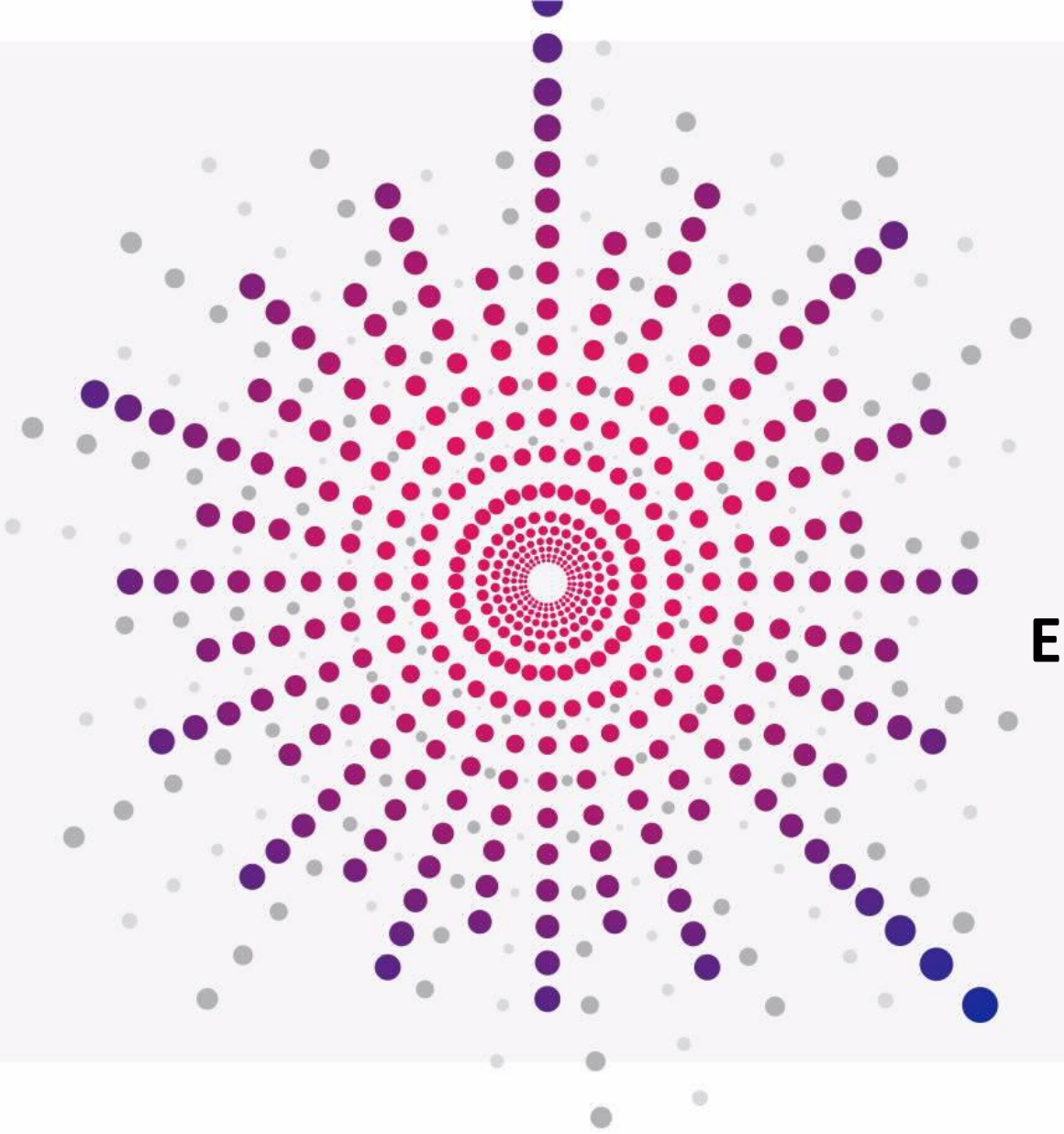

BD4NRG
Big Data for Next Generation Energy

LSP11 -De-Risking investments in Energy Efficiency and Increasing the efficiency and comfort in buildings

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AJUNTAMENT DE SantCugat

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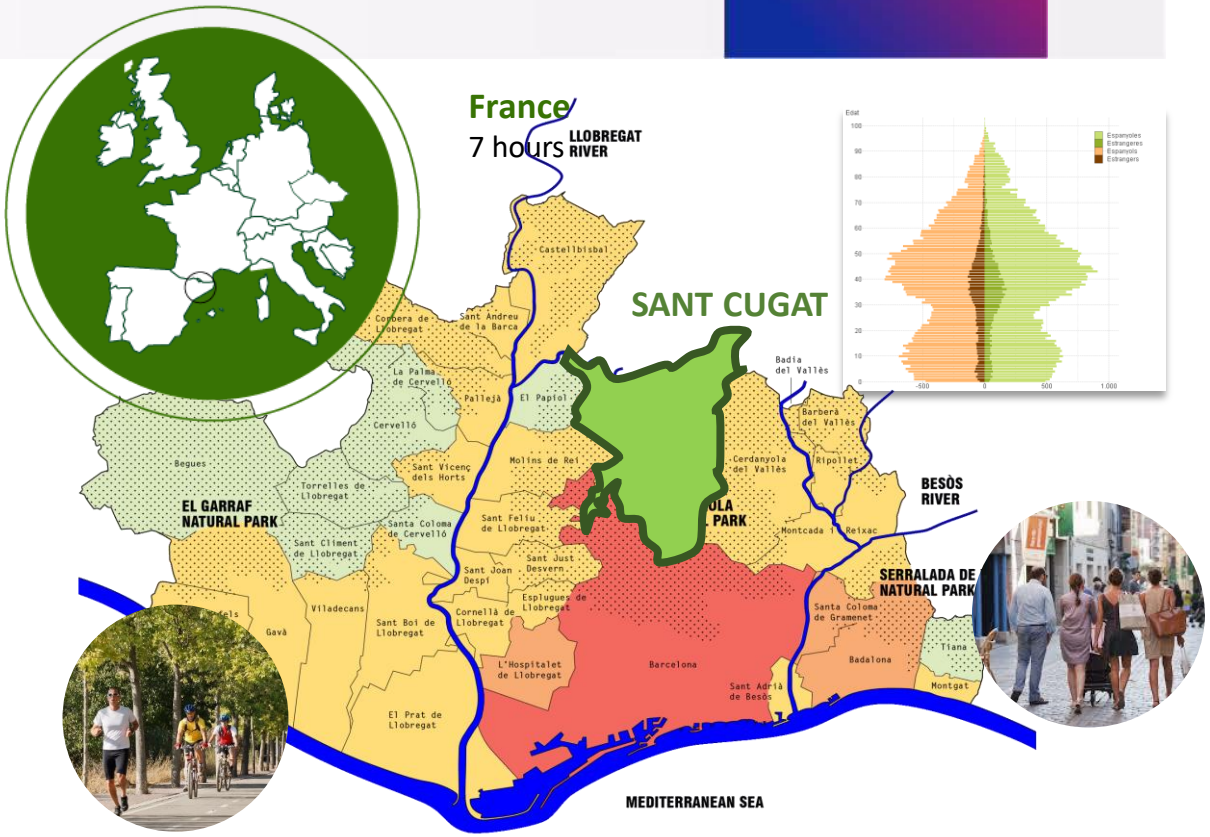
Introduction to Sant Cugat City

- **Directly connected** to the highway infrastructure network leading to the airport and port of Barcelona in 30 min. Well established public transport system by train and bus.
- Surrounded by Collserola Natural Park with over 8,000Ha of nature reserve. The total surface area of the municipality is 48,320 ha, of which **(44%) are protected.**
- 34,000 dwellings, 8,500 are single-family houses. **88 municipal buildings** (schools, sport facilities, administrative, libraries…)
- Around **21 GWh** consumption/year **4,000 Tn CO2** emissions/year
- **2019-2023 1st municipality in Catalonia** in number of domestic PV self-consumption installations ahead of Barcelona (more than 2,500 to date).
- **One of the youngest cities** in Spain, with 95,000 inhabitants and an average age of 38. 75% Population with higher education level. 3rd highest GPD in Catalonia
- **92% of inhabitants feel happy to live in Sant Cugat** and 78.5% believe it to be civic and safe.



Introduction to LSP11 & The Challenge

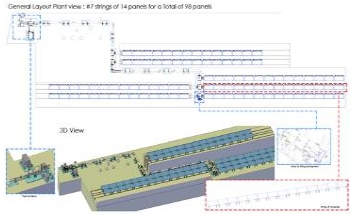
- More than **a third of the total final energy consumed in the European Union** is consumed in buildings in the residential and tertiary sector. The LSP11 project is focused on promoting private-oriented business models for implementing energy retrofitting actions with a primary emphasis on improving the thermal comfort of building occupants.
- The **primary goal** of the LSP11 project is to encourage private-sector business models that facilitate **energy retrofitting actions** through to leverage **ML algorithms** to model comfort levels while optimizing energy efficiency within buildings.
- The project's **main benefit** lies in achieving a more precise and **accurate prediction of thermal comfort**, considering potential variations in fuel consumption and their impact on building energy efficiency.
- The solution obtained allows a direct application to the municipal buildings included in the pilot and paves the way to scaling it to the rest of the municipal buildings (88) that have the necessary data structure to be able to apply it. **Reducing energy consumption but guaranteeing the thermal comfort of users.**

Description of the Pilot Use Case

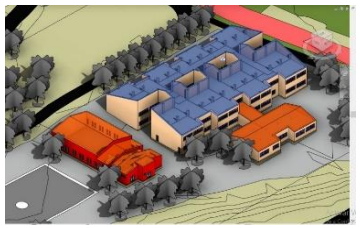
Use Case: Building energy efficiency optimisation with thermal comfort considerations.

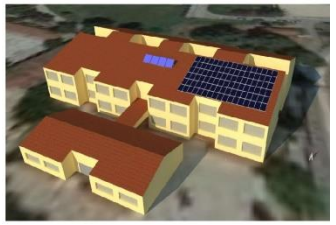
Scope of the Pilot: Two buildings have been tested in LSP11.

Building 1: Mira-Sol Civic Center



Building 2: Pins del Vallès School





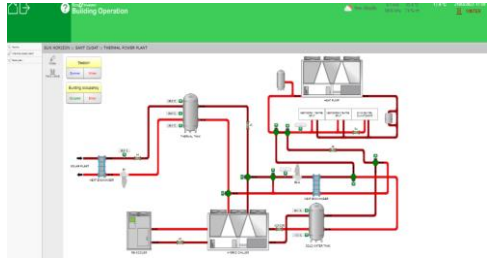
Specific actors / Stakeholders

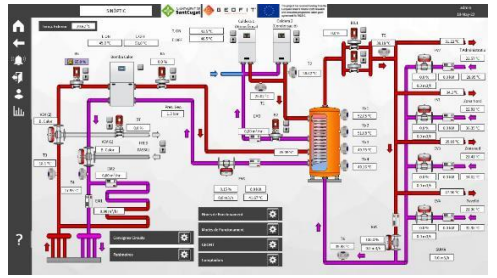
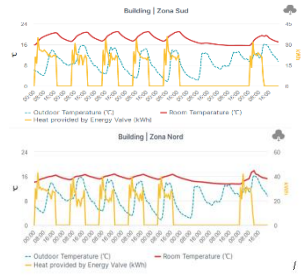
- Maintenance Service Company: Provided expertise in energy retrofitting and data providers.
- Other Data Providers: Contributed essential data sets for modelling as weather prediction. Also requested to other European project partners.
- Sant Cugat city council: owners of the buildings and supervisors of the improvement.
- BD4NRG partners: technology Developers: Supplied ML algorithms and BEMS solutions.
- Building Users: Occupants feedback and needs with a stake in improved comfort and efficiency.

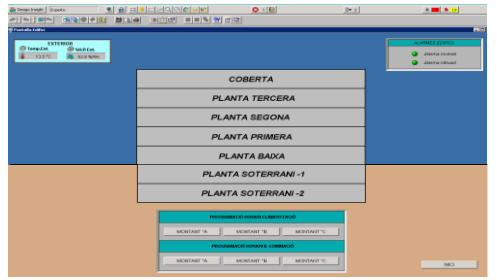
The Key Components

Infrastructure & Data Used:

- **BEMS** dynamic data from sensors (e.g., room temperature, windows, presence and temperature), operating temperatures for building uses, PLCs of energy production and distribution systems and HVAC machine settings.
- **Data frequency** varies from 1 to 15 minutes.
- Data is **stored** in a BEMS solution **on the cloud**.
- **RES production** from a local PV plant installed can be consulted and downloaded via a web portal or API with variable frequency (daily, weekly, monthly, or yearly).
- **Access to data** is available through a web portal, and data can be downloaded in CSV and XLS formats
- **Weather** public data



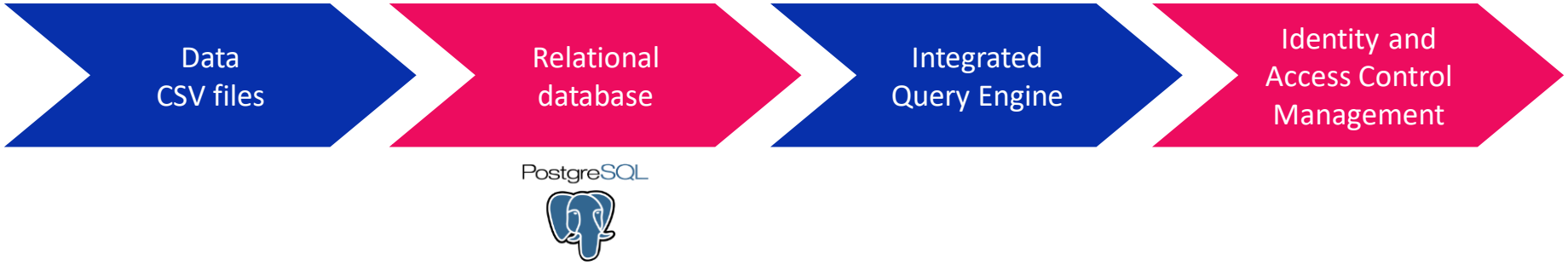







The Key Components

Connections and Integration with BD4NRG components:

- Data provided in **csv files**
- Stored to a **relational database** (PostgreSQL)
- Database integrated with the **Integrated Query Engine**, to facilitate efficient querying for BD4NRG platform users as well as BD4NRG Analytics services.
- Access control is performed through the **Identity and Access Control Management** component, which grants access to the requested resources after verifying that; the user is registered to BD4NRG platform and it has the appropriate permissions to access the requested resources

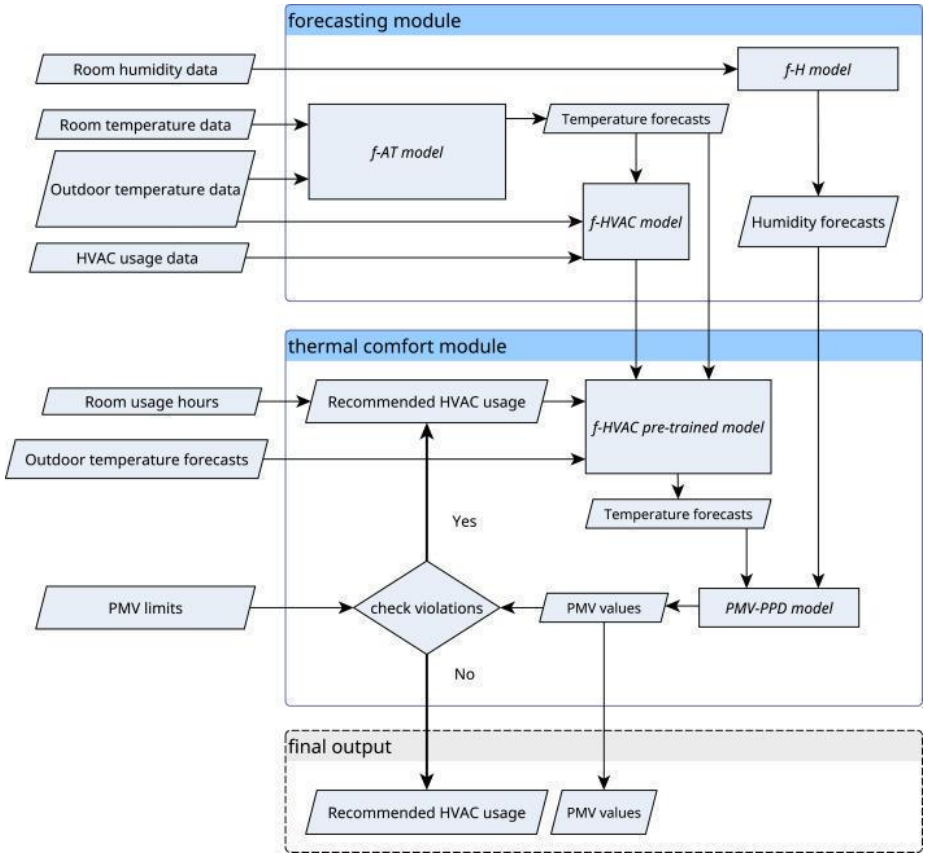


The Analytics Solutions

Analytics Service Implementation:

- This service implements a data-driven methodological framework that manages central HVAC systems in buildings with the objective to achieve thermal comfort with the minimum energy required and, as a result, simultaneously reduce greenhouse gas emissions.

- The service involves two modules,
  - **forecasting module**: the indoor air temperature and relative humidity are forecast using machine learning methods.
  - **thermal comfort module**: using the output of the other module, the PMV-PPD (Predicted Mean Vote - Predicted Percentage of Dissatisfied) model is used as a basis to predict the level of thermal comfort inside each room, identify possible violations, and suggest changes in HVAC operation

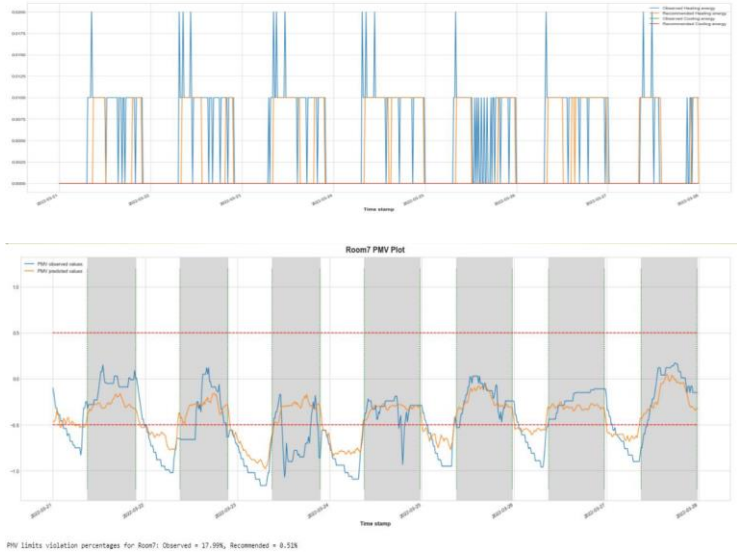


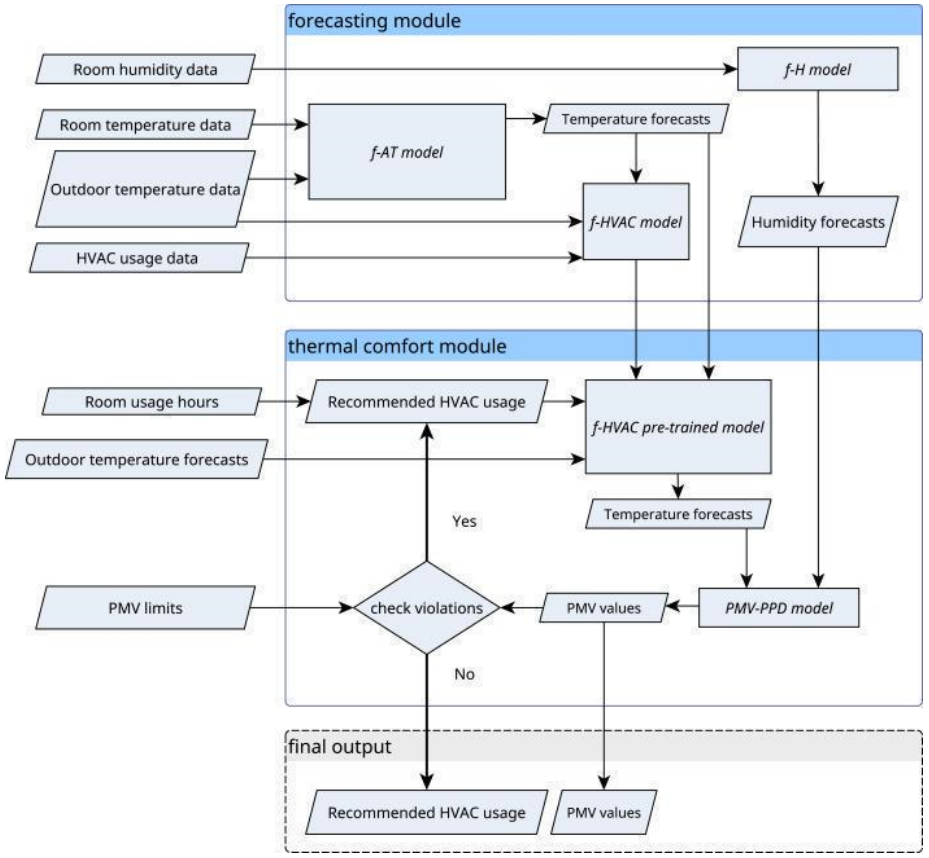
The Analytics Solutions

Analytics Service Implementation:

- The service provides a mechanism for rationally scheduling the operation of HVAC systems based on thermal comfort forecasts and user preferences and calculation of the PMV values.

Hour	Monday	Tuesday	...	Sunday
00:00	OFF	OFF	...	OFF
01:00	OFF	OFF	...	OFF
...	...	...	...	...
11:00	LOW	HIGH	...	OFF
12:00	LOW	HIGH	...	OFF
13:00	HIGH	HIGH	...	LOW
...	...	...	...	...
22:00	OFF	OFF	...	OFF
23:00	OFF	OFF	...	OFF

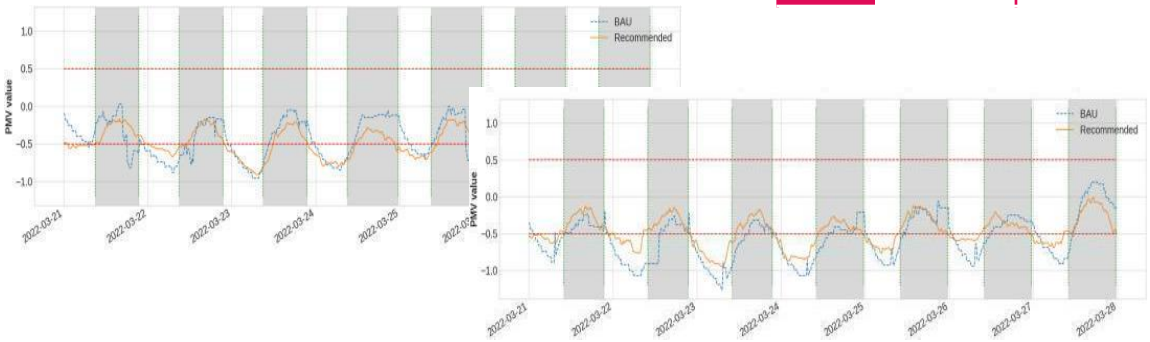




The Results (Building 1)

Building 1:
Mira-Sol Civic Center

Room No.	BAU	Proposal
1	0.00%	0.51%
2	5.14%	16.71%
3	4.11%	6.17%
4	0.00%	0.00%
5	1.54%	1.54%
6	1.94%	2.77%
7	0.51%	0.51%
8	0.00%	0.00%
9	0.00%	0.00%
10	0.00%	0.00%

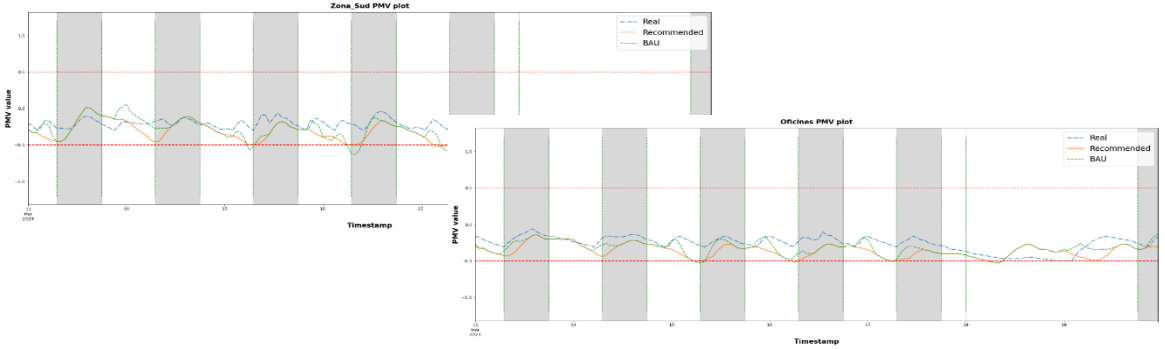


- Under the BAU schedule the number of violations is similar or lower than the recommended schedule for four of the rooms, being however the same for the remaining six.
- While the HVAC system currently operates most of the occupancy hours, the proposed approach tries to achieve thermal comfort using the minimum amount of energy
- By computing the total energy consumed by the HVAC system for each schedule across the test set, we find that our recommendations reduced energy consumption by 69% (3.800 MWh versus 1.160 MWh).

The Results (Building 2)

Building 2:
Pins del Vallès School

Zone Name	BAU	Proposal
Zona Nord	51.52%	28.79%
Zona Sud	10.61%	0.00%
Oficines	3.03%	0.00%
Gimnàs	24.24%	0.00%



- Under the BAU schedule the number of violations is higher than the recommended operation of the heating system.
- By computing the total energy consumed by the heating system for each schedule across the test set, we find that our recommendations reduced energy consumption by 49% (from 3.766 kWh to 1.918 kWh).

The Results (Specific KPI)

KPI	Baseline	Target	Progress
B05: Building comfort conditions	1.32% 22.35%	<20%	Theoretical reduction of comfort violations of 2.82% and 7.19%
11101: Energy Savings from Thermal Comfort Actions/ Measures	114 kWh per working day (spring period)	Up to 10% reduction	Theoretical reduction of 69% and 49%
11102: Energy Efficiency Measures Proposed	0 (#)	>0	1
11103: Number of Buildings Involved	1 (#)	3	2

The Aftermath

- **Operational impact:** Weekly monitoring of HVAC operating load, energy demand forecasts, and energy storage is crucial for proper functioning. Preparing operating hours requires real and predicted data, with communication between users and energy managers. Technicalization of the system requires management and maintenance.
- **Technical impact:** The pilot tested current sensors, energy meters, and BEMS system in two installations. Scaling sensorization in buildings is needed, and BEMS systems are essential for improvement. Monitoring data is crucial for building managers.
- **Business impact:** As a City Council, it can be said that the initial impact is to be able to guarantee, with sensors and BEMS, the thermal comfort of the building's users. The added value that BD4NRG provides is that it also allows for more accurate and advanced expenditure forecast over time. In terms of the impact of the business on third parties, this new way of managing on the part of the building managers and contracted companies offers a know-how that allows them to expand the service they provide, with higher quality and more efficient.
- **Next steps:**
  - Develop an friendly interface for users and the maintenance service company.
  - Use the BD4NRG toolbox for other municipal buildings that are currently monitored.
  - Include real-time datasets into the service.
  - Add new datasets (energy price, new sensors and meters,…)

Thank you!

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