Construction Industry

Too smart to use?

How increased user involvement is key to make smart building concepts thrive

Porsche Consulting

Strategic Vision. Smart Implementation.

INSIGHTS

//01

Smart systems are in vain without customer-centric usability

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Stand-alone silo concepts and various external interfaces create a multitude of barriers for potential customers and the success of smart building concepts

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The construction and its supplier industry must finally catch up and align their smart activities to customer needs to make them thrive

//04

Standardization of data transmission and external interfaces is key to increase usability and trust in technologies—and to add more value for the customer

01

The vision of smart

68 percent of the world's population will live in urban areas by 2050; this is the conclusion of a study conducted by the United Nations.[1] In total this will be over six billion people—a huge challenge for the urban environment. It must be ensured that economic, social, and environmental well-being of citizens can be secured over the long term. Technology can make a significant contribution to achieving this goal. Essential to human needs in this regard are the design and optimization of indoor spaces. Therefore, a focus must be placed on buildings that can be described as an urban subsystem, capable of providing much more than just shelter.

A variety of different technologies already exist that could contribute to these goals. Automatic face recognition as access control for buildings, indoor smartphone navigation, closing the shutter by voice control, or the heating system starting operation before the user enters the living area are just a small excerpt of possible smart technologies that can be applied. Does this sound futuristic? It does indeed, even though actualization—despite the market hesitance—is possible, as some facilities have shown in recent years. However, it is not something the average customer or the majority might get excited about—it is nice to have, but often not easy to use. Plenty of apps, different logins, and no interconnection between them. And besides all that, no real savings. The missing spark? User-centric and user-friendly smart building concepts instead of single-supplier solutions. This will lead to significantly more convenient use of the concepts. In addition, real cost savings will be possible through intelligently networked systems and in total increased demand.

The word "smart" is inflationarily used to describe a specific additional feature set—mostly with regard to connectivity and innovative touch to traditional goods—that evolved with the invention of the Apple iPhone and the computerization of these traditional goods in the Internet of Things (IoT) universe. It is customers themselves who influence their individual experience.[2,3] There also exist various smart x concepts for buildings, in which smart technology is used for different purposes like comfort or more efficient use of resources. However, there is usually a lack of user involvement. This is surprising, as users or occupants of a building play an important role in its operation. Increased energy efficiency can only be achieved by integrating occupants, just as the driver is responsible for fuel consumption in a car. User-friendly solutions that that allow people to understand smart systems are required. At the end of the day, technology only for the sake of technology does not make any sense.

From smart to smart—how a word expanded its meaning

"Smartification refers to the digital refinement of an existing product by embedding digital technologies and smart services."[4]

When talking about "smart," it is necessary to ask the question what is smart? In addition, to answer this is not as easy as suspected at first glance. Where in the past "smart" was—among other meanings—used to describe people who are very intelligent or able to think quickly, the term also describes things that have a clean and tidy appearance or attract fashionable and stylish people. However, times have changed; in the last few decades, "smart" more and more describes products (hardware) and software that act and interact in a very handy, modern, and intelligent way. Things even become artificially intelligent. One of the most common examples used to describe this change is the telephone or in particular the cell phone, which is nowadays rarely used in its original sense. The phone became smart, resulting in the new term "smartphone." Since then, it has been used for texting but also to send voicemail instead of calls, has replaced cameras or mp3 players, understands human voice, and gives recommendations and support for whatever people need, just to give a short enumeration. To sum up, smartification can have huge influences and the power not only to change products but also human habits and working methods. Although, this is common sense, individual industries have developed differently.

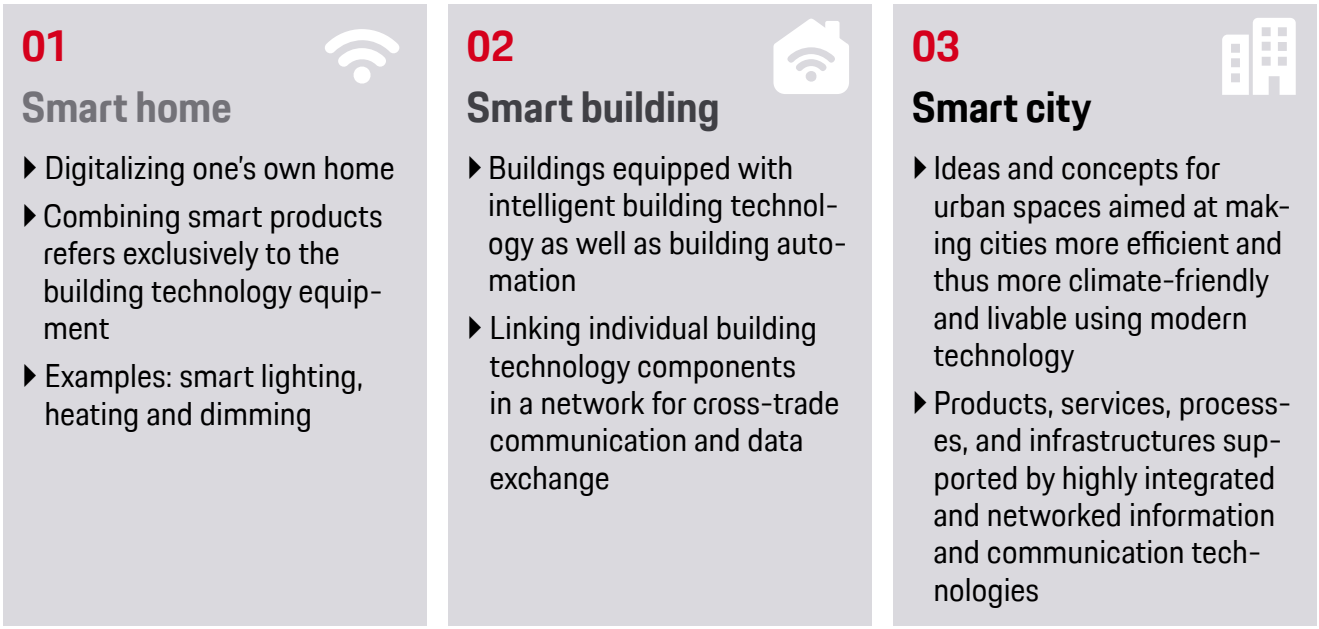


Fig. 1. The development from smart home to smart city

To have a better understanding and to better distinguish between the different smart concepts, a differentiation between the different terms is made in Figure 1. The term "smart home" describes the network of individual computerized machines such as the smartphone to lighting or smartphone to TV connection in a single residence. In contrast, the "smart building" idea aims at connecting an entire building with its users.[5] By that the use cases and user base expand such that synergy potentials might become achievable. Smart cities are created by connecting multiple smart buildings with outside infrastructure. Smart buildings primarily contribute value by growing comfort and optimizing users' time efficiency, as well as the building's environmental impact. For example, checking into a building with your own Google account. This takes place automatically: when the address of the building is entered in the navigation system, on-site preparations—i.e., in the building—start. The building coordinates parking lot availability, elevator and meeting room use and thus anticipates, forecasts, and learns to optimize user comfort and evoked costs. As users link their face data to the account, the face recognition enables the building to not only simplify the entry authorization process but enables the central control system to follow the user throughout their stay.[6,7] The next time this account enters the building, their personal settings are remembered and activated.[8] Lunchtime and favorite dishes, coffee preferences, light settings, and other convenience settings are set. Environmental impact is reduced, as locally sourced renewable energy is used to cover basic energy requirements. Laptops, electric vehicles, batteries, and hot water tanks are charged intelligently to mitigate peak power gains. Essentially, a central, learning and adapting system is in charge to manage multiple users, a variety of demands, and minimize occurring dissonances, useless energy consumption, and defects in the facility. This opens new use cases.

A meeting room can be overbooked. Smart buildings can, not only by optimizing booking requirements but also by enabling free space configuration with, for example, in-ceiling stored furniture, significantly increase flexibility. All these potential technologies are smart and promising, but they also need to be deployed in a targeted and user-friendly way. It is the user who must be targeted to demand smart buildings and who needs to be willing to pay a price premium, for the investor to see upside potential when realizing the concept. Demand drives investment. Thus, it is the user who must be targeted first. However, other industries are several steps ahead in aligning their smart activities to customers' needs and, hence, there are many concepts and ideas that can be transferred. Furthermore, new competitors are pushing into the market with the idea to gain data

sovereignty over data retrieved from building components. These new players strongly focus on fulfilling the wishes and demands of the users. The resulting real smart products and services will grow rapidly and bring risks but opportunities at the same time.

The technologies of the smart home form the basis, followed by their use in smart buildings; the next level is the smart city. The smart city connects multiple smart buildings, thereby making optimal use of all available interconnected information to increase and improve the optimization on a citywide basis. This includes aspects such as traffic and transportation, waste reduction, safety improvements, automated urban farming, public internet, and network connection, energy optimization, and others to improve living quality and public well-being. Here, the whole city, not only the individual buildings know and support members of the public. Infrastructure then connects to the personal data, which some technology companies have already collected for their services today and build their growth on. This creates huge upside potential for participating enterprises.[9]

The following paper deals with the degree of development and implementation maturity of smart components in the construction industry. The aim is to create a common understanding of the current state of developments, as well as the challenges that need to be overcome to fully exploit the added values of the technologies. To this end, a basic understanding of the smart vision will first be provided, followed by a discussion of implementation to date and application scenarios in the construction industry. Based on this, possible reasons for the construction industry's lagging behind other industries to date will be listed. The fields of action and challenges derived from the analysis to date result in a final evaluation that makes concrete recommendations for action to drive the market for smart concepts in the future. The paper is intended to serve as a guide, especially for companies developing smart concepts, to show them how greater value can be delivered with their products and how silos in development can be broken down. In addition, investors and regulating authorities are also addressed. Through the earlier involvement of the users and customer centricity and the introduction of standards, smart concepts can be used in a meaningful and targeted manner. The previous white paper, "Smart Building as a Service," defines five steps as a guide for the transition to smartification. In this paper, the focus is on the importance of a user-centric approach in developing systems that are not too smart for the user to understand.

02

From vision to reality

Fig. 2. Smartification opportunities for different stakeholders from a micro and macro perspective

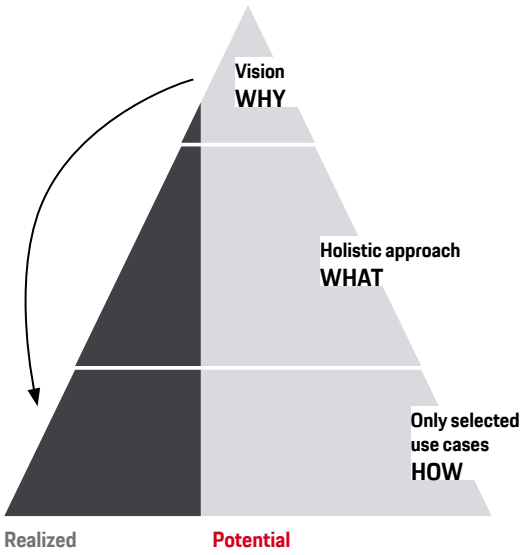
As outlined, smart buildings and smart city concept provide multiple opportunities. Figure 2 classifies them into the different stakeholders. From the micro perspective, smart solution customers such as project developers and investors can reduce the risk of rental price reductions by optimizing user needs in building layout, organization, and maintenance, so that all facilities continue working perfectly and spaces always have a high occupancy rate. In the short term, usage data also enables optimized maintenance and reduced management effort, as the building automatically reports individual status news. In the long term, the fully integrated sensor technology makes it possible for investors to collect detailed data and user profiles in the building, and by that, transform from pure consumers of digital solutions into sources of digital information for future projects. In the process, customer profiles can be precisely defined.[10] Additionally, smart buildings might enable new payment and monetarization schemes. Data collected can be monetized by making it available to third parties.

From a user standpoint, using facilities during low times, such as nights, might be priced differently than in peak times. This creates a win-win situation for investors and users. Additionally, smart buildings optimize on user experience, comfort, and efficiency increases so that waste is minimized. A highly promising market exists, coupled with a wide user base for smart building solutions.

From the macro perspective, smart buildings are anticipated to decrease overall energy demand and thereby make a significant contribution to world climate targets, as housing EU-wide accounts for about 40 percent of energy consumed and 36 percent of greenhouse gases.[11] Affecting both the macro and micro perspective, generated data could for example benefit variable insurance policies. However, despite the enormous upside for various stakeholders, these visions have not been realized. The status of smart buildings is dominated by hesitance. According to The German Association for the Digital Economy (BVDW), this results from a low perceived marginal value added, a lack of expertise, missing system interconnection, and regulatory burdens.[12]

The as-is situation, as visualized in Figure 3, is much more diverse compared to the existing smart city vision. While the smart city vision as a future scenario is already being widely applied, the transitional stage of smart buildings is more difficult and there is a long way to go to the target situation.

> "We spend a lot time designing the bridge, but not enough time thinking about the people who are crossing it."
>
> **Dr. Prabhjot Singh**
> Director of Systems Design at the Earth Institute



Current situation

- Lack of widely shared and accepted visions and upside potential offered to various stakeholders
- Unclear why society requires smart buildings—for what pur pose?
- Lack of technologically mature, holistic solutions
- Silo thinking of marke participants results in multiple individual applications and no central optimization tool or data pool
- Cost-intensive pilots—tangibility and understanding
- Different technological maturity states depending on perceived importance of use cases
- Examples include security, heating, ventilation, air conditioning, and lighting
- Use cases are not connected with each other

Target situation

- Holistic, superordinate concept/system with functioning interfaces between the individual components.
- Functions geared to society—user centricity
- Technical maturity and holistic solutions
- Comprehensive, general technologies must be available
- Modular system for individual adaptations to stakeholder needs, no tailor-made solutions
- Technical maturity of the individual systems
- Networking of the individual use cases for interconnectivity and exchange
- Implemented standards

Fig. 3. Comparison between the current and target situation

First, smart buildings have not yet reached every participant here and have only limited prominence. For most users the purpose remains unclear. Existing solutions and projects place the investor and external perception first and users second. Thus, only a small part of the overall vision is aspired to and realized. There is a lack of understanding and a lack of utility brought to the table with regard to upside potential offered to various stakeholders by connected smart buildings at present.

Second, there is only limited focus on holistic solutions. A few cost-intensive exceptions and prestige projects are worth mentioning here. Those projects are the first cost-intensive pilots of a normally silo-thinking market. Even in some of those pilot projects, individual enterprises tend to offer a total package instead of specializing and collaborating. Despite these pilots, the implementation and especially the scope of implementation of smart buildings is very limited. It seems that the opportunities offered by smart buildings have not yet reached the critical masses of users. Technology currently is specifically tailored to individual buildings.[13]

Third, the focus is predominantly on individual applications. Due to the lack of a holistic approach, only a small number of possible use cases are realized. They are considered in isolation, even though the user only gains added value through the combination. Heterogeneous stages of technological maturity indicate the perceived respective need for specific use cases today. Depending on the perceived importance, systems such as alarm, security, or fire extinguishing systems often represent the highest degree of technological advancement and sensor connectivity in buildings. Systems of lower perceived importance, such as energy management or lighting systems, can therefore be classified technologically lower.

Overall, four stages of technological maturity are present:

- Non-digitalized (passive)
- Digitalized (with sensors)
- Internet-based (linked / connected / remote control)
- Smart (self-learning / optimizing / gapless / ecosystem)

"Digitalized" represents the first usage of technical facility equipment, such as electrical sunshades. "Internet-based" aims at systems that allow online remote control. Those systems also track and save activity and data around the facility. In addition, smart systems and especially interconnected smart systems use this data to learn and adapt to user behavior and optimize user comfort. Data is not only sourced locally but also shared with other smart buildings and infrastructure

to create a gapless interconnected network to optimize not only user comfort but energy usage and other parameters. An ecosystem is built. More information regarding this topic will be provided in the 2019 white paper "Smart Building as a Business."

But why do obstacles to implementation persist when intelligent concepts can provide solutions to a wide range of challenges? The reasons for hesitance in the smart building market can be segmented into four fields as shown in Figure 4. When considering the fields, their connection is decisive. Like a SWOT analysis, fields can stand individually, as well as in conjunction with the respective adjacent fields. The user as the market driver is central to this approach.

01
Cost/usage relationship
Perceived value added and focus on existing solutions

03
Social component
Acceptance, enthusiasm, demand, understanding, and ability to integrate smart building after construction

02
System communication and integrability
One-stop shopping and technology silo thinking

04
Outside factors and regulations
Data security, privacy rights, and climate and energy usage regulations

Fig. 4. Four reasons for missing smartness

First, there is the cost/usage relationship. While the first movers in limited pilot projects are already taking advantage of the wide-ranging comfort benefits thanks to their openness to technology, only a few smart buildings are being planned and calculated, even for today's office buildings, due to a lack of demand from users, and therefore ultimately from investors. The perceived marginal added value of existing solutions is therefore not sufficient. This in turn can be attributed to two sub-factors. Either there is too little knowledge about the existing solutions, there is a lack of actual solutions, or it is a combination of both.

Focusing on the second field, enthusiasm and acceptance drive the cost/usage relationship. Here, current solutions are not sufficiently visible to the user. It is not a normal day-to-day activity to interact with smart building systems and facilities. Lack of exposure makes it difficult to build trust and thus enter the collective understanding of buildings and their use in society. The fact that buildings should be smart and must be smart is not yet anchored as a shared assumption. At the same time, the significant objective benefit of smart buildings is divided among several participants. However, since the user does not have the lion's share of this benefit, his or her demand for the technology is consequently also limited. Thus, acceptance and enthusiasm can be concluded to be crucial hurdles. To change that, potential customers need to experience a fully functional lighthouse. In the context of this paper, the term “lighthouse” is used as a synonym for a

building or concept that is the basis for a mass application. For differentiation, however, the pilot is merely a first step or use case with increased integration effort, significant costs, and a pull effect on the customer side. A lighthouse makes the next step towards the finished product. As mentioned above, it is a matter of trust and feeling comfortable as users spend most of their time in or with the respective technology. No previous interaction or contact significantly reduces the likelihood of purchasing smart building systems. The perception of a running, finished, easy-to-use product then pays dividends to the social component. Faulty, complicated systems, however, prevent a gradual social development and shift towards smart building technology.

Moving over to the third field, there is no overarching understanding and system that users expect. Current systems use different communication standards, which makes it difficult to connect them, i.e., a holistic smart building approach, and involves higher costs. Systems vary in ISO standard, network technology, encryption, and authentication features. The first attempts to pursue this holistic approach of uniform communication protocols have been made. Examples include KNX, EIB, BACnet, ZigBee, and EnOcean.[14] Nevertheless, different protocols and technologies are still in use here, as shown by way of example. Even the few pilot projects in which smart total solutions are offered come from a single source as a complete package instead of individualized special solutions and the combination of a variety of different systems. Examples include the DSTRCT.BERLIN project, which is currently under construction, THE EDGE in Amsterdam, cube Berlin, and Crystal in Oslo.[15,16,17] DSTRCT. BERLIN, an office building, provides its users with on-demand information about space availability, air quality, temperature, and lighting, and adjusts to the preferred settings of the respective user to maximize user comfort. Moreover, the HI.DSTRCT app keeps the user updated on events, lunch options, and sports programs offered in the facility. In a similar fashion, THE EDGE connects users based on a customized app. In addition, the building optimizes its energy consumption based on energy input by the sun, people, and outside temperature. In the ideal case, based on utilization data, the facility automatically cuts down on space available for users to save costs of climatization, cleaning, and rental fees. Focusing on climatization, panels with water pipes work as sunshades in the summer months. The hot water is then pumped into a central water tank with high-quality insulation, which serves as a buffer, about 120 meters below the surface. As temperatures fall, the water reserves are then pumped up and utilized in the heating system.[18] Thereby natural resources, which would otherwise not be utilized, are used ideally. The lean concept is expanded as waste is reduced. Similarly, both buildings increase user comfort when it comes to arrival and departure. When arriving by car or bike, light navigation to available parking spots omits the search. This multitude of intelligent technologies and associated added values should complement and expand each other and not represent isolated silo solutions. Another impediment is the installation timing. Highly networked systems should already be considered by the planner in the planning of new buildings. At the same time, even if the first solutions for this keep emerging, retrofitting such a system in existing buildings, the majority, is associated with high expenses.[19] Both aspects put pressure on the user's benefit and thus on the cost/usage issue. Contrary to the effect of field three on two, there is also a connection from two to three. Thus, not only does the lighthouse drive social acceptance, but social acceptance also drives the need for a lighthouse. Thus, with an initially high user and thus customer demand for such networked technology, the market would have followed this demand. However, this amplification effect is not currently being applied.

The fourth field is used to support the first three. Standardization of data transmission and external interfaces could be achieved through regulation if this does not occur naturally through, for example, open interfaces. At the same time, regulation makes data processing and storage, as well as the sharing of data with third parties, more difficult. It is unclear what data may be collected and in what form. In addition, regulation has a confidence-building effect. Failure to regulate does not take advantage of this potential.

The history of smart (building)

Smart building, building information modeling, and the Internet of Things are closely interconnected. Originally, the smart building concept started with the Internet of Things idea in 1999. However, some argue that as smart building requires various preconditions such as the Internet itself, computer development, and network connection, the concept has been around for a longer time and the starting point must be located earlier.[20,21] The first time the term "intelligent building" was used was in the US, to describe the City Palace Building in Hartford by the Building Systems Company. The next intelligent buildings followed shortly after that, in New York, Dallas, and Washington, D.C. Intelligent, at that time, included a fiber-optic network that connected heating, ventilation, lighting, transportation, security, fire protection, and, most important, telecommunications and electronics to a central basic computer system.[22]

The IoT development is enabled by sensor technology, web-enabled hardware, and the automation of devices. Following this further, harvesting data with multiple sensors and IoT-enabled devices then made it possible to take the next step.[23] Thus, the development went from information and communication technologies to building information modeling, the IoT, and, combining all of that, to smart buildings.[24]

Smart in the real estate and construction industry

The real estate and construction industry uses smart in many ways. This begins with the start of a building life-cycle in the phases of developing and planning where word combinations like "smart planning" describe new ways of how architects design buildings. Moreover, during the construction phase, new technologies find their way to the sites and new terms like "smart construction" describe the industries' digitalization in general.

On the other hand, with a share of about 80 percent, the use phase of a building is not only the longest period but also the area that generates the highest costs in financial terms. For this reason, this phase seems to be relevant to consider developments in connection with smartification. While 5 on the left side shows the four main life-cycle phases of a building in total, the right half shows how the use phase can be further subdivided.

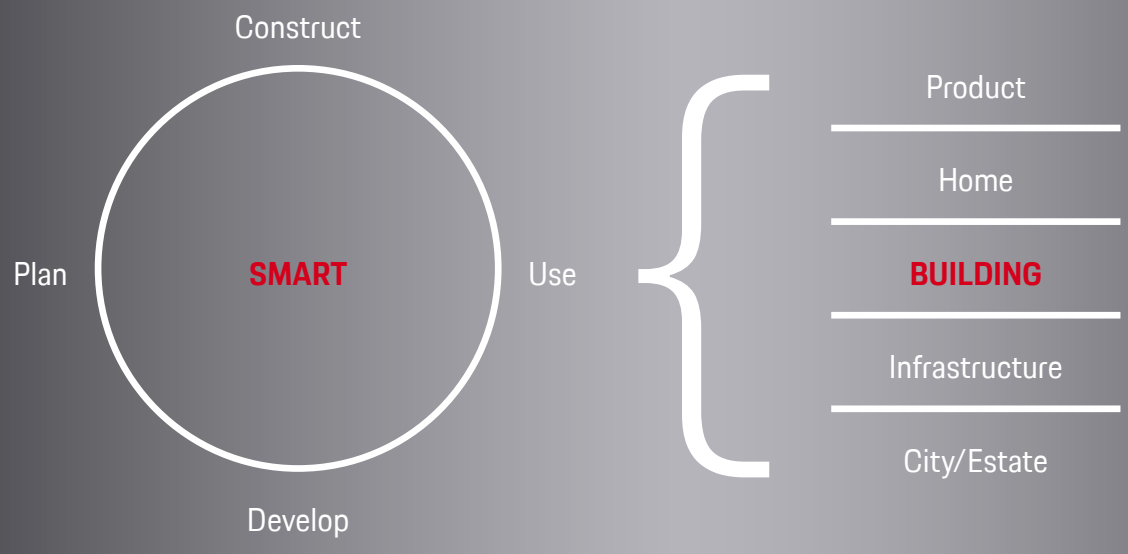


Fig. 5. Smart in real estate and construction industry

At the simplest and highest level (of development), these are smart products. A smart product is characterized by the following: the user usually purchases, installs, and subsequently uses it. The resulting advantage is that the product manufacturer generally knows the user's needs very well and develops products directly to meet these needs. Overall, this results in fewer interfaces or possible loss of information, which in turn means that many different smart products are available on the market. These include, for example, remotely controllable LED lamps or lighting systems, intelligent sockets, cameras that can be observed remotely or online, or programmable shutters. While the individual products normally function flawlessly, the unregulated and non-standardized market creates the problem for stakeholders that there is little or no cross-product communication. Although internal manufacturer product communication works in most cases, cross-manufacturer communication can be difficult or impossible.

The use of several smart products in combination represents the transition to a smart home or smart building. Smart home, however, is limited, as the name already suggests, to smartification in the home. Common smart home applications include the automatic control of lighting, heating, and dimming depending on wind, weather, and time of day. The term smart building, on the other hand, refers to all other buildings and real estate, which creates another special feature compared to the smart home. This is because, unlike residential property, the actual user of smart buildings is not the owner and therefore not the customer of the product manufacturer. In addition, smart buildings often use significantly more smart products and associated sensor technology, which makes planning and installation more difficult. It often means that several specialized planners should be deployed, ideally in the design phase or at the latest in the planning phase. In addition, smart buildings generally must comply with higher legal requirements, for example in data protection, than is necessary in the private area of the smart home. At the same time, however, it can be stated that with increasing networking, the ease of operation and use of the respective building increases, and further advantages arise from the use of the data generated in this way—in the sense of continuous optimization of the operating phase by evaluating the individual interactions.

Similar approaches are also being pursued in the field of infrastructure with smartification, creating smart infrastructure. The difference from smart homes or buildings, however, is, apart from the usually much larger area, essentially the increased number of users, which at the same time is constantly changing. In addition to human users, smart infrastructure also includes bicycles and e-scooters, but also cars, buses, trains, ferries, ships, and airplanes as users.

If the smart infrastructure comes together with smart homes and buildings, smart cities emerge—a complex interaction of countless actuators and reactors, which currently cannot be handled in total due to the diverse (data) interfaces. There is a lack of legal guidelines and standardization. As a demarcation to the smart city, the smart estate also represents the interaction of smart infrastructure with smart buildings, but in the private sector (e.g., residential quarter or company premises), which generally makes it easier to agree on a uniform system due to clear organizational and disciplinary regulations.

03

How to adjust reality and achieve benefits

Now that the hurdles of smart building integration have been analyzed, some possible solutions emerge. However, a change in the overall market is elementary. The core is to maximize user comfort in the most environmentally sustainable fashion. That is the purpose of the smart building and city concept. This requires a holistic, inclusive approach where the network of connected use cases is extended. How this is reached is detailed in the paragraphs below.

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Required market adaptations

Initially, the effect of this gradual change in the whole market is visualized in Figure 6.

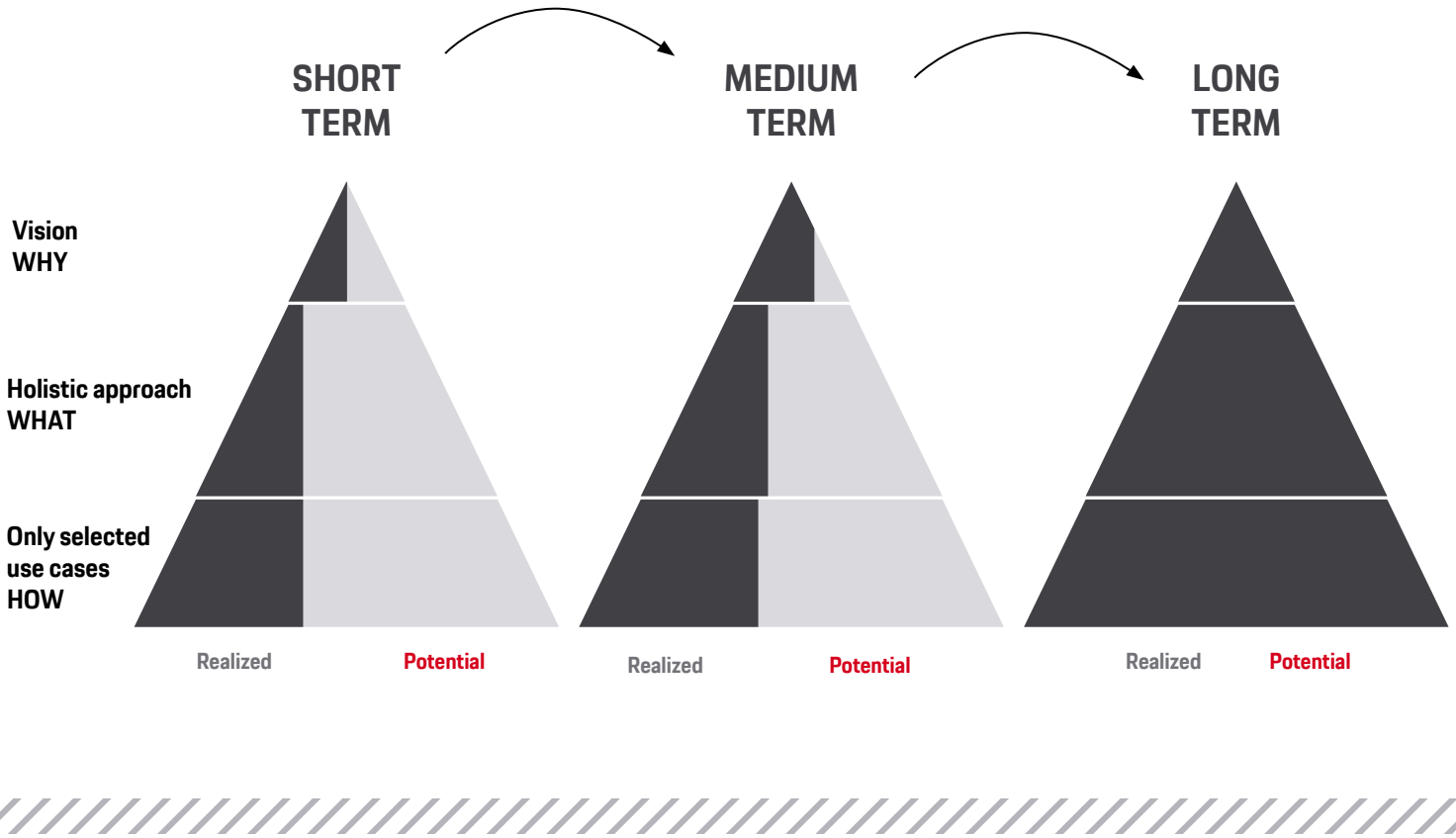

Fig. 6. Situational changes from short term to long term

In the short term, it is necessary to work out a vision. This is the basis of the concept. It is necessary to influence the why as well as the why for the user. Based on this, a change in the overall market will result over a time horizon. So why should users demand smart buildings? However, this vision does not change the holistic nature of the solution, nor does it result in any direct new use cases.

In the medium term, however, these two points will follow suit. The vision is becoming more and more detailed. Concepts such as smart building have been accepted by the market and the realistic goal of a smart city is in sight. Now the solution offerings are following suit. Providers are working on holistic platforms and solutions that are in line with the vision. The combination of existing use cases in a lighthouse results

in new ones. The added value created for the user and the customer grows as they are more in the focus. This answers the question of how the vision is achieved. Lighthouses make smart building tangible. The user and the customer can actively experience their moment of truth. No longer do isolated users proactively want to have such a system. The task is to convince the users through real added value.

In the long term, all levels of development are converging. More holistic, integrative solutions are established on the market. The self-evidence of smart building solutions, and the change from a push to a pull market, leads to partnerships and standard setting. This significantly broadens the corridor of possible use cases. In the outlook, the smart city concept is targeted. The first buildings will begin to communicate with the infrastructure and other buildings. This again creates new use cases.

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Actions by individual market participants

The central question for companies, however, is whether these aspects can be significantly influenced and implemented through independent action in the medium term. A distinction must also be made between this and long-term solutions, which are characterized by further technological development and changing boundary conditions. Solutions and possible reactions to the hurdles mentioned in Chapter 2 highly depend on the respective time horizon, which is visualized in Figure 7.

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Lighthouse vs. pilot

For this paper, a clear differentiation between a lighthouse and a pilot is required even though no widely accepted clear boundary or definition currently exists. The distinction between a pilot and a lighthouse is their technological maturity. A pilot is a first step or use case that can be understood with increased integration effort, significant costs, and a pull effect on the customer side. A lighthouse is more. While a pilot only addresses the needs of a single customer on a one-off basis, a lighthouse provides the basis for a mass application. A lighthouse takes the next step towards the finished product. However, no previous pilot is required to construct a lighthouse. The other way around, pilots do not necessarily transition to lighthouse applications. Technological advancement, ease of use, and scalability are decisive. It generates an initial understanding of the system in the customer's and user's head and remains in the user's mind. The user now knows that such a system exists, what it can do, and what added value it offers him or her. A lighthouse can create a single moment of recognition or truth from the customer's and user's perspective.

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Experience ability

Central to all solutions is the ability to experience the product as a user like in the lighthouse. As already illustrated in Chapters 2 and 3, to break down the core of the problem, greater user integration is required, which then goes hand in hand with trust-building and social change. In summary, a functioning lighthouse is essential.

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Intensity and degree of required action

But what can be done to change the aspects already considered and initiate change? Figure 7 shows the market participants relevant for successful implementation broken down by time horizon. The color gradation from gray (low) to red (high) symbolizes the need for proactive action to make the smart building concept a success, or to avoid being displaced by other market players and to realize further potential in the growing smart building market. The "high" classification indicates that there is urgent need for action. Not acting could result in severe negative business implications in the near future. To avoid that, actions must be taken now. The "medium" classification implies that there is a need for action. However, in this case, either the negative effect is lower or the firm can prepare to turn away those negative effects for the near future. The "low" classification indicates that there is a need to support other players, execute and take care of existing solutions, react to the market, and prepare for new technology and innovation to avoid increasing need for action. The timeline is divided into three parts. The development phase is seen in the short term. In the medium term, it comes to the integration phase. Over the long term, there is an extension phase for mass usage.

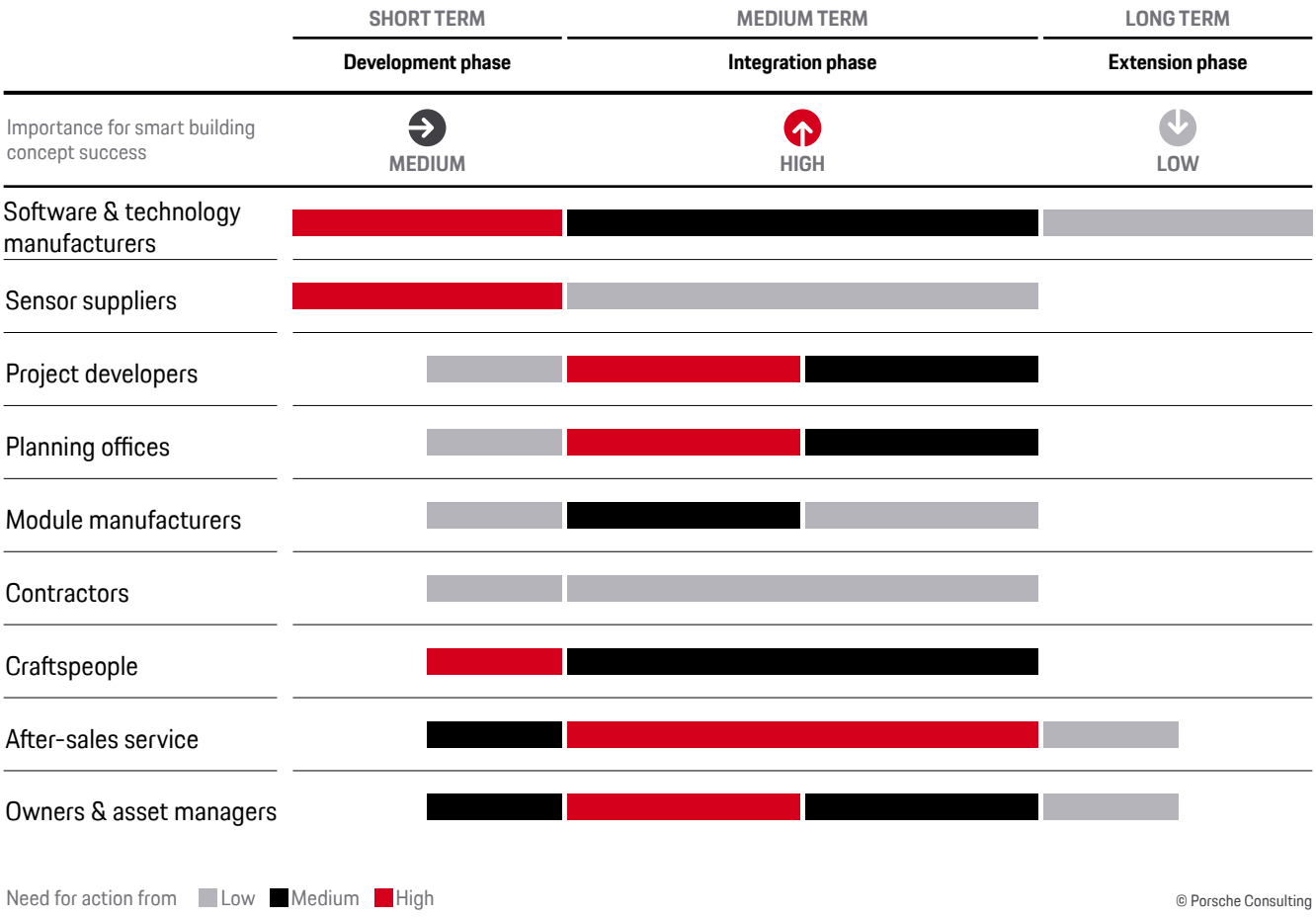


Fig. 7. Need for action by segment and time horizon

Short term: Development phase

Open systems, established technology, technical partnerships, lighthouse requirements

In the short term, neither the cost-benefit ratio, nor the regulatory framework, nor social acceptance can be influenced directly and sustainably by an individual company. Of course, the prices for such solutions could be lowered, but this would have a minor impact on the current reluctance. A customer is unlikely to buy a product just because it is now cheaper if the added value remains unclear. Thus, companies should focus on the technical aspects, system functioning, and interconnectivity.

Here, it is crucial to offer an openly accessible, easy-to-work-with system. Third-party companies should be able to connect their applications, sensors, and devices directly to this system. Companies need to integrate solutions of other companies into their offering. Partner companies might offer sensor technology or other software tools. Two applications together are more than one plus one, as the customer or user just gets output from the combination of devices and systems and not from the individual system or device. Through a clever choice of partners, a more potent solution can be found. In addition, the system should be usable and controllable with existing devices that are set for the customer. A smartphone application and connection can be mentioned here as an example. The established device is used to make the new technology feel less different or new. Existing basic trust in known technology is used and transferred to smart building solutions. This creates a foundation for further acceptance in the long term. All this, in turn, should be considered in a future lighthouse.

Medium term: Integration phase

Lighthouse set-up, integration partnerships, first implementations

In the medium time frame, a functioning lighthouse must be created according to the specified criteria catalog. A functioning, well-made lighthouse is, as previously described,

the decisive first impression of the customer or user with the smart building technology. Users must understand why they need smart buildings. What problem does the lighthouse solve for the user? The first criterion of this lighthouse can be based on the characteristics of smart products that are already in use. For example, clean, simple, understandable, and visually appealing. In addition to the lighthouse itself, integration partnerships and the resulting initial implementations are crucial. It is important to convince society. Through partnerships, for example with hotels or employers, many potential customers and users will be directly exposed to the system within a short time. For individual enterprises, this also has a branding and positioning effect. It might add an innovative or premium touch to some solutions or brands. Brand equity could be built. An alternative approach could be to open pop-up stores or exhibition boxes in shopping streets. All this starts a social change, and the market starts to become wider. As a company, the right choice of partner and positioning is crucial here. It must be examined whether and how a vertical integration along the value chain towards customer proximity can be possible. In addition, there is the question of how cooperation with corresponding partners should be designed. Especially due to the system openness, a wide variety of competing models of, for example, sensor technology or platforms will push onto the market. Companies should also plan for monetization, for example with shared revenue models, and the resulting limited distribution of market power to prevent possible constriction.

Long term: Extension phase

Platform, single point of interaction, industry standards

Between the integration and extension phases, market leaders establish themselves and the overall market begins to consolidate in some areas, such as software. Users and their data accumulate at a single point of interaction. Now two scenarios are conceivable. Either the platform takes over the entire product, technology and sensor distribution or the platform is offered to original equipment manufacturers (OEM) of smart building sensors and technology as a customer interface. Monetization models ranging from pay-per-user to leasing or purchase are conceivable here. In the first case, only one platform is visible to the user, which can establish industry standards for all other market participants. From the point of view of a company that does not provide the dominant platform technology, price pressure might increase. This price pressure can be countered from two sides. Either through price leadership, in other words, low production cost and high volume, or constant product innovation, i.e., a more premium positioning. The exact reaction again depends on the initial positioning and core capabilities. An alternative approach depends on the visibility of the product to the user. The more visible the product, the more likely a shift in bargaining power towards the manufacturer appears. The customer is asking for it, so the platform must deliver. In scenario two, like scenario one, the manufacturers' margins will come under pressure. Even if several platforms still exist in the medium term and the situation for OEM thus appears relaxed, they will come under increasing pressure because of market consolidation. The formerly low fees for the use of the established platform then increase. At the same time, the customer and user will be able to choose from a variety of sensor and technology providers and will not be satisfied with a single, possibly less established, platform. In both scenarios, early participation in the platform or the creation of direct customer visibility is crucial for the later positioning and scope of action of OEM. Subsequently, based on open system communication, industry standards will develop, which will also be included in the regulatory framework. Over time, most buildings will become smart buildings.

Finally, the exact positioning and reaction approaches are subject to value chain positionings, market participant size, and bargaining power distribution. Software or sensor suppliers face other challenges and need to proactively drive the topic in other phases compared to, for example, contractors or module manufacturers. Also, the individual financial situation and importance for the local economy of the companies is decisive for future action.

3.1 Views from individual perspectives

SOFTWARE MANUFACTURERS

Software manufacturers must be proactive right from the start. A backbone is needed for further developments. Software manufacturers must therefore create an accessible platform. The current lack of solutions thus also offers new companies opportunities to offer their solutions. However, the selection of partnerships is crucial, as is the universality of the solutions offered. For established software manufacturers who may be entering this market from other areas, the question arises as to whether this should be done organically or inorganically. What are the most promising start-ups? Which business case is the most convincing? How should integration or collaboration proceed in the inorganic case? What are the stumbling blocks? In case of organic development, the shaping is interesting. Will the development be driven in a separate company with its own spirit? Does the lean start-up approach apply? What is the process towards the minimum viable product? How can the core competencies be ideally applied?

SENSOR SUPPLIERS

Manufacturers of current technology, especially sensor technology, are also in demand in smart building. It is important to participate in the design of the lighthouses and to keep the sensor technology compatible with the software solutions. In addition, it is necessary to examine whether a stand-alone solution is feasible and what it could look like. In the medium to long term, the market for sensor technology will become more and more competitive. Most sensor technology will then be developed, and economic growth will then increasingly depend on individual positioning. However, the big changes will have taken place in the short- to medium time horizon.

PROJECT DEVELOPERS

Project developers drive market penetration. In the first phase, they are responsible for providing information. What solutions exist? How can they be implemented and what added value does their integration offer? Here, project developers must empower themselves. This helps them during the following middle phase, in which users must be informed and persuaded to use the systems. The keyword here is “nudging.” At the beginning of the middle phase, the role of the project developer is crucial for the success of the concept. Once the critical mass has been reached, demand becomes more and more self-sustaining. This determines how long a project developer must make increased active efforts.

ENGINEERING COMPANIES

The different planners follow the project developers. Engineering and design companies must follow their requirements. Project developers are in the customer position. However, project developers represent only a part of the customers from the architect's point of view. This is the reason why engineering companies must answer the same questions as project developers. They have the same tasks—information responsibility and nudging—and the integration of such systems into the design of the respective building. This results in the same need for action as for the project developer. What partnerships might be of interest? Are there standardization elements? How can the position as an engineer or designer in the value chain be secured in the long term? Which niches arise?

MODULE MANUFACTURERS

In the short term, module manufacturers have only limited obligations. In the medium term, however, they have a much greater obligation. As a supplier of standardized units, mass production can thus be used to install networked technology at potentially low cost. This can create a win-win situation. Module manufacturers will have the chance to develop a unique selling point through sophisticated technology and to strengthen their brand, for example in terms of innovativeness. Brand equity can be developed. On the other hand, the user has the pleasure of such a technology due to the price advantage it offers.

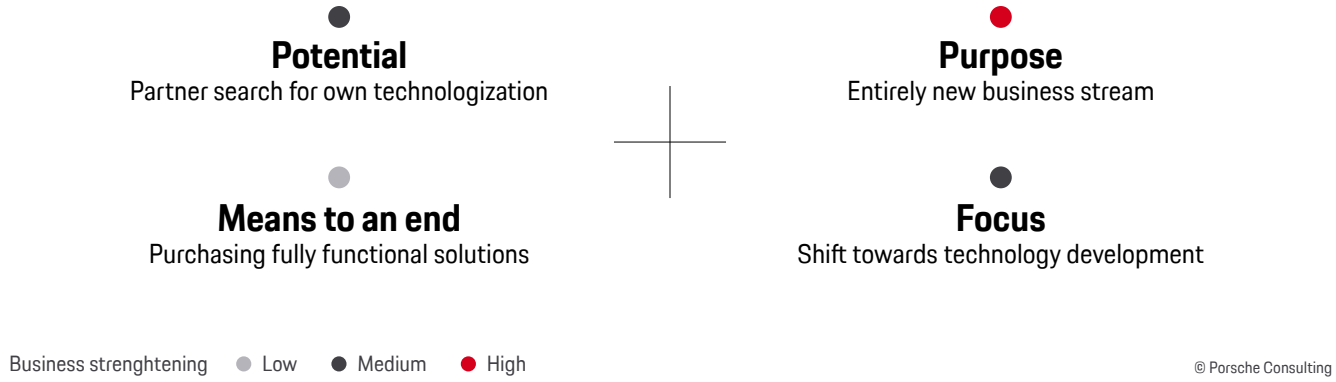


Fig. 8. Manufacturers' reaction options

In Figure 8, different ways for action are clustered based on their impact on strengthening the business. While the purchase of functional solutions does not represent a hurdle for the product in the long term, i.e., the presence of a smart building solution does not deter the customer from buying, this solution only has a low potential. However, it is important to identify the right solution. What is important to customers? Which solution will last? How can individual manufacturers make unproblematic adaptations to their production? Alternatively, the module manufacturer can decide to realize unrealized potential in the area of smart building through suitable partnerships along the value chain. Expertise that is not yet available can thus be built up within a short time. The right strategic partner must be chosen. What form of cooperation is recommended? Based on which criteria should a selection take place? Another approach is an integration of the company's own technology development. Here, parallel partnerships are a good way to facilitate access to the latest knowledge. The company's learning curve is accelerating. How can the learning process be formalized here? How can external know-how be ideally harvested? What is the positioning implication of this decision? The most profound change is caused by the strategy adaptation.

CONTRACTORS

Contractors have an accompanying role. They must be prepared to install the appropriate systems. They are closely linked to craftspeople.

CRAFTSPEOPLE

Craftspeople or installers must initially rely on their own competence. From their point of view, the ease of installation as well as the retrofit ability of smart building systems is crucial. In direct customer contact, they must convince both existing customers and new customers of smart building. Their core competence—the ability to interface between customers and manufacturers/solution providers—must be included. Should the craftsperson specialize in smart building systems? Does it make sense to offer after-sales service as an integration? Does the craftsperson have a gatekeeper function? What role does the craftsperson play in sales?

AFTER-SALES SERVICE

After sales service, i.e., problem solving, is crucial for long-term concept success. Users who are confronted with challenges in early phases that can only be solved with increased personal effort or cost are unlikely to advise their friends to adopt such a system. Their negative experiences will discourage others from joining. But who takes on this role? Do system manufacturers or craftspeople provide this service? What is the collaboration and integration like? What approaches are there in terms of individual problem solving? This is especially important in the medium term.

OWNERS AND ASSET MANAGERS

Buyers and investors of buildings are particularly interested in the short and medium term. In the short term, they must decide whether smartification of their buildings is financially attractive. However, the development of user demand must also be assessed. Even if the investment is not profit maximizing in the short term, the long-term view can change completely. A lack of smartification can even become an inhibiting factor. However, this must already be considered today. In the short term, it is therefore critical to be informed about current solutions and to be able to bring them closer to users. After all, they must be convinced. It is therefore necessary to take a risk. A change in positioning in the value chain may be an option here. Is it worthwhile to invest in sensor providers or software manufacturers? As a potentially very large investor, is the knowledge available or a vision what is wanted to be realized? Can this strengthen the company's core business or give their units a unique selling point or even drive customer loyalty? What potential effects are seen on the margins? In the medium term, this decision-making pressure increases. Not only because it becomes more critical to the user to establish the concept, but also because the potential investment decision becomes more capital intensive as the software and sensor providers grow. In the medium to long term, data handling must be organized. How can this data be monetized? What are the options for action? Has there been a shift in market power distribution? This offers many opportunities for the development of new business areas.

3.2 Example: Large OEM

From the perspective of a large OEM, the issues illustrated in Figure 4 are partly influenceable. For small and medium enterprises (SMEs), the influence on components such as regulation or general social perception tends to be lower than that of a large company with corresponding market penetration. OEMs might also have a chance to directly influence the social component and integrability. With large-scale cooperation, more research and development can be financed and therefore also more patents can be generated. Furthermore, larger firms tend to have more knowledge to create more complex products, simply by the amount of highly qualified staff, which they can finance. This follows the resource-based view concept. By building a lighthouse, large cooperation projects thus boost the social component. Furthermore, finding a partner for technology gaps, product integration, and an organic growth might be easier than with an SME. Therefore, in the short term, large OEMs should evaluate whether to develop a lighthouse or not. Is there a strategic fit to the existing vision or does the strategy require rework? If the answer is positive, multiple questions need to be answered.

"Is it feasible? What does the business case indicate? Does the required technology already exist in-house? Does that match the company's criteria catalog? What use cases are seen in the market? Which company should be chosen to partner with? What resources are required?

If the answer is negative, how does the OEM compete in the future? Is there another promising path? What are promising enterprises to purchase? Can standards be established in the future?"

In the medium term, the cost/usage relationship changes only indirectly. As expected, financially strong corporations can hold on to market share longer through low prices and resulting thin margins, but this does not change the user's perception of the actual utility. It is pure pay-for-revenue. Here, it requires answers to questions like:

"What is the company's product differentiation or are they selling by price? How can the production be optimized to make the products even more attractive?

What does it require to persuade hesitant customers? How can the company gain more user touchpoints and how can the customer recognize the company's added value?"

01
Cost/usage relationship →
Perceived value added and focus on existing solutions

- Indirectly influenced
- As customers start to accept and value the new and optimal working solutions, their willingness to pay rises

02
System communication and integrability ↑
One-stop shopping and technology silo thinking

- Offer open systems
- Proactively seek technology partnerships

03
Social component ↑
Acceptance, enthusiasm, demand, understanding, and ability to integrate smart building after construction

- Develop and distribute a lighthouse based on specific user wishes
- Establish partnerships to boost "experience ability" and the need from the customers and users perspective

04
Outside factors and regulations ↓
Data security, privacy rights, and climate and energy usage regulations

- Low direct influence
- Time-intensive and rather slow process

Influenceability by individual enterprises Low Medium High

Fig. 9. Example of the reaction of a larger OEM divided into four fields of action

04

The way to smartification

Now that the reasons for smart buildings, the opportunities offered by the technology, market developments, social development, and reactions have been explained, the question for companies is how they can participate in the smart building market.

Porsche Consulting recommends six specific steps, listed in Figure 10. These correspond to some points and core questions already mentioned in the example in Chapter 3. The key to success here is adopting an end-to-end perspective of the value chain. Not only the customer, but also the user is at the center of all activities. In many cases, the customer only takes on a middleman function. The use cases must therefore be directed primarily at the user and secondarily at the operator and customer.

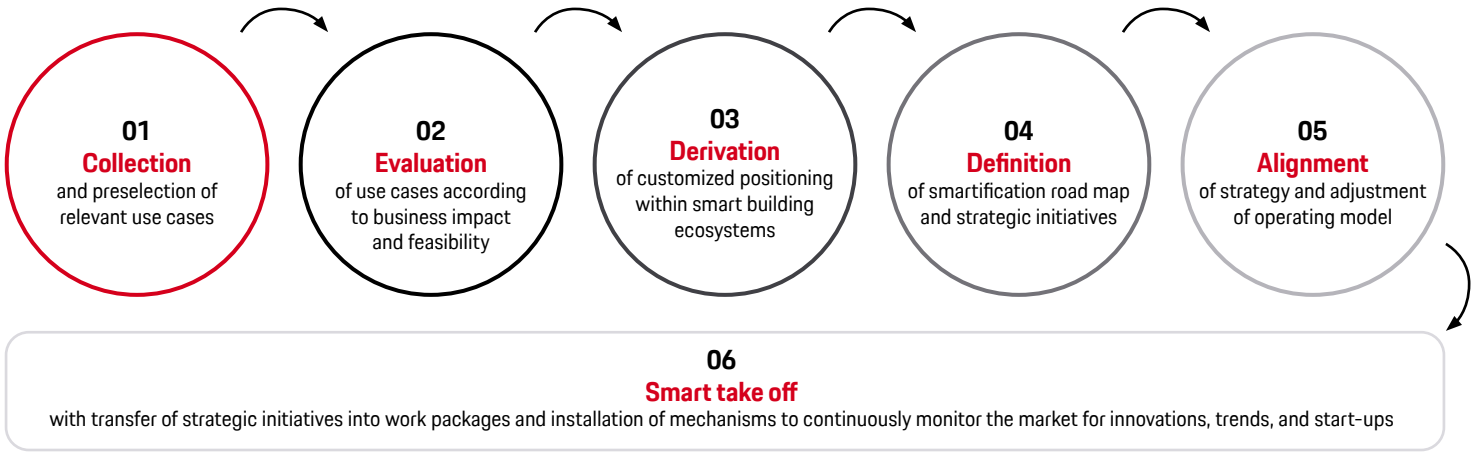


Fig. 10. Six steps to smartification

01 | Collection

Use cases previously piloted in the market or other industries can serve as a starting point. To enrich the initial collection of use cases, additional ideas need to be generated through the following:

- In-house innovation workshops (e.g., design thinking)
- Interviews with sales employees
- Customer visits ("go gemba")
- Joint idea generation
- Open innovation formats via related (online) communities in a crowd-sourcing approach

02 | Evaluation

A simple but effective approach using the two-criteria business impact and feasibility for evaluation has proved successful. Business impact is calculated by a specific market model per use case based on assumptions regarding the volume and potential pricing. Feasibility is determined by comparing existing and required competencies per use case. A helpful structuring element in evaluating technological requirements is the smart building IoT stack.

03 | Derivation

After having prioritized a reasonable number of use cases, companies will have a much better understanding of which role is available to them in the smart building ecosystem. The positioning is determined from two directions: from the perspective of product/service offering, the evaluation results from the basis for an informed decision on which use cases to take on. From the perspective of capability, the company needs to consider three different dimensions in use cases for smart buildings: development, operation, and commercialization.

04 | Definition

The targeted positioning needs to be translated into a smartification road map. Starting from a fit-gap analysis of required versus existing capabilities in development, operation, and commercialization, companies must define strategic initiatives to implement the smartification strategy. Development capabilities are acquired through investments in R&D and hiring new employees with expert knowledge in specific areas. Hardware manufacturers might also consider collaborating with external software developers or start-ups to accelerate the transition.

05 | Alignment

The final step is to align the smartification strategy with the organization's other strategic perspectives. The overall strategic fit is key to overcoming typical challenges of ambidexterity. Any strategic inconsistencies must therefore be identified and tackled with appropriate solutions. Potential strategic conflicts between the hardware business and smartification can range from investment policies to marketing campaigns. Our approach is to perform the strategic alignment process on all levels: corporate strategy, business unit strategy, and functional strategies.

06 | Smart take off

Strategic initiatives are transferred to work packages with clear responsibilities and a timeline. Furthermore, the company needs to make sure that any future trends will be recognized early to make use of the early-mover advantage. Therefore, setting up proper innovation management with technology, trend and start-up radars is vital. A software solution can be implemented to facilitate the scouting work.

Conclusion

Multiple industries have already gone through a smartification process. The building market has not, even though first concepts and projects have evolved. Smart buildings bring multiple benefits to individual users and society. They optimize user comfort, energy consumption, efficiency, and open new growth opportunities for enterprises. However, the market is dominated by hesitance as users are not in the center of current use cases. This can be split up into four main reasons:

- **Cost/usage relationship**
- **System communication and integration ability**
- **Social component**
- **Outside factors**

To tackle those reasons, depending on development, integration and persuasion, and the rollout phase, different market participants are required to act. For their own success as well as for the smart building concept success. This goes hand in hand. One central aspect for this is lighthouse creation. The built-in smart technologies are adapted to the users and can be experienced by them. Users learn about the benefits of the systems, become familiar with them, and these technologies become more widespread in society. This results in a turning point of users towards the smart building technology, as their needs will become unavoidable requirements for project developers and planners. The smart building value chain is starting to pull on all participants, and suppliers can place their products on the market. The function of an individual company in this interplay depends on its positioning, the production chain, the timing, financial strength, size, and brand equity. Individual answers must be found here. Companies can become smart by long-listing and collecting relevant use cases, evaluating their financial and technical feasibility, and deriving a specialized positioning, defining a smartification road map, and aligning all that with their strategy. Transferring this into work packages and constantly monitoring the smart building market trends and start-ups will lead an enterprise to smart take off.

In Brief

01 The rapidly growing population in urban environments poses a significant challenge, calling for smart building concepts in the construction industry

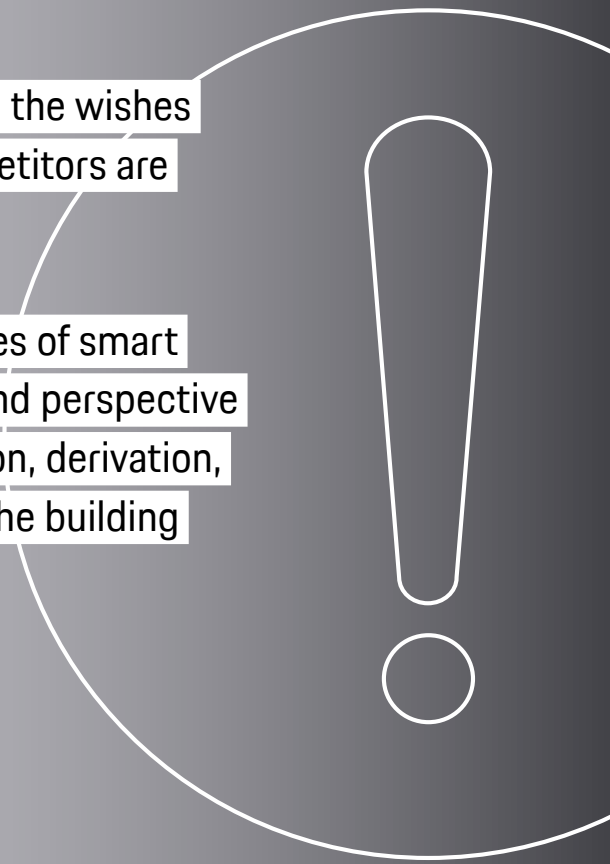
02 The construction and its supplier industry must seize the opportunity and finally align their smart activities to customer needs

03 A user-centric approach is thereby key to actually implement smart solutions and make them accessible to potential customers/users

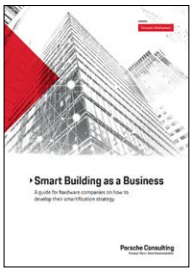
04 The highest need for action lies in the medium term: the integration phase

05 Incumbents must adjust their effort towards the wishes and demands of the customer, as new competitors are continuously pushing into the market

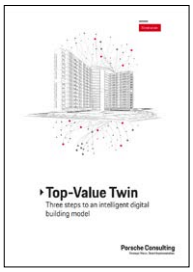
06 Six steps are crucial to address the challenges of smart building concepts and to adopt an end-to-end perspective of the entire value chain: collection, evaluation, derivation, definition, alignment, and smart take off of the building concepts



Further reading



Smart Building as a Business



Top-Value Twin

Thinking from the customer's point of view

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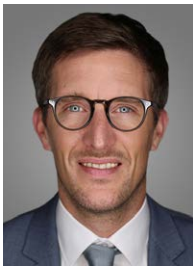

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