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List of Abbreviations

BIM	**Building Information Modeling**
EE	**Energy Efficiency**
EU	**European Union**
ESCA	**European Secretariat for Cluster Analysis**
EPC	**Energy Performance Certificate**
AI	**Artificial Intelligence**
SME	**Small and medium Enterprises**

Executive Summary

The purpose of this deliverable is to introduce business process innovations that facilitate the green and digital transition for small and medium-sized enterprises (SMEs) operating in the building sector. The focus is on promoting innovative solutions related to energy efficiency and smartness in buildings. By adopting these solutions, SMEs can improve their organizational performance and contribute to sustainable development. This deliverable aims to provide SMEs with guidance on adopting and integrating innovative tools into their business processes effectively.

The building sector plays a significant role in global energy consumption and environmental impact. To address these challenges, a green and digital transition is crucial. Green technologies and practices enhance energy efficiency, reduce carbon emissions, and promote sustainable building designs. Digital solutions enable smart building management, automation, and data-driven decision-making. SMEs in the building sector can benefit from the opportunities presented by these transitions and gain a competitive edge. The green and digital transition presents unprecedented opportunities for SMEs in the building sector to improve their organizational performance while contributing to sustainability. By adopting business process innovations tied to the adoption of technologies, SMEs can position themselves as industry leaders, attract eco-conscious customers, and meet evolving environmental regulations. The journey towards a greener and digitally integrated future requires careful planning, collaboration, employee engagement, and a commitment to ongoing innovation. As SMEs embark on this transformative path, they have the potential to create a positive impact on both their business and the environment.

This document avoids the “one-size-fits-all” strategy in supporting digitalization in SME and adopt a fine-grained approach that takes into account differences between SMEs of different sizes and those that engage in R&D versus non-R&D SMEs. In this sense, questionnaires were presented to the SMEs who are members of the clusters of the SUSTAIN consortium, in order to probe their primary needs and requirements regarding the field of innovation in the construction sector.

1. Introduction

The fourth industrial revolution, also known as Industry 4.0, reduces first and foremost the positive effects of economies of scale. The ongoing industrial revolution, therefore, opens up great opportunities for companies in terms of process efficiency, cost reduction and productivity improvement by enabling customized production capacity on a large scale. The small size of a company from an element of disadvantage becomes a source advantage: it no longer detects the size of the single organization, as much as its ability to position itself in the strategically most suitable point of its value (eco)system. Digital transformation more generally changes the way of doing industry through the introduction of advanced solutions that allow companies to re-interpret their role, impacting the entire value (eco)system.

The global push towards sustainability and digitalization has led to a paradigm shift in the way businesses operate. Small and medium-sized enterprises (SMEs) in the building sector are no exception to this transformation. The building sector plays a critical role in shaping the global sustainability landscape. It is responsible for consuming a substantial amount of energy and resources while generating a considerable share of greenhouse gas emissions. As the world faces mounting environmental challenges, the building sector must undergo a transformative green and digital transition to address its environmental impact effectively. The building sector accounts for a significant portion of global energy consumption and carbon emissions. Embracing green technologies and practices can lead to energy efficiency improvements, reduced greenhouse gas emissions, and more sustainable building designs. Simultaneously, digital solutions enable smart building management, automation, and data-driven decision-making, further enhancing the sector's overall performance and sustainability.

The adoption of green and digital technologies presents numerous opportunities for SMEs to enhance their competitiveness, reduce their environmental impact, and contribute to a more sustainable economy. This deliverable explores business process innovations tied to the adoption of technologies for SMEs' green and digital transition, with a specific focus on the building sector.

This document provides a comprehensive review and analysis of existing literature related to the adoption of digital strategies in the business processes of small and medium-sized enterprises (SMEs). As the world increasingly embraces digitalization, SMEs must navigate this technological transformation to remain competitive and relevant in today's dynamic business landscape. The literature review aims to identify key areas where digital solutions can have a significant impact on SMEs, as well as the benefits of collaboration, employee training, and engagement in fostering innovation and sustainability. The implementation of technology is indeed a critical aspect of digital innovation, but it is not enough on its own to fully realize the potential of Innovation technologies to effectively leverage digital transformation, companies must know how to combine and orchestrate various enabling factors. This involves integrating different technologies, processes, and strategies to create a cohesive and effective digital ecosystem.

Transitioning from theory to practice can be complex, and companies embarking on this path need to go through several steps. One of the challenges is dealing with various stakeholders, including technology companies, software vendors, plant designers, general contractors, and specialized operators in robotics and automation. Collaboration and communication among these different entities are essential for successful digital transformation. Among the various Innovative technologies, the Industrial Internet of Things (IoT) stands out as a game-changer. By connecting physical objects and production resources to digital networks, IoT enables smart and intelligent objects that can collect, transmit, and receive data in digital formats. Companies that embrace IoT can gain a significant competitive advantage, as it empowers them with real-time data and insights, leading to better decision-making, predictive maintenance, and improved operational efficiency.

However, some companies adopt a cautious "wait and see" approach, hesitating to invest until the technologies become more widely adopted. While being cautious has its merits, waiting too long can risk falling behind more proactive competitors who have embraced digital innovation early on and reaped its benefits. Early adopters often gain a competitive edge and can drive innovations that disrupt traditional markets.

In conclusion, successful digital transformation requires a strategic approach that combines technology integration, collaboration among stakeholders, and early adoption of innovative solutions. Embracing the potential of Innovative technologies, especially the Industrial IoT, can lead to increased internal efficiency and open new opportunities for growth and innovation in the rapidly evolving digital landscape.

1.1 WP2 Goals and tasks

WP2 (Work Package 2) plays a crucial role in the project, focusing on fostering innovation, enhancing digital and green transformation, and supporting SMEs in adopting energy-efficient building solutions.

The main objectives of WP2 are outlined below:

Innovation in Building Capacity for Strategic Autonomy:
The first objective of WP2 is to build the capacity for strategic autonomy within the building construction domain. This involves exploring innovative ideas and concepts that have already been successfully demonstrated in real-life pilots from previous projects. By identifying and analyzing these existing tools and solutions, the project aims to leverage proven strategies for achieving energy-efficient and sustainable buildings.

Adopting Processes and Technologies for a Greener and More Digital Economy:
WP2 seeks to drive the transformation of the building sector into a greener and more digital economy. This objective involves introducing and implementing business process innovations that enable SMEs to adopt the identified innovative solutions. By integrating these solutions into their operations, SMEs can enhance their environmental performance and adapt to the evolving digital landscape. One of the primary objectives of the green transition in the building sector is to improve energy efficiency. Traditional buildings often suffer from high energy consumption due to inadequate insulation, inefficient heating, ventilation, and air conditioning (HVAC) systems, and outdated lighting technologies. These inefficiencies not only contribute to higher operational costs for building owners but also exacerbate the industry's overall carbon footprint.

By adopting green technologies and practices, such as energy-efficient appliances, advanced insulation materials, and renewable energy sources like solar panels and wind turbines, buildings can significantly reduce their energy consumption. Energy-efficient buildings require less energy for heating, cooling, and lighting, leading to lower utility bills and decreased reliance on fossil fuels. Ultimately, this helps in achieving sustainability goals by lowering greenhouse gas emissions and conserving natural resources.

Identifying Innovative Existing Solutions:
A key task in WP2 is the identification of innovative solutions and technologies that have shown promise in real-world applications. By analyzing successful case studies from previous projects, the project aims to highlight effective strategies for energy-efficient building practices.

Supporting SMEs in Adopting Innovative Solutions:
Once innovative solutions are identified, the project aims to support SMEs in their adoption. This involves providing recommendations and guidance to SMEs on how to incorporate the identified tools

and technologies into their business processes effectively. The goal is to empower SMEs to embrace energy-efficient practices and improve their overall organizational performance.

Offering Technical Assistance to SMEs:
As part of the support to SMEs, WP2 will offer technical assistance to help them implement the proposed solutions. This assistance may include training, consultation, and guidance on the practical implementation of the identified digital tools and energy-efficient practices.

Providing Digital Tools for Enhanced SRI Estimation:
The project aims to develop and provide digital tools that assist in estimating Sustainable Renovation Index (SRI) values. These tools will help building stock actors in the planning and evaluation of efficient construction and operational energy performance monitoring. Additionally, they will support flexibility utilization and other relevant aspects related to energy-efficient building practices.

Networking and Best Practices Exchange Events:
Finally, WP2 aims to facilitate networking and knowledge exchange among participants in the project. This will involve organizing events in all participating countries (Greece, Latvia, and Spain) to share best practices, lessons learned, and successful case studies. These events will enable stakeholders to learn from each other's experiences and foster collaboration for sustainable building initiatives.

In summary, WP2's objectives revolve around promoting innovation, driving the adoption of energy-efficient building solutions, and supporting SMEs in their digital and green transition efforts. By identifying and implementing successful strategies and technologies, the project aims to contribute to a more sustainable and resilient building sector.

In T2.1 an identification of the existing tools and solutions in the field of energy-efficient buildings will take place. Ideas and concepts that have already been presented in several other projects, and have managed to further demonstrate parts or combinations of the above in real-life pilots will be investigated. In T2.2 business process innovations are introduced in order to support SMEs to adopt the innovative solutions that were identified in T2.1.

The concept of a business model is both intricate and multifaceted, lacking a universally defined and fixed definition. This fluidity is integral, as it distinguishes itself from a mere corporate strategy, which is encompassed within it, augmenting comprehension and facilitating delegation. A business model serves as a lens through which a company discerns its inherent structural makeup, molding it to generate value in harmony with its strategic choices. This dynamic instrument equips enterprises to orchestrate their operational pursuits and procedures. It unveils what a company fabricates, the modus operandi of its production, its intended audience, and the resources that fuel its endeavors. Additionally, it delineates the clientele it caters to, the suppliers it collaborates with, and the fundamental traits that characterize its production processes.

The divergence of business models is not only manifest across various sectors but is also evident within ostensibly homogenous industries. Take, for example, the smartphone market, wherein behemoths like Apple and Samsung exhibit divergent business models. Apple's model hinges on offering premium products emblematic of status, whereas Samsung employs a multi-tiered pricing strategy to cater to a broader spectrum of consumers. Thus, the business model serves as a prism to illuminate a company's predominant attributes: the objective of its pursuits, the route it charts to actualize them, and the audience that benefits from its entrepreneurial initiatives.

Yet, a universal and quintessential business model eludes formulation. It cannot be universally adaptable to every context or enterprise, for it is the idiosyncrasies of each entity—its structure, synergies with collaborators, network of associations—that shape the most fitting business model. While universal optimality remains elusive, some foundational constituents are integral to every business model. These foundational elements necessitate manipulation to unveil the optimal configuration. Ergo, the corporate business model emerges as an amalgamation of strategic and organizational strategies through which a company gains a competitive edge. It maps an organizational structure that fosters knowledge dissemination within the company, harnessing its human resources to nurture innovation. It also embeds interactions with suppliers and clients within the value chain and employs suitable methodologies to scrutinize attained outcomes, benchmarking them against competitors.

Hence, the corporate business model stands tall as a pivotal tool in management's arsenal. It empowers leaders to decipher and navigate internal and external currents that sway the enterprise. It is a dynamic apparatus that adapts, transforms, and aligns the company's course with its intended objectives. In essence, the business model captures the essence of a company's identity, operations, and aspirations, allowing it to thrive in a dynamic and ever-evolving business landscape.

During task T2.2, there take place recommendations and support to SMEs for getting familiar with the innovative tools that are relevant to the building sector and include them in their business process in order to involve also new systems and methods for improving organizational performance. Finally, Task 2.3 will provide customized support through the offering of technical assistance to SMEs and industries for adopting the new proposed solutions (including the SRI assessment innovative digital tool, and other relevant digital tools for answering building stock actors' needs in terms of efficient construction planning, operational energy performance monitoring and management, flexibility utilization etc. Moreover, there will take place some networking and best practices exchange events in all the participating countries (at least one per country, Greece, Latvia, and Spain).

1.2 Structure of the Deliverable

The deliverable D2.2 New-to-firm products and/or services in the industrial ecosystem/s is structured according to the following sections.

- Section 1 contains the introduction of the deliverable, the structure and the objectives of the deliverable and summarizes the ambitions of work package two.
- Section 2 outlines, through a literature review analysis, innovative business methods for SMEs.This part presents a comprehensive review and analysis of existing literature on the adoption of digital technologies in SMEs' business processes. It identifies key areas where green and digital solutions can be integrated for maximum impact. The document, in its first part, proposes a business focus explication of some technological innovation tools in line with 6 technological pillars, some of which previously described in D2.1
    1. Additive Manufacturing,
    2. Augmented Reality,
    3. Simulation,
    4. Cloud computing,
    5. Industrial Internet of Things,
    6. Big Data & Analytics.
- Section 3 presents the integration of innovative technologies and methodologies within an organization's internal processes has far-reaching implications for the development of business strategies. These advancements touch upon various aspects, including internal processes, resource management, products, relationships with customers, external processes, societal impacts, and financial outcomes. In this section, we delve into how these innovations influence the formulation and execution of business strategies across these domains. Moreover, it outlines the benefits of collaboration and partnerships with suppliers, technology providers,

industry experts, and government agencies in facilitating the transition. Additionally, the chapter emphasizes the importance of employee training and engagement to foster a culture of innovation and sustainability within SMEs. In the present work, structured literature review methodology has been adopted.

2. Understanding Strategic Innovation and Its Implementation in the Construction sector

In this section, the literature review highlights the transformative potential of digital solutions for SMEs. Embracing digital strategies offers numerous benefits, from improved operational efficiency and customer engagement to data-driven decision-making and supply chain optimization. Collaboration and employee engagement are essential components of successful digital transformation, while challenges and barriers must be navigated to reap the full rewards. The review provides valuable insights and best practices that can guide SMEs in their journey towards a more digitalized and sustainable future[1].

In today's rapidly changing business landscape, the concept of innovation has become synonymous with survival and success. Among the various types of innovation, strategic innovation stands out as a crucial driver for creating new business models and gaining a competitive advantage.[2] However, the term "strategic innovation" can encompass various definitions, which all share the common goal of transforming the way businesses operate and deliver value to customers.

This section aims to delve into the concept of strategic innovation, exploring its multiple definitions and highlighting its key components. Additionally, we will outline the necessary steps for initiating and implementing strategic innovation within an organization, enabling businesses to adapt to evolving market dynamics and meet the ever-changing needs of their customers[3].

The literature review stress the critical role of digital strategies in SMEs' business processes. By integrating digital solutions into their operations, SMEs can enhance efficiency, engage customers, make data-driven decisions, and optimize supply chain management. Collaborations and partnerships with technology providers and industry experts offer SMEs access to expertise and customized solutions, while employee training and engagement foster a culture of innovation and sustainability.

Indeed, the success of digital transformation and the adoption of Industry 4.0 technologies heavily depend on the skills and strategic vision of the entrepreneur or manager leading the organization. Modern technologies offer vast opportunities to rethink business models, expand services, and optimize production and maintenance processes. However, to fully seize this potential, a managerial revolution is required in the Italian productive fabric, as well as in many other contexts. The common trait of new digital technologies application, which require new skills and skills, is the possibility of interconnection between resources and company processes.

Management innovation is a crucial step alongside technological innovation. While day-to-day operations are vital for immediate financial results, it is equally important for leaders to raise their perspective and focus on broader strategic visions. Understanding the strategic competitive framework is necessary to leverage technology effectively and avoid potential risks. In the interconnected world we live in, companies must be ready to reconsider their organizational structures. Traditional pyramid models may hinder the flow of information and collaboration. Breaking down barriers between functions, forming micro teams, and empowering individuals with decision-making authority can foster

[1] Biloslavo, R.; Bagnoli, C.; Edgard, D. «An Eco-Critical Perspective on Business Models: The Value Triangle as an Approach to Closing the Sustainability Gap». J Clean Prod., 10, 2018, 746-62.
[2] Govindarajan, V.; Gupta, A.K. «Strategic Innovation: A Conceptual Road Map». Bus. Horiz., 44(4), 2001, 3-12.
[3] Massa L. & Tucci C., 2013, “Business model innovation”, The Oxford Handbook of Innovation Management

entrepreneurship and innovation within the organization. This requires effective communication and sharing to ensure seamless coordination.

Furthermore, adopting new leadership models is essential to drive the diffusion of digital culture within the organization. Corporate ethics should be emphasized to create a conducive environment for collaboration and trust among employees. Digital platforms are disrupting traditional power dynamics and intermediating relationships, highlighting the need for mutual trust and openness among team members.

Reengineering culture, values, processes, and organizations is crucial for successful digital transformation[4]. Leaders should embrace a new vision for their organizations, fostering a culture of innovation, adaptability, and continuous learning. They need to be agile, and open to change to lead their companies into a future where digital technologies play a central role in shaping business strategies and operations.

In summary, digital transformation and innovation requires not only technological investment but also a strategic vision, managerial innovation, and a cultural shift within organizations. Successful leaders will be those who can navigate the complexities of Industry 4.0 technologies while fostering a culture of innovation, collaboration, and continuous improvement[5]. The phenomenon of the rapid evolution of technologies and radical changes requires companies to look at new business models to face change and maintain their competitiveness in a de facto global market.

The assets to manage change are many, of different natures and partly external to the company. It is therefore clear that, to innovate, small and medium-sized enterprises need a new model that allows access to these assets in a sustainable and fast way, which can be reconfigured as environmental variables (economic, political, social, technical) change. In other words, we need a network system for innovation, in which the company is only one of the main players and where the subject who effectively manages and ensures the connection between knowledge production, production system and market, a connection which, albeit with numerous variations, finds its definition in the term "technological transfer".

In analyzing what is meant by "management quality", i.e. what are the specific requirements and connotations that "give managerial quality", a spectrum of strongly renewed characteristics has opened up compared to the traditional managerial figure: both from the point of view of the positioning in the company, of the meaning it assumes also concerning the corporate culture, of the functions it performs, of which of these functions are maintained in the role of manager and which instead should be delegated to other roles; and, consequently, to the key skills and abilities that the manager must possess.

The drive towards digital transformation is motivated by the belief that new technologies have great potential to drive innovation and competitive advantage (Solberg et al., 2020). The digital revolution extends the business boundary from supply chain and value chain systems to value network systems and incentivizes the development of a digital innovation ecosystem.

SMEs do not have the same R&D opportunities as large enterprises and often lack skills, managerial knowledge and digital specifications, e.g. big data analysis, implementation of artificial intelligence solutions, cloud computing, etc. Limited internal knowledge resources and less ability to invest in internal knowledge could make the external sourcing of knowledge, as a major form of open innovation, particularly important for small firms.

[4] Digital in Engineering and Construction. Boston: BCG, The Boston Consulting Group, 2016.
[5] The Factory of the Future. The industry 4.0. – The challenges of tomorrow. S.l.: KPMG, 2016.

SMEs have a variety of possibilities for establishing and maintaining external links through digitalisation. The innovation links of companies are diverse and involve several different partners, also depending on the innovative ecosystem of the territory, such as supply chain links with customers and suppliers, links with competitors, universities, research and development laboratories. At the same time, small businesses differ in their attitudes towards strategy implementation and particularly in their ability to commit resources to digitalisation. Furthermore, the launch of new products or processes depends on a specific innovation strategy and different types of internal and external knowledge sources.

Firms in traditional sectors invest in the digitally-skilled workforce to master new innovation domains and other skills needed to develop and implement new business models. From a few studies focusing on the impact of digitalisation on SMEs, four reasons have recently been identified as to why digital transformation is slowly being adopted in SMEs. First, small businesses with their own specific focus are less exposed to the need for rapid digitisation. Second, small businesses often lack the resources and managerial vision to fully understand the impact of digital transformation on business performance. Thirdly, SMEs usually take a phased approach to digitalisation, unlike larger companies. Finally, investments in digitization within this type of enterprises strongly depend on the financial resources of the enterprises which are limited, especially in micro and small enterprises. Leading digital technologies open up new opportunities for SMEs. such as the definition and structure of global value chains and international trade. The process of digitization and innovation, also in the field of machinery and materials used, invests the building market, increasingly attentive to environmental sustainability and to keep up with the times also for the construction sector in Italy, digitization of businesses is now an inevitable reality and revolutionizes the entire modus operandi of the supply chain, both in terms of management and in terms of operations. To overcome all the obstacles that do not allow the sector to grow, a lot has been invested in the development of resources that enhance the elements that count most in a construction site, i.e. the data. Their management becomes a crucial element in the process of digital innovation.

In this sense, SMEs must recognize the potential of digitalization and proactively embrace these transformative technologies to remain competitive and resilient in an ever-evolving business landscape. By leveraging digital strategies and fostering a supportive work culture, SMEs can pave the way for growth, success, and a more sustainable future. Small and medium-sized enterprises in the building sector have a unique opportunity to capitalize on the green and digital transition. By integrating innovative technologies into their business processes, SMEs can enhance their market competitiveness, attract environmentally-conscious customers, and comply with evolving regulations and sustainability standards. SMEs should embrace digital tools and automation across various business processes. Implementing smart building management systems, Internet of Things (IoT) devices, and data analytics solutions can optimize resource usage, improve operational efficiency, and enhance decision-making capabilities. Establishing a feedback loop for continuous improvement and staying updated on emerging technologies will further enhance the effectiveness of these innovations[6]. Data analytics plays a pivotal role in driving informed decision-making in the building sector. By collecting and analyzing large volumes of data from various sources, including sensors, utility meters, and weather forecasts, building managers can gain valuable insights into energy usage patterns and occupant behaviors. With data-driven decision-making, building owners can identify energy-saving opportunities, optimize resource allocation, and implement targeted sustainability initiatives. For instance, data analysis may reveal that certain areas of a building consume more energy than others, prompting a deeper investigation and the implementation of specific energy-saving measures in those areas. Furthermore, data-driven insights enable building managers to measure the effectiveness of green initiatives over time. By continuously monitoring performance metrics, they can assess the impact of energy-efficient upgrades and adjust strategies as needed to achieve long-term sustainability goals.

[6] Prause G. «Sustainable business models and structures for Industry 4.0». J Secur Sustain Issues, 5(2), 2015, 159-69.

The green and digital transition in the building sector not only contributes to environmental sustainability but also generates economic and social benefits. Energy-efficient buildings experience reduced operational costs, which translates into significant savings for building owners and occupants. Lower utility bills can lead to increased disposable income for occupants or higher returns on investment for building owners.

Additionally, the adoption of green technologies and digital solutions creates job opportunities in the renewable energy sector and the technology industry. As demand for green building materials, energy-efficient appliances, and smart systems grows, businesses specializing in these areas experience growth and expansion. From a social perspective, green and digitally transformed buildings provide healthier and more comfortable living and working environments. Improved indoor air quality, natural lighting, and thermal comfort contribute to occupant well-being and productivity. Moreover, by reducing greenhouse gas emissions, these buildings contribute to the broader effort of mitigating climate change and safeguarding future generations.

In conclusion, the green and digital transition in the building sector is a vital step towards achieving sustainability goals and mitigating the environmental impact of the industry. By embracing green technologies, optimizing energy usage through digital solutions, and leveraging data-driven decision-making, the building sector can pave the way for a greener, more efficient, and sustainable future. The economic and social benefits derived from this transition underscore its significance and highlight the potential for positive change at both local and global levels.

2.1 The Elements of Strategic Innovation in Business models elaboration.

Strategic innovation can be understood as the process of developing a new business model through the creation of innovative products, services, processes, and value chains. These innovations aim to provide customers with a radically different and transformative experience, touching them on emotional, intellectual, and even spiritual levels. The outcome is the generation of new market spaces, rendering competition irrelevant and driving increased value for both the company and its customers.

The current industrial revolution, Industry 4.0, stands out from previous revolutions due to its potential to optimize the use of material resources, particularly through the integration of digital technologies. At the core of Industry 4.0 are cyber-physical systems (CPS) and cyber-physical production systems (CPPS), which merge physical components with virtual ones to create intelligent and interconnected production processes[7].

Cyber-physical systems (CPS) are product systems consisting of both physical and virtual components. The physical component comprises a device equipped with sensors, memory, connectivity, computational capacity, and actuators, enabling it to interact with the real world and other devices physically and virtually. The virtual component, represented by a digital twin, allows for simulation, support during implementation, optimization of operating conditions, monitoring of performance, and identification of reusable parts upon disposal. CPS facilitate error prevention, cost reduction, and enhanced efficiency throughout the product life cycle[8].

Cyber-physical production systems (CPPS) take CPS a step further by integrating multiple CPSs and additional archival systems to share data for self-monitoring, self-learning, self-management, and self-adaptation. This shift from focusing on individual machines to overall intra- and inter-company production flow contributes to the creation of intelligent factories and digital threads. The digital thread represents the digital representation of the entire physical life cycle of the product, from design to manufacturing and monitoring during use or disposal. By leveraging the digital thread, companies can

[7] Montanus, M. Business Models for Industry 4.0. Delft: University of Technology, 2016.
[8] Roadmap for Industry 4.0. S.l.: Ernst & Young, 2017.

maximize productivity, quality, time efficiency, and sustainability by transforming data into functional knowledge in real time.

The fourth industrial revolution is enabled by different technological pillars, which combine both innovative and incremental technologies. These technological advancements are becoming increasingly powerful and cost-effective due to exponential progress. Those pillars of Industry 4.0 can be grouped into enabling software technologies for data collection, transmission, storage, and security; fundamental software technologies for data processing and automation of knowledge-based work; and integrative hardware technologies for real-time interaction between humans and machines, horizontal and vertical process integration, and automated digital-to-physical conversion.

Industry 4.0's strategic innovation lies in its ability to optimize resources, create intelligent production processes, and leverage the digital representation of products' life cycles. By embracing the potential of CPS, CPPS, and the nine enabling technologies, businesses can drive productivity, quality, and sustainability to new heights. The fusion of the physical and virtual worlds within Industry 4.0 paves the way for a new era of efficiency, innovation, and value creation across various industrial sectors. In the subsequent chapters, we will explore the implementation of Industry 4.0 and its impact on driving strategic innovation in greater detail.

A central goal of strategic innovation is to resolve the paradox between delivering high value to customers while maintaining a competitive unit cost. Achieving this delicate balance requires organizations to embrace novel approaches and rethink their business models.
To embark on a strategic innovation journey, companies must address fundamental questions to (re)define their business models:

1. Who are our customers?
2. What should we offer them?
3. How can we efficiently and effectively deliver our offerings to them?

Answering these questions is directly linked to the strategic dimensions of intimacy with customers, product leadership, and operational excellence. Each dimension caters to specific customer needs and desires, and by aligning with one or more of these dimensions, businesses can craft a unique value proposition that sets them apart from their competitors.

In the pursuit of strategic innovation, several crucial elements come into play:

1. Innovative Products and Services: Organizations need to develop novel products and services that challenge conventional norms and expectations. These innovations must either present existing products and services in new ways or combine them in unique and transformative manners, creating compelling customer experiences.
2. Innovative Processes: Strategic innovation also involves rethinking and redesigning production and distribution processes. By introducing innovative processes, companies can cater to new clienteles, capture untapped markets, and increase their operational efficiency.
3. Innovative Value Chains: Transformative value chains play a pivotal role in strategic innovation. By creating entirely new market spaces, businesses can offer unmatched value propositions, elevating their competitiveness and delivering exceptional value to customers.

To achieve strong performance, companies must embrace the concept of being part of a larger ecosystem, fostering partnerships and collaborations that revolve around customer needs. Such partnerships offer greater flexibility and agility, crucial factors in today's fast-paced business environment. Notably, innovation is not limited to internal processes; it can also thrive between different companies within the ecosystem, generating benefits for all involved parties.

The smart ecosystem serves as a hub for innovation, facilitating connections between various actors and paving the way for sustainable innovations. These innovations can be classified into two types: outside-in innovations, which originate in society and are subsequently adopted by firms within the value chain, and inside-out innovations, which are born within a company and then transferred externally through partners and customers. Such innovation processes are facilitated by digital technologies, which streamline knowledge transfers and collaboration among ecosystem participants.

Embracing Industry 4.0 technologies not only maximizes operational excellence in terms of productivity, quality, time efficiency, and sustainability but also opens possibilities for new business models[9]. These transformative technologies enable strategic innovations that lead to the creation of new market spaces through innovative value propositions.

Within the smart ecosystem, community platforms play a pivotal role in nurturing relationships between diverse actors. These platforms become catalysts for bringing together the best ideas from strategic partners, quickly and cost-effectively transforming them into competitive innovations that benefit all firms involved.

Collaborative efforts in the ecosystem enable companies to stay agile and responsive to evolving customer needs and market dynamics. Instead of relying solely on internal resources, firms can tap into the collective knowledge and expertise of their ecosystem partners. By doing so, they gain a competitive edge by delivering cutting-edge products and services that meet customer demands effectively.

The smart ecosystem, driven by digital technologies, reshapes the traditional boundaries of companies, creating a network of interconnected players united by a common goal of innovation and value creation. In this dynamic ecosystem, innovation thrives not only within individual organizations but also through collaborative efforts that harness the power of collective intelligence[10].

In this sense, digital transformation means the process of innovation and technological integration within the company. Digital transformation requires, in addition to the abandonment of legacy technologies, substantial changes in terms of methodologies and techniques, corporate culture and production processes, thus bringing about an evolution/revolution of pre-existing business models. Despite being a recurring and very current theme, digital transformation is a topic that has been discussed for more than twenty years and over time its meaning has partly changed. This concept was assimilated into digitization and the collection and archiving of data using ad hoc software, which looks fundamental to digital transformation but certainly not exhaustive. This revolutionary process is not limited to innovating pre-existing processes but substantially modifies the company's business model, leading to a new vision based no longer on the product but on the customer. Satisfying the customer and offering products and services associated with it that solve problems and critical issues encountered by customers must be the corporate mission of an increasingly automated organisation. Knowledge of the customer, of his specificities and emerging needs therefore requires the adoption of techniques but above all tools that make this task possible. Digital Transformation also changes the company's commercial offering[11]. The product must be the answer to the customer's emerging need and must be developed from a data-driven perspective, since the data, now collected directly from the machinery, represents the fulcrum on which to base the strategies and re-engineering of the product. The company therefore depends on the reliability, completeness and timeliness of data collection. Digital transformation also brings changes in the commercial and promotional fields, making it necessary to carry out increasingly precise and timely collection and management of contacts through CRM software and lead management activities to manage the customer's customer journey. The company must create homogeneous customer targets to which it can propose offers inspired by various types of customers or personalized based on individual consumers.

[9] The Strategic Policy Forum on Digital Entrepreneurship. Digital Transformation of European Industry and Enterprises. S.l.: European Commission, 2015.
[10] MÜLLER J.M., BULIGA O., VOIGT K., "Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0", Technological Forecasting and Social Change, 2018.
[11] DOZ Y. & KOSENEN M., “Embedding Strategic Agility: A Leadership Agenda for Accelerating Business Model Renewal”, 2010

Technological development is an incessant and dynamic process that manifests within companies the need to adapt and transform traditional processes so that the organization can survive, without leaving wide decision-making margins. The 4.0 company will thus be able to compete in a market characterized by an increasingly informed and dematerialized final consumer due to digitalisation[12]. The company must be able to modify and adapt its business model to the new technological frontiers which lead to automated businesses even in the simplest processes and which allow the elimination of complex relationships with intermediaries in the value chain[13]. The design of the strategies to be pursued therefore plays a fundamental role so that the processes can evolve and the technologies can be implemented.

Digital Innovation firstly requires a change of mentality and vision in management, which is entrusted with the task of redesigning the organizational structure and the strategies to be implemented and of proposing future changes and investments necessary. It is essential to create a culture within the company that is open to change and innovation since in the absence of this, technological implementation will be hindered[14]. So that, digitization implies the introduction of new skills and the development of new training courses for all employees, called to manage new work processes, interface with online platforms and new digital tools, and analyze the data collected in the company. The development of new skills by human resources is a process that can prove more complex than in the past in which traditional business models required skills that were valid for long periods of time. Company employees are now called upon by digital transformation to embrace the evolution of processes if they are more efficient than those already used.

In conclusion, participating in a smart ecosystem and fostering strategic partnerships are essential for companies seeking strong performance and competitive advantages[15]. Embracing Industry 4.0 technologies enables firms to drive innovation, develop new business models, and create new market spaces through transformative value propositions. The smart ecosystem, fueled by digital connectivity and knowledge-sharing, sets the stage for sustainable and impactful innovations, benefiting both companies and their customers.

2.2 Additive manufacturing

For product development, additive manufacturing empowers designers with greater creative freedom, allowing intricate and aesthetically pleasing designs. It facilitates rapid prototyping through CAD/CAM software, enabling swift transformation of designs into scale models[16]. Beyond prototypes, additive manufacturing supports the production of first-series products for market testing before investing in mass production.

The layer-by-layer production principle eliminates or reduces the need for assembly activities, streamlining the manufacturing process and enabling more complex product structures. As additive manufacturing continues to evolve, businesses can benefit from increased efficiency, accelerated production times, and the ability to produce intricate and innovative components that previously seemed impossible.
Additive manufacturing, or 3D printing, presents a myriad of benefits that significantly enhance the efficiency, safety, and productivity of various processes. By reducing inventory and design and manufacturing times, companies can streamline their operations, leading to improved overall efficiency

[12] Montanus, M. Business Models for Industry 4.0. Delft: University of Technology, 2016.
[13] BOCK A., OPSAHL T. & GEORGE G., “Business Model Innovations and Strategic Flexibility: A Study of the Effects of Informal and Formal Organization”, 2010
[14] CHESBROUGH H., “Business Model Innovation: Opportunities and Barriers, Long Range Planning”, 2010
[15] Davies R. Industry 4.0. Digitalisation for productivity and growth. European Union, 2015.
[16] Gartner. Forecast: 3D Printers. Worldwide, 2016.

and cost-effectiveness. This technology also aids in minimizing waste due to its transition from subtractive to additive manufacturing, resulting in more sustainable practices.

The adoption of 3D printing fosters a faster, flexible, and dynamic approach, allowing companies to respond quickly to changing market demands and customer needs. It impacts essential resources, including raw materials, materials, and human resources. The range of materials compatible with 3D printing has expanded beyond traditional polymers and metals to encompass biological, food, and cement materials, broadening the possibilities for product development and customization[17].

To capitalize on the opportunities of additive manufacturing, companies must equip themselves with 3D scanners, printers, and digital development software, including parametric CAD and CAE. This technology empowers companies to independently produce tools and utensils, such as molds and matrices, using various materials, thereby streamlining the production process.

The introduction of additive manufacturing in production plants also necessitates a shift in the professional profile of human resources. The demand for specialists and technicians increases, while the need for unskilled labor decreases, reflecting the technology's sophisticated requirements.

One of the significant advantages of additive manufacturing is its ability to accelerate customized production, meeting individual customer needs more effectively. With 3D printing, companies can position the production stage closer to the customer, optimizing logistics and ensuring quicker delivery times.

Additive manufacturing has revolutionized the manufacturing landscape by offering numerous advantages that drive efficiency, reduce waste, and enhance customization. This technology enables companies to optimize their processes, streamline production, and meet customer demands more effectively. By leveraging 3D printing, businesses can foster a dynamic, agile, and customer-centric approach, positioning themselves at the forefront of Industry 4.0 and innovation. 3D printing, holds immense potential in reshaping how products are designed, manufactured, and delivered to customers. Its impact goes beyond traditional production, unlocking new possibilities for customization, speed, and efficiency. As more companies embrace additive manufacturing, its influence on business models and production processes will continue to shape the landscape of Industry 4.0, fostering innovation, ingenuity, and design-driven enterprises. Additive manufacturing, with its ability to create various types of objects, has a profound impact on the product aspect of the business model. It enables the creation of functional parts, generic components, prototypes, sales test products, and finished and complete products. This versatility leads to an expanded product range without increasing warehouse stocks, as components can be printed on-demand. As a result, companies can cater to the growing demand for product customization from customers, offering quick configuration and reconfiguration of machinery to meet individual needs. The use of 3D printing allows for the production of personalized products without the inefficiencies and cost increases associated with traditional manufacturing methods. Products manufactured through additive technologies demonstrate improved physical and technical characteristics, such as lighter weight, better mechanical performance, and innovative and complex geometries. Importantly, the quality of products made using 3D printing is comparable to those produced through traditional means.

Additive manufacturing is further enhanced by topological optimization, a numerical technique that synthesizes mechanical component shapes from allocated volumes. This technique enables the creation of innovative component forms that ensure desired performance while minimizing weight and adhering to production constraints[18]. In the B2B segment, additive technologies have the potential to transform the concept of the product itself. Instead of selling physical objects, companies could shift towards an immaterial concept, wherein they transmit the digital model to customers who own 3D printers. This change would allow companies to provide updated component designs directly to customers, enhancing the customer experience and fostering a more dynamic relationship between the company and its clients.

[17] Mellor S.; Hao L.; Zhang D. Additive Manufacturing: A Framework for Implementation. Amsterdam: Elsevier, 2012.
[18] Additive Manufacturing – next generation AMnx. S.l.: Roland Berger Strategy Consultants, 2016.

Overall, additive manufacturing revolutionizes the product aspect of the business model, offering enhanced customization, improved product performance, and a shift towards more dynamic and personalized product interactions with customers. As these technologies continue to advance, they will undoubtedly shape the future of manufacturing and open up new possibilities for businesses across industries.
The economic and financial impact of IoT technology is significant for companies, offering various cost benefits and revenue opportunities.

One of the main cost benefits comes from predictive maintenance. By using IoT-enabled sensors and actuators, companies can remotely monitor the condition of their equipment and assets, reducing the need for manual inspections. This leads to a reduction in unexpected failures and unplanned downtime, saving on maintenance costs and improving overall efficiency. Additionally, the technology streamlines data collection and transmission activities, leading to cost savings. However, the large volume of data generated by IoT devices can also present challenges in terms of data processing and storage costs. Analyzing and managing this vast amount of data can be complex and potentially expensive for companies.

Despite these challenges, the investment in IoT technology is often justified by the potential for increased competitiveness. Companies that embrace IoT solutions can gain a competitive advantage by offering improved products and services to customers, leading to higher revenues. On average, companies investing in IoT technologies may expect revenue surcharges of 2%-3% per year. Moreover, the combination of reduced costs and increased revenues can lead to added value growth that surpasses the proportion of the initial investment. This means that the return on investment in IoT technology can be significant, providing long-term benefits for companies that adopt these solutions. Overall, the economic and financial impact of IoT technology is positive for companies, with cost savings, increased revenues, and improved competitiveness contributing to their growth and success in the market. As IoT technology continues to evolve and become more accessible, its benefits are likely to extend to an even broader range of industries and sectors.

2.3 Augmented reality

Augmented reality is a pivotal technology supporting Industry 4.0, enabling the overlay of multimedia information onto the real-world environment through mobile devices or smart glasses. This versatile technology caters to various user categories and is commonly used for 3D vision applications. It allows users to seamlessly perceive digital elements superimposed on physical objects, enhancing their understanding and interactions with the surroundings.

In contrast to augmented reality, virtual reality completely immerses users in a parallel digital reality, isolating them from the external environment. Augmented reality, therefore, empowers users with valuable information and enhances their capabilities, making it an essential tool in a wide range of industrial applications. One of the significant advantages of augmented reality lies in its capacity to optimize human resources and expertise. Experts can remotely train and guide specialized technicians precisely when their intervention is needed, eliminating the constraints of physical location. This technology finds applications in various fields, including maintenance, assistance, production, quality control, and logistics.

Augmented reality's touch interfaces provide a novel form of human-machine interaction, revolutionizing how personnel interact with machines and production processes[19]. Moreover, augmented reality serves as a valuable training tool, often preferred over virtual reality for its ability to provide training without the need for physical presence at industrial sites. This flexibility allows personnel to receive training without disrupting regular operations.

In conclusion, augmented reality is a transformative technology that enhances human capabilities, improves industrial processes, and offers a new way of interacting with machines and the surrounding environment. Its integration into Industry 4.0 solutions presents countless opportunities for businesses to enhance productivity, efficiency, and overall performance. As the technology continues to advance,

[19] Seth A.; Vance J.M.; Oliver J.H. «Virtual reality for assembly methods prototyping: A review». Virtual Real, 15(1), 2011, 5-20.

we can expect even greater innovations and applications in the industrial landscape. The advent of augmented reality has ushered in a revolutionary change in the way workers manage production processes. Thanks to augmented reality tools and advanced technology infrastructure, workers now have the capability to virtually control and monitor production remotely. By using their smartphones, computers, and augmented reality glasses, they can access real-time information and oversee assembly lines through webcams and sensors strategically placed at various points in the production process.

One of the significant applications of virtual and augmented reality technologies is in operator training. These technologies provide a safe and controlled environment, digitally representing the factory for training purposes. New employees can observe experienced workers' actions through augmented reality, allowing them to learn and familiarize themselves with various tasks and processes. Equipped with augmented reality glasses, employees can access logistics and production information directly within their visual field. This immersive experience enables workers to efficiently carry out tasks while staying updated on real-time data and information.

Furthermore, production and manufacturing technicians utilize 3D glasses to create a collaborative environment. This collaborative approach fosters problem-solving and quick decision-making, as technicians can work together and address challenges collectively. Overall, augmented reality has become an indispensable tool in the industrial setting, offering benefits such as remote production control, efficient training, and collaborative problem-solving. As this technology continues to evolve, we can expect further advancements that will streamline processes and enhance the overall productivity and safety in the industrial landscape. The adoption of augmented reality technologies has led to the virtualization of industrial processes, a transformative approach that involves developing physical production based on virtual products and plants. This process begins with simulating and virtually verifying each production process before translating it into the physical world. Utilizing software, parameters, and numerical arrays, machinery can be controlled effectively during actual production based on the virtual simulations.

Virtual industrialization brings several advantages to manufacturers. They can design and test new plants or factories in the digital realm before physically installing them. This significantly reduces the occurrence of errors and allows for corrections to be made proactively, leading to more efficient and error-free physical installations. In the design phases of an industrial plant, virtual reality is often preferred over augmented reality due to its immersive view. Virtual reality enables a comprehensive understanding of how the plant will appear and function once constructed, using CAD models to provide an in-depth visualization of the project. The use of smart glasses simplifies assembly and maintenance activities. With the operating procedures displayed on the lenses of the glasses, workers can improve their work processes and reduce errors through real-time information assistance. Smart glasses also facilitate quality checks, automatically documenting and storing any problems detected, thereby reducing the reliance on paper documents. Incorporating augmented reality and virtual reality technologies in industrial processes enhances productivity, efficiency, and safety. These technologies empower workers with real-time information, facilitate better decision-making, and enable businesses to identify and address potential issues early in the production process. As these technologies continue to advance, they are expected to play an increasingly crucial role in optimizing industrial processes and driving innovation in the manufacturing sector.

Augmented reality has a significant impact on both external processes and customer engagement in the manufacturing sector. In external processes, augmented reality finds applications in logistics activities. Operators can use smart glasses to view the intended products present in the warehouse directly on the lens during shipping. This real-time visualization streamlines the picking and packing process, reducing errors and improving overall efficiency in logistics operations.

For customers, augmented reality offers a highly interactive and personalized experience. Consumers can actively participate in the configuration and design of their products. They can perceive the product in a realistic manner, observe it from different angles, and add or modify parts as if it were physically present before their eyes. This level of engagement enhances customer satisfaction and leads to a sense of ownership and involvement in the product creation process.

While the initial investment in augmented reality technologies may appear high due to purchase costs, businesses can quickly recover the investment through increased efficiency and reduced operating costs. By leveraging augmented reality in production, assembly, and maintenance processes, manufacturers can streamline operations, minimize errors, and optimize resource utilization. These improvements lead to cost savings and greater overall productivity, compensating for the initial investment in the technology.

Moreover, the adoption of augmented reality in after-sales services extends the value proposition to customers. Businesses can offer virtual assistance, remote troubleshooting, and interactive user guides, enhancing customer support and fostering stronger customer relationships. Overall, augmented reality is a transformative technology that positively impacts various aspects of the manufacturing industry. From internal processes to customer engagement and after-sales services, it opens new opportunities for customization, efficiency, and improved business performance. As the technology advances and becomes more accessible, its widespread adoption is likely to continue to drive economic and financial benefits for manufacturing businesses.

2.4 Simulation

Simulation technology stands as one of the pivotal founding technologies within the context of Industry 4.0. It involves the use of computer simulation systems to analyze and enhance production processes, as well as to assess potential real-world problems.

Simulation achieves this by leveraging real-time data, recreating the physical world within a virtual environment, and populating it with machines, products, and human elements. By coupling data with the physical knowledge available about a given process or product, simulation models can be created using sets of mathematical equations.

Historically, the utilization of simulation models has primarily focused on design and configuration phases—strategic aspects of production systems that usually occur offline. However, it is increasingly evident that the significance of this technology extends to operational phases, where it can operate directly online via a platform[20]. These models empower the virtual simulation of real-world actions, thereby enhancing process efficiency, optimizing productivity, ensuring product quality, reducing waste production, minimizing wait times, and streamlining the workload.

In recent times, simulation techniques have evolved even further, enabling the description and prediction of complex nano-structured systems. This progress extends across various domains, including materials engineering and life sciences, offering innovative possibilities within industrial sectors. These techniques complement sophisticated experimental methods, leading to a synergy of experimental and simulated data that fuels the realm of Big Data. These extensive datasets are subsequently analyzed using business analytics techniques, yielding valuable insights for designers and decision-makers alike.

2.5 Data and Cloud computing

Data analytics plays a pivotal role in driving informed decision-making in the building sector. By collecting and analyzing large volumes of data from various sources, including sensors, utility meters, and weather forecasts, building managers can gain valuable insights into energy usage patterns and occupant behaviors.

With data-driven decision-making, building owners can identify energy-saving opportunities, optimize resource allocation, and implement targeted sustainability initiatives. For instance, data analysis may reveal that certain areas of a building consume more energy than others, prompting a deeper investigation and the implementation of specific energy-saving measures in those areas.

Furthermore, data-driven insights enable building managers to measure the effectiveness of green initiatives over time. By continuously monitoring performance metrics, they can assess the impact of energy-efficient upgrades and adjust strategies as needed to achieve long-term sustainability goals.

Cloud computing has emerged as a crucial technology to handle the increasing volume of data that companies collect and process for business intelligence and control in the Industry 4.0 era. Traditional

[20] Manufacturing’s next act. McKinsey&Company, June 2015, 12-5.

servers are often unable to efficiently manage the massive amounts of data, leading to the need for additional computing resources that are flexible and cost-effective. Cloud computing solutions provide the necessary scalability and agility to meet these demands.
Cloud computing operates through remote and geographically distributed infrastructures, typically virtualized on a platform. This platform allows data to be collected, processed, and stored on scalable storage media, enabling efficient archiving and subsequent processing without the risk of overloading. As one of the pillars of Industry 4.0, cloud computing offers significant benefits to companies.
On one hand, cloud computing allows businesses to leverage IT efficiency provided by specialized data centers and the powerful computing capabilities of modern computers. On the other hand, it fosters business agility by providing scalable resources on-demand, enabling companies to respond in real-time to the diverse needs of their users without the burden of setting up, maintaining, and managing their own infrastructure.
Cloud computing offers various categories of cloud services to cater to different business needs. These services are delivered via the Internet and can be categorized into three main types:

1. Infrastructure-as-a-Service (IaaS): This service provides a computing infrastructure that includes virtualized hardware, such as computing resources, storage, and connectivity, allowing companies to have flexible and scalable computing power.
2. Platform-as-a-Service (PaaS): PaaS offers a web-based platform for developing applications and services, making it easier for businesses to create and deploy software without the complexities of managing underlying infrastructure.
3. Software-as-a-Service (SaaS): SaaS delivers application software to customers on a subscription basis, eliminating the need for companies to install and maintain software on their local systems. Instead, users access the software over the internet.

Cloud computing's ability to provide scalable resources, cost-effective solutions, and remote access to various services has revolutionized how businesses operate, collaborate, and innovate in the digital age of Industry 4.0. As companies increasingly embrace cloud computing, it continues to play a critical role in powering the digital transformation and enabling the next wave of technological advancements.

The adoption of cloud computing has introduced a significant distinction between public, private, and hybrid cloud offerings, each catering to different organizational needs. The private cloud is built on either self-managed internal infrastructure or external IT provided by third-party vendors. It offers a secure and distinct cloud space accessible only by a specific user or organization, providing greater control and privacy. If the private cloud infrastructure is hosted within the organization itself, it is referred to as an on-premise cloud. On the other hand, the public cloud is offered by service providers who serve multiple customers through a shared infrastructure, offering services on a pay-per-use model. Finally, the hybrid cloud is a combination of both private and public cloud deployments, where non-critical information may be managed by the public cloud, while services and sensitive data remain under the control of the private cloud.
Cloud computing offers numerous benefits to businesses. It allows access to vast amounts of data via the network in real-time, limited only by the connection bandwidth. Various technologies such as Big Data & analytics, IoT, additive manufacturing, and augmented reality are connected to the cloud, enhancing its potential and providing a foundation for their functionality.
One of the key advantages of cloud technology is the flexibility it provides to human resources, enabling employees to work remotely and access information from anywhere and through any device. Cloud-based maintenance processes are also improved, as stakeholders can access relevant information and perform maintenance operations more effectively. Big Data & analytics systems analyze data stored in the cloud, helping companies identify and address issues related to machine degradation and component wear, supporting predictive maintenance processes, and optimizing production.
Cloud computing also plays a vital role in the operation of smart products, as they can remotely provide information that allows for the customization of product functions. Furthermore, the cloud enables the offering of new services through the development of innovative features.

Cloud technology has transformed the roles and relationships between businesses and stakeholders. Cloud technology providers offer not only the necessary technology but also essential skills for system management, including maintenance and updates. Legislators are also actively developing regulations to safeguard the privacy and security of personal data in cloud-based systems.
From an economic and financial standpoint, cloud computing can lead to cost reductions in computer processing, archiving, and hardware expenses. The pay-per-use model ensures that businesses only pay for the resources they utilize, leading to cost efficiencies.
Overall, cloud computing has become a fundamental enabler of Industry 4.0, empowering businesses with greater flexibility, efficiency, and scalability in their operations while transforming traditional business models and creating new possibilities for innovation and growth.

2.6 Internet of Things

The concept of the Internet of Things (IoT) was conceived by Kevin Ashton, an English entrepreneur, in 1999. He envisioned a system where the entire physical world is interconnected, allowing objects and devices to exchange information collected through sensors and make decisions based on this data. Over the next decade, the number of connected devices surpassed the world's population, making the IoT a significant and pervasive technological phenomenon.
The IoT is a fundamental element of Industry 4.0 and can be defined as a network of physical systems that interact with each other through standard communication protocols to achieve common goals[21]. These physical systems, often referred to as "things," include sensors, actuators, communication modules, and devices that collaborate with one another through intelligent components and applied software to accomplish tasks that heavily rely on transmitting and processing information.
The communication within the IoT is multi-directional, enabling seamless interactions between machinery, components, and products. A key feature of IoT technology is machine-to-machine communication, where devices communicate directly without the need for human intervention. This is achieved through programmable electronic devices and wireless technologies, facilitating efficient and autonomous data exchange and decision-making.
The IoT's potential goes beyond simple communication and data exchange; it also contributes to the development of Cyber-Physical Systems (CPS). These systems integrate physical processes with digital technologies, creating intelligent, interconnected systems that bridge the gap between the physical and digital worlds. As a result, CPS can revolutionize various industries, optimizing processes, improving productivity, and enhancing decision-making.
IoT technology has widespread applications across industries, enabling smart cities, connected homes, industrial automation, healthcare advancements, and more. In manufacturing, the IoT plays a crucial role in enabling predictive maintenance, real-time monitoring of production processes, and efficient supply chain management.
The growth of the IoT has been exponential, and it continues to reshape how businesses and society function. As more devices and systems become connected, the IoT's impact on Industry 4.0 and daily life is expected to be transformative, driving innovation, efficiency, and convenience in ways that were once unimaginable.
With the immediate availability of real-time data from sensors, predictive maintenance processes can be initiated, and potential issues can be identified and resolved remotely. This level of data accessibility also enables processes to adapt in real-time to changing needs, leading to optimization of time, increased efficiency, and greater flexibility.
The IoT creates a comprehensive ecosystem where various tools and resources interact to transfer information and data. The fundamental resource generated by the IoT is data collected in real-time by sensors, which is used to improve process efficiency and problem-solving. The sensors, actuators, and transmitters that collect and transmit data are becoming increasingly affordable, smaller, and more sophisticated due to advancements in miniaturization and wireless communication.
However, the widespread adoption of IoT devices poses certain challenges, such as ensuring interoperability through common standards, addressing energy consumption issues for battery-powered devices, and handling maintenance and updates for a large number of interconnected devices.

[21] Industrial Internet of Things: Unleashing the Potential of Connected Products and Services. Cologny, Geneva: World Economic Forum, 2015.

The integration of IoT devices also demands a change in the skills required of human resources. The workforce needs to possess higher levels of qualifications in software development, IT, and analytical skills. This shift in skillsets allows workers to transition from mere operators to problem solvers. As a result, companies investing in the IoT must equip their workforce with technical personnel, such as engineers, data scientists, and experts in interface management.

Overall, the Industrial Internet of Things is reshaping manufacturing processes, leading to increased productivity, cost-effectiveness, and customer involvement in product usage. As the technology continues to advance and become more prevalent, its impact on Industry 4.0 will undoubtedly continue to grow, shaping the future of manufacturing and beyond. The introduction of Internet of Things (IoT) technologies, such as sensors, processors, and interconnected components, has given rise to a new category of products known as smart products. These products have unique features that enable them to monitor user behavior or product status, track data, and analyze collected information. This data can then be used to offer new products and services that cater to specific customer needs and preferences. Smart products activated by the industrial IoT also lead to personalized solutions, as customers are integrated into the engineering and design phases of products and services. Through the connection with IoT-enabled products, customers gain the ability to track the entire lifecycle of the product, enhancing their consumer experience. Companies leverage the data collected through these interactions to better understand their customers, identify their needs, and offer tailored experiences and services.

Moreover, the IoT enables customers to be actively involved in the value creation process. Through cyber-physical platforms and systems, customers become part of a network of data and service exchange relationships. This collaborative and interactive approach allows customers to play an active role in the co-creation of value with the company

To implement IoT technology, companies need to collaborate with specific suppliers, including hardware and semiconductor suppliers for sensors, RFID tags, and video cameras. Additionally, they require communication and machine-to-machine communication service providers and system integrators. These specialized suppliers enable the development of smarter and more connected systems.

2.7 Big data

Big Data & Analytics is a crucial technology of the fourth industrial revolution, focusing on collecting, organizing, and analyzing vast amounts of data from diverse sources. The term "Big Data" not only refers to the sheer quantity of information but also the computational capacity required to process data in real-time. It is a product of innovations in algorithms and forecasting models.

The challenge with Big Data & Analytics lies in efficiently managing the enormous volume of data that companies collect. This technology requires addressing four fundamental dimensions: volume (handling large amounts of data from various sources), speed (collecting data rapidly), variety (managing the heterogeneity of data), and veracity (ensuring data reliability).

To handle the processing demands of Big Data, companies use high-performance computing equipment, which can be costly. However, Big Data technologies offer an alternative approach by leveraging distributed systems and off-the-shelf hardware to achieve high performance at a lower cost. This flexibility allows companies to scale up their hardware as needed.

Data Science plays a crucial role in the context of Big Data & Analytics. It encompasses methodological principles based on the scientific method and various multidisciplinary techniques aimed at interpreting and extracting knowledge from data. Data Science deals with both structured and unstructured data, utilizing statistical, mathematical, programming, and problem-solving techniques. It includes various subfields, such as machine learning, deep learning, artificial intelligence (AI), and natural language processing (NLP).

Internally, companies have witnessed the emergence of new processes for data analysis, sharing, and storage. With timely data collection and real-time analysis, businesses can react quickly to changes in their environment and promptly resolve issues. The adoption of algorithms, statistical models, and machine learning enables automated operational-level decisions and informed decision-making.

In production processes, Big Data allows for predictive maintenance planning based on acquired information, leading to improved process quality and reduced unplanned downtime. Data is considered the main asset of Big Data technology and is used to enhance all business processes, including product development and functioning. These data can come from various sources, both internal and external, such as machinery, production lines, customers, suppliers, and other players in the value chain. With the use of data, companies can evaluate and sell targeted and customized products and services, meeting customer needs more effectively.

Big Data & Analytics also impacts human resources, as it requires data science skills to handle and analyze the vast amount of information. Data scientists are becoming increasingly crucial in understanding company needs and identifying appropriate technologies within the context of Big Data & Analytics.

Overall, Big Data & Analytics empowers companies to gain valuable insights from the vast amount of data they collect, leading to informed decision-making, enhanced efficiency, and improved business strategies. The integration of Data Science principles and technologies enables companies to unlock the potential of Big Data, transforming raw information into actionable intelligence and innovation. Big Data & Analytics technologies have opened up new possibilities for businesses to analyze large amounts of data and offer personalized and tailored services to individual users. This level of analysis was not possible with traditional systems and operations, allowing companies to better understand customer habits and needs and anticipate their requests. This, in turn, improves customer relations and leads to greater customer loyalty.

Externally, Big Data & Analytics technology accelerates data distribution processes for new products and services, optimizing delivery times, resource utilization, and geographical coverage in logistic processes. It also transforms communication channels between the company and its customers, making them more effective with targeted advertising based on sophisticated algorithms and social data like clicks, likes, and shares of web pages. Indeed, the economic-financial impact of Big Data & Analytics technology is twofold. On the cost side, the advanced analysis made possible by this technology helps reduce errors in production processes, leading to cost savings. By identifying inefficiencies and streamlining operations, companies can optimize their resources and minimize wastage, resulting in reduced production costs.

On the revenue side, data can be monetized directly through its sale. Companies can leverage the valuable insights gained from analyzing large datasets and offer data-driven services or sell the data itself to other businesses or research organizations. Additionally, data can be exploited indirectly to improve processes and products. By understanding customer behavior and preferences through data analysis, businesses can develop better-targeted products and services, leading to increased sales and customer satisfaction.

The integration of Big Data & Analytics technology in business operations enables companies to make data-driven decisions, reduce costs, and capitalize on data assets to generate additional revenue streams, making it a valuable investment for their economic and financial growth.

Applications for data management and collection – using applications directly on tablets and smartphones allows for excellent real-time communication and the ability to work from anywhere. Data collection apps help professionals and companies to collect data directly on-site faster and more accurately. Integrating this type of technology into current processes is simple. It requires a minimal initial investment while offering essential benefits, including significant time savings and reduction of data entry errors, improved workflows, use of any digital device, and safety. Data collection apps can facilitate everything from daily equipment inspections to incident reporting to a comprehensive workplace safety analysis.

3. Business model transformation through technological solutions

In the modern era, companies are constantly seeking ways to optimize their internal value chain, and technological advancements have played a pivotal role in this transformation. The integration of cutting-edge solutions has not only made internal processes more efficient but also resulted in products and services that cater to the evolving needs of consumers. In this chapter, we will explore how technological solutions are revolutionizing various aspects of the internal value chain, ultimately leading to smarter, more sustainable, and customer-centric operations.

3.1 Resources: Enhancing Traceability and Efficiency

One of the key areas where technology has made a significant impact is in resource management. Advanced solutions have facilitated better traceability of the flow of raw materials within organizations. This heightened traceability is not only essential for compliance and sustainability but also encourages the creation of novel materials and optimal resource utilization.

Technological innovations have enabled companies to minimize waste and emissions, contributing to cleaner manufacturing processes. By leveraging common communication standards between Cyber-Physical Systems (CPS) and accessing data across platforms, production resources have become interconnected and interoperable. This interconnectivity allows for the seamless exchange of information, making material flow more flexible and responsive to changing demands.

Resources play a pivotal role in the functioning of any organization, encompassing both physical and intangible assets. Physical resources such as raw materials, land, machinery, and buildings are essential for manufacturing and production processes. Additionally, financial resources like cash reserves and credit lines are crucial for ensuring smooth operations and managing unforeseen financial challenges. In today's rapidly evolving business landscape, the strategic management of resources is tightly intertwined with technological innovation. Resources, which encompass physical, financial, and intellectual assets, are the lifeblood of an organization. Effective utilization of these resources can determine an organization's competitive advantage and its ability to foster innovation.

Resources within the context of business operations encompass a diverse array of economic goods, each playing a unique role in powering an organization's processes. These resources are broadly categorized into two main types: those with simple fertility and those with repeated fertility. Resources with simple fertility include raw materials and semi-processed goods, which are typically consumed during the production process. They serve as the foundational elements upon which value-added processes are built. On the other hand, resources with repeated fertility encompass assets like land, buildings, plants, and machinery. These assets have the capacity to be used repeatedly over time and are integral to an organization's long-term operations.

The intersection of resources and innovation technology is at the forefront of modern business strategy. Successful organizations recognize the importance of optimizing their resources through technology, harnessing the power of data, nurturing intellectual capital, and embracing collaborative innovation to remain competitive and drive continuous technological advancements. As technology continues to evolve, resource management and innovation will remain inextricably linked, shaping the future of industries across the globe.

In addition to physical resources, modern businesses also rely heavily on financial resources. These encompass a company's monetary assets, such as cash availability and credit lines. Financial resources are essential for day-to-day operations, ensuring liquidity and providing a safety net for unforeseen financial challenges. However, in today's knowledge-driven economy, intellectual resources have emerged as increasingly critical components of an organization's success. Intellectual resources are multifaceted and encompass a wide range of intangible assets. They can be broadly classified into three categories:

1. **Human Capital:** This category encompasses the skills, education, experience, values, and social skills of an organization's members. It's the collective knowledge, expertise, and capabilities of the workforce that contribute to the organization's competitive advantage.
2. **Organizational Capital:** Organizational capital comprises the procedural and structural elements that enable an organization to function efficiently. This includes organizational procedures, routines, management systems, information and communication technology (ICT) infrastructure, and intellectual property owned by the organization. These components provide the framework within which employees operate and drive innovation.
3. **Relational Capital:** This category encompasses the relationships an organization maintains with external stakeholders, such as customers and suppliers. It also includes elements like brand equity, reputation, and the overall image of the organization. Strong relational capital can foster trust, loyalty, and long-term partnerships, all of which contribute to a company's competitiveness.

The distinction between resources in the business context lies in their ability to confer a competitive advantage. Resources are considered distinctive if they possess inherent value and enable the organization to respond effectively to environmental threats and opportunities that are rare, difficult to imitate, and can be exploited to the organization's advantage. The strategic combination of these original and distinctive resources leads to the development of unique skills and capabilities, setting the organization apart from its competitors. For instance, the ability to miniaturize products or processes can be a distinctive resource, creating a competitive edge. Furthermore, knowledge is a particularly critical resource because it empowers organizations to combine various resources and skills in novel ways, thereby generating additional value for customers and driving innovation. In today's rapidly evolving business landscape, the management and leveraging of these distinctive resources and intellectual assets are essential for sustainable success.

In today's knowledge-driven economy, intellectual resources have gained significant prominence. These intellectual resources are multifaceted, including human capital (comprising skills, education, experience, and social skills of employees), organizational capital (encompassing procedures, routines, management systems, ICT, and intellectual property), and relational capital (encompassing customer and supplier relationships, brands, and the organization's reputation). The value of these resources lies in their ability to enable organizations to respond to unique environmental threats and opportunities, which are rare, difficult to imitate, and exploitable.

The advent of IoT (Internet of Things) technology has a profound impact on resources, particularly in terms of data and connectivity. IoT creates an ecosystem where tools and resources interact to collect and transfer data seamlessly. Data, generated through the digitalization of the physical world, becomes a fundamental resource, collected in real time by sensors on IoT devices. These data are used to enhance process efficiency and solve problems effectively. IoT tools, such as sensors, actuators, and transmitters, are becoming smaller and more sophisticated thanks to miniaturization, enabling interconnected wireless communication. The integration of network software into machinery and devices enables machine-to-machine communication, predictive maintenance, and increased customer engagement. However, challenges like interoperability, energy consumption, and maintenance must be addressed[22]. Furthermore, the adoption of IoT necessitates a change in the skills required of human resources, with a greater emphasis on technical expertise in software development, IT, and analytics. In this context, cloud computing plays a pivotal role by facilitating access to vast amounts of data and

[22] Burmeister, C.; Lüttgens, D.; Piller, F.T. «Business Model Innovation for Industrie 4.0: Why the “Industrial Internet” Mandates a New Perspective on Innovation». Die Unternehmung, 70(2), 2016, 124- 52

enabling remote work, enhancing the flexibility of human resources and simplifying access control and management.

In order to harness the power of simulation models and create virtual replicas of the physical world, it is imperative to equip organizations with virtual manufacturing technologies, including simulation tools, software, and specialized systems[23]. These technologies leverage innovative resources, such as real-time data collected through sensors. For example, the integration of 3D representation models further enhances the optimization of resource flow within these virtual environments. Effectively utilizing this technology necessitates a skilled workforce proficient in data evaluation, adept at using simulation tools, and, where applicable, capable of enhancing or developing these tools in-house. Consequently, businesses should initiate training sessions to facilitate the acquisition of these essential skills.

In essence, foe example the successful adoption of simulation technologies relies not only on the implementation of appropriate tools and systems but also on the development of a capable workforce proficient in harnessing the potential of these advanced resources. In this aspect, data stands as the cornerstone of Big Data technology, driving improvements across all facets of business processes and product development. This data can originate from various sources, including internal company assets like machinery, production lines, and production control systems, as well as external sources such as suppliers, customers, and other actors within the value chain. Customer data, in particular, plays a pivotal role in tailoring products and services, allowing businesses to set prices and create personalized offerings. In today's global economy, data is considered a valuable resource, and unlike traditional raw materials, its volume continues to expand exponentially. As data becomes increasingly abundant and accessible, its effective utilization becomes critical for staying competitive and innovative in various industries.

These technologies also revolutionize how human resources operate, offering a robust database for analyzing and resolving issues more efficiently. However, managing the sheer volume of data requires specialized skills in data science, including expertise in software and algorithms, as well as knowledge of methods for analyzing, evaluating, designing, and managing complex systems, structures, and processes. This has given rise to the role of the data scientist, who plays a pivotal role in bridging the gap between understanding the needs of a company's reality and identifying the most suitable technologies within the realm of Big Data and analytics to fulfill those needs. In essence, data scientists are essential in harnessing the power of data to drive informed decision-making and business growth.

Furthermore, these solutions have empowered organizations to estimate the remaining useful life of production resources more accurately. The abundance of data, now readily available, has emerged as a valuable resource for recycling and reusing materials, reducing the environmental footprint of operations. Additionally, as technological solutions reshape the landscape, human resources within companies find themselves tasked with new roles and responsibilities, reflecting the evolving demands of the modern workplace.

In this sense, one of the primary areas where 3D printing exerts its influence is in product development. This technology offers a new level of freedom in product design, both in terms of aesthetics and the complexity of shapes. Designers and engineers are no longer constrained by traditional manufacturing methods, allowing them to explore innovative and intricate designs. Rapid prototyping, made possible by 3D printing, is a hallmark of this technology. CAD/CAM software, in conjunction with 3D printers, enables the swift transformation of digital designs into tangible prototypes. This accelerated prototyping process is invaluable for iterative design and testing, reducing time-to-market and development costs.

[23] Westkämper, E. «Digital Manufacturing In The Global Era». Cunha, P.F.; Maropoulos, P.G. Digital Enterprise Technology. Boston: Springer 2007, 1-11.

3D printing goes beyond just prototyping; it empowers companies to manufacture first series products for market testing before committing to large-scale production systems. The 'layer-by-layer' manufacturing principle inherent to 3D printing enables the creation of integrated parts in a single process, thereby reducing or even eliminating the need for complex assembly processes.

The impact of 3D printing extends to inventory management and internal logistics processes. The technology provides the capability to revolutionize inventory management policies, not only for semi-finished products but also for spare parts. 3D printing facilitates 'just-in-time' production, allowing companies to print parts as needed, reducing the need for large inventories.

The reduction in inventory levels, along with shortened design and processing times, translates into enhanced process efficiency and safety. Furthermore, the transition from subtractive manufacturing (e.g., machining) to additive manufacturing (3D printing) significantly reduces waste, further promoting sustainability. 3D printing also fosters a more dynamic and responsive approach to production, aligning with customer demands. Customized production can be expedited, and production stages can be located closer to the customer, reducing lead times and transportation costs. The technology's ability to economically handle low production volumes is crucial, enabling the creation of small batches of customized products without the prohibitive costs associated with machine re-setting and assembly activities. The versatility of 3D printing technology has led to its widespread adoption across various industries. In the mold-making sector, it revolutionizes the creation of molds by introducing cooling channels that facilitate faster casting cycles. In the biomedical field, 3D printing plays a pivotal role in producing prostheses, tailored to individual patients' needs. The aeronautical industry harnesses 3D printing's capabilities for topological remodulation of components, leading to substantial weight reduction in aircraft.

3D printing integrates seamlessly into the context of agile product development methodologies, such as the 'agile scrum' approach. This methodology is renowned for its efficiency in engineering new products. For instance, when designing a functional prototype that must meet specific requirements, the agile scrum approach involves iterative phases of reengineering and prototyping, with empirical evaluations at the end of sequential cycles, known as 'sprints.' 3D printing accelerates this process due to its rapid prototyping capabilities, reducing sprint cycles and expediting the creation of final prototypes. In conclusion, 3D printing has fundamentally transformed internal processes within companies. Its influence on product development, inventory management, and logistics is marked by increased efficiency, flexibility, and responsiveness. This technology's ability to redefine product design, streamline production, and enhance the iterative development process has made it an indispensable tool in today's fast-paced and competitive business landscape. As 3D printing continues to evolve, its impact on internal processes is set to deepen, offering new possibilities for innovation and efficiency across industries.

Resources are indeed the cornerstone of cloud computing's most significant impact. When corporate information systems migrate to the cloud, they gain the ability to access vast amounts of data almost instantaneously, limited only by the bandwidth of the network connection. This data accessibility revolutionizes business operations, enabling real-time decision-making and analysis. Big data and analytics technologies thrive in this cloud-driven environment, as they can efficiently process and derive insights from massive datasets stored in the cloud. Similarly, the Internet of Things (IoT) relies on the cloud's scalability and storage capabilities to manage and analyze the data generated by countless connected devices, leading to improvements in efficiency and predictive maintenance. Additionally, additive manufacturing and augmented reality technologies are elevated by the cloud, as they can leverage cloud resources to enhance their capabilities, such as rendering 3D models or providing real-time guidance. Furthermore, cloud computing fosters greater flexibility in human resources. It empowers employees to work remotely, as they can access information from anywhere and through any device with an internet connection. While remote work options existed before the advent of cloud computing, the cloud simplifies the process and solidifies the practice's widespread adoption. This flexibility not only improves work-life balance but also expands the talent pool for organizations, as they can hire individuals from anywhere in the world. Additionally, cloud-based tools for remote access control make human resource management more efficient, allowing employers to monitor and manage employee activities and data securely, even when they are working from various locations. In this way, cloud computing not only enhances resource accessibility but also facilitates the effective management of human resources in the modern digital workplace.

3.2 Internal Processes: Real-time Optimization and Automation

The integration of cyber-physical systems has ushered in a new era of real-time optimization of internal processes within companies. This integration has automated high-know-how activities while providing greater flexibility for routine tasks. Consequently, overall production efficiency has improved significantly. The digitization of process control and performance monitoring, facilitated by the wealth of data available, enables statistical and advanced controls of processes. This not only leads to more efficient energy consumption but also enhances product traceability and raw material management. Moreover, remote monitoring capabilities have emerged, allowing for predictive maintenance processes to be initiated, reducing machine downtime, enhancing operational safety, and mitigating operational risks. The adoption of enabling technologies has also empowered organizations to produce complex components and small batches on-site. Production processes can now self-organize and self-adapt, thanks to intelligent production units that autonomously optimize production planning to maximize profits and monitor their own status. Additionally, these innovations enable companies to improve the allocation of production capacity, enhance product quality, and adapt design and production processes to customer needs through virtual prototyping and analytics.

In the realm of internal processes, one area where 3D printing has made a profound impact is in the production process itself, specifically in product development, processing, and assembly phases. This transformative technology has introduced a host of changes that enhance efficiency and flexibility within organizations. Additive manufacturing has revolutionized product development. It offers an unprecedented level of freedom in product design, both in terms of aesthetics and complexity of shape. Designers and engineers are liberated from the constraints of traditional manufacturing methods, enabling the exploration of innovative and intricate designs.

One of the hallmark advantages of 3D printing in product development is rapid prototyping. Supported by CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) software, this technology allows digital designs to swiftly transform into scale models. This acceleration in prototyping is invaluable for iterative design and testing, dramatically reducing time-to-market and development costs. Moreover, 3D printing extends beyond mere prototyping. It empowers companies to produce first series products for market testing before committing to large-scale production systems. The 'layer-by-layer' manufacturing principle inherent to 3D printing enables the creation of integrated parts in a single process, thereby reducing or even eliminating the need for complex assembly activities. This reduction in assembly components paves the way for more intricate and sophisticated product structures. 3D printing has also revolutionized inventory management and internal logistics processes. It enables organizations to modify inventory management policies drastically, not only for semi-finished products but also for spare parts, which can now be produced 'just in time.'
This shift toward on-demand manufacturing significantly reduces inventories and design and processing times. Consequently, internal processes become more efficient and secure. The transition from subtractive manufacturing (e.g., machining) to additive manufacturing (3D printing) contributes to reduced waste, further bolstering sustainability efforts. Moreover, 3D printing facilitates a faster, more

flexible, and responsive approach to production. It enables personalized production, aligning with customer needs. Production phases can be strategically located in proximity to customers, reducing lead times and transportation costs. Additive technologies make low production volumes economically viable, facilitating the creation of small batches of customized products while eliminating the need for machinery re-setting and assembly activities. This shift is particularly significant since traditional production processes, such as molding, are often cost-prohibitive for small batches due to high fixed costs like molds.

The versatility of 3D printing technology has led to its widespread adoption across various industries. In the mold-making sector, 3D printing allows the creation of cooling channels inside molds, enabling much faster pressure casting cycles. In the biomedical field, it plays a pivotal role in producing customized prostheses tailored to individual patients' needs. The aeronautical industry harnesses 3D printing's capabilities for topological remodulation of components, leading to substantial weight reduction in aircraft.

Within the context of product development processes, additive manufacturing seamlessly aligns with agile product development methodologies, such as the 'agile scrum' approach, known for its efficiency in engineering new products. For instance, in designing a functional prototype that must meet specific requirements, the agile scrum approach involves iterative phases of reengineering and prototyping, with empirical evaluations conducted at the end of sequential cycles, called 'sprints.' 3D printing accelerates this process significantly due to its rapid prototyping capabilities, leading to shorter sprint cycles and faster achievement of the final prototype.

A significant advantage derived from cloud technology is the ability to conduct maintenance work remotely, as both people and machines interact with each other through the cloud infrastructure. This remote maintenance capability leads to substantial improvements in maintenance processes, primarily driven by enhanced visibility and accessibility of relevant information for all stakeholders involved. With access to the cloud, interested parties can retrieve real-time data and insights pertaining to the state of machinery and equipment, which in turn empowers them to execute maintenance operations more effectively. Cloud-stored information is also subjected to analysis by Big Data and analytics systems, enabling companies to detect and address hidden issues like machine degradation or component wear before they lead to costly breakdowns. Additionally, cloud computing supports and streamlines predictive maintenance processes by leveraging the wealth of data collected by the company. This proactive approach ensures optimal production and reduces downtime through data-driven decision-making.

In essence, cloud technology transforms maintenance from a reactive to a proactive endeavor, significantly reducing downtime and costs associated with unexpected equipment failures. By harnessing the power of the cloud, businesses can access timely and accurate data, utilize advanced analytics, and implement predictive maintenance strategies that not only extend the lifespan of their assets but also enhance overall operational efficiency. The ability to monitor and maintain equipment remotely, along with the insights provided by cloud-enabled analytics, represents a game-changer for industries reliant on machinery and equipment, paving the way for more reliable and cost-effective operations.

On the side of the Internet of Things (IIoT), this techology is playing a transformative role in reshaping internal processes across various industries. By introducing intelligent machines and interconnected objects that communicate with key production stakeholders, such as workers, smart machinery, robots, and supervisory systems, the IIoT facilitates seamless information sharing. This, in turn, enables rapid adaptations to processes and swift responses to changes in real-time. IoT technologies can even lead to the virtualization of entire processes and supply chains, creating a dynamic and interconnected network of devices and systems. The integration of data from diverse sources empowers organizations to decentralize the monitoring of physical processes and enables remote control, allowing for the identification and resolution of issues without physical intervention.

Moreover, the immediate availability of data from IoT sensors enables the implementation of predictive maintenance processes. These sensors can track every item in the production process, allowing for real-time adjustments to meet changing requirements. The IIoT's ability to optimize processes in real-time results in improved efficiency and flexibility, making large-scale customized production more cost-effective and productive. This technological advancement not only enhances overall operational efficiency but also contributes to higher levels of productivity, enabling industries to stay competitive and responsive to the ever-evolving market demands.

3.3 External Processes: Redesigning Customer Engagement

Technological solutions have not only transformed internal processes but also revolutionized the way companies engage with customers. This transformation encompasses the redesign of communication and distribution channels and the pursuit of on-demand manufacturing to provide greater flexibility in value chains. Companies now offer services remotely, catering to consumer needs through virtually guided 'do it yourself' assistance. Maintaining long-lasting relationships with customers, these companies offer product monitoring and diagnosis to reduce defects and uncertainties in their operating systems. Constant traceability of products, starting from remote monitoring of the transport service, offers maximum transparency on product status and usage by customers. These services not only reduce processing times and machinery downtime at customer premises but also reduce the need for maintenance and repair, enhancing value for the customer. Industry 4.0, driven by digital technologies and Cyber-Physical Systems (CPS), is reshaping the external value chain of businesses, leading to a reduction in complexity and an increase in end-to-end integration and automation. This transformation extends the physical boundaries of a company, effectively turning it into an extended enterprise. Real-time interactions within the industrial ecosystem become possible, fostering a networked and collaborative environment within the value system.

One of the key enablers of this transformation is the concept of the "digital thread," which involves the continuous identification of a product throughout its entire production process. This virtual recreation of supply flows, free from interruptions, forms an integrated system that offers enhanced transparency and efficiency within the value system. It allows for the early recognition and resolution of inefficiencies and risks at their source, strengthening the value system's resilience and adaptability to external changes. As a result, the establishment of a smart value system enhances forecasting accuracy, accelerates collaboration in innovation processes, and contributes to overall operational excellence.
Industry 4.0 also brings about transformations in relationships with both suppliers and customers. Suppliers become part of a network of smart suppliers, fostering project-based partnerships and ad hoc collaborations. The interconnected nature of the value system enables real-time supply chain optimization, ensuring a more responsive and efficient flow of materials and information. On the customer front, Industry 4.0 allows for the integration of customer needs and preferences into product development processes. Companies can co-create products with customers, leveraging data and analytics to predict demand and tailor offerings that reduce the customer's operating costs, thus enhancing the Total Cost of Ownership. Moreover, technological innovations in Industry 4.0 are giving rise to the phenomenon of "emerging expectations," where customer expectations from one context are transferred to other sectors. Companies that can identify and respond to these evolving expectations gain a competitive edge by capitalizing on emerging opportunities and driving innovation.

These changes in external processes driven by innovative technology led to a reduction in time to market, enabling companies to gain a deeper understanding of their customers and involve them more in the product development process, ultimately increasing customer satisfaction. Companies increasingly employ platforms as tools for distributing products and seek proximity to customers through relocation efforts.
The ability to collect and analyze customer data allows companies to attract new customers through targeted communications without the need for intensive marketing activities.
Simulation's applicability extends to all phases of the manufacturing process, including external processes such as warehousing, transportation, and product logistics. Simulation models, spanning the entire product life cycle, enable the management of the entire network of stakeholders involved in various phases, from design to sustainable disposal. These models have the capability to provide sustainability parameters for decision-making, benefiting both businesses and public bodies in managing environmental impacts.

In line with that, the advent of IoT technologies has not only transformed businesses but also revolutionized the way customers engage with products and services. IoT has seamlessly integrated customers into the value chain, fostering a collaborative and interactive relationship. Consumers now have the ability to engage with products throughout their entire lifecycle, from manufacturing to end-of-life disposal. This connectivity has enabled businesses to differentiate the consumer experience significantly. Through IoT-enabled products, companies can collect a wealth of data and information about their customers' behaviors, preferences, and usage patterns. This data-driven approach allows companies to gain a deep understanding of their customers, identify their needs in real time, and engage with them directly. By offering more personalized and tailored experiences, businesses can not only meet customer expectations but also anticipate and exceed them.

IoT has essentially transformed customers into active participants in the value creation process. Through cyber-physical platforms and interconnected systems, customers are now part of a network where data and services are exchanged seamlessly. This collaborative ecosystem allows for the co-creation of value, where customers can provide feedback, receive personalized recommendations, and benefit from enhanced services based on their individual preferences and needs. As a result, the customer experience is elevated to new heights, fostering loyalty and long-lasting relationships. In this interconnected world driven by IoT, the boundaries between businesses and their customers blur, and both parties benefit from a more dynamic and mutually beneficial relationship.

3.4 Products: The Era of Smart Products and Services

Smart products equipped with new features and functionality have emerged as a central component of this technological transformation. These products possess the capability to self-manage, self-adapt, and exchange information with other smart devices via machine-to-machine (M2M) communication.
These products are equipped with software systems that allow for constant updates and parameter improvements. They facilitate the traceability and digital monitoring of product use and disposal, enhancing the overall user experience. User interaction with these products is simplified through communication interfaces, further promoting customer engagement. The ability to personalize products based on customer needs and requirements enhances customer satisfaction. Smart products maintain a continuous connection with the producer, providing valuable information for optimization and innovation throughout their life cycle. This ongoing relationship with the customer allows companies to expand their product range and offer complementary after-sales services, such as predictive maintenance, based on customer information. The combination of smart goods and services represents a significant innovation, leading to an enhanced customer experience and fostering a stronger relationship between the customer and the company.

In conclusion, the integration of technological solutions has fundamentally transformed the internal value chain of companies. From resource management to internal processes, external interactions, and product offerings, these solutions have ushered in an era of intelligence, efficiency, and customer-centricity. As businesses continue to embrace these innovations, they are poised to thrive in an increasingly dynamic and competitive marketplace[24].

The cloud plays a pivotal role in the functionality of smart products, enabling them to offer enhanced user experiences and customized features. With cloud technology, smart products can remotely provide valuable information and updates to users, allowing for real-time adjustments and customization of the product's functions. For example, a smart thermostat can continuously access weather data from the cloud to optimize heating and cooling settings, ensuring comfort and energy efficiency. Moreover, the cloud facilitates the delivery of new services and features for smart products. Manufacturers can roll out updates and improvements via cloud computing, expanding the capabilities of these products even after they have been purchased. This dynamic and ever-evolving nature of smart products is made possible by the cloud, offering consumers more value and extending the lifespan of their devices.

Additionally, the integration of cloud-based applications in smart products can significantly enhance their performance. These applications don't require installation on the device itself but instead work through cloud technology, accessed from the user's device. This approach not only conserves valuable device resources but also ensures that the product can benefit from the latest software and services available in the cloud. For instance, a smart camera can leverage cloud-based image recognition algorithms to improve its ability to identify and categorize objects, offering more accurate and useful features to users. The cloud's flexibility and scalability enable smart products to tap into a vast ecosystem of software and services, ensuring they remain cutting-edge and adaptable to evolving user needs.

Virtual prototyping stands as a fundamental tool, enabling the creation of small batches of customized products. The implementation of modular simulation techniques further enhances the ability to adapt and accelerate product innovation processes. Simulation technology also extends its benefits to warehouse management and internal logistics processes. Through simulation, it becomes possible to optimize warehouse and production plant layouts, thereby improving operational efficiency. Moreover, the production process undergoes a significant positive transformation due to the ability to simulate the production line. This is achieved through the creation of a virtual production system, generated from real-time data collected in the physical world. With contemporary technologies, machinery behavior can be accurately simulated, leading to performance optimization and a reduction in the need for experimental tests. Additionally, the concept of the digital twin is introduced, representing a digital replica of the production system. This digital twin serves as an asset for process optimization and reconfiguration phases, contributing to minimizing the time between product design and delivery.

3.5 The Economic-Financial Impact

While the initial investment in simulation technologies may appear substantial due to high acquisition costs, the efficiency gains and subsequent reduction in operational costs result in a rapid return on investment[25]. Additionally, businesses can strategically allocate investments to contribute to the development or customization of simulation tools deemed necessary for their specific needs.

[24] Industry 4.0 – Challenge for the F&B industry in Greece, advantage or competitive disvantage? Roland Berger Strategy Consultants, 2016

[25] Kagermann, P.; Wahlster, W.; Helbig, J. Recommendations for implementing the strategic initiative INDUSTRIE 4.0. Final report of the Industrie 4.0 Working Group. Acatech - national academy of science and engineering, 2013

Cloud computing has ushered in a significant economic-financial revolution by drastically reducing the costs associated with computer processing and storage. One of the most compelling examples is the scalability of cloud resources. Unlike traditional on-premises infrastructure, cloud services allow businesses to scale their computing and storage resources up or down based on their needs, effectively eliminating the need to over-provision hardware to accommodate peak loads. This means that organizations no longer have to invest heavily in expensive data centers and servers that may sit idle for much of the time. For instance, a retail company can handle the surge in online shopping traffic during the holiday season without the burden of maintaining additional servers year-round. This flexibility in resource allocation results in significant cost savings and efficient resource utilization.

Furthermore, cloud computing also reduces hardware costs for various devices. For example, the rise of thin clients and mobile devices is made possible by the cloud. These devices rely on cloud servers to handle most of the processing and storage, reducing the need for powerful, expensive hardware components in individual devices. This not only lowers the manufacturing costs of these devices but also extends their lifespan as they can remain useful for longer periods without becoming obsolete due to hardware limitations. Similarly, the advent of serverless computing allows businesses to run code without the need to manage servers, leading to lower maintenance costs and freeing up resources that can be redirected towards innovation and growth. Overall, cloud computing's impact on cost reduction is not only substantial but also transformative, enabling businesses to allocate their financial resources more efficiently and strategically.

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4. Conclusions

In conclusion, the operational benefits brought forth by Industry 4.0 enabling technologies are transformative, extending from individual building blocks, such as the 'Internet of Industrial Things' and 'Big Data & Analytics,' to broader concepts like 'Predictive Maintenance' within the realm of 'Internal Processes.' These benefits have a profound impact on critical success factors, which, in turn, underpin value propositions and strategic dimensions, exemplified by the influence of 'Predictive Maintenance' on 'Reliability,' 'Productivity,' and ultimately 'Operational Excellence' (as depicted in Table 1).

The potential of Industry 4.0 to shape critical success factors and strategic dimensions offers a fertile ground for innovation in value propositions and the creation of novel business models. These opportunities are inherently tied to the capabilities that Industry 4.0 technologies provide for data collection, utilization, and sharing. Data, in this context, emerges as a strategic asset, driving value generation and enabling the development of integrated solutions and new services.

This convergence of factors positions both manufacturing and non-manufacturing companies to harness the value emerging from Industry 4.0. By leveraging these technologies and the strategic insights they provide, organizations can adapt, innovate, and thrive in an increasingly data-driven and interconnected industrial landscape. In essence, Industry 4.0 presents not only a technological evolution but also a pathway to reimagine and redefine the business landscape for those prepared to seize its full potential.

Industry 4.0 represents a transformative paradigm that is still in its maturation phase, offering profound implications for the reconfiguration of business models across various industries. This paradigm shift holds the promise of delivering numerous positive scenarios, with significant potential for process efficiency, cost reduction, and enhanced productivity, especially for small and medium-sized enterprises (SMEs)SMEs stand to benefit greatly from Industry 4.0 technologies, particularly through the capacity for customized manufacturing on a large scale. Innovations like additive manufacturing not only improve production quality and efficiency but also enable investments in product customization, thereby fostering the "mass customization" business model. Furthermore, these technological advancements open doors to the introduction of new pre- and post-sales services and enhance the agility to respond swiftly to market demands, aligning with other recognized Industry 4.0 business models.

However, the path to widespread Industry 4.0 adoption is not without its challenges. Barriers related to corporate culture, the readiness of internal human resources for change, the complexity of assessing real implications and benefits, and a shortage of necessary skills can hinder progress. Additionally, limited integration within the value chain and difficulty in identifying competent partners present formidable obstacles for businesses. Overcoming these challenges will be essential for organizations looking to fully realize the potential benefits of Industry 4.0 and navigate the transformative journey effectively. As Industry 4.0 continues to evolve, addressing these barriers will become increasingly crucial in ensuring its successful implementation across a wide range of industries and business sizes. Moreover, as reported in D2.1, the endeavor to present a questionnaire aimed at exploring critical aspects of technological innovation in the construction sector, specifically for small and medium-sized enterprises (SMEs), marks a significant milestone in the evolution of this vital industry. While we encountered challenges with the initial response rate, we view this as an opportunity rather than a setback. It compels us to reassess and refine our strategy for disseminating the questionnaire.

The consortium commitment to broadening SME participation, including small businesses, remains unwavering, particularly within the framework of Work Package 3, which encompasses targeted training courses. We recognize that these courses and awareness-raising initiatives are essential for actively involving companies. By helping them understand the significance of their input and participation in the questionnaire, we aim to foster growth and innovation within the construction sector.

The dissemination of the questionnaire and the promotion of training courses are central to our mission of supporting SMEs in the construction sector. Technological innovation is the cornerstone of competitiveness in an ever-evolving market. We firmly believe that involving businesses in defining their needs is fundamental to the success of any initiative. Moving forward, we are committed to continued collaboration with SMEs, attentively listening to their voices, and providing tailor-made training programs to equip them with the latest technologies and advanced practices. We are resolute in our determination to raise awareness and participation, which we believe will lead to a more robust response to our questionnaire and, ultimately, a more innovative and competitive construction sector in the future. Together, we can drive positive change and empower SMEs to thrive in this dynamic industry.

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ANNEX A: Questionnaire for adoption of innovative tools by SMEs in building construction field

Content

The data collected will be used exclusively for the project, processed and disclosed only in an integrated manner in the sector's interest.

You can indicate your interest in a more in-depth interview and a technological audit on technological innovation. Thanks for your collaboration.

QUESTIONNAIRE

Name and Surname __________ Position: _____ email: ______________

SECTION 1: TECHNOLOGY AND INNOVATION

1.1 - Considering some current technological trends, which do you think are most interesting for your company? (tick one or more topics)

Digital innovation: adoption of new digital and IT tools (e.g. BIM, IFC, …) ☐

New technologies: use of new materials, new machinery, new systems that enable new processes ☐

Home automation / control / sensors ☐

New business models (activities, resources and key partners, value proposition, customers, …) ☐

Perception of value by the market: product/service quality, methodologies and processing techniques, increase in consumer awareness (e.g. constitution of an intermediary trust instrument) ☐

1.2 - On which topics/technologies is your company already active? (choose one or more options)

Energy efficiency ☐

Environmentally friendly materials and products ☐

Innovative materials and products ☐

Innovative processing techniques ☐

Tools/software for acquiring, viewing and analysing images ☐

Industry 4.0 and digitization (New equipment, machinery, technologies, …) ☐

1.3.-Could Your company specify technologies (tools and solutions) used in Your projects regarding energy-efficient buildings and renovation projects at the moment?

1.4 - What are the topics of technological innovation in the near future that you consider important for your company?

1.5 - Is your company interested in participating in working groups on the subject of technologies?

1.6 - In which areas does your company deem it appropriate to invest in the next two years? (choose one or more options)

Product or service technological innovations ☐

Personalization, efficiency, specialization ☐

New technologies applied to machinery, equipment, software ☐

Opening up to new markets ☐

Digital Transformation ☐

Business models/Communication/marketing/sales network ☐

Staff skills ☐

Other (specify):

1.7 Other comments, recommendations and experience sharing from Your company regarding tools and solutions in the field of energy efficient building industry.

1.8. Any negative experience with energy-efficient innovations? If so, please provide examples.

1.9. Can You name partners Your company cooperates with in terms of receiving innovations for energy-efficient tools and solutions?

1.10. Is there any specific legal regulations that slow down the implementation of innovations? Our opposite.

1.11 Other comments, recommendations and experience sharing from Your company regarding tools and solutions in the field of energy efficient building industry.

SECTION 2: OPERATING STRUCTURE OF THE COMPANY

2.1 - Company number of employees: ACTIVITY SECTOR Company type
2.2 - Are there members/owners under 40 in the company?
2.3 - Turnover last year:

decrease ☐

stable ☐

increase ☐

SECTION 3: RESEARCH AND DEVELOPMENT

3.1 - Does the company carry out or has it carried out in the last two years Research and Development activities on topics of technological innovation? Yes No
IF:

3.1a - Making use of internal skills (specify which: owner/partners, technical department, ...) ☐
3.1a bis - Number of internal personnel dedicated to R&D (also specify educational qualification: diploma, degree, master, doctorate...

3.1 b - Making use of external expertise (professionals, research institutions, universities, consultancy firms) ☐

3.2 - Has the company ever hired researchers?
Yes ☐
No ☐
3.3 - Does the company make use of external training institutions?
(If yes, specify training areas of the last two years)
Yes ☐
No ☐

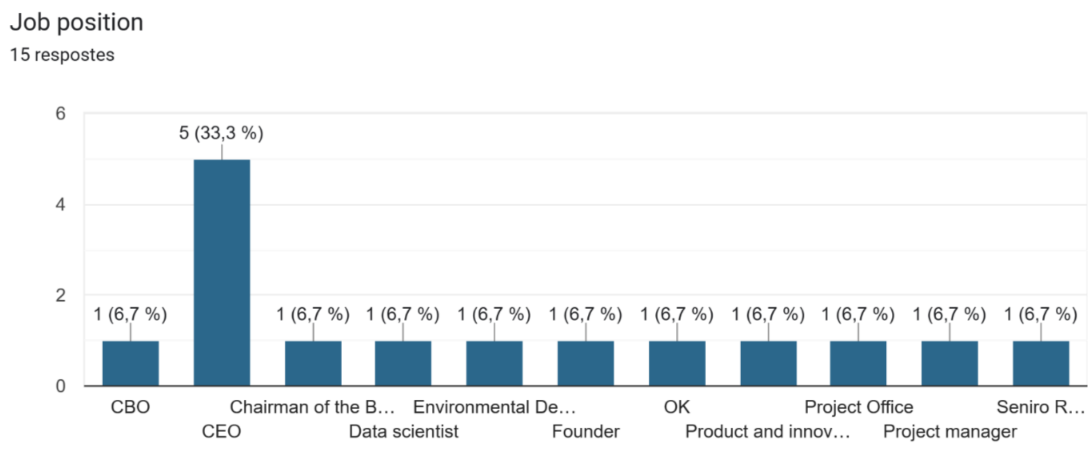
3.4 - Does the company carry out internal training activities?
(If yes, specify training areas of the last two years)
Yes ☐
No ☐

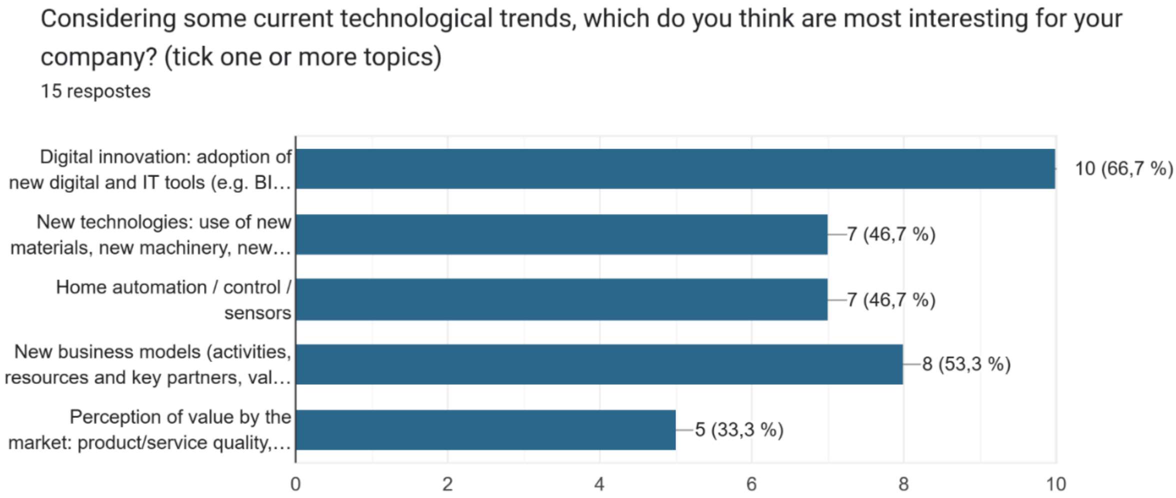
3.5 - Has the company developed patents and/or specific industrial technologies? (If yes, specify scope)
Yes ☐
No ☐

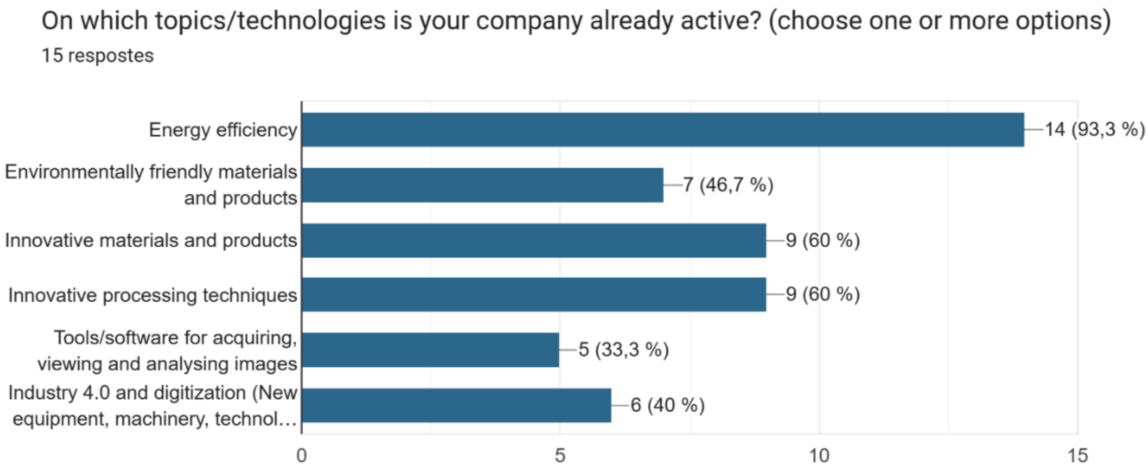
3.6 - Has the company ever used third-party patents (universities, research centres, companies, start-ups)? (If yes, specify scope)
Yes ☐
No ☐

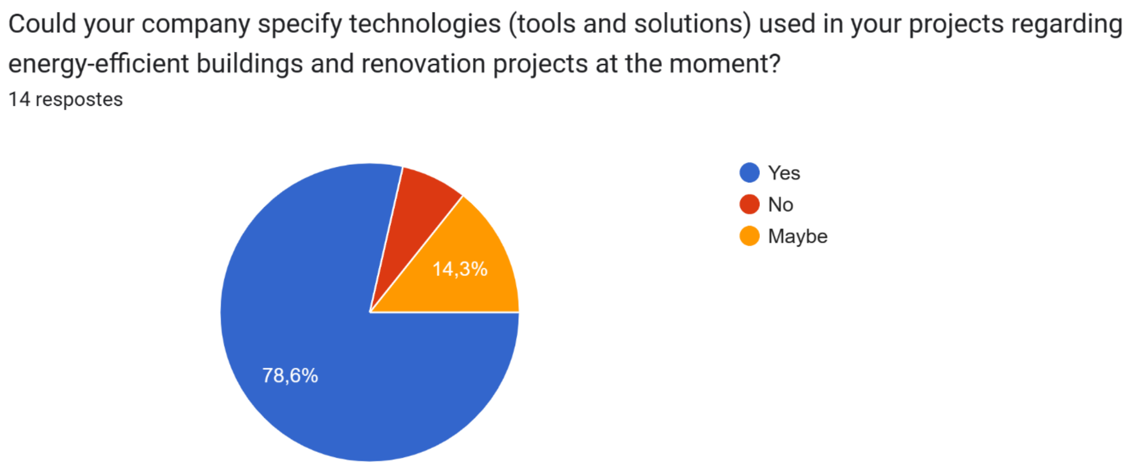
3.7 - Has the company ever made use of public funding for Research and Development? (If yes, specify which, e.g. MIUR, European Funds, ...)
Yes ☐
No ☐

Request/expression of interest for Technological Audit?




Considering some current technological trends, which do you think are most interesting for your company? (tick one or more topics)
15 respostes
Digital innovation: adoption of new digital and IT tools (e.g. BI…
New technologies: use of new materials, new machinery, new…
Home automation / control / sensors
New business models (activities, resources and key partners, val…
Perception of value by the market: product/service quality,…
10 (66,7 %)
7 (46,7 %)
7 (46,7 %)
8 (53,3 %)
5 (33,3 %)
0
2
4
6
8
10

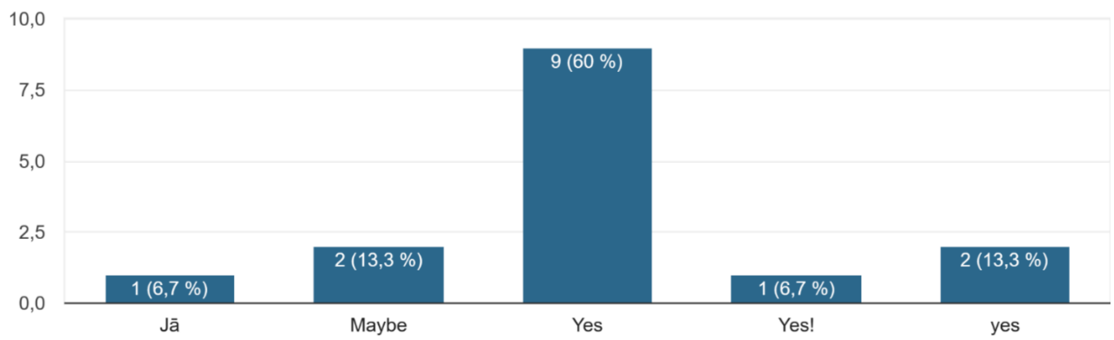

On which topics/technologies is your company already active? (choose one or more options)
15 respostes
Energy efficiency
Environmentally friendly materials and products
Innovative materials and products
Innovative processing techniques
Tools/software for acquiring, viewing and analysing images
Industry 4.0 and digitization (New equipment, machinery, technol…
14 (93,3 %)
7 (46,7 %)
9 (60 %)
9 (60 %)
5 (33,3 %)
6 (40 %)
0
5
10
15

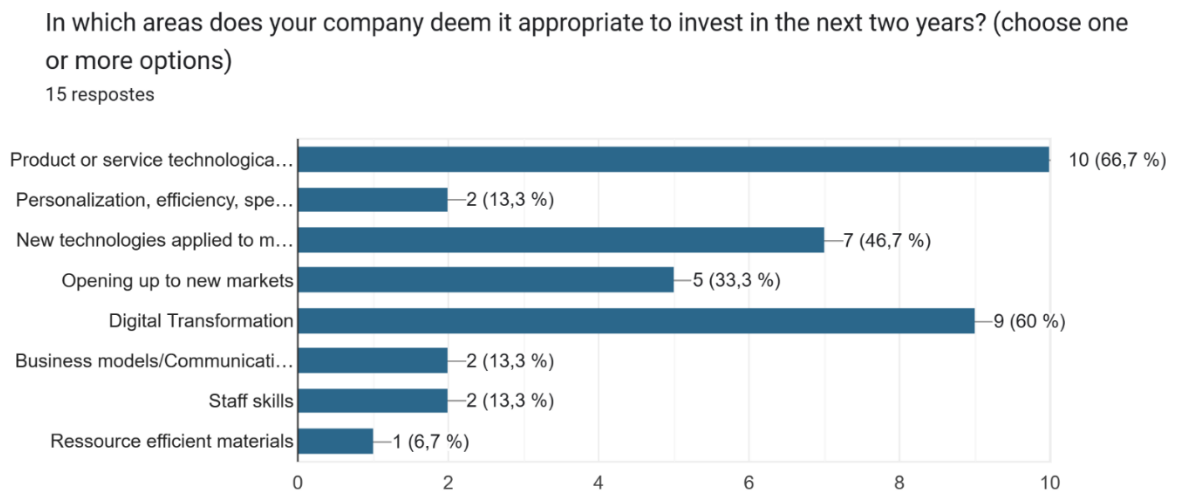

Could your company specify technologies (tools and solutions) used in your projects regarding energy-efficient buildings and renovation projects at the moment?
14 respostes
14,3%
78,6%
Yes
No
Maybe

What are the topics of technological innovation in the near future that you consider important for your company?

- Building digitalization and industrialization of the construction sector
- Energy efficiency
- Software
- Interactive Augmented Reality Software
- energy-efficient control
- Materials for thermal and acoustic insulation
- Advanced manufacturing
- Develop for an optimized production M2/hour of plastic boards. Artificial intelligence for traceability on the whole chain
- Nevajag d.................................
- sensorics
- Environmental simulations, AI/ML, BIM, Digital Twins
- The implementation fo AI in our software
- Edge Intelligence and Deep AI
- Edge Computing Sensors and agnostic cloud IoT platforms
- Artificial Intelligence

Is your company interested in participating in working groups on the subject of technologies?
15 respostes





Other comments, recommendations and experience sharing from your company regarding tools and solutions in the field of energy efficient building industry.

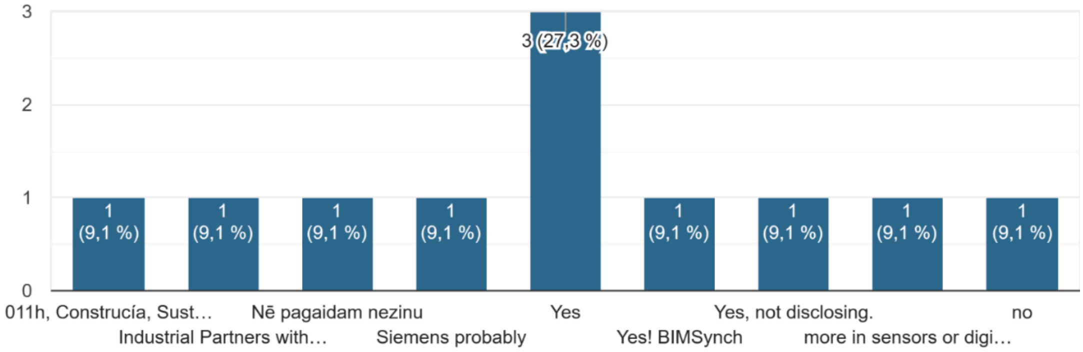
-

- Previous answer is based on my personal experience and not necessarily linked with the company's development strategy
- Pay more attention to the XR industry!
- Carrying out energy audits and energy efficiency projects. In addition, innovation and development projects are carried out, in the context of energy audits and in the optimization of the consumption of facilities in buildings.
- Lack of EU raw resources, in particular bio-source while the capacity is available.
- Easier bureaucracy and optimized process for certification of new materials that are not the common products in the market
- Focus more on proactive processes
- Our tools offer benefits to building managers to save energy but they do not save by themselves, they need an involved energy manager to get their full potential. The commitment, awareness, training or available time of a manager can become a barrier to demonstrate the usefulness of any energy management support tool
- Sensor technology is shifting towards battery operated edge computing devices.

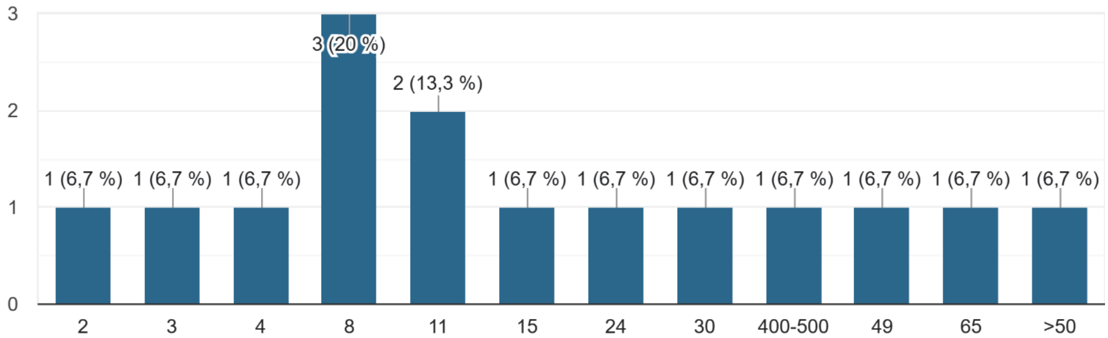
Any negative experience with energy-efficient innovations? If so, please provide examples.

- Difficult in build strong demo cases in real built environment. Difficult in data collection for exhaustive real impact assessment.
- Slow rate of innovation adoption within the construction market in reference to new material and products. Focus on red innovation (low risk, low impact).
- Post-active actions that mitigate consequences, rather than proactive actions that prevent causes. Such a post-active approach generates unnecessary costs and has an negative impact on sustainability of construction objects .
- Client perceptions of Costs-benefits, rigidity of legislation and certification processes and calculations, 'greenwashing'
- Fragmentation of IoT solutions and Interoperability issues

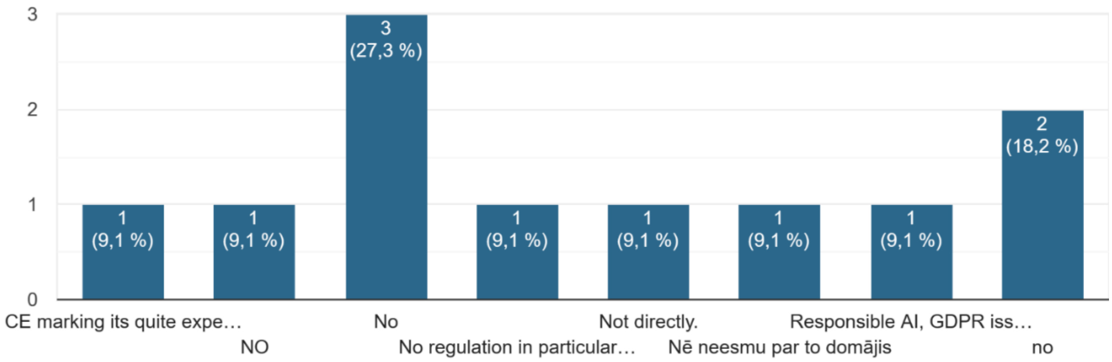
Do you know of any companies with innovative products that you would like to work with in the near future?
11 respostes



Company number of employees
15 respostes



Are you aware of any legal regulations, both on the state and EU level, that can slow down the implementation of innovations.
11 respostes

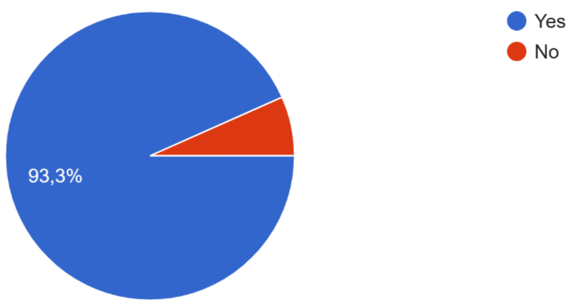


Activity Sector/Company type

- Research Center
- windows & Insulation materials
- Design&build
- XR 3d technologies in architecture and construction industry
- Engineering and Architecture, Energy efficiency, Renewable energy, Facility Services, Training courses
- Thermal insulation materials for the building's envelopeenvelope
- Construction/Scale-up
- Construction
- construction sector/ leak detection techologies / limited liability company
- Cross-disciplinary design|engineering|geospatial consultancy
- software for building energy management
- Software & Hardware Solutions (IOT)
- Sensor Manufacturer
- Energy, HVAC

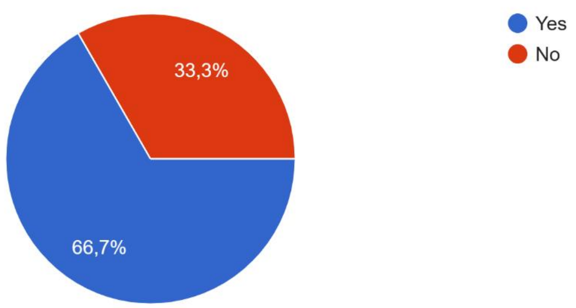
Does the company carry out or has it carried out in the last two years Research and Development activities on topics of technological innovation?

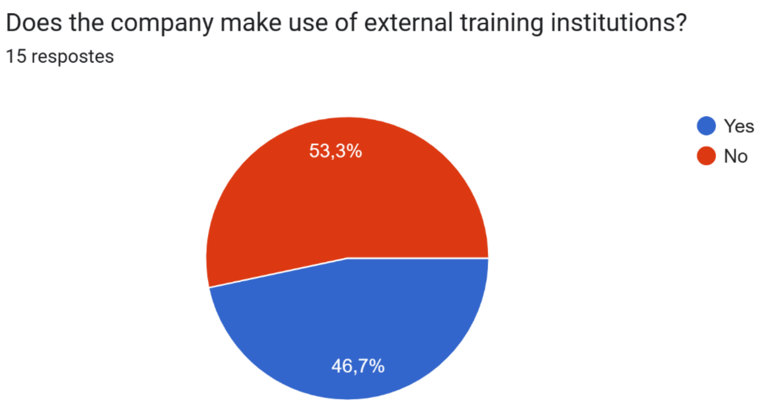
15 respostes

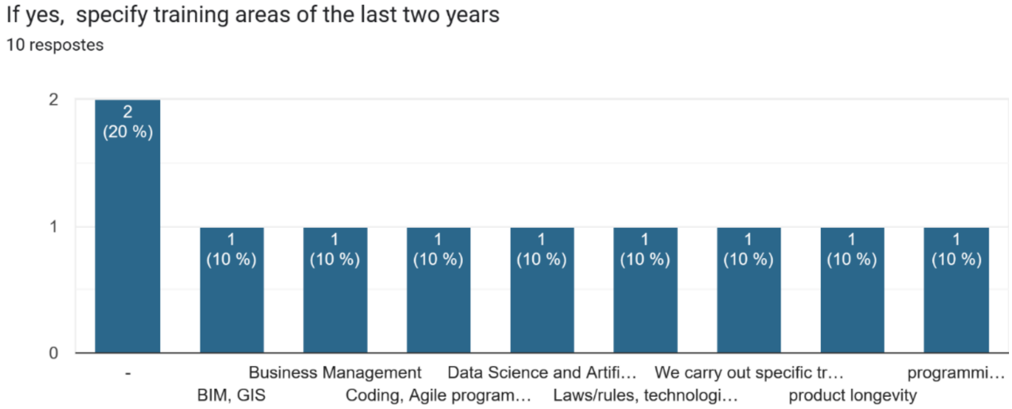


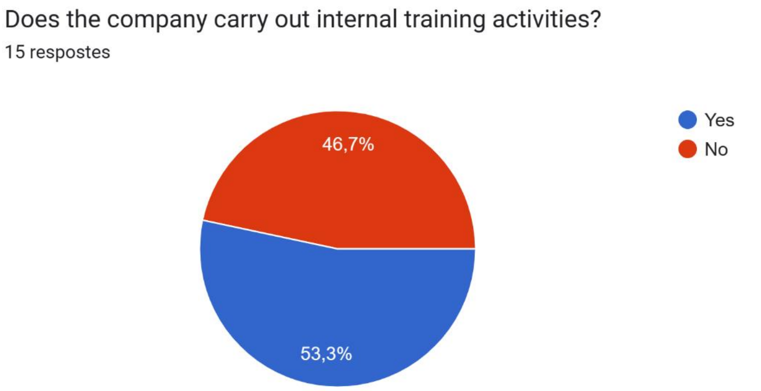
Has the company ever hired researchers?

15 respostes

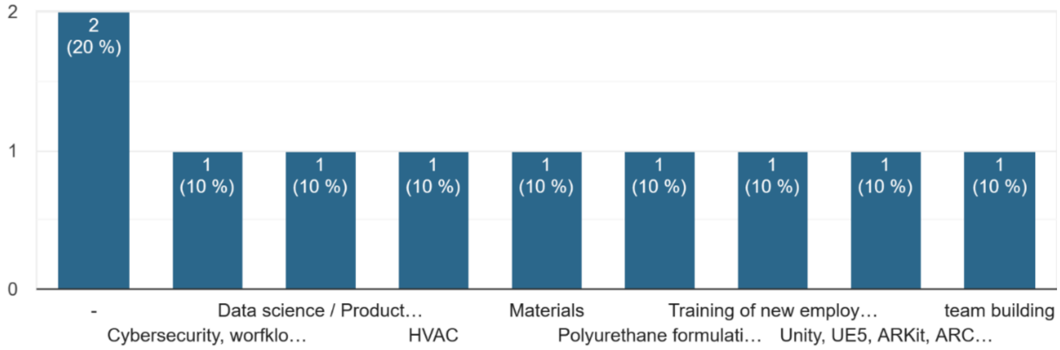



Does the company make use of external training institutions?
15 respostes
53,3%
46,7%
Yes
No

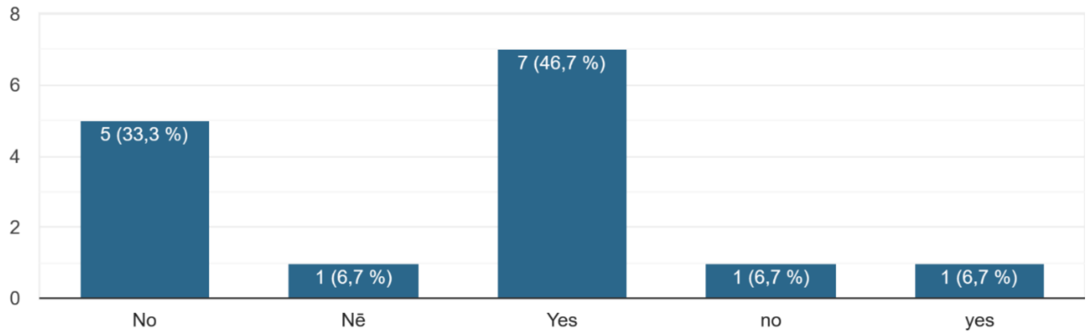

If yes, specify training areas of the last two years
10 respostes
2
1
0
2
(20 %)
1
(10 %)
-
BIM, GIS
Business Management
Coding, Agile program…
Data Science and Artifi…
Laws/rules, technologi…
We carry out specific tr…
product longevity
programmi…


Does the company carry out internal training activities?
15 respostes
46,7%
53,3%
Yes
No

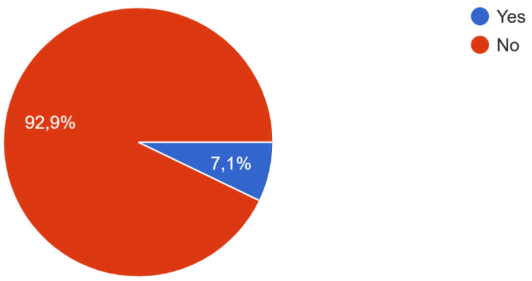
If yes, specify training areas of the last two years
10 respostes



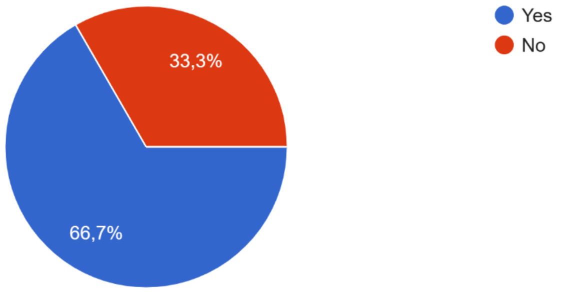
Has the company developed patents and/or specific industrial technologies?
15 respostes



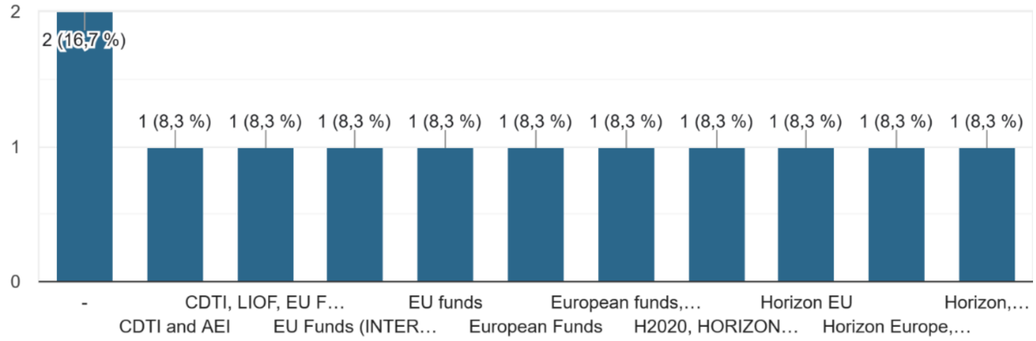
Has the company ever used third-party patents (universities, research centres, companies, start-ups)?
14 respostes



Has the company ever made use of public funding for Research and Development?
15 respostes



If yes, specify which (e.g. MIUR, European Funds)
12 respostes



Request/expression of interest for Technological Audit?
15 respostes