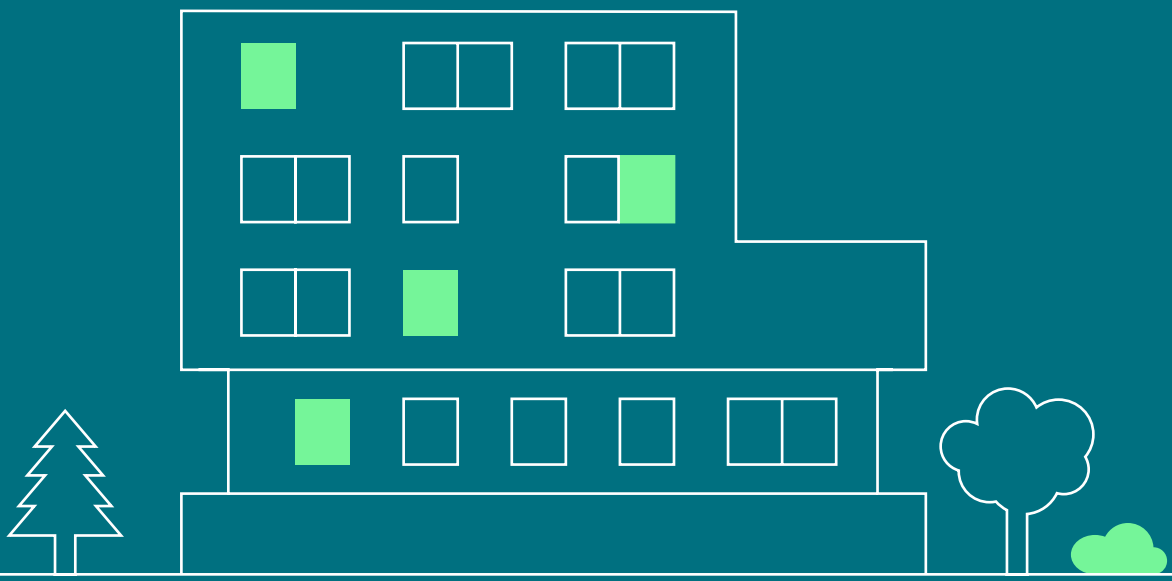
Investing in HVAC Buildings Automation & Control Systems to save energy and reach Europe's decarbonization targets



Danfoss Climate Solutions Public & Industry Affairs, March 2025

Executive Summary

Buildings significantly impact our quality of life and, as they account for 40% of the EU's final energy use, also shape our economy and environment. For these reasons, the newly adopted EU Energy Performance of Buildings Directive sets targets to renovate existing structures, enhance new construction quality, and accelerate technology deployment.

This paper highlights how to achieve these goals in the most cost-effective way, turning compliance into a massive opportunity to save energy and costs by optimizing heating and cooling with Building Automation and Control Systems (heating, ventilation and cooling controls are called "HVAC BACS" in this document). In particular, three main findings stand out:

1

The upgrade of HVAC BACS performance can deliver **between 15% and 38% energy savings** and achieve a return on investment within **1 to 3 years**. This should always be the first step due to its high cost-effectiveness, paving the way for further measures.

2

Investing in **HVAC BACS improves** - on average - the **Energy Performance Certificate** by **1.0 class** for residential buildings and by **1.3 classes** for non-residential buildings, thereby increasing the commercial value of the building, improving health and comfort, and reducing energy bills.

3

HVAC BACS alone **can deliver the savings necessary to comply with the EPBD's** Minimum Energy Performance Standards (MEPS) across Europe.

Why we must prioritize the energy renovation of buildings

Buildings are an essential element in our society; after all **we spend** an average of **85-90% of our time indoors** at home, in school, at work, or during leisure time.

Moreover, **buildings account for** 40% of final energy consumption in the European Union and **36 % of** its **energy-related greenhouse gas emissions**. Strikingly, 75% of the EU buildings are still energy inefficient[1].

Investing in **the renovation of buildings allows us to reach several objectives**: improving our **quality of life, saving money**, making progress in the **fight against climate change** and **reducing energy price hikes** associated with our dependence on energy imports especially affecting low-income families.

[1] https://ec.europa.eu/commission/presscorner/detail/en/ip_24_1965

Accelerating renovation: the Energy Performance of Buildings Directive

In its latest iteration, adopted in 2024, the Energy Performance of Buildings Directive (EPBD) represents the **most impactful piece of EU legislation for buildings renovation** and energy efficiency in new constructions.

Among several provisions, it introduces the obligation to renovate buildings following National **Building Renovation Plans** (NBRPs) in accordance with **Minimum Energy Performance Standards** (MEPS). The long-term ambition is to transform the existing building stock into Zero Energy Buildings (ZEBs) by 2050.

MEPS are the cornerstone of the Directive to accelerate renovation. They set minimum efficiency requirements for residential and non-residential buildings, starting as early as 2026 for some building types[2]. Achieving MEPS can be simple, cost-effective, and good for people and the planet. This paper explains the crucial role of BACS in that respect.

[2] Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings, see article 9

Building Automation and Control Systems: the brain of our buildings

Building Automation and Control Systems (BACS) are the products and solutions that **monitor and automatically adjust energy consumption in buildings** to deliver a comfortable environment while optimizing the energy use.

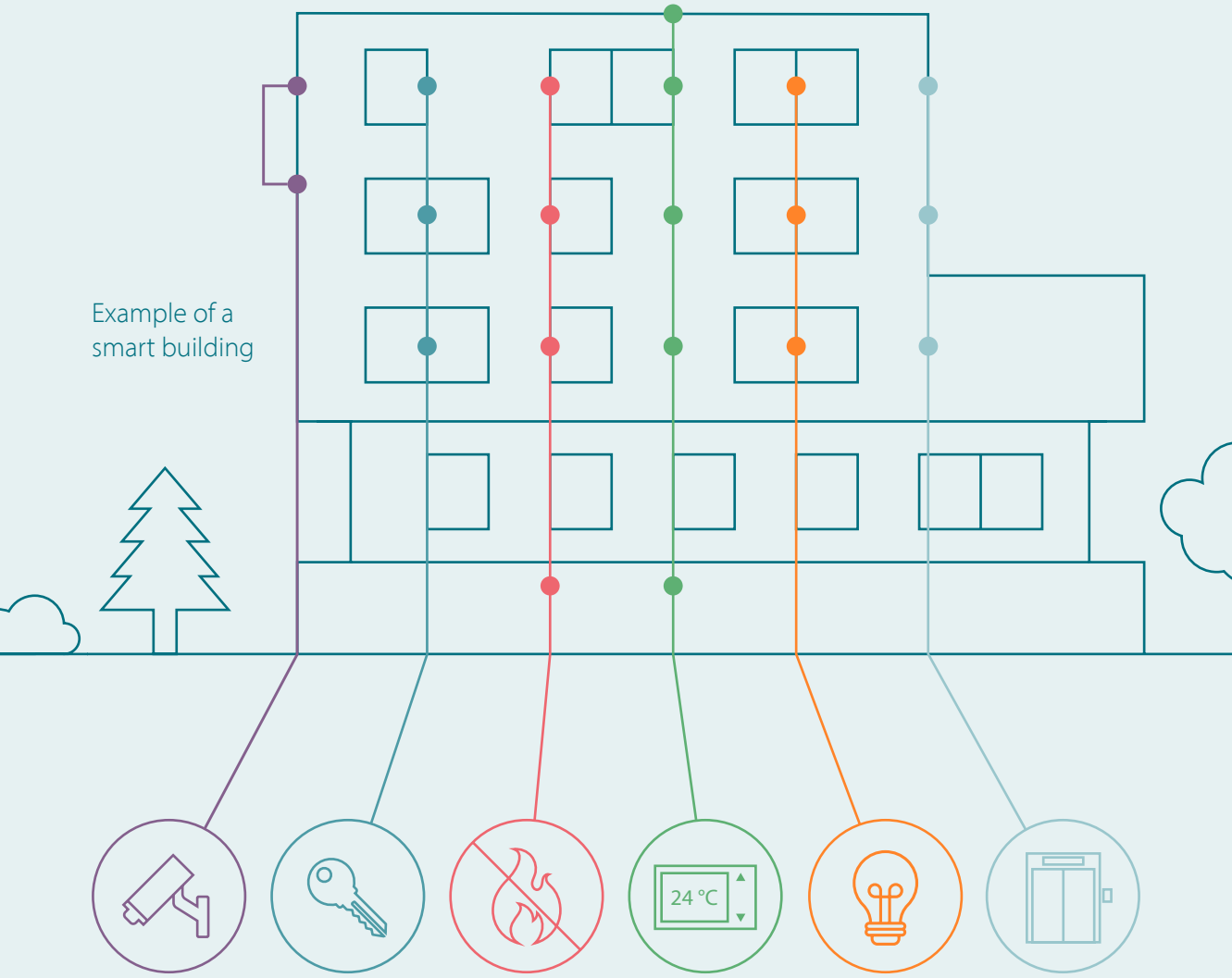
Solutions can range from self-regulating radiators valves, thermostats for heating and cooling to advanced management systems in large buildings controlling ventilation, lighting, shading, etc.

BACS can be considered the "brain" of the building, significantly **increasing overall building efficiency while optimizing** specific **technical building systems** and services.

Moreover, **BACS make buildings "smart" and future-proof**, in particular by equipping them to **interact with an advanced energy system** that increasingly relies on demand response mechanisms, consumption prediction and energy storage.

Finally, data collected by BACS can be stored and shared with building managers enabling cloud-based analytics, reporting and services.

Example of a smart building



Closed circuit camera system

Access control systems (badges and door locks)

Fire annunciation and suppression

Heating, ventilation and air condition control systems

Power/lighting control system

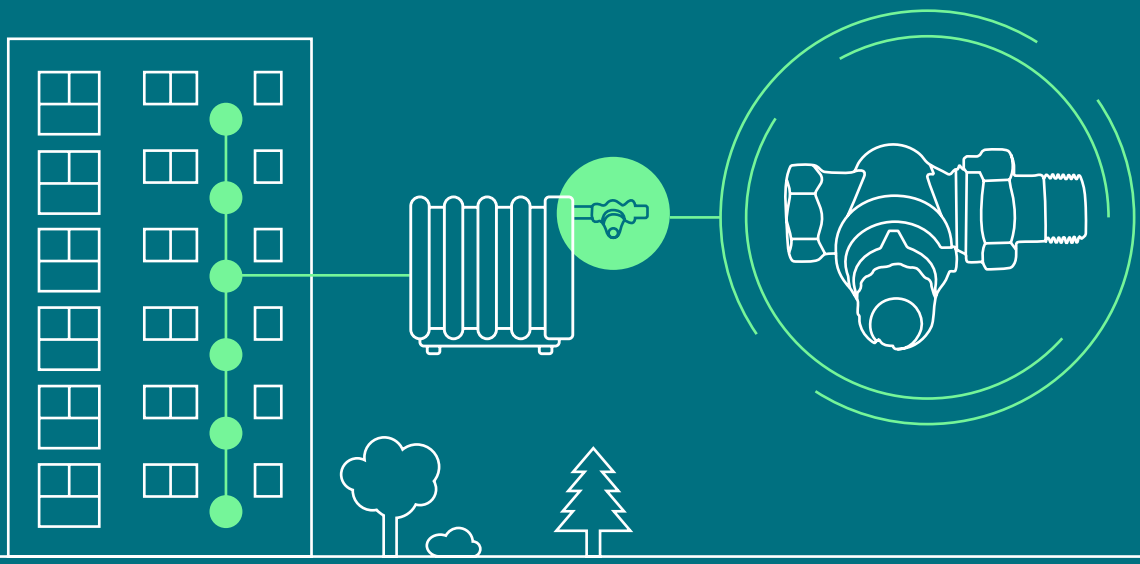
Elevator control system

HVAC BACS:
efficient heating and cooling

HVAC (Heating, Ventilation, and Air Conditioning) BACS are an **integrated system that utilizes sensors, controllers, and software to automatically monitor and regulate the indoor environment, optimizing energy efficiency, occupant comfort, and system performance**. These comprise thermostatic radiator valves, control valves for air-based heating & cooling systems (common in tertiary buildings), smart thermostats for room temperature control and dynamic balancing valves for hydronic circuits.

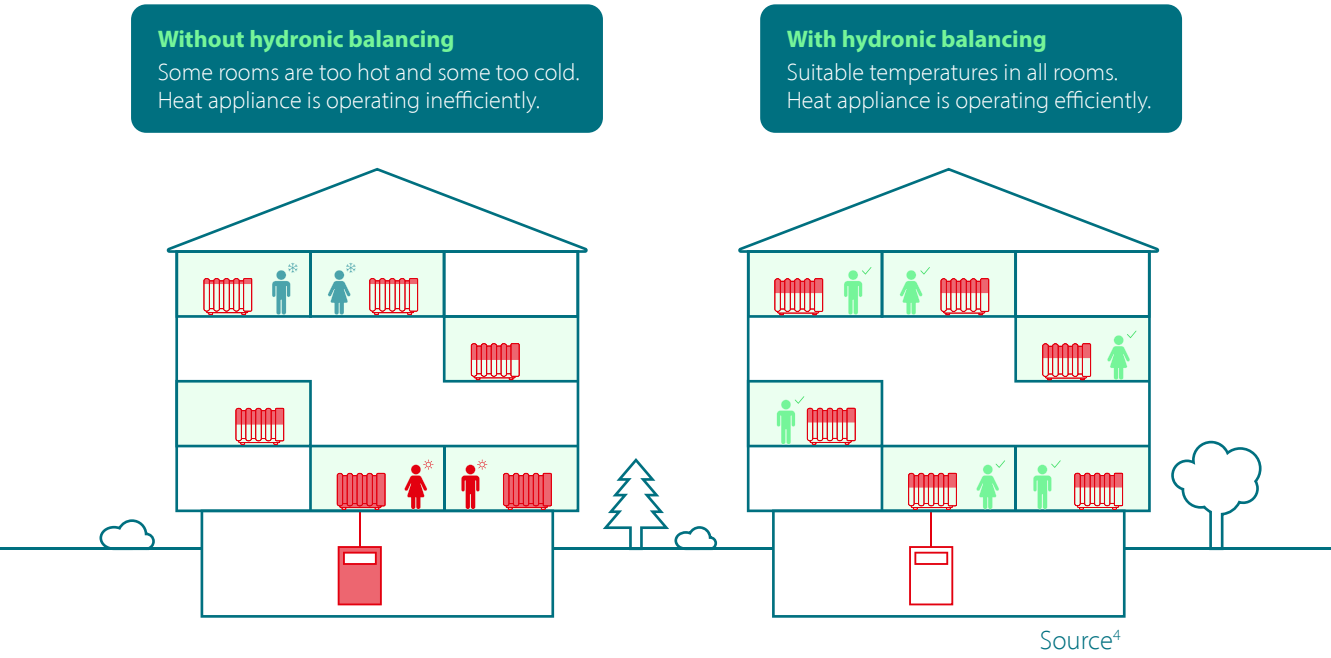
Thermostatic radiator valves maintain the desired temperatures for optimal comfort, room by room. By optimizing the functioning of the heating system, significant savings can be realized – for example, up to 46% with electronic self-balancing thermostatic valves replacing manual valves[3] on radiators.

[3] Rainer Hirschberg, "Energy efficiency related to the change of thermostatic radiator valves"



Dynamic hydronic balancing ensures optimal flow distribution in a heating or cooling system, meaning that the right amount of hot or chilled water is available at terminal units (e.g. radiators or air conditioning units), according to demand. This allows the system to operate at partial load, minimizing energy production and water pumping.

Conversely, buildings with an unbalanced system, still very common in the EU, suffer from insufficient heating (or cooling) in the rooms more distant from the generator. This is compensated by over sizing the generator, running the water pumping system at full load, and more generally wasting a lot of energy in an attempt to ensure user comfort.



Source[4]

- Multifamily housing with radiator heating typically **saves between 6 and 16 kWh/m²** on thermal energy consumption.
- The highest savings are achieved with dynamic balancing.
- Payback time is below 3,5-4 years.

- Studies suggest **energy savings between 11% and 22%** in space heating when **hydronic balancing** is replacing traditional TRVs

Moreover, **HVAC system can be further optimized** with **AI-driven technology** to lower energy consumption and operational expenses, and even using buildings as virtual heat storages. Digital solutions typically integrate weather forecasts, heating system data, energy tariffs, and other signals to optimize heating offering real-time control.

[4] EUBAC, System balancing for technical building systems : a great opportunity for energy savings and comfort, 2021 https://eubac.org/wp-content/uploads/2021/03/20210322_eubac_System_Balancing_for_TBS.pdf

HVAC BACS as the most cost-effective solution for building renovation

Investing in performing HVAC BACS in line with requirements of the EPBD (e.g. temperature control plus balancing), is a **very cost-effective option** to accelerate the renovation of buildings in the EU. Moreover, this **increases their market value** and unlocks all the benefits associated with energy efficiency, namely **lower energy bills, health and comfort**.

The figures in the table indicate that upgrading HVAC BACS, for example, by installing a smart thermostat connected to thermostatic and dynamic balancing valves, delivers the savings needed to comply with the EPBD targets at a limited cost.

According to a recent study[5], costs for upgrading to an energy efficient HVAC BACS range from 3,5 to 6,5 €/sqm, depending on the building typology.

Sector	Building type	[€/sqm]
Non-residental	Offices	5,0
	Trade	5,0
	Education	3,5
	Health	3,5
	Hotels and Restaurants	3,5
	Others	5,0
Residental	Single family – Terraced houses	6,5
	Multifamily houses	5,0
	Apartment blocks	5,0

TABLE 1: Cost for renovating HVAC BACS in selected buildings

[5] Politecnico di Milano, "Building Automation and Control Systems impact on EPC classes in Europe", July 2024 https://eubac.org/news/webinar-recap-unlocking-epc-gains-with-building-automation-and-control-systems-bacs/

To put this into perspective: in an average flat (class F, 110m^2), as commonly found in social housing, upgrading HVAC BACS would deliver roughly 25% energy savings while ensuring compliance with the EPBD. Assuming an average EU gas price of 0.4 €/m^3 in 2025, this would translate into a return of investment of less than 1 year. By means of comparison, the deep renovation of such a flat, leading to energy efficiency improvements of up to 80% would require investments of approximately 45,000 €.

In summary, the very first step of any renovation should always be dedicated to BACS as "low hanging fruits", to achieve quick improvements. In addition, BACS support and facilitate the transition to heat pumps by ensuring that they can deliver on their full potential.

System	Investment
Thermal envelope	27.000 €
Efficient windows	18.000 €
Heat pump installation	7.000 €
Condensing boiler installation	3.000 €
Photovoltaic panels	3.700 €

TABLE 2: average cost of selected energy efficiency technologies for a 110sqm flat

HVAC BACS are the most cost-competitive solution to deliver on the EPBD Minimum Energy Performance Standards

Buildings in the lowest energy efficiency class (E, F, G) account for the largest share of all buildings in all EU Member States, i.e. they represent the largest potential for renovation, benefitting the most from cost-effective improvements.

HVAC BACS alone, if upgraded to high-performing systems, can deliver the savings necessary to comply with the EPBD Minimum Energy Performance Standards across Europe[6], including in buildings in the lowest energy-efficiency class.

Furthermore, **investing in HVAC BACS will improve the Energy Performance Certificate, on average, by 1.0 class for residential buildings, and by 1.3 classes for non-residential buildings.**

This enhances the market value of property and improves access to both public financing and private credit, such as more favorable loan rates. For example, research on the Italian real estate market indicates that the most energy-efficient houses sell at a 25% premium compared to the least efficient ones.[7]

[6] Politecnico di Milano, note 4, see pages 27-30 for an estimation of costs
[7] Banca d'Italia, "The capitalization of energy labels into house prices. Evidence from Italy", 2023 https://www.bancaditalia.it/pubblicazioni/qef/2023-0818/QEF_818_23.pdf

Final considerations: BACS multiplier effect

Upgrading HVAC building automation and control systems a triple benefit:

1. **achieve compliance in the most cost-effective way.**
2. **maximize investments.**
3. **improve quality of life.**

Given the short payback time of these technologies, significant net economic savings are realized within 3 to 4 years since the first intervention. This unlocks private financing that can be reinvested in other renovation technologies with a higher capital investment cost. A positive renovation cycle can be initiated by starting with simpler interventions and focusing on a staged approach to the renovation.

Moreover, well-performing, efficient heating and cooling reduce energy poverty and contribute to a healthier indoor environment. Several studies confirm the strong correlation between efficient buildings and lower healthcare costs. For example, a 2023 study based on healthcare bills of 5,8 million households in the Netherlands, revealed a 5% increase in healthcare costs for low-income households living in poorly performing houses.

[8] "The correlation between energy efficiency and health", EED Concerted Action, Eileen O'Connor et al., 2024 www.ca-eed.eu/ia-document/energy-renovation-energy-poverty-and-health/

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