Ref. Ares(2022)8967525 - 23/12/2022

COLLECTiEF

MARKET AND STAKEHOLDER ANALYSIS

Project acronym: COLLECTiEF

Project title: Collective Intelligence for Energy Flexibility

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

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

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Project no.	101033683
Project acronym:	COLLECTiEF
Project title:	Collective Intelligence for Energy Flexibility
Call:	H2020-LC-SC3-2018-2019-2020
Start date of project:	01.06.2021
Duration:	48 months
Deliverable title:	Market and stakeholder analysis
Deliverable No.:	D6.1
Document Version:	6.1
Due date of deliverable:	30.11.2022
Actual date of submission:	23.12.2022
Deliverable Lead Partner:	Partner No. 5, R2M SOLUTION SRL (R2M)
Work Package:	6
No of Pages:	60
Keywords:	Market analysis, BACS, Energy flexibility markets, State of the Art, Competitors, Stakeholders, PESTEL.

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

Dissemination level

PU	Public

History

Version	Date	Reason	Revised by
1.0	01.06.2022	First draft, TOC, description of sections	Marco Pietrobon, Ignacio Torrens (R2M)
1.1	11.06.2022	Initial TOC agreement/review	Jelena Lazic, (GEO)
2	10.10.2022	Second version	Ignacio Torrens (R2M)
3	20.11.2022	Third version	Ignacio Torrens, Marco Pietrobon Bishnu Babu (R2M)
4	05.12.2022	Fourth version	Ignacio Torrens, Marco Pietrobon Bishnu Babu (R2M)
4.1	12.12.2022	Internal review	Christian Johansson (NODA)
5.0	19.12.2022	Fifth version	Ignacio Torrens (R2M)
5.1	21.12.2022	Review before final version and document approval	Christian Johansson (NODA)
6.0	22.12.2022	Final version	Ignacio Torrens (R2M)
6.1	22.12.2022	Final approval	Mohammadreza Aghaei (NTNU)

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Executive Summary

COLLECTiEF is a Horizon 2020 project implementing an interoperable and scalable energy management system to smart up buildings and their legacy equipment on large scale.

This report (D6.1 “Market and stakeholder analysis”) of Work Package 6 (WP6) of the COLLECTiEF project is the first deliverable of the exploitation work package. Its main purpose is the identification of external market conditions related to business opportunities for the COLLECTiEF solutions and boundary conditions for market uptake of the project’s foreground. More in detail, it assesses and analyses the relevant market structures, trends actors and current solutions in target fields such as building automation and controls, smart homes, smart metering, and user interfaces.

The document is structured as follows:

Section 1 – contains an overview of this document, providing its introductory elements (i.e., the partner contributions, intentions, and next steps within COLLECTiEF to carry forward the work).

Section 2 – provides an overview of the key characteristics of the COLLECTiEF solutions, including how this solution relates to the concept of the Grid-Interactive Energy Building.

Section 3 – provides a state-of-the-art of market trends and conditions, focusing on global and European perspectives, with the key characteristics of the COLLECTiEF solution as starting point.

Section 4 – presents a BACS market analysis, evaluating the market readiness for COLLECTiEF solutions.

Section 5 – explores and assesses the potential customer segments of the COLLECTiEF solutions, this segmentation analysis helps prioritize and design the communication/marketing strategy to reach target customers.

Section 6 – focuses on key stakeholders for COLLECTiEF solutions, identifies their preferences and evaluates in a power-interest matrix their influence within the market and society.

Section 7 – summarizes sales channels and the key actors for COLLECTiEF solutions, identifies the primary sales channels to the market used by BACS manufacturers including direct and indirect sales.

Section 8 – this chapter identifies comparable solutions in the market that are “leading the way” The products behind these success stories are assessed in key categories.

Section 9 – this chapter concludes the findings in the report, and provides a summary of the conclusion made during the report creation.

The comprehensive market analysis of the present deliverable will serve to inform and strengthen the whole exploitation process and to establish robust baselines for the next steps of the exploitation process, such as definition of exploitable results, IPR protection and the agreements between partners, and the updates of the analysis on the exploitable results and on the business models and business cases suitable to resultant COLLECTiEF solutions.

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Table of Contents

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List of Acronyms

BA	Building Automation
BACS	Building Automation and Control System
BAT	Building Automation Technologies
BAU	Business as Usual
BC	Base Case
BEMS	Building Energy Management System
BMS	Building Management System
BRP	Balancing Responsible Party
B2B	Business to Business
B2B2C	Business to Business to Customer
B2C	Business to Customer
CI	Collective Intelligence
D	Deliverable
DIY	Do-it-Yourself
DSF	Demand Side Flexibility
DSO	Distribution System Operator
EC	European Commission
EED	Energy Efficiency Directive
EPBD	Energy Performance of Buildings Directive
ER	Exploitable Result
ESCO	Energy Service COmpany
EU	European Union
EV	Electric Vehicle
GA	Grant Agreement
GDP	Gross Domestic Product
GHG	Green House Gas
GIB	Grid Interactive energy Building
HMS	Home Management System
HVAC	Heating Ventilation and Air Conditioning
ICT	Information and Communication Technology
KPIs	Key Performance Indicators
LTRS	Long-term renovation strategies
nZEB	near Zero Energy Building
Partner	The beneficiary in the COLLECTiEF Project
PEB	Positive Energy Building
PESTLE	Political, Economic, Social, Technological, Legal, and Environmental)
RED	Renewable Energy Directive
RES	Renewable Energy System
SDG	Sustainable Development Goal
TBS	Technical Building Systems
TRL	Technology Readiness Level
TSO	Transmission System Operator
UN	United Nations
UK	United Kingdom
USA	United States of America
WP	Work Package
ZEB	Zero Energy Building

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List of Figures

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

List of tables

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1. Introduction

1.1 WP6 Overview - Roadmap of Exploitation activities

The COLLECTiEF consortium will 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.

Work Package (WP) 6: "*Exploitation of results and Business models*" leads the exploitation of the project, developing its business models and managing the intellectual property arising from it. Figure 1 presents the tasks structure of WP6 and the main aspects and decisions covered. All partners of the consortium contribute to it.

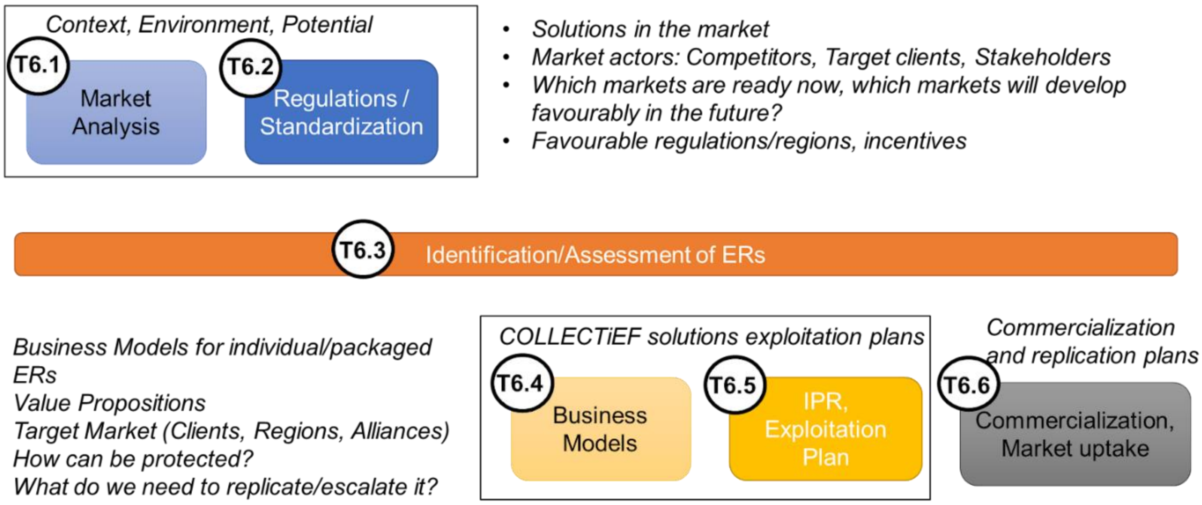

Figure 1. Structure of the Exploitation work package and its tasks

1.2 Market and stakeholder analysis

Task 6.1 assesses and analyses the relevant market structures, trends, and players in the fields of systems and solutions for building automation and controls.

The goal of this deliverable, D6.1, in line with its corresponding task is to identify and analyse the target market for the COLLECTiEF solution, who are the stakeholders and their different roles, identify potential customers and relevant competitors already participating in the market. For this, as a starting point the different core characteristics and added value of the COLLECTiEF solution are discussed in a market context.

In summary, this deliverable fulfils the following objectives:

- Perform market research of COLLECTiEF's sector/areas of influence
- Identify COLLECTiEF's ecosystem (regulation, technology, potential future...) in order to narrow down the areas of influence to the ones that COLLECTiEF has more potential to impact (i.e., target market)

- Identify potential customers and relevant stakeholders in this ecosystem - This will influence COLLECTiEF's marketing, communication, and advocacy strategies
- Perform a desk study of (successful) competitors in the potential target market - This will influence COLLECTiEF's development of solutions, exploitation and marketing strategies

This deliverable D6.1 is complemented by D6.2: "*Analysis of regulatory framework and standardization needs*" giving the COLLECTiEF project a full picture of the market environment.

1.3 Structure of the document

The document is structured as follows:

Section 1 – contains an overview of this document, providing its introductory elements (i.e., the partner contributions, intentions, and next steps within COLLECTiEF to carry forward the work).

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2. Key characteristics of the COLLECTiEF solution

2.1 Overview

COLLECTiEF is developing and testing 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. This is done through developing software and hardware packages to install and smart up buildings and their legacy equipment on a large scale, meanwhile, to maintain simple and robust communication with the energy grid.

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COLLECTiEF promises an energy management system for buildings, capable of creating an intelligent collaborative network (within the building, between buildings and with the electric grid). The result will be a user-centred platform controlling technical building systems that improves building performance. In short, the COLLECTiEF solution will focus on the following characteristics, see Figure 2.

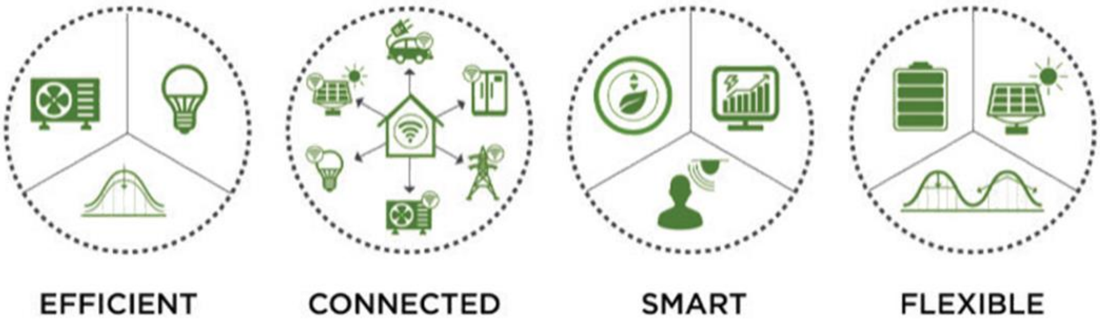

Figure 2. Key characteristics of COLLECTiEF (source: U.S. DOE Grid-interactive Efficient Buildings 2019 [1])

2.2 Efficiency

The most important element of any BEMS is the efficient operation of building systems, reducing therefore the building load. COLLECTiEF aims to enhance energy flexibility and resilience in urban areas, using open-source components and cost-effective equipment available on the market.

2.3 Connectivity

There has been a transition in the role that buildings have, a transition that it is still in process. Traditionally buildings have represented loads in a unidirectional electricity grid. With the adoption of decentralized renewable generation and improvement in technology such as smart metering and actuators, IoT, cloud applications, etc. the relationship between buildings and the grid has changed to include the potential for a more bidirectional interaction. Two-way communication flow between buildings and external entities (EVs, RE systems, smart appliances, grid, HVAC) offers a much greater potential for energy efficiency, energy flexibility and to achieve user-centred solutions. The trade-off is an increase in complexity for BEMS as well as added requirements for distributed communication and computational capacity.

2.4 Smartness

COLLECTiEF solutions will not only enable energy management with intelligent building systems and appliances, but it will also develop software and hardware packages to smart up different types of buildings and their legacy equipment on a large scale. Thus, allowing maximum interoperability and integration of legacy equipment with new solutions, ultimately driving the smartization of buildings.

2.5 Flexibility

COLLECTiEF aims to create user-centred, flexible energy management. Building operations are optimized for the needs of the occupants and external stimulus (grid signals and tariffs, weather conditions, etc.) enabling Demand response availability to offset, shift or flatten building loads.

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3. State of the art analysis

As presented in Section 2, COLLECTiEF is built on the concept of creating 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.

Building Automation (BA), Building Automation Technologies (BAT) or Building Automated Control Systems (BACS) are equivalent terms to refer to Home and Building Energy Management Systems (HEMS/BEMS). These technologies have traditionally focused on HVAC systems with different levels of complexity and integration between building systems and services. BEMS have shown that they are among some of the most cost-optimal measures to produce economically viable energy savings [2]. In general, the main benefit of BACS was energy efficiency (energy savings), also offering other functionalities for specific applications like advanced monitoring and reporting, fault detection and diagnosis, etc [3].

This section presents a market analysis of BACS, evaluating the most significant market forces and trends impacting these products, identifying the political and industrial European context and describing the state of the art in BACS technology and solutions. This state-of-the-art qualification of current market trends using a PESTLE format. The PESTLE (political, economic, social, technological, legal, and environmental) methodology has been applied to give a deep overview of the different conditions in the considered market, with particular focus on impact domains for COLLECTiEF such as Energy Management, Energy Efficiency and Energy Flexibility, Building smartization. However, other aspects which aren’t directly related to these ones but are still relevant might also be addressed.

It’s important to note that a detailed analysis of policy/regulatory aspects will be presented more in detail in deliverable D6.2: “*Analysis of regulatory framework and standardization needs* “. In this section, some key relevant aspects of EU policy are identified and briefly described to simply give an overview and complete the PESTLE analysis with all its perspectives.

The following schematic figure advances some of the most significant topics identified and discussed more in detail in the PESTLE analysis, which is focusing on the context of the European Union, see Figure 3.

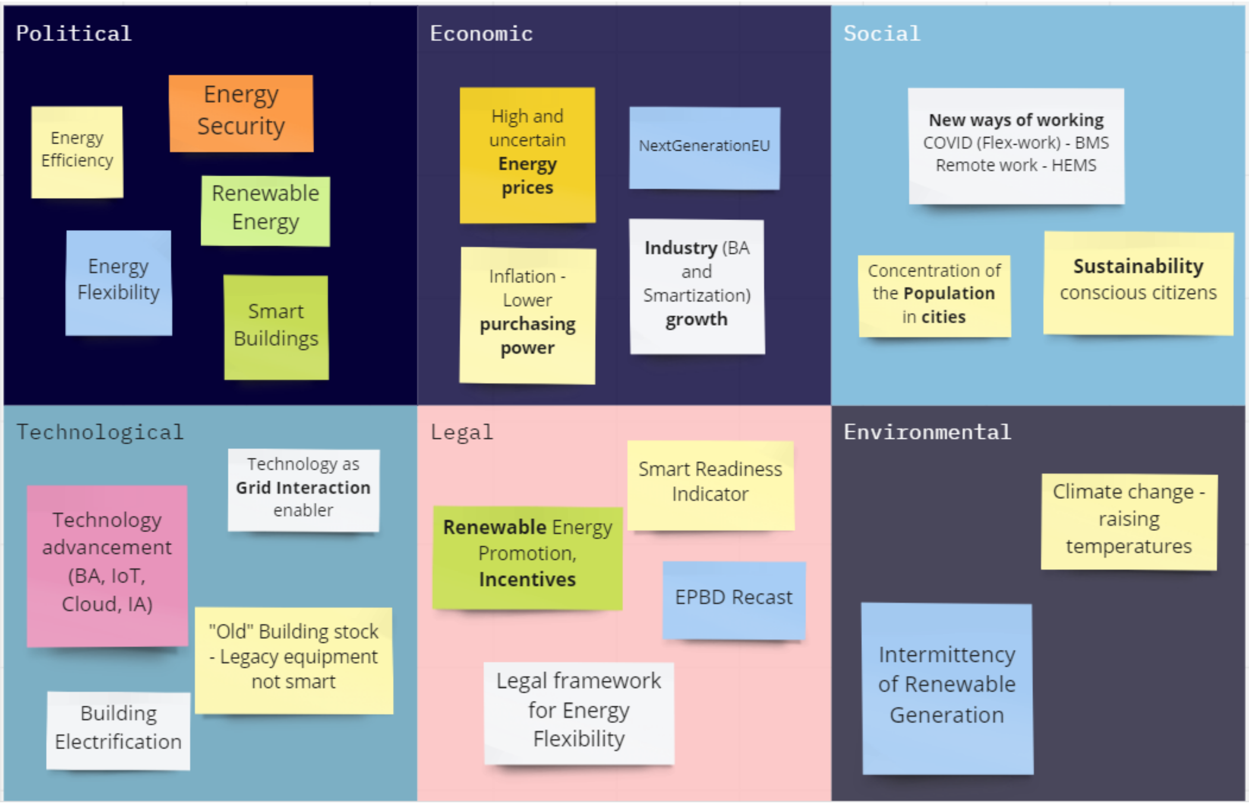

Figure 3. Summary of key topics of the PESTLE Analysis.

Political and Legal

As stated before, these aspects will be covered in detail in D6.2: "*Analysis of regulatory framework and standardization needs* ". For the purpose of having a complete overview of the market environment, this document also addresses the political and legal perspectives, combining them to give a brief understanding of current policy trends and their translation into European and EU member states laws. D6.2 will cover a more in-depth analysis of these two aspects.

The global economy aims to achieve net zero CO2 emissions by 2050, complying with the Paris Agreement goal of keeping global temperature rise to well below 2°C. A significant number of countries and organisations have committed to a net zero goal, including for the buildings sector (e.g., through the Race to Zero, Science-based target initiative, Zero Carbon Buildings for all, CEM GlobalABC, Buildings as Critical Climate Solution, etc.), although the scope and details vary [4]

Carbon emissions from operations in buildings account for around 27% of global energy-related emissions, and this figure increases to around 40% if the emissions related to the manufacturing of building materials are considered.

In its report, Net Zero by 2050 [5]: A Roadmap for the Global Energy Sector, the IEA recently illustrated the implications that meeting these ambitions would have for the global economy and the buildings sector alike. Figure 4 shows a possible pathway towards net zero emissions for the buildings sector by 2050 [6].

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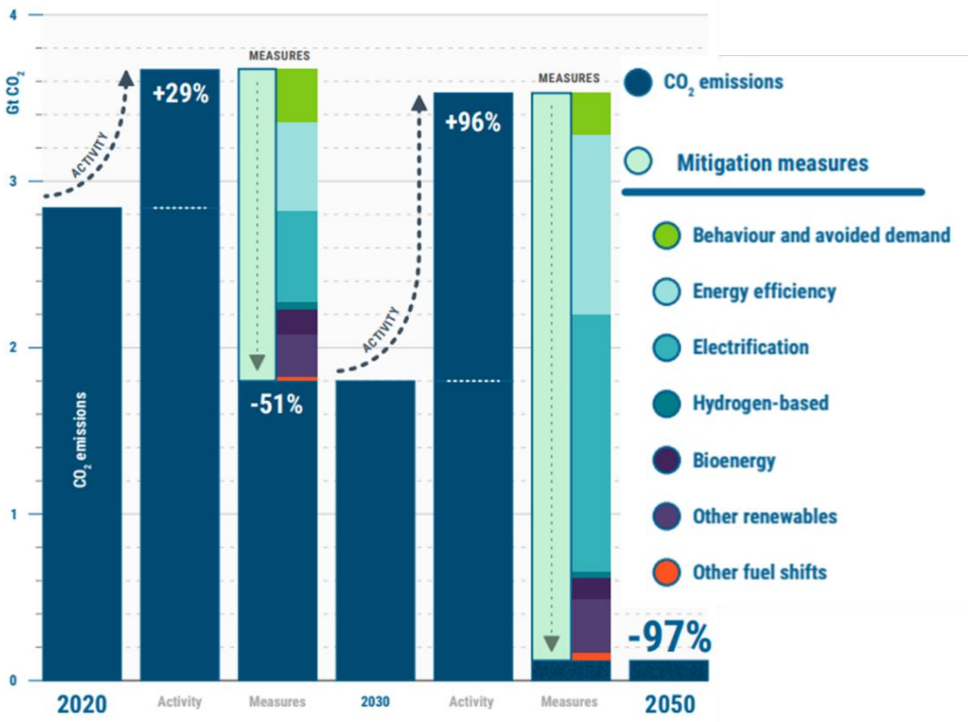

Figure 4. Global direct CO2 emission reductions by mitigation in building in the net zero energy scenario 2050 (Sources: IEA 2021)

The net zero energy analysis of the buildings sector shows that although building activity more than doubles by 2050 (more floor area, more access to energy services and higher living standards), energy demand is reduced (behaviour change, energy efficiency) and electrification, renewable generation and other heating technologies allow nearly eliminate carbon emissions from building sector operations by 2050.

This pathway would indicate that **Electrification** and **energy efficiency** account for nearly 70% of buildings-related emissions reductions through to 2050, followed by solar thermal, bioenergy and behaviour.

The GlobalABC global and regional roadmaps [7] outline eight categories (urban planning, new buildings, existing buildings, operations, systems, materials, resilience, and clean energy) to decarbonize the buildings and construction sector. These roadmaps indicate the necessity for governments to put in place policy and technology measures supporting these categories. For the purpose of this report, Figure 5 displays the target category of COLLECTiEF, Building operation.

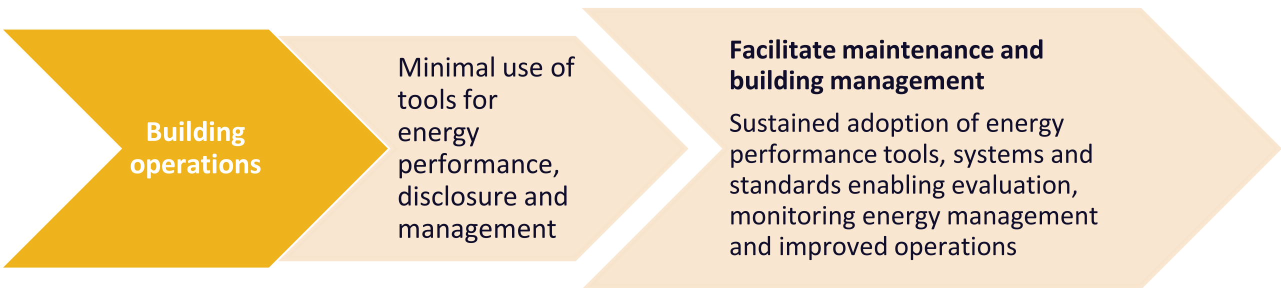

Figure 5. Regional decarbonization roadmaps: Building operations (extracted from key categories - GlobalABC)

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In this line, The European Union has set an interim 2030 climate target of reducing GHG emissions by at least 55% compared to 1990, and climate neutrality by 2050. For this, increasing the rate (3% annually, from the current 0.2%) and depth of building renovation will be key to reduce GHG emissions from buildings by 60% compared to 2015. [8]

EU Energy Union

The original overarching energy-policy framework in the European Union, established in 2015, is called the Energy Union. This framework is built on five pillars, as seen in Figure 6, providing EU citizens with secure, sustainable, competitive, and affordable energy.

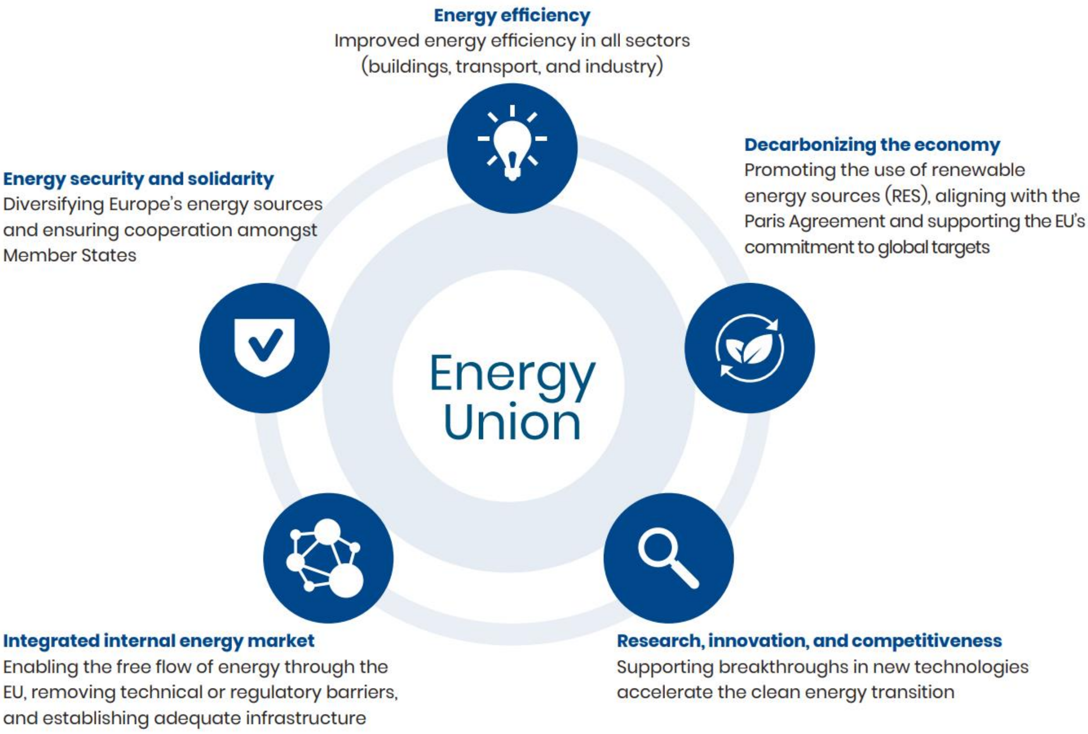

Figure 6. Energy Union 5 dimensions (source: European Commission)

Overview of European clean-energy governance and policymaking

The Energy Union strategy materialised into several key pieces of legislation, initiatives, and policy packages. The most important with regard to energy efficiency is the Clean Energy for All Europeans (Clean Energy) package, which was adopted in 2018. While the Clean Energy package comprises eight different pieces of legislation aimed at accelerating the energy transition in Europe, the main list of relevant directives and regulations for energy efficiency of buildings includes the Energy Performance of Buildings Directive (EPBD), the Energy Efficiency Directive (EED), the Renewable Energy Directive (RED), and the Regulation on Governance. [9]

Table 1 summarizes how these directives and regulations impact the topics of interest and impact for COLLECTiEF:

Table 1. Summary of most important EU directives and regulations impacting the buildings sector.

The Energy Efficiency Directive	Revised in 2018 - EED now sets an indicative EU-wide 32.5% non-binding energy-efficiency target for 2030
Energy Performance of Buildings Directive (EPBD)	Recast launched in 2021, to be adopted in 2023 - Sets a clear direction for the full decarbonization of Europe's building stock by 2050
National long-term renovation strategies (LTRS)	The EPBD requires member states to develop national LTRS
European Green Deal	The Green Deal covers health, transport, food, jobs and upskilling, and the economy. However, specific emphasis is placed on making a 'just transition to a zero-carbon building stock', which in turn leads to the Renovation Wave and associated initiatives
Fit for 55	EU communication released in July 2021 accompanied by a set of legislative proposals outlining how the EU will deliver its interim targeted 55% reduction of GHG emissions by 2030. Central to building energy performance, the Fit for 55 package is a recast of the EPBD
Renovation Wave	The Renovation Wave [11] highlights key areas of intervention to boost the renovation of buildings in the 2021-2024 period. The goal of the Renovation Wave is to help meet the 2030 climate target and to decarbonize the building sector through a wide range of policies, measures, and tools

EU policy has set ambitious goals for full, society-wide decarbonization of the built environment, aiming to reach climate neutrality by 2050. This goal is supported by EU Climate and Energy legislation and initiatives. Key aspects in these buildings policies and incentives are directly related with the COLLECTiEF's market space, the energy management of buildings. Some of the key related policies extracted from the Green Deal and Fit for 55, are:

- Monitoring and Benchmarking Energy Performance, disclosing it in building energy performance certificates.
- Public buildings must be ZEB by 2027, all buildings by 2030, making decentralized renewable generation a key aspect in the operation of buildings
- More ambitious energy efficiency improvements targets for buildings (from the previous 32.5% to 39%) required to all member states
- A revision to the renewable energy directive, where EU governments will have to increase the incentives and facilitate financing mechanisms for the promotion and adoption of renewable energy in buildings.

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- The inclusion of the Smart Readiness Indicator, valuing the "intelligence" of the building, connectivity, sensing and monitoring, energy management, etc.
- Empowering buildings as micro energy-hubs, enabling their interaction with the electric grid and facilitating their participation in cities as renewable energy producers, storage providers and demand response.

More specifically related to this last point, enabling Energy flexibility in buildings, the Energy Efficiency Directive of the EU, in particular in its Art. 15.8 [11] states:

- Member States shall ensure that national energy regulatory authorities encourage demand side resources, such as flexibility, to participate alongside supply in retail markets.
- Member States shall ensure that transmission system operators and distribution system operators, in meeting requirements for balancing and ancillary services, treat flexibility providers, including aggregators, in a non-discriminatory manner, on the basis of their technical capabilities

EU policies are reinforcing the crucial role of buildings in reaching climate neutrality by 2050. Net-zero buildings are achieved through **energy efficiency** first but clearly in interaction with the **electrical grid** and with the support of onsite **renewable generation**. The combination of these factors strengthens the need **for intelligent, collective, smart energy management systems** operating the buildings of the present and the future.

Economic

A number of megatrends are impacting the world economy [12] [13]. Impacting urban environments and buildings, the following trends can be perceived as of direct impact to COLLECTiEF:

Population growth, especially in developing countries, and its **concentration in urban environments**, as also mentioned in the *Social* perspective of this analysis. Not only higher % of the global population live in cities but humans increasingly spend more time indoors.

- *Greater global population means more residential/commercial/industrial buildings, associated to higher indoor comfort standards connected to health and productivity, and going hand to hand with the necessity of delivering healthy indoor environments at a minimum energy consumption/cost (energy efficiency and flexibility)*

The **wide spread of renewable energy generation** that is able to compete economically with fossil fuel-based electricity generation but that is inherently intermittent, a characteristic that is transforming the grid to be decentralised, interactive, collaborative, and intelligent.

- *Buildings will have an active role in a bi-directional electricity grid. Flexible buildings will be able to act as generation, storage and demand. A trend that is causing a gradual electrification* *of the building sector highlighting the need for more advanced building and home management systems (BMS and HMS).*

Digitalization and Disruptive technologies such as Artificial intelligence, IoT, big data are changing the volume access and affordability to performance data, and the capability to learn from this data to improve processes. This exponential growth of data accessibility and the capacity to manage it is enabling a more effective and inclusive interaction between energy generation, transmission, and demand.

- *Data acquisition, storage and management is now accessible to all buildings. Sensors, actuators, smart meters are slowly being adopted in the building sector. This unprecedent volume of performance data and new techniques to process it is starting to be leveraged by BACS.*

Investments for Energy Efficiency are driven in part by the renovation and refurbishment of existing buildings, for the most part replacing HVAC systems, followed by improvements or retrofits of building envelopes. This occurs either through direct investments by building owners, or through government policies using incentives and programmes. In major developing economies such as China, India and Southeast Asia, efficiency investments are mainly related to new construction, whereas refurbishment is the dominant activity in Europe and North America, where annual replacement of the building stock is low. COVID-19 recovery packages to rebuild economies have brought opportunities for deep building renovation and performance standards for newly constructed buildings. Stimulus programs for the building and construction sectors are a proven tool to respond to economic crises. They have large macroeconomic impacts, as many countries have a large need for new buildings and renovation of existing buildings, and because the sector has strong potential for activating local value chains. Incentives that compensate for a higher investment cost of green renovation or construction projects stimulate investments into green buildings. In exchange, a “green conditionality” sets the bar higher for buildings that receive support, through simple principles such as rewarding performance with higher financial incentives or basing funding decisions on project certification and labelling. Figure 7 below provides a snapshot of recovery spending commitments focusing on buildings and construction as a proportion of 2021 GDP, by country [5].

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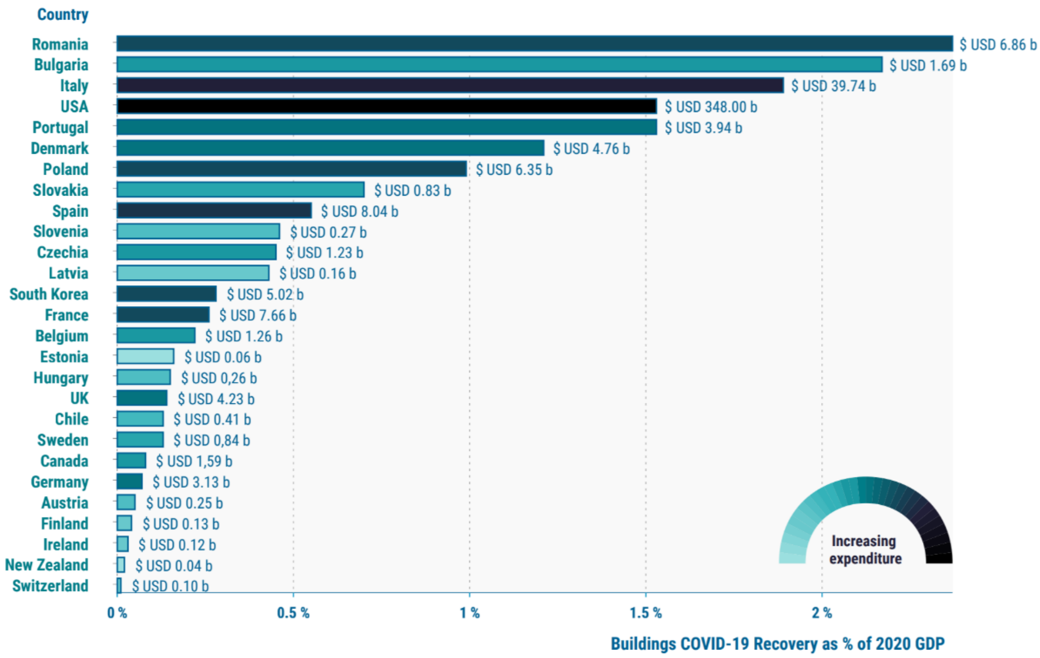

Figure 7. COVID-19 recovery funding related to buildings as % of 2020 GDP (United Nations Environment Programme 2021)

According to the International Energy Agency (IEA), global government policies were anticipated to rise the investments in energy efficiency by nearly 10%, to reach around $300 billion. The flow of finance to this area continues to accelerate.

The global warming and climate change has forced the countries and the people to consider how to reduce the carbon footprints. Rising demand for energy conservation and environment safety will strengthen the Energy management systems market. Evolution of smart grid and favourable government mandates are other factors fuelling the market growth.

Increasing awareness in industrial sectors for the efficient utilization of energy consumption is the major component which is driving energy management system market growth. Moreover, increasing alertness about carbon emission management serves as a major factor to fuel the growth of energy management system market over forecast periods. However, lack of awareness of consumer and financial resources are restraining the energy management system market growth. Nonetheless, technological advancement such as software-as-a-service is expected to spur the market growth of energy management system market over the next years.

As seeing in Figure 8 and Figure 9, the global Energy Management Systems Market accounted for USD 45.3 Billion in 2020 and is expected to reach USD 118.2 Billion by 2028, growing at a CAGR of around 12.8% between 2021 and 2028.[14]

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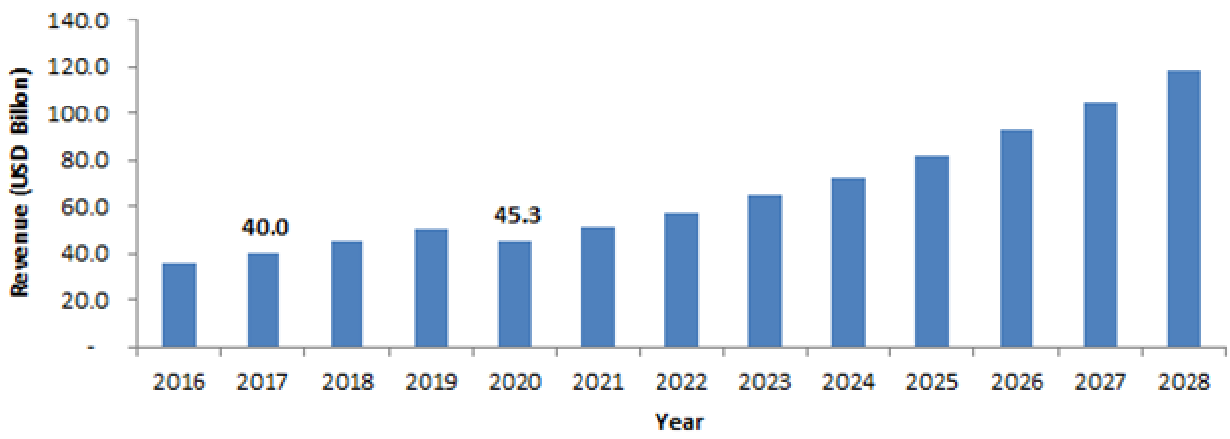

Figure 8. Global Energy Management System Market (source: Zion Market research)

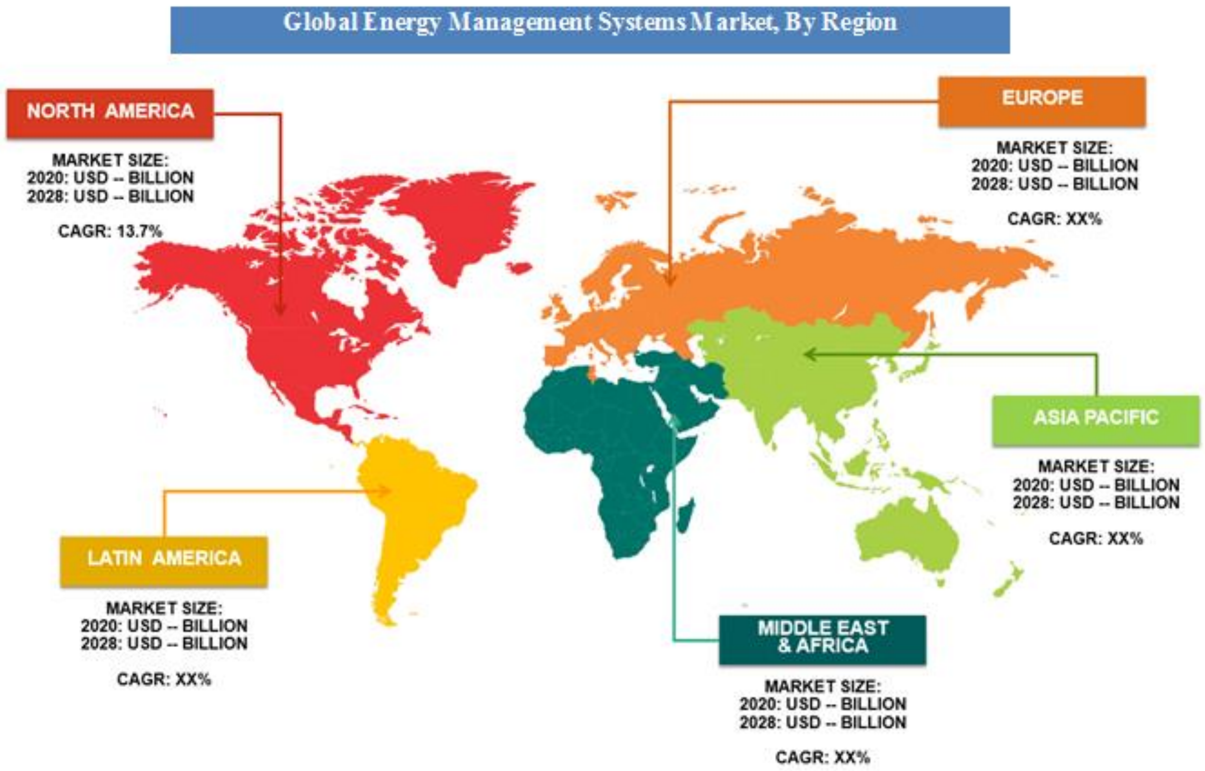

Figure 9. Global Energy Management System Market by region (source: Zion Market research [14])

The construction sector is a key component of Europe's economic growth and its employment sector. With more than 3 million enterprises and a total direct workforce of 18 million people, **the construction sector generates about 9% of the GDP of the EU**.

Micro, small and medium-sized enterprises (fewer than 250 employees) represent the immense majority (99.9%) of the European construction sector, with micro enterprises displaying the biggest part of the sector with 94.1%. As reference, in 2016, construction SMEs made up for 88% of total employment and 80% of total value added of the construction sector in the EU-28 [15].

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The Copper Alliance Institute claims that BA has a potential of saving 15-22% of the total energy consumption in European buildings. It is highly cost-effective, with benefits being nine times higher than costs. As shown in Table 2, two scenarios are generally presented to analyse economic impact:

- The optimal scenario: based on a perfectly functioning construction-market scenario, where all cost-effective energy-saving opportunities are seized, without serious constraints to effective service delivery.
- The recommended scenario: a more realistic depiction of the potential to deliver additional savings beyond the business-as-usual.

Table 2. Market evolution, economic and environmental impact of BA [16]

BA	Job creation	Economic impact	Environmental impact (yearly after peak)	Environmental impact (2013 – 2035)
Optimal scenario	4 million new jobs from 2013 – 2034	Savings = 1.1% of EU GDP Average payback per system = 1.5 year	150 Mtoe 9% of total EU energy consumption	2100 Mtoe 5.9 Gt CO_2eq
Recommended action scenario	(no data available)	Invest = €6.2bn/year Savings = €54bn/year	89 Mtoe 5% of total EU energy consumption	1000 Mtoe 3.4 Gt CO_2eq

Many of the projected newly created jobs will be for installers and energy experts for whom it will be necessary to establish competence requirements supported by accreditation and certification.

Innovation in the Building Automation Sector is strongly linked to innovation and change in the IT and energy sector. These sectors will strongly impact the technology evolutions of BA.

The US and Japan have strong BA markets, but most product developments for the European market will occur within Europe (mainly Germany, Switzerland, France, the UK and Italy), although many components/sub-components may be sourced from outside. This is even more the case for BAT, where the technologies tend to be quite specifically geared towards the nature of the HVAC systems used.

Social

As advanced in the previous section, the growth of global population has direct economic and social impacts. While especially relevant in developing countries, it is as well the trend observed in Europe. **The growth in Europe's population** is extracted from Eurostat and shown in Figure 10. The figure shows a clear growth of the EU27 from 2011 to 2020.

GDP/capita and population are important underlying drivers of BACS demand. On average GDP per capita has increased by 1.2% per annum in the EU27 from 2010 to 2019 [17]. This rate of growth may be equivalent to the upcoming one, as it includes the financial crisis from 2007 and the associated economic downturn, thus it was a period of economic contraction and recovery much as the one we

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might be seeing after the COVID pandemic, and the energy crisis exacerbated by the recent illegal Russian invasion of Ukraine.

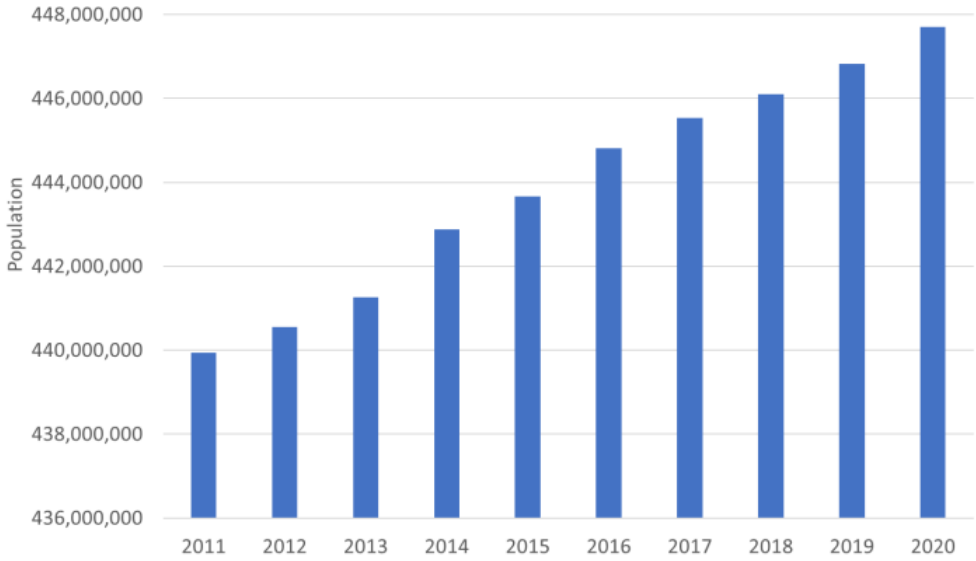

Figure 10. Evolution in the EU27's population (source: Eurostat)

The development of the COVID-19 pandemic in 2019 led most organizations worldwide to implement remote work policies, generally as a response to government guidelines and regulations that were intended to maintain the health and safety of employees [18]. This induced a massive shift of employees from the office space to the home environment [19], either full-time or part-time home and part-time in-office work (i.e., hybrid). As a result, not only the use of offices changed but residential dwellings acted as office spaces.[20]

This trend, although ignited by the COVID-19 pandemic and its effects, was already developing in the last decades: The transformation of traditional office environments in more flexible spaces.

This operative flexibility needs of corresponding flexibility in building operation, e.g., HVAC systems, which need to adapt to dynamic building occupation and schedules. Accordingly, remote work (working from home) increases home energy bills and might identify the need of better indoor comfort conditions. In summary, this trend strengthens **the need for more flexible building management** as well as might **trigger a new need of home management systems** for the residential sector.

Climate change, the recent energy crisis (fuels, shortage of gas, high prices of electricity) and their consequences have strengthened an already **environmentally conscious population**. Where sustainability is not only taken as added value but a necessity of the communities' people live in and their direct impact to their environments and finances.

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Technological

Building Automation (BA) can refer to Building Automated Control Systems (BACS), Building Automation Technologies (BAT) as well as Home and Building Energy Management Systems (HEMS/BEMS) solutions. Today these technologies mainly focus on HVAC systems, and they can be applied in varying degrees of integration and sophistication. Building Automation (BA) is a cost-effective measure for all type of buildings, regardless of their type, climatic conditions, and local energy prices.

The BACS market has traditionally been focused on operating the control needs of HVAC (heating, ventilation, and air conditioning equipment), such that current BACS provide fully integrated building controls on a single platform. This is intended to synchronise and optimise the usage of building services, improving energy efficiency, allowing the integration of renewable energy systems, and providing better indoor comfort conditions.

As global trend, the **reduction of cost in ICT components** has also benefit the BACS industry, ultimately creating improved functionality at lower costs. Most companies servicing the BACS market offer complete integrated systems that can control all relevant building systems on a single software platform and a platform as a service approach. Asides from these traditional BACS providers, other IT companies have started to offer products and services, especially in the home market, and this is reported to be encouraging the traditional incumbents to adopt more innovative business models, such as the adoption of open-source platforms that can allow different applications to operate on them. **Interoperability of building automation systems is thus a growing trend**.

Other technological trends influencing the evolution of BACS are:

- control of BACS through smart devices or legacy equipment smartened
- networking of BACS on the cloud
- Predictive capabilities, self-learning techniques, AI are set to allow better performance optimisation.

The current development of BACS focuses on dynamic or even self-learning control systems. Instead of static, predefined parameters for control, the system itself can define and steer the relevant parameters (e.g., optimal temperature, heating time, light lumen, operational-time installations, overheating protection), in a specific moment, and based on occupation, (predicted) inside- and outside temperature and so on. With the ongoing transition towards the “Internet of Things”. the market will move to smart systems able to learn user behaviour/lifestyle and operate optimally.

When properly installed and commissioned, BACS average net energy savings per installation are about 37% for space heating, water heating and cooling/ ventilation, and 25% for lighting. Currently only about 25% of service-sector buildings have properly installed BA [2]. Proper installation and operation of Home Management Systems in households will on average save 30% of heating and hot water energy compared to the average default control systems installed.

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BA is very complex to install and requires highly skilled monitoring and commissioning to ensure they keep working optimally. Compatible communication protocols between software and hardware remain a problem to ensure a qualitative installation.

BACS product information could simplify the work required to calculate, for example, the Smart Readiness Indicator (SRI) for a building [21] or could generally facilitate new applications to support consumers specifying BACS requirements and verify commissioning

Renewables and smart metering technologies are creating a new energy system that requires of constant interaction between supply and demand, in need of **flexibility**. BA is a complement to smart meters and is crucial in the roll-out of the building's interaction with the energy market (i.e. energy production, storage and demand response).

New technologies are changing the way the energy system works. As the energy system relies more and more on renewables, and more and more energy use is electric (for example because of e-mobility and electric heat pumps for heating) the electricity system becomes more decentralised and interactive.

Flexibility markets help energy networks to monitor energy flows and create market signals to motivate changes in energy supply and demand, integrating smart meters, smart appliances, renewable energy resources and energy efficient resources accordingly.

Environmental

In 2020, the buildings and construction sector accounted for 36% of global final energy consumption and 37% of energy related CO2 emissions, as compared to other end use sectors (Figure 11). While the level of emissions within the sector are 10% lower than in 2019, reaching lows not seen since 2007, this was largely due to lockdowns, slowing of economies, difficulties households and businesses faced in maintaining and affording energy access and a fall in construction activity. Efforts to decarbonize the sector played only a small role [7]. The transition towards mainstream net zero carbon standards calls for immediate action such as promoting building renovation instead of demolition [22].

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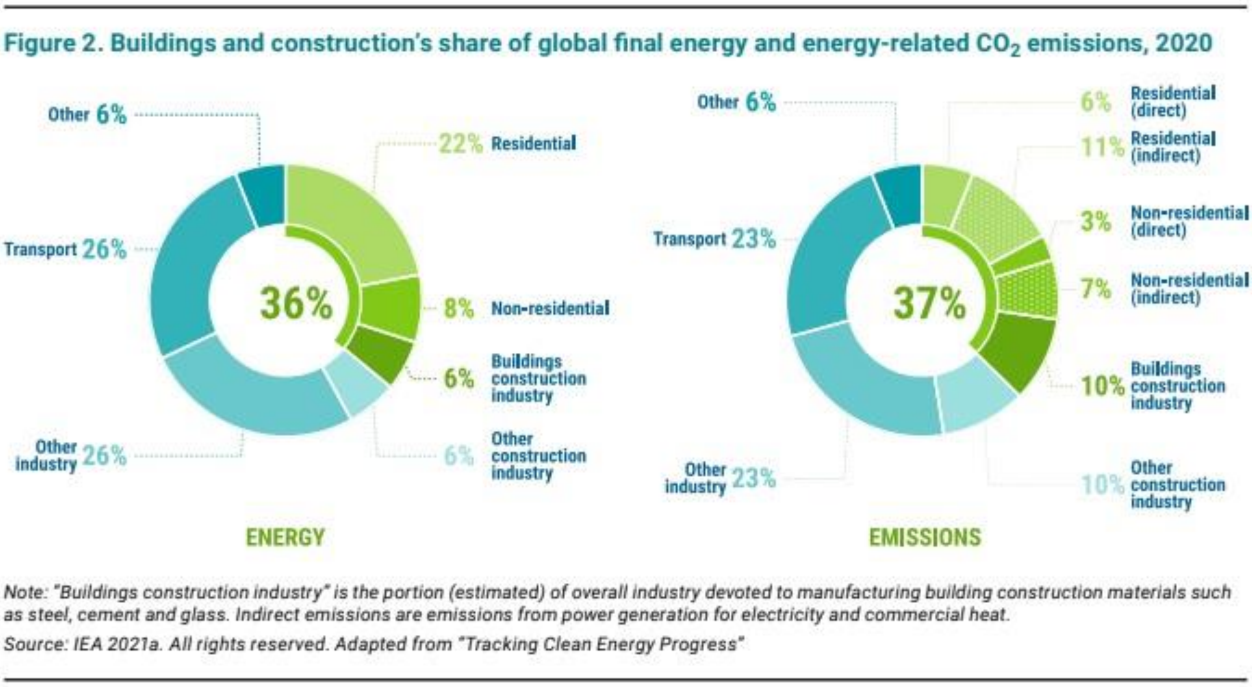

Figure 11. Buildings share of global final energy-related CO2 emissions in 2020 source: GABC [7]

By 2030, to be on track to achieving a goal of net zero operational emissions by 2050, the International Energy Agency (IEA) suggests that direct CO2 emissions from buildings would need to decrease by 50% and indirect emissions from the sector would need to decline through a 60% reduction in power generation emissions by 2030. In doing so, building sector emissions would fall by around 6% annually from 2020 to 2030. Energy efficiency needs to support decarbonization, and renovation rates must increase. The energy demand of buildings per square meter needs to drop 45% by 2030, which is five times faster on an annual basis than what it did over the past years. A whole-life carbon perspective includes carbon emissions arising from the built environment during both the use of buildings (operational emissions) and their construction (embodied emissions). The importance of embodied emissions is set to increase dramatically as more buildings are constructed and renovated to higher energy efficiency standards (United Nations Environment Programme 2021).

According to the World Energy Outlook [23] cost-effective, proven, energy efficiency and decarbonisation measures in buildings could contribute over 6.5 Gt CO2 reductions in annual emissions by 2040, compared to the current course of action under the Stated Policies Scenario. Reductions in emissions from buildings represent one-third of the total reductions required to align with the IEA's Sustainable Development Scenario [24]. This Scenario is designed to achieve the outcomes of the UN Sustainable Development Goals most closely related to energy: to achieve universal access to energy (SDG 7), to reduce the severe health impacts of air pollution (part of SDG 3) and to tackle climate change (SDG 13).

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4. Market analysis

This section presents an initial market analysis to investigate the feasibility and potential uptake of the COLLECTiEF solution.

As seen in section 3, EU policy has set ambitious goals for full, society-wide decarbonization of the built environment, ultimately achieving climate neutrality by 2050. This goal is supported by EU Climate and Energy legislation and initiatives. All buildings will be required to be Zero Energy Building (ZEB) by 2030 (Public buildings by 2027), this goal to be reflected in the Energy Performance of Buildings Directive (EPBD) recast.

This transition to ZEB level for all buildings will help mitigate the stress put on the energy system, reducing GHGs, social benefits due to reduced energy bills as well as better living conditions and economic effects through a smarter and more dynamic energy use. The EU is sharing a vision of buildings as micro energy-hubs, this is a building, or a group of buildings flexibly connected and synchronized with an energy system, being able to produce, store and/or consume energy efficiently. It can be flexible, adapting to the needs and simultaneously strengthening the energy system.

This section tries to identify and prioritise the best suited market for the COLLECTiEF solutions. For this, the key elements of COLLECTiEF are described (section **Error! Reference source not found.**), and a market study focusing on the BACS market and a feasibility assessment of the flexibility market to evaluate its readiness is presented in the following sections.

4.1 Building Automation systems

BACS are designed in advanced as many other electronic components but require significant effort in their assembly and customization 'in situ'. Their functionality and impact can only be assessed once installed. So, in order to analyse the BACS market, an appropriate indicator is the additional building floor area that receives a given level of BACS functionality over a period of time (i.e. a year). The final installed product produces value for different actors, not only for BACS manufacturers. Wholesale, retail, installation, and maintenance will share a portion of the monetised service. Finally, this value chain, or more specifically, the weight the actors of this value chain have might differ depending on the building typology and its characteristics (e.g., new-low energy, old-existing)

For an initial overview of the BACS market size, this section extracts the most relevant information of the market study performed in the "Ecodesign preparatory study for Building Automation and Control Systems (BACS)" of the European Commission Directorate- General for Energy [25].

4.1.1 Building stock

As stated previously, the usable floor area of a building is one of the best indicators to assess quantitatively the market potential of BACS. This indicator will vary depending on the building typology. As can be seen in Figure 12 residential floor area is significantly greater than non-residential, including single and multi-family homes.

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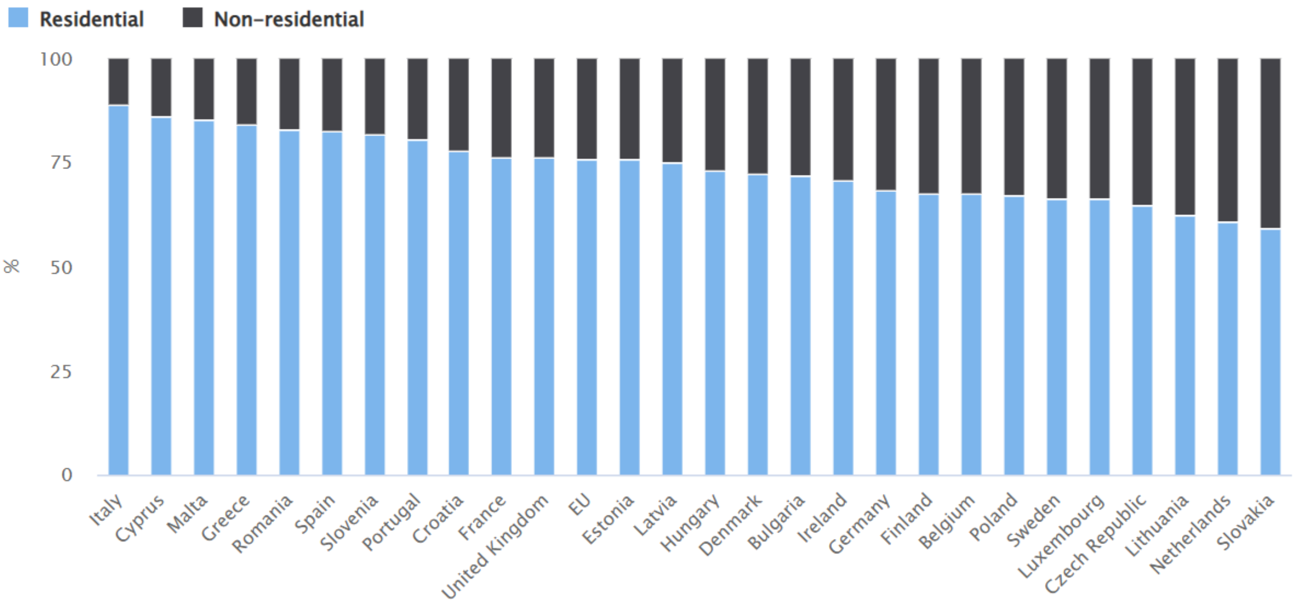

Figure 12. Breakdown of building floor area (2013 - EU Building stock observatory)

As seen in Figure 13, the distribution of floor areas by types of non-residential buildings is not homogeneous and depends on the economic structure of each country. On average, three quarters of the service floor area is covered by offices (including both private and public; 30%), wholesale (27%) and education (16%).

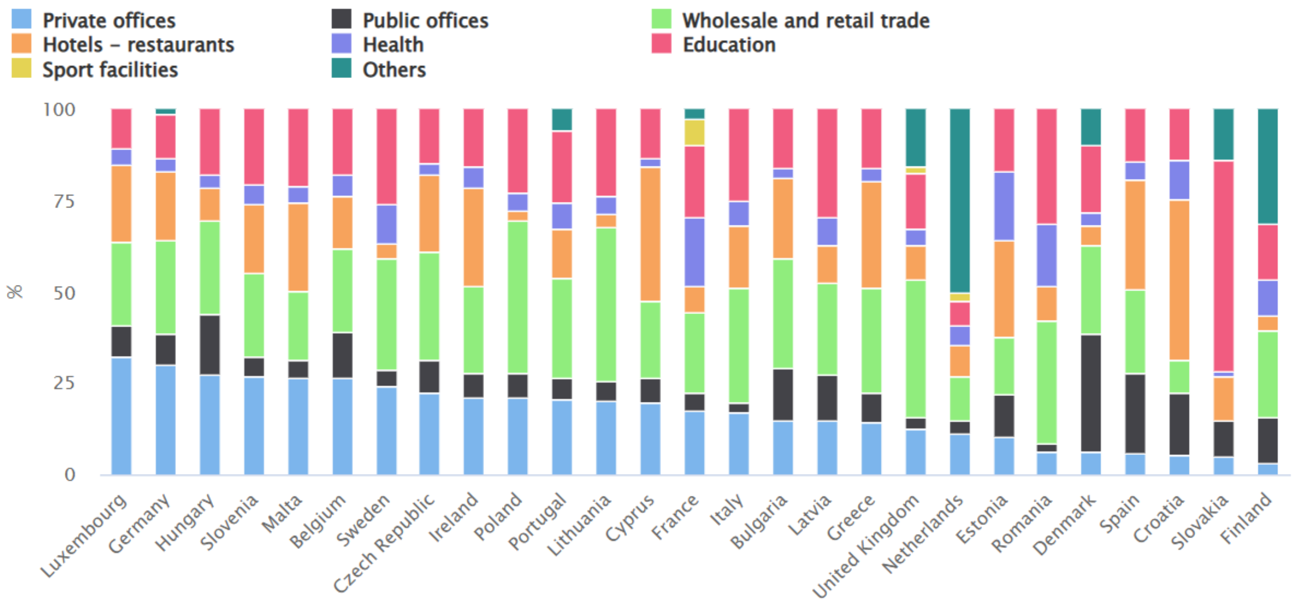

Figure 13. Distribution of non-residential floor area by area of use (2013 - EU building stock observatory)

The source of this data is the Commission's Building Stock Observatory [26], that is currently being revised and updated. The floor area values for the most significant types of European residential and non-residential buildings are shown in Table 3.

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Table 3. Estimated EU27 building stock for 2020 (derived from the EBPD Impact Assessment)

Sector	Floor area (M m2)	
Single Family Homes	10102	**Total Residential** 18058
Multi-Family homes	7956	
Offices	1874	**Total Non-Residential** 9601
Retail	1694	
Education	1137	
Other non-residential	4897	

Finally, derived from the EPBD [27] Impact Assessment the following projection on the evolution of number of buildings is presented for the period 2020-2050.

Table 4. Projected EU27 building stock to 2050 (derived from EBPD Impact Assessment)

Sector	Floor area (M m2)			
	2020	**2030**	**2040**	**2050**
Single Family Homes	10102	10831	11812	12788
Multi-Family homes	7956	8653	9425	10193
Offices	1874	1979	2143	2328
Retail	1694	1790	1938	2105
Education	1137	1200	1300	1412
Other non-residential	4897	5172	5601	6084

4.1.2 Energy consumption of building systems

Another perspective to analyse is the energy consumption of the building stock, associated to the different technical building systems, which directly affects the total energy and cost savings potential of BACS.

The EPBD Impact Assessment reports several building energy consumption values and projects them to 2050, including for 2020. Derived from this data and aligned with Eurostat 2018 data projected to 2020, Table 5 shows the results separately for residential and non-residential buildings.

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Table 5. Residential and Service sectorEU27 final energy consumption by Building system (estimated for 2020)

Building Systems	Final Energy Consumption (TWh)	
	Residential Buildings	Service Sector Buildings
Space Heating	1679	644
of which electricity	*250*	*189*
Sanitary hot water	404	294
of which electricity	*122*	*83*
Space cooling	11	116
Ventilation	14	53
Lighting	NA	231

4.1.3 BACS market Value-chain

As mentioned in previous sections, it's important to identify the different actors that constitute the BACS market value chain. These are manufacturing, wholesale, retail, installation, and maintenance of the final installed solution. It is also important to determine the costs breakdown associated to the installed BACS. Table 6 presents the costs and their estimated market value share:

Table 6. Market value share 2020 by product type (estimate)

BACS Product type	Share of the market
Software	9.3 %
Hardware	17.2 %
Controllers	33.9 %
Field devices	39.7 %

These composition of the value-chain and breakdown of costs will vary significantly depending on the type of market (residential, non-residential, typology, etc.) In the residential and small non-residential segment, a proportion of the market will be via retail sales channels. Systems integrators will also be more prevalent than in the large non-residential buildings market - where turnkey solutions sold by a single vendor are more common. Sales through wholesale distribution channels will be a feature of the BACs market for both smaller and larger buildings, see Table 7.

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Table 7. Market value share in 2020 across BACS value chain (estimated)

BACS value chain	Share of the market
BACS product	42.5 %
Engineering, installation, wiring, etc.	34.5 %
Additional third-party services	23.0 %

The mentioned study estimated an EU27 **BACS market value for 2020 of €8.1bn**, as the value paid by the final client. Giving a total **BACS product value of €3.4 billion** (42.5% of the whole BACS value chain market).

4.2 Energy Flexibility

4.2.1 Methodology

In order to assess the initial feasibility and market readiness of the COLLETiEF solution in the EU market, an analysis is conducted with respect to the demand side flexibility market. This assessment mirrors faithfully the 2021 report "EU Market Monitor 2021" by SmartEN [28], which interviewed 100 industry contacts and gathered more than 40GB of market data to assess and score (from 1 to 5) each country against four categories:

Potential market size of flexibility

The score in this category is given based on the spending on the ancillary services.

- Scoring system: 1 to 5 based on the volume and prices of ancillary services procured by TSOs:
  - 1 = < 50M €
  - 2 = 50M € to 99M €
  - 3 = 100M € to 249M €
  - 4 = 250M € to 500M €
  - 5 = > 500M €

Demand side flexibility regulatory progress

Markets scoring highly indicate that not only are markets open to DSF, but that aggregation is allowed and an agreement with a balancing responsible party (BRP) is not required. If the score is low, then DSF is either not permitted or only with high barriers to entry.

- Scoring system: 1 to 5 based on the availably and accessibility of DSF into ancillary services

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Local flexibility

Countries with commercial DSO offerings scored the highest. This is followed by countries that have implemented legal frameworks for collective self-consumption, citizen energy communities and/or renewable energy communities.

- Scoring system: 1 to 5 based on the development of local flexibility.

Future of flexibility

High scores highlight the countries that have the most potential to increase monetisation of DSF in the future, reflecting those with large flexibility markets with plans to open to DSF in the next 1-2 years. Where markets are already open, high renewable targets in relation to current renewable generation capacity will increase the need for flexibility

- Scoring system: 1 to 5 based on a planned development of DSF and future potential.

The score will then fall into one of this three qualitative groups:

Table 8. Three market groups classification depending on their flexibility market maturity

Early Markets	Emerging Markets	Maturing Markets
'Low' scoring countries typically are markets which are not established or are yet to open fully to DSF and have limited activity. • These markets have few, if any, value streams open commercially to DSF. • These markets often have limited need for DSF due to low renewable targets, bilateral contracts with generators, or lack a transmission system (as is the case with Malta). • With time these markets will develop the need for DSF, however commercial interest will remain limited over the next 3 years.	Countries scoring 'medium' are generally active markets undergoing development to open more fully to DSF. • Some value streams are open to DSF but there are often significant barriers in high minimum bid sizes, challenging metering requirements or regulatory constraints. • Despite the (current) lack of accessibility to DSF these countries have a high spend on flexibility, including Poland, Romania, and Greece. • These countries are aiming to join the coordinated EU markets for ancillary service (MARI, PICASSO, TERRE) over the next two years.	Countries scoring 'high' are more developed markets for DSF. This does not necessarily mean there are no barriers to participation. • Maturing markets have most (if not all) markets open to DSF, although barriers to entry are still present. • Local flexibility is developing, with some examples of commercial offerings (e.g., the Netherlands) at distribution level. • Even at their current stage of development, some markets have the potential to grow further due to increasing renewable targets (e.g., France, Germany and Great Britain).

4.2.2 Assessment

Technical aspects

Integrating building flexibility into energy markets is feasible only when control and communications technology is secure and low-cost. Standardised protocols for building-operation technologies and their interoperability with control boxes and metering devices are key. Furthermore, easy integration

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in the communication systems of grid operators allows for standardised participation in grid services. To achieve this, EU-wide protocols for flexibility by building technologies, especially electric heating and cooling appliances, and a common definition of technical requirements for flexible building technologies are necessary.

The roll-out of smart meters is the prerequisite for engaging in DR, as well as the definition of technical modalities and compensation rules. As an indicator for the technical potential for the end-users to engage in explicit DR, the roll-out of smart meters is illustrated in Figure 14. In eight countries, the roll-out is high or complete [29]

Low roll-out of smart meters											Medium roll-out of smart meters							High/ complete roll-out of smart meters							
BE	BG	CY	CZ	DE	GR	HU	PL	PT	RO	SK	AT	HR	IE	IT	LT	NL	SI	DK	EE	FI	FR	LV	LU	ES	SE

Figure 14. Status of smart meter roll-out at the residential level in 2021. Source: JRC, 2021

Despite not adopted as variable for the market assessment, this is implicitly included as only with smart meters demand side flexibility is possible.

Regulatory progress to enable Demand Side Flexibility

Belgium, Finland, France, Great Britain, Netherlands, Norway and Sweden remain open and accessible. Ireland, Slovenia, and Switzerland are opening.

Most countries have commercial and remunerated ancillary services. However, only ~50% allow DSF, fewer still allow participation from aggregated assets. In order to meet the requirements of the Clean Energy Package most countries will need to make significant improvements. Even those countries where the markets are accessible (for example Germany) have additional regulatory barriers that hinder participation to DSF.

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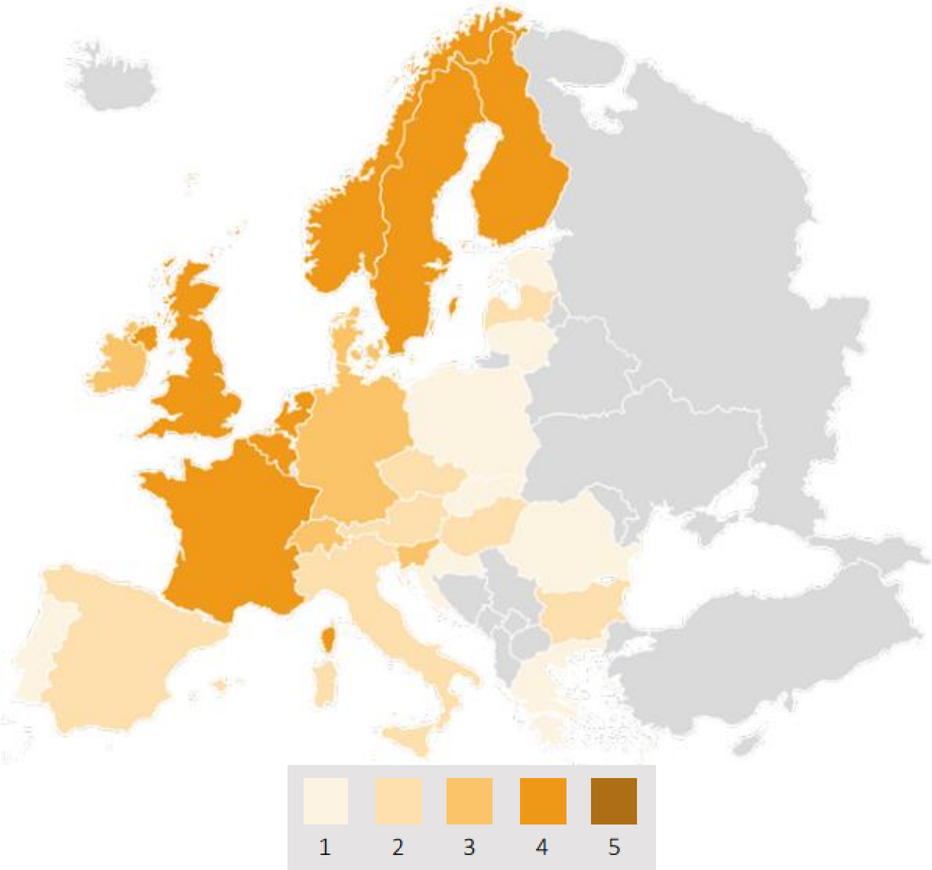

Figure 15. Graphic EU member states assessment (Regulatory progress)

Italy through the UVAM (translated to 'virtually aggregated mixed assets') mechanism DSF assets can participate in some ancillary services. In December 2021, this was extended to aFRR (energy payments only). High metering and testing requirements still present a barrier to DSF participation.

While progress is being made to implement the Clean Energy Package, there are still significant improvements required to increase accessibility to DSF.

Development of local flexibility and energy communities

Local flexibility is still an emerging space, with pilots and trials ongoing even in the most advanced countries. Great Britain and the Netherlands are the only countries with commercial distribution flexibility. A further 11 have trials.

The market in Great Britain has a very active local flexibility space with all six distribution network operators procuring flexibility. Additionally, several marketplace platforms (e.g. Piclo) are further enabling the participation of local flexibility by reducing complexity and streamlining procurement. However, collective self-consumption is only allowed within regulatory sandbox conditions and there is no implementation of citizen or renewable energy communities.

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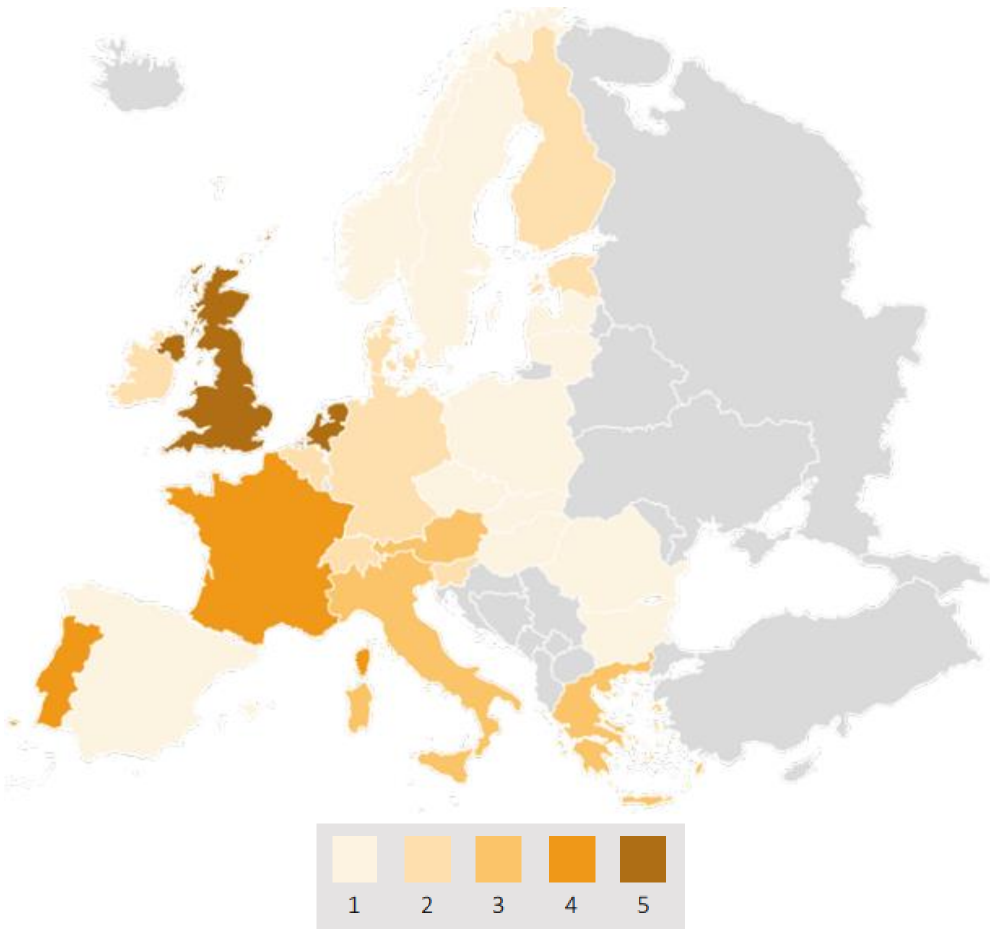

Figure 16. Graphic EU member states assessment (Local Flexibility & Energy communities)

~30% of EU countries have frameworks for implementing CSC, citizen and renewable energy communities, Great Britain and the Netherlands are leading in DSO flexibility.

Potential market size of flexibility

The highest ranking five countries (France, Germany, Great Britain, Italy and Spain) account for ~60% of the total value of flexibility.

This is the total market value that is theoretically open to DSF – not the actual participation of DSF in those markets. Total TSO spend on ancillary services has increased significantly in Q4 of 2021 due to the European wide high wholesale costs.

Spain has a high market value despite having relatively few value streams accessible to DSF. Due to Spain's limited interconnection, there is a large need for flexibility provided locally. Coupled with high utilisation prices due to European wide high wholesale prices the value of the Spanish market is high.

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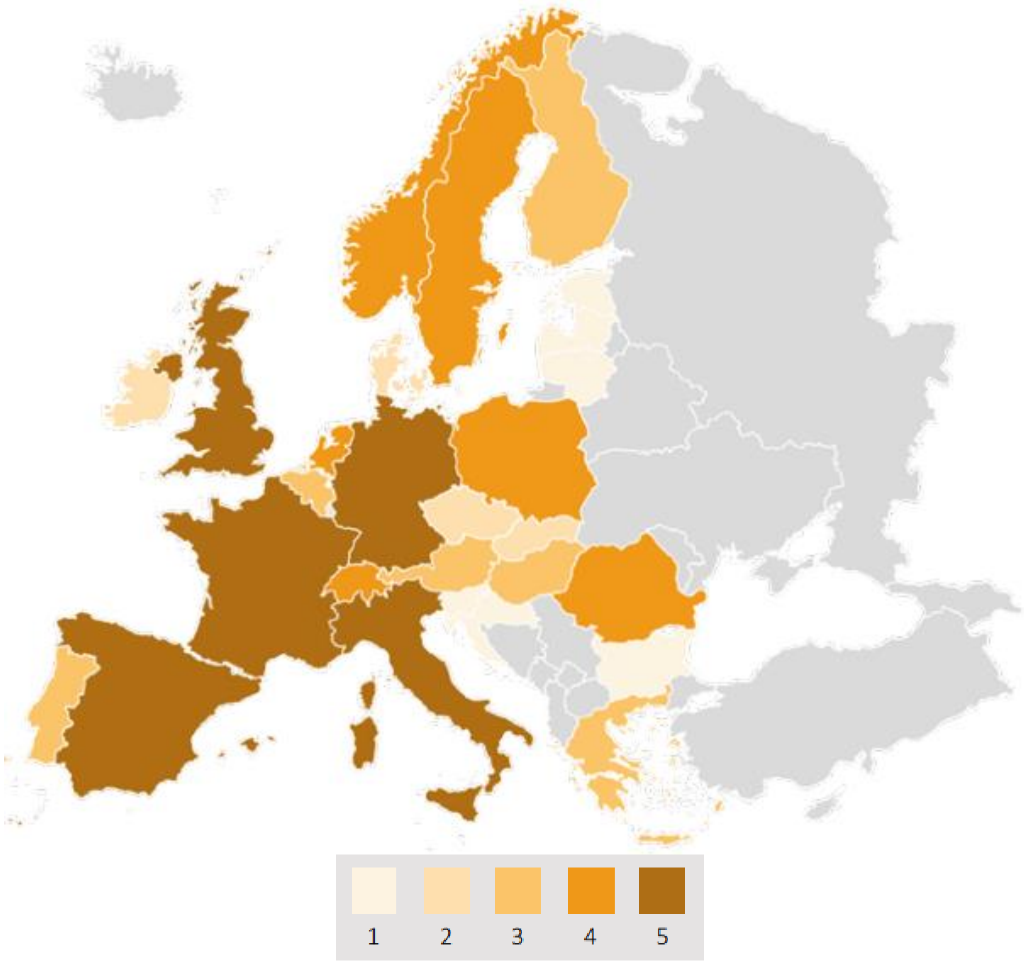

Figure 17. Graphic EU member states assessment (Potential market size)

This map illustrates the total spend by TSO on ancillary services. High scores for monetisation do not always mean DSF can access this value in practice.

Future development of demand side flexibility

Poland and Greece followed by Spain, Italy and Romania are the most prominent emerging markets due to opening of value steams to DSF and a high need/value of flexibility.

Broadly there are three routes to future development of DSF markets:

- Countries that are currently closed but have formalised plans for opening to DSF. For example, Poland and Greece.
- Countries that are open to DSF but due to technical and administrative barriers have limited participation (for example Spain and Portugal).
- Countries with existing open and accessible market but have high renewable targets so there is scope to grow.

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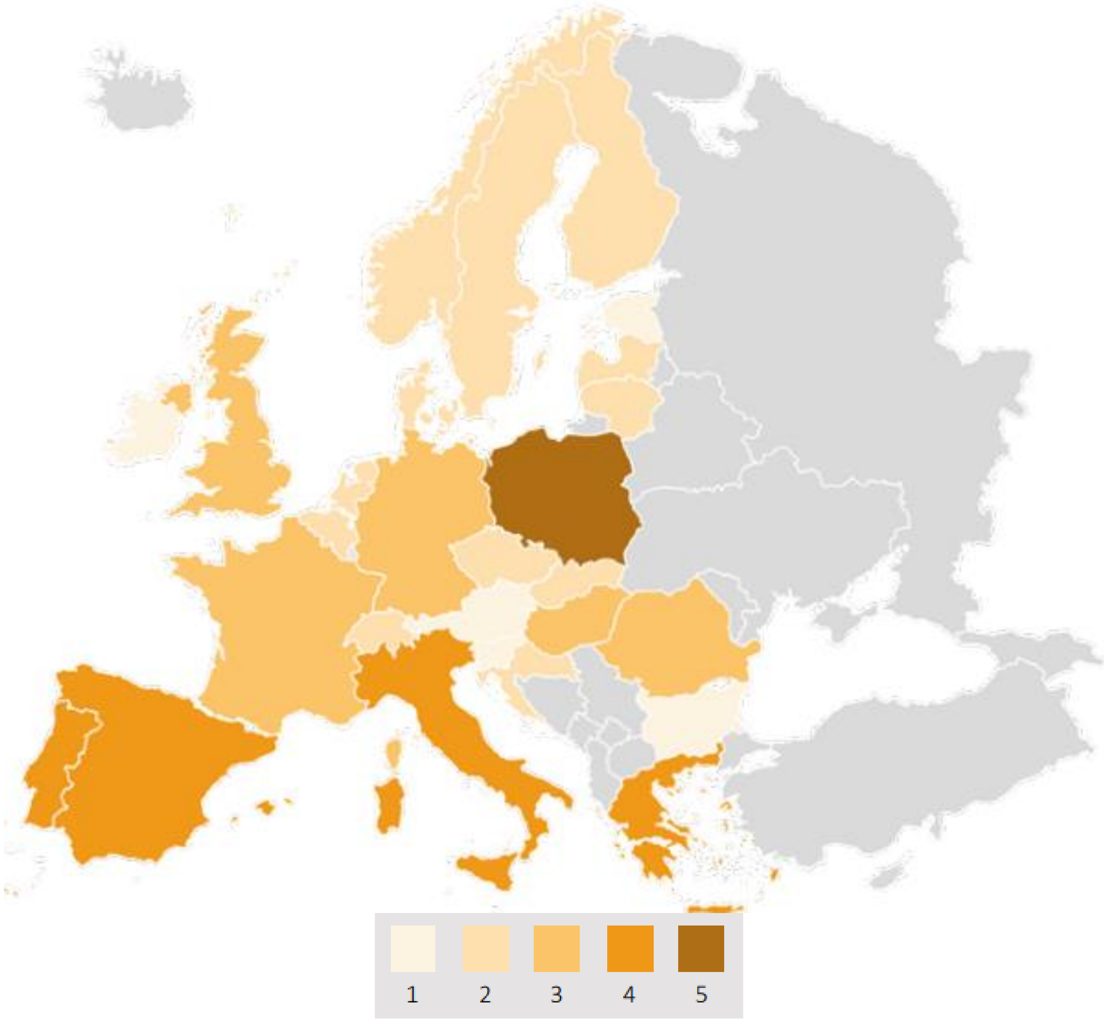

Figure 18. Graphic EU member states assessment (Future development of Demand side flexibility)

The creation, and opening of, markets to DSF in addition to ambitious renewable generation targets influences the future market for DSF.

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Table 9. Feasibility assessment evaluation in the EU27

	Regulatory progress	Potential market size of flexibility	Local flexibility and energy communities	Future of flexibility
Belgium	■■■■□	■■■□□	■■□□□	■■□□□
Finland	■■■■□	■■■□□	■■□□□	■■□□□
France	■■■■□	■■■■■	■■■■□	■■■□□
Great Britain	■■■■□	■■■■■	■■■■■	■■■□□
Netherlands	■■■■□	■■■■□	■■■■■	■■□□□
Norway	■■■■□	■■■■□	■□□□□	■■□□□
Sweden	■■■■□	■■■■□	■□□□□	■■□□□
Denmark	■■■□□	■■□□□	■■□□□	■■□□□
Germany	■■■□□	■■■■■	■■□□□	■■■□□
Ireland	■■■□□	■■□□□	■■□□□	■□□□□
Slovenia	■■■□□	■□□□□	■■□□□	■□□□□
Switzerland	■■■□□	■■■■□	■■□□□	■■□□□
Austria	■■□□□	■■■□□	■■■□□	■□□□□
Bulgaria	■■□□□	■□□□□	■■□□□	■□□□□
Croatia	■■□□□	■□□□□	□□□□□	■■□□□
Czech Republic	■■□□□	■■□□□	□□□□□	■■□□□
Hungary	■■□□□	■■■□□	■□□□□	■■■□□
Italy	■■□□□	■■■■■	■■■□□	■■■■□
Latvia	■■□□□	■□□□□	■□□□□	■■□□□
Spain	■■□□□	■■■■■	■□□□□	■■■■□
Cyprus	■□□□□	■□□□□	□□□□□	■□□□□
Estonia	■□□□□	■□□□□	■■□□□	■□□□□
Greece	■□□□□	■■■□□	■■■□□	■■■■□
Lithuania	■□□□□	■□□□□	■□□□□	■■□□□
Luxembourg	■□□□□	■□□□□	□□□□□	■□□□□
Poland	■□□□□	■■■■□	□□□□□	■■■■■
Portugal	■□□□□	■■■□□	■■■■□	■■■■□
Romania	■□□□□	■■■■□	■□□□□	■■■□□
Slovakia	■□□□□	■■□□□	■□□□□	■■□□□
Malta	■□□□□	□□□□□	□□□□□	■□□□□

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Feasibility assessment results and conclusions

The result of the COLLETiEF feasibility analysis for the pilot countries is summarized in Table 10.

Table 10. Feasibility assessment evaluation in COLLECTiEF's pilot countries

	Regulatory progress	Potential market size of flexibility	Local flexibility and energy communities	Future of flexibility
France	■■■■□	■■■■■	■■■■□	■■■□□
Norway	■■■■□	■■■■□	■□□□□	■■□□□
Italy	■■□□□	■■■■■	■■■□□	■■■■□
Cyprus	■□□□□	■□□□□	□□□□□	■□□□□

From Table 10, the following conclusions are made:

- Based on this first initial analysis, France and Norway are the most “flexibility market” ready countries from those of COLLETiEF pilots.
- Italy, despite its early adoption of smart meters is falling behind. High metering and testing requirements are precisely the key barrier to DSF participation.
- Cyprus falls into the early market category, with much to advance. It’s limited by its lack of interconnection due to its nature (i.e., island) and its need to import most of its energy (fossil fuels)
- Given that the targeted countries have different status for the assessed topics, there is still the need for standardization and progress toward the goal of a harmonized EU energy market suitable for flexibility management.

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5. Customer segmentations

The products under development in COLLECTiEF project and the related services addresses two main target groups of customers: one consists of all the market actors who want to offer and manage flexibility in the energy market, such as ESCOs, aggregators for the energy market, energy communities, organizations owning or managing buildings private or public stocks. These customers could be interested first in the COLLECTiEF Cluster Node, the software platform allowing to create and manage energy flexibility. They can benefit from the direct energy savings and by the revenue generation from selling flexibility on the energy market with related advantageous tariffs and incentives.

The second group of customers could be mainly interested in the products of the COLLECTiEF Edge Node, thought to offer energy savings, energy flexibility and better indoor comfort conditions in their buildings and homes. These customers will be buildings and systems designers, construction companies, systems installers, ESCOs, public bodies managing residential or office building assets, and final users like people who live in homes as owners or tenants.

In addition to the main products under development in the project, a proper COLLECTiEF Community could be set, where participants can be part of different kinds of energy community, with physical meaning or with more general one. Wider and more open groups of customers can be interested to join the community, that will be thought as organized groups where revenues gained from the energy flexibility can be managed and reinvested in the ways established within the dame community.

Table 11. Different categories of potential customers for the COLLECTiEF solutions

Actors	Objectives
Prosumer	Save money and lower their electricity bills.
	Respect of comfort preferences and desired electricity use.
Energy Service Company	Maximize its margin when offering auxiliary energy-related services to prosumers.
Aggregator	Maximize the value of flexibility for its portfolio, taking into account customer needs, economic optimization and grid capacity.
Supplier	Maximize its benefit when sourcing, supplying and invoicing energy to its customers. (i.e. Portfolio optimization)
DSO	Reduce grid congestion.
	Guarantee security of supply.
	Efficient network capacity planning

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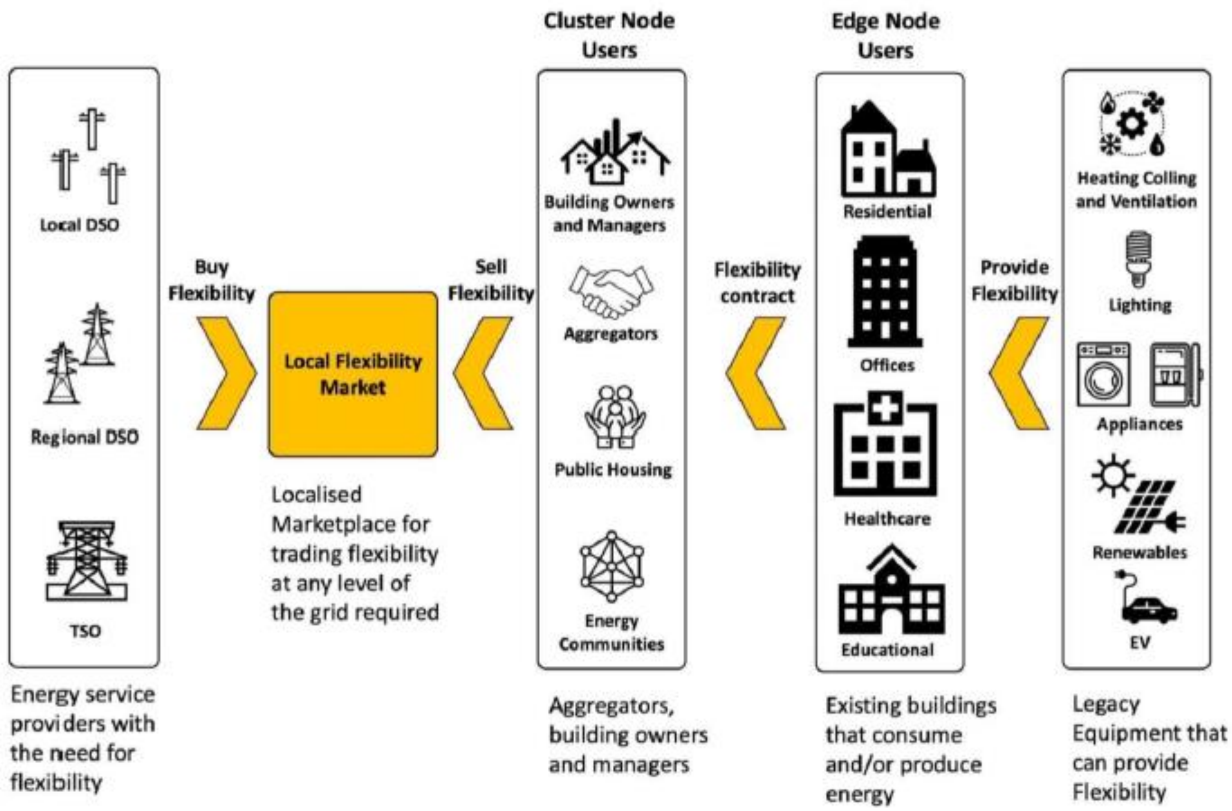

Figure 19. Scheme of the main customers segments in the energy market and in the building sector

Here below the main customers groups are listed in Table 12. Many of them are more related to the energy sectors, some others are in the real estate and buildings sectors. These kinds of customers will be addressed by the COLLECTiEF products and services mainly with business models of the typologies of business-to-business (B2B) or of business-to-business-to-customer (B2B2C).

We can recognize also potential customer in public entities, which directly or indirectly manage public buildings stock, such as municipalities and district and regional authorities. Potential customers are also the final users, such as single buildings owners and occupants or their associations. In these cases, the model will be the business-to-customer ones (B2C).

Unlike other smart-home solutions, in the case of the COLLECTiEF system, the specific market segment will be not the one closest to entertainment and communication (i.e., internet, etc.), but will be that of smart control of legacy equipment and components in existing systems.

Table 12. Customer groups

Customer groups
Energy communities and cooperatives
Electrical distribution system operator
Energy sales company
ESCOs
Energy utilities
Facility and building management

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Systems maintenance companies
Electronic devices reseller (BACS related)
Municipality and local authority
Buildings owners and housing association
Household and occupant
District heating supplier
Energy system aggregator

In parallel to the categories of customers listed above, Table 13 shows the market segments that can be recognized as more suitable for the COLLECTiEF solutions:

Table 13. COLLECTiEF market segments

Segments	Type
Buildings typologies:	residential, tertiary, offices, schools.
Scale:	from single apartment to cluster of buildings
Systems typologies:	Legacy equipment and systems in the field of HVAC and electrical equipment

6. Stakeholder landscape

Table 14 presents the list of the stakeholder categories for the solutions developed in the COLLECTiEF project and for the thematic fields of energy flexibility and energy management, of the smart controls in buildings and BMS, and in general of the management of the buildings and of the energy sector.

Table 14. Stakeholder categories

Stakeholder categories
energy producers
electrical distribution system operator (DSO)
energy utility
energy sales company
energy cooperative
energy community
ESCO - energy service company
facility and buildings management
building and system designers or consultant
construction company

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systems maintenance company
buildings automation and controls provider
systems components and equipment provider
electronic devices resellers
research and educational organization
standardization body
policy makers
local authority
buildings owners and housing association
real estate operator
environmental association
household and occupant
district heating supplier
energy system aggregator
energy consultant
venture capital association
research and innovation foundation
communication and media organization

The main stakeholder categories have been analysed in the power-interest matrix presented in Figure 20. It represents a method to analyse the different stakeholders of the related fields, that are grouped according to their influence within the market and the society and according to their interest on the fields of solutions of the project.

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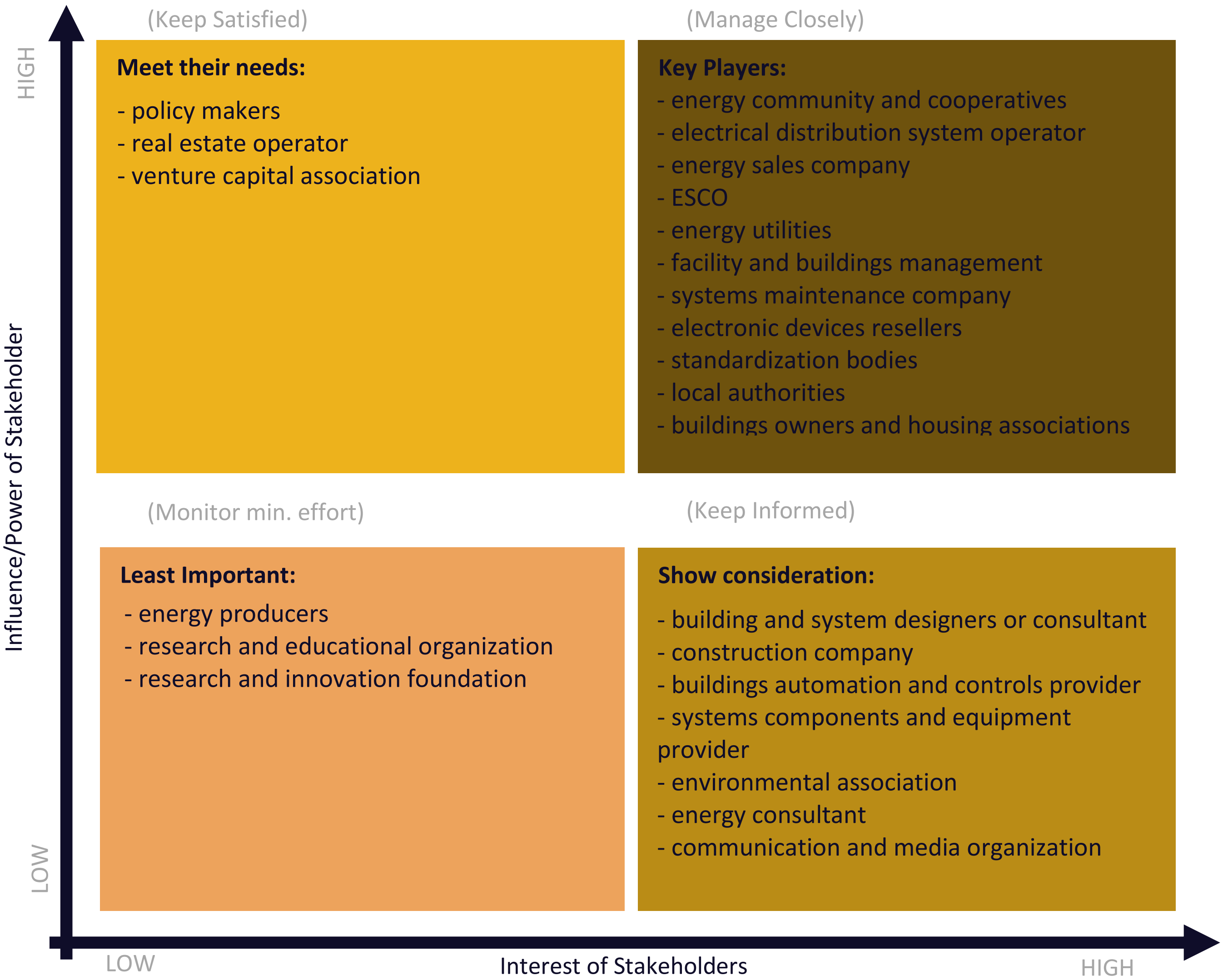

Figure 20. Power-interest matrix of the stakeholder landscape

7. Sales channels and actors

There are two primary sales channels to the market used by BACS manufacturers: direct and indirect sales:

- For large and high-end buildings/projects direct Turnkey solutions predominate where a single supplier provides the whole solution. This makes accountability easier and often brings some economies of scale resulting in lower costs and greater reliability.
- At the other end of the market, i.e., smaller buildings, systems integrators are predominant. There is a part of the market where BACS solutions are installed by building owner/occupiers themselves. This is more prevalent in the residential sector

A 2015 BSRIA study [26] estimated the global HVAC controls related supply chain market share for each sales channel (Table 15).

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Table 15. BSRIA estimate of market shares by sales channel

Sales Channel	Market share
Mechanical contractor/installer	22 %
Energy service/Facilities Management Company	4 %
Controls contractor/systems integrator	27 %
Reseller/Wholesaler/Distributor	13 %
OEM	9 %
Direct with end-customer/building	21 %
Sales to maintenance businesses	4 %

8. Competition and examples of success

The building automation and controls industry is quite fragmented with many players involved, but the very large players dominate the market. The major BACS suppliers are:

- Siemens Building Technologies Ltd
- Honeywell Technologies S.a.r.l.
- Johnson Controls, Inc.
- Schneider Electric Buildings AB

These companies have reported to account of 54% of the non-residential market in value terms. Because these conventional actors operate on closed-source software and systems or focus mainly on the non-residential market, more small players are entering the market, offering simple open-source HEMS.

Some large new actors, like Google NEST and Apple, have entered the home market discarding, maybe only to date, more complex building systems. They often have innovative open-source platforms, allowing different applications to run. These new players in the market could push or influence traditional companies to a more “open” development, updating their business models. It might also stimulate the necessary change towards more flexible and dynamic systems.

Eu.bac[1] are the principal BACS trade association representing the product manufacturers (covering 85% of the European BACS market).

[1] https://www.eubac.org/about/current-members/index.html

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8.1 Technology overview – Edge Computing and cloud computing

Digital processes generate a large amount of data. Often, communication via the cloud is not fast enough and effective enough[2]. In edge computing, computation is performed on distributed device nodes reducing processing speed and security concerns. Batch uploads are sent on scheduled intervals for wider trends analysis across assets. in truth many solutions take a hybrid approach, batch processing some of the data at the edge, before sending it to either an intermediary processing server away from the centralized cloud system [3] Edge Computing keeps data local, and makes data storage and processing: sustainable, efficient, real time, offline, and secure[4]. During the current market assessment, it is understood most products available in the market are cloud based. But there seems to be a shift towards hybrid solutions.

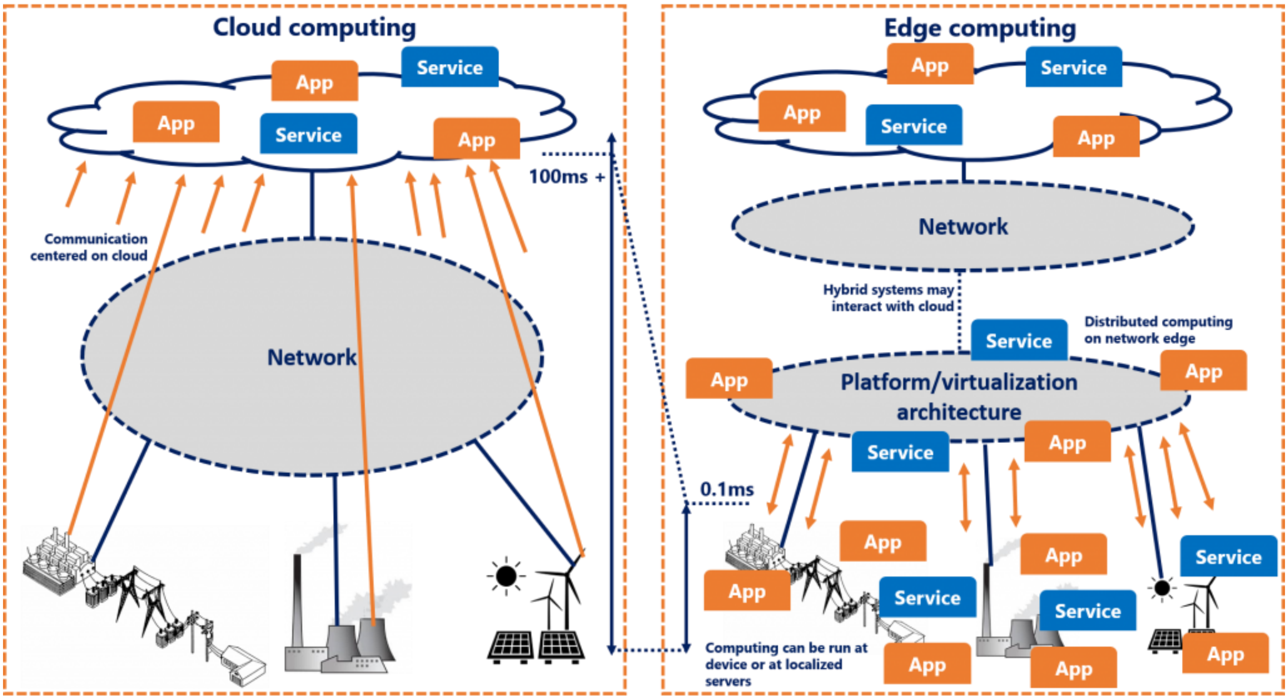

Figure 21 comparison of the cloud and edge computing frameworks[5]

The following section assess various BACS (BMS, HMS) solutions commercially available, with features similar to that of COLLECTiEF solution. During the analysis, it is understood that many solutions exist for Commercial / Tertiary sectors, which can be directly integrated with existing BMS system. Residential sector with legacy equipment is a niche market, and it was hard to find commercial products. Further most of the solutions Following is the list of solutions (refer product list section for detailed description) that have shortlisted for further assessment.

[2] https://www.iis.fraunhofer.de/en/ff/lv/iot-system/tech/edge-computing.html#Edge%20Computing
[3] https://www.cleantech.com/energy-power-shifts-from-iot-cloud-to-edge-computing/
[4] https://objectbox.io/energy-edge-computing/
[5] https://www.cleantech.com/energy-power-shifts-from-iot-cloud-to-edge-computing/

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Table 16. List of solutions assessed

	Product	Country	Market segment	Computing
1	Google nest	USA	Residential	Edge\Cloud
2	Life smart	China	Residential	Cloud
3	75F	USA	Residential	Cloud
4	BrainBox AI	Canada	Commercial / Tertiary	Cloud
5	Enerbrain	Italy	Commercial / Tertiary	Cloud
6	Accenta	France	Commercial /Tertiary	Cloud
7	Honeywell Forge	USA	Commercial /Tertiary	Cloud
8	Siemens Navigator	Germany	Commercial / Tertiary	Cloud
9	Arloid	UK	Commercial / Tertiary	Cloud
10	Ecopilot	Sweden	Commercial / Tertiary	Cloud
11	brain4energy	USA	Commercial / Tertiary	Cloud
12	C3 AI	USA	Commercial / Tertiary	Cloud
13	Verdigris	USA	Commercial / Tertiary	Cloud
14	Eco energy insights	USA	Commercial / Tertiary	Cloud
15	Fraunhofer OGEMA	Germany	Residential/ Commercial / Tertiary	Edge

8.2 Product assessment metrics

The following section tries to access the BACS that have been shortlisted quantitatively. Metrics or KPI (Key performance indicators) have been identified and has been validated within R2M team of experts in order to assess the BACS available in the market. A weighted score has been assigned to each metrics based on the relevance to COLLETiEF solution.

Table 17. Assessment metrics

Metrics	Rationale	Weighted score
Easy integration with legacy equipment	Possibility to integrate with existing legacy systems in the buildings	0.2
Effectively manage consumer energy demand	Manage consumer demand for energy using machine learning techniques, considering other influencing parameters (such Consumer preferences, weather conditions, incentives etc.)	0.2
Interoperability	Since different system using different protocols to communicate, an ideal candidate should be able to communicate with all or majority legacy systems. A simple	0.2

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	communication logic (among energy systems, buildings, and appliances)	
Scalability or multi-domain	Manage energy in scalable manner within existing buildings and neighbourhoods (i.e., scalability at different levels from appliances inside buildings to the city Level)	0.1
Energy flexibility	Cross talk between grid and building thus providing energy efficiency and flexibility	0.1
Privacy	keep the user data at the building scale thus ensuring privacy and meanwhile use the IT efficiently.	0.1

The following table contains the product assessment i.e., evaluating various products against the predetermined metrics:

x	Information available
-	Information not available

Table 18. Product assessment (available/not available)

	BrainBox AI	Enerbrain	Accenta	Forge	Navigator	Arloid	Google nest	Life smart	75F	Ecopilot	brain4energy	C3 AI	Verdigris	Eco energy insights	Fraunhofer OGEMA
Easy integration with legacy equipment	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Effectively manage consumer energy demand	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Interoperability	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Scalability or multi-domain	X	X	X	X	X	X	-	-	-	X	X	X	X	X	X
Energy flexibility	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Privacy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X

If the product under consideration possesses the predefined metrics, corresponding weighted scores are assigned. If the product doesn't possess the predefined metrics or if the information is not available, a score of 0 is assigned. During the assessment it its understood more or less all the products under assessment have similar features. But information was unavailable regarding the metrics - Energy flexibility and Privacy for most of the products (Fraunhofer OGEMA is a compelling solution that has more similar features to that of COLLETiEF solution.

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Table 19. Product assessment (scored)

	BrainBox AI	Enerbrain	Accenta	Forge	Navigator	Arloid	Google nest	Life smart	75F	Ecopilot	brain4energy	C3 AI	Verdigris	Eco energy insights	Fraunhofer OGEMA
Easy integration with legacy equipment	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Effectively manage consumer energy demand	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Interoperability	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Scalability or multi-domain	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1
Energy flexibility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
Privacy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
Total	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	1

8.3 Product list

The following section gives detailed description regarding various products that have been assessed in the previous section.

- **Commercial or Tertiary buildings** – Buildings open to public like shopping centres, hotels restaurants etc. as well as buildings office buildings, business centres, administrative buildings, commercial warehouse space frequented by workers
- **Residential buildings** - Buildings with more than half of its floor area for dwelling purposes.

Table 20. Product card: Brainbox AI

Product	BrainBox AI	**Country**	Canada
Market segment	Commercial / Tertiary	**Markets served**	Worldwide
Cloud-based or edge-based	Cloud based	**Legacy system compatibility**	Yes
	BrainBox AI uses predictive and self-adapting AI to optimise buildings. By bringing autonomous AI to the built environment, the building learns to anticipate and foresee thermal behaviour and make smart decisions ahead of time to ensure maximum comfort with minimum energy expenditure. This will reduce the carbon footprint, lower energy bills, and contribute to meaningful, sustainable change. Various phases in BrainBox AI deployment are Mapping and learning + Predicting + Real-time optimising + Continuously improving		

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Table 21. Product card: Enerbrain

Product	Enerbrain	**Country**	Italy
Market segment	Commercial / Tertiary	**Markets served**	EEA
Cloud-based or edge-based	Cloud based	**Legacy system compatibility**	Yes
enerbrain® For an intelligent use of energy	Enerbrain optimises HVAC energy consumption, improving ambient comfort and reducing CO_2 emissions using Hardware and Software tech solutions. Enerbrain collects the data of the building, processes it using cloud-based technology and provides the best output to meet the energy efficiency and indoor comfort goals. The intelligent system optimises system performance guaranteeing energy savings, improved indoor ambient comfort and reducing CO_2 emissions and carbon footprint		

Table 22. Product card: Accenta

Product	Accenta	**Country**	France
Market segment	Commercial / Tertiary	**Markets served**	Worldwide
Cloud-based or edge-based	Cloud based	**Legacy system compatibility**	Yes
accenta.	The. PILOT SmartBuilding service is a software layer that interfaces with all the BMS systems to intelligently control the operation of your equipment. The objective is to respect the comfort target level while consuming as little as possible. By delivering the right quantity of energy at the right moment. A single platform allows uniform access to all your equipment's (regulators, thermostats, BMS, connected objects) and universal approach ensures compatibility with the different protocols on the market. The services come together with an Energy Performance Contract that secures the achievement of the objectives over time.		

Table 23. Product card: Honeywell Forge

Product	Forge (Honeywell)	**Country**	USA
Market segment	Commercial / Tertiary	**Markets served**	Worldwide
Cloud-based or edge-based	Cloud based	**Legacy system compatibility**	N/A

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HONEYWELL FORGE	Honeywell Forge is an Enterprise Performance Management solution for commercial real estate operations. Honeywell Forge suite unites real-time data across assets, people and processes into a system of record for a 360-degree view that helps our customers transforms and drives intelligent operations. Using domain-specific AI/ML based upon decades of industrial expertise, it empowers decision making to surface inefficiencies, mitigate risk, reduce cost and support achieving sustainability goals.

Table 24. Product card: Siemens

Product	Navigator(Siemens)	**Country**	Germany
Market segment	Commercial / Tertiary	**Markets served**	Worldwide
Cloud-based or edge-based	Cloud based	**Legacy system compatibility**	N/A
SIEMENS	Navigator is Siemens' cloud-based advanced analytics platform designed to optimize the performance of the buildings. The Navigator platform adds a layer of intelligence for continuous monitoring, allowing you to achieve your energy, sustainability, and system performance targets. It seamlessly integrates complex sources of data from energy procurement, energy consumption, system performance, and sustainability		

Table 25. Product card: Arloid

Product	Arloid	**Country**	UK
Market segment	Commercial / Tertiary	**Markets served**	Worldwide
Cloud-based or edge-based	Cloud based	**Legacy system compatibility**	Yes
arloid.	Arloid AI uses Deep Reinforcement Learning tools that can continuously analyse endless combinations of site-specific factors, which then determines the most efficient parameters for each autonomous zone in your building in real time. Arloid AI Solution can deliver optimal HVAC performance – creating a more comfortable and more efficient building at the same time. Aside from internal stimulants, Arloid AI uses external factors including weather conditions and air humidity as well as millions of data points from previously trained AI models. The device is quick and easy to deploy as it can be installed to your existing systems		

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Table 26. Product card: Google NEST

Product	Google nest	Country	USA
Market segment	Residential	Markets served	Worldwide
Cloud-based or edge-based	EDGE based \ Cloud based	Legacy system compatibility	Yes
	The Nest Learning Thermostat is the first thermostat to get ENERGY STAR certified. The Nest Thermostat works with heating and cooling systems, including gas, electric, forced air, heat pump, radiant, oil, hot water, solar and geothermal It learns what temperature you like and builds a schedule around yours. And independent studies showed that it saved people an average of 10% to 12% on heating bills and 15% on cooling bills.		

Table 27. Product card: LifeSmart

Product	Lifesmart	Country	China
Market segment	Residential	Markets served	N/A
Cloud-based or edge-based	Cloud based	Legacy system compatibility	N/A
LifeSmart	LifeSmart provides smart home solutions to offer our customers control over appliances and the home environment, bringing convenience to life, as well as security and energy-saving. All the appliances are controlled at the touch of a button. LifeSmart provide customers with end-to-end AIoT (AI and IoT) solutions which include application software, cloud service, hardware and AI integration.		

Table 28. Product card: 75F

Product	75F	Country	USA
Market segment	Residential / Commercial / Tertiary	Markets served	N/A
Cloud-based or edge-based	Cloud based	Legacy system compatibility	Yes
75F	The 75F system is easily installed, requires zero programming and delivers sophisticated HVAC and lighting control at a fraction of the cost of comparable systems through cloud computing, the Internet of Things (IoT) and machine learning. 75F's intelligent, low-cost solution solves comfort and energy issues in commercial buildings and increases your bottom line through easy-to-use technology		

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Table 29. Product card: Brain4Energy

Product	brain4energy	**Country**	USA
Market segment	Commercial / Tertiary	**Markets served**	USA
Cloud-based or edge-based	Cloud based	**Legacy system compatibility**	Yes
	AI-powered energy conservation software for commercial buildings. Brain4Energy is capable of adapting to any building with a BMS via API. Brain4Energy software connects to the BMS via industry-standard protocols such as OPC-UA, BACnet, Modbus. The building size doesn't matter. The AI analyzes the building independently using available sensors and historic data. The AI analyses the building's usage and calculates an algorithm for optimal HVAC and lighting system settings. Brain4Energy continuously self-adapts and self-adjusts its algorithms.		

Table 30. Product card: Ecopilot

Product	Ecopilot (Nordomatic AB)	**Country**	Sweden
Market segment	Commercial / Tertiary	**Markets served**	EEA / Canada/USA
Cloud-based or edge-based	Cloud based	**Legacy system compatibility**	N/A
	Ecopilot was first commercially installed in 2008, but its technology is based on extensive research dating back to the 1970s from the KTH Royal Institute of Technology in Stockholm, Sweden. Ecopilot is Artificial Intelligence for Real-Time HVAC Efficiency. Once integrated with existing, BMS, Ecopilot goes to work finding the building's "balance point temperature". Ecopilot continuously calculates the energy balance between factors like real-time indoor data, weather forecasts, and the building's unique capacity for thermal mass to automatically and continuously adjust set points for heating, cooling and ventilation – every two minutes.		

Table 31. Product card: C3.ai

Product	C3 AI	**Country**	USA
Market segment	Commercial / Tertiary	**Markets served**	USA / EEA
Cloud-based or edge-based	Cloud based	**Legacy system compatibility**	N/A

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C3.ai	C3 AI Energy Management is an enterprise AI application that helps enterprises gain visibility into their energy consumption and GHG emissions across the operational footprint and prioritize actions reduce operational costs while meeting sustainability targets. C3 AI Energy Management uses machine learning techniques to enable accurate forecasting, benchmarking, building optimization, demand response, and anomaly detection to lower costs and meet sustainability goals across a global real estate footprint.

Table 32. Product card: Verdigris

Product	Verdigris	**Country**	USA / Asia
Market segment	Commercial / Tertiary	**Markets served**	USA / Asia
Cloud-based or edge-based	Cloud based	**Legacy system compatibility**	Yes
VERDIGRIS	Verdigris AI learns the building's patterns, combining real-time, high-frequency meter data with local weather, utility pricing, and building management system (BMS) data to develop forecasts. Verdigris Adaptive Automation continuously optimize baseline efficiency for equipment that operates 24/7 and automate demand management and response to shed and shift loads without compromising tenant comfort.		

Table 33. Product card: EcoEnergy

Product	Eco energy insights (Carrier)	**Country**	USA
Market segment	Commercial / Tertiary	**Markets served**	N/A
Cloud-based or edge-based	Cloud based	**Legacy system compatibility**	Yes
ECOENERGY INSIGHTS	The CORTIX platform is an Artificial Intelligence (AI) and Internet of Things (IoT) platform that offers predictive insights, prescriptive recommendations and autonomous actions to optimize equipment performance and building operations. The platform is technology-agnostic and can connect, control and offer insights on connected equipment across an organization's building network, which could range from hundreds to thousands of locations. Connecting to the CORTIX platform is simple with multiple BMS and IoT connectors available, including an open API for streaming data.		

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Table 34. Product card: OGEMA

Product	Fraunhofer	**Country**	Germany
Market segment	Residential / Commercial / Tertiary	**Markets served**	N/A
Cloud-based or edge-based	Edge based	**Legacy system compatibility**	Yes
	OGEMA (Open Gateway Energy MAnagement) is an open software platform that supports standardized building automation and energy management. The OGEMA platform can be applied in households, commercial environment and industries. OGEMA enables the implementation of individual and needs-based solutions, especially for local energy management. Typical applications are public buildings such as schools or hospitals, commercial enterprises and private households. OGEMA modular concept makes it easy to plan, install, operate and maintain on-site data capture, including connectivity to the cloud. The built-in security mechanisms facilitate secure communication with the energy management system. Thanks to the app concept, measurement data can already be aggregated on site. So only the relevant information from the field of customer privacy is sent. The system allows the function as a gateway to the outside and can thus communicate with other participants in the future intelligent power grid. This allows OGEMA systems to make a contribution to supply stability through communication with the grid operator or to integrate them into a virtual power plant		

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9. Conclusions

The current public report "6.1 Market and stakeholder analysis" investigated the project's commercial landscape – namely Building automation and control systems – looking globally at the market environment (Section 3) and analysing, based on COLLECTiEF's key characteristics (Section 2), the factors to consider for the adaptation of COLLECTiEF's Energy Management solutions and identification of their target markets (sections 4 and 5). The different actors of the complete value chain are also identified, described, and evaluated (Sections 5, 6, 7)

- **Section 2** broke down the COLLECTiEF approach in its main characteristics, these key characteristics: efficiency, connectivity, smartness, and flexibility are the agreed initial set of perspectives to approach this deliverable market research and analysis.

- **Section 3** was a state of the art using the PESTLE assessment methodology, with the aim to understand current trends from a wider perspective to see where the project results fit within their markets. The main findings show that the building industry is going through a transitional phase in terms of digitisation, energy efficiency, and sustainability. Governmental initiatives and economic incentives are measures that are helping boost this transition to grid interactive buildings.

- **Section 4** identified the most relevant characteristics of the market for COLLECTiEF solutions. The BACS market traditionally focused on the management and control of HVAC systems is analysed from the different building typologies that serves. A second analysis is performed in this section to evaluate the market feasibility or readiness for Energy Flexibility in the European Union, with special emphasis on the COLLECTiEF pilot countries (Norway, France, Cyprus, Italy).

- **Section 5 and 6** identify and describe the complete stakeholder assessment of the BACS value chain, with particular focus on the types of customers potentially available to COLLECTIeF's solutions (Section 5: customer segmentation)

- **Section 7** presents a quantitative assessment of 15 successful products that can be initially seen as competitors of COLLECTiEF, this analysis is performed considering the key characteristics of COLLECTiEF with the aspiration to serve as a benchmarking source in the current "development" phase of the COLLECTiEF project.

D6.1 Market and Stakeholder analysis is the first deliverable of the Exploitation Work package, and together with D6.2: "*Analysis of regulatory framework and standardization needs*" give the COLLECTiEF project a full picture of the market environment (as seen in Figure 22). This deep understanding of the potential exploitation landscape will support the definition of the COLLECTiEF exploitable results (T6.3) and adapt marketing, exploitation, and communication strategies to better target stakeholders (not only potential customers, but also sales channels, and other relevant stakeholders along the whole value chain).

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Figure 22. First phase of the exploitation work package. Context, Market environment and Assessment of ERs

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