score of 25.9%, with the score in the range between 20% and 35%. The domains present in the building, and used for the SRI assessment, are presented in the following table:

Table 40 Domains present in Moa Helsehus building.

Domain	Present?
Heating	Present
Domestic hot water	Present
Cooling	Present
Ventilation	Present
Lighting	Present
Dynamic building envelope	Absent – not mandatory
Electricity	Present
Electric vehicle charging	Absent – not mandatory
Monitoring and control	Present

2.6.5.1 Impact Scores

Considering the impact scores of Moa Helsehus, the main improvement that this project can achieve is in the impact scores related to “Energy Flexibility and storage”, having the lowest score among all the impacts.

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Table 41 Impact scores of the current status of the building Moa Helsehus.

Impact	Score
Energy efficiency	45.2%
Energy flexibility and storage	3.9%
Comfort	40.0%
Convenience	31.3%
Health, well-being, and accessibility	35.8%
Maintenance and fault prediction	33.3%
Information to occupants	30.9%

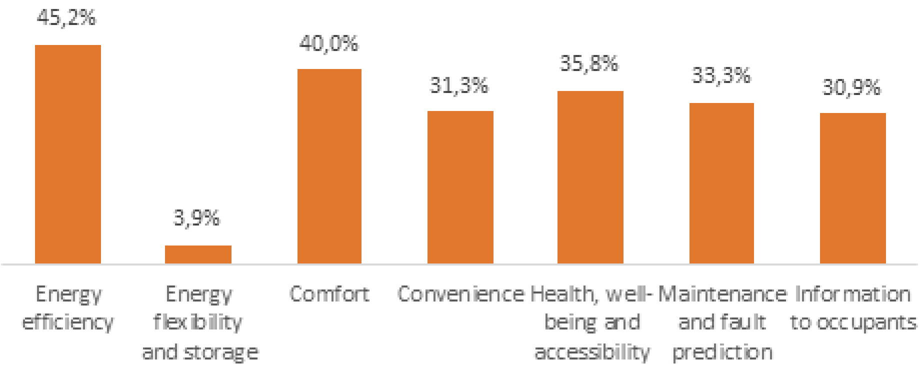

Figure 23 Impact scores of the current status of the building Moa Helsehus.

2.6.5.2 Domain Scores

Similarly, the electricity domain score is notably low together with "Cooling" and "Heating", but it presents good scores in the domains of "Ventilation# and "Monitoring and control".

Table 42 Domain scores of the current status of the building Moa Helsehus.

Domain	Score
Heating	26.5%
Domestic hot water	43.3%
Cooling	17.8%
Ventilation	44.5%
Lighting	29.3%
Dynamic building envelope	0.0%
Electricity	13.3%
Electric vehicle charging	0.0%
Monitoring and control	29.7%

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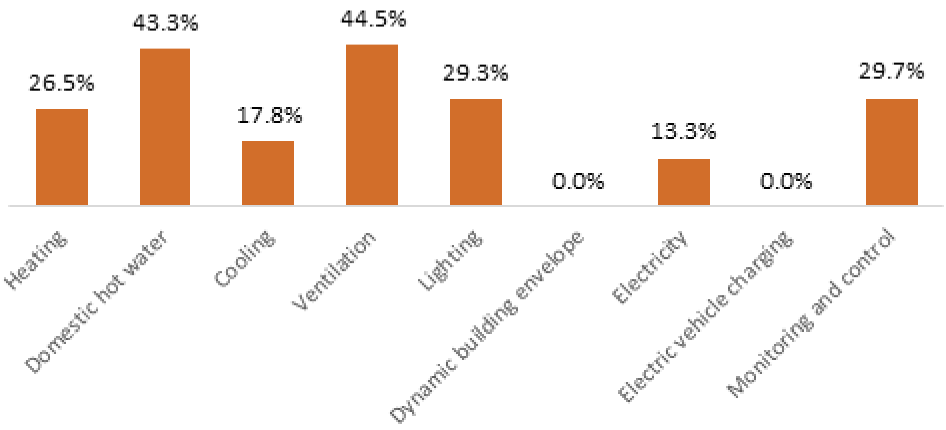

Figure 24 Domain scores of the current status of the building Moa Helsehus.

2.6.6 Spjelkavik Ungdomsskole

The present building, Spjelkavik Ungdomsskole, corresponds to an educational building with an overall score of 30.8%, with the score in the range between 20% and 35%. The domains present in the building, and used for the SRI assessment, are presented in the following table:

Table 43 Domains present in Spjelkavik Ungdomsskole building.

Domain	Present?
Heating	Present
Domestic hot water	Present
Cooling	Absent – not mandatory
Ventilation	Present
Lighting	Present
Dynamic building envelope	Absent – not mandatory
Electricity	Present
Electric vehicle charging	Absent – not mandatory
Monitoring and control	Present

2.6.6.1 Impact Scores

Spjelkavik Ungdomsskole shows a good level of smartness in all the impact scores, except for “Energy Flexibility and storage”, having differences up to 44 percentual points with other impact scores.

Table 44 Impact scores of the current status of the building Spjelkavik Ungdomsskole.

Impact	Score
Energy efficiency	50.5%
Energy flexibility and storage	6.0%
Comfort	48.5%
Convenience	39.3%
Health, well-being, and accessibility	48.8%
Maintenance and fault prediction	39.2%
Information to occupants	29.6%

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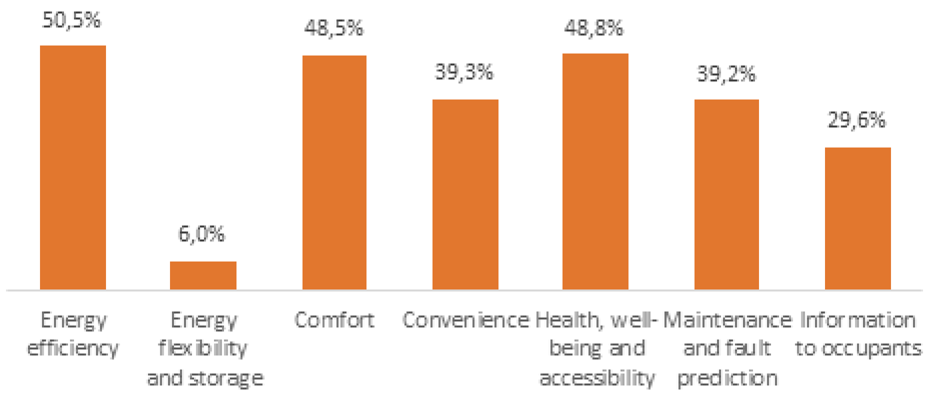

Figure 25 Impact scores of the current status of the building Spjelkavik Ungdomsskole.

2.6.6.2 Domain Scores

Given the low "Energy Flexibility and storage" impact score, the "Electricity" domain score is affected from this, having the lowest score for this building. Nevertheless, the COLLECTiEF project aims to improve in this specific domain, so it is expectable to have an improvement at the end of the project.

Table 45 Domain scores of the current status of the building Spjelkavik Ungdomsskole.

Domain	Score
Heating	31.6%
Domestic hot water	55.6%
Cooling	0.0%
Ventilation	53.6%
Lighting	29.3%
Dynamic building envelope	0.0%
Electricity	13.3%
Electric vehicle charging	0.0%
Monitoring and control	30.5%

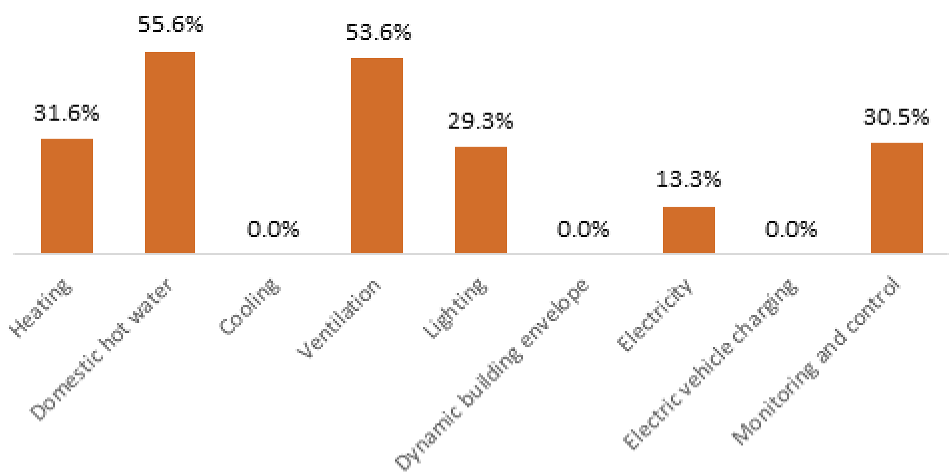

Figure 26 Domain scores of the current status of the building Spjelkavik Ungdomsskole.

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2.6.7 Tennfjord Barneskole

The present building, Tennfjord Barneskole, corresponds to an education building with an overall score of 27.9%, with the score in the range between 20% and 35%. The domains present in the building, and used for the SRI assessment, are presented in the following table:

Table 46 Domains present in Tennfjord Barneskole building.

Domain	Present?
Heating	Present
Domestic hot water	Present
Cooling	Absent – not mandatory
Ventilation	Present
Lighting	Present
Dynamic building envelope	Present
Electricity	Present
Electric vehicle charging	Absent – not mandatory
Monitoring and control	Present

2.6.7.1 Impact Scores

Considering the impact scores of Tennfjord Barneskole there exists room for improvement, in terms of smartness in the category "Energy Flexibility and storage" given its low impact score. All the other categories present good impact score, being the highest one "Energy efficiency" with 50.6%.

Table 47 Impact scores of the current status of the building Tennfjord Barneskole.

Impact	Score
Energy efficiency	50.6%
Energy flexibility and storage	5.1%
Comfort	45.8%
Convenience	32.2%
Health, well-being, and accessibility	36.2%
Maintenance and fault prediction	34.1%
Information to occupants	30.6%

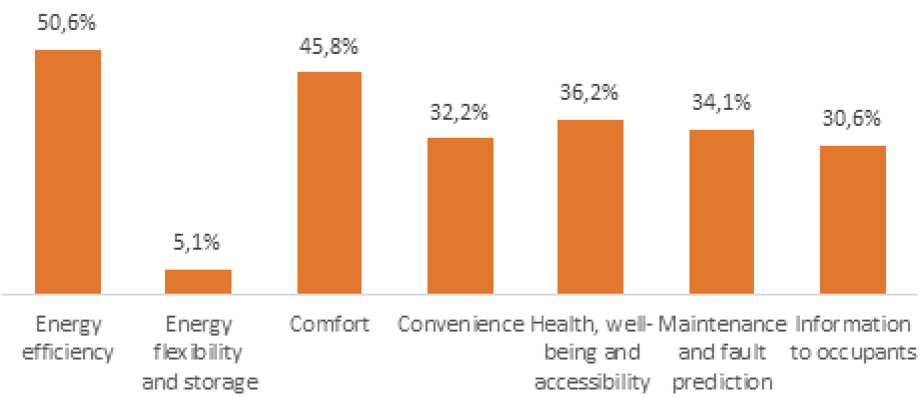

Figure 27 Impact scores of the current status of the building Tennfjord Barneskole.

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2.6.7.2 Domain Scores

Given the low “Energy Flexibility and storage” impact score, the electricity domain score is directly affected from this, giving a final domain score of 13.3%. Nevertheless, the COLLECTiEF project aims to improve in this specific domain, so it is expectable to have an improvement on it at the end of the project.

Table 48 Domain scores of the current status of the building Tennfjord Barneskole.

Domain	Score
Heating	26.5%
Domestic hot water	43.3%
Cooling	0.0%
Ventilation	44.5%
Lighting	29.3%
Dynamic building envelope	0.0%
Electricity	13.3%
Electric vehicle charging	0.0%
Monitoring and control	29.7%

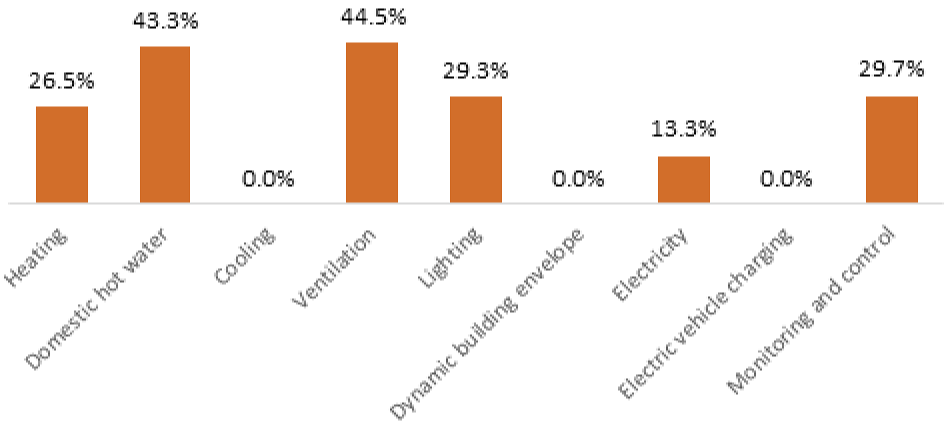

Figure 28 Domain scores of the current status of the building Tennfjord Barneskole.

This project has received funding from the European Union's H2020 research and innovation programme under Grant Agreement No 101033683

3 BMS software – Norwegian pilot buildings

For each of the Norwegian pilot buildings there is a building management and control system (BMS) already installed and running. Common for all these buildings is that this BMS system is of the brand EMS Server developed by EM Systemer AS, EM.

EM Systemer AS was founded in 1992 with the aim to focus entirely on building automation solutions, primarily for the Norwegian market. The company has always had a strong focus on research and development and has developed and manufactured its own range of PLC's, SCADA software and other field devices used in the building automation segment.

From the beginning, the company focus has been to solve the customers' needs for controls and visualization and to be a cost-effective way to save energy consumption in the buildings. As the market requirements have changed, product development has followed, and there is now a much bigger IT influence in the software development with focus on openness, security, and data exchange between different applications.

3.1 General

The intention of the BMS system is to have a single software package that gives the end user complete control and overview of all the technical installations in the building. This includes everything from common technical installations such as ventilation systems, heating systems, domestic hot water to more infrequent or complex installations such as heat pump systems (borehole), solar collectors, EV charging, photovoltaic (PV) cells and more. In addition to visualization of the complete technical installations, the end user will easily be able to monitor processes such as how the temperature and air quality is in the different rooms, and how temperature- and air control has been performing over time.

Regardless of the product manufacturer and installation company of the different technical subsystems in the buildings, they will all be integrated into and visualized by the BMS system. There should be no significant difference in the visualization, controls and user interface based on who delivers the systems and hence the owner of the building will be free to choose the products they desire and prefer based on the product price, the project technical requirements, communication protocols availability, and other deciding factors.

In addition to adding a uniform user interface, visualization of the control processes and logging/trending of data, the BMS system applies different control on an administrator level. There are different types of control that can be applied, depending on the type of project and the customer and end users need. An example of such a control process can be load shedding.

Depending on the BMS system, it will also offer a uniform way to allow data exchange with other software applications. There are several ways this is being offered in the market today, but in the case of EMS Server, the preferred method is by using the system's integrated REST API.

3.1.1 Building automation systems

A system with the main objective to add user control and visualization of the buildings technical installations is often referred to as a building automation system (BAS), building automation and control system (BACS), building management system (BMS) or a SCADA system (Supervisory Control and Data Acquisition). There are some slight differences in these terminologies, but often they overlap and are used interchangeably. A SCADA system, however, is more like an open integration and visualization software that is designed to cover a wider range of installations found in industrial organizations.

Another slight difference between the terminologies is the amount of hardware added in the total system architecture, but again, this is a bit overlapping and depends on who is defining the scope of the delivery.

There are several companies that develop and manufacture building automation systems and offer these on the market today – either through direct sales or through a partner network of system integrators and installers. There are differences in the way they present information to the end user, differences in terms of communication protocols they have implemented in their software, different configuration tools and software and other nuances and distinctions in the way they have solved logging, trending, reporting, GUI framework, etc. – that makes the different products unique and possibly adapted to the local region and/or target market.

Typically, a BMS system consist of several layers defined through the pyramid hierarchy:

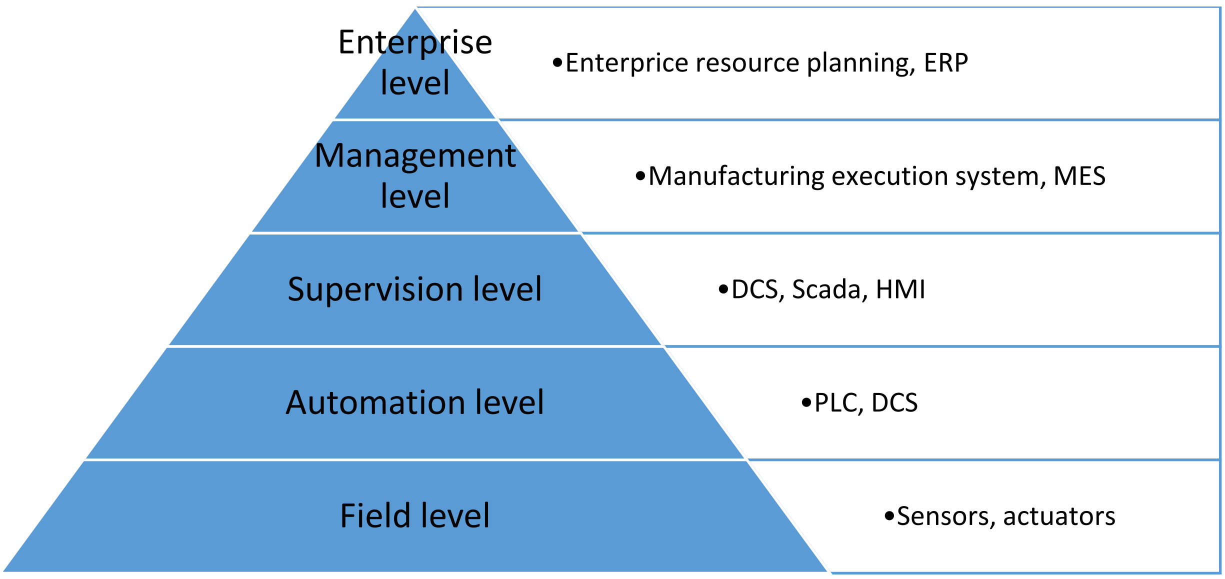

Figure 29 Automation system hierarchy

- **Field level:** At the field level you will find sensors, actuators and other instruments that provide data to the control system. Pressure, air quality, temperature and level data come from sensors in the field. Instruments are usually hardwired to a programmable logic controller (PLC) or a distributed control system (DCS).
- **Automation level:** At the automation level you will find hardware that allows you to apply controls to the process. Depending on the scale of the system, this is typically a PLC or a DCS. The controls can be applied based on input from different sub-systems as well as user input variables.

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- **Supervision level:** On the third level you will find the SCADA software (or BMS, BA(C)S) that links everything together into one user interface and supervisory control system. This level facilitates data access and control for operators from one location.
- **Management level:** On the management level you will typically find information about the processes beyond the mere control and supervisory of the processes. This can include production uptime, production output, etc. and can be coupled with other kinds of data such as the price of goods and commodities.
- **Enterprise level:** On the top of the pyramid, you will find the enterprise level that provides insight into different areas such as finance, supply, manufacture, logistics and customers.

Typically for the building automation world, seen from an integrator perspective, we are concerned with the lower three levels, while providing data to the fourth level.

3.1.2 EMS Server

EMS Server is a supervisory control and data acquisition (SCADA) software suite developed by EM Systemer AS. The EMS Server software resides on a building automation server and allows user access either through its MS Windows application interface or through a Web interface (either locally or through EMPortal.no cloud solution).

The software suite itself is designed to cover the needs of the Scandinavian building automation market with a strong focus on energy savings and controls. In addition to traditional visualization and control needs, there has been a move towards more complex solutions based on integrations with other sub-systems to enhance the customers' end value. Examples of this is control of energy flow in buildings with PV cells, EV charging and batteries for energy storage.

Another important area of software investment is the systems JSON REST API. This part of the software package ensures an openness and an easy way for integration and data exchange with other software applications. The company philosophy is that the openness, REST API, should be an enabler for other companies or individuals to create something that enhances the total smartness of the system and add customer value. By choosing an API to ensure openness, as opposed to traditional building automation protocols such as BACnet, the company open the possibility for a much wider range of collaborators – and enables the software to be part of the customers technical platform.

3.1.3 EMPortal.no

EMPortal.no is EM Systemer AS' cloud solution and a platform to collect and group the customers multitude of buildings/projects. Today there are about 1500 buildings/projects connected on the platform, and more than 600 registered organizations, and about 3000 unique users.

In addition, it offers organization and user control, remote access, enhanced building information, energy visualization across different buildings and projects, degree day adjustments in reports, slideshow, backup, FDV documentation, integration with external booking services and much more.

One important feature the EMPortal.no offers, seen from the COLLECTiEF project point of view, is the way it enables uniform access to the buildings' JSON REST API. In addition, it offers control of organization and user access for the API down to the detail of POST and GET commands and a log of all the API calls from any given source.

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3.1.4 Application Programming Interface (API)

API stand for Application Programming Interface and corresponds to mechanisms that enable software applications to communicate with each other using a set of definitions and protocols.

The intention of the API in EMS Server / EMPortal.no is twofold:

- **EMS Web:** EMS Web is a HTML5 based web user interface in the EMS Server BMS system portfolio. The web display and graphical user interface is built around the REST API application layer. This is the same API that can be made available for 3rd party software and applications. Since it is part of the internal communication between different parts of the BMS system, it is continuously under development and maintenance (on a daily level).
- **External access:** As part of the company strategy, the REST API can be offered to 3rd party software/companies for communication and data exchange purposes. There are several different companies that have access today, creating applications and extracting data based on the systems' REST API, all while supplying with different levels of functionality and added value for EM Systemer end users. Examples of such added functionality and 3rd party users:
    - External energy savings software modules
    - Level 4 in the automation system hierarchy
    - AI functionality
    - External booking systems

The API will be used in the COLLECTiEF project for integration between the BRiG device on site and the BMS system. Data from the BMS will be used in the COLLECTiEF algorithms, and controls will be applied to the BMS system through the API.

The API in the EMS Server BMS software have, among others, the following API queries that are going to be used by the COLLECTiEF algorithms:

GetOne/T/_ID_: Used to get information from a "T-Zone" in the BMS system, where "_ID_" is the zone number in the system. A T-Zone can contain an analogue value and its corresponding control settings and metadata. One example is room temperature and its setpoints (in different building operating status/modes), the gain from the heater, and more. A ***GetOne/T/_ID_*** request will have the following data fields in its response:

Table 49 List of data fields returned from the GetOne/T API query.

Id	Identifies the zone number of the analog value is in the BMS system.
Zoneletter	There are different zone types in the BMS system, representing different value types. Type T corresponds to analog values and will represent variables such as temperature, CO2, rH, etc.
Description1	Description for the analog zone, field 1. This is a configuration parameter and a description written by the system integrator upon configuration of the BMS deliverance.
Description2	Description for the analog zone, field 2. This is a configuration parameter and a description written by the system integrator upon configuration of the BMS deliverance.
MaxNumberOfZones	This field represents how many available zones of this type are in the project. Not all of them are necessarily in use.

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MaxValue	Maximum allowed setpoint value.
MinValue	Minimum allowed setpoint value.
MaxAllowed	Maximum value read.
MinAllowed	Minimum value read.
DaySetPoint	Day setpoint (occupied) for the analog zone. Might not be in use and adjustable.
DeltaTemperature	Used in hysteresis control regulations.
LowSetPoint	Setpoint outside of schedule. E.g., after working hours.
ClosedSetPoint	Setpoint when there are no scheduled time slots that day. E.g., weekends.
PMin	When the analogue zone is part of a load shedding algorithm, this variable represents the minimum temperature the zone is allowed to have.
Type	Type of the analog zone. There are several different types, each have its own role in the BMS system. Examples: undefined, with optimal start, without optimal start, outdoor temperature, booking interfaced, calculated, etc.
Acceleration	Time it took to reach the day setpoint (last time).
AccelerationStr	Time it took to reach the day setpoint in text/string format.
Unit	Measure unit used. Examples, "°C", "%", etc.
OverrideStatus	The current state of the zone in text format.
BackColorString	Color code of the string.
ForeColorString	Color code of the string.
ActualValue	Actual value of the zone as read from the sensor.
SetValue	Actual working/operating setpoint.
Gain	Output of the gain. This is typically the gain on an electrical heater, given in percentage from 0% to 100%.
OutdoorTemperature	The system's measured/calculated outdoor temperature.
RefZoneLetter	Reference zone type of the analog value. Typically, this will be letter "S" which refers to the Schedule object.
RefZoneID	Reference zone ID/zone number.
HasEffectRegulation	If the zone is included in a load-shedding scheme, this value returns true.
IsEffectRegulation	If the zone is temporarily (by the user) excluded from the load shedding scheme, this value returns false.

GetOne/M/_ID_/1: The GetOne API call will also be used to get data from energy meters in the building, and in particular data from the AMS meter, providing energy and power data at the building level. This will be used by the algorithms residing in the BRiG device to make available measurement date to the COLLECTiEF solution.

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A ***GetOne/M/_ID_/1*** request will have the following data fields in its response:

Table 50 List of data fields returned from the GetOne/M API query.

Id	Identifies the zone number of the analog value is in the BMS system.
Zoneletter	There are different zone types in the BMS system, representing different value types. Type M corresponds to meter values and will typically be kWh.
Description1	Description for the meter zone, field 1. This is a configuration parameter and a description written by the system integrator upon configuration of the BMS deliverance.
Description2	Description for the meter zone, field 2. This is a configuration parameter and a description written by the system integrator upon configuration of the BMS deliverance.
MeasureType	This is the type defined in the meter zone. It can be liters, m3, number, but most typically it will be kWh or MWh.
MeasureTypePerHour	This is the type defined within the hour. Typically, kW or MW.
Consumption_Last2min	This data field contain the power consumption calculated over the last 2 min period.
Consumption_CurrentHour	This data field contains the total consumption within current hour.
Consumption_LastHour	This data field displays the consumption for the last (whole) hour.
Current_MaxValue	MaxValue is the control setpoint for a load shedding algorithm in the meter zone – if any such control scheme has been applied.

GetMany/T: Used to get all the T zones defined in the BMS system. This call efficiently collects all the T zone information from every zone in one query. The response from the BMS system is the same as for **GetOne/T/_ID_** except it replies with every zone defined. This call will be used to gather BMS data in the data repository.

GetMany/A: Used to get the status all the A zones defined in the BMS system. An A zone is a digital zone that hold status of on/off signals, alarms, etc. Example if on/off signals can be window open/closed, door open/closed, alarm on/off, system running/not running, etc.

A ***GetMany/A*** request will have the following data fields in its response:

Table 51 List of data fields returned from the GetOne/A API query.

Id	Identifies the zone number of the analog value is in the BMS system.
Zoneletter	There are different zone types in the BMS system, representing different value types. Type A corresponds to alarms and digital status values.
Description1	Description for the digital/alarm zone, field 1. This is a configuration parameter and a description written by the system integrator upon configuration of the BMS deliverance.
Description2	Description for the digital/alarm zone, field 2. This is a configuration parameter and a description written by the system integrator upon configuration of the BMS deliverance.
AlarmActive	This field will return either true or false depending on the state of the alarm or digital input. This is after any constraints or limitations

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	is applied in the BMS system. E.g., a digital input can be delayed in the BMS system before an alarm is generated and the AlarmActive status switch to true.

GetGaugeData/0: This is a post command that can be used to fetch consumption/energy data from the meters for a user-defined time interval. The response from the BMS system is hourly, or daily, weekly, monthly consumption data depending on the recursion used in the query.

GetAMSEnergyData/_ID_: With this query the BMS will provide information on the Smart Meter(s) (AMS) integrated in the system. The BMS response will include power consumption, phase voltage and currents, meter name and serial number, and much more. The following table list the fields returned from the BMS system with the GetAMSEnergyData query:

Table 52 List of data fields returned from the GetAMSEnergyData/-1 API query.

Id	Identifies the zone number of the meter (AMS) in the BMS system.
Name	This is the descriptive name configured by the system integrator during configuration of the BMS deliverance.
Maks_Kw	If the zone is part of a load shedding configuration, Maks_Kw represents the load shedding limit.
OBISString	Each AMS meter has an OBIS code associated with it that represents the physical quantity measured by the meter.
AMSSerialNr	The AMS serial number is a unique identifier hardcoded in the meter.
AMSUnitModel	This is the model of the AMS meter.
ActPowerPluss	Active power positive.
ActPowerMinus	Active power negative.
ReactPowerPluss	Reactive power positive.
ReactPowerMinus	Reactive power negative.
CurrL1	Current, phase 1
CurrL2	Current, phase 2
CurrL3	Current, phase 3
VoltL1	Voltage, phase 1
VoltL2	Voltage, phase 2
VoltL3	Voltage, phase 3
ActEnergyPluss	Accumulated active energy, positive. This represents the amount of energy delivered to the building.
ActEnergyMinus	Accumulated active energy, negative. This represents the amount of energy delivered from the building to the grid.
ReactEnergyPluss	Accumulated reactive energy, positive. This represents the amount of reactive energy delivered to the building.
LastHourEffect	The total consumption previous hour.

Note that all the information, except ID, Name, Maks_Kw and LastHourEffect, are given from the AMS meter. The other variables are from within the BMS system.

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Providing the GetAMSEnergyData API call with the right recursions, the user can get the following added information:

Table 53 List of data fields returned from the GetAMSEnergyData/0 API query.

LogDateTime	Date and time for the log.
EnergyKwt	Energy consumption, kWh, at the logging time.
OutTemp	Outdoor temperature, provided from the BMS system, at the logging time.
VoltMinL1	Minimum voltage during the 1-hour recording period for phase 1.
VoltMinL2	Minimum voltage during the 1-hour recording period for phase 2.
VoltMinL3	Minimum voltage during the 1-hour recording period for phase 3.
VoltMaxL1	Maximum voltage during the 1-hour recording period for phase 1.
VoltMaxL2	Maximum voltage during the 1-hour recording period for phase 2.
VoltMaxL3	Maximum voltage during the 1-hour recording period for phase 3.
VoltAverageL1	Average voltage during the 1-hour recording period for phase 1.
VoltAverageL2	Average voltage during the 1-hour recording period for phase 2.
VoltAverageL3	Average voltage during the 1-hour recording period for phase 3.
CurrentMinL1	Minimum current during the 1-hour recording period for phase 1.
CurrentMinL2	Minimum current during the 1-hour recording period for phase 2.
CurrentMinL3	Minimum current during the 1-hour recording period for phase 3.
CurrentMaxL1	Maximum current during the 1-hour recording period for phase 1.
CurrentMaxL2	Maximum current during the 1-hour recording period for phase 2.
CurrentMaxL3	Maximum current during the 1-hour recording period for phase 3.
CurrentAverageL1	Average current during the 1-hour recording period for phase 1.
CurrentAverageL2	Average current during the 1-hour recording period for phase 2.
CurrentAverageL3	Average current during the 1-hour recording period for phase 3.

The BMS respond with the data described above for 7 days plus todays data up until last hour. In addition, the query provides daily aggregated data for Energy_Kwt and the average outdoor temperature.

3.2 Interfacing between BRiG device and EMS Server

The BRiG will integrate the BMS system on site through the REST API. Authentication and API keys for the different pilot buildings have already been assigned and distributed to the responsible project members. Further allocation and administration of project members and access levels will be done through EMPortal.no.

There is an application allocated to the Edge Node Resource Management level of the BRiG device that deals with interfacing of different protocols and with the BMS in particular. More on the architecture and design can be found in deliverable D3.1 chapter 3, Conceptual Architecture.

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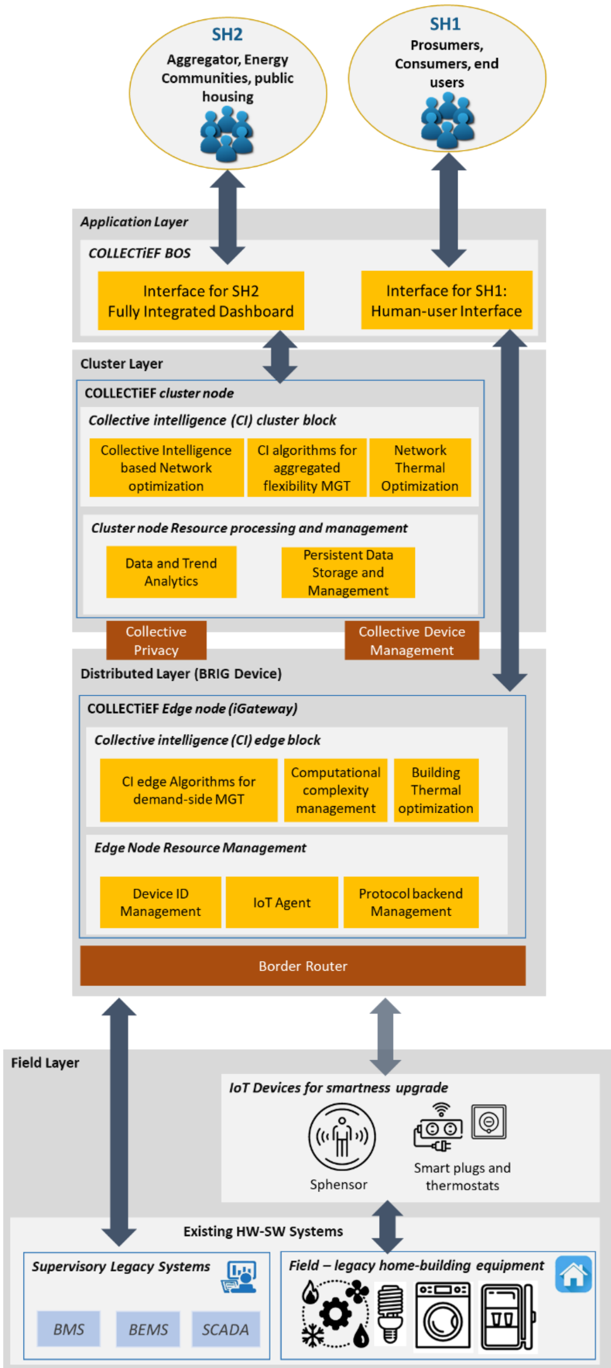

Figure 30 COLLECTiEF Conceptual Architecture.

There will be a configuration tool in the software deployed on the BRiG that allows for integration with the different zones in the BMS system and the AMS meter for power and energy data. The zones are already identified in the project and correspond to the zones where Sphensors and POE questionnaires are set up.

For each zone, the COLLECTiEF solution will read the temperature from the BMS system and apply changes to the setpoint for individual room control. This will be used for optimalization of user comfort, as well as response to energy demand signals and grid response.

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3.3 AMS, smart meters

The Norwegian pilot buildings will integrate with the AMS (smart) meter on the site. The reason behind doing this is to get accurate power and consumption data on the building level that can be used for different BMS functionality such as load shedding and energy flow control, as well as for reporting on energy consumption in the building.

For the COLLECTiEF project, the purpose is to provide power consumption data for the algorithms through the BMS REST API.

There are two ways to integrate the AMS meter into the BMS system – either through serial communications or through UDP/IP. The selected interfacing will vary from building to building, based on system topology and ease of access for serial communication lines.

3.4 Upgrade to latest software

As part of the COLLECTiEF system integration and large-scale demonstration phase, the BMS software on site will be upgraded to its latest version. This was done early in the project to ensure that the pilot buildings could provide data for the data repository through the associated REST API calls.

During the project progress, depending on the need for software development and changes on the BMS system, the BMS software will be upgraded with new functionality. This will be performed remotely through the EMPortal.no cloud solution.

3.5 EMPortal.no access

The COLLECTiEF organization has been created on the EMPortal.no and project members that need access to the BMS system user interface for one or more pilot buildings have been added as EMPortal.no users. The portal has been used to assess and evaluate the buildings technical systems and will be used as part of the monitoring and evaluation phase of the project.

Further, EMPortal.no has been configured so that the COLLECTiEF project participants have the needed authorization and access to the individual BMS system data through allocated API keys.

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4 Description of the integration process based on the characteristics of the legacy equipment in each demonstration building

4.1 General

The deployment of the solutions offered by COLLECTiEF implies a positive effect in the recalculation of the SRI assessments of the buildings, affecting directly the different aggregated scores. The first solution is associated with the implementation of decision-making algorithms for energy efficiency and flexibility (Grid and Building aggregated scores) with the grid, which is completed with the implementation of BRiG and smart devices that helps with the aggregation and connection with the grid for a group of building to improve their intelligence in a collective manner. Next, the implementation of novel setpoint definition for indoor spaces together with the decision-making process will have a direct effect in the comfort of the final user, making the use of HVAC systems more efficient and flexible but helping to cope the needs of the user (Grid and User aggregated score). Finally, the implementation of a unified users' interface with the historical and current data of the measured consumption, together with setpoints and indoor zones variables (such as temperature, CO2, etc.) will imply an effect on the User aggregated score.

4.1.1 How do we improve the different domains

In specific, for the 54 possible services that the SRI assessment considers, 10 services are expected to be improved in the development of the COLLECTiEF project. Accordingly, in the following table, the modified services (for all the pilot buildings if they are applicable) and their impact in the aggregated score of the SRI assessment are shown.

Table 54 Expected modification in the services (if they are applicable) for the pilot buildings with the implementation of COLLECTiEF project.

Domain	Code	Smart ready service	Expected functionality level	Description of the level	Effect on Aggregated Score		
					Building	User	Grid
Heating / Cooling	H/C-4	*Flexibility and grid interaction*	3	Heating/cooling system capable of flexible control through grid signals	Yes	Yes	Yes
Electricity	*E-4*	*Optimizing self-consumption of locally generated electricity*	2	Automated management of local electricity consumption based on current renewable energy availability	No	Yes	Yes
Electricity	*E-8*	*Support of (micro)grid operation modes*	1	Automated management of (building-level) electricity consumption based on grid signals	No	Yes	Yes
Electricity	*E-12*	*Reporting information regarding electricity consumption*	2	real-time feedback or benchmarking on building level	Yes	Yes	No
Monitoring and control	*MC-13*	*Central reporting of TBS performance and energy use*	1	Central or remote reporting of real time energy use per energy carrier	Yes	Yes	No
Monitoring and control	*MC-25*	*Smart Grid Integration*	2	Coordinated demand side management of multiple TBS	Yes	Yes	Yes
Monitoring and control	*MC-28*	*Report demand performance information (DSM)*	2	Reporting information on current historical and predicted DSM status, including managed energy flows	Yes	Yes	Yes

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Monitoring and control	*MC-29*	*Override of DSM control*	4	Scheduled override of DSM control and reactivation with optimized control	Yes	Yes	Yes
Monitoring and control	*MC-30*	*Single platform that allows automated control & coordination between TBS*	2	Single platform that allows automated control & coordination between TBS	Yes	Yes	No

4.1.2 Expected SRI Assessment

With the application of the expected modifications in the SRI assessment of the buildings, the recalculation of the SRI score and the associated aggregated scores are presented in the following table:

Table 55 Expected overall SRI score with the application of the measures imposed by COLLECTiEF project.

#	Building	SRI Range	SRI Class	SRI Score	Aggregated Score		
					Building	User	Grid
	Cypriot Pilots						
1	Guy Ourisson Building	*20%-35%*	*F*	*34,6%*	*24,2%*	*27,5%*	*52,1%*
2	Graduate School	*35%-50%*	*E*	*41,9%*	*26,5%*	*29,1%*	*70,2%*
3	Novel Technologies Laboratory	*35%-50%*	*E*	*45,8%*	*39,7%*	*35,7%*	*62,0%*
1	G2Elab	*65%-80%*	*C*	*71,1%*	*69,5%*	*69,0%*	*74,7%*
	Italian Pilots						
1	Valsesia C2	*35%-50%*	*E*	*39,0%*	*34,0%*	*28,9%*	*54,1%*
2	Valsesia C3	*35%-50%*	*E*	*39,0%*	*34,0%*	*28,9%*	*54,1%*
3	Valsesia C4	*35%-50%*	*E*	*39,0%*	*34,0%*	*28,9%*	*54,1%*
	Norwegian Pilots						
1	Eidet Omsorgssenter	*50%-65%*	*D*	*56,8%*	*56,1%*	*58,6%*	*55,6%*
2	Ellingsøy Idrettshall	*50%-65%*	*D*	*52,7%*	*53,4%*	*54,5%*	*50,2%*
3	Flisnes Barneskole	*50%-65%*	*D*	*61,0%*	*49,8%*	*46,6%*	*86,8%*
4	Hatlane Omsorgssenter	*50%-65%*	*D*	*51,5%*	*54,2%*	*51,7%*	*48,5%*
5	Moa Helsehus	*50%-65%*	*D*	*57,5%*	*50,0%*	*48,2%*	*74,3%*
6	Spjelkavik Ungdomsskole	*65%-80%*	*C*	*66,9%*	*54,0%*	*53,4%*	*93,3%*
7	Tennfjord Barneskole	*50%-65%*	*D*	*63,0%*	*53,7%*	*48,8%*	*86,3%*

Accordingly, in table 56 is shown the SRI assessment score for the pilot buildings with their current status and their expected improvement. It is possible to observe that in all the pilots the minimum increase is at least one class, but in the majority of the cases the improvement is two classes. The buildings that currently have a better level of smartness, such as Eidet Omsorgssenter and G2Elab, show a lower increase in the score with respect to the other buildings since some of the services that should be updated in the new SRI already had the required smartness with their legacy equipment.

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Table 56 Comparison between the SRI score of the buildings in their current status and the expect SRI score with the application of the measures imposed by COLLECTiEF project.

#	Building	Current Status		Expected Status		Class Increase
		SRI Score	SRI Class	SRI Score	SRI Class	
	Cypriot Pilots					
1	*Guy Ourisson Building*	*5,8%*	*G*	*34,6%*	*F*	*1*
2	*Graduate School*	*5,7%*	*G*	*41,9%*	*E*	*2*
3	*Novel Technologies Laboratory*	*19,1%*	*G*	*45,8%*	*E*	*2*
	French Pilots					
1	*G2Elab*	*50,6%*	*D*	*71,1%*	*C*	*1*
	Italian Pilots					
1	*Valsesia C2*	*12,2%*	*G*	*39,0%*	*E*	*2*
2	*Valsesia C3*	*12,2%*	*G*	*39,0%*	*E*	*2*
3	*Valsesia C4*	*12,2%*	*G*	*39,0%*	*E*	*2*
	Norwegian Pilots					
1	*Eidet Omsorgssenter*	*36,9%*	*E*	*56,8%*	*D*	*1*
2	*Ellingsøy Idrettshall*	*33,9%*	*F*	*52,7%*	*D*	*2*
3	*Flisnes Barneskole*	*27,9%*	*F*	*61,0%*	*D*	*2*
4	*Hatlane Omsorgssenter*	*32,5%*	*F*	*51,5%*	*D*	*2*
5	*Moa Helsehus*	*25,9%*	*F*	*57,5%*	*D*	*2*
6	*Spjelkavik Ungdomsskole*	*30,8%*	*F*	*66,9%*	*C*	*3*
7	*Tennfjord Barneskole*	*27,9%*	*F*	*63,0%*	*D*	*2*

This project has received funding from the European Union's H2020 research and innovation programme under Grant Agreement No 101033683

5 Identification of the relevant field devices to install on each demo zone

In order to perform the desired control logic introduced with the COLLECTiEF system, there is a need for different field devices to bridge the gap between the BRiG device and the actual appliance or device to be controlled in the pilot building.

The BRiG resides on the building level and communicates with the desired control points and sensors on the building and is performing the controls added by the COLLECTiEF system.

In the COLLECTiEF project there will be introduced different field devices, based on the different pilot buildings infrastructure and possibilities for integration.

In all cases, the overall goal is to keep costs low, and introduce ready-to-be deployed off-the-shelf products, already available on the market. The importance of choosing available commercial products is significant, to demonstrate the versatility of the COLLECTiEF solution and to show that it can be easily adopted into a real-life environment.

5.1 General

The following field devices have been chosen as part of the COLLECTiEF project to demonstrate the validity, versatility and effectiveness of the system algorithms and control functions.

5.1.1 Sphensor ™

In order to have a uniform platform of indoor air quality (IAQ) measurements and a uniform way to collect these data across all the pilot sites included in the COLLECTiEF project, there has been chosen at the start of the project, field devices for gathering IAQ values.

Sphensor is the line of sensors produced by LSI LASTEM for monitoring environmental parameters and air quality control in indoor environments.

These devices have been chosen due to their simplicity to install (no cabling needed, only power supply – mini-USB or battery), their relatively low cost, the numerous indoor air quality parameters that they collect and their low power consumption. The sensors send their data to a Sphensor Gateway which in turn transmits the data securely to the project database through an MQTTS broker.

In addition to being able to create a uniform platform with measurements that have the same sensor type origin, not branching out and selecting different sensors for the different pilot buildings, ensure that the internal development cost in the project stays low. This is due to the fact that there is only one sensor type to integrate in the BRiG and with the project database.

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5.1.2 Smart plug and valves

Smart plugs and valves have been chosen since they are products easily available on the market and they allow for the interface with the legacy equipment in the buildings. Particularly in the Italian pilots, the smart plugs have been selected to interface with some selected household appliances and electrical heaters for domestic hot water, while the smart valves will be used to improve the control of the water radiators for space heating. Smart plugs and valves represent low price and easy to be installed components which can allow the integration with the BRiG.

Initially within the consortium, the pilot responsible and the industrial partners selected the smart plugs and valves of the brand Shelly (https://www.shelly.cloud/en), because they are easily available on the market at lower prices compared to other brands, and they seemed to be easy to configure and to connect through Wi-Fi. Preliminary, the industrial partners checked also that the devices are suitable to be integrated with the BRiG and the COLLECTiEF system. Despite this, after the installation and several tests in the Italian pilots, the devices by Shelly showed several issues, particularly related to the fact that they need a very strong signal from the Wi-Fi network and at the same time the structural features of walls and slabs in the pilot and the floors shape don't allow the best Wi-Fi signals in the rooms. This causes malfunctioning and control issues of the valves and plugs. Several verifications and tests have been deployed on field by Teicos and R2M, with the support of LSI Lastem and E@W, also adding Wi-Fi repeaters and performing different trials with the devices, and despite this many issues remain. In addition, the smart valves present a quite weak mounting system, that in some cases give issues to the users to provide a right control.

For this, the consortium had to consider different other solutions. After a new analysis of the devices available on the market, a different model has been selected for the smart plugs and valves. To overcome the issue with the Wi-Fi connectivity, it has been decided to use smart plugs and valves with wireless communication based on the LoRaWAN protocol. They are available on the market at accessible prices. In Milan, where the Italian pilots are located, a wide LoRaWAN connectivity is present almost in the whole city. It is managed by the utility "a2a", in which the Municipality of Milano is one of the main owners. A connectivity test has been successfully deployed in the different apartments of the pilots, and it has been decided to select the smart plugs and valves of the brand "a2a Smart City", who acts as system integrator for these solutions. So far, their installation has been deployed in one of the selected apartments to check their operation and integration with the COLLECTiEF solutions. After this testing phase all the needed smart plugs and valves will be bought and their installation is scheduled before the end of July 2023, to be in time for the deployment of the COLLECTiEF controls starting from the heating season 2023-2024.

The new solution based on the LoRaWAN network can be interesting also to follow the chance to integrate the COLLECTiEF system with this smart city infrastructure in Milano.

According to the goals and the budget of the project, the smart valves will be installed on 45 radiators, that correspond to 5 apartments where all the radiators will be controlled through the smart valves excluding bathrooms and to 7 apartments where 3 or 2 radiators will be controlled in selected rooms, for a total of 12 apartments in the 3 pilot buildings.

In addition, 5 smart plugs will be installed to control selected appliances, like washing machines, clothes dryers, air conditioners, water heaters, dishwashers, ovens, microwave ovens, refrigerators, freezers, and other possible small appliances (e.g., humidifiers, fans, etc.).

Teicos and R2M are deepening the features of the appliances in the selected apartments to define which ones will be controlled by the smart plugs. They are gathering information from the occupants on these aspects: available appliances, production year, brand, energy class, main functionalities, presence of automatic on/off or scheduling functions.

5.1.3 Heat meters and heat cost allocators

Heat meters and heat cost allocators are being used to monitor the thermal energy use for heating for each of the selected apartments and for each of their radiators in the Italian pilots. The monitoring system was already installed in the buildings, and it represents the typical layout that is installed in the last decade in many apartments blocks built in 70s and 80s in Italy. These devices don't directly allow the control of the heating systems, but they measure and send data to the related user interface software.

The COLLECTiEF partners are working to complete the integration of these data sources with the project solutions.

5.1.4 Sensibo Sky and Ecobee lite 3 thermostats

The Sensibo Sky and Ecobee lite3 thermostats aim to provide a room-level control of the HVAC units at the Cypriot pilot buildings.

More precisely, the Ecobee lite3 will be integrated in the fan-coil units (FCUs) and offer (i) monitoring and control of temperature, (ii) fan speed control (auto, on), (iii) system on/off, (iii) creation of new schedules (away, home, sleep, …), and (v) Application Programming Interface (API) connectivity. These units will be installed at the Novel Technologies Laboratory (NTL) and the Guy Ourisson Building (GOB) building.

The Sensibo Sky will be integrated with AC split units and variable refrigerant volume (VRV) systems installed at the Graduate school buildings. The Sensibo Sky offers (i) on/off, (ii) monitoring and control of air temperature, (iii) mode (heat, cool, fan, dry, auto) (iv) fan speed control (quiet, low, medium, high, auto, strong), (v) creation of schedules, and (vi) Application Programming Interface (API) connectivity.

Since the HVAC systems for the Cypriot pilot buildings (i.e., GOB, GS, and NTL) are not IoT-enabled devices or do not offer an Application Programming Interface (API) connectivity, a low-cost solution was to replace the legacy thermostats with new smart thermostats. Following a market-research and dealing with compatibility issues, we have chosen to replace conversional thermostats with smart, IoT-enabled thermostats. In particular, for the buildings or rooms operated by A/C split units we have chosen to install the Sensibo Sky unit, which covers a wide range of A/C brands, offers an up-to-date API documentation and zero cabling/installation effort. On the other hand, for the buildings or rooms operated by fan-coil units (FCUs) we have chosen Ecobee lite3 solution. However, due to the physical incompatibility of the FCUs and the Ecobee lite3, a custom electrical panel needed to be installed in every FCU for transforming the AC 230V supported by the FCUs to 24V DC, supported by the Ecobee lite3.

The corresponding APIs will be integrated on the BRiG devices and a solution for this is already developed and verified for the two test devices installed on site. Currently, as a good practice, only one testing device per type i.e., one Sensibo Sky and one Ecobee lite3 is installed, to provide a holistic integration and test of these devices, before replacing all of them. The plan is to install one per HVAC unit, which corresponds to 11 Ecobee lite3 and 9 Sensibo Sky.

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5.1.5 Power meters (Cyprus)

Power meters installed at the CyI pilot buildings communicate data every 15 minutes to an external broker that belongs to a third party (Ether). Data are accessible by CyI through a web portal, from which E@W has created a script (data scraper) and regularly collects them.

The data will be gathered in the BRiG device and used for controls within the COLLECTiEF solution and its algorithms.

5.2 Norwegian pilot buildings

For the Norwegian pilot buildings there will be an integration with the existing BMS system. This integration will be performed with the BMS system's application programming interface (API) that resides on a cloud solution and is accessible for all the buildings through one access point, but with different authentication/authorization keys.

In order to do the integration with the BMS system, only an internet access and the right authentication method and API keys are necessary. User access and API access are controlled in the BMS software cloud solution (EMPortal.no) and ensure that no unauthorized software gets access to data it is not supposed to have access to.

Other than internet access, there is no need for any further field devices to apply controls to the BMS system in the Norwegian pilot buildings as the BMS system already have connection and a way to communicate setpoint and desired changes to the devices the COLLECTiEF project aims to control.

One aspect to consider when applying COLLECTiEF logic and controls on top of the existing BMS system is how the two systems and control logics will cooperate. There are already several control functions locally that perform different types of control. One example is temperature control that will be overridden by the COLLECTiEF algorithms when a signal for grid demand requires action on the BRiG device. Just expanding the range of temperature control according to user defined limits is straightforward, but there must be taken into account that the temperature control can also be part of other control functions, residing in the BMS system, such as load shedding.

On the Norwegian pilots there will be installed smart plugs to control certain appliances or energy consumers. Since these buildings are government institutions and there are rules that govern the interference with equipment such as appliances, there is a limitation on how much controls can be applied to for example fridges, coolers, washing machines, etc. Further, there is the practicality on applying controls on some appliances that make it unsuited to be part of the COLLECTiEF solution. For example, the dishwasher in the health care centers is being used constantly and it would potentially interrupt the service of food distribution to the elderlies if the up time were limited during regular working hours. Also, some appliances will restart their cycle if powered off/on and hence will not give good energy savings/benefits if used in such a control scheme. In schools there are strict rules on temperature deviations on fridge and cooling systems for food storage, and since there is no control of how often the fridge door is being opened, it would potentially cause deviations from the rules and food would be considered unfit to eat and must be thrown away.

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6 Description of the activities and the timeframe to carry them out for each of the demonstration buildings

This chapter will provide a description of the activities needed to prepare and deploy the COLLECTiEF solution on the pilot buildings and an overview of the timeframe to carry them out.

The project has several pilot buildings in different locations in Europe, and they all have variations in the way they will incorporate the COLLECTiEF solution as well as different maturity levels in the project. It is therefore important to choose the best suited pilot buildings to start the integration process with the COLLECTiEF solution, gain experience and use this for the large-scale implementation and completion of the integration process.

6.1 Evaluation of early installation

When starting the process of integrating and deploying the COLLECTiEF solution on the projects pilot buildings, it will be natural to start in one end and confirm that the majority of the solution and applied controls is working as intended before deploying it in the rest of the buildings.

It is expected that the project will encounter some unforeseen challenges when doing the initial installation/deployment of the solution and therefore it is important that the project group do a continuous evaluation and correction of the installation procedures before doing a full installation across all the pilot buildings in all the regions chosen for the project.

When choosing what pilot building to implement first, there are some considerations to take into account:

- **Available data:** There will be an evaluation of certain KPI's identified in WP5, that will say something about the success rate of the COLLECTiEF project. It is important to choose pilot buildings that have as much data available at this current stage first, to get indications on the performance of the solution as quickly as possible.
- **Level of completeness:** Some pilot buildings are better prepared to start the integration process than others. Not all pilot buildings have the solution finalized and ready for integration with appliances and others have more limited possibilities for integration with control units. The building that has the best options available for complete integration will be highly preferred at an early stage.
- **Monitoring:** When deploying the COLLECTiEF solution it will be paramount to be able to monitor its performance. It will also be beneficial if the project group is able to monitor the controls and result of the deployed algorithms through other 3rd party independent platforms/visualization tools to verify the outcome of the solution and to verify that the project dashboard and internal developed visualization tools are aligned with the 3rd party visualization tools.
- **Access:** At the early stages of installation, it will be important to have easy access to the BRiG device for continuous software updates, and to other parts of the buildings' infrastructure that is included in the COLLECTiEF solution and deployment on site. The project aims to interfere (negatively) with the stakeholders as little as possible. If the project needs to access the site physically repeatedly and for an extended period, it will affect the

user response and participation negatively. This needs to be avoided, and interfering with stakeholders at their homes will feel more intrusive than interfering at their place of work.

- **POE responses:** There are clearly some users that show a higher level of participation and engagement than others. It is natural to look at the pilot buildings, or zones within these buildings, with a higher user engagement when evaluating what pilot building/zones to start the integration process.
- **Energy/power data:** Since power data is needed in the algorithms in COLLECTiEF, it is necessary to choose pilot buildings that have access to near real time power/consumption data. Example, for the Norwegian pilot buildings there is one building that has the main meter integrated into the BMS system and therefore being able to provide power/consumption data, on the building level, real time, through the BMS API.
- **Region:** The pilot buildings are located in different regions in Europe and have different weather types and climatic control needs. The project would like to cover different climates as early as possible to ensure the applied control algorithms are working under different weather and climate types at an early stage. Also, it is beneficial to get more pilot responsible partners involved at the early stages of the installation to have more peers to evaluate both the installation process, integration, and performance of the system.
- **Building complexity:** It might be beneficial to start with some of the simpler buildings to better understand and evaluate the COLLECTiEF solutions actual impact on the buildings control, regulations, user comfort and energy consumption. The more complex the building tends to be, the more difficult it will be to get an exact extraction of the COLLECTiEF solution impact.

6.1.1 Sphensor data collection

For all the pilot buildings, the Sphensors have been installed and indoor air quality data have been transmitted to and stored on the project data repository. The Sphensors were installed and deployed in the different pilot buildings at the end of August.

Data, for post evaluation, of the COLLECTiEF system is available through the API created on the project data repository and will be used both as a continuous evaluation process of the Sphensors availability and data quality, as well as for the impact assessments that will be performed in WP5.

A thorough description of the deployment and state of installation for the Sphensors can be found in deliverable D5.2 chapters 3.1 *Design and configuration of monitoring system* and chapter 3.2 *Deployment and monitoring system in the pilot sites*.

In the same document, a description of the data management plan for Sphensor data as well as the data structure of the repository can be found. Furthermore, a detailed description of the available API function calls associated with the data repository is included.

There have been some issues with Sphensors being broken, unplugged, out of range or for other reasons not being able to transmit data to the Sphensor gateway, so the project group has set up different ways to monitor the quality of the data being stored in the repository.

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- **Monthly reporting:** An Excel sheet, predefined with the information to report on, has been set up and filled out monthly by the pilot responsible partners. In this document, the number of days with Sphensor communication is recorded for every month as well as the amount of POE responses for each individual zone. All the recordings are being read through the data repository API and therefore the project group will see the status of the complete communication chain. An application that can be configured to read multiple pilot buildings over a given timeframe and store the results in both Excel and a graphical representation has been created by EM in order to make this process more efficient and less time consuming. This application can also be used to discover deviances in the values stored on the project data repository and count/ plot the number of POE responses for the associated zone/building within the same reporting tool. An example of the visualization is shown in the figure below.

Figure 31 Monthly report, displayed visually.

- **Weekly status report:** Every Friday, LASTEM send out a Sphensor status report as seen from the MQTT broker. Here the pilot responsible partner easily sees if any Sphensor is not transmitting its values as expected. The report is sent out to each pilot responsible, and to WP4 and WP5 leader and project coordinators, with an overview of status and suggestions on how to improve or fix the issues reported.
- **Alarming on Sphensor status at data repository:** CETMA is currently working on generating alarms on low Sphensor count and Sphensor values being out of range. The exact alarming limits will be undergoing changes as the project evolves as the limits will probably be more rigid as the installation is more settled.

Furthermore, there is set up a stock specifically for the project to ensure fast delivery should hardware failure and malfunctions occur on pilot sites.

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Building	Zone type	POE Code	Sensor ID	Sphensor serial no.	Sum of days on record	jul.22			aug.22			sep.22			okt.22			nov.22		
						a 15	b 16	LSI Comme	a 15	b 16	LSI Comme	a 15	b 15	LSI Comme	a 15	b 16	LSI Comme	a 15	b 15	LSI Co
Eidet Omsorgsenter	Health care	B01Z01	B01Z01S001423	22050177	213	0	0		0	6		15	15		15	16		15	15	
	Health care		B01Z01S002401	22040204	203	0	0		0	6		15	5		15	16		15	15	
	Health care	B01Z02	B01Z02S003423	22050178	213	0	0		0	6		15	15		15	16		15	15	
	Health care		B01Z02S004401	22040205	210	0	0		0	6		12	15		15	16		15	15	
	Health care	B01Z03	B01Z03S005423	22050179	213	0	0		0	6		15	15		15	16		15	15	
	Health care		B01Z03S006401	22040214	144	0	0		0	6		15	9		3	0		8	15	
	Health care	B01Z04	B01Z04S007423	22050180	213	0	0		0	6		15	15		15	16		15	15	
	Health care		B01Z04S008401	22040215	212	0	0		0	6		15	15		15	16		15	15	
	Shared office	B01Z05	B01Z05S009423	22050181	213	0	0		0	6		15	15		15	16		15	15	
	Shared office		B01Z05S010402	22040278	213	0	0		0	6		15	15		15	16		15	15	
Ellingsøy Idrettshall	Sports hall	B02Z01	B02Z01S011423	22050183	85	0	0		0	6		15	15		15	16		8	0	
	Sports hall		B02Z01S012401	22040216	133	0	0		0	6		15	15		15	16		8	0	
	Sports hall		B02Z01S013423	22050184	121	0	0		0	6		15	15		15	16		8	0	
	Sports hall		B02Z01S014401	22040219	133	0	0		0	6		15	15		15	16		8	0	
	Sports hall		B02Z01S015423	22050185	133	0	0		0	6		15	15		15	16		8	0	
	Sports hall		B02Z01S016401	22040220	133	0	0		0	6		15	15		15	16		8	0	
	Sports hall	B02Z02	B02Z02S017423	22050186	0	0	0		0	0		0	0		0	0		0	0	
	Sports hall		B02Z02S018401	22040225	133	0	0		0	6		15	15		15	16		8	0	
	Sports hall		B02Z02S019423	22050187	133	0	0		0	6		15	15		15	16		8	0	
	Sports hall		B02Z02S020401	22040230	133	0	0		0	6		15	15		15	16		8	0	
Flisnes Barneskole	Classroom	B03Z01	B03Z01S021423	22050188	213	0	0		0	6		15	15		15	16		15	15	
	Classroom		B03Z01S022402	22040279	213	0	0		0	6		15	15		15	16		15	15	
	Classroom	B03Z02	B03Z02S023423	22050189	213	0	0		0	6		15	15		15	16		15	15	
	Classroom		B03Z02S024402	22040280	213	0	0		0	6		15	15		15	16		15	15	
Hatlane Omsorgsenter	Health care	B04Z01	B04Z01S025423	22050190	213	0	0		0	6		15	15		15	16		15	15	
	Health care		B04Z01S026401	22040236	209	0	0		0	6		15	15		15	16		15	15	
	Health care	B04Z02	B04Z02S027423	22050239	213	0	0		0	6		15	15		15	16		15	15	
	Health care		B04Z02S028401	22040238	208	0	0		0	6		15	15		15	16		15	15	
	Health care	B04Z03	B04Z03S029423	22050240	206	0	0		0	5		9	15		15	16		15	15	
	Health care		B04Z03S030401	22040239	207	0	0		0	6		14	15		13	16		15	15	
	Health care	B04Z04	B04Z04S031423	22050241	0	0	0		0	0		0	0		0	0		0	0	
	Health care		B04Z04S032401	22040244	213	0	0		0	6		15	15		15	16		15	15	
	Shared office	B04Z05	B04Z05S033423	22050242	175	0	0		0	6		14	15		15	16		15	15	
	Shared office		B04Z05S034402	22040281	0	only reported "null" for press value for every day														
	Shared office	B05Z01	B05Z01S035423	22050243	184	0	0		0	5		15	15		15	16		15	15	
	Shared office		B05Z01S036402	22040282	213	0	0		0	6		15	15		15	16		15	15	

Figure 32 – Excel sheet with Sphensor status for monthly reporting

Building	Zone type	POE Code	Sphensor serial no.		aug.22			sep.22			okt.22			nov.22			des.22			jan.23			feb.23		
				LSI Comments	a	b	LSI Comments	a	b	LSI Comments	a	b	LSI Comments	a	b	LSI Comments	a	b	LSI Comments	a	b	LSI Comments	a	b	LSI
GOB	Individual office	B09Z01	22050335		0	0		0	0		0	0		0	0		0	0		0	0		0	0	
	Individual office		22040325		0	0		0	0		0	0		0	0		0	0		0	0		0	0	
	Individual office	B09Z02	22040319		0	6		15	15		15	16		15	15		13	16		15	13		14	14	
	Individual office	B09Z03	22040326		0	6		7	0		0	0		0	0		0	0		0	0		0	0	
	Individual office	B09Z04	22050338		0	6		15	14		15	10		13	11		12	12		13	11		7	14	
	Individual office		22040321		0	6		15	14		15	16		15	14		13	16		15	13		14	14	
	Shared office	B09Z05	22050342		0	6		15	15		15	16		15	15		13	16		15	13		14	14	
	Shared office		22040322		0	6		15	15		15	16		15	15		13	16		15	13		14	14	
	Individual office	B09Z06	22040320		0	6		15	15		15	16		15	15		13	16		15	13		14	14	
	Individual office		22050334		0	6		15	15		15	16		15	15		13	16		15	13		14	14	
	Individual office	B09Z07	22040324		0	6		15	15		15	15		15	13		13	16		15	13		14	14	
	Individual office	B11Z13	22040335		0	0		0	0		2	0		0	0		0	0		0	0		0	0	
	Individual office	B11Z14	22040334		0	6		15	15		15	16		15	15		13	15		15	13		14	14	
GS	Classroom	B10Z01	22050336		0	2		8	4		0	7		15	15		13	16		15	1		0	0	
	Classroom		22050333		0	2		9	4		0	7		3	0		0	0		0	13		14	14	
	Classroom		22040323		0	2		9	4		0	7		15	15		13	16		15	13		14	14	
	Shared office	B10Z02	22050341		0	2		8	4		0	7		15	15		13	16		15	13		14	14	
	Shared office		22040330		0	2		9	4		0	7		15	15		13	16		15	13		14	14	
	Individual office	B10Z03	22040328		0	2		9	4		0	7		15	15		13	16		15	13		14	14	
	Shared office	B10Z04	22050339		0	2		9	4		0	7		15	15		13	16		15	13		14	14	
	Shared office		22040332		0	2		8	4		0	7		15	15		13	16		15	13		14	14	
	Shared office	B10Z05	22050337		0	2		8	4		0	1		0	0		0	0		0	0		0	0	
	Shared office		22040333		0	2		8	4		0	7		15	15		13	16		15	13		14	14	
NTL	Individual office	B11Z15	22040337		0	0		0	0		9	16		15	15		13	16		15	13		14	14	
	Shared office	B11Z17	22050346		0	6		15	15		15	16		15	15		13	16		15	13		14	14	
	Shared office		22040340		0	6		15	15		15	16		15	15		13	16		15	13		14	14	
	Shared office	B11Z18	22050345		0	6		15	15		15	16		15	15		13	16		15	13		14	14	
	Shared office		22040336		0	6		15	15		15	16		15	15		13	16		15	13		14	14	
	Shared office	B11Z16	22050343		0	6		15	15		15	16		15	15		13	16		15	13		14	14	

Figure 33 Excel sheet with POE status for monthly reporting

6.1.2 BMS data collection

Through the BMS API, all the available analogue and digital status data have been read every 1 minute and stored on the project data repository. There are two function calls that are being queried for every Norwegian pilot building – GetMany/T and GetMany/A. The response from these queries are all the analogue values (and its metadata) and the status from all digital (on/off) values (and its metadata). Se chapter 3.1.4 Application Programming Interface (API) for more information on these REST API calls and the BMS response.

These data will be used to evaluate the performance while doing the impact assessment of the COLLECTiEF project. The data has been read and stored on the project database since early august 2022 and will be made available to the project partners through a new REST API on the project data repository.

Data collected through the BMS API are anonymous and do not contain any user sensitive information.

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6.1.3 Energy/power data

Consumption data is needed on two levels in the project – energy data for calibration and data modelling, and power data as an input to the COLLECTiEF algorithms for system controls.

Energy data for calibration and modelling are needed with a time resolution of once per hour, kWh, while the power data needed for the COLLECTiEF algorithms need a much higher sample rate and more frequent update.

Energy data for calibration and data modelling

For the Norwegian pilot buildings, energy data at the building level, can be found through the national centralized IT system called Elhub:

> *Elhub is a central IT system that supports and streamlines market processes such as electricity sales, move-in/-out, termination of supply etc. in the Norwegian electricity market, as well as supporting the distribution and aggregation of metering values for all consumption and production in Norway. Statnett's wholly owned subsidiary, Elhub AS, is responsible for establishing and managing Elhub.*

Data, as consumption per hour, is available through an API for registered 3rd party companies on Elhub, but to keep within the project budget the data has been downloaded in a CSV format at no cost and imported into the project data repository. Through the data repository internal API functionality, energy data is made available to a selected number of the COLLECTiEF project members.

For the Italian pilot buildings, the daily energy data is available through the ISTA portal and the COSTER software. Each heating radiator in the residential apartment has a heat cost allocator that upload their data to a web portal. With the right access it is possible to download these data in a text file. There will either be a direct integration with the ISTA web portal for gathering energy data, or the files will be downloaded manually and imported into the project database and made available to the project members through its internal API. These data are used in conjunction with the measured data from the heat meters, that are managed by the systems of the brand COSTER.

For the Cypriot pilot buildings, energy data is available from smart meters, measuring building overall consumption and consumption at subsystem level for one of the pilot buildings – namely Novel Technologies Laboratory (NTL).

Power data for system algorithms

For the Norwegian pilot buildings, power and consumption data on the building level will be available through the BMS system. On each building there is installed a smart meter called an AMS meter. This meter is the same meter that transmit its consumption data to the Elhub portal.

The BMS system will integrate this meter through the meters interface port, HAN port, and the meters data will be made available through the BMS system API. Among the data available through the HAN port is energy consumption, power consumption, phase current and phase voltage, accumulated power consumption and accumulated power production (delivered to the grid if any).

Depending on the type of AMS meter, the instantaneous power consumption is delivered to the BMS system every 2 or 10 seconds.

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There is one pilot building, Eidet Omsorgssenter, amongst the Norwegian pilots that already have the AMS meter integrated into the BMS system, and hence have the energy and power consumption at building level available. For the rest of the pilot buildings, there is a plan to integrate the AMS meters to the BMS system and make live data available through the API.

For the Italian pilot buildings, the BRiG device will integrate directly with the heat cost allocators and with the smart plugs through the A2A platform to receive a continuous update on the power consumption on the apartment level that will be used for COLLECTiEF controls.

At the Cypriot pilot buildings, live energy and power consumption will be gained through an integration with the smart meters.

6.1.4 Weather data

Weather data is needed to train the algorithms and use predictive methods to obtain an optimum control strategy over time.

Weather and forecast weather data has been collected for all the pilot sites and stored in the project data repository since February 2023. The project has used https://openweathermap.org/api for all the pilot locations. All weather and forecast weather data is available to the project members by API queries created on the data repository.

6.1.5 POE

Post-Occupancy Evaluation (POE) is used to evaluate the correlation between the thermal data in the zone and the user's subjective perception of thermal comfort.

The questionnaires have been created and POE QR codes deployed on the pilot sites. POE responses have been collected since July-August and stored on the project data repository.

The user engagement varies quite a lot between the different pilot sites, and even between the different zones defined within each pilot building.

As with the Sphensor data, there is a monthly report on POE response status for each pilot building. The POE count is gathered through the project data repository by using the API call designed for this specific purpose.

A thorough explanation on POE design, deployment of POE QR codes for the pilot building zones, user interaction and engagement, can be found in deliverable D5.2 chapter 3, *Pilot monitoring*.

6.1.6 Pilot access

Access to the pilot buildings/installations will be important during both the deployment phase, but also at later stages for monitoring, bug fixes and software alterations.

At every pilot site, there is a BRiG device installed where the main COLLECTiEF solution software will reside. All the BRiG devices are accessible through a VPN connection to ensure an easy way for deployment and maintenance of software.

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For the Norwegian pilot buildings, the BMS system are accessible for the project members through EMPortal.no. This allows for easier configuration of the COLLECTiEF solution by coupling the different zones selected for the project deployment with the configuration in the BRiG, as well as another way to monitor the impact of the COLLECTiEF solution and therefore also verifying the visualization tools created for the project.

In the Italian pilots, Teicos has access to the buildings. Meetings and interventions in the apartments are scheduled with the occupants. Communication and support to the participants are also provided with emails, phone messages and phone calls. In each of the 3 buildings a BRiG is installed in the common corridor on an intermediate floor with a dedicated modem router that provides the internet connection to the whole system. As well, the repeaters that allow for the communication between the BRiG and the Sphensors are installed on the common corridors on different floors, to provide the coverage of all the selected apartments. The Sphensors, the smart plugs and the smart valves are installed inside the selected flats.

6.2 Norwegian pilot buildings

All the Norwegian pilot buildings had a BMS system already in place before the COLLECTiEF project was initiated. At an early stage it was identified the need to maintain, upgrade and ensure the technical installations were working in all of these buildings.

An amendment was forwarded, and accepted, to change the start month of WP4 to allow for work on the pilot buildings BMS system to be better prepared for system integration. Another important aspect was to ensure that the project could extract data from all the pilot buildings through its API in order to use for the system verification and impact assessment process performed in WP5.

6.2.1 Upgrade BMS software

On all the pilot buildings, the existing BMS software, EMS Server, has been upgraded to the latest version. This has been done to ensure that the pilot building has access to the latest BMS functionality and that it has access to all the available API calls.

It is foreseen in the project that there might be some development done on the API side of the BMS software as the project matures and needs and possibilities manifests themselves, but this can be easily maintained through the cloud solution, EMPortal.no, that allow for remote access to both the web-based user interface as well as backend admission to the system server.

6.2.2 Identification of potential problems with the BMS system

At an early stage of the project every BMS system was investigated to check for problems of such a magnitude that it would potentially interfere with the COLLECTiEF system performance, functionality, and robustness. At the same time, it was identified the communication paths and equipment used to reach end points such as room thermostats and heaters.

6.3 Timeframe, installation

The following installation/deployment timeframe is based on the project action plan for implementation (excel sheet).

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The timeframe list deployment months for the different pilot buildings, as well as a follow-up and evaluation of the installation process. The deployment will follow different phases, where the pilot buildings are being chosen based on an evaluation based on the criteria discussed in chapter 6.1.

Table 57 Implementation timeframe

Project month	Task/objective	Description	Buildings
M25-M30	Deployment – first phase	Deployment of the COLLECTiEF solution on the first pilot buildings.	G2Elab (WP2 and 3) Eidet Omsorgssenter Novel Technologies Laboratory (NTL)
M25-M48	Evaluation and enhancement of installation processes	A continuous evaluation and documentation of the installation process, including observations on problems and failed strategies as well as improvements for an easier, less error prone and more efficient deployment.	All pilot buildings.
M30-M33	Deployment – second phase	Second deployment phase. Some experience gained from deployment phase one.	Valsesia Tower C2 Tennfjord Barneskole Ellingsøy Idrettshall
M32-M34	Deployment – third phase	Third deployment phase. More experience gained; a much more rapid deployment phase expected.	Hatlane Omsorgssenter Flisnes Barneskole Valsesia Tower C3 Guy Ourisson Building
M34-M35	Deployment – fourth phase	Deployment of the COLLECTiEF solution for the remaining pilot buildings.	Moa Helsehus Spjelkavik Ungdomsskole Valsesia Tower C4 Graduate School
M36-M42	Monitoring phase	Monitoring of the deployed solutions on the pilot buildings	All pilot buildings.
M43-M48	Evaluation and assessment phase, WP5	Assessment of the project impact for all the pilot buildings based on KPI’s identified in WP5.	All pilot buildings.

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An extract of the Implementation timeframe – Gantt chart, excel sheet can be seen in Figure 34:

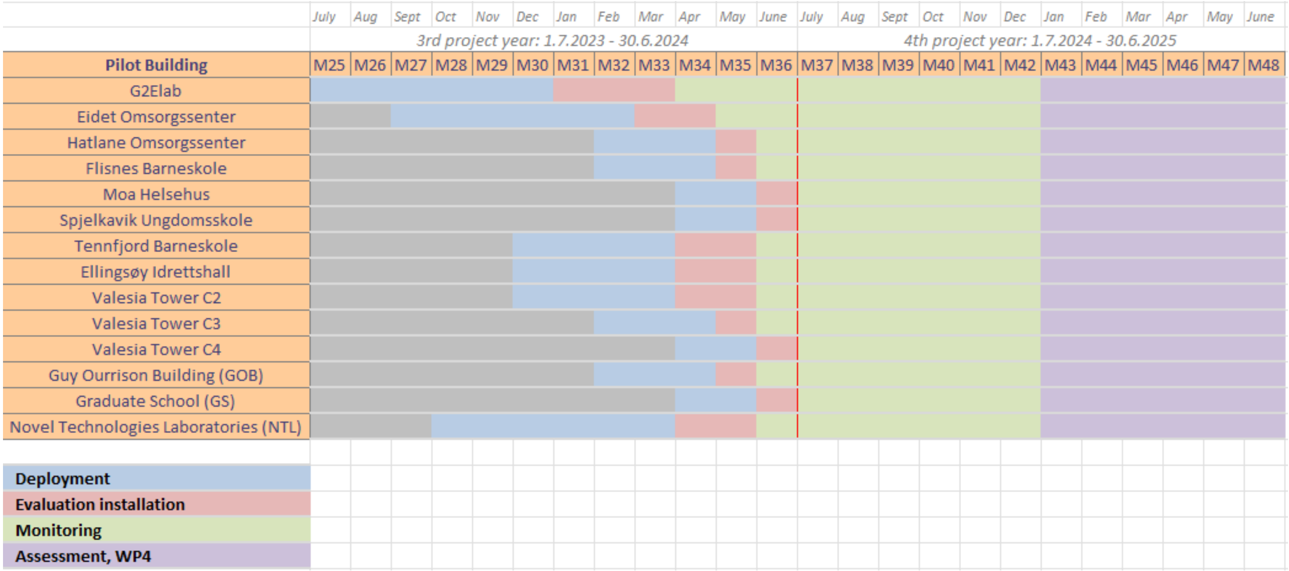

Figure 34 Excel sheet, Implementation timeframe – Gantt chart, with monthly overview of installation phases

6.3.1 Deployment – first phase

During these initial months the COLLECTiEF project will be deployed on the first pilot sites. The first pilot sites are chosen based on an evaluation according to previously mentioned key parameters. The first pilot buildings to deploy will be, in the following order:

- G2Elab
- Eidet Omsorgssenter
- Novel Technologies Laboratories (NTL)

The reasoning for this choice is:

G2Elab: G2Elab has already been part of the implementation, testing and small-scale demonstration, and is a pilot building that is quite mature and has the best SRI score in the COLLECTiEF project portfolio.

Since the project already have experience from an earlier stage with this pilot building, it is natural that we approach the integration and large-scale demonstration phase with this building first in line. The building has been integrated with the COLLECTiEF solution, in its test version, since beginning of march, and the project has successfully been able to integrate the following monitoring points:

- Room air temperature (°C)
- Room CO2 level (ppm)
- Inlet water temperature (°C)
- Outlet water temperature (°C)
- Water flow (m3/h)
- HVAC power (W)

For more information on the small-scale testing in the G2Elab, see deliverable D2.5 chapter 2.2 and D2.9.

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When it comes to data availability, G2Elab, has all the Sphensor data from August 2022 and has data accessible through its own locally installed BMS system. This also means that this pilot has the possibility to monitor and verify the COLLECTiEF solution impact through other 3rd party applications and hence allowing the project to also validate internal dashboard and visualization solutions. Energy data is available on the level of detail that is needed to calibrate and model the pilot and to get an overview of the projects impact on the different technical solutions and subsystems based on its different energy sources.

We see that the user engagement on this pilot building is among the better ones, although, as for all pilot buildings, the project could benefit from an overall higher user engagement and participation.

The building represents the warmer part of Europe and since it is a living lab, it is also monitored and evaluated continuously by its peers. Hence, feedback on the COLLECTiEF solution will be expected also from outside of the project organization.

On the negative side, this is a complex building, and it requires extra attention to distinguish impacts caused by the COLLECTiEF project solution and not get the results mixed up with other internal technical solutions or smartness already embedded in the building infrastructure – such as the BMS system.

Eidet Omsorgssenter: Eidet Omsorgssenter is one of the more mature buildings in the project portfolio. Among the Norwegian pilot buildings, it is the only building per date that has the AMS meter integrated in the BMS system and hence can provide the necessary energy and power consumption data needed for the COLLECTiEF algorithms. Further, the building has several submeters installed and integrated in the BMS system that can be used both for building calibration, modelling, and continuous evaluation of the COLLECTiEF project performance.

All the available indoor air quality and environmental data, both from the Sphensors and the BMS, have been stored and are available in the project data repository.

Applied controls can be done through the BMS API interface and is ready to be integrated with the BRiG device on site, no further field devices are needed to do this. The BRiG device is also installed on site. There will be a few appliances integrated into the COLLECTiEF solution through field devices (smart plugs). The appliances are yet to be identified and the field devices will be installed after choosing the appropriate appliances. There are some restrictions on the appliances since this building is a care centre for elderly, so that must be taken into consideration.

The building is accessible through the BMS cloud solution for configuration, visualization, and monitoring. This ensures that the changes applied by the COLLECTiEF project can be monitored and evaluated not only through the project internal dashboards, but also through the regular BMS user interface. This way the project will also have a means to verify the visualization and monitoring tools developed particularly for this project.

Since the building is part of Ålesund Kommunale Eiendomsforetak (ÅKE) building portfolio, there are technicians within this organisation with significant know-how and experience with the building performance and behaviour over many years that will passively assess and evaluate the result of the COLLECTiEF implementation and give important feedback to the project group.

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Eidet Omsorgssenter represents well the Nordic countries, and the project group can expect to quickly see energy demands arising due to temperature drops and an early heating season. This speeds up the evaluation process of the algorithms related to heating demands and grid response.

On the negative side of choosing this pilot building, we find that the POE and user engagement is low, and that the building is one of the more complex buildings in the project portfolio. The user engagement is something the project group needs to improve for all the pilot buildings and zones. The complexity of the building means the result of the COLLECTiEF implementation will be more difficult to assess as there are several external systems and internal BMS functionality that will have an impact on the building performance over time.

Novel Technologies Laboratories (NTL): Novel Technologies Laboratories (NTL) is another building in the COLLECTiEF portfolio that are quite mature and among the Cypriot pilot buildings it is the only that has available energy data per technical subsystem. This allows for the project to make better models and calibrations and to monitor the performance of the COLLECTiEF solution on a more detailed level that is necessary during the initial deployment and monitoring phase.

All indoor air quality and environmental data from the Sphensors have been collected and stored on the project data repository since end of august 2022 without any interruptions or malfunction.

When it comes to user engagement and POE count, NTL has engagement that matches any other pilot, disregarding one zone. This is useful for the evaluation of user comfort and satisfaction level.

The Novel Technologies Laboratories represents a warm climate zone that will have different control requirements compared to the Norwegian pilot buildings in particular. And choosing this building will allow for evaluation of that specific control part of the COLLECTiEF solution at an early stage.

Since the Cypriot partners in the COLLECTiEF project reside in these buildings, access for hardware configuration/alteration and maintenance is within reach. The software on the BRiG will be accessible through the VPN connection and maintained by the representative COLLECTiEF project members.

The installation of Ecobee thermostats for the remaining pilot zones needs to be completed before deployment. This is expected to be done October/November 2023.

6.3.2 Evaluation and enhancement of installation processes

A continuous evaluation of the installation process will be performed, and all shortcomings, issues, limitations, which will occur in each of the pilot cases, will be identified, analyzed, and fixed and will be documented thoroughly in order to constitute the basis for a troubleshooting section that will accompany the innovative products and services ameliorated in the COLLECTiEF project. This is part of WP4 task 4.4 starting M24.

Also, the parts of the installation process that work well will be highlighted to make the installation process as uniform, simple and error free as possible. This is particularly important for the pilots sites/zones where the project will have to interfere with the personal private time of the occupants.

It is important that the project group finds uniform and standard ways to perform the implementation of the project so that the evaluation is similar across the pilot sites/buildings.

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Equally important is it that the project group can limit the installation and deployment time considering the aim to commercialize the solution, and keeping installation and deployment costs low is essential to have a solution that has an overall cost that match the desired market.

It is expected that the first deployments, including the initial test and monitoring phase with subsequent bug fixing and changes to the software code and algorithms, will take much longer than the last deployments. This is reflected in the deployment plan visualized in the Excel sheet Implementation timeframe – Gantt Chart, where the first deployment is expected to take 6 weeks, while the last deployments are expected to take 2 weeks.

NB. It is important to state that this will be an ongoing process and not allocated to specific timeslots in the project timeline – even though it has been done so for the sake of visualizing the process in the Gantt diagram.

6.3.3 Deployment – second phase

During the second phase of deployment the project will get one of the Italian pilots involved. By doing so, all the pilot responsible partners are involved and have buildings to monitor and evaluate.

The second phase of deployment is expected to take less time based on experience gained from the previous deployment phase.

- **Valsesia Tower C2:** This pilot building is a representative of the residential buildings and will be deployed with the individual flat owners' comfort in mind. This means the project group must make sure that there will be as little physical intrusion on site during the deployment as possible. The monitoring will be performed using the internally developed visualization tools, the user-friendly Human-Building interface developed in task 2.4, and comfort satisfaction level assessment based on POE responses. The reason why this building is chosen among the Italian pilots is explained by its better user engagement, seen from both POE response and by talking to the stakeholders, and by better overall coverage of smart plugs/valves and Sphensor data.

In addition, two of the less complex Norwegian pilot buildings will be implemented. The buildings chosen are:

- **Ellingsøy Idrettshall:** This building is a sports hall and represent something different compared to the previous research institutes and health care centers deployed in phase one. In addition, it is a relatively straight forward building without complex technical installations that will help to isolate the effect and impact of the COLLECTiEF solution for easier evaluation of the system performance.
- **Tennfjord Barneskole:** This school has the highest user engagement and amount of POE response among the Norwegian pilots and is a good candidate when it comes to evaluation of user comfort and satisfaction level for students at elementary school level. This pilot building is a very typical school building in Norway and a good representation of such learning institutes.

The experience from integration with the BMS system from the deployment of Eidet Omsorgssenter in phase one will help to speed up the deployment phase for these pilot buildings.

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Both pilot buildings are available for monitoring through the 3rd party EMPortal.no solution which can help in verification of internally developed visualization tools.

Both pilot buildings require the AMS meter to be integrated into the BMS system before deployment: This integration is planned to be completed during May 2023.

6.3.4 Deployment – third phase

The third deployment phase is expected to be even more rapid than the previous two, and 3 weeks of deployment are allocated for the pilot buildings chosen at this stage. During the third phase the COLLECTiEF project will be deployed on the following pilot buildings:

- **Guy Ourisson Building (GOB)**
- **Valsesia Tower C3**
- **Hatlane Omsorgssenter**
- **Flisnes Barneskole**

To be ready for COLLECTiEF deployment, the following prerequisites must be met:

- GOB: Installation of Ecobee thermostats must be completed. This is expected to be done October/November 2023.
- Valsesia Tower C3: Installation of smart plugs/valves must be completed. This is expected to be completed by the end of July 2023.
- Hatlane Omsorgssenter: Integration with AMS smart meter must be completed. This is expected to be completed by the end of May 2023.
- Flisnes Barneskole: Integration with AMS smart meter must be completed. This is expected to be completed by the end of May 2023.

6.3.5 Deployment – forth phase

The fourth, and last, deployment phase will only last 2 weeks and will be performed based on all the previous experiences gained during the deployment and evaluation phase of the preceding pilot buildings. The project group should by now have identified and corrected challenges during earlier deployments and narrowed down the installation process to be closer to a commercial scenario. During the fourth phase the COLLECTiEF project will be deployed on the rest of the pilot buildings.

- **Graduate School (GS)**
- **Valsesia Tower C4**
- **Moa Helsehus**
- **Spjelkavik Ungdomsskole**

To be ready for COLLECTiEF deployment, the following prerequisites must be met:

- GS: Installation of Sensibo Sky thermostats must be completed. This is expected to be done October/November 2023.
- Valsesia Tower C4: Installation of smart plugs/valves must be completed. This is expected to be completed by the end of July 2023.
- Moa Helsehus: Integration with AMS smart meter must be completed. This is expected to be completed by the end of May 2023.

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- Spjelkavik Ungdomsskole: Integration with AMS smart meter must be completed. This is expected to be completed by the end of May 2023.

6.3.6 Evaluation and assessment phase, WP5

The last phase of system integration and large-scale demonstration work package is devoted to WP5 and assessment of project impact. This will be performed according to identified KPI's found through WP5 and starting from month 2 after the installation.

6.4 Main concerns, foreseen risks, and mitigation actions

Deployment issues: There will be unforeseen problems that the project group will encounter and discover during the first initial deployments of the COLLECTiEF solution on pilot sites.

This anticipation is reflected in the Implementation timeframe – Gantt Chart excel sheet. The first three deployments (deployment phase one) are set to 6 weeks, while the next deployment phase is reduced to 4 weeks, and the third deployment phase set to 3 weeks and finally the fourth and last deployment phase set to 2 weeks.

If the project encounters issues during the first deployment phase that require physical presence at the pilot sites, and in particular at the specific pilot zones, then the deployment of the Italian pilot building, Valsesia Tower C2, might be pushed back to a later stage and possible being exchanged with a Norwegian pilot building currently located in phase 3.

User engagement: There is a risk that the project might alienate some of the current participants if the deployment becomes too intrusive or the algorithms malfunction and in worst case cause higher energy consumption and reduced thermal comfort. This is very important for the Italian pilot stakeholders as the installation and deployment of the COLLECTiEF solution are being done in their private homes.

The project group must monitor the deployment phase and evaluate potential challenges and possibly reschedule the deployment time for the Italian pilots if there are any challenges that might interfere with the stakeholder's privacy.

Delayed installation of Ecobee and Sensibo Sky thermostats: The smart thermostats chosen for the Cypriot pilot building needs to be purchased and installed before the deployment can be finalized. There is a risk that this process might be delayed as the installation needs to be performed by a 3rd party electrical utility company.

In case there will be delays in the installation the project might swap the NTL building with a building from the Norwegian portfolio currently listed in deployment phase 2.

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Not having enough knowledge of the appliances to control: There is a risk that some of the appliances intended for control in the COLLECTiEF solutions are not well suited for the designed control scheme. One example is a washing machine that might restart its cycle if powered off/on.

Another aspect might be that the project doesn't have enough knowledge and information on the user pattern of the controlled appliance, so that the control algorithms will be too intrusive and feel burdening in daily life.

Keeping field devices alive: When applying controls based on sensory input, it is essential that the input is valid and a live, reliable value. Since the project group, in many of the pilots, are working with sensors, Sphensors, that is a physical object that can be easily tampered with by the occupants, this risk is a very likely one.

There must be built in some logic in the code to evaluate and verify the validity of the sensor input, and some fallback state in case the sensor value is not alive.

Internet connectivity/stability: Parts of the controls and logic applied on the pilots are based on an internet connection to work. For example, the connection/interfacing with the BMS system will, in this project, be done through the EMPortal.no cloud solution and the controls on the smart plug/valves will go through the A2A platform.

The project group needs to set up notifications that inform the pilot responsible of problems with internet connection, and connectivity with different field devices in general. This will be part of a notification/alarming scheme created for each pilot building.

Not getting detailed energy data for calibration and modelling: Energy data for many of the pilot buildings can be found on building level only. This could make the calibration and modelling of the pilots less accurate. This must be taken into consideration when evaluating the impact of the COLLECTiEF solution after deployment.

Not being able to pick up different control schemes (BMS) interfering with the COLLECTiEF solution: The BMS systems, in particular, can be expected to have some higher-level controls already applied to its respective installation and pilot building. This must be identified and taken into consideration during deployment of the COLLECTiEF solution. The risk is that the COLLECTiEF solution could be "fighting" for control of the devices that it intends to use and the impact difficult to evaluate due to the fact that other control logics, delivered by the BMS system, are being applied to the same control points.

Not getting power data for controls: Since the solution is depending on power data for applying controls, there is a risk that these data will not be available at the frequency and saturation required for the project solution to perform properly.

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In general, the solution must identify challenges and report on them to the project group so that corrective measures can be taken. Also, the design of the algorithms and control logic in the solution must be made robust, with a solution for lack of sensor or other control input embedded in the code already in place.

7 Conclusions

This deliverable has shown the current status of the legacy equipment in all the pilot buildings by means of the smart readiness indicator (SRI) methodology. This has been applied to every building included in the project and a detailed report included in this deliverable.

A new theoretical SRI assessment has been performed based on a successful implementation of the COLLECTiEF solution and the results have been provided in this deliverable with a discussion on the results, showing that the solution can improve the SRI class by one for all pilot buildings.

Information on the BMS in the Norwegian pilot buildings have been provided and a discussion on how to interface with the BMS system using the REST API has been provided. The solution has been tested and it is verified that data is available and BMS data has been stored on the project data repository since august 2022.

Field devices needed for project deployment has been identified and described with intended use and how to integrate them with the COLLECTiEF solution.

An action plan has been created for implementation of the COLLECTiEF solution on all the pilots included in the large-scale demonstration phase. The action plan will be the guideline for project implementation throughout task 4.4 (deployment and system integration on the pilot buildings) that will start at M24 and last until M48.

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