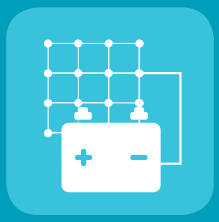
SMART BUILDINGS DECODED



THE CONCEPT BEYOND THE BUZZWORD

BPIE

Main Authors
Maarten De Groote
Jonathan Volt
Frances Bean

Review and editing team
Oliver Rapf
Cosmina Marian
Roberta d'Angiolella

Graphic design
Ine Baillieul

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BPIE HAS EXPLORED THE CONCEPT OF SMART BUILDINGS, THIS SECTION ANSWERS THE QUESTION:

WHAT IS A SMART BUILDING?

A smart building is highly energy efficient and covers its very low energy demand to a large extent by on-site or district-system-driven renewable energy sources.

A smart building (i) stabilises and drives a faster decarbonisation of the energy system through energy storage and demand-side flexibility; (ii) empowers its users and occupants with control over the energy flows; (iii) recognises and reacts to users' and occupants' needs in terms of comfort, health, indoor air quality, safety as well as operational requirements.

THE NEW FUNCTIONS OF BUILDINGS

Mounting challenges for the European Union – climate change, security of energy supply, the volatile nature of an increased share of renewable energy sources, energy poverty, global competitiveness – together with new technologies for the construction value chain, have created a buzz around smart buildings. The buzz also derives from a transformed perception of what a building is. Buildings have just started a journey to evolve from shelters to dynamic habitats with a comfortable living and working environment, a transformation destined to continue. The purpose of this paper is to analyse the concept and provide an answer to one simple question:

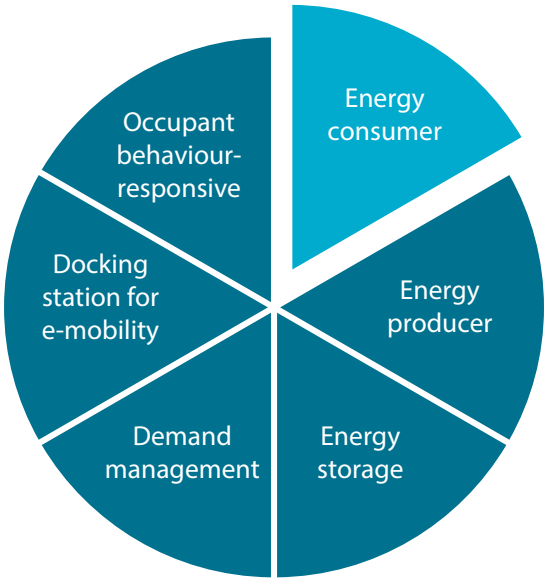
What is a smart building?

To answer this question, it is required to shed some light on the new functions of smart buildings. The nature of buildings' energy use is changing from energy consumers to dynamic micro energy-hubs [1]. While the energy system is transforming, the relevance of the different functions of buildings will change correspondingly. To speed up this transition it is primarily important to fully exploit their energy efficiency potential.

In the energy system, flexibility will be needed for both supply and demand sides. Increased integration of distributed energy (re)sources, renewables and storage and the growing peak demand for electricity will drive the need for more flexibility, demand response capabilities and empowerment of the consumer to further develop an affordable, reliable and decarbonised energy system. Buildings have the potential to drive the flexibility of the energy system, through energy production and control, storage, demand response as well as through an interconnection with electric vehicles.

Besides fostering flexibility, smart buildings enable and ensure, at the same time, a healthy and comfortable living and working environment for the occupants. Smart buildings are better aligned with occupants' preferences (e.g. through connected, interactive and self-learning control systems) and more suited to ensure higher quality (e.g. through monitoring and verification) at a lower cost for the occupant (e.g. by optimising the energy use).

Figure 1 – New functions of smart buildings (Source: BPIE)

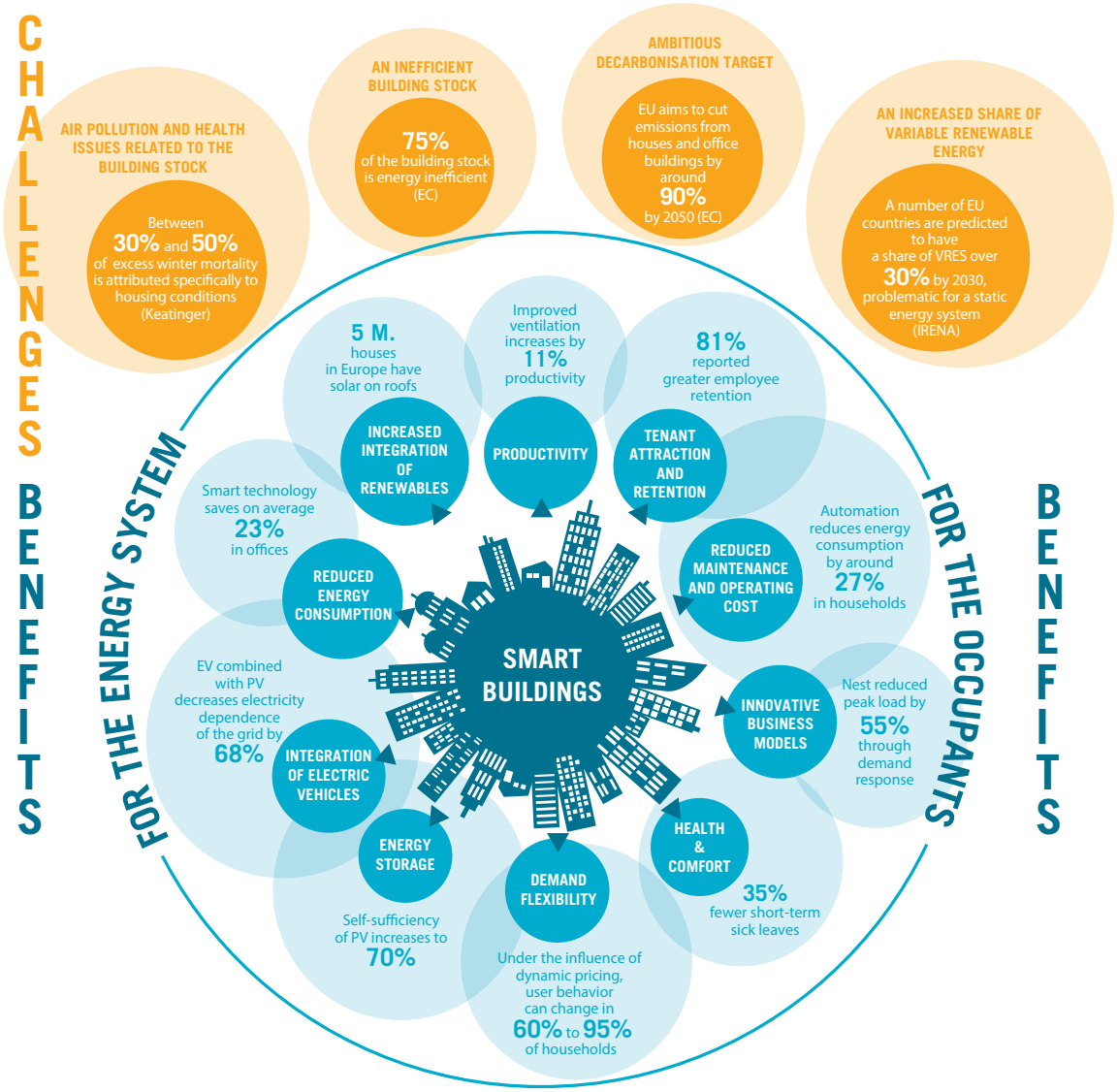


SMART BUILDINGS FOR WHOM?

Two narratives seem to compete to be the 'real' beneficiaries of smart buildings.

1. ENERGY SYSTEMS	2. OCCUPANTS
Smart buildings contribute to the stabilisation of the energy system through storage capacity and demand response activities, enabling a larger uptake of renewable energy and electric vehicles, while decreasing fossil fuel dependency and reducing end-use energy.	Smart buildings enable occupants to optimise comfort inside the building in a favourable way. The occupants save energy and money while having a healthier and more comfortable living and working environment.

BPIE has explored both aspects in previous reports [1] [2]. The reality is that neither of them can realise a successful market uptake without the other. For smart buildings to be interesting to the market, they must benefit both the occupants and the energy system. Occupants will reap the advantages of (i) a more reliable energy system and (ii) smart technologies adapting to their specific needs and preferences, while reacting to an external signal (responsive to dynamic price signals and activation). The energy system will benefit from a more flexible and efficient building stock (responsive to dynamic price signals and activation), balancing the variable effects of an increased renewable energy production. For smart buildings to become a success story the two narratives must be combined.



AN EVOLVING CONCEPT

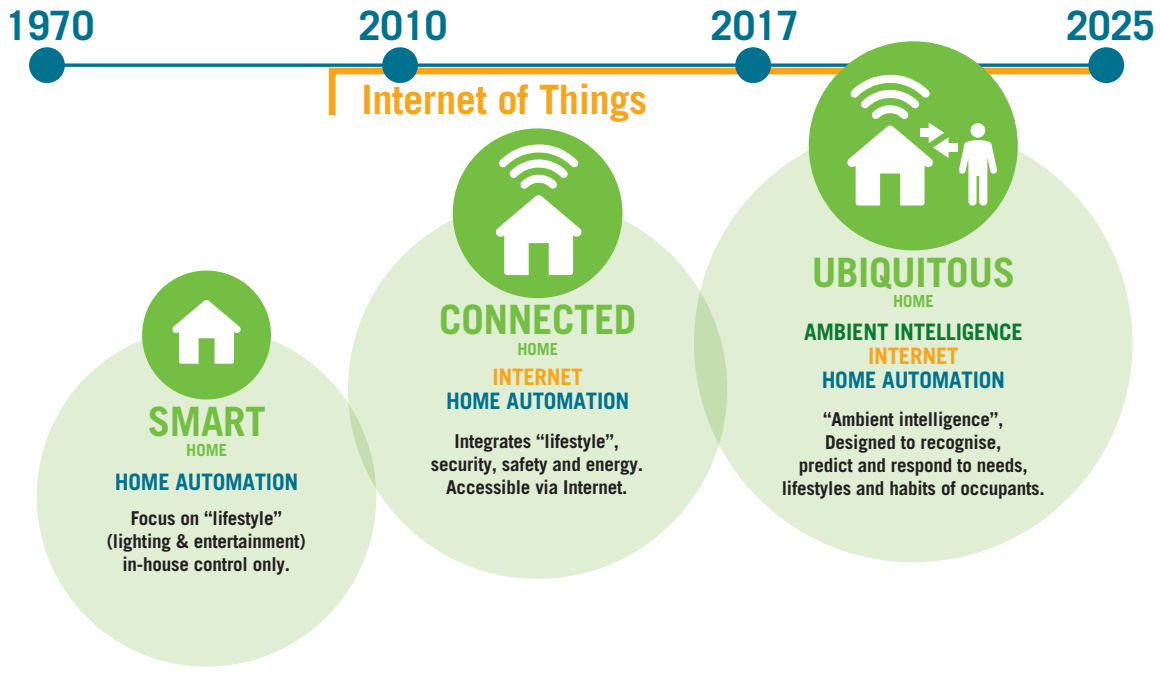
The smart building concept is constantly evolving. It is elastic in its nature and various actors are inserting different components, functions and preferred outcomes into the concept to fit with their perception. At the same time, many existing definitions share central ideas of what a smart building is – interconnected, flexible, automated, energy efficient and comfortable for the occupants.

The attention on smart buildings can be traced back to the early 80s in the USA, at the time the Intelligent Building Institution described a smart building as *"one which integrates various systems to effectively manage resources in a coordinated mode to maximise: technical performance; investment and operating cost savings; flexibility"* [3]. Since then, the concept has expanded due to technological innovations and external events, such as the growing anxiety over climate change, which has amplified the importance of energy efficiency and the awareness around the environmental impact of buildings.

The emerging global economy is shaped by the decarbonisation imperative and by other drivers of change, such as digitisation, automation, mass customisation, servitisation, greater circularity and resource efficiency. These concurrent events are having a substantial impact on the built environment as we know it. They also affect what we need smart buildings for and thus also the concept.

Figure 2 depicts the evolving concept of a *smart home*, with a focus on the progressing level of intelligence. When the concept was launched, the level of intelligence within a smart building was very basic. The intelligence is much more sophisticated in today's (smart) buildings. The next step is ambient intelligence, referring to the notion that the building is sensitive and responsive to the needs of occupants and the energy system. An ambient-intelligent building is also a human-centric building; the building recognises and automatically adapts according to the occupants' behaviour and preferences, and thereby optimises comfort, security, energy use and well-being.

Figure 2 - Evolution of connected and smart homes (Source: BSRIA)



BUILDING ON EXISTING DEFINITIONS

The shared elements of existing definitions are overshadowed by the many differences. The following section lists some snippets of key smart building definitions and highlights related concepts.

Smart Buildings are buildings which integrate and account for intelligence, enterprise, control, and materials and construction as an entire building system, with adaptability, not reactivity, at the core, in order to meet the drivers for building progression: energy and efficiency, longevity, and comfort and satisfaction.

Buckman & Beck [4]

A smart home needs to be a comfortable, energy efficient living space in which consumers can benefit from self-generation of electricity and smart and interoperable appliances which have been designed to last and manage consumption through consumer-friendly smart metering systems.

BEUC [5]

Smarter buildings are well managed, integrated physical and digital infrastructures that provide optimal occupancy services in a reliable, cost effective, and sustainable manner.

IBM Research Collaboratory

Smart Buildings are self-aware and grid-aware, interacting with a smart grid whilst focusing on the real-time demand side response and an increased granularity of controls.

Kiliccote et al [8]

A smart building is the integration of building, technology, and energy systems. These systems may include building automation, life safety, telecommunications, user systems and facility management systems.

Smart Buildings LLC [7]

ENERGY EFFICIENCY
COMFORT
INTEROPERABILITY
SELF-GENERATION
CONSUMER-FRIENDLINESS
RELIABILITY
HEALTH
AUTOMATION
GRID-AWARENESS
DEMAND FLEXIBILITY
RENEWABLE ENERGY
COST-EFFECTIVENESS
PRODUCTIVITY
ANALYSIS
INTEGRATION
SELF-AWARENESS

A Smart Building has a functional, comfortable and healthy indoor environment and its very low energy demand allows for a wide choice of cost-effective, renewable energy sources to be used to fulfil that demand.

EuroACE [10]

[…] the power of buildings to make our bodies healthier, our minds calmer, and our work more efficient. From workplace sensors that continuously monitor air quality to wearables that track your health data, we have more information about the environment and health than ever before.

WELL Building Institute [9]

Smart buildings give us unprecedented insight into a building's performance – at a single site or across an enterprise - by integrating building systems and utilizing advanced analytics in order to monitor, measure and manage the building in the most efficient way.

Johnson Controls [12]

Smart buildings figure out behaviour and behave according to impacts of parameters around it.

CABA [13]

Smart buildings improve the productivity of people and processes by leveraging technology & actionable information to help you & your building make better decisions and become smart, efficient and sustainable.

Siemens [11]

CLARIFYING THE CONCEPT

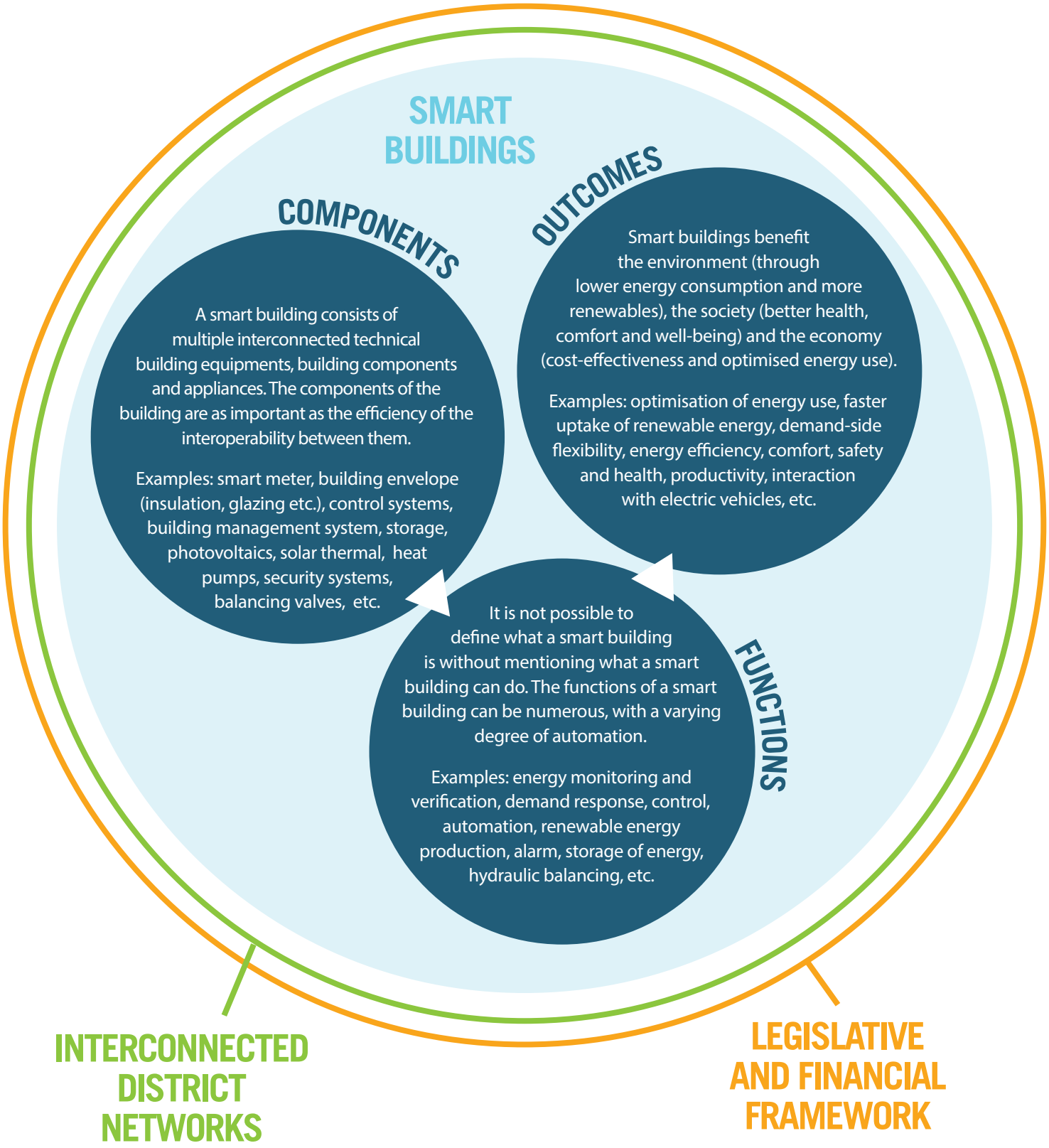
Building on existing definitions of smart buildings together with the findings of two previous reports [1] [2], in which BPIE has explored the concept of smart buildings, this section answers the question:

WHAT IS A SMART BUILDING?

The most fundamental requirement of any smart building is that it is energy efficient and provides a healthy living and working environment for the occupants. For a building to be considered smart, it should encompass additional functions in terms of flexibility, automation, renewable energy production and user-friendly control. How smart a building is depends on the capacity of the building functions and the interoperability of the different components.

Based on existing definitions, a smart building can be construed by its components, functions and outcomes. For example, occupants in a building equipped with a smart meter, energy storage capacity and a control system can engage in demand response activity, leading to a more flexible system. As Figure 3 shows, the effectiveness and societal gains of smart buildings depend on the legislative and financial framework and the degree of interaction within the district system the smart building is part of. Every smart building should be designed based on the occupants' preferences, as well as on regional characteristics (climatic zone, energy mix, building stock, etc.), in order to maximise the potential benefits.

Figure 3 - Components, functions and outcomes of a smart building in a wider energy framework
(Source: BPIE)



THERE IS NOTHING AS STABLE AS CHANGE

The transition to a smarter and more efficient building stock will help mitigate the fluctuating stress put on the energy system and bring positive environmental effects through the reduction of greenhouse gas emissions, social benefits due to reduced energy bills, as well as better living conditions and economic effects through a smarter and more dynamic energy use. This paper decoded the concept of smart buildings, with the aim to clarify its meaning.

While the concept of smart buildings has been around for almost 40 years, there is still much ambiguity about its meaning, clouding the prospect of a coherent approach. One reason is that the discussion often includes confusions between components, features and outcomes of smart buildings. Another reason stems from a perspective bias when different actors define smart buildings. For the concept to be widely accepted, it is clear, however, that it must bridge the benefits of the occupants and the wider energy system.

Smart buildings can fundamentally change the role for the building stock, by including new functions and providing valuable services to occupants and energy systems. What we consider smart today was not imaginable just 10 to 20 years ago. In order, not to lock-in on the wrong technological path, it is essential that the long-term strategy for the building stock is dynamic and encourages new – and even disruptive – business models.

The technology exists and current innovative projects prove that the building stock can become smart within a not-too-distant future [2]. Investing in smart buildings and setting up an enabling financial and regulatory framework would bring real benefits, for the occupants and the wider energy system.

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Buildings Performance Institute Europe (BPIE)

Rue de la Science 23
1040 Brussels
Belgium
www.bpie.eu