SATO: Self-Assessment Towards Optimization (Smart Readiness) in (Non-Industrial) Building Energy

Vinicius Cogo, Miracle Aniakor

This project receives funding in the European Commission's Horizon 2020 Research Programme under Grant Agreement Number 957128

Who we are

16 partners across
7 European countries

Funding

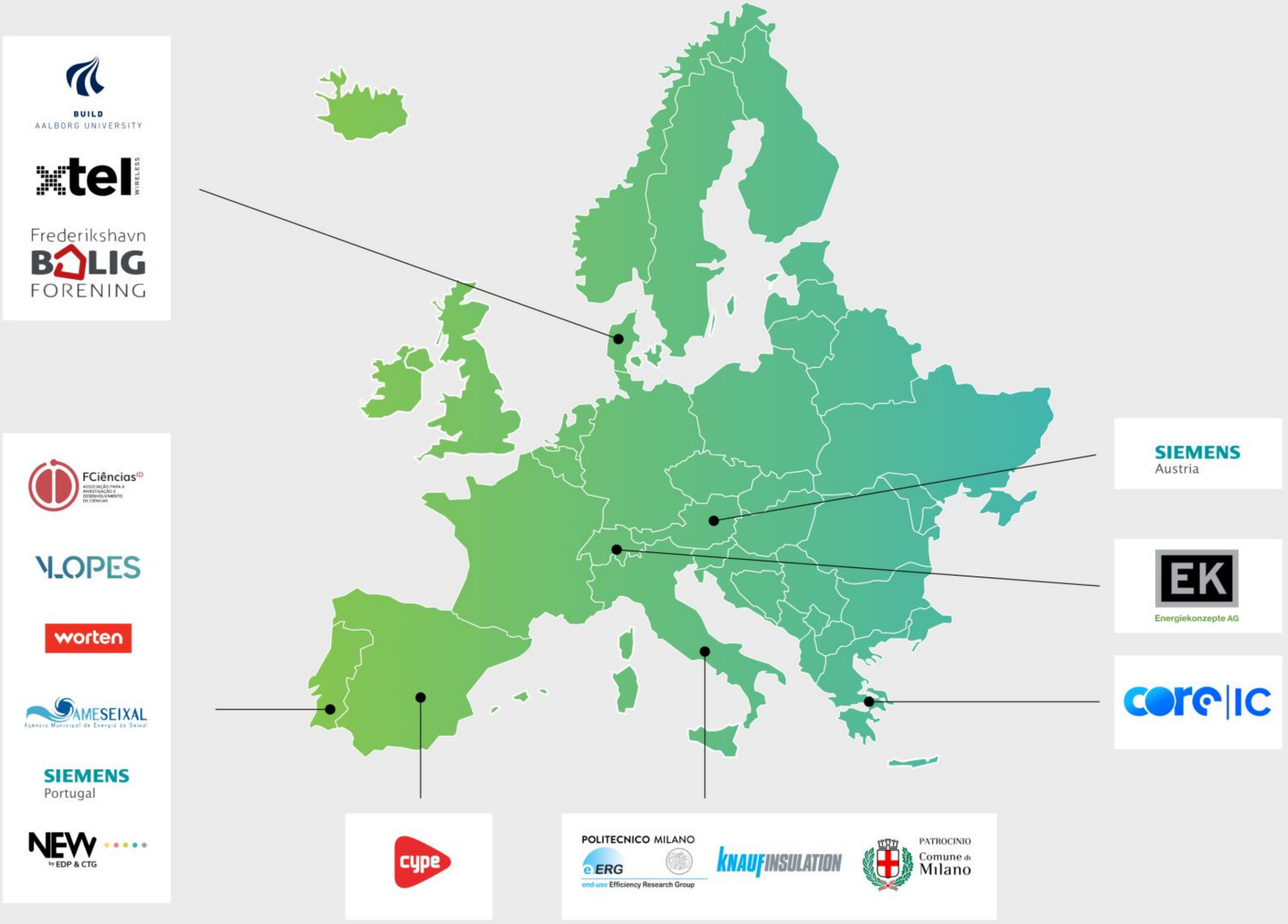
~7M€ over 48 months
(Oct. 2020 → Sept. 2024)

Pilots

9 pilots, 15 use cases

Challenge

Building stock unable to properly **assess and optimize** whole building energy consumption



SATO Overview

- Create an **IT platform** for the **automated self-assessment and self-optimization**

- **Real-life** building energy use, smartness, and occupancy

- **Semantic-based interoperability** to integrate heterogeneous **data and systems**

The SATO Platform

- **Develop** a cloud-based **platform** and **integrate** it **with** the **commercial platforms** in operation at the pilot buildings **and** with other **external** data **sources**

- Employing **enterprise-level software** widely used in industry to implement components **agnostic to the computing platform underneath**

Actors

External Data Sources

Buildings

SATO OF BUILDING ENERGY

SATO Platform

Self-assessment and optimization:

- Building energy
- Systems and EBCs
- Energy flexibility
- User comfort

The SATO Platform

- **Standardized data models and interfaces** to represent and implement data from sensors, KPIs, assessments, and services
- **Standardized semantic models** for devices, buildings, and other entities involved in the self-assessment and optimization processes

Actors

External Data Sources

Buildings

SATO
OF BUILDING ENERGY

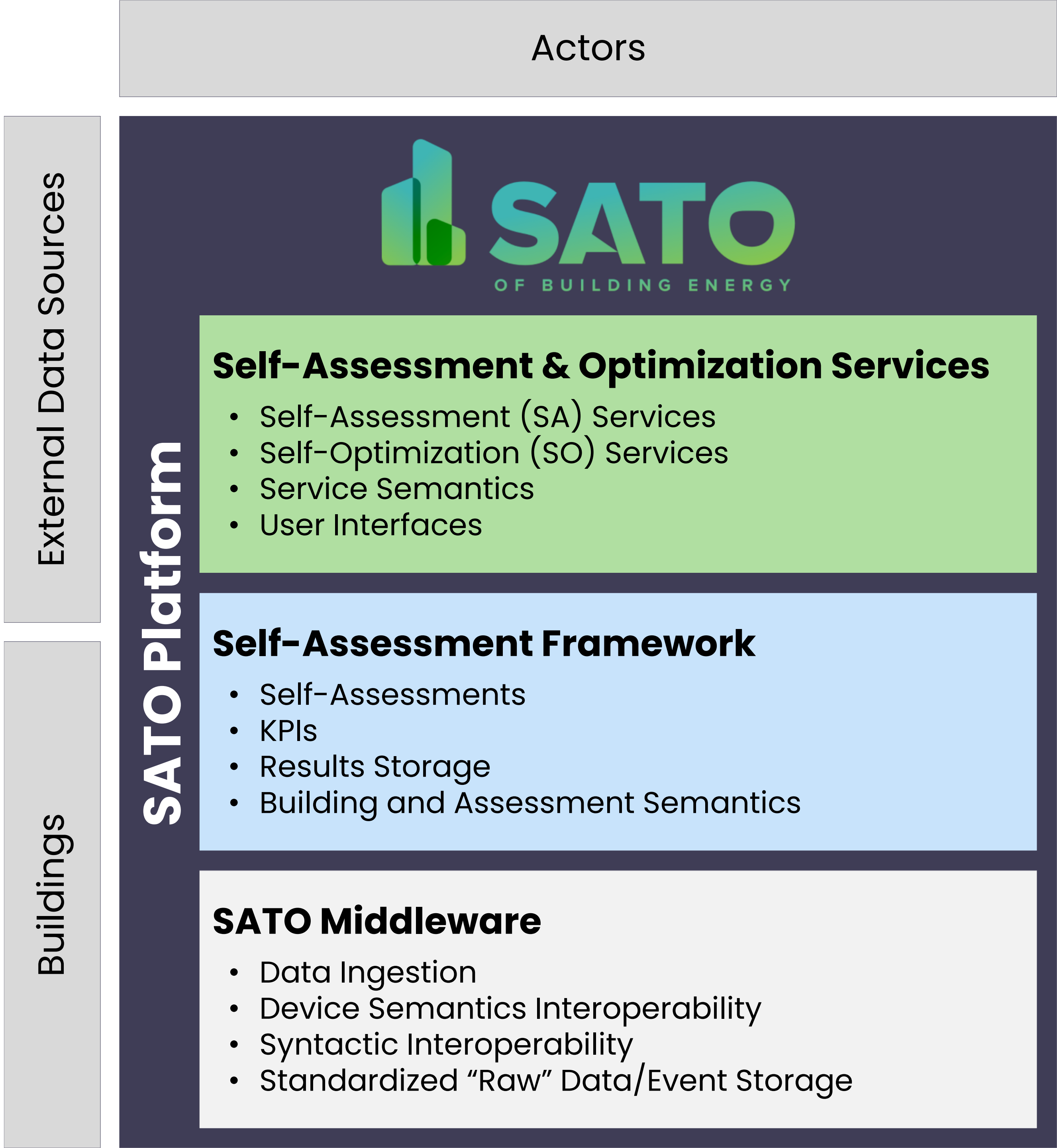
SATO Platform

Self-assessment and optimization:

- Building energy
- Systems and EBCs
- Energy flexibility
- User comfort

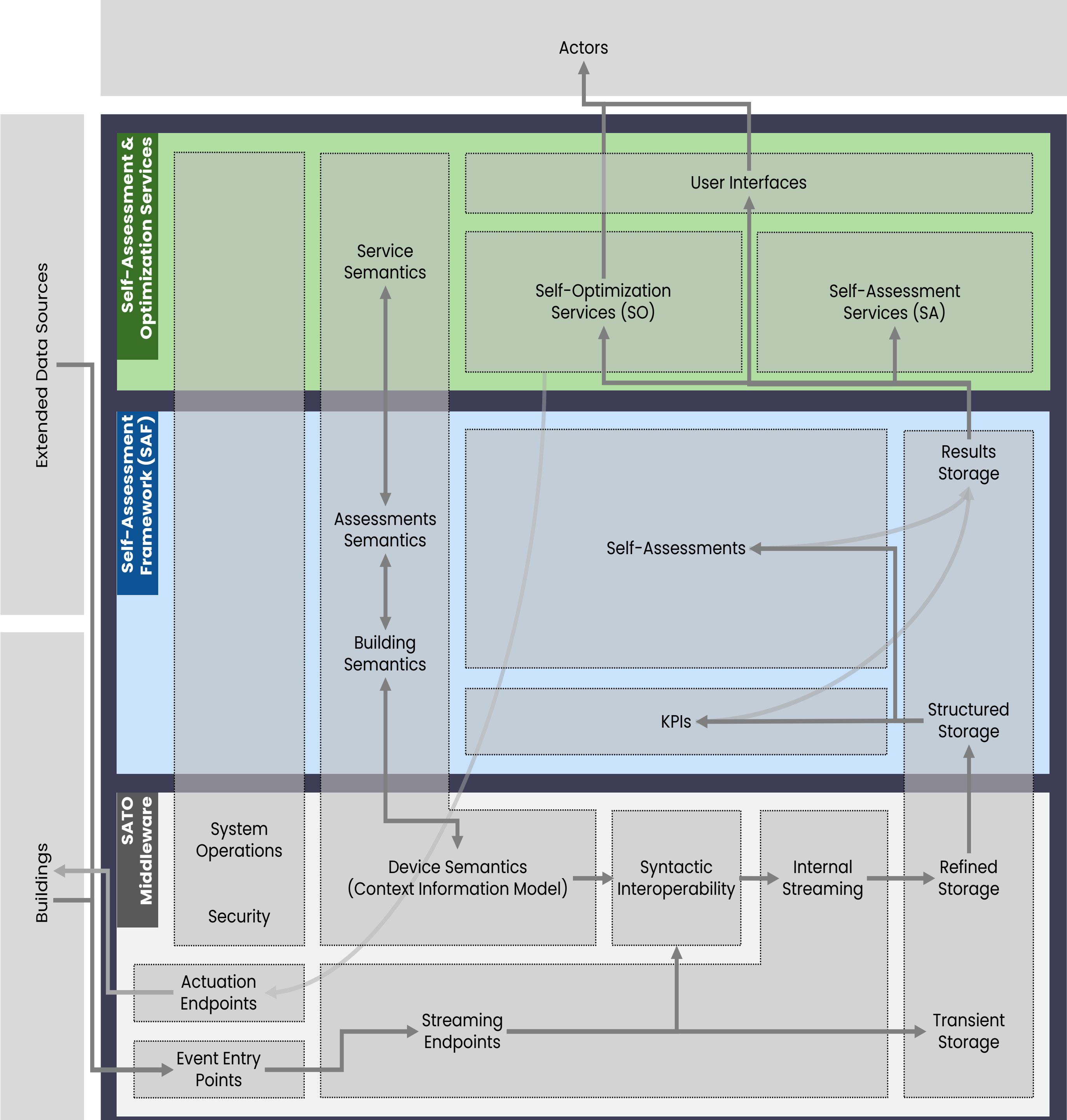
The SATO Platform

- **Top-down approach** in integrating the SATO platform with its ecosystem (actors, buildings, and external data sources)
  - **3** main conceptual layers



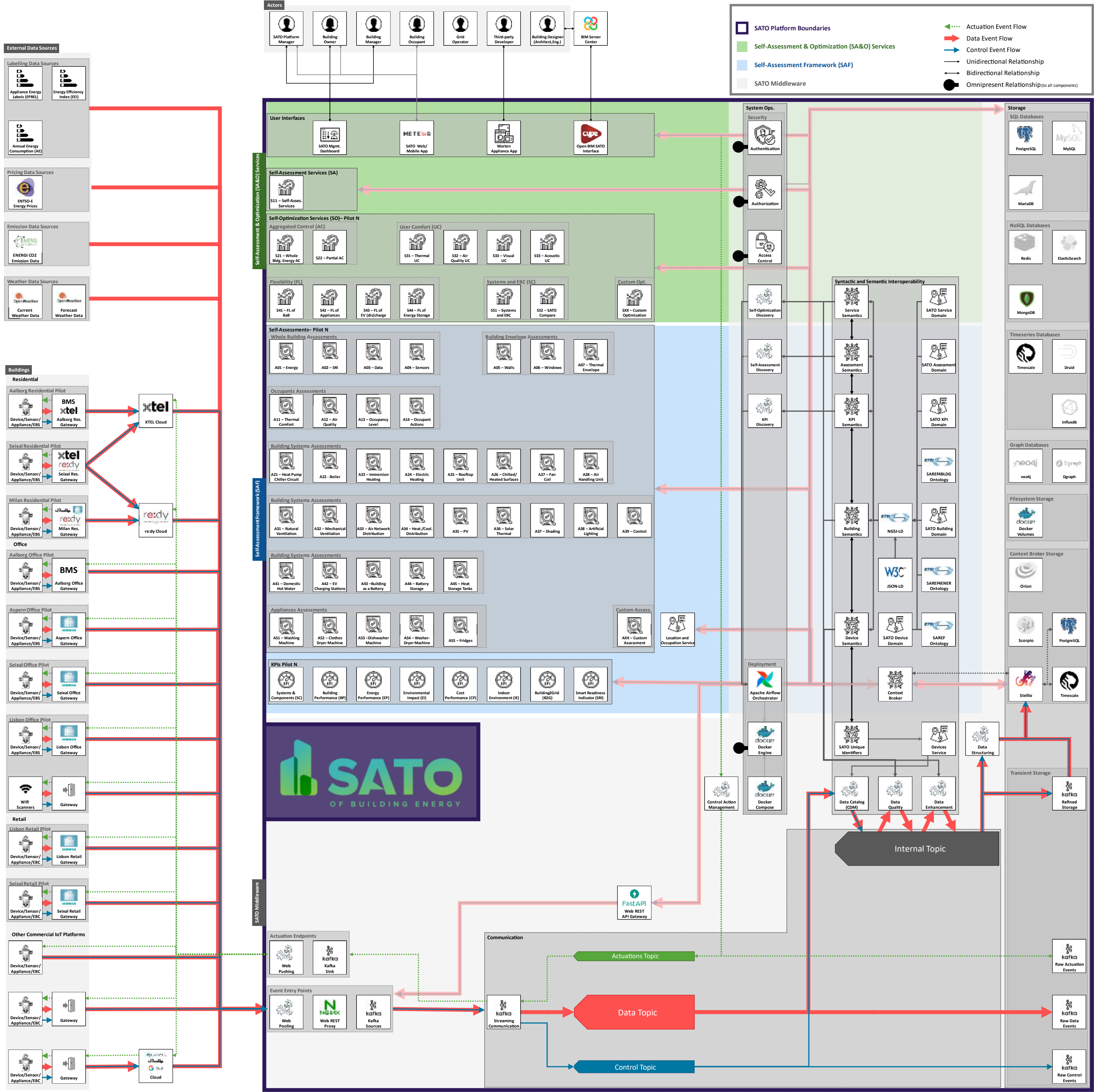
The SATO Platform

- **Top-down approach** in integrating the SATO platform with its ecosystem (actors, buildings, and external data sources)
  - **3** main conceptual layers
  - **25+** conceptual components



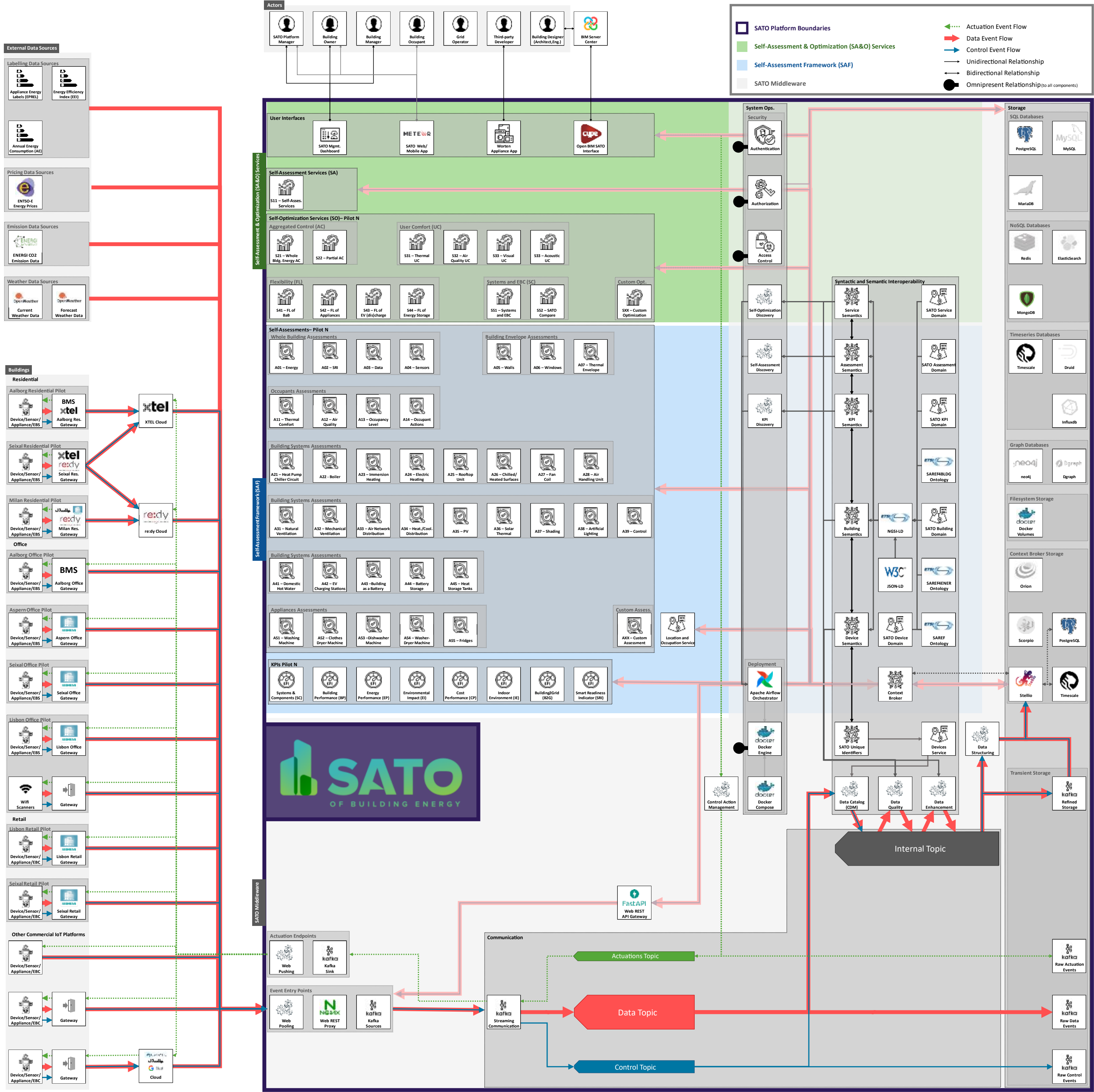
The SATO Platform

- **Top-down approach** in integrating the SATO platform with its ecosystem (actors, buildings, and external data sources)
  - **3** main conceptual layers
  - **25+** conceptual components
  - **170+** implemented components



The SATO Platform

- **Top-down approach** in integrating the SATO platform with its ecosystem (actors, buildings, and external data sources)
  - **3** main conceptual layers
  - **25+** conceptual components
  - **170+** implemented components
  - **Hundreds** of component instances since each pilot building may instantiate multiple KPIs, assessments, and services



SATO SUSTAINABLE PLACES 2024

SATO Platform in Numbers

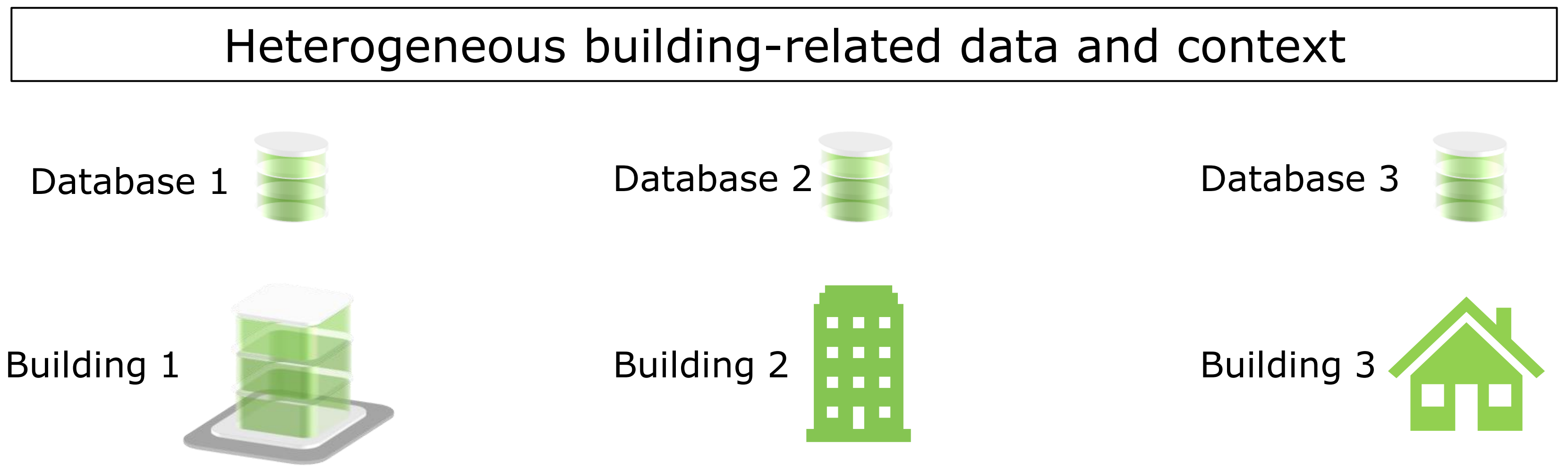
9	80+	450+	3.3k+
Pilots	Buildings*	Zones+Spaces	Devices

(each home in residential pilots is considered a building)

124	104	26k	11k
KPI instances	Assessments instances	Lines of code (platform)	Lines of code (KPIs, assessments, optimizations)

Motivation

- Heterogeneous representation of building-related data and context
    - Different labels associated with devices



IoT **integration**, **interoperability**, and **process automation** platform

Seamless
data and systems integration
through
Semantic-based interoperability

Automated discovery
of assessments and services,
based on **semantically annotated models of building components**

What to do?

- Represent **data and semantics** with a homogeneous language
- Represent highly connected **knowledge**
- Track **historical data**

What to do?

- Represent **data and semantics** with a homogeneous language
  - Using ontologies, smart data models, and NGSI-LD
- Represent highly connected **knowledge**
  - Using knowledge graphs with CIM
- Track **historical data**
  - Using timeseries databases like TimescaleDB

Modeling SATO Context Information Model (CIM) using Ontologies, Smart data models, and NGSI-LD

- Adopting semantic web technologies
  - Proven to be effective in other domains
  - Provide a formal and standardized representation of **conceptualization** using **linked data approach**

NGSI-LD

- **NGSI-LD** is way to represent building-related **data and context**

- SATO adopts the **Smart data models** to create a common system and **data format** to foster **collaboration** and **reusability**

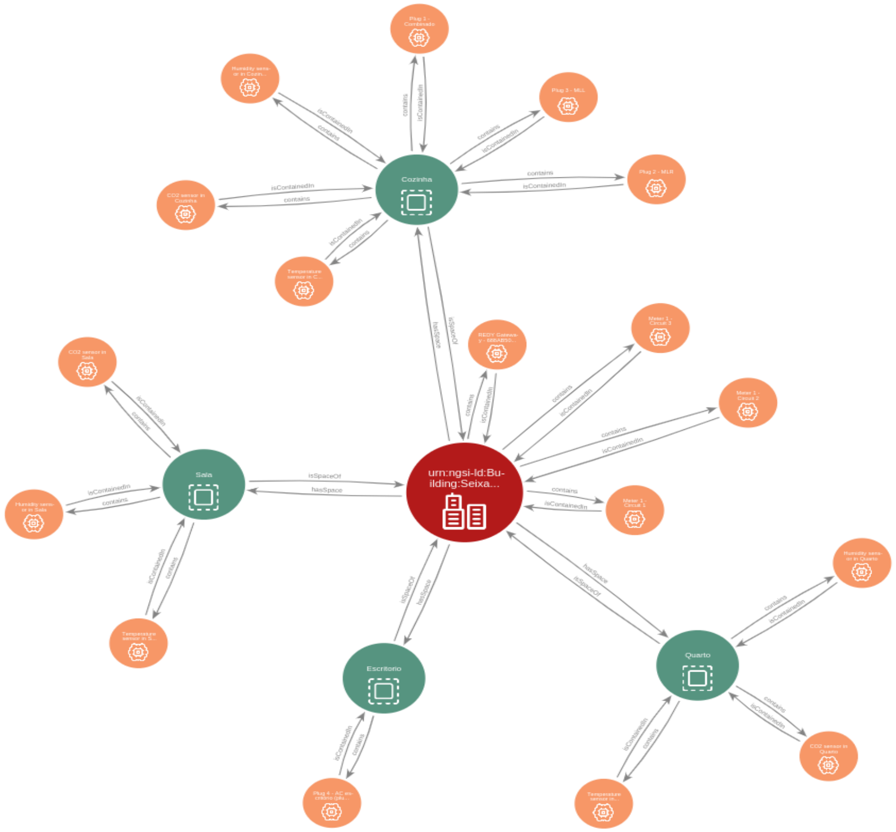
- To represent concepts
  - Building
  - Space
  - Device

- Introduce the zone concept
  - Virtual space


```
"id": "urn:ngsi-ld:Building:Lisbon-FCUL-Library",
"type": "Building",
"category": "Office",
"ifcId": "0tvQI$v8D1XApAUu_bKepf",
"contains": "urn:ngsi-ld:Device:Lisbon-FCUL-Library:HVAC:RTU-North:Actuator_CO2-air-quality-control-setpoint",
"address": {
    "addressCountry": "Portugal",
    "addressRegion": "Lisbon",
    "streetAddress": "Campo Grande 016, 1749-016 Lisboa",
    "addressLocality": "Campo Grande"
},
"peopleCapacity": 250.0,
"name": "FCUL Library"
```

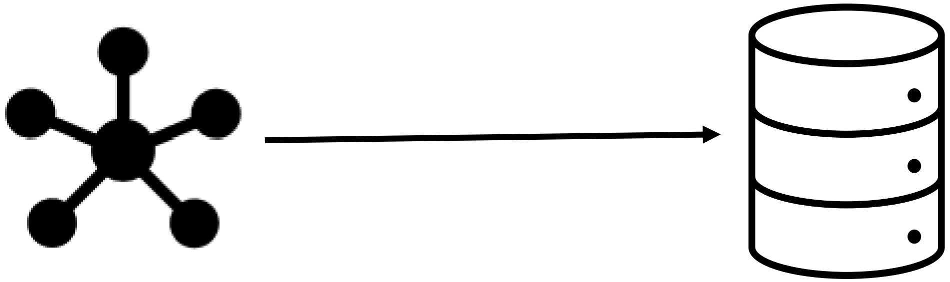
SATO Context Information Model

- **CIM** provides a knowledge graph that shows how all the entities are connected with others in the platform



Timeseries DB

- Timeseries databases (e.g., **TimeseriesDB**) keeps track of **historical records** and changes



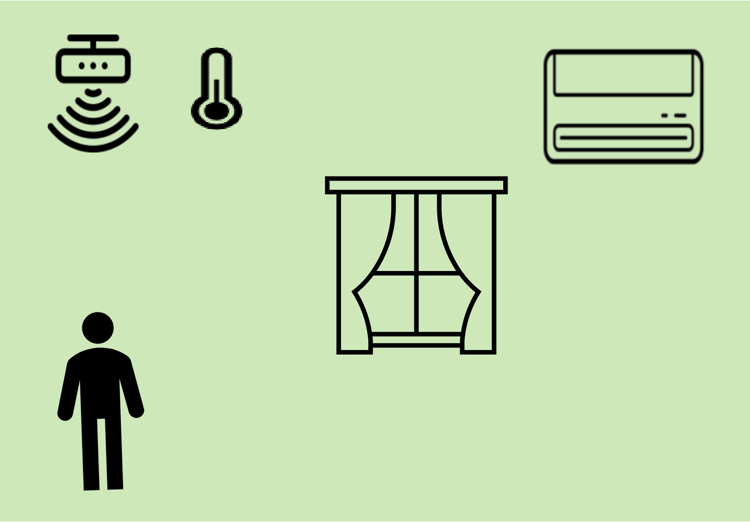
Context aware Applications

- Context-aware applications refers to an **intelligent system** that adapt its **functionality** based contextual data from the building environment
  - User comfort implies how comfortable an occupant is based on environmental conditions like Temperature, Humidity, Co2 concentration level and so on

- Introduce the concept of task
  - Elucidate what tasks are involved within the building
  - Create task definitions and integrate them in the **CIM**
  - Autonomous creation of task instances and scheduling for deployment

Context aware Applications

- Example: Thermal comfort

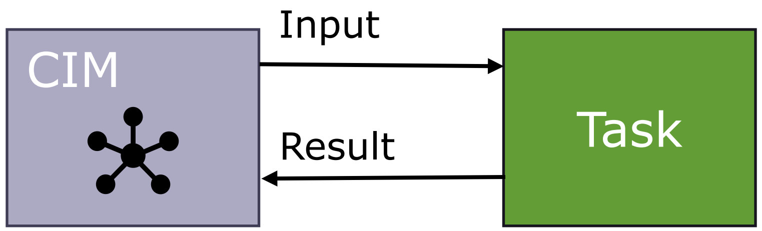


- Gets occupancy estimation
- Gets the temperature of the space
- Checks temperature deviation based on reference
- Adjust room temperature based on control or actuation service

Limitations in representing concepts related to Tasks

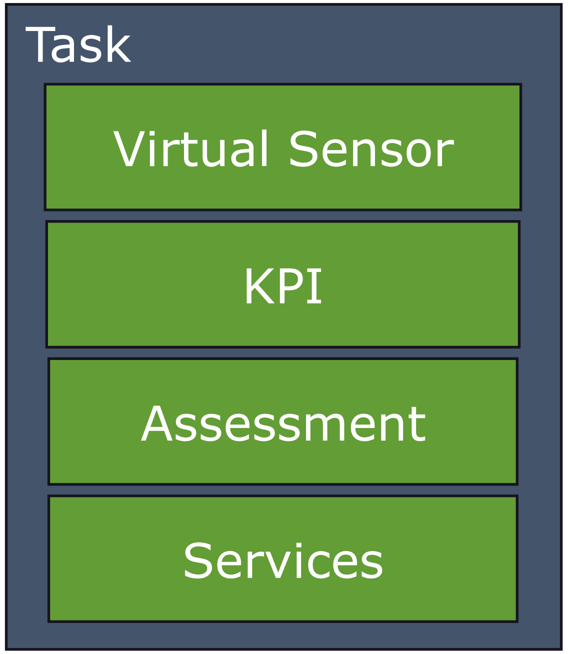
- The core of **SATO** is not only confined for building monitoring purposes but extends beyond that to:
  - **Assess** the building performance
  - Better insights into the current state of the building

- The precepts of **tasks** in **SATO platform**
  - There are not yet models that represents the concept of tasks



Task categories

- In SATO, tasks has **four** main categories
    - **Virtual Sensors**: Simple computation
    - **KPI**: Computes metrics using virtual sensors, sensor data, and other KPIs
    - **Assessment**: Final report comparing KPIs and sensor data to baselines (historical, external datasets, or standards)
    - **Services**: provides actions that impact a building



Modelling tasks generically

Task properties

- **Entry Point**: Points to a **function** for the execution of a task
- **Requires**: What **input** is needed to the task to be executed
- **Frequency**: Specified **periodic** interval of execution

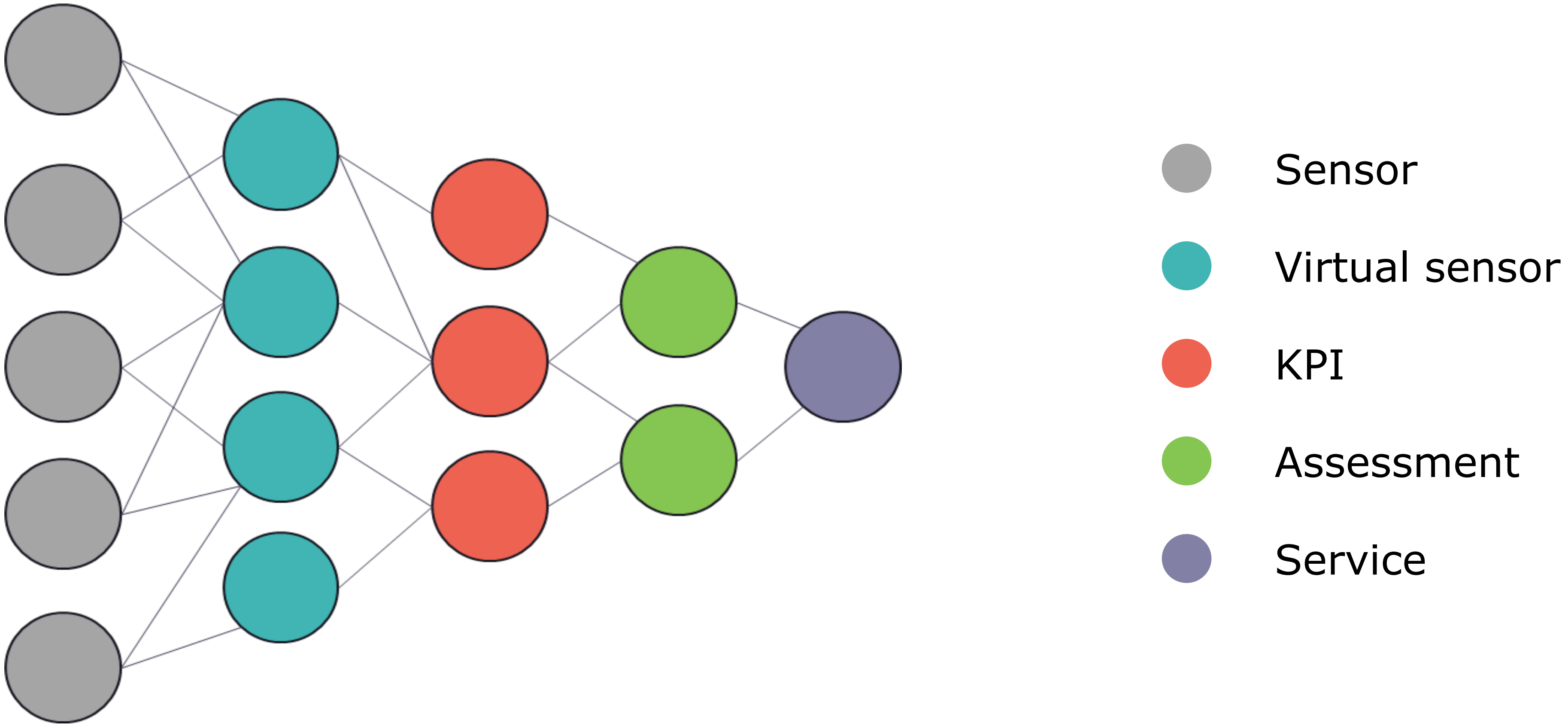
Defining and instantiating tasks

Task Definition	
ID	A11_Thermal-Comfort
REQ	{"temp_sensor": {"categorty": ["Sensor", "VirtualSensor"], "measuresProperty": "Temperature},...}
ENTRY	A11-A:FCR-V01
FREQ	[@hourly, @monthly, @daily, @yearly, <any cron pattern>]

Task Instance	
ID	Lisbon-FCUL-Library:Assessment-Instance_Thermal-Comfort
REQ	{"temp_sensor": "Lisbon-FCUL-Library:VirtualSensor_Average-Temperature", "occ_sensor": "Lisbon-FCUL-Library:VirtualSensor_Average-Temperature"}
ENTRY	A11-A:FCR-V01
FREQ	@hourly

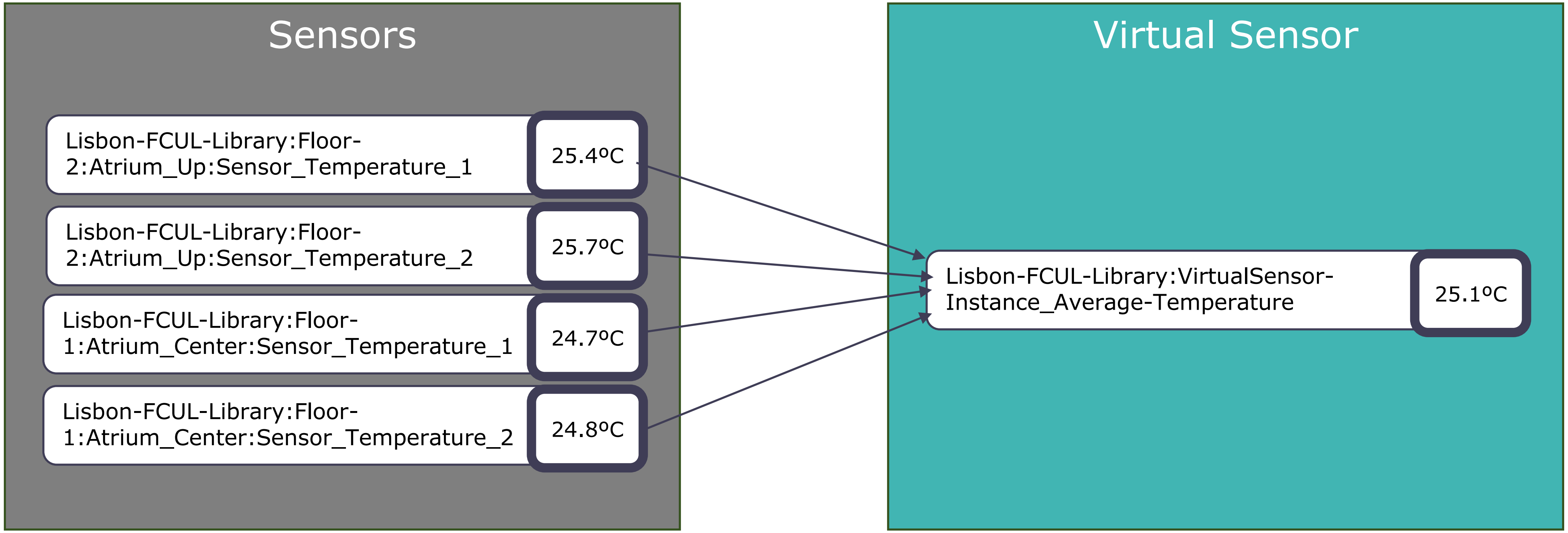
Self Assessment Framework (SAF)

- Directed Acyclic Graph (DAG)

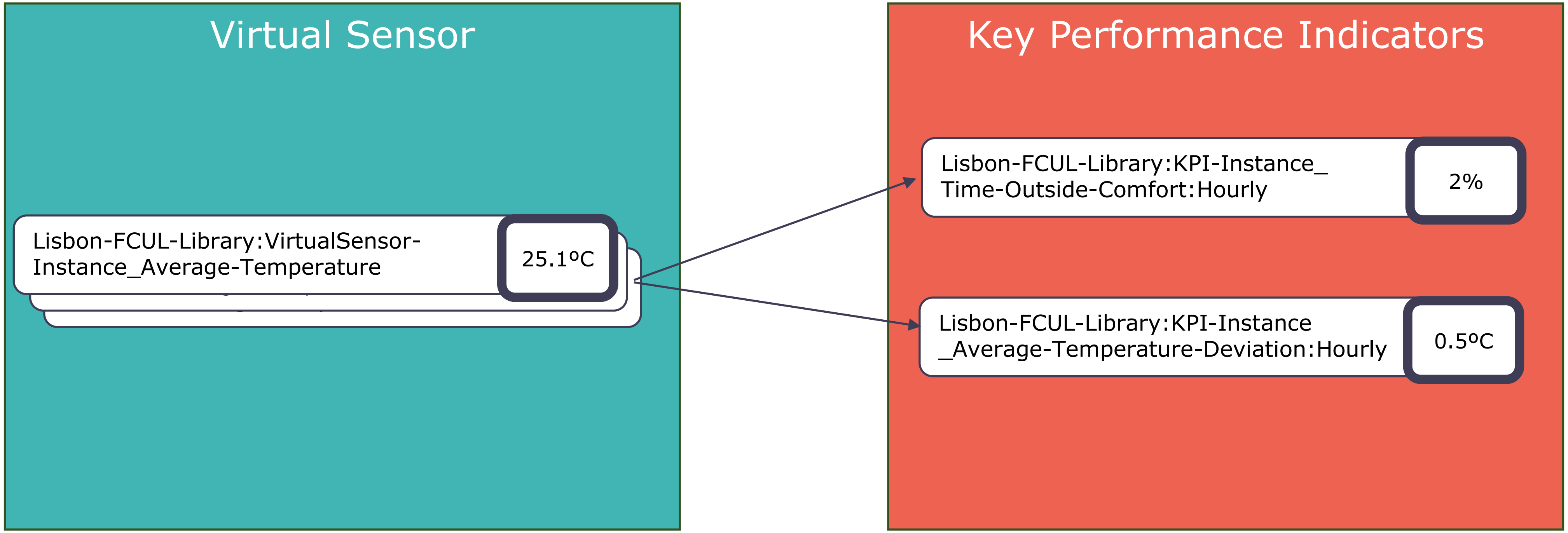


Scenario: Thermal Comfort

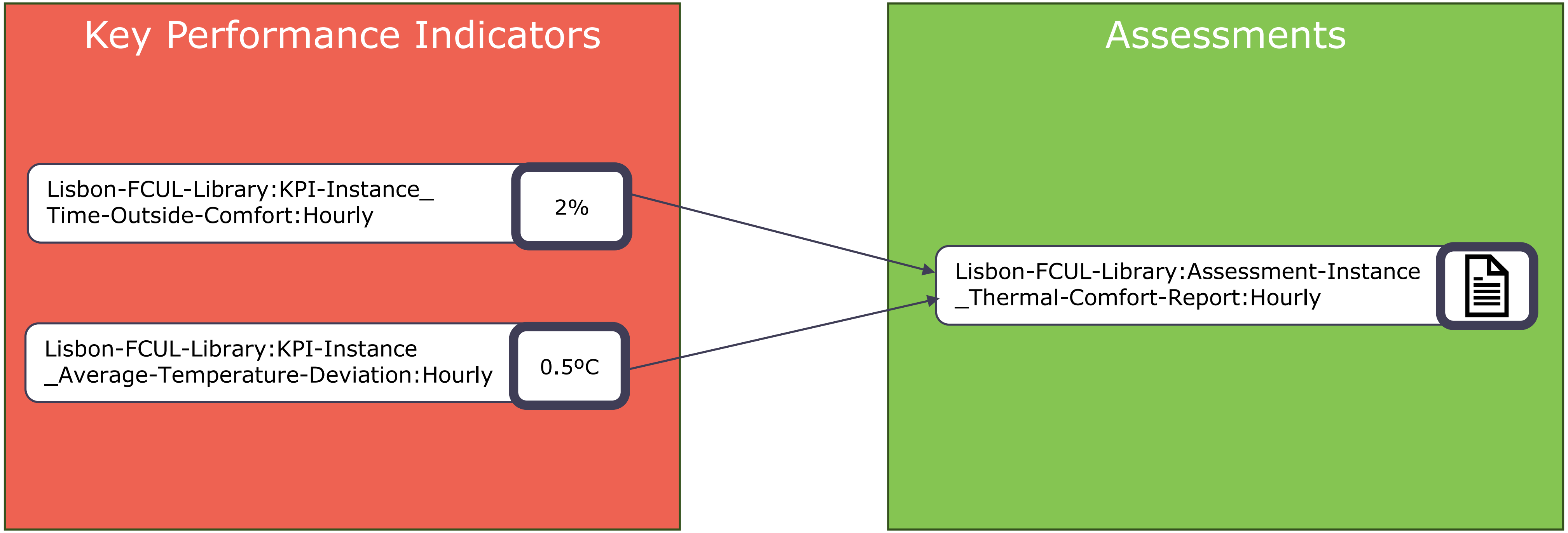
Thermal Comfort Scenario - Tasks



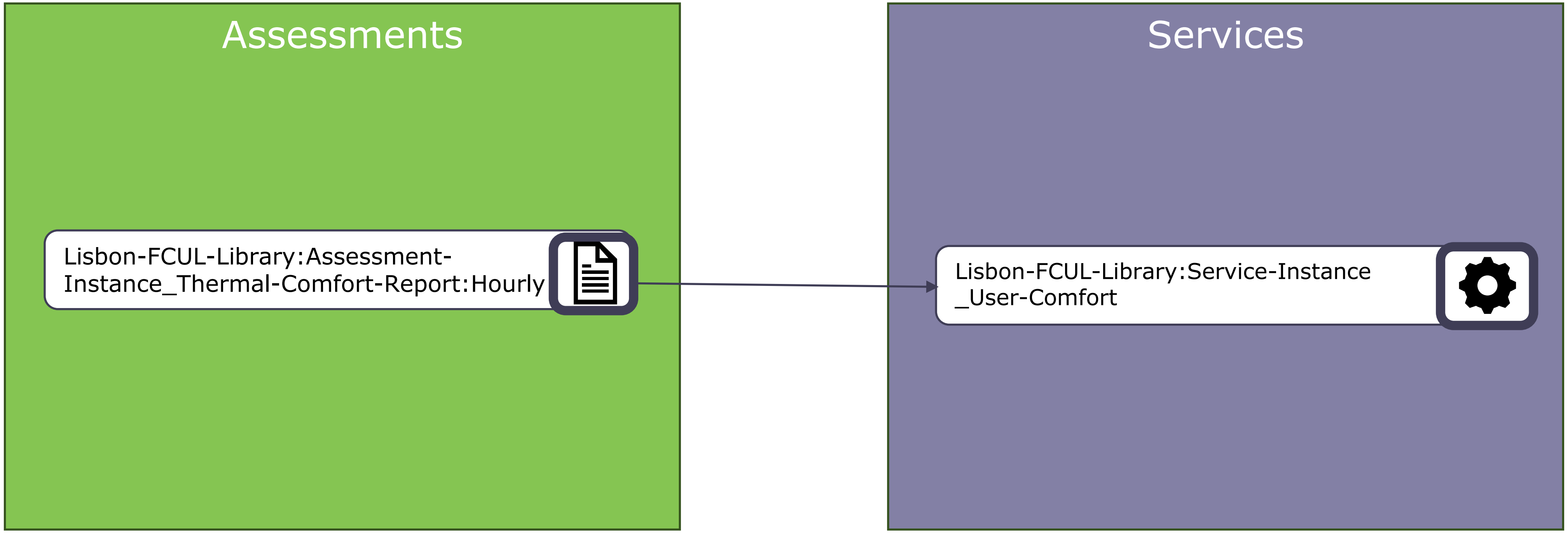
Thermal Comfort Scenario - Tasks



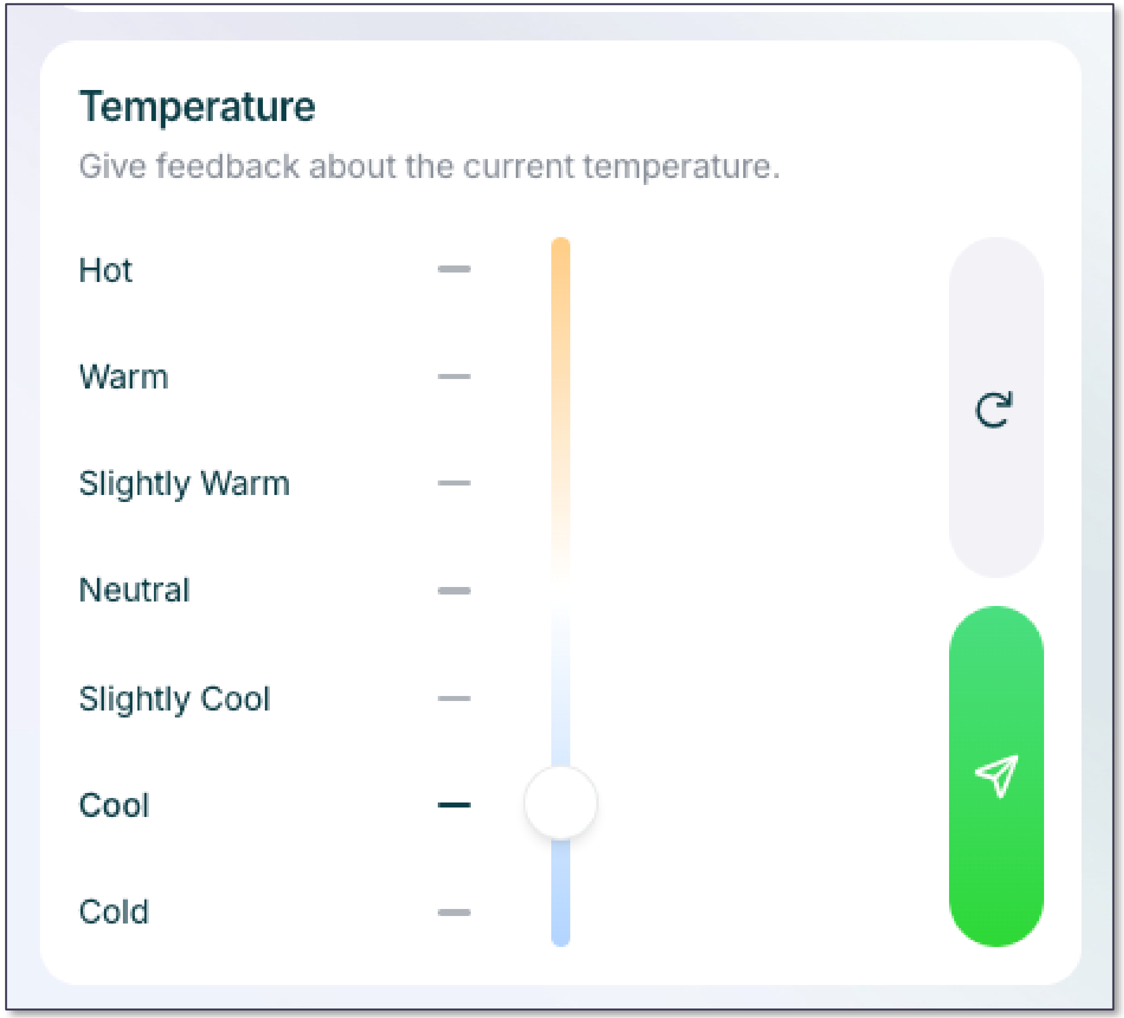
Thermal Comfort Scenario - Tasks

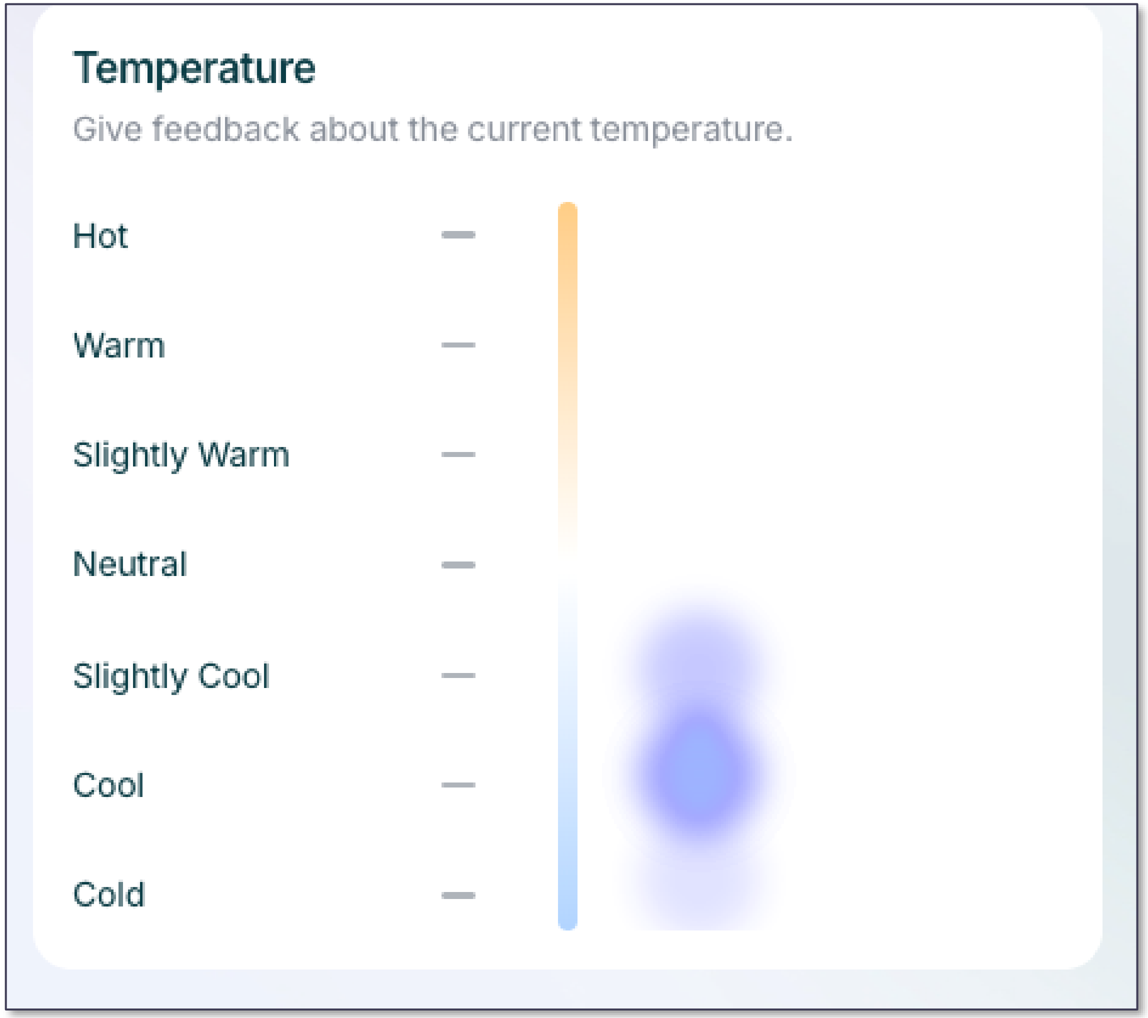


Thermal Comfort Scenario - Tasks

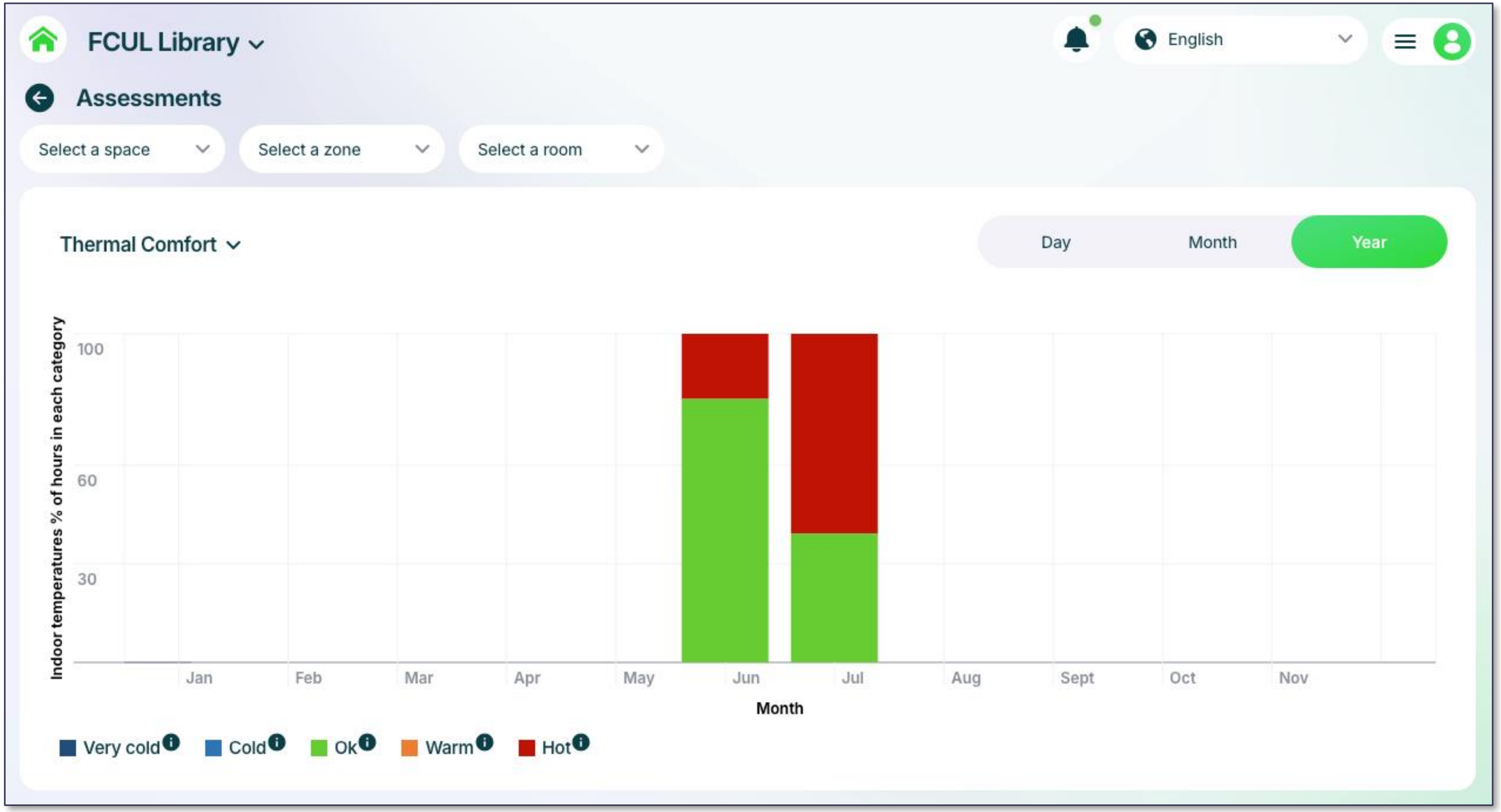


Thermal Comfort Scenario - Feedback





Thermal Comfort Scenario – Assessment Results



Challenges with many Tasks

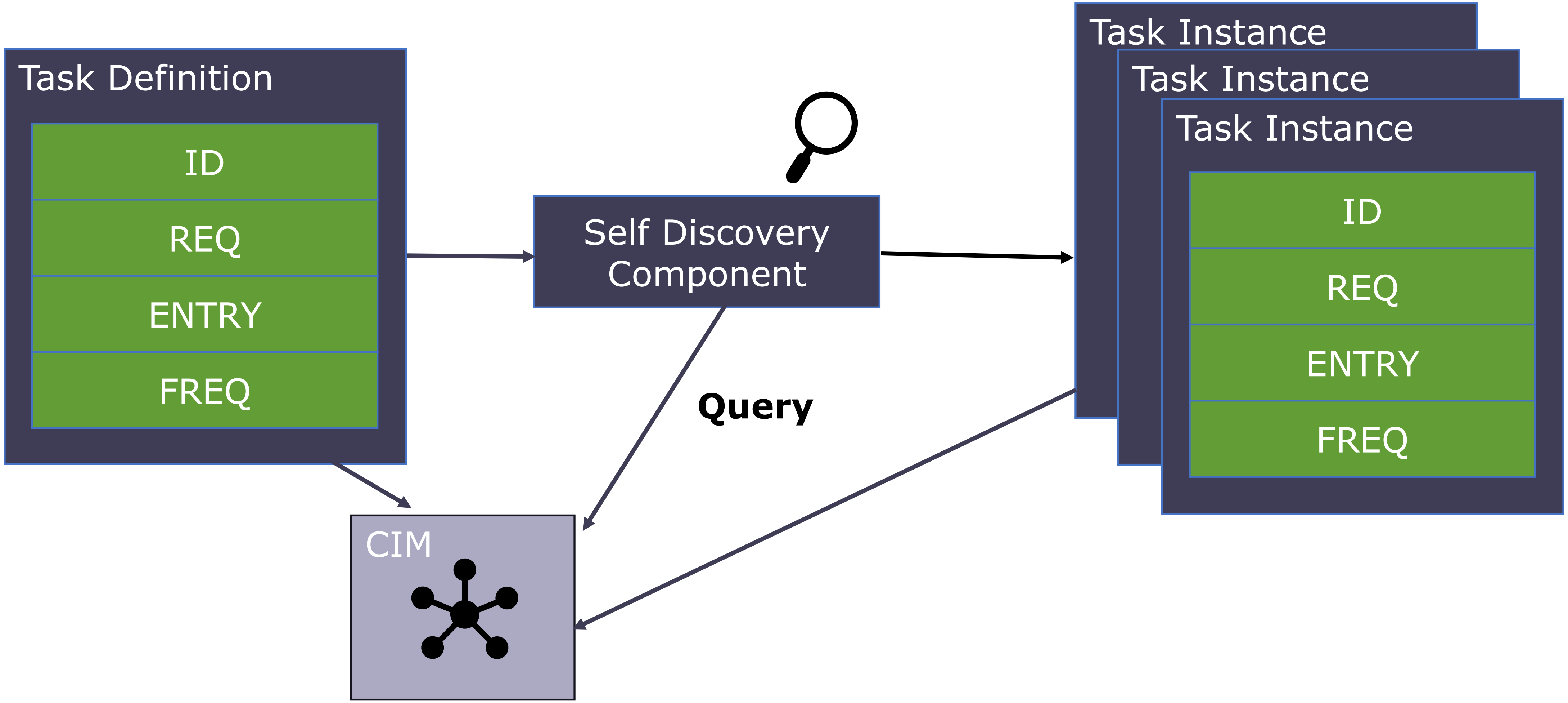
- Thermal Comfort task instance discovery

	A	B	C
1	TA1 OA1 ✓	TB1 ✗	TC1 OC1 ✓
2	OA2 ✗	TB2 OB2 ✓	TC2 ✗
3	TA3 ✗	OB3 ✗	✗

Requirements

- **O** - Occupancy Sensor
- **T** - Temperature Sensor

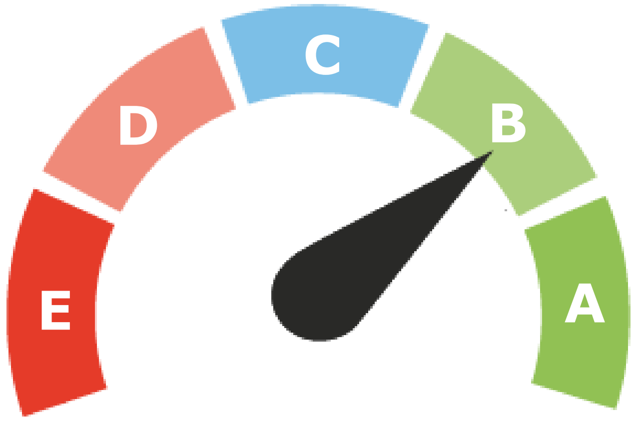
Self-discovery for autonomous execution of tasks



Scenario: Smart Readiness Indicator (SRI)

Smart Readiness Indicator (SRI)

- A **single score** to classify the **building smart readiness**



1

Readiness to

adapt in response to the needs of the occupant

2

Readiness to

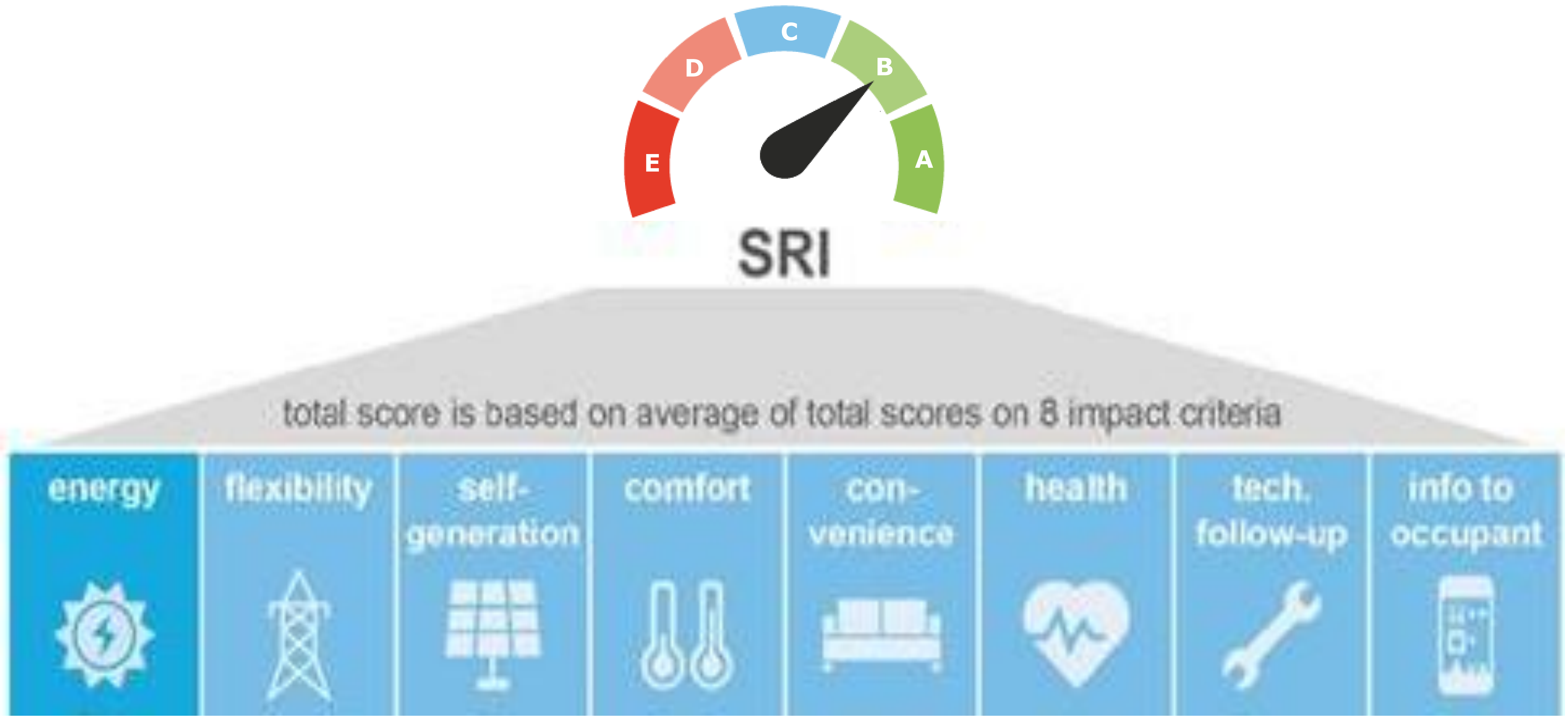
facilitate main-tenance and efficient operation

3

Readiness to

adapt in response to the situation of the energy grid

Smart Readiness Indicator (SRI)

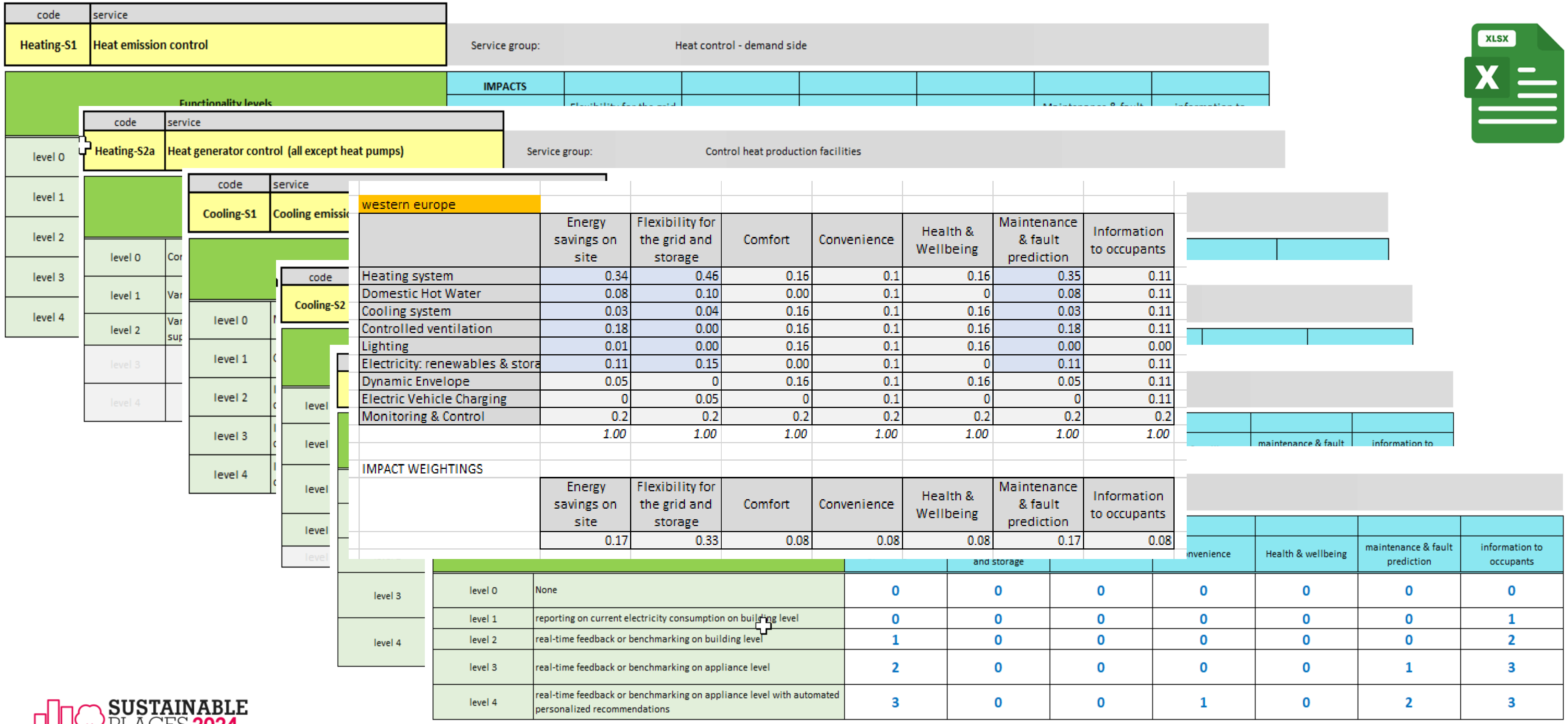


Impact Criteria

… influenced by Technical Domains

(Original) Static SRI Calculation

- Experts inspect buildings and manually fill out excel sheets



code	service		
Heating-S1	Heat emission control	Service group:	Heat control - demand side
Heating-S2a	Heat generator control (all except heat pumps)	Service group:	Control heat production facilities

western europe	Energy savings on site	Flexibility for the grid and storage	Comfort	Convenience	Health & Wellbeing	Maintenance & fault prediction	Information to occupants
Heating system	0.34	0.46	0.16	0.1	0.16	0.35	0.11
Domestic Hot Water	0.08	0.10	0.00	0.1	0	0.08	0.11
Cooling system	0.03	0.04	0.16	0.1	0.16	0.03	0.11
Controlled ventilation	0.18	0.00	0.16	0.1	0.16	0.18	0.11
Lighting	0.01	0.00	0.16	0.1	0.16	0.00	0.00
Electricity: renewables & stora	0.11	0.15	0.00	0.1	0	0.11	0.11
Dynamic Envelope	0.05	0	0.16	0.1	0.16	0.05	0.11
Electric Vehicle Charging	0	0.05	0	0.1	0	0	0.11
Monitoring & Control	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	1.00	1.00	1.00	1.00	1.00	1.00	1.00

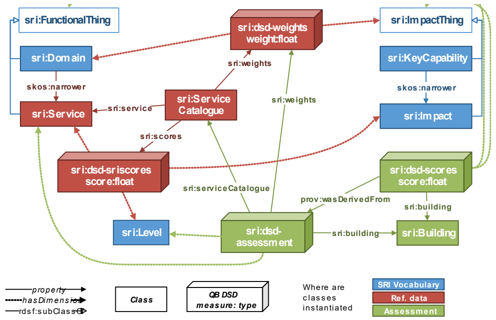
IMPACT WEIGHTINGS

Energy savings on site	Flexibility for the grid and storage	Comfort	Convenience	Health & Wellbeing	Maintenance & fault prediction	Information to occupants
0.17	0.33	0.08	0.08	0.08	0.17	0.08

			and storage		nvenience	Health & wellbeing	maintenance & fault prediction	information to occupants
level 0	None	0	0	0	0	0	0	0
level 1	reporting on current electricity consumption on building level	0	0	0	0	0	0	1
level 2	real-time feedback or benchmarking on building level	1	0	0	0	0	0	2
level 3	real-time feedback or benchmarking on appliance level	2	0	0	0	0	1	3
level 4	real-time feedback or benchmarking on appliance level with automated personalized recommendations	3	0	0	1	0	2	3

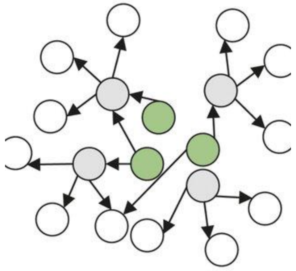
Semantically Describing SRI

https://w3id.org/sri




```
{
  "id": "Aspern-Office:SRI-Report:Domestic-Hot-Water",
  "type": "Task",
  "category": "SRI-Report",
  "dateCreated": "2023-11-02T15:54:50Z",
  "dateObserved": "2023-11-01T00:00:00Z",
  "dateModified": "1970-01-01T00:00:00Z",
  "taskValue": 0.6111111111111113
}
```


SATO OF BUILDING ENERGY



Excel Files

SRI Ontology

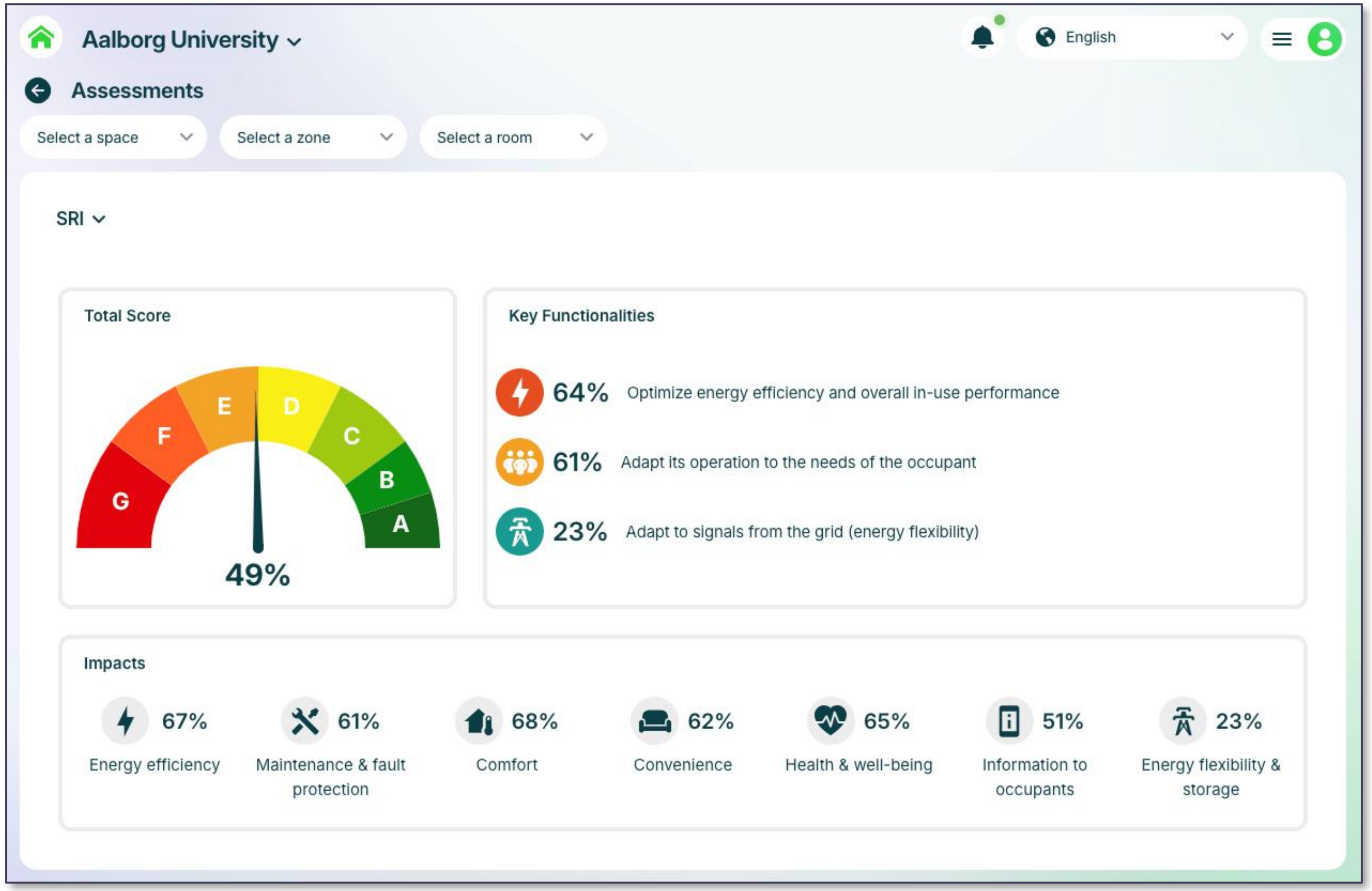
Semantically-enriched TRiG files or JSON objects

SATO Knowledge Graph

[1] Stefan Bischof, Erwin Filtz, Josiane Xavier Parreira **Semantic Smart Readiness Indicator Framework**. *SEMANTiCS* 2024. [DOI | resource: https://w3id.org/sri]

Dynamic SRI Assessment Visualization

- Continuously self-assessing SRI
- Based on the status of active devices, assessments and services
- Compare with the static baseline
- Improvements are reflected on SRI
- Help in fault-detection



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Conclusions

- Adopt **semantic web technologies** to support standardization of building concepts

- Creating the concept of **tasks** in the CIM
  - Support self-discovery and autonomous executions of tasks

- This principle can also be adopted by many other context-aware applications, such as:
  - Fault detection and diagnosis
  - Building state prediction
  - Control optimization and others

SATO

OF BUILDING ENERGY

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SUSTAINABLE PLACES 2024

Thank you

SUSTAINABLE PLACES 2024

23-25 September 2024

Luxembourg

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY LIST

R2M RESEARCH TO MARKET SOLUTION

COLLECTiEF

Collective Intelligence for Energy Flexibility

An EU H2020 Project for Enhancing Energy Efficiency and Flexibility in Existing Buildings

Mohammadreza Aghaei
Project Coordinator, NTNU

25 September 2024

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101033683.

COLLECTiEF

Collective Intelligence for Energy Flexibility

- **15 partners**
  from 6 European countries
- **4 Years**
  June 2021-May 2025
- **4 urban pilots**
  to test our energy management system

COLLECTiEF Consortium

- Norwegian University of Science and Technology NTNU (Norway)
- Lund University (Sweden)
- The Cyprus Institute (Cyprus)
- Energy@Work (Italy)
- R2M Solution SRL (Italy)
- EM Systemer AS (Norway)
- NODA Intelligent Systems AB (Sweden)
- Geonardo Environmental Technologies Ltd. (Hungary)
- Scientific and Technical Center for Building (France)
- CETMA - Technologies Design and Materials European Research Centre (Italy)
- LSI Lastem (Italy)
- Ålesund Municipality (Norway)
- Teicos UE SRL (Italy)
- Virtual Manufacturing AB (Sweden)
- Politecnico di Milano (Italy)

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COLLECTiEF Team

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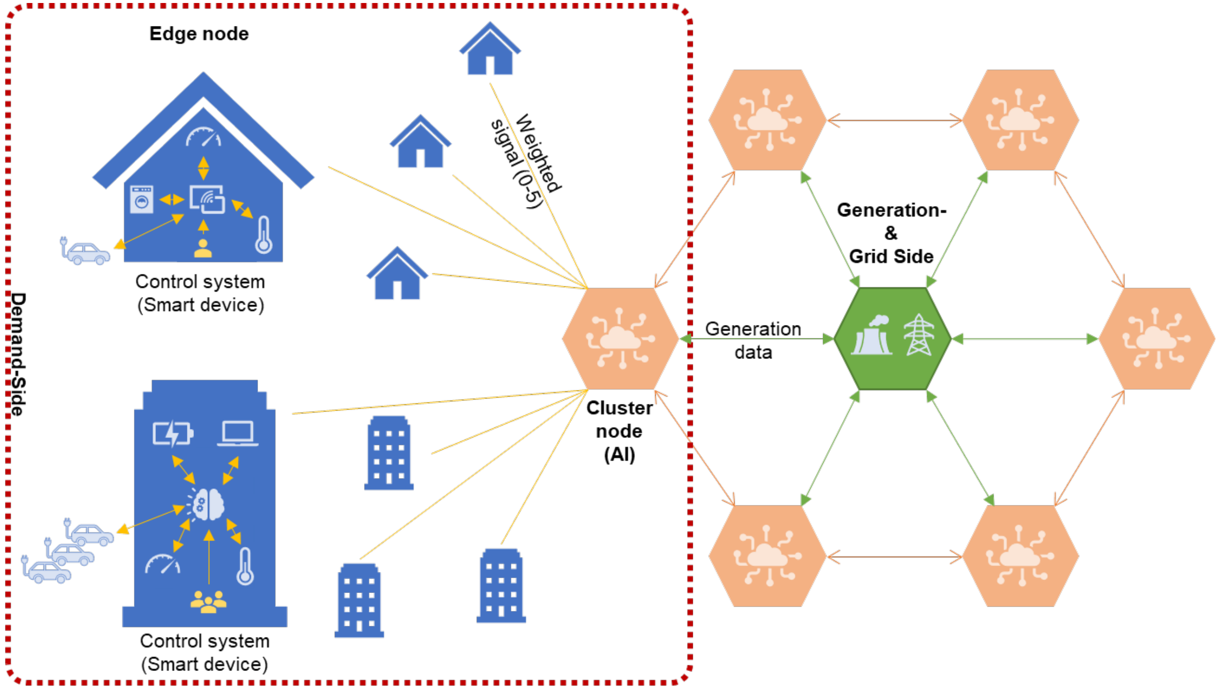
Our Objectives

- We create **a CI-based energy flexible network** that ensures **low-cost installation** and **maximum data security**.
- We use **cost-effective components** to make our system **compatible** across Europe.
- We **test our system in 14 buildings** across the EU to prove its efficiency and adaptability to different climate zones
- We achieve more accurate and **non-invasive environmental monitoring** through sensors **focusing on user needs**
- We design a **smart, user-centric and user-friendly platform** to improve building management and **maximize energy saving**.



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COLLECTiEF
How?

The solution

We use **Collective Intelligence** to smart up existing buildings and their legacy equipment and improve their **energy performance** and **climate resilience**.

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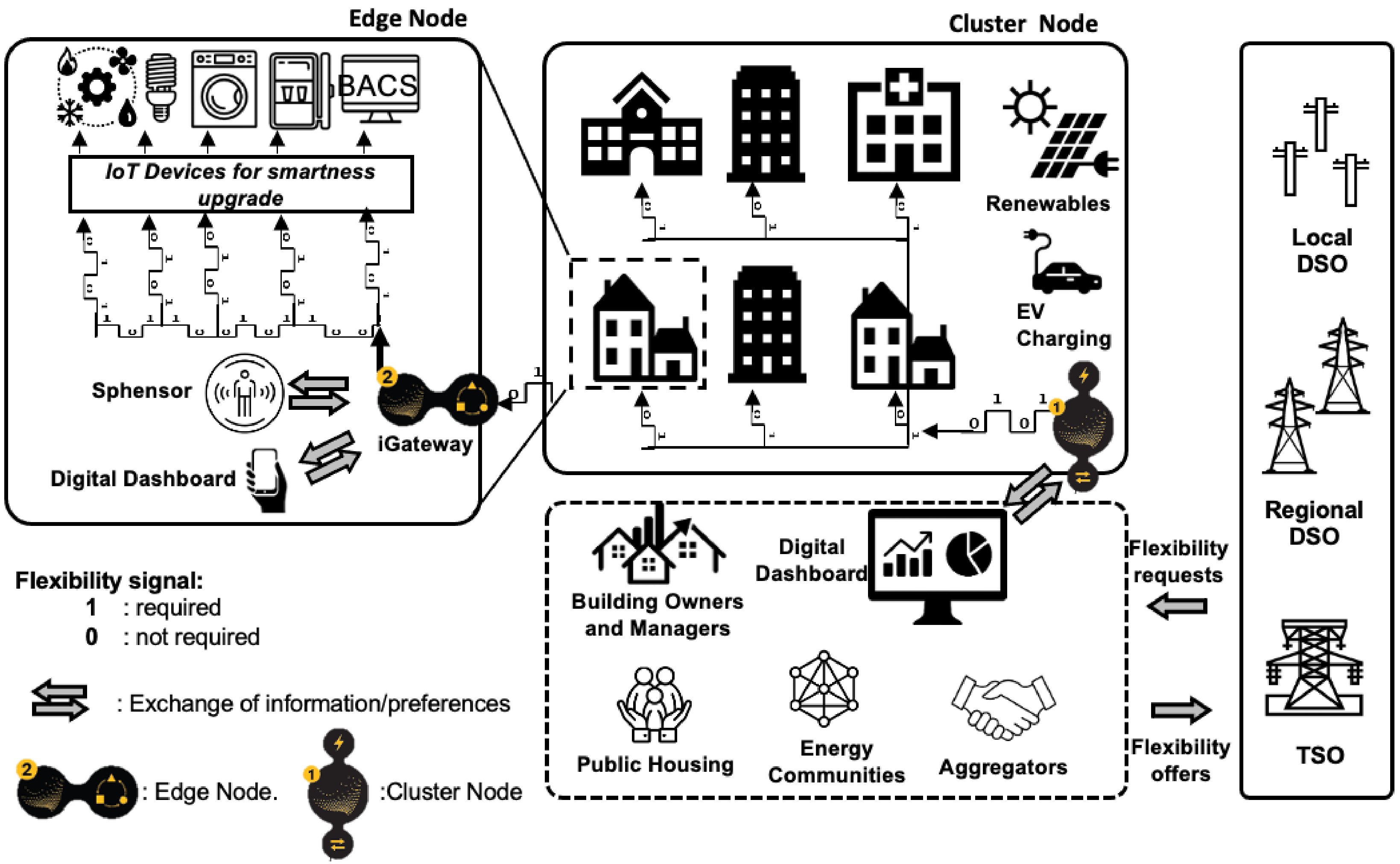
COLLECTiEF
How?

Edge & Cluster Nodes



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COLLECTiEF
How?

How it works!

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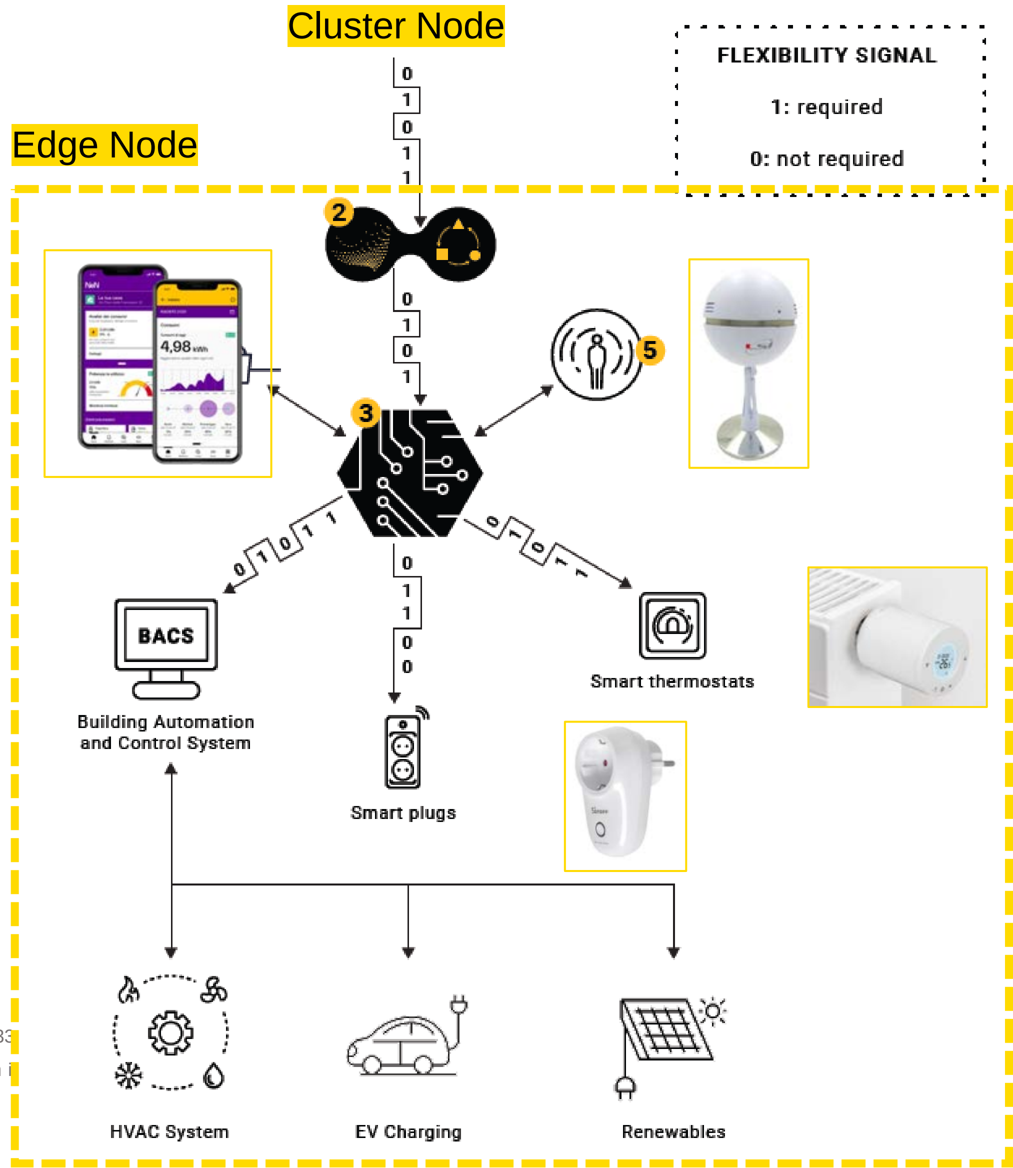
COLLECTiEF: Digital Technologies

1. Supplier Node (CI-DSM, Noda Heat Network)
2. End-User Node (CI-DSM, NODA Building)
3. Interoperability platform (iGateway)
4. Building IoT operating system (Virtual)
5. Occupant-centric sensing unit (SphenSor)



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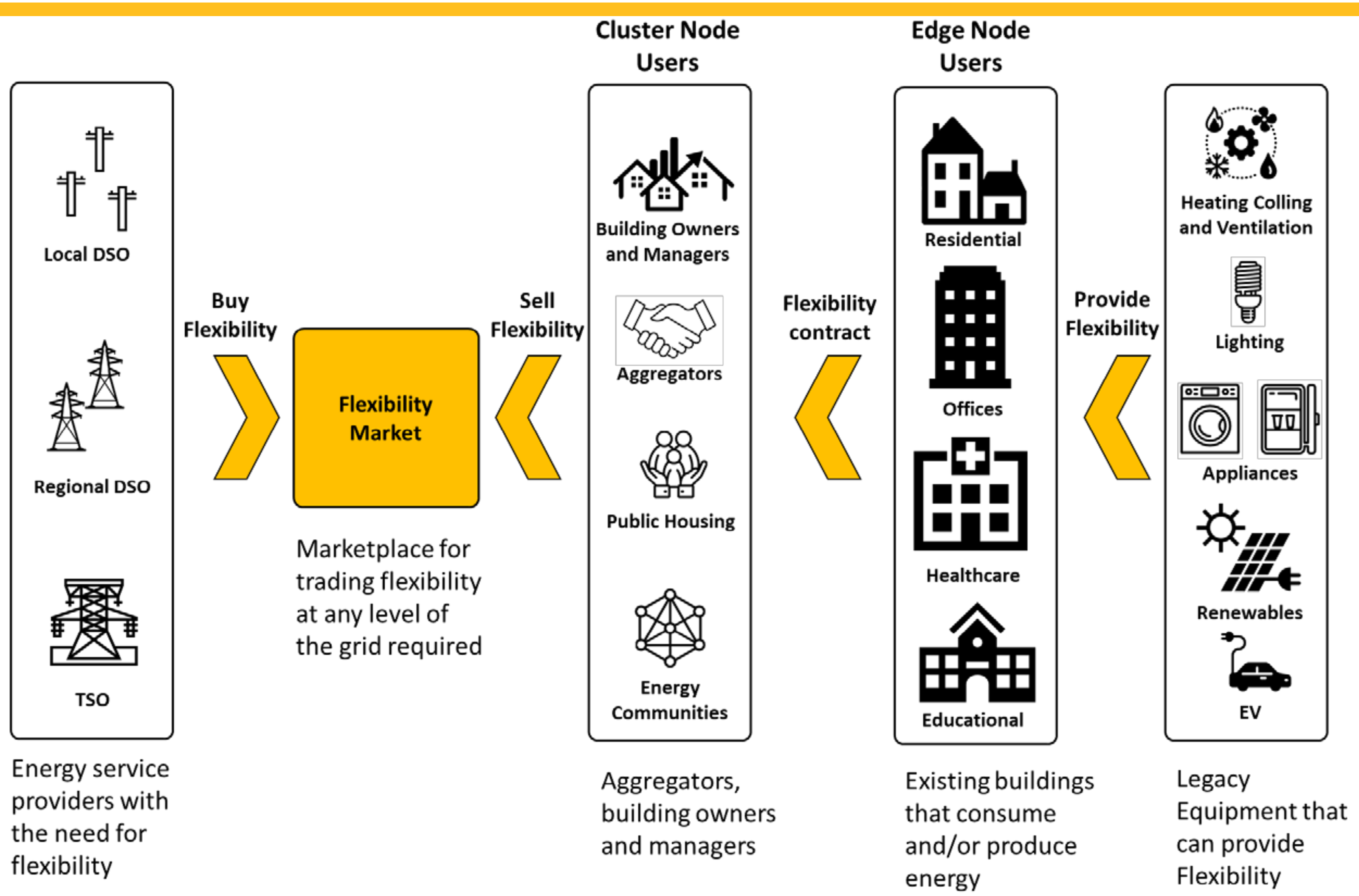
COLLECTiEF
How?

Business Model



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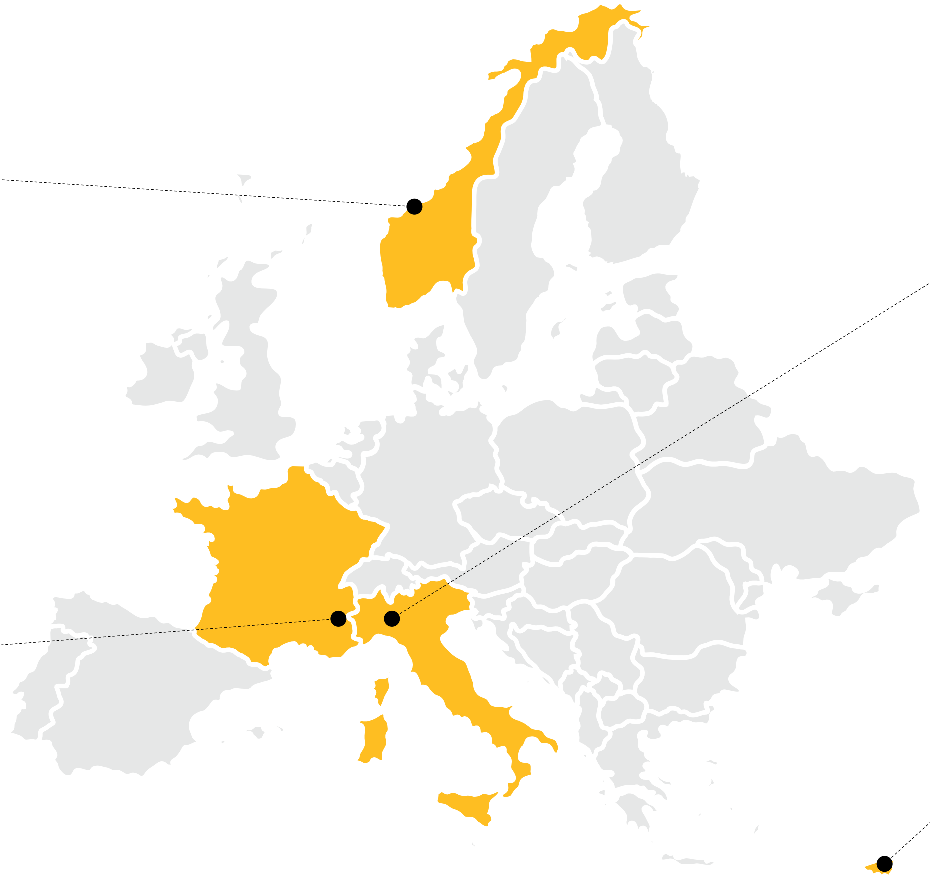
Our Pilots

Ålesund

Milano



Grenoble

Nicosia

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Pilot Buildings

EDUCATIONAL BUILDINGS

HEALTH CARE CENTERS

SPORTS ARENA

MEDICAL CENTER

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COLLECTiEF

Pilot Buildings

HIGHER EDUCATION (30%) WITH OFFICES (40%), LABORATORIES (30%), RESTAURANT (10%)

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COLLECTiEF

Pilot Buildings

RESIDENTIAL BUILDINGS

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COLLECTiEF

Pilot Buildings

OFFICE BUILDING

LABORATORY BUILDING WITH OFFICES

EDUCATIONAL BUILDING

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COLLECTiEF

The Benefits

Upgrade the smartness level of existing buildings:

16%
On average reduce the primary energy use

0.2-3 €/m²
annual energy cost savings

15%
Increase user satisfaction

24%
Increase the demand flexibility

Upgrade existing buildings to higher **smartness levels**	Reduction in **energy consumption** and **costs**	**Primary Energy Savings**	Investments in **sustainable energy** triggered by the project	Improve **User** satisfaction	Increased **climate flexibility** and **resilience** in urban areas, inducing larger integration of renewable generation

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COLLECTiEF's solutions

- COLLECTiEF project **upgrades the smartness of existing buildings to a higher level** and creates a **collaborative network of a large number of buildings** providing grid flexibility while still ensuring the quality of service to the **end customer**.
- COLLECTiEF methodology connects buildings, household appliances, and energy systems with a **minimum need for data transfer and storage**.
- COLLECTiEF uses **low-cost and open-source components** with cost-effective equipment available on the market such as smart plugs and smart thermostats.
- COLLECTiEF solutions can have direct application for **energy management in "Positive Energy Buildings and Districts"**.

Upgrade existing buildings to higher **smartness levels**

Reduction in **energy consumption** and **costs**

Primary Energy Savings

Investments in **sustainable energy** triggered by the project

Improve **User** satisfaction

Increased **climate flexibility** and **resilience** in urban areas, inducing larger integration of renewable generation

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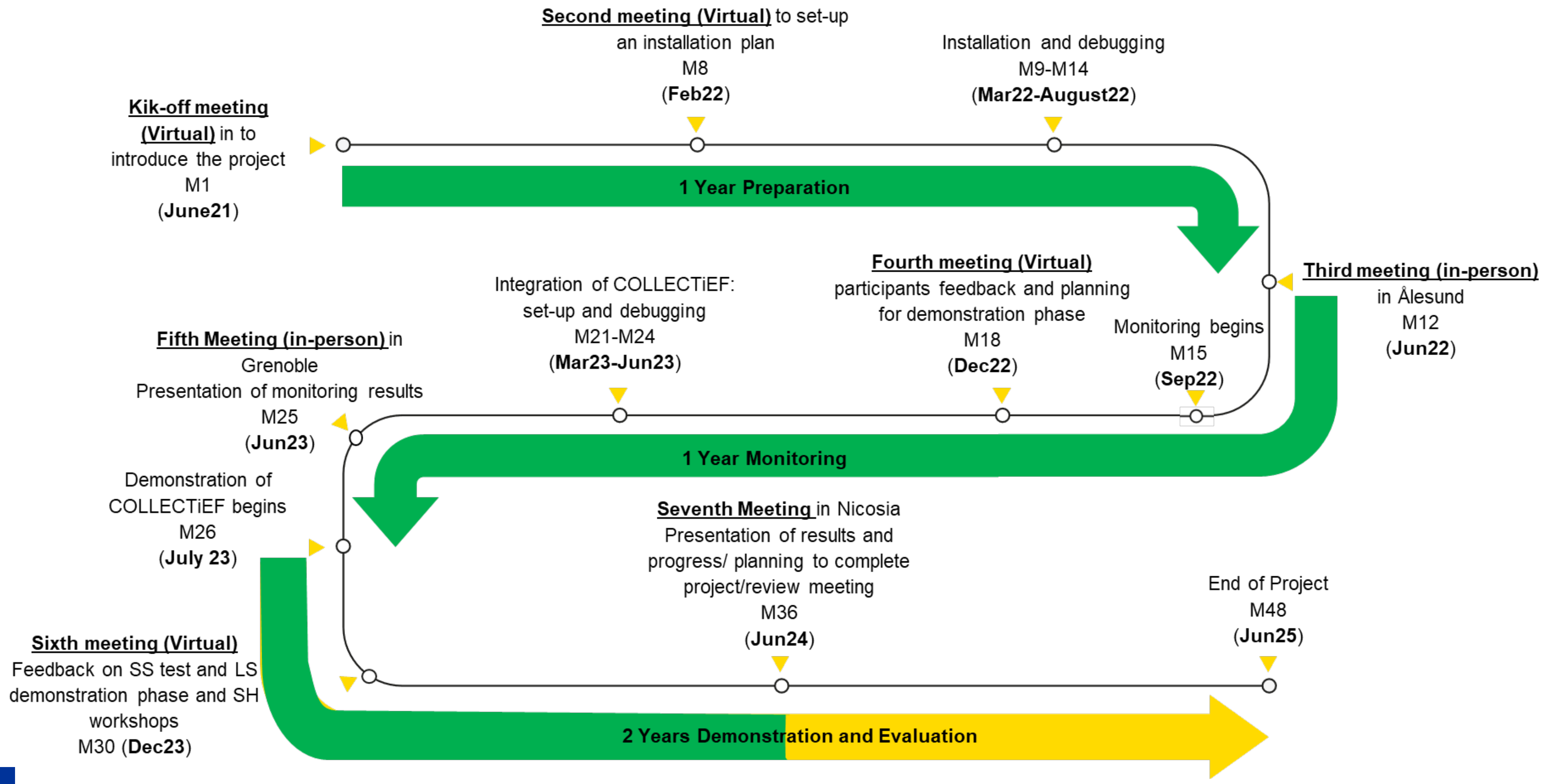
Timeline



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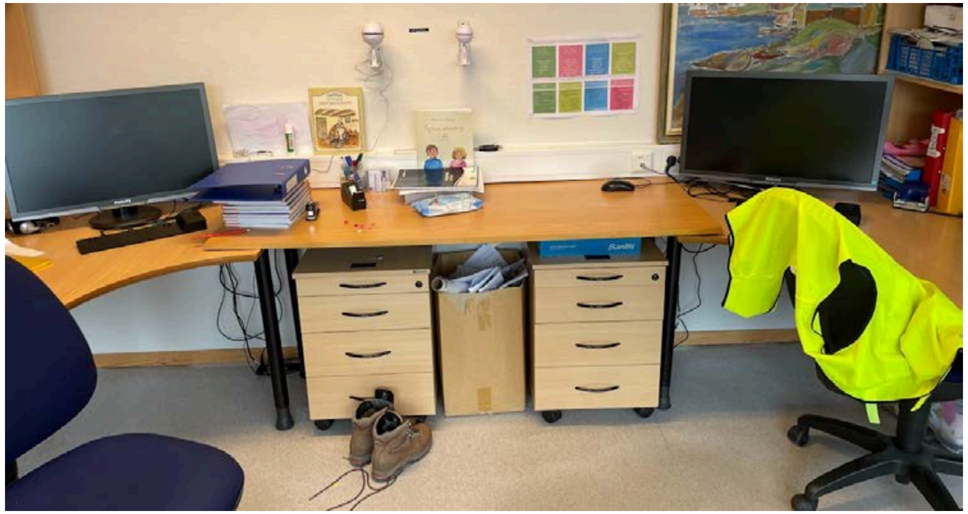
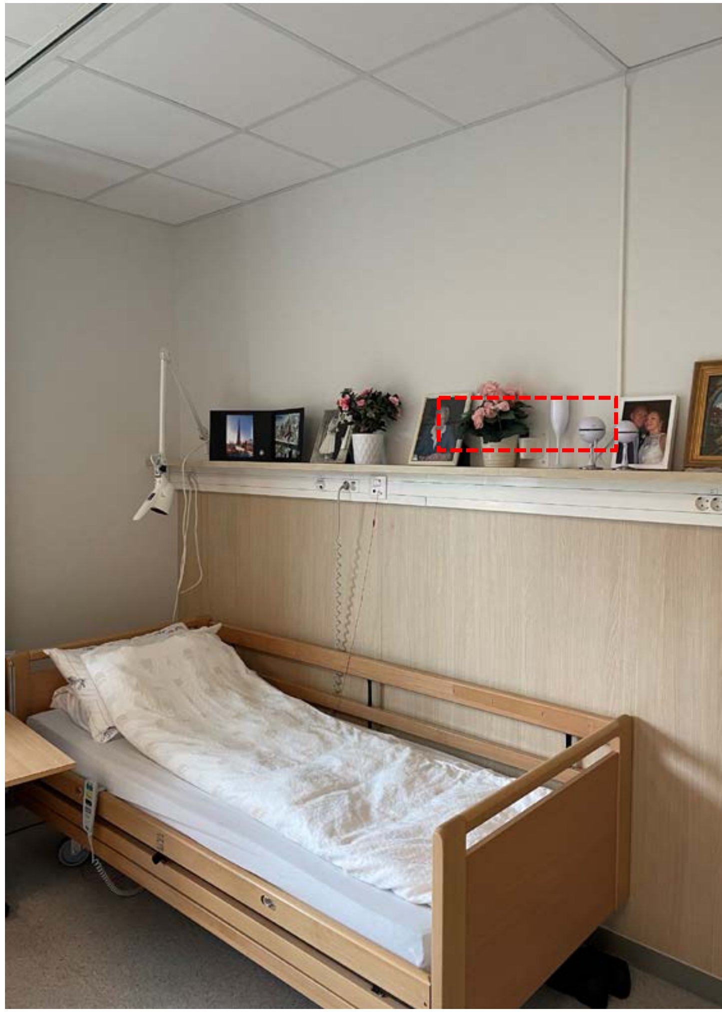
Deployment of Monitoring System





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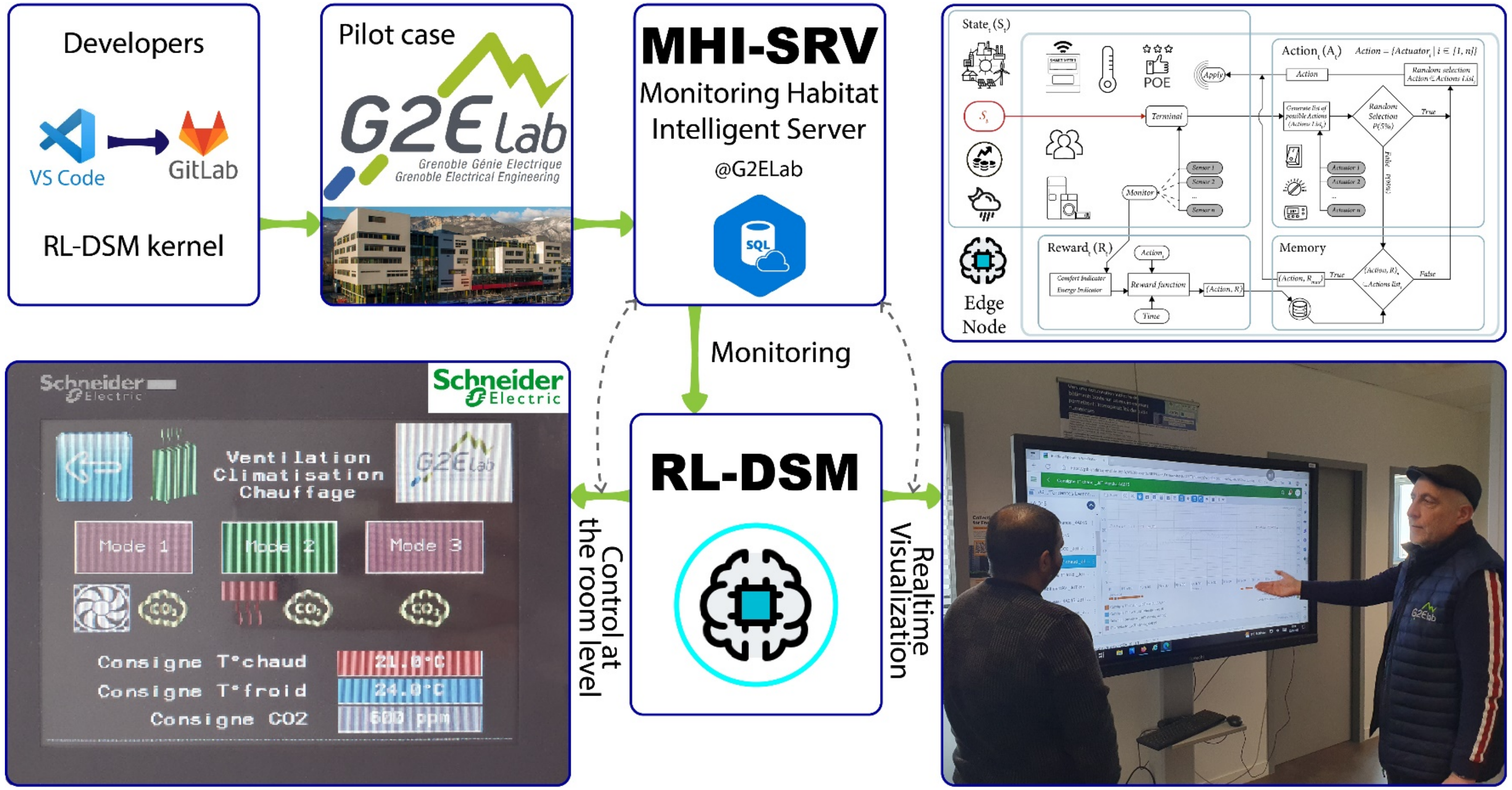
Small-Scale Demonstration



Workflow of the small-scale test in G2ELab. bottom-left: BMS panel in the rooms, top-right: flowchart of the developed algorithm, bottom-right: real-time visualization platform to demonstrate the performance of the code.

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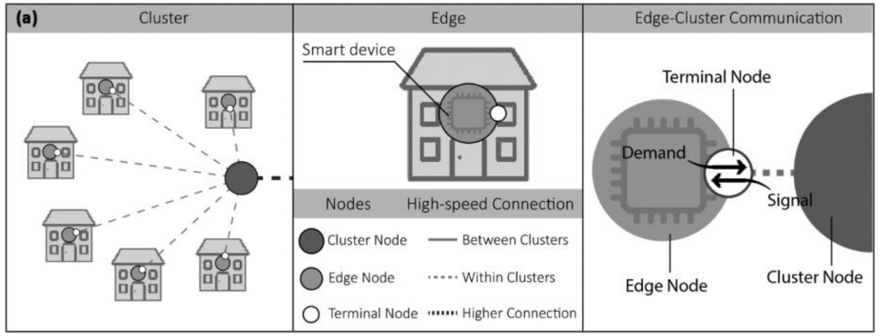
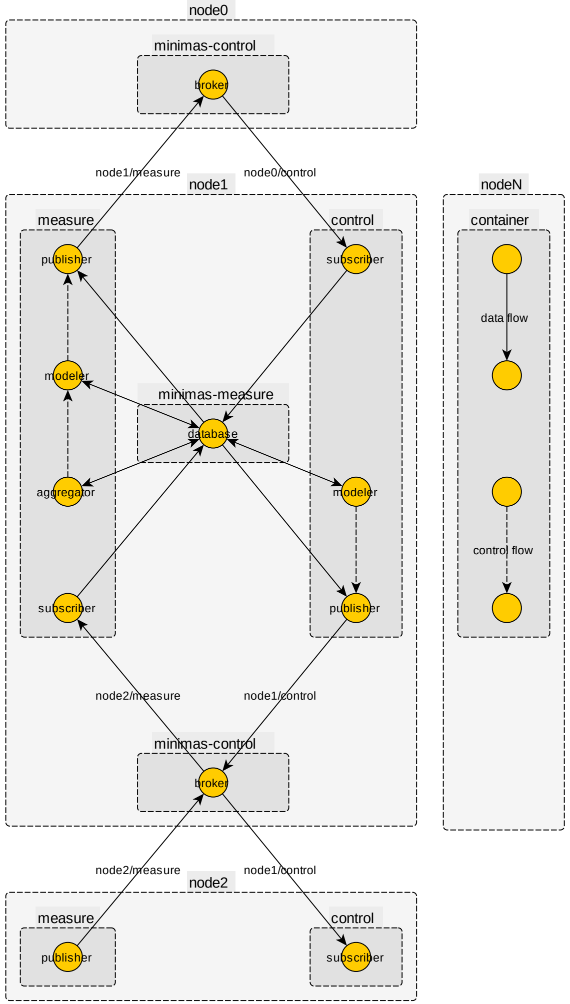
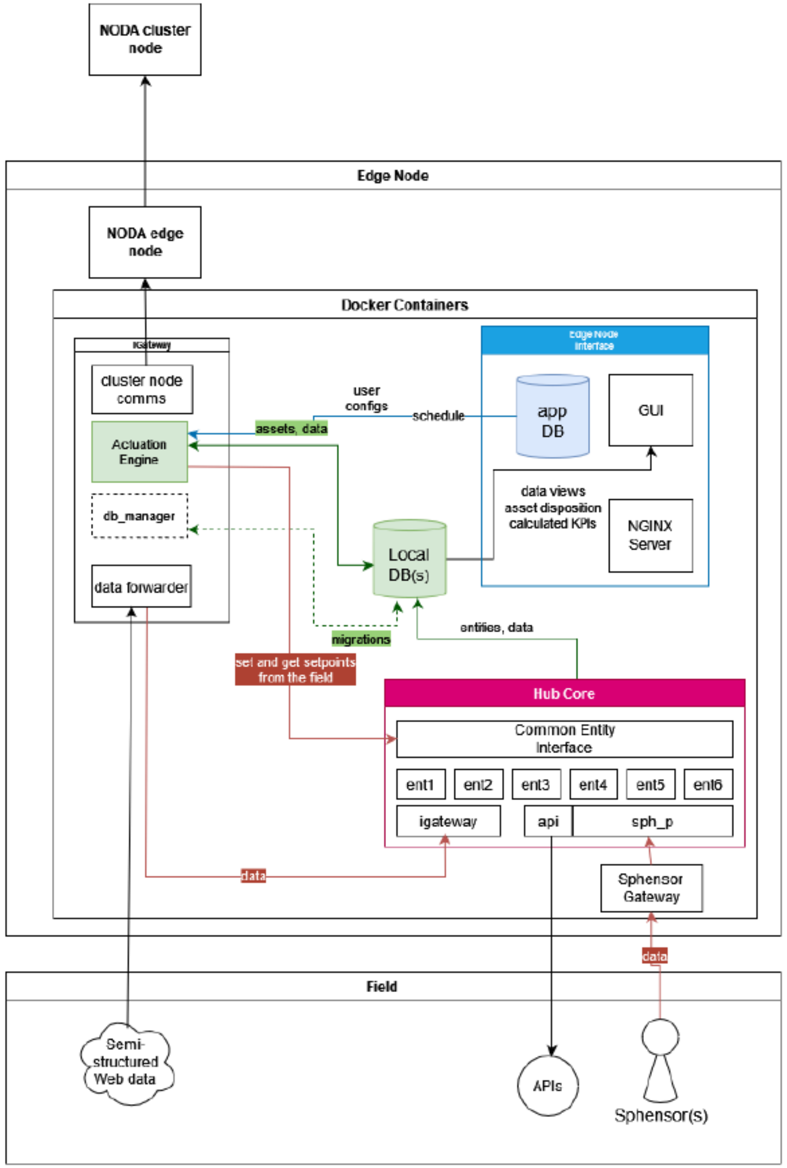
Integration of Edge Node and Cluster Node



Cluster Node, Edge Node, and the Edge-Cluster communication in the CIRL-DSM algorithm





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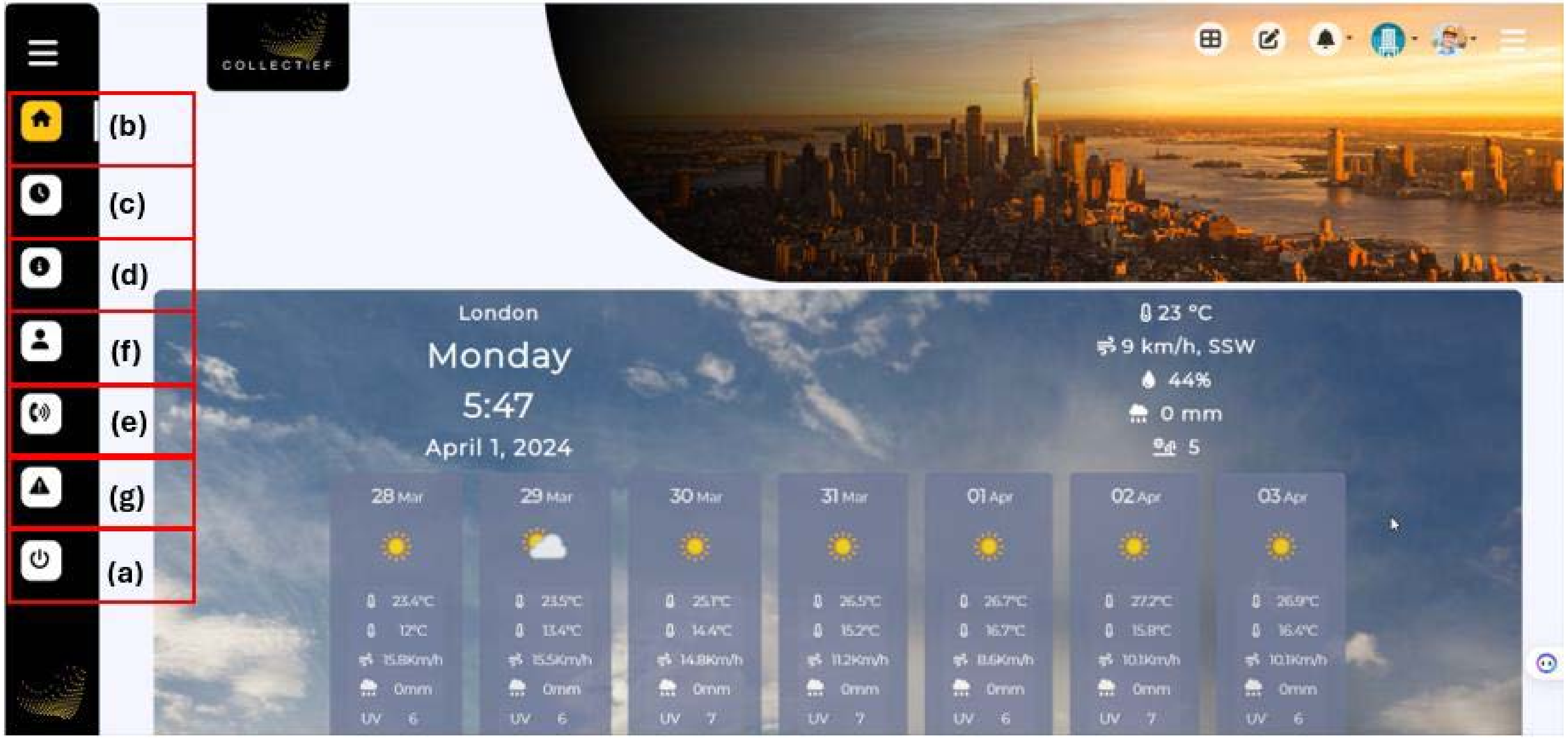
User Interface and Digital Dashboard



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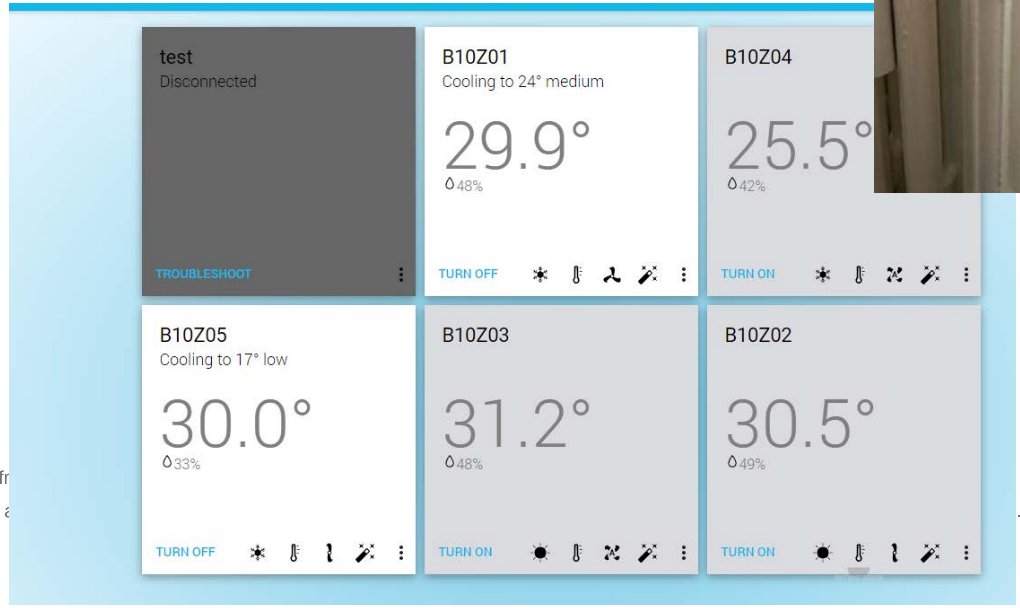
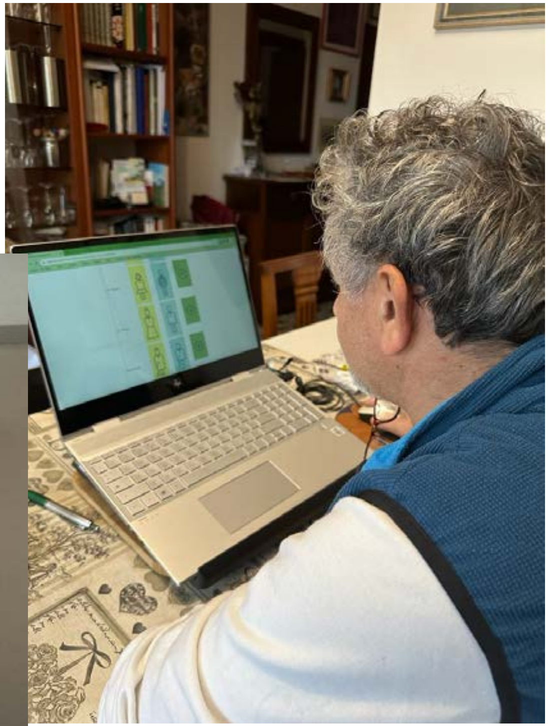
Large-Scale Demonstration

- Data collection phase
- Applied controls phase
- Norwegian pilot buildings
- Italian pilot buildings
- Cypriot pilot buildings





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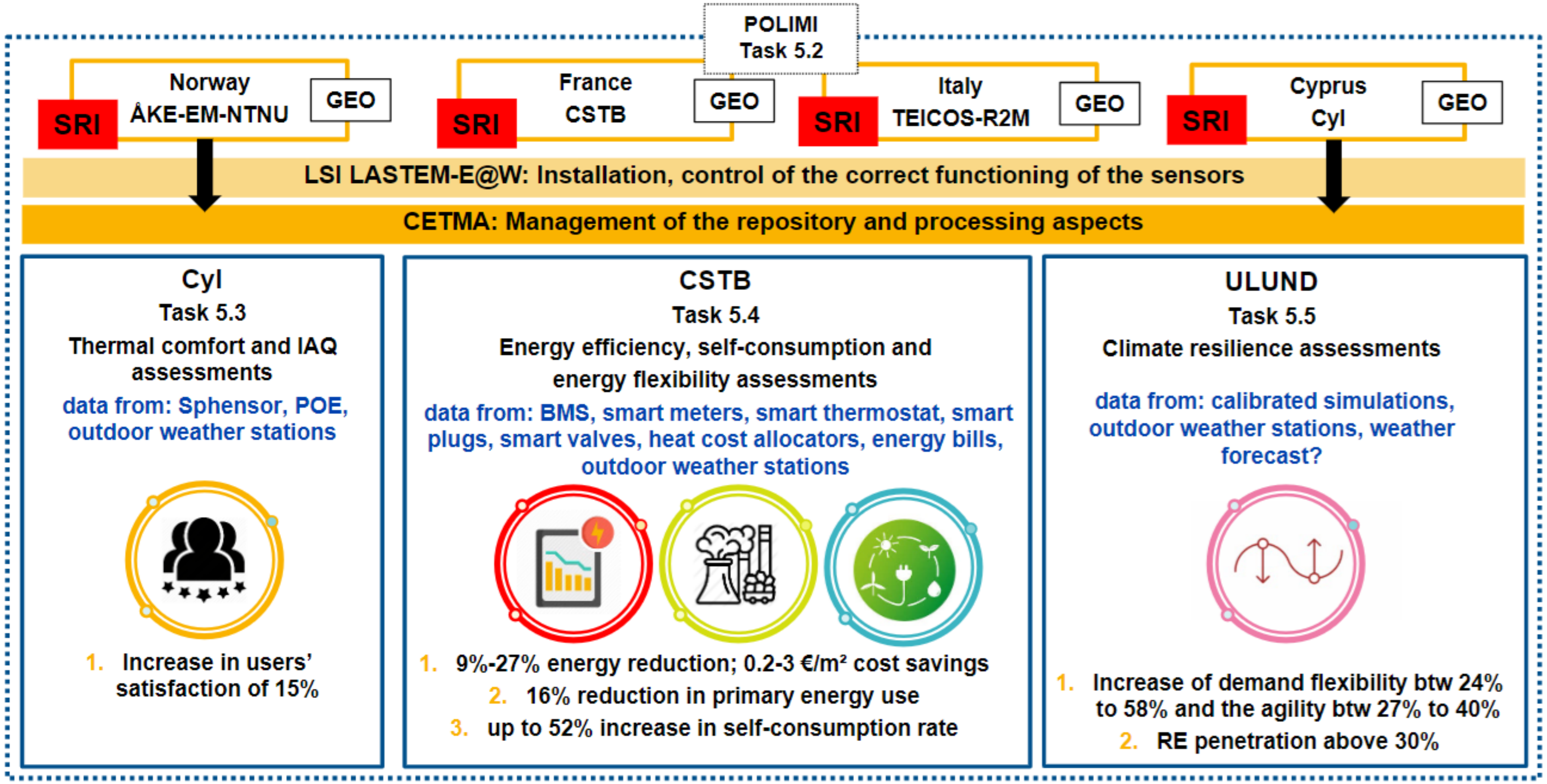
Data analysis and impact assessment



Overview of the impact assessment

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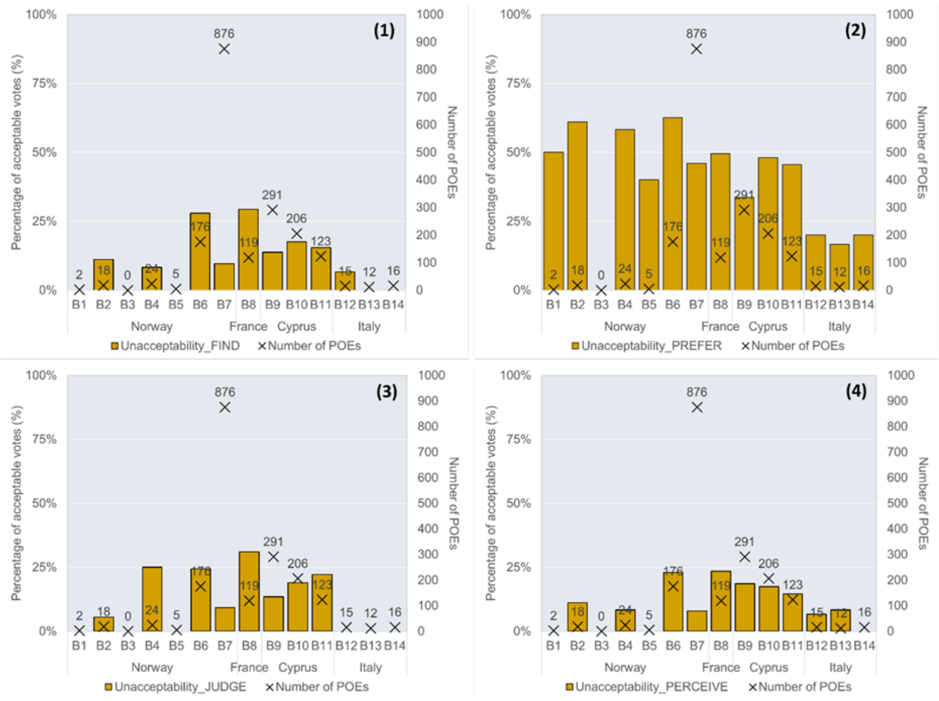
Data analysis and impact assessment

Zone type	Average % of target	lug-22	ago-22	set-22	ott-22	nov-22	dic-22	gen-23	feb-23
Classroom Classroom	0%	0%	0%	0%	0%	0%	0%	0%	0%
Classroom Classroom	0%	0%	0%	0%	0%	0%	0%	0%	0%
Classroom Classroom	1%	0%	25%	0%	0%	0%	0%	0%	0%
Classroom Classroom	70%	0%	0%	138%	300%	1175%	313%	350%	238%
Classroom Classroom	58%	0%	38%	113%	438%	663%	225%	338%	263%
Classroom Classroom	51%	0%	13%	1200%	88%	263%	138%	0%	125%
Shared office Shared office Shared office Shared office	0%	0%	0%	13%	0%	0%	0%	0%	0%

Example of a synthetic report which displays the operating status of the IEQ monitoring system in one of the pilot buildings

Average of days on record	lug-22			ago-22			set-22			ott-22			nov-22			dic-22	
	a	b	LSI Commer	a	b	LSI Commer	a	b	LSI Commer	a	b	LSI Commer	a	b	LSI Commer	a	b
50%	0%	0%		0%	38%		100%	100%		100%	100%		100%	100%		87%	100%
47%	0%	0%		0%	38%		100%	33%		100%	100%		100%	100%		87%	100%
50%	0%	0%		0%	38%		100%	100%		100%	100%		100%	100%		87%	100%
49%	0%	0%		0%	38%		80%	100%		100%	100%		100%	100%		87%	100%
50%	0%	0%		0%	38%		100%	100%		100%	100%		100%	100%		87%	100%
34%	0%	0%		0%	38%		100%	60%		20%	0%		53%	100%		80%	81%
50%	0%	0%		0%	38%		100%	100%		100%	100%		100%	100%		87%	100%
50%	0%	0%		0%	38%		100%	100%		100%	100%		100%	100%		87%	100%
50%	0%	0%		0%	38%		100%	100%		100%	100%		100%	100%		87%	100%
50%	0%	0%		0%	38%		100%	100%		100%	100%		100%	100%		87%	100%

Example of a synthetic report which displays the progress in POEs collection in one of the pilot buildings



Thermal Discomfort from POE questionnaires per pilot building for the baseline period

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Data analysis and impact assessment

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						
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%*

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THANK YOU!

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@CollectiefP
COLLECTiEF project
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COLLECTiEF

Algorithm development for COLLECTiEF System

Vahid M. Nik, Lund University

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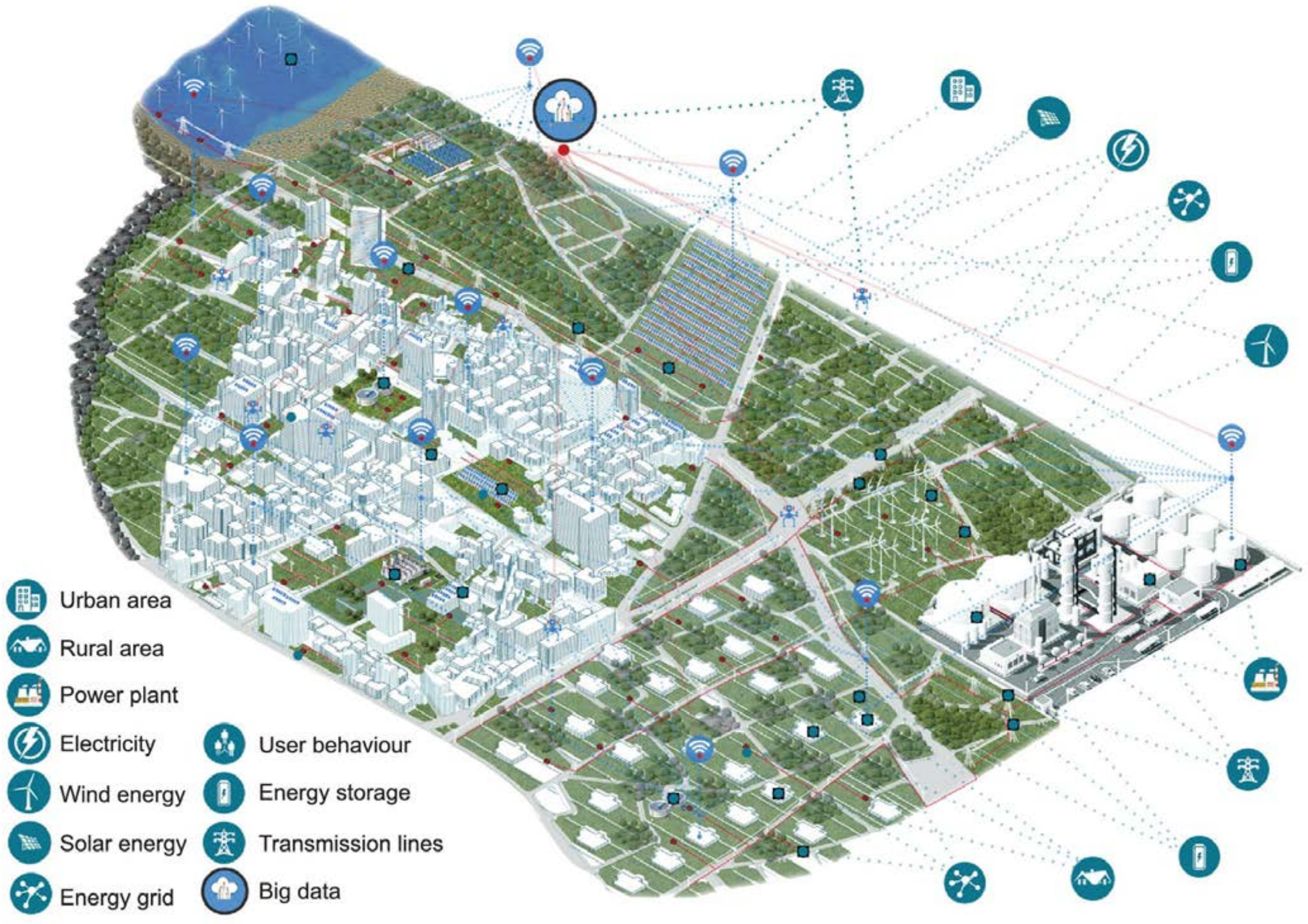
Urban energy systems are **complex systems**, affected by several factors, such as building energy performance, user behavior, other urban utilities etc. Impact of extreme climate events can become much larger in complex systems such as urban energy systems, therefore we should increase the ‘climate resilience’ of such systems and make them more resistance and flexible for the future climate.



Nik VM, Perera ATD, Chen D. “Towards climate resilient urban energy systems: A review”, National Science Review, March 2021, 8, 3. doi:10.1093/nsr/nwaa134.

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Climate change results in warmer climate conditions on average and intensified climate variations, resulting in stronger and more frequent extreme events such as heatwave, tornado, flooding etc.

www.ethlife.ethz.ch

When it comes to energy management, there is a need for innovative approaches for energy system design and control

→ White/Grey/Black-box modelling

→ AI-driven approaches
    → ML and RL approaches

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Our solution

Combining **C**ollective **I**ntelligence and **R**einforcement **L**earning in **E**nergy **M**anagement

CIRLEM

Nik VM, Hosseini M. "**CIRLEM**: a synergic integration of Collective Intelligence and Reinforcement learning in Energy Management for enhanced climate resilience and lightweight computation", Appl Energy 2023;350:121785. doi:10.1016/j.apenergy.2023.121785.

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COLLECTiEF

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Collective intelligence (CI)

- Distributed intelligence
- Based on collaborative problem solving
- Three characteristics: adaptation, self-organization, and emergence.

Self-organization

- Dynamic mechanism (real-time response)
- System automatically transforms itself to adapt to a changing environment
- No central control
- Arises from the interactions of individuals at the local level

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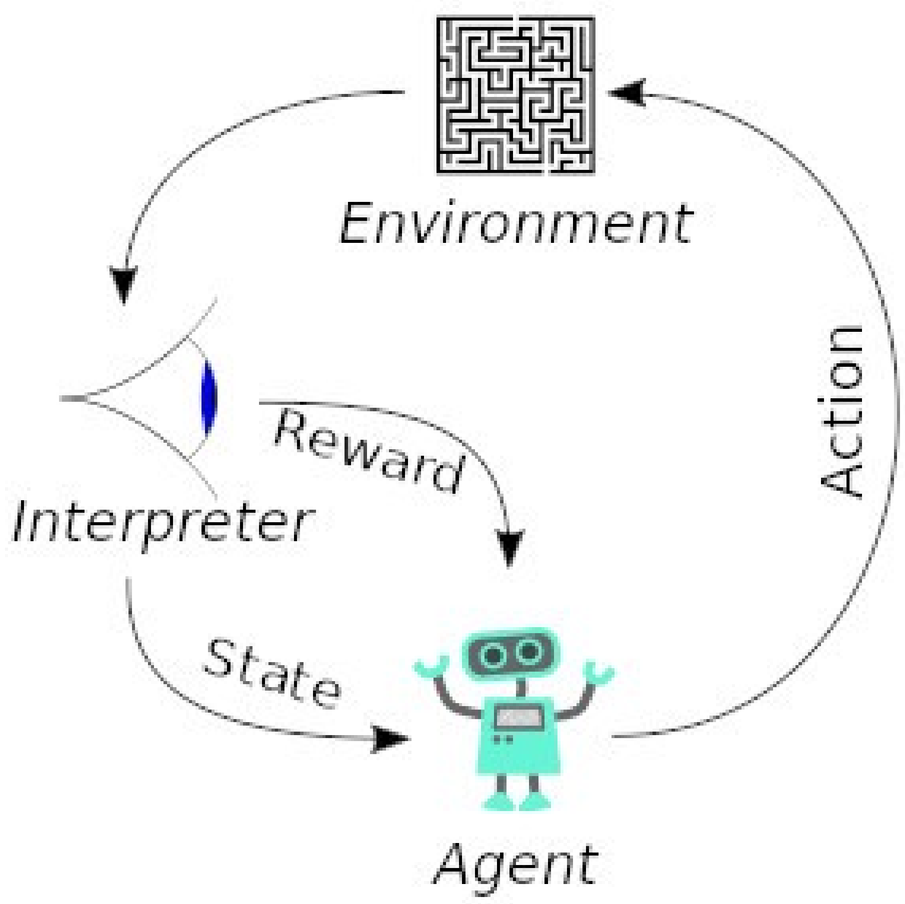
Reinforcement Learning

- Learning by doing
- Learning without requiring historic data
- Maximizing the reward by keeping the state close to the defined conditions
- Low computation



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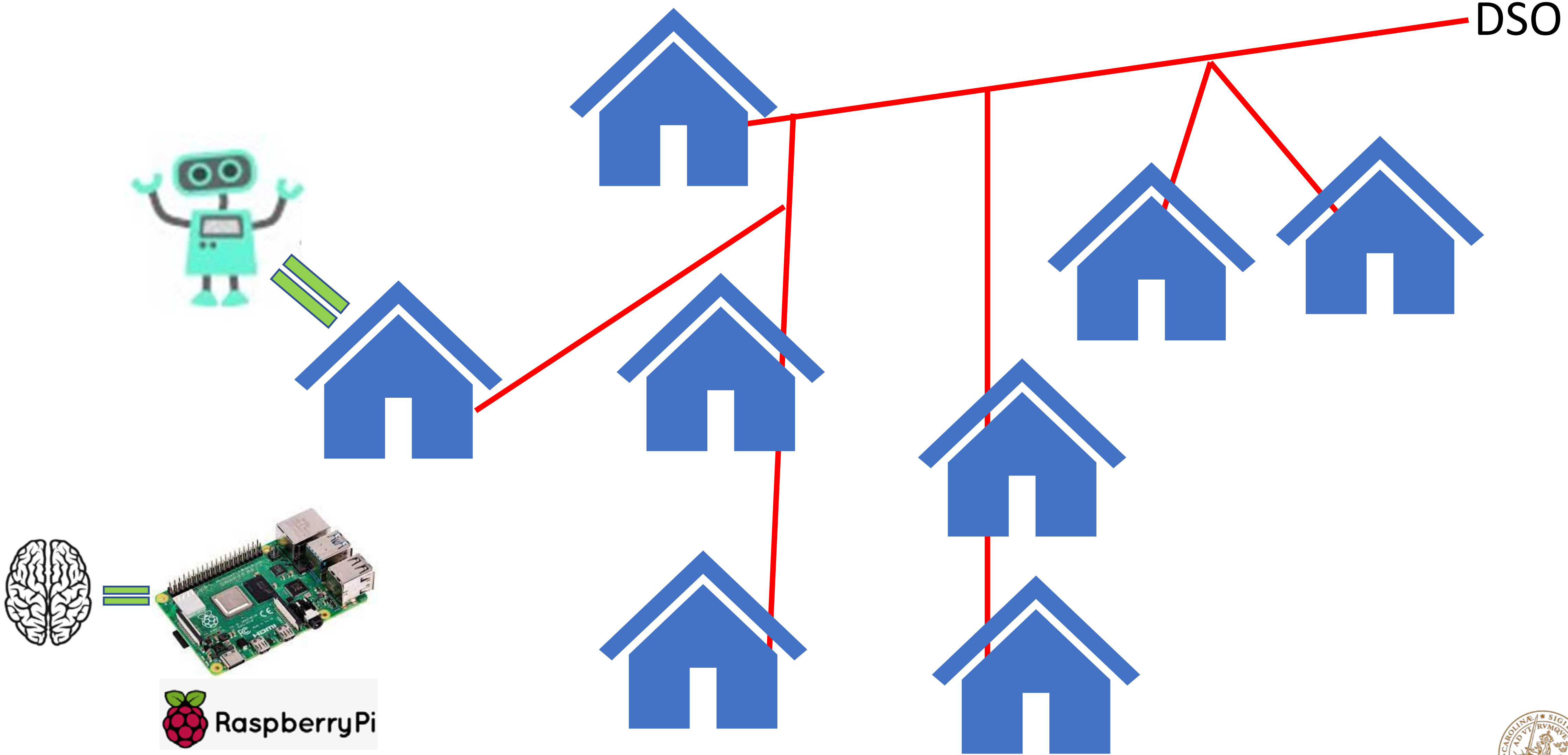

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WP2 overview

T2.1 Enhancing the available control algorithms for COLLECTiEF ClusterNode
T2.2 Developing IoT and occupant-centric control algorithms for COLLECTiEF Edge Node
T2.3 Providing inputs and boundary conditions data for COLLECTiEF network to be used in virtual test-bed
T2.4 Testing of COLLECTiEF algorithms via co-simulation based on building and energy system modelling and analysis
T2.5 Deployment and testing of algorithms and control strategies at small-scale pilot

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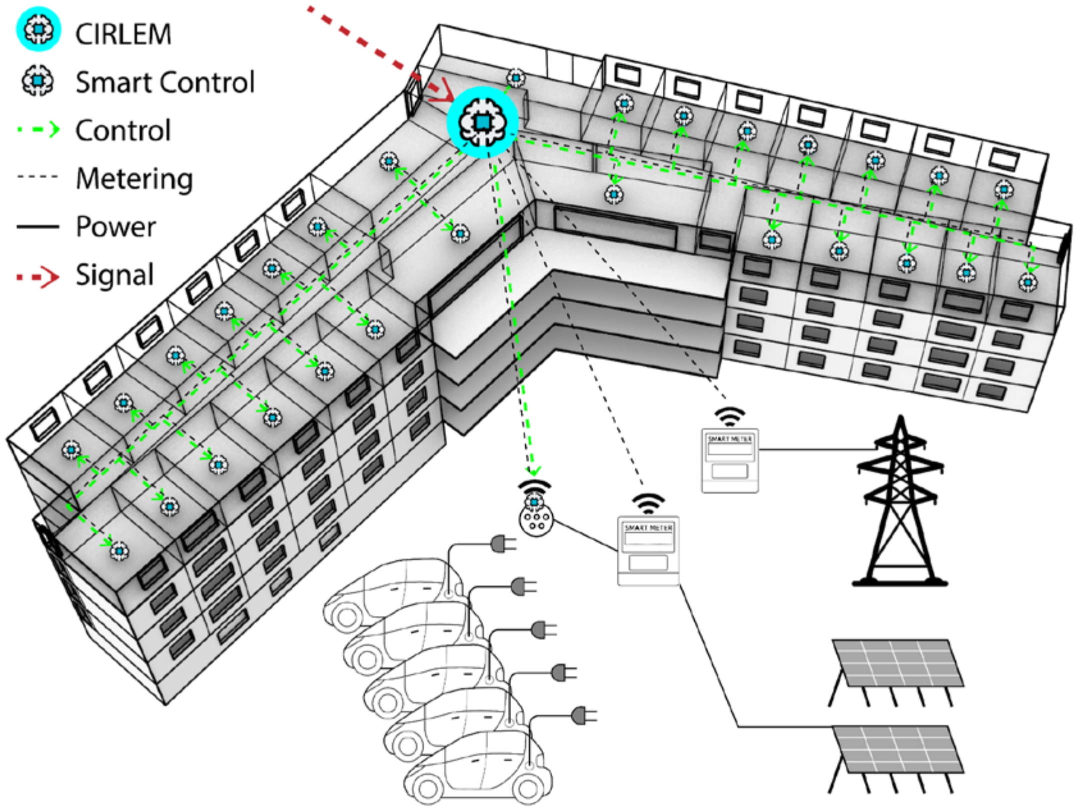
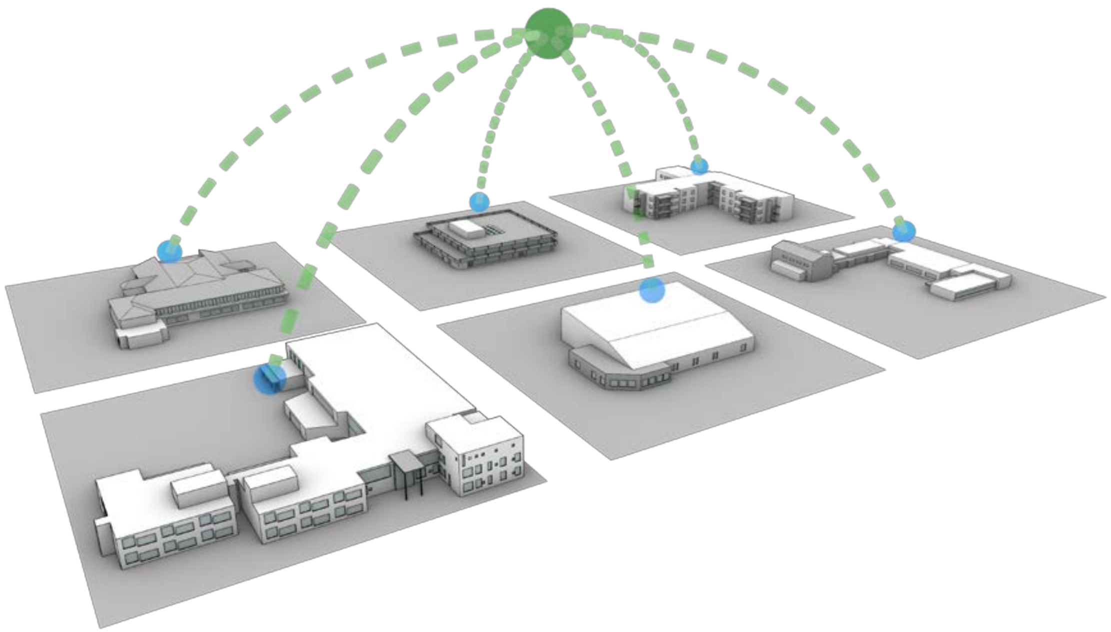


Edge **N**ode (Building Level)



Cluster **N**ode (Urban Scale)

Hosseini M, Erba S, Hajialigol P, Aghaei M, Moazami A, Nik VM. “Enhancing climate resilience in buildings using Collective Intelligence: A pilot study on a Norwegian elderly care center”. Energy Build 2024;308:114030. doi:10.1016/j.enbuild.2024.114030.

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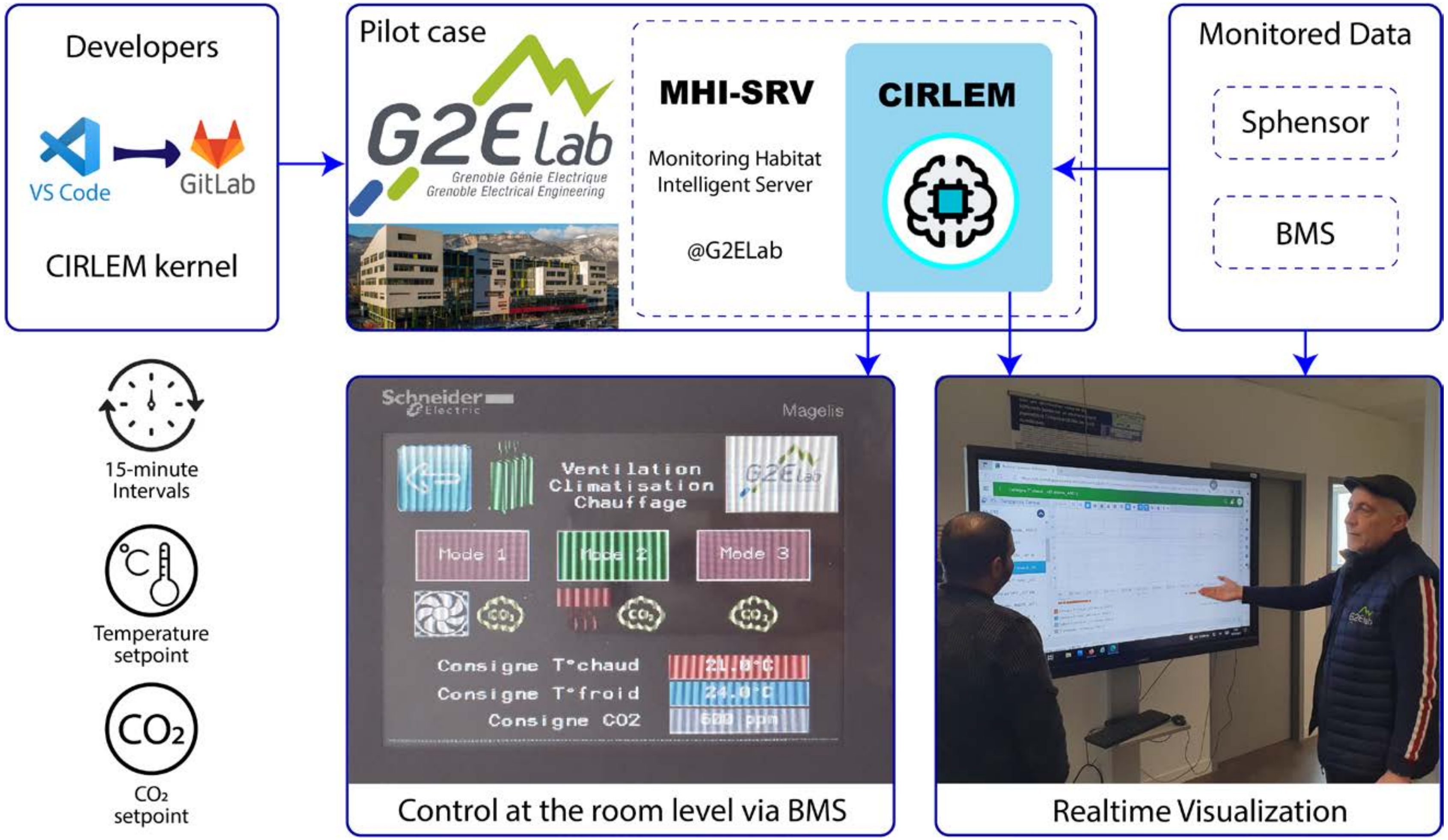
Experiment in a Living Lab in France



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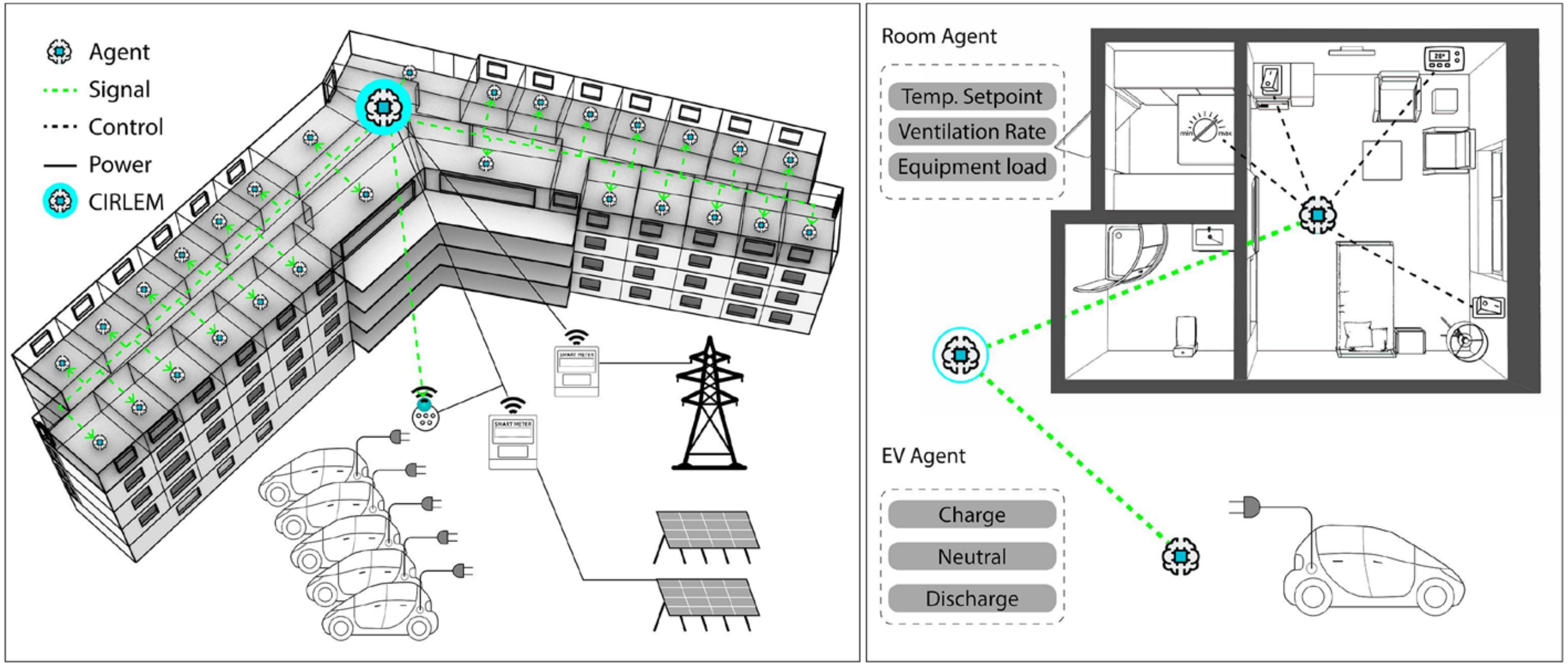
Experiment in Ålesund, Norway



Hosseini M, Erba S, Hajialigol P, Aghaei M, Moazami A, Nik VM. “Enhancing climate resilience in buildings using Collective Intelligence: A pilot study on a Norwegian elderly care center”. Energy Build 2024;308:114030. doi:10.1016/j.enbuild.2024.114030.

Experiments in Milan, Italy and Nicosia, Cyprus

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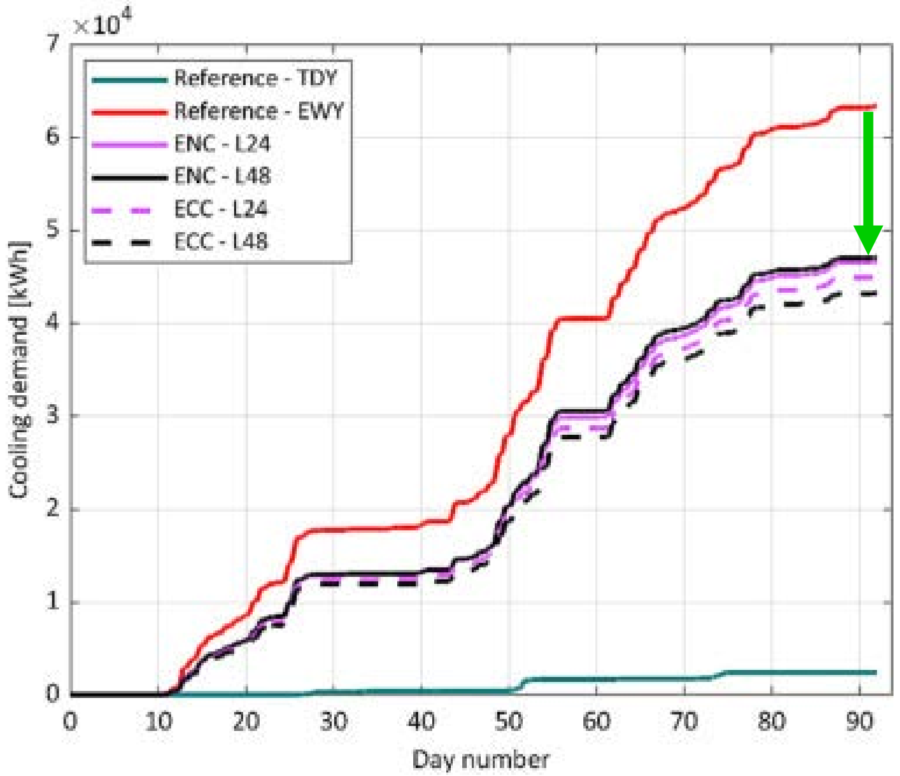
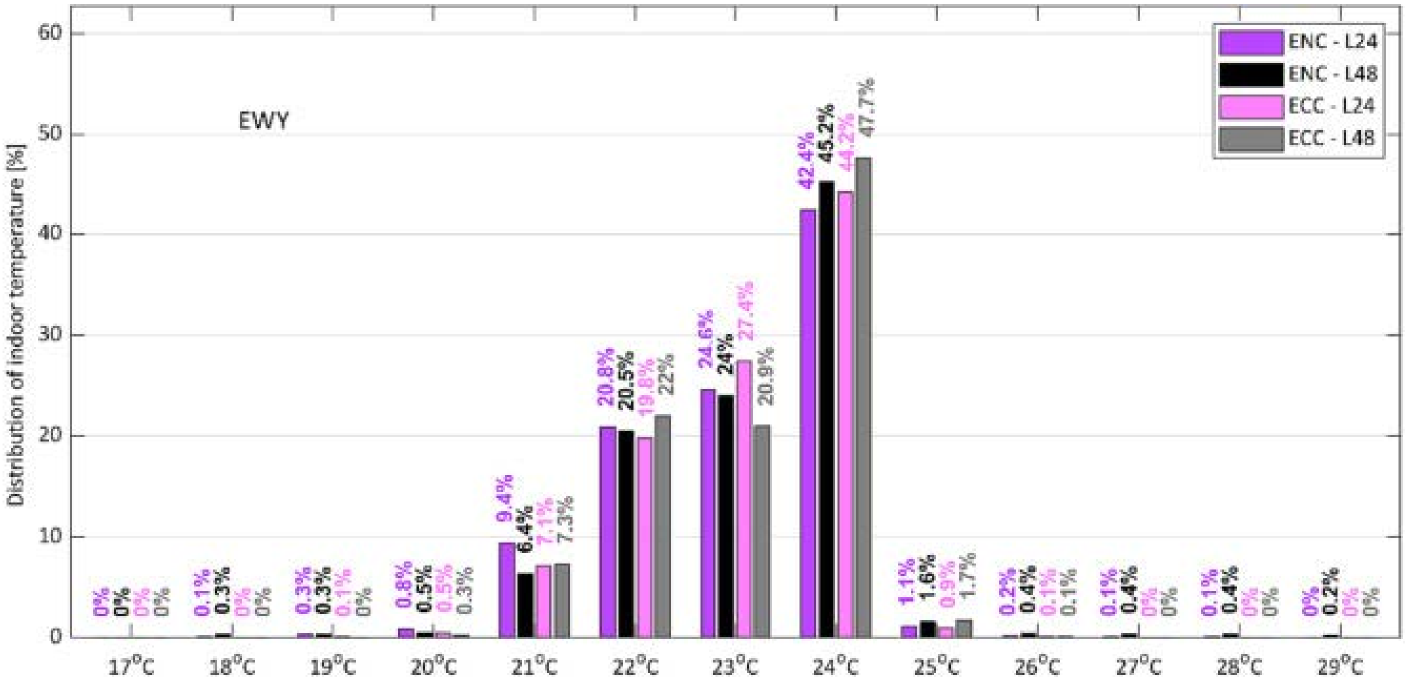
Extreme Warm Summer during 2040-2070





Nik VM, Hosseini M. "CIRLEM: a synergic integration of Collective Intelligence and Reinforcement learning in Energy Management for enhanced climate resilience and lightweight computation", Appl Energy 2023;350:121785. doi:10.1016/j.apenergy.2023.121785.

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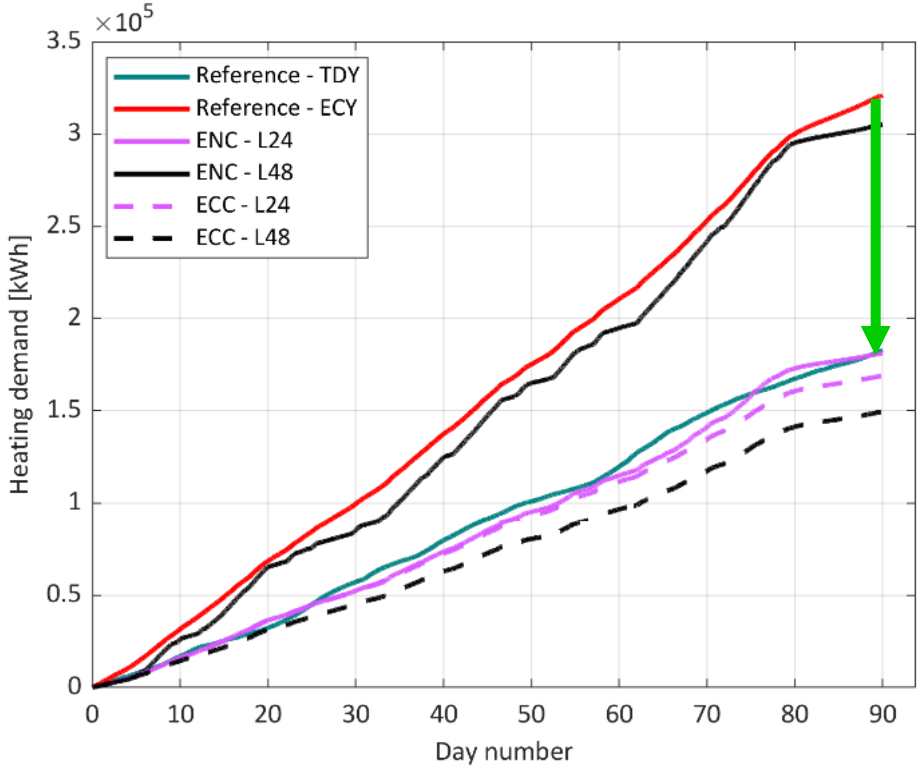
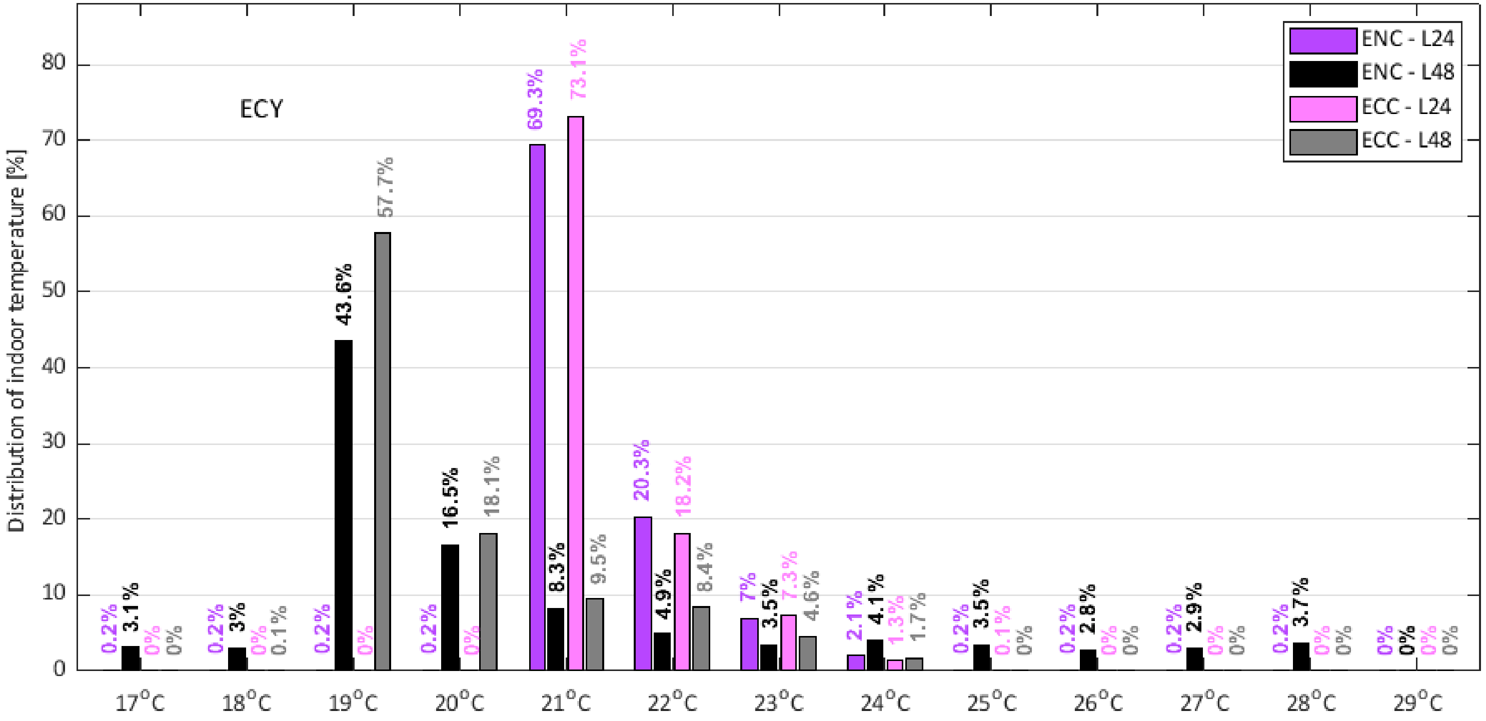
Extreme Cold Winter during 2040-2070





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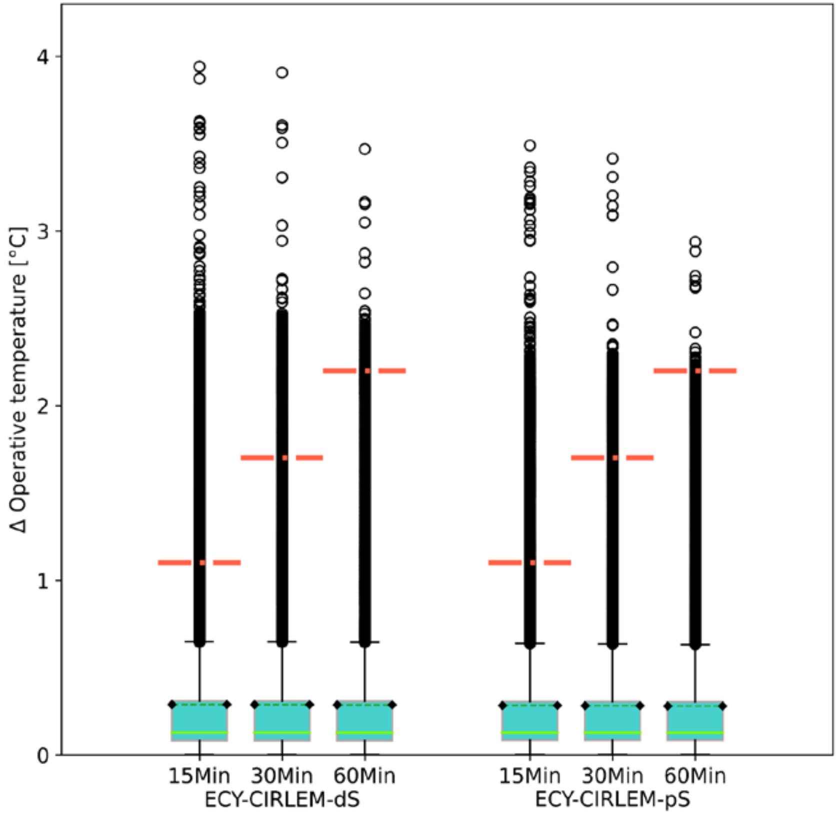
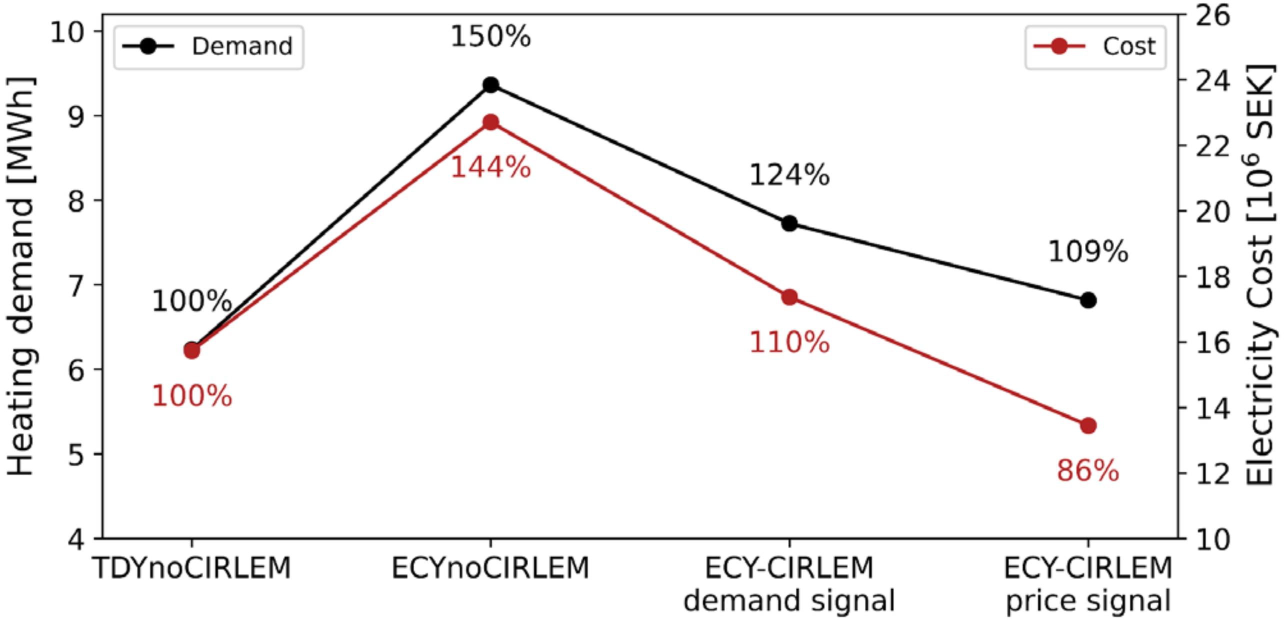


Thermal comfort



Cost saving

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- CIRLEM can considerably decrease the energy demand during extreme climate events while keeping the indoor temperature mostly at the comfort level.
- It enables the entire ecosystem to overcome shocks.
- No need for central control.
- Minimum data gathering and information sharing.
- Enhances over time (self-learning).
- High performance in complex energy systems.
- Tailor-made reward function for each building use type.
- Inclusion of user preferences.
- Operating on different modes depending on the conditions and user preferences.

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CRAFTCIRLEM

CARUACI

Thank you!

The algorithm development was supported by the Swedish Research council for Sustainable Development, Formas (project ID: 2022-01120 - CRAFTCIRLEM), the Crafoord Foundation under CARUACI project, the Joint ERA-Net Call 2020 (MICall20) on digital transformation for green energy transition under DigiCiti project (project ID: 108807), and the European Union's Horizon 2020 research and innovation programme under grant agreement for the COLLECTiEF (Collective Intelligence for Energy Flexibility) project (grant agreement ID: 101033683).