Positioning document of the Spanish construction sector in R&D&I in the European context.

2022

Spanish Construction Technology Platform

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Content

SUMMARY

On a mission to promote the transformation of the sector through R&D&I, with a stable structure of public-private collaboration in this field, the Spanish Construction Technology Platform PTEC has developed this document in the aim of helping to better position our productive fabric.

To contextualise the present document, it is indicated that the PTEC's European Positioning of the construction sector Working Group worked on a strategic document in 2019 and 2020 in the aim of analysing the situation and the framework of the construction sector in Spain with regard to its European positioning in R&D&I.

After 2 years and driven by the coordination of the Working Group (TECNALIA and PTEC), a new strategic document has been drawn up, updated to the social and economic environment and circumstances of the year 2022.

The document mentions the R&D&I priorities that are considered key to solving the sector's global challenges, expanding or qualifying those set out in 2020, going into detail on the sector's priority technological lines and, of course, on its digital transformation.

The document describes the updates of the R&D programmes at a European level after two years, in which a very relevant change has taken place, the programmed leap from H2020 to HORIZON EUROPE.

An important part of the document is the topic-technology line mapping, which specifically refers to the analysis of the adequacy of PTEC's priority technology lines to the topics of HORIZON EUROPE's 2021-2022 work programmes.

Finally, the document contains a last section on *Keys to evolve as a sector*, which we hope will inspire all the agents that participate or are involved and help to achieve a digitalised, competitive, efficient, safe and sustainable sector through R+D+I.

1. INTRODUCTION

The current situation of the construction sector in Spain

The construction sector in Spain plays a decisive role in the economy and in the generation of employment in the country. It has been a key sector during 2021, although activity did not reach the pace that was expected at the beginning of the year, mainly due to the delay in the implementation of the National Recovery, Transformation and Resilience Plan and the alarming increase in energy and building materials prices, shortages of some of them or significant delays in their supply.

In 2020, the construction sector suffered considerably from the consequences of the economic and social crisis caused by the Covid-19 pandemic, with a tremendous negative impact on companies and workers. The data on production and employment in the second quarter of the year showed an unprecedented fall in production and employment; in the following months, the pace of activity recovered very gradually, but certainly not sufficiently because the year ended with a fall in Gross Fixed Capital Formation of 11.7% compared to 2019. It should be recalled that the construction industry suffered a standstill of almost all its activity in the period between the 30th of March and 9th of April 2020, due to the fact that, in order to deal with the serious health emergency, the Government declared a standstill of non-essential activities in the aforementioned period; subsequently, restrictions were still maintained, until the end of May, in the area of carrying out intervention works on existing buildings.

In 2021, in terms of Gross Fixed Capital Formation (GFCF) which stood at € 119,029 million, the construction sector accounted for nearly 10% of Gross Domestic Product (GDP). In terms of Gross Value Added (GVA), construction accounted for 5.2% of GDP.

On the housing front, the number of approvals for new housing in 2021 stood at 108,000, slightly higher than in 2019, i.e., recovering from the decline in 2020. In 2021 there was also an increase in all other visa, extension and refurbishment types, compared to 2020.

From the perspective of public works tendering, in 2021 there was a significant increase to € 23.66 billion, although still far from the desirable level considering also that the effects of the National Recovery, Transformation and Resilience Plan were expected to be seen in a clearer way with a higher volume of tenders.

In 2021, the sector employed around 1.3 million people, 4% more than in 2020. It is also important to note that employment in the sector accounted for 6.7% of the total number of people employed in the Spanish economy as a whole.

In addition to the above data on production and employment generated directly by the sector, it would be necessary to add its indirect or multiplier effect on the economy in order to be able to visualise its full impact and potential.

Turning to employment in the sector in Spain, there is great concern about the ageing of the working population. According to data from the Construction Industry Observatory (FLC) in its report on the sector in 2021*, since 2008 the number of people under 30 years of age has gone from 25.2% to 9.1% in 2021; on the other hand, the employed population aged 55 and over has gone from 9.4% in 2008 to 19.1% in 2021. As for the percentage of women employed in construction, in 2021 it accounted for 9.6% of the total employed population.

With regard to the number of construction companies registered with the Social Security, the figure for 2021 was 132,857, an increase of 4.7% compared to the figure recorded in 2020. By firm size, all strata grew compared to 2020 with the exception of firms with 250 to 499 employees. Of the total number of enterprises, 98% are small enterprises.

Another noteworthy feature about the Spanish construction sector is its international presence and leadership, which demonstrates its solvency and competitiveness to take advantage of business opportunities in a globalised economy.

We believe that, in 2022, the implementation of the National Plan for Recovery, Transformation and Resilience should lead to a significant revival of construction activity in our country, as the sector has a major role to play, especially due to the objectives of building renovation and investments in the field of sustainable mobility infrastructures, both urban and interurban. However, the positive effects of the Plan could be less than expected if public administrations do not take timely measures to minimise the negative impact of rising energy and material prices on current and future contracts, both in building and civil works. If forecasts for 2022 were difficult to pinpoint due to the evolution of energy and material prices and supply problems, after Russia's invasion of Ukraine the scenario is even more uncertain.

Russia's war of aggression against Ukraine has exacerbated the problem of rising energy and commodity prices and supply difficulties. Inflationary pressures are being seen globally and a faster than expected monetary policy response has started to emerge. The European Commission's latest economic forecasts published on the14th of July 2022 clearly point to lower economic growth and higher inflation in the EU this year: although the EU economy will grow in 2022 compared to 2021, it will do so at a rate of 2.7%, a significantly lower rate than forecast at the beginning of the year. For Spain, the European Commission predicts 4% growth. In any case, the results of economic activity and inflation will depend to a large extent on how the war evolves and, in particular, as the European Commission stresses, on its repercussions for gas supplies to the EU.

**Construction sector report 2021. Construction Industry Observatory (FLC) https://www.observatoriodelaconstruccion.com/informes/detalle/informe-sobre-el-sector-de-la-construccion-2021*

2. ROLE OF THE SPANISH CONSTRUCTION TECHNOLOGY PLATFORM

2.1. PTEC's mission

The Spanish Construction Technology Platform PTEC (https://plataformaptec.es/) was born in 2004 with the mission to promote the transformation of the sector through R&D&I by establishing a stable structure for public-private collaboration in this field.

The Board of Trustees is the highest governing, representative and administrative body of the Foundation. The Assembly meets annually, under the chairmanship of the President of the Board of Trustees and with representation from all PTEC members, to report on the progress of the Platform. The Permanent Commission is the central management body of the PTEC, which is supported by the work carried out by the Delegate Commission, both Commissions being coordinated by the Managing Director.

The Working Groups are responsible for the definition and development of the activities, in collaboration with the Management and the Secretariat. The PTEC and the Working Group leaders define the actions to be developed that will be implemented by the members of each Working Group involved in the actions that are of most interest to them on an annual basis. Therefore, small Working Groups are formed within the parent Working Groups of the PTEC, with very specific objectives. In general, the type of initiatives developed in the Working Groups are as follows:

- To encourage the participation of PTEC members in R&D&I proposals at national and international level.
- Organisation and coordination of thematic conferences of different kinds of interest to the construction sector.
- Organisation of specific training activities associated with different Working Groups.

- Preparation of documents, reports, publications on positioning for the construction sector.
- Preparation of documents describing the know-how of the members in different fields.
- Organisation of communication and dissemination activities of European projects of PTEC members.
- Production of a specific fortnightly newsletter on a particular topic.

2.2. PTEC's objectives

PTEC develops the following specific objectives:

- The internationalisation of R&D&I

Activities related to the Internationalisation of R&D&I are promoted through the different Working Groups, in which the member entities with the most international activity participate together with the support of the Management, joining forces to support SMEs in the sector. In addition, the international R&D&I field is present in the contents of the meetings and events of all PTEC Working Groups, disseminating the experiences of some members in international projects, informing about international R&D&I programmes, etc. PTEC is a member of the ECTP (http://www.ectp.org/), the European Construction Technology Platform, a mirror of PTEC, with the aim of channelling European actions that may arise in the Spanish construction sector.

- The drive for innovation

The development of the activities of the Working Groups and activities of the PTEC is in line with the expectations of the construction sector in the coming years in terms of its transformation through R&D&I.
Aware of this relevance, there is a Working Group to promote innovation, which promotes specific actions in this field and in which the most experienced member entities participate.

- Promoting the image of the construction sector through R&D&I.

The PTEC aims to position companies in the sector through their innovation activity. At the state level, public outreach actions focus on:

- Establishment of Strategic Plans with the Administration.
- Positioning of the sector in the area of technology.
- Organisation of and participation in trade fairs and congresses.
- Collaboration and participation in forums with other technological platforms complementary to PTEC's activities, such as the Spanish Railway

Technological Platform (PTFE), the Spanish Technological Platform for Industrial Safety (PESI), etc. ...
    - Definition and promotion of national and international standards.

The activity of the W.G. is noteworthy in this section. Positioning of the sector in R&D&I strategies: Horizon Europe Programme, whose general objective is to promote investment in R&D&I in the construction sector, with the aim of making it a priority industrial sector at a European, national and regional level.

- Revitalisation and renewal of PTEC membership

Members are the core of the PTEC, not only because of the financial support that can come from having a large social mass, but also because they identify the association with a collective.
Given the economic situation of the sector and the challenges it faces in terms of adopting new technologies and promoting innovation among all the agents involved, another of the priority objectives is to attract new members, not only those belonging to the construction sector, but all types of entities that provide added value for the promotion of the sector.
The Platform is aware of the opportunities and threats present in the market, as well as the strengths and weaknesses faced by companies directly or indirectly linked to construction. Therefore, attracting new members through trade fairs, networking or media coverage is another one of its main objectives.

- Improving service to its members

The activities related to the objective of improving the service to its members are articulated through:
    - Carrying out training activities and/or Specific Workshops on topics of interest.
    - Internal working sessions to improve functioning and establish priority lines of action.
    - Ongoing innovation helpdesk for partners

2.3. PTEC Positioning

The Spanish Construction Technology Platform (PTEC) considers that, in order to improve the competitiveness of this industry, to satisfy the needs of society, to face the environmental challenges to which the sector can respond and, finally, for the structural transformation of the sector, it is necessary that all the agents involved work towards achieving these common objectives. This is why the technology platforms, clusters and sectoral associations play a fundamental role in this respect.
As a Technology Platform, we believe it is necessary for companies and other organisations that are sometimes direct competitors both in the domestic and

international markets to "sit around the same table" in order to promote the idea that, indeed, unity is strength; collaboration between agents of different natures and the transfer of knowledge between them opens a direct channel of communication with regulatory agents and with all the actors involved in the sector.
Aware of the importance of being in the "same boat" as Europe, PTEC belongs to the European Construction Technology Platform (ECTP), through which it aims to achieve the following goals:

- Contribute to the identification of R&D&I needs in the European construction sector.
- Contribute to the implementation in the Spanish sector of the needs identified at European level, where appropriate for our sector.
- Transferring the needs of the Spanish sector to Europe through participation in the ECTP.
- Help the ECTP to build lines of work aligned with the needs of the sector.
- To support the ECTP and the European Commission for sector-related consultations.
- Encourage participation in the Horizon Europe programme by small, medium-sized and large enterprises, research centres and universities.

The collaboration between ECTP and PTEC is carried out through:

- PTEC's participation as an active member of the ECTP General Assembly.
- The participation of several PTEC members (Acciona, Ferrovial, INDRA, Tecnalia) as vice-presidents of the ECTP.

- Positioning of PTEC in European Programmes

Within the Innovation and Research Framework Programme "Horizon Europe" (https://www.horizonteeuropa.es/) for the period 2021- 2027, endowed with €85.543 million, the construction sector is mainly located in Cluster 4- Digital World, Industry, Space and Defence and in Cluster 5- Climate, Energy and Mobility, both with a budget of €13.429 million each (See Point 4).

One of the main new features of HORIZONTE EUROPE are the MISSIONS. A mission is a multidisciplinary project with an impact on science, society and citizens. Of particular relevance to our sector is Mission 3 - Climate-Smart and Climate-Neutral Cities.

In the area of partnerships, of particular impact is the People - centric sustainable built environment, Built4people, part of Cluster 5-Climate, Energy and Mobility and led by the European Construction, built environment and energy efficient building Technology Platform (ECTP).
Also noteworthy is the European initiative JPI Cultural Heritage, which aims to respond to the need to conserve European cultural heritage, as one of the most

powerful elements of identity, through the coordination between companies, universities and public administration.

The new LIFE 2021-2027 Programme, despite not being a specific R&D aid programme for the construction sector, aims to achieve the objectives established by the European Union's environmental and climate legislation, policies and plans, as well as in the field of energy and, in particular, the objectives set out in the European Green Pact, with clear opportunities for our sector.

A new initiative was launched by PTEC in 2020 to boost the participation of PTEC members in European projects. This initiative is piloted from Brussels, with a permanent staff member based there, and continues to be successfully implemented today. Specifically, the initiative is based on the grouping of a number of entities within the PTEC which, on a voluntary basis and with an added fee, work exclusively for the generation and preparation of European proposals in our sector.

- Positioning PTEC in National Programmes

The PTEC aims to serve as a reference and point of contact with the administrations to communicate the needs of the sector and to collaborate in order to achieve joint and integrated progress. Helping to build and foster programmes of interest to the sector that take it to a higher level of technological capacity building.

PTEC is committed to collaborative projects with a high impact on the sector and focused on the challenges identified in this document. PTEC supports and coordinates R&D proposals in national calls for proposals such as CIEN Strategic Projects or the MISSIONS in Science and Innovation Programme.
PTEC also supports and promotes smaller R&D projects that are of interest to its members and the sector, such as CDTI R&D Projects, CDTI Innovation Projects or CDTI International Cooperation Projects.

3. R&D&I PRIORITIES TO MEET THE SECTOR'S GLOBAL CHALLENGES

3.1 Priority technology lines

3.1.1 Energy transition

a. Energy efficiency

The most sustainable and cheapest energy is energy that is not consumed. Improving the energy efficiency of infrastructures, which can be defined as the achievement of production or comfort targets using the minimum amount of energy possible, is a line that has been worked on for many years and in which great progress has been made but where there is still room for improvement. In many cases this improvement comes from the application of technologies such as those discussed below, but in other cases it is also achieved through operational improvements. In this respect, the ongoing work to raise public awareness is very important and must continue.

Buildings consume about 40% of all energy in the EU, with 36% of associated CO2 emissions, and an ageing and inefficient building stock. In Spain, new constructions are being promoted that are obliged to comply with the CTE (Spanish Technical Building Code), which limits the energy demand of buildings, with much lower consumption than buildings constructed 40 years ago (in general, less than half) and with the incorporation of renewable energies. A further step in this direction are nearly zero-energy buildings, even energy-positive buildings, which generate more energy than they consume.

With regard to the renovation of existing buildings, these works allow reducing energy consumption and improving comfort, favouring efficient materials and using innovative energy rating systems, taking into account national experiences and those of other EU countries, which facilitate these renovations.

The potential of smart technologies in the building sector was strongly highlighted in the 2018 revision of the European Energy Performance of Buildings Directive (EPBD) and the concept of the Smart Readiness Indicator (SRI) was introduced. This indicator allows rating the intelligent fitness of buildings, i.e. the ability of buildings (or units of buildings) to adapt their operation to the occupant's needs, also optimising energy efficiency and overall performance, and to modify their operation in reaction to signals from the grid (energy flexibility). The SRI will make building owners and occupants aware of the value behind building automation and electronic monitoring of technical building systems and should give occupants confidence in the real savings of these new enhanced functionalities. The SRI is calculated based on the following factors:

- Heating
- Domestic hot water
- Air conditioning
- Ventilation
- Lighting
- Dynamic envelope
- Electricity
- Electric vehicle charging
- Monitoring and control

b. Integration of renewables and storage

Considering the challenge of climate neutrality in Europe by the year 2050, the installation of renewable energies is promoted to cover an ever increasing energy demand. The path towards net zero emissions in Europe requires the development of new building technologies, which broadly combine energy efficiency, local renewable energy generation, progressive electrification of the sector, district level developments and decentralised energy storage.

The storage of electrical energy, both in distribution networks and in buildings, is becoming competitive in some construction sites, usually by using batteries for this purpose or even recycling batteries from electric cars. However, electrical energy storage is not enough and the development of low-energy thermal storage systems is also necessary for the air-conditioning of buildings or even for industrial processes.

The wide range of existing storage technologies can contribute in combination to provide the flexibility that the system needs for its gradual decarbonisation towards climate neutrality.

In the building sector the storage technology systems used would be batteries, sensible heat, latent heat and thermochemical storage. Also noteworthy is the potentially revolutionary development of fuel cells, a very promising energy technology with a myriad of possible applications, and it is precisely the different properties of these devices that make them very attractive, especially when compared to other conventional energy conversion technologies.

The challenges facing storage are of various types: regulatory and market challenges, economic and business model challenges, challenges related to standardisation and the need for interoperability standards, cybersecurity, industry integration, research and development of energy storage technologies, behavioural challenges, lack of information or risk perception, social and environmental challenges, critical materials and strategic challenges.

Now, in addition to the penetration of different types of renewable energies, we face the challenge of energy management of buildings and infrastructures, both public and private, where energy storage at building level is essential.

Such systems must be combined with new technologies: artificial intelligence for predictive systems, IoT for monitoring buildings, digital twins; so that they can be used to build a smart grid that makes the most of all the system's resources in an integrated way. Supporting smart building systems, smart communities and smart grids

Development of innovative solutions to improve energy contracting conditions considering sustainability aspects (e.g. green contracts, incorporation of renewables in buildings, etc.).

c. Electrification

Electrification is a phenomenon that is occurring in all sectors due to how easy it is to transport and distribute electricity. Moreover, electrification makes it possible to make better use of photovoltaic energy. In the construction sector it has an effect on two very important aspects that will be of great importance in the coming years; the deployment of electric vehicles and heat pumps.

The deployment of electric vehicles requires the massive deployment of charging points. In the private sector, this will have a direct impact on the design and adaptation of buildings to be able to use these charging points and integrate them into energy management systems. In this respect they will be a very important point in future active demand management.

Air conditioning is the biggest energy consumer in most buildings. Heat pumps achieve high efficiency in their conversion from electricity to heat and even cooling. Heat pumps will make it possible to replace many fossil fuel boilers with a corresponding benefit for the environment. Moreover, heat pumps combined with photovoltaic production and active demand-side management can be more economical than existing boilers.

In the long term, electrification will also reach construction machinery, but this will still require major advances in smart grids and battery storage capacities.

Although electrification of demand and 100% renewable generation is a clear objective for 2050, it is possible to incorporate some solutions such as biofuels or biogas, as well as the temporary use of natural gas in those places where switching exclusively to renewable energies is not possible in the short or medium term. This may be the case for large heat networks or systems that currently run on oil or coal and can be temporarily replaced by gas-fired systems.

d. Energy communities

Local energy self-consumption has gained relevance in recent years, due to its importance in accelerating the transition towards a CO2-free energy system that favours the democratisation of energy. Energy communities are based on the production of energy for own, individual or collective use, in the same place where it is generated, with a high environmental and social component.

The first local energy community in Europe is located in the municipality of Crevillent, thanks to the Enercoop Group. Comptem (Community for Municipal

Energy Transition) is based on collective self-consumption, a public energy information system and a mobile phone application.

Most of the energy communities and shared energy self-consumption in Spain include photovoltaic solar energy, as it is a technology that is currently highly profitable.

Other systems to be included may be district energy, for which integrated energy planning and mapping is required, supported by a designated coordination unit or a public-private partnership.

The city of Vancouver, Canada, has developed a demonstration project that captures residual heat from the waste water system, which has stimulated private sector investment in other networks.

As stated by UNEP (United Nations Environment Programme) a complete district energy system is achieved by bringing together the following actions:

- Connecting renewable electricity generation
- Connecting commercial demand
- Connecting industrial demand
- Solar thermal energy connected to district heating
- Capturing residual heat from sewage and waste water.
- Waste incineration
- Connecting free cooling sources
- Connecting residential consumers
- Absorption chiller that captures residual heat
- Cogeneration plant (CHP)

3.1.2 Sustainable materials and circular economy.

The circular economy is a new paradigm of production and consumption as opposed to the classic linear model of "extract, make, use and dispose". It is based on three principles: the elimination of waste from the design phase itself, the maintenance of products and materials in use and the regeneration of natural systems, all powered by renewable energy sources.

The magnitude of its impacts explains why it has a specific treatment in both the Spain Circular 2030 Strategy and the New EU Circular Economy Action Plan. Indeed, the latter anticipates the future regulatory environment characterised by:

- The sustainability performance of construction products will be enhanced by including targets for the incorporation of secondary materials at the design stage.

- There will be higher demands on the durability, ageing resistance and adaptability of buildings and civil works.
- Targets for the identification and recovery of materials in construction and demolition waste (CDW) will also be increased.
- Increased expectations of greenhouse gas (GHG) emission reductions, largely through circular economy initiatives themselves.
- Consolidation at European level of Level(s) , the voluntary framework of indicators to improve the sustainability of buildings incorporating the whole life cycle.

This context will pose major challenges for actors in the construction sector, but will also offer many opportunities for innovation and competitiveness. At the product level, new materials will be developed that will be less resource-intensive, more efficient and renewable (e.g., biopolymers). Technology will enable the incorporation of sensors that allow them to "communicate" with other objects (via the Internet of Things, IoT), providing information on their performance and maintenance needs, while some will even be able to repair themselves (e.g. self-repairing concrete).

All information on the composition, impacts and potential use scenarios of materials used in construction will be contained in so-called digital product passports, so that once disassembled they can start a new cycle of reuse, restoration or remanufacturing, without losing their value. In this scenario, building assets will become real material banks, as anticipated by the European project Buildings as Material Banks, which promotes this paradigm shift in the industry.

At the process level, one of the first to evolve will be the design itself; its crucial importance for the circular economy is demonstrated by the fact that 80% of the environmental impacts of a product or service are determined at this stage. The need for efficiency and flexibility may lead to the increased use of modular construction, a building system in which modules are manufactured and then moved and integrated into the construction site. Its processes are significantly different from what might be called "traditional" construction. The adaptability and flexibility of assets will also require new processes for assembling and disassembling site elements, maintaining their integrity in a way that facilitates subsequent cycles.

Finally, the integration of the circular paradigm into the organisations' own vision will lead them to rethink their business models and explore new service-oriented options, maintaining ownership and charging for use. This presence throughout the entire lifecycle will allow them to optimise performance and extend the life of building assets, for example by managing shared use between multiple users or platforms. Apart from the business opportunities that will open up in all loops and circulation of materials. In some cases, new players will emerge specialising in activities such as catering or remanufacturing, but in others it will be the sector's own companies that will undertake these activities in a sort of "circular integration".

In short, the circular economy will offer endless opportunities in the construction sector. Organisations that have a systemic vision and are able to innovate and collaborate with other actors in the ecosystem will be in a better position to take advantage of them. Due to its cross-cutting nature, it has numerous connections and synergies with other lines proposed in this document, such as energy transformation, smart infrastructures and digitalisation. Parallel to its economic and social importance, the construction sector generates a significant percentage of greenhouse gas emissions and waste. In this context, the sector is making significant efforts to mitigate the impact of the sector for a sustainable future and a 21st century construction industry.

The construction sector is traditionally a recycling industry (despite what the general public may think), with examples ranging from the material recovery of waste from other industries in products such as cement (blast furnace slag or fly ash), to the use of recycled aggregates or steel aggregates. The challenge today is much greater, as global strategies and industrial development of completely new, high-performance materials are being pursued. It is therefore necessary to support the actors in the innovation ecosystem (research centres, universities, platforms and associations, and, above all, companies) in the study and development of the materials that will be used to manufacture our future homes, roads, etc.

In this context, the development (technological and industrial) of sustainable materials and circular economy strategies, the following lines of work are proposed in three fields:

– Development of circularity technologies

  - The incorporation of recycled materials and products in the new ultra-high-performance materials mentioned above, so as to minimise the need for new natural raw materials. Therefore, these materials should be designed with the basic principle that they should be easily recyclable at the end of their useful life, incorporating this principle at the time of their conception. These objectives must be met while guaranteeing the safety and structural reliability of infrastructures that incorporate this type of material, so that current regulations and codes are strictly complied with, banishing the idea that a certain regulatory flexibility is necessary to increase the sustainability of infrastructures, since for an infrastructure to be sustainable, the first requirement it must meet is to guarantee the safety of users. For this reason, and given that, in general, recycled products lose performance as recycling processes progress, it is essential to precisely delimit the fields of application of new materials, so as to match performance and technical and regulatory requirements.

  - Separation and treatment of construction by-products (CDW) to facilitate their recovery as recycled material within the sector.

- Joint innovation with other industrial sectors for the recovery of CDW as a material for other applications.

– Development of sustainable materials

- Development of new ultra-high-performance materials that adapt to new construction designs and improve performance.
- Development of new eco-designed materials that are easy to reuse and/or recycle.
- Development of bio-based and/or sustainably sourced materials.
- Innovation in advanced materials that improve the useful life of infrastructures, reduce maintenance needs and/or energy consumption needs during operation.
- Design and development of materials and manufacturing processes that are oriented towards/ favour lower CO_2 emissions.
- Development of lower embodied energy materials
- Development of new thermal insulation materials and products with improved durability performance of existing infrastructures and buildings.
- Design and development of materials and systems that contribute to reducing energy demand, with the capacity to reflect or capture UV rays and store energy.
- Design and development of materials for application in CO_2 capture, conversion and utilisation.

– Active systems development

Traditionally, most building materials and elements have consisted of passive systems with pre-established performances that only vary due to the effect of degradation phenomena. However, in the age of automation and digitalisation, the construction industry needs the development and implementation of active systems that react to external stimuli by providing information about their status and/or varying their properties, either automatically or at the user's will. This, together with the great progress made in information technology, will make it possible, on the one hand, to have real-time knowledge of the state of the equipment and, on the other, to adapt the services to the needs at any given moment. The information generated will be used to develop more accurate models of material/element behaviour (and thus for improvement), to plan maintenance tasks, to decide whether an infrastructure is no longer safe, which will undoubtedly contribute decisively to the improvement of such materials. It will also help in the planning of maintenance and repair work, thus saving money. And, of course, it will be key in the prevention of accidents, as it will make it possible to know when and why an infrastructure is no longer safe without the need for on-site inspections.

The building-integrated photovoltaic systems (BPIV) will also enable energy generation and contribute decisively to the achievement of the Nearly Zero Energy Building (NZEB) while meeting aesthetic and functional criteria.

The control capacity offered by some materials, such as smart glass, will also make it possible to vary the level of luminosity or radiation in order to improve environmental conditions and air conditioning.

3.1.3. Industrialisation and digitalisation.

One of the key factors behind the poor productivity growth is that construction remains a largely unindustrialised process. To increase productivity and quality in the construction sector, it is necessary to evolve towards greater industrialisation of construction solutions and the digitalisation of information flows, from the initial phases of project conception to the demolition or rehabilitation of the building or infrastructure.

Therefore, it is necessary to develop prefabricated construction solutions that allow the development of construction elements in a more efficient way (less time, less waste...), of higher quality (fewer errors, elements developed by specialists...) and multifunctional (more complex elements can be developed, such as elements of active envelopes or with integration of renewables). Likewise, the on-site construction process is shortened and simplified, avoiding inconvenience to citizens and making project execution times more predictable.

Moreover, the industrialisation of building solutions will facilitate the digitalisation of the sector, as the link between data and the real world is more direct and continuous. For example, an element of a curtain wall is mapped directly with the corresponding element of the BIM model/digital model from the project design, being able to easily trace the purchase order, delivery date, place of installation...

Digitalisation is the process of changing data from an analogue (and usually manual) form to a digital one. In relation to the built environment, it refers to the flow of digitised information within and between phases of a building's life cycle.

Digitalisation is the integration of digital technologies into everyday life. Digitalisation means that interactions, communications, business functions and business models are transformed into (more) digital forms, thus changing the process.

Digitalisation, the development and implementation of digital technologies and processes, has the potential to enable greater transparency, efficiency and new functionalities along the entire value chain, i.e. from the design phase to the end of an asset's useful life, the demolition phase. Digitalisation promotes collaborative work and improved efficiency through the intelligent use of data and its analysis.

Faced with these challenges, digital transformation in the construction sector is an essential requirement for its solution thanks to the potential offered by new technologies and their synergies with the Building Information Management (BIM) methodology, the new guiding thread of the sector's value chain where all the elements will be connected. In particular, the digitalisation of the sector will allow us to:

- IoT enables the detection of logistical problems and allows real-time monitoring for infrastructure maintenance.
- Through the virtual replication provided by the digital twin in a building, real-time information on the energy efficiency of the building is available, errors are detected, simulations are carried out and even the level of wear of walls or main beams can be analysed.
- Artificial Intelligence applied to construction can uncover hidden patterns, detect problems before they appear, predict trends, detect anomalies, optimise construction processes, etc.
- Robotics is a mature field in other sectors, which in construction is still in its infancy but will increase its deployment thanks to digitalisation. Currently, it is used in the industrialisation of construction, but not so much in on-site construction itself. As construction becomes more industrialised, in-situ construction will have a greater assembly component and it is in this area that robotics has the greatest advantages.
- The BIM methodology promotes collaboration and centralises all activity around a digital model, encompassing the features and elements of a building throughout its life cycle, and representing them in a digital model, using data-driven 3D visualisation techniques, replacing traditional blueprints. In addition, it allows the integration of systems and the incorporation of state-of-the-art technologies such as those described above.
- The BIM methodology is based on collaboration and sharing. Digitalisation facilitates sharing, but makes it more difficult to control. To improve sharing, cybersecurity and usage control technologies need to be improved and more established.

The application of all these technologies will greatly boost the efficiency of the sector, improving both its productivity to do more with less, to address the growing need for access to housing and infrastructure, and its sustainability, facilitating the reduction of energy costs, greater reuse of materials and minimising waste. In fact, it is estimated that by 2025, large-scale digitalisation will result in annual cost savings of 13 to 21% in the design, engineering and construction phases and 10 to 17% in the operations phase.

3.1.4. Sustainable and intelligent mobility.

Infrastructures are the essential support element for the development of any commercial activity, necessary for the organisation of cities, as well as for their communication and the facilitation of mobility. There are many types of infrastructure: transport, energy, water, telecommunications and building. Specifically in this strategic line PTEC focuses on transport infrastructures: roads, railways, airports, stations, ports, etc.

Spain, with 17,228 km of toll motorways, toll-free motorways and dual carriageways, is the third country in the world in terms of the number of kilometres, behind China and the USA, making it the European country with the highest number of such kinds of roads.

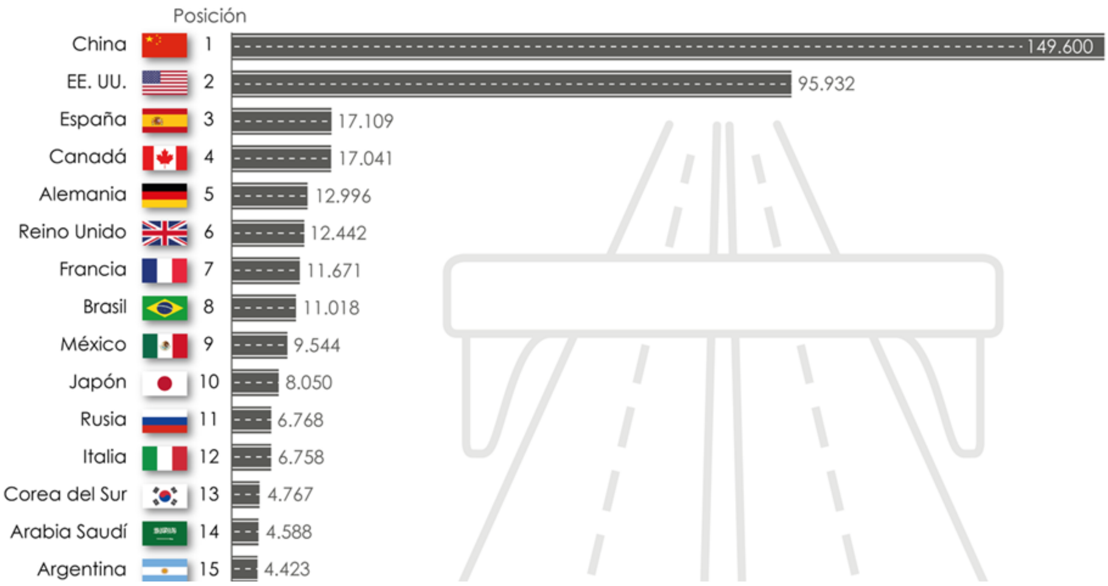


Figure 1. Ranking of kilometres of motorway and motorway network worldwide. 2019 Source: UNECE (United Nations Economic Commission for Europe)

In addition, the Spanish High Speed Railway (AVE) has been the main protagonist of infrastructure development at national level in recent years. This places Spain in third place in the world for this type of road. It should be noted that Spain alone has more kilometres of AVE than some of the major European powers such as France, the United Kingdom and Italy combined. Thus, Spain has three times more than both Germany and Italy in terms of AVE kilometres per surface area and number of inhabitants; and with the same parameters, it has five times more than the United Kingdom and up to fifteen times more than France.

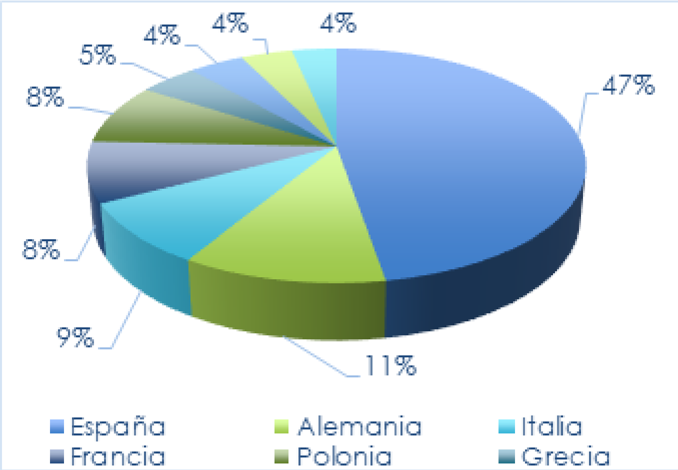


Figure 2. Overview of co-funding for high-speed rail by Member State (2000 - 2017). Source: European Commission.

Having such a large network of transport infrastructures introduces certain conditioning factors and complexity in their maintenance and management. This is something that PTEC is aware of, and for which it aims to establish lines of work to overcome the main challenges faced by the Spanish construction sector with regard to its infrastructures:

- Accelerated ageing of the infrastructure stock.
- Adaptation to new traffic volumes and weather conditions.
- Trends in mobility

– Accelerated ageing of the infrastructure stock

Most of Europe's infrastructure was built in the 1960s and 1970s and was designed for a lifetime of 40 to 50 years. This means that many of them are approaching the end of their useful life and therefore require technical interventions, which often result in the construction of new infrastructure.

In Spain the situation is somewhat better, with a lag of approximately 10 years with respect to the European situation. In any case, projections indicate that we are following the same trend due to the reduction in investment in infrastructure that has been taking place since the great crisis in the sector almost 15 years ago.

In 2007, only 14% of Spanish infrastructure was more than twenty years old and in 2016 the figure rose to 24%. If the trend of low investment in infrastructure in the last decade continues until 2030, ageing will advance significantly: 47% of infrastructure will be at least 20 years old, and this percentage will be over 50% in road (51%), water (71%) and rail (52%) infrastructure.

In addition, we must take into account that ageing has increased as infrastructures are facing higher than design service volumes and climatic conditions that have become more and more extreme.

This creates the need to advocate for new asphalt mixes, not only from a sustainability point of view, but also to provide new properties, to optimise rolling, to reduce noise and to facilitate water channelling. It is necessary to take into account certain critical parameters that must be ensured, such as increased safety, low noise, high adhesion and longitudinal regularity. For this reason, the latest trends focus on recycling pavements, using construction by-products or reducing pollutant emissions, which will not only improve road conditions, but also reduce future maintenance.

– Adaptation to new traffic volumes and weather conditions.

National transport infrastructures were built at the end of the 20th century, according to design criteria that corresponded to the living conditions and future mobility prospects that were estimated at the time. However, technological advances have allowed for greater development than expected, which, together with climate change, is beginning to show negative consequences on the country's infrastructure despite the fact that the useful life for which it was built has not yet ended.

Although all infrastructure is oversized in design to perfectly meet future demands, current traffic volumes have now exceeded mobility projections beyond the oversizing that was established. A higher than estimated traffic flow leads to great deterioration, causing risky situations for the safety of users, as well as the need for a large investment in maintenance.

It is estimated that by 2030, due to a doubling of world GDP, air traffic could increase by about 5% per year, maritime traffic by about 6% and rail traffic, both passenger and freight, by about 2-3%. According to some studies, global investment in transport infrastructure could reach €10.1 trillion in order to modernise existing networks and make them fit for current and future traffic.

Spain is no stranger to these trends and must therefore increase the level of investment in the adaptation and modernisation of its transport infrastructures.

Meteorological phenomena are another critical point in infrastructures. In recent years, the frequency of extreme events, such as heat and cold waves, floods, droughts, storms or fires, has increased exponentially. This represents a major risk to the stability of infrastructures as well as to the safety of users. In Spain, the weather forecast estimates an increase of between 1.2 and 2°C by the end of the century. As a consequence, extreme events such as heat waves will intensify and become more frequent. The forecast also predicts an approximate decrease of 5 to 10% in precipitation. However, despite decreasing in frequency, rainfall will intensify, leading to an increased risk of flooding in infrastructure.

Design regulations must adapt to cope with these changes and ensure the construction of resilient transport infrastructure in the future.

– Trends in mobility

The various technological advances and social and consumer changes are having a transformative effect on mobility as a whole. Their gradual introduction and the different projections of their evolution define major trends that will shape the future of mobility and guide new value propositions and business models.

These are:

a. connectivity
b. reduced environmental impact
c. automation
d. intermodality and integration

a. Connectivity

Connectivity is the main consequence of society's increase in digitalisation in general and of mobility in particular. It can be defined in transport systems as the ability of different elements to obtain, process and communicate data. In its most comprehensive version, it can encompass the vehicle, the driver (and passengers) and its environment (in electric mobility, mainly the charging infrastructure). It enables transport systems to achieve a variety of goals, primarily improving efficiency and safety.

This makes electric vehicles elements that benefit from their relationship with the environment. This relationship, applied to the energy domain, is mainly between the vehicle and the infrastructure (V2I) and with the electricity grid (V2G), although other forms of connection with various elements such as other vehicles (V2V) and information in the cloud (V2C) can also be part of a connectivity solution supporting electrification, within the broader vehicle-to-everything (V2X).

V2I connectivity, in a general sense, encompasses the relationship with different elements of the road infrastructure, so in the particular case of electric vehicles it is oriented towards knowing in real time the availability of charging points through navigation and route planning functionalities. This can help overcome the psychological anxiety that the combination of limited range and scarcity of charging infrastructure produces in potential EV buyers, one of the major barriers to electric mobility. A major challenge is to optimise the distribution of charging points in order to ensure that the infrastructure is an enabler and not a barrier to the introduction of electric mobility.

b. Reducing the environmental impact

One of the main drivers for electric mobility is the mission to reduce GHG emissions and pollutants. From the point of view of technological neutrality, there are different energy, technological and transport organisation alternatives to meet the environmental challenges. However, many of the strategies or analyses of the evolution of mobility include among the main trends, in particular, the electrification of transport as a response to the claim of current policies to avoid the impact of these emissions on climate and health, and on the environment in general.

However, transport has other impacts that electric mobility can help mitigate, in particular the issue of noise pollution. Other aspects, such as light pollution or the impact of vibrations, require further action on infrastructure or the geographical distribution of vehicle flows.

c. Automation

One of the major trends in automotive is the progressive introduction of forms of driving automation in vehicles, derived from sensorisation and the ability to transmit and process data. There are many automated functionalities that make driving and transport processes safer and easier, but ultimately the sum of these is geared towards moving towards the autonomous vehicle.

Large-scale commercialised developments to date do not yet imply full autonomous driving (level 5), with the state of the art lying somewhere between levels 2 and 3 as defined by SAE International (2019). However, there is a growing diversity of mobility ecosystem actors testing technologies, models and services at level 4 (within a specific geo-localised area and external circumstances, such as visibility), which are generally based on electric propulsion.

One area where work is already being actively pursued in the automation of the driving of are extractive works that are carried out in fairly controlled environments.

The automation of driving will force the conditioning of all types of roads by providing facilities for the identification of routes and all types of risks, avoiding those elements in the vicinity of the roads that could generate problems for autonomous driving. The design of such pathways will give rise to a new area of knowledge.

In this sense, automation, either of the vehicle or of its components and functionalities, is a necessary support for the development of new forms of recharging that are being tested today and for which greater implementation is expected in the future. This is the case for wireless charging, the use of pantographs in urban transport or catenaries in freight transport.

d. Intermodality and integration

The transport system as a whole can be presented in different forms or modes. Moreover, the current movement of people cannot be understood without the existence of public and collective transport capable of meeting the different social needs. Especially since the various trends noted so far point to the use of digital technologies to link modes together, put the focus on the last mile and offer alternatives to private ownership of vehicles.

In these circumstances, intermodality, or the combination of different modes of transport, which can be both public and private, is increasingly necessary in the development of policies that are able to maintain a balance between economic, environmental and social concerns.

In this sense, the ultimate goal of intermodality is to offer a sufficient number of available means and possible combinations to cover the different needs in the most balanced way. For this reason, we can speak of integration of means, infrastructures, needs, geographies, groups, etc., so that an intermodal transport system is presented more as a tool to achieve this heterogeneous integration as an objective.

However, large collective means of transport, such as trains, metros or trams, are also forms of electric mobility that can meet the demands when electric vehicle penetration faces difficulties. By filling the gap that may exist between the capacity of the technology and the needs to be covered, such as travel from one province to another, they can be complemented by forms of shared mobility for the last mile, such as Flinkster, an initiative of the German rail operator DB to offer carsharing at the end of journeys, or the new intermodal platform to be launched by RENFE.

In this line, the railway station can be seen as a transport hub combining rail transport with new electric transport methods including not only electric vehicles but also bicycles and scooters which will play a very important role in last mile transport and will have to be taken into account in the design of roads in cities.

However, for modes such as rail transport to be a constructive part of electric mobility, it must be taken into account that not all railway lines are electrified. In Spain in 2016, almost 40 % of the railway lines in use were not electrified, a percentage that varies widely across the EU.

This is often difficult for administrations because the high cost of rail infrastructure must be overcome. In these cases, there is the possibility of adapting battery-powered trains to take advantage of existing tracks without the need to build catenaries or other solutions that the Basque railway industry can provide, such as fast-charging accumulators (ACR) to compensate for the absence of catenaries in trams or the use of hydrogen.

In any case, the development of greater transport infrastructures linked to electric mobility can be framed within the guidelines of the Trans-European Transport Network (TEN-T). In this network, not only long-distance road and rail transport must be able to integrate alternative energies such as electricity, but also other modes such as inland waterways. In the longer term, the most challenging means of decarbonisation would be shipping and aviation, also key parts of an intermodal system in an increasingly globalised world.

3.1.5. Healthy cities.

The population is becoming increasingly urban. By 2030, 60% of the world's population is expected to live in cities [1]. There is a global trend towards the megacity [2], represented in Europe by Moscow, London and Paris. But other concepts coexist, such as Smartcity, Slowcity, networks of medium-sized cities or the polycentric city-region.

The city is becoming, more than ever, a node of residential, work and leisure activity. It proposes and updates the meaning of quality of life. It is the largest consumer of energy and emitter of CO_2, but also the crucible of environmental solutions for the planet.

In the case of Europe, the scarcity of land, the value of historic fabric, EU policy in the face of global challenges, awareness on natural and cultural diversity, the search for a place of one's own in the face of emerging powers, the empowerment of citizens and the commitments of the welfare state make cities alternatives for sustainability.
Under this scenario, the main motivations for the selection of the technological orientation of the PTEC in this axis are the following:

- To create smart, sustainable, attractive, adaptable and accessible urban environments that ensure the quality of life of present and future inhabitants.
- Promote appropriate building and urban types and morphologies to improve environmental quality and comfort and resolve the mix of private and public uses.
- Reduce energy dependence and GHG emissions, in order to meet the challenges set out in the European Green Deal [3].

- Regenerate and rehabilitate degraded areas of the urban fabric so that buildings, public space and infrastructure meet future requirements for liveability, health, mobility and accessibility.
- Ensure the conservation of all significant elements of natural and historical heritage.

To this end, the main lines of innovation proposed are:

The efficient city:

- Strategies, methodologies and solutions for the rehabilitation and regeneration of the existing city, with special emphasis on energy rehabilitation.
- Developments that enable positive energy districts to be obtained.
- Sustainable mobility strategies for the reduction of carbon emissions.
- Urban planning for energy transition, incorporating dynamic sustainability indicators and sources for measuring them.
- Low carbon footprint solutions and materials, and incorporation of nature-based solutions.
- Rational management of resources and waste from a circular economy perspective.

The inclusive city:

- New accessibility solutions for the existing city, with special emphasis on the ageing population.
- Systems and methodologies for citizen participation in city planning and management.
- Integrated urban regeneration, to ensure the right mix of uses, activities and lifestyles, allowing the integration of all citizens.
- Mobility strategies based on the recovery of public space for people.

The smart city:

- Development of technologies and systems for dynamic city planning based on models and data.
- Innovative building and civil works products and systems to speed up commissioning, improve maintenance and the management of the building stock.

- Intelligent management of mobility and city infrastructures (energy, water, waste, etc.).
- Improved safety in public spaces and in the city as a whole, through digital technologies.

The healthy and resilient city:

- Urban planning and solutions for improving resilience to climate change.
- Strategies, systems and solutions for improved safety and evacuation in case of natural or human-induced disasters
- New solutions for efficient decontamination of contaminated land
- Air and water quality monitoring and improvement

The historic city:

- Strategies, methodologies and tools for the maintenance and preventive conservation of the cultural heritage of our cities.
- New strategies, methodologies, systems and products for the sustainable management of urban cultural heritage, ensuring the enhancement of historic centres, their habitability and comfort, and their recovery as a central element of the city.
- Solutions for the tourist management of heritage cities, mitigating excessive pressures that hinder the development of life in them.

The degree of urban liveability of public space can be estimated from the evaluation of those conditions favourable to the physiological, physical and psychological well-being of people in public space:

a. Air quality

Air pollution poses an environmental risk to public health. The current urban mobility model based on private vehicles has made road traffic the main source of pollutant emissions. Improving urban air quality requires the implementation of mobility and public space plans that achieve a change in modal split: modal shift from private vehicles to other less polluting modes (walking, cycling or public transport).

b. Inclusiveness

A sustainable infrastructure will allow for social cohesion (of cultures, ages, incomes, professions) as it provides a balance between the different actors in the city. In these spaces, there is a homogeneity of income that influences all other aspects, including the idea of diversity and cohesion.

Good planning will encourage public space to be occupied by people of different statuses, facilitating the establishment of interactions between them, which determines the stability and maturity of a system.

[3] Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. The European Green Deal Brussels, 11.12.2019 COM (2019) 640 final

c. Resilience

Infrastructures must be able to withstand the new situations posed by climate change and be the most resilient to meteorological, geological, and other events.

d. Compact occupation

The land use model of ecological urbanism is configured as a compact land use model with the aim of reducing land consumption and seeking maximum efficiency in the use of natural resources, thus reducing the pressure of urban systems on support systems.

e. Urban diversity.

In the new urban development processes, urban diversity is encouraged through the integration of uses and functions at different scales of intervention.

3.2 Boosting innovation in construction

The construction sector has barriers to innovation and it would be interesting to try to develop actions to reduce them, with public administrations playing a fundamental role.

These barriers include: the atomisation of the sector; the limitations of public procurement; project-based management (difficulties in control, replication, knowledge transfer and developing strategic collaborations in the value chain); risk management of innovation in construction projects; the limitations of the regulation of the application of new technologies; the low effectiveness of science-university-business collaboration; and the lack of experience in aspects such as open innovation, start-ups, venture capital and industrial property management.

It should be noted in this regard that the construction sector is sometimes not represented in national R&D&I funding programmes, which are sometimes more oriented towards specific industrial sectors associated with metrics and parameters that cannot be assimilated in our sector. The wide range of disciplines and activities inherent to the sector's own activity requires, for adequate growth and development, support in the form of aid and R&D&I funding programmes, which drive and vectorise the necessary transversal innovation.

The sector promotes actions such as: workshops, forums, webinars, training, reports, publications, awareness-raising actions in cooperation with the Administration... with the aim of raising awareness and training, transferring recommendations, good practices, real cases and/or information on related areas of knowledge (open innovation, venture capital, strategic IP management, knowledge management ....) and existing instruments (new formulas for more collaborative contracts, legislation, Innovative Public Procurement, innovation assessment tools...).

3.3 Digital transformation of the sector

The previous document mentioned the European Commission's Digital Europe Programme for the 2021-2027 cycle, which aimed to digitally transform Europe's economy and society.
Its five objectives cover high-performance computing, artificial intelligence, cybersecurity and trust, advanced digital skills and the best use of digital capabilities and interoperability, all of which are linked to construction to a greater or lesser extent and society in general.

In Europe today, the NextGenerationEU macro-programme is already pushing that within this decade:

- You will be able to connect wherever you want with 5G technology and ultrafast broadband available across the EU;
- you will receive a digital identity that will make it easier for you to access public services online and give you more control over your personal data;
- our cities will be smarter and more efficient;
- online shopping will become more secure;
- artificial intelligence will help us fight climate change and improve healthcare, transport and education.

Meanwhile, in Spain, thanks to the NextGenerationEU funded Recovery, Transformation and Resilience Plan and, in particular, the components of the

Plan as well as strategic plans and projects for Digital Transformation, there is a unique opportunity for the adoption of these new technologies in our sector.

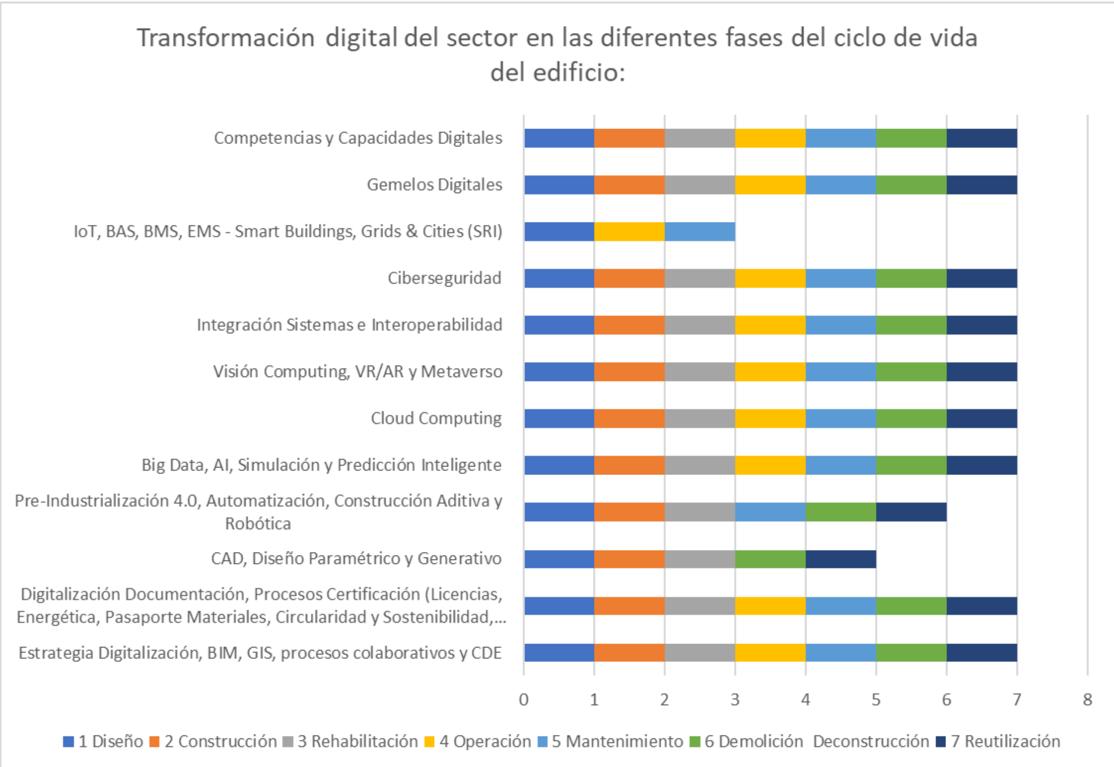
In the previous document, the digitalisation process of the construction sector was divided into the following 3 fields:

1. Digitalisation of construction materials and products.
2. Digitalisation of construction processes.
3. Digitalisation of the infrastructure and the finished building for its management during the operation phase and its integration in digital and intelligent environments (smart cities).

3.3.1. Technologies Digitalisation during the life cycle:

At this time, already immersed in the digital transformation of the sector, we consider that we must extend the fields to the entire life cycle and its different processes.

Therefore, we introduce this new proposal for the use of new technologies for the digital transformation of the sector in the different phases of the life cycle of the building:



The European Commission is propelling the implementation of the "Digital Building Logbook (DBL)". The aim is to support the widespread use of DBLs across Europe. It also promotes data transparency and its availability to a wide range of market actors, such as landlords, tenants, investors, financial institutions and public administrations. In addition, the DBL will contribute to a number of major policy initiatives, such as the Digital Ready Europe strategy, the European Green Deal and its Wave of Renewal, the new Circular Economy Action Plan and the forthcoming Sustainable Built Environment Strategy. To achieve the DBL it is necessary to integrate all digital tools such as BIM, GIS, CDE, cloud computing, cybersecurity and digital product passport throughout the whole building life cycle.

It is also very important to ensure data usage control so that it is possible to share certain information from the DBL with certain actors without compromising access to other information that is not desired due to confidentiality or copyright. These data usage control technologies are undergoing major development in order to be able to deploy construction data spaces that facilitate the development of Big Data and artificial intelligence technologies that can also be applied in all phases of the life cycle, such as simulations of design behaviour in both new construction and refurbishment, scheduling of construction or demolition work, optimisation of operation and maintenance or predicting the cost of the entire construction life cycle.

BIM together with artificial intelligence technologies is the basis of the digital twin in the design and construction phases. With the integration of building management systems such as SCADA, BAS, BMS, BEMS, CMMS and IoT, a digital twin will be achieved, allowing the behaviour of the building in operation to be simulated in the event of different renovations and optimising the operation in real time, as well as predictive maintenance.

The advantages of parametric design in CAD are evident in the design phase where different configurations are tested, but it is even more powerful in construction where parameters must be modified to adapt them to the As-Built and especially in refurbishment where it will be easier to make changes to the original design and simulations of possible variations.

As in other industries where components are manufactured and then assembled, robotics is an enabler for industrialisation by automating the assembly of industrialised parts.
It is also a great support to additive manufacturing as it allows the automation of construction from digital design. As in other industries, additive manufacturing can also support the generation of joints between parts or the recovery of damaged areas. Robotics, together with Artificial Intelligence and Vision Computing technologies, also facilitate collaborative and agile co-design and remote inspection, improving quality and safety and monitoring of the construction "in situ".

Thanks to the use of 3D CAD, virtual and augmented reality technologies have a great application in all phases of construction, from immersion in designs for conflict detection, approval of technical or aesthetic solutions, rehabilitation, simulation of construction processes, remote operation of facilities, inspection for maintenance or waste separation and finally the new trend of incorporating the user experience with immersive visualisations in the metaverse.

3.3.2. Analysis and collaboration with other reference sectors (Aeronautics, Automotive, Manufacturing).

The construction sector is not the only industry facing the challenges of digital transformation. The introduction of innovation and automation in construction can draw on the example of other industries that have undergone the same process, such as the automotive or manufacturing industry. Both have increased their productivity in recent years since introducing these technologies. By investigating possible commonalities between the construction sector and the digital experiences of other industries, a number of key lessons can be identified. It is therefore recommended to promote synergies with these industries through Associations, Clusters and/or companies in these sectors, apart from the obvious need for collaboration between companies, administrations and R&D&I centres in our own sector.

3.3.3. Recommendations for horizontal integration of the sector.

Digitalisation requires a cultural shift within companies, towards a focus more on delivering value rather than cost. Substantive change will require collaboration with competitors across the industry. A single company cannot drive transformation alone.

Especially as climate change, urbanisation and consumer demands transcend the dimensions of individual projects, collaboration is needed.

Collaboration is especially relevant as the complexity of the challenges at hand, such as climate change, resource scarcity and urbanisation, requires a harmonised approach that crosses sectoral and regional boundaries. A concerted and considered effort by public, private and institutional actors is needed to foster alignment and to build and maintain these collaborative platforms.

Improving the accessibility of environmental and asset data improves the quality of design, engineering and construction solutions and can provide opportunities for innovation.

For a platform to become a valuable collaboration tool there are some considerations to take into account:

- Platforms should facilitate cross-sector collaboration and information exchange;
- Platforms should encourage harmonisation between the various participants in a platform;
- Platforms should provide a pre-competitive arena in which organisations have the freedom and security to collaborate, share knowledge.

However, the development of such harmonised data frameworks is complex and requires substantial investment, making it difficult for individual private sector organisations to build a meaningful business case. Therefore, governmental, institutional or NGO stakeholders are important drivers for concerted action by private and public actors.

The main recommendations for a horizontal integration of the sector are:

1. Harmonisation:

Create harmonisation to facilitate information exchange, increase mutual understanding and stimulate digitalisation at scale in the construction sector.

2. Facilitate collaboration:

Foster platform collaboration to co-create innovations, exchange relevant information flows, support collaboration and harmonisation.

3. Support capacity building:

Support capacity building by stimulating education and awareness raising. Develop knowledge and share open source data on the built environment.

4. Provide resources to scale:

Provide resources to experiment, test and scale digitalisation. Adopt regulations and compliance systems to create an enabling environment to scale promising digital developments.

5. Change procurement to foster innovation:

Procurement strategies traditionally rely on risk and low prices and tight planning. Procurement policies should encourage innovation and stimulate cross-sector collaborations.

Plataforma Tecnológica Española de Construcción

4. MONITORING AND EVALUATION OF R&D PROGRAMMES

HORIZON EUROPE

The Horizon Europe programme is one of the main R&D&I programmes for the construction sector. Among the different axes of action, 2 of them should be highlighted due to their relevance for the construction sector:

- Pillar 2: Global challenges and European industrial competitiveness.
- Pillar 3: Innovative Europe. And more specifically the European Innovation Council (EIC).

Source: CDTI

Pillar 2: Global challenges and European industrial competitiveness.

Pillar 2, in turn, is divided into 6 clusters, each of which is structured in different thematic areas, called destinations.
In each of the clusters, these are the most relevant destinations for the construction sector:

Cluster 1: Health. Although it has a very medical and health oriented approach, it includes some topics linked to the built environment through the wellbeing of citizens.

Relevant destination:

- Destination 2. Living and working in a health-promoting environment. This area aims to deepen the understanding of the impacts of environmental, occupational and socio-economic risk factors that have the most significant or widespread social impacts.

Cluster 2: Culture, creativity and inclusive society. This cluster brings together topics oriented towards the historical heritage as a whole, including buildings and urban environments.

Relevant destination:

- Innovative research on European cultural heritage and cultural and creative industries. This area will promote projects oriented towards the monitoring, safeguarding and transmission of cultural heritage, the promotion of cultural and creative industries and cultural diversity.

Cluster 3: Civil security for society. This cluster includes topics oriented towards the resilience of the built environment (buildings, infrastructures and urban environment) to natural disasters and attacks by people.

Relevant destinations:

- Resilient infrastructures. This area promotes projects aimed at protecting and making all types of critical infrastructure more resilient.
- Disaster Resilient Society for Europe. This area promotes projects aimed at reducing the risks arising from both natural disasters and attacks.

Cluster 4: Digital world, industry and space. This cluster includes topics oriented towards the development of new materials and manufacturing processes, including construction processes.

Relevant destinations:

- Destination - Climate-neutral, circular and digitalised production systems (Twin Transition). This area promotes projects aimed at making production processes, including building processes, more sustainable.
- Destination - Increased autonomy in key strategic value chains for a resilient industry. This area promotes projects aimed at developing materials and business models that strengthen the autonomy of European production chains.

Cluster 5: Climate, energy and mobility. This cluster includes topics aimed at improving the energy performance of the built environment and improving transport infrastructures.

Relevant destinations:

- D4 - Efficient, sustainable and inclusive use of energy. This area focuses on energy from the demand side, in particular on more efficient energy use in buildings and industry.
- D6 - Safe, resilient and smart mobility transport services for passengers and freight. This area addresses issues directly related to transport infrastructures.

Cluster 6: Food, bioeconomy, natural resources, agriculture and environment. This cluster includes topics aimed at improving the circularity of the construction sector.

Relevant destination:

- Circular economy and bioeconomy. This area promotes projects aimed at promoting the transition towards circularity and the bioeconomy in order to achieve climate-neutral industrial sectors.

Strongly linked to these clusters are the 5 missions identified by the EC, two of which are closely related to the construction sector:

- Adaptation to climate change, which aims to support at least 150 European regions and communities towards climate resilience by 2030. The mission will promote the development of innovative solutions to adapt to climate change and encourage regions, cities and communities to lead societal transformation.
- Smart and climate-neutral cities, which aims to achieve 100 smart and climate-neutral cities by 2030 and ensure that these cities act as centres of experimentation and innovation for all European cities to follow by 2050.

These two missions are complemented by the New European Bauhaus (NEB) initiative, which aims to build together a more sustainable, inclusive and beautiful built environment future.

Each of these clusters and missions establishes a biannual (clusters) or annual (missions) work plan in which the topics to be funded in each of them are established. The programmes for the period 2023-2024, although unofficial drafts, already identify topics (although as they are not official, these may vary in the final version).

Pillar 3: European Innovation Centre (EIC).

In addition, the European Innovation Centre (EIC) is part of Pillar 3, Innovative Europe. While the clusters and missions follow a top-down approach (in general, the work programme defines the research topics), the EIC follows a bottom-up approach (there are no predefined topics). In the EIC, the programme is articulated around three complementary instruments covering TRL-1 to TRL-9:

- Pathfinder: Aimed at developing projects in low TRLs (TRL<3-4). It would be the evolution of FET projects in H2020.
- T2Innovation: Aimed at increasing the TRL of developments carried out in previous FET or Pathfinder projects (TRL<4-5) with high exploitation potential.
- Accelerator: Aimed at bringing to market developments at TRL 5-6. It combines subsidies to complete technological development with funding for industrial deployment and is aimed at SMEs, especially start-ups and spin-offs with high growth potential.

Source: CDTI

Presence of PTEC technology lines in the work programmes 2021-2022.

The topics of the 2021-2022 work programmes that are aligned with the priority technological lines for PTEC are identified below. Although there are a series of topics specifically oriented towards the construction sector (green background cells), there are other topics of a more global nature in which the construction sector also has a place. In any case, the topic-technology line mapping has been done according to the priority themes of the topic, but given the great interdependence between many of the technology lines in general, each topic indirectly covers multiple technology lines that are not explicit in the table.

CLUSTERS	Cluster 1	Cluster 2	Cluster 3		Cluster 4		Cluster 5		Cluster 6
	ENVHLTH[1]	HERITAGE[2]	INFRA[3]	DRS[4]	TWIN-TRANSITION[5]	RESILIENCE[6]	D4[7]	D6[8]	CIRCBIO[9]
Energy transition									
Energy efficiency						*2022-RES-01-16*	2021-D4-01-01 2022-D4-01-01 2022-D4-02-02		
Integration of renewables and storage							2021-D4-02-02 2022-D4-01-02		
Electrification							2022-D4-01-01		
Energy communities							2021-D4-02-01 2022-D4-01-01 2022-D4-02-04		
Sustainable materials and circular economy									
Circularity technologies					2021-TT-01-11 2021-TT-01-14		2021-D4-02-02 2022-D4-02-05		
Sustainable materials						*2022-RES-01-11* *2022-RES-01-16*	2022-D4-02-05		*2022-CIRCBIO-02-01*
Active systems									
Industrialisation and digitalisation									

[1] Living and working in a health-promoting environment
[2] Innovative Research on the European Cultural Heritage and the Cultural and Creative Industries
[3] Resilient Infrastructure
[4] Disaster-Resilient society for europe
[5] Twin green and digital transition
[6] Digitised, resource-efficient and resilient industry
[7] Efficient, sustainable and inclusive energy use
[8] Multimodal and sustainable transport systems for passengers and goods
[9] Circular economy and bioeconomy sector

Construction processes							2021-D4-02-02		
IoT					2022-TT-01-09		2022-D4-01-03		
BIM methodology					2021-TT-01-10		2021-D4-01-03		
Digital twin					2022-TT-01-09		2021-D4-01-02		
AI							2022-D4-01-03 2022-D4-02-04		
Robotics					2021-TT-01-12		2021-D4-01-02		
Sustainable and intelligent mobility									
Maintenance and life extension								2022-D6-02-06	
Mobility								2021-D6-01-03	
Healthy cities						*2021-RES-01-32*	2022-D4-02-02		
Efficient city						*2021-RES-01-32*	2022-D4-02-02		
Inclusive city									
Intelligent city									
Healthy city	2021-ENVHLTH-02-02		2022-INFRA-01-01						
Resilient city			2022-INFRA-01-01	2021-DRS-01-01 2021-DRS-01-02 2021-DRS-01-03 2022-DRS-01-02 2022-DRS-01-03			2022-D4-02-01		
Historic city		2021-HERITAGE-01-01 2021-HERITAGE-01-04 2022-HERITAGE-01-08 2022-HERITAGE-01-10					2022-D4-02-03		

MISSIONS	Adaptation to climate change	Climate neutral and smart cities	Deployment of NEB lighthouse demonstrators in the context of missions
Energy transition			
Energy efficiency		HORIZON-MISS-2021-CIT-02-01 HORIZON-MISS-2021-CIT-02-04	
Integration of renewables and storage		HORIZON-MISS-2021-CIT-02-04	
Electrification		HORIZON-MISS-2021-CIT-02-04	
Energy communities		HORIZON-MISS-2021-CIT-02-04	
Sustainable materials and circular economy			
Technologies of circularity			
Sustainable materials			
Active systems			
Industrialisation and automation			
Construction processes			
IoT			
BIM methodology			
Digital twin		HORIZON-MISS-2021-CIT-02-01	
AI			
Robotics			
Sustainable and intelligent mobility			
Maintenance and life extension			
Mobility		HORIZON-MISS-2021-CIT-02-02 HORIZON-MISS-2022-CIT-01-01	
Healthy cities			
Efficient city		HORIZON-MISS-2021-CIT-02-01	
Inclusive city			HORIZON-MISS-2021-NEB-01-01
Intelligent city			
Healthy city			
Resilient city	HORIZON-MISS-2021-CLIMA-02-03 HORIZON-MISS-2021-CLIMA-02-04 HORIZON-MISS-2022-CLIMA-01-06	HORIZON-MISS-2021-CIT-02-01	HORIZON-MISS-2021-NEB-01-01
Historic city			HORIZON-MISS-2021-NEB-01-01

6. KEY FACTORS TO EVOLVE AS A SECTOR

- **Sustainability**

Objective tools must be created to guarantee the sustainability of the sector, promoting recycling, recyclability and decarbonisation of the sector in general and of buildings and materials in particular.

- **BIM**

The current barriers to BIM implementation must be removed. There are still many, and they involve technical, industrial, legal, planning, economic, etc. factors.

- **Supply chain management**

Process management should be based on the life cycle of the project and take into account the personnel involved. On the other hand, supply chain management should be separated from construction site management.

- **Industrialisation of construction**

The industrialisation of construction should be a priority for the construction sector in order to evolve as a sector, allowing, among others things, to improve productivity; reduce on-site operations with no added value; reduce environmental pollution; and save energy and resources.

- **Health and safety management**

Methodologies need to be developed to improve workers' ability to identify hazards along with other techniques and monitoring. Synergies between safety measures and intelligent tools should be explored. On the other hand, work should be done to reduce the variability of worksites, as this is an effective means of controlling and improving safety.

- **Using new methodologies such as Lean Construction**

It should contribute to the use of tools and methodologies to optimise the sector, such as Lean Construction, which eliminates non-value-added activities and strives to increase the delivery of value during the construction process. It allows improving the effective use of resources.

- **Improving Innovation Management and Impact**

Tools and measures must be put in place to enable objective quantification and measurement of the impacts on the company and their returns.

- **Equipment and R&D&I system for continuous improvement**

Efforts should be made to optimise and monitor companies' R&D&I systems, which will improve the technical capabilities and innovative skills of the entities.

7. LIST OF MEMBER ORGANISATIONS

List of organisations participating in the drafting of the document:

- Tecnalia (Coordinator) www.tecnalia.com
- Tekniker www.tekniker.es
- Universidad Politécnica de Cartagena (UPCT_CTAC) www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=81
- BIM6D www.bim6d.eu
- Escan www.escansa.com
- Confederación Nacional de la Construcción (CNC) https://cnc.es/
- Plataforma Tecnológica de la Construcción (PTEC) https://plataformaptec.es/

List of organisations participating in the PTEC European Positioning Work Group:

- A3D Additive Printer www.a3dprinter.es
- Accenture www.accenture.com/es-es
- ACCIONA www.acciona-construccion.com/es/
- AEC-on soluciones www.aec-on.com
- AIDIMME Instituto Tecnológico www.aidimme.es
- AIMPLAS www.aimplas.es
- Albatros Construcció https://albatrosai.com/
- Amplía www.amplia-iiot.com
- Colegio Oficial de Aparejadores y Arquitectos Técnicos de Madrid www.aparejadoresmadrid.es
- Asociación de Empresas de Consultoría e Ingeniería Independientes de Infraestructuras, Arquitectura, Instalaciones, Medio Ambiente y Nuevas Tecnologías (ASECI) aseci.es
- Grupo Azvi www.azvi.es
- Becsa www.becsa.es
- BIM6D www.bim6d.eu
- Butic www.butic.es
- Grupo Campezo www.grupocampezo.com
- Centro Tecnológico CARTIF www.cartif.es

- Centro para el Desarrollo Tecnológico Industrial CDTI www.cdti.es
- Cementos Cruz www.cementoscruz.com
- CEMOSA www.cemosa.es
- Centro Tecnológico de Investigación Multisectorial CETIM www.cetim.es
- Chatu Tech www.chatu-tech.com
- Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT) www.ciemat.es
- Centre Internacional de Métodes Numèrics en Enginyeria (CIMNE) www.cimne.com
- Confederación Nacional de la Construcción (CNC) https://cnc.es/
- Comsa Corporación www.comsa.com
- Conkau www.conkau.io/
- Asociación de Empresarios de la Construcción, Promoción y Afines de La Rioja (CPAR) www.cpar.es/asociacion/
- Centro Tecnológico de la Construcción (CTCON) www.ctcon-rm.com
- Cupa Group www.cupagroup.com
- Danosa www.danosa.com
- Eraikune www.eraikune.com
- Eurecat https://eurecat.org/
- NTT Data nttdata.com
- Fundación laboral de la Construcción www.fundacionlaboral.org
- Fakolith Chemical Systems www.fakolith.es
- Fundación Agustín de Betancourt www.fundacionabetancourt.org
- FCC www.fccco.com
- Ferrovial www.ferrovial.com
- Frumecar www.frumecar.com
- Fundación CIAC www.fciac.es
- Celsa Group www.celsagroup.com
- Grant Thornton www.grantthornton.es
- Idonial www.idonial.com
- IDP www.idp.es
- Idvia Ingeniería www.sitioweb.com
- Instituto Español de Cemento y sus Aplicaciones (IECA) www.ieca.es
- Instituto de Ciencias de la Construcción (IETCC) www.ietcc.csic.es
- Grupo Increscendo www.increscendo.es
- Indra www.indracompany.com
- Ingeniería y Prevención de Riesgos www.imasp.net

- Instituto de Matemática Multidisciplinar de la UPV www.imm.upv.es
- Instituto Tecnológico de Rocas Ornamentales y Materiales de Construcción (INTROMAC) www.intromac.com
- Instituto de Tecnología de la Construcción de Cataluña (ITEC) www.itec.es
- Kairos DS www.kairosds.com
- Keraben www.keraben.com
- Lurtis www.lurtis.com
- Servicios Técnicos NAPAL www.stnapal.com
- Notio www.notio.es
- OHL www.ohla-group.com
- ONIX SOLAR www.onyxsolar.es
- Sacyr www.sacyr.com
- Signe Block www.signeblock.com
- Spika Tech www.spikatech.com
- Subterra www.subterra-ing.com
- Grupo Tecopy www.grupotecopy.es
- Grupo de Investigación Tecnológica de la Construcción de la Universidad de Cantabria (Giteco Unican) www.giteco.unican.es
- Universidad Politécnica de Cartagena (UPCT_CTAC) www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=81
- Universidad Politèctica de Catalunya (UPC) www.upc.edu
- Universidad Politécnica de Madrid (UPM) www.upm.es
- Fundación General de la Universidad de Valladolid (UVA) http://funge.uva.es/innovacion/
- VT-LAB www.vt-lab.com