RESEARCH DIVISION
REFERENCE DOCUMENT

2030 VISION

CSTB
LE FUTUR EN CONSTRUCTION

SUMMARY

FOREWORD

THE CSTB

(Centre Scientifique et Technique du Bâtiment) can lay claim to more than a certain maturity on the subject of construction, having been founded in the last century, in 1947. Its historical references bestow on it the ability to "imagine" its future, at least through the experience of the past. As well, it is able to lend support to construction day to day, through its different achievements and developments.

As regards its research work, the CSTB nonetheless suffers from a major anonymity syndrome -- or from a case of esoterica, if you ask the layman; it's all a matter of perspective. No one, however, disputes its central and abiding role in the development of construction.

This is true with respect to safety, first of all, in an approach to controlling natural and accidental risks, now being re-examined in the light of climate change. The same goes for health and comfort, in each of the uses made of buildings in the day-to-day. It is true too of energy and environmental issues, and the need to improve the performance of the built environment. And of course, it applies to the economy and uses, both understood in the broad sense, ranging from the individual and the citizen, to the area of activity known as construction. It is an area that needs to be supported and developed towards an essential digital modernisation, so as to fulfil the hopes placed in it, in the face of the challenge of climate change adaptation.

Is the CSTB not at the heart of demographic, environmental, social, economic and, more widely speaking, societal issues?
Does it not operate in contexts and in the face of challenges that have already been clearly identified, in which it is both a key and a cause, to provide responses to each of the points listed above?

Indeed – but what do these challenges mean in the current world, where information, condensed to a few lines, if not characters, is seen as authoritative, outshining the scientific approach, when the latter requires time, investment and critical thinking?

It is unfortunately a fact that the research conducted by the CSTB remains within the comfortable confines of the scientific community, which often has little inclination to popularise it in an educational manner. Yet, all the issues in the building sector lend themselves to such an approach, which would enable its users to easily identify their role and impact in different usage situations.

First of all, one must understand that it is a complex object in the fullest sense of the term. This object can only be approached from a logic of interlocking scales, engaging in a constant back-and-forth between materials, components, equipment and the very building system itself, which then becomes but one component in a system much more complex than its urban environment.

Secondly, there must be understanding that its robustness, management, and even resilience to use, deserve better than just responses to service failures, these being incidentally few and far between...

This assumes that, for the layperson, the scientific topics at hand, beyond potentially being brilliantly presented, can be seen in a tangible reality. Indeed, safety, risk, comfort, energy, digital and uses are terms that can just as easily be applied to other sectors, if one replaces "building" with "transport", for instances, as the concepts they represent remain quite generic and thus not very likely to rally people to action.

Change is needed, and buildings and their urban environment must be put back in the spotlight!
This is why, in order to transform this image, via the refounding of its research between now and 2030, the CSTB has decided to innovate in the very structuring of its efforts, so as to answer the simple questions which anyone might have: what topics is the CSTB working on, concretely? What are the objectives in this regard? Am I affected?

Consequently, the new organisation of research, quite obviously focused on construction in its urban environment, is organised around four strategic areas of action. These are based on:

- **An aspiration:** "Designing buildings and neighbourhoods to foster good community living";
- **An imperative:** "Buildings and cities in the face of climate change";
- **Works in progress:** "Renovation, reliability assurance in construction, and innovation";
- **Means for action:** "The circular economy and resources for construction".

Fundamentally cross-cutting and multi-disciplinary, this refounding commits us, along with our partners, to delivering operational solutions, which support all the players involved, at multiple levels. It draws on both the experience and expertise of the CSTB and its partners, and on shared national and international forward-looking perspectives.

This is not another way of telling the story, but another way of building it. In our world, where partnerships, communities and collective intelligence are central to the thinking, to the point of shaping the way research is conducted, it is of benefit to first know what it's all about and where it is headed. We should establish this at least each in our own imagination-scapes, then set out together to build the operational solutions addressing our problematics.

It is this vision which the present document offers readers the chance to understand, so that you, too, can join in this compelling adventure.




	Designing buildings and neighbourhoods to foster good community living	Buildings and cities in the face of climate change	Renovation, reliability assurance in construction, and innovation	The circular economy and resources for construction
Quality of living	***	**	*	
Preserving existing built structures	*	**	***	**
Preserving the environment	**	***	**	***
Uses of digital technology	**	**	**	**
Service development	**	*	*	*
Adaptability	**	***	*	***
Sustainability	*	*	***	***
Greenhouse gas reduction		***	**	*
Frugality	*	***	**	***
Resilience	*	***	***	
Business models	**		*	***
The construction sector's progression	***	***	***	***
Support for innovation		*	***	**
Support for taking action	**	**	**	**
Improving users' practices	***	*	*	**

INTERCONNECTION BETWEEN OUR ROADMAPS

The societal issues which we need to address are multiple and link in to the policies set out for preserving buildings and the environment.

Tackling these issues requires a cross-disciplinary approach, a global and cross-cutting vision of the problematics, and the resolute determination to shine light on the scientific disciplines so as to come up with operational solutions that bring visible and tangible progress to everyone's lives:

→ solutions for reducing our environmental impact;
→ responses to inhabitants' new lifestyles and aspirations (digital uses, more services, etc.);
→ tools and methods for those involved in the construction industry;
→ support for innovation, etc.

This table is a summary presentation of how each of our scientific and technical roadmaps contributes to these major issues, and how they complement each other to fully respond to them.

AN ASPIRATION

DESIGNING BUILDINGS AND NEIGHBOURHOODS TO

FOSTER GOOD COMMUNITY LIVING

Good community living means collectively "recognising and respecting all forms of diversity, fighting discrimination and facilitating harmonious coexistence[1]". Buildings, which shelter us, enable our activities, and neighbourhoods, which constitute our living environment and form the ties in our societies, contribute to this aspiration in an essential manner.

1. The International Association of French-speaking Mayors' Standing Committee on Community Living (2018)

OUR CHALLENGES

Providing a healthy and sustainable living environment in response to the expectations of a diverse, constantly changing society, subject to major environmental constraints.

Providing for everyone's essential needs is a prerequisite for "good community living". Maslow's pyramid offers a hierarchy of the five basic "universal" needs. Living spaces are closely connected with many of these needs: physiological (sleeping, breathing, being in thermal balance, etc.), safety (being sheltered in a stable and controlled environment), belonging, esteem and fulfilment (taking ownership of a place through personal expression, social relations, etc.). Workplaces and recreational facilities also have a part to play in fulfilling most of these needs.

The challenge is thus to offer a form of continuity in "good community living", from the private sphere formed by housing to the public space, encompassing each living space and means of travel along the way.

One of the priority challenges is to ensure housing for all and offer everyone, throughout their lives, safe, healthy and comfortable spaces. This assumes a wide-ranging offer in order to respond to the great diversity of aspirations and resources in society. While certain fundamentals must form the foundation for decent and sustainable housing, new expectations and constraints also need to be taken into account, connected with today's hyperconnectivity or a context of systemic crisis, such as the pandemic just experienced by our world. The other living spaces (education, work, leisure, health, etc.) have specific functions that lead to levels of complexity and services justifying greater technical sophistication and requirements.

We also need to offer pleasant, "appeased" neighbourhoods and towns that encourage sustainable socio-economic activities and have the benefit of public spaces that foster social cohesion and individual thriving. These – indissociable – criteria contribute to the overall attractiveness of living spaces, essential to the virtuous circle of the sustainable city.

Putting people back at the centre of our thinking is the condition for "good community living". This implies a cross-disciplinary approach, a holistic vision of the issues and a desire to shine the light on the scientific fields. In other words, our approach needs to be multi-scalar, dynamic and systemic.

DESIGNING BUILDINGS AND NEIGHBOURHOODS TO FOSTER GOOD COMMUNITY LIVING

OUR COMMITMENTS

Our analysis of the existing situation and future expectations has prompted us to develop a vision of how buildings and towns will look in the future, in response to people's new lifestyles and aspirations, while continuing to focus on problems that have not yet been resolved.

The CSTB is continuing its studies on health, comfort and safety issues in their scientific dimension and will also translate them into practical and operational knowledge, taking into account the fact that we are addressing people who are "integrators" of sensations and perceptions. Good living in one's home or neighbourhood needs to be assessed as a whole, not just through a collection of indicators. This premise changes the performance-based approach to which we are accustomed.

Let us analyse buildings as a system, in which imbalances need to be avoided in order to sustain the comfort and safety of their users. Let us weigh the criteria with respect to how they contribute to achieving well-being. Let us observe the effects, define the causes and, if necessary, approach the issues from a new angle. Rather than lamenting over the figures on poor housing, let us ask ourselves, for example, about the costs of poor living and, in so doing, change our perspective. Let us challenge current practices to confirm the relevance of certain choices. Let us ask ourselves, "What purpose does this serve?" at the same time as we ask, "how does this work?" without letting the latter question overshadow the former.

Let us look at neighbourhoods and cities in their physical and socio-economic dimensions, and identify the key factors in quality of living. The perpetual construction of the city over the city must generate more benefits than it does nuisances, and the issue of construction sites, in particular, must be considered carefully. The low-carbon city to which we aspire to must be "walkable" and amenable. It is a city of convenience and services, accessible to all.

We must offer continuity in "good living", from the private realm of housing all the way to the public space.

THE KEY STRANDS

The strategic action area "Designing buildings and neighbourhoods to foster good community living" is structured by two main strands.

GOOD LIVING IN BUILDINGS

1
Decent buildings

→ **Producing, renovating and maintaining buildings that enable comfort and health safety at least above the "decency" strand;**

→ **Taking care to reduce the proportion of indecent buildings, with a special focus on housing.**

CSTB's work will help identify today's obstacles and catalysts, so that a greater proportion of buildings, particularly in private housing, can be brought up to standard.
Towards this end, the CSTB's research will enable socio-economic players with the ability to provide insight on the following subjects:

__ which standards -- economically sustainable while being socially and politically acceptable -- are needed for decent buildings?

__ how can we ensure that all buildings exceed the "decency" threshold (in particular in housing)? How can we better assess the cost of poor living and/or the benefits of better living be assessed? What are the levers?

2
Buildings "to be lived"

→ **Designing and renovating buildings so that they meet expectations in terms of comfort, well-being and health, and meet the occupants' societal aspirations: functionalities, uses, representations, etc.**

Here, the idea is to offer stakeholders methods and tools (for assessment, diagnosis, modelling, operation, etc.) at each stage of their projects. Concretely, they will make it possible to address the following subjects, in a multi-faceted vision:

__ buildings for good living: what are society's needs and expectations? How can we move towards more inclusive buildings, better suited to privacy and work, adaptable to ageing and disability, intergenerational and scalable?;

__ overall comfort towards quality of interior environments;

__ the healthy building or the sanitary quality of spaces;

__ resilient buildings in the face of climate change, economic and health crises, etc.

3
The "augmented" building

→ **Designing and adapting buildings so that they provide improved services to occupants and/or operators;**

→ **Integrating smart features and connectivity to reduce constraints and increase the level of well-being.**

The CSTB's research will shed light onthe subject of sensors and connected objects, the expectations they stir in society and the actual level of service they provide to occupants and operators. The role of the CSTB will be to question their impacts on practices.

4
Buildings for good living in the present and the future

→ **Designing and renovating "fit for purpose" and high-quality buildings, on delivery and throughout their life cycle.**

Beyond the expected performance forecast and the verification thereof when the structures are delivered, the key now is to secure the evolution of their performance as a service over time. The objective is not so much to determine whether buildings are keeping their promises, but rather to ascertain that these will still be kept ten or twenty years later. The aim is to ensure that the buildings delivered – new or renovated – meet the expectations of occupants and operators, and that the services provided will continue over time thanks to appropriate maintenance.

DESIGNING BUILDINGS AND NEIGHBOURHOODS TO FOSTER GOOD COMMUNITY LIVING

NEIGHBOURHOODS THAT FOSTER GOOD COMMUNITY LIVING

1
Comfortable and "appeased" neighbourhoods

→ **Designing and developing neighbourhoods where nuisances are under control, in which residents can live in a quiet environment, away from pollution, enjoy pleasant and comfortable outdoor spaces, etc.**

This implies an all-encompassing approach – multi-disciplinary and multi-scalar (building, neighbourhood, city) – to diagnose, analyse and control the nuisances inherent in the urban structure. Ever evolving, cities inevitably generate chronic, but also acute (construction sites) forms of pollution, which we must attempt to mitigate. These disturbances, whether of climate-related, technological or anthropogenic origin, can be challenged in different ways (from the source to the effect) and by observing the behaviours of city inhabitants.

2
The neighbourhood as key factor in social bonds

→ **Designing and developing neighbourhoods in which interaction between residents is facilitated, where social diversity is possible, intergenerational links are fostered and citizen initiatives encouraged.**

Man is a social animal and, even more so, according to Aristotle, a "political animal". He can thus only be happy in the heart of a city, in interaction with his peers. The downfall of certain urban forms is probably rooted in this lack of social bonds, where functionality is prioritised and individualism given free rein. Accordingly, beyond the material issues, the question of "good living" embraces major sociological dimensions: enjoying good living in a given place implies, in particular, a commitment to the environment, to the "local way of doing things" and to the people around one (residents and economic and social players).
Look, for example, at the issues in the citizen city, the attractiveness of neighbourhoods, address the issue of the "walkable" and accessible city, or the scope of the city of tomorrow and its relationship to work.

3
Sustainable neighbourhoods and cities

→ **Designing and developing frugal neighbourhoods that are resilient in the face of climate change and health crises.**

Sustainable neighbourhoods and cities must fulfil a variety of requirements that integrate the environment, social issues and the economy. The economic factor, often pointed to as a barrier, can also become a lever for action by monetising intangibles such as maintaining health and increasing well-being.

4
The smart city, the services city

→ **Designing and developing neighbourhoods and cities that provide services based on data and connectivity.**

The challenge is to use the data available and turn it into services for the inhabitants and players of the city so that it is optimised, simpler, easier to grasp, more helpful and more inclusive.

The question of "good living" spans major sociological dimensions

OUR PRIORITIES

Our priorities consist of organising knowledge derived from disciplinary research carried out in previous years, to serve systemic projects with more operational benefits.

The quality of indoor environments (QEI)

The goal is to build a body of knowledge that aggregates our current understanding of indoor air quality (IAQ), indoor environment quality (IAQ) and applied building physics, in order to structure and enrich databases that will be shared with the scientific community and economic players. This knowledge will serve as material for existing or developing calculation codes. The CSTB will define unified QEI indicators, diagnostic and decision-making support tools, consolidate predictive models and make them available for engineering. Lastly, it will work towards the creation of a QEI Observatory.

Integrated urban approaches

The aim is to define and implement urban strategies thanks to the development of multi-criteria and multi-scalar diagnostic methods and tools, assistance in decision-making with the choice of programming for development operations, comparison of public space design scenarios, and reporting on performance achieved. It is expected that these methods and tools will make it possible to prioritise investments and form a framework for evaluating urban innovations.

Health safety in buildings

The aim is to continue existing work on health safety in built spaces, structuring it around: characterisation (identifying pollutants and sources, metrological developments, influence of environmental conditions); prevention-remediation (technological and organisational innovations, developing functionalised materials and support for the deployment of solutions); and monitoring (new detection methods and measurement tools, global management strategy). Consequently, in the context of a health crisis, the CSTB is directing its thinking towards the interaction between pathogenic biological agents and built spaces. It is developing an interdisciplinary research strategy to provide responses, at different time scales, with a view to prevention, anticipation and remediation.

DESIGNING BUILDINGS AND NEIGHBOURHOODS TO FOSTER GOOD COMMUNITY LIVING

OUR AMBITION

The topics covered here are extremely varied and, by their very nature, multidisciplinary. They raise socio-eco-technical research questions on different scales. To address them, the challenge for the coming years will be to bring together the knowledge already formed and develop new knowledge in a resolutely systemic and pragmatic approach.
The maturity of certain subjects enables us, from as early as the present, to assist construction players in their design processes through expertise services, as well as to transfer them simplified methods and tools to improve their practices in the everyday. For the CSTB, this means shaking up its scientific and technical approaches by bringing into close association the so-called "hard" sciences and the human and social sciences, including economics. In this manner, we will be able to provide realistic answers to the concrete questions which society asks of us and, in particular, those brought about by an increasingly rapid evolution and unprecedented systemic crises. We need only broaden our perspective.

DESIGNING BUILDINGS AND NEIGHBOURHOODS TO FOSTER GOOD COMMUNITY LIVING

Programming up to Horizon 2030

Integrated urban approach

Quality of indoor environments (QEI): measurement and modelling

Quality of indoor environments (QEI): data and indices

Health safety in buildings

Pandemic and built environments

2024

Development of an integrated urban analysis tool

—

Qualification of urban environments to design cities using a systemic approach built around people
Partner: CNRS - UMR Ambiances, Architectures, Urbanities

—

Nature in the city: biodiversity accounting in development projects - ZAN (Net Zero Artificialization) objective
Partners: MNHN, CEREMA, Soprema

Construction of short-/medium-term QEI forecasting models using continuous data received by sensors

—

Predictive models of the overall quality of indoor environments
Partners: LOCIE, LASIE, Artélia

Consolidation of existing databases and production of continuous data by sensors on QAI and QEI
Partners: ANSES, SPF, INERIS

—

QEI data enrichment

—

Development of QAI and QEI indices by types of data, environments and users (CERTIVEA)

Emerging and re-emerging health risks: characterisation of exposure to micro and nano-plastics, ultra-fine particles, cleaning products, etc.

—

Remediation and prevention: development of biocides and eco-compatible treatments for air and water

—

Development of biological contamination indices (bed bugs, dry rot) for building health management, including those with heritage value
Partners: IMT Nord Europe, IMT Alès, CNRS LRGP, INERIS, INRAE, MNHN

Behaviour of pathogen agents: study of their survival dynamics
Partners: Institut Pasteur, CERTES UPEC, ansES, CNRS

—

District-wide sentinel network via wastewater monitoring

—

Study of the performance of building management solutions to prevent their propagation

2027

Development of practical multi-criteria diagnostic tools (physical and socio-economic) and decision-making assistance in the design and operation of urban spaces for urban players
Development partners: Paris la Défense, Paris Saclay, Grand Paris Aménagement, SNEF, Euratlantique, Euroméditerranée, Epamarne, INRIA, Ingérop

Nature in the city: objectifying its physical impact by quantifying the role of plants in the city as a source of refreshment and as a particle well

National Health and Environment Plan: mapping of exposure to electromagnetic waves throughout France
Partner: ANFR

Enhanced IAQ and IEQ databases as regards environmental and climatic characteristics, buildings/neighbourhoods/cities and homes made available to the scientific community, construction players, building managers and the general public. Connection to the CSTB's National Building Database (BDNB)

Interoperability of models around a common platform, **MATHIS**

Creation of an emissions database (materials and combustion for heating)

—

Study of understanding of certain interactions between pollutants and places/lifestyles

—

Deployment of technical remediation solutions

Innovative technologies for inactivating aeropathogens and creation of a support system for family caregivers in a health emergency
Partners: INRAE, ANSES, industrial companies

Coupling of these mappings with the BDNB

Having QEI indices that meet users' various needs by collating them and making them easily readable according to the type of environment

—

Short- to medium-term QEI data forecasting models based on continuous data gathered using sensors depending on the type of environment

Consolidation of predictive models integrating occupant behaviour

—

Diagnostic methods are operational and shared with construction players

—

The QEI observatory is formed and dynamic

2030

AN IMPERATIVE

BUILDINGS AND CITIES IN THE FACE OF CLIMATE CHANGE

Climate change is a major component of current events and even more so of our future. It already has a direct impact on our daily lives, whether at the level of the territories, urban areas or buildings. Taking action to mitigate it is a vital imperative. It is expected that this will lead the construction sector and the various players to adapt their practices, uses and, more generally, the installed base to comply with national (37% reduction in greenhouse gas emissions for the building value chain between 2019 and 2030) and international (keeping the level of global warming to 1.5°C) commitments.

OUR CHALLENGES

The reasons for and speed at which climate change is taking place are unprecedented. The manifestations of these changes are already raising questions as to our resilience capabilities. The vulnerability of environments and populations varies widely. To ensure the safety of people and property, and the health and quality of life of current and future generations, it is essential to adapt the local areas, the urban environment and the built environment.

Achieving carbon neutrality for the construction sector's value chain by 2050

The construction value chain, which encompasses the entire life cycle of a building and the players who contribute to it, plays a substantial part in climate change, being responsible for around 25% of France's carbon footprint, or almost 153 MtCO2 in 2019. The building sector is thus an essential source of leverage towards meeting the mitigation objective, set to keep the average increase in global surface temperature under +1.5 and +2°C by the end of the century, in accordance with the Paris Agreement. It is accordingly one of the priority sectors of the French Climate Energy Strategy, which aims for carbon neutrality for territorial emissions by 2050 and a carbon footprint across the French population limited to 2 tonnes per person. In order to achieve these goals, we need to fundamentally rework the way we live, renovate and build.

Adapting to rapid a nd significant climate change

Whatever our efforts, due to past and future greenhouse gas (GHG) emissions, we are headed for an increase in the frequency and intensity of climate phenomena. Reducing our GHG emissions is an essential, but not sufficient, requirement for limiting these phenomena.

As climate change is a major component of our future, the role of the CSTB is to help the various players prepare for it in order to enable the built environment to continue fulfilling its role as a shelter for human activities and to preserve health and the social bond. This adaptation needs to be carried out while intensifying the process of climate change mitigation and its effects.

The massive rehabilitation of our property assets and the production of buildings suited to the climate of tomorrow, to uses and to users, are essential towards achieving this dual objective of mitigation and adaptation. In a context of growing urbanisation, sustained innovation and experimentation, and increasingly widespread digitalisation, buildings must contribute to ensuring quality of life, safety and comfort for their users. Beyond the buildings themselves, the neighbourhoods, cities and territories will need to meet the same requirements. To weave them into the environmental transition, currently focused on energy and carbon, will require drawing on a reinvented design.

Thinking environmental impacts holistically

It is important that the design and rehabilitation processes not integrate carbon as the sole compass: taking into account the rarefication of resources, through the implementation of the circular economy, optimising the quality of construction and production conditions and protecting biodiversity are all amongst the necessary "new" decision-making criteria.

BUILDINGS AND CITIES IN THE FACE OF CLIMATE CHANGE

OUR COMMITMENTS

In the face of climate change, this strategic area of action is structured by two lines: mitigation and adaptation

The mitigation initiatives in the building sector are aimed at implementing long-term solutions for the reduction of those GHG emissions sources falling within the scope of responsibility of the players in its value chain, but also to help other players reduce emissions within their own scopes (e.g. for mobility), as well as to protect, multiply and improve GHG wells. Adaptation, meanwhile, refers to all the processes set in motion to adjust to the current or expected climate, as well as their consequences, by mitigating harmful effects while taking advantage of beneficial effects.

These two strands mobilise all the scientific components connected with the problematics of buildings in their urban integration, at both the socio-economic and technical levels, whatever the uses. Results are expected, necessarily visible in the short term on buildings, quality of living and comfort and, in the long term, on the climate.

This strategic area of action is integrated into a more comprehensive approach by the CSTB to act in favour of climate change mitigation and the adaptation of the construction sector. Through its role as advisor to public and private stakeholders, assessor, knowledge transfer belt and reference party, it holds different levers to take part in this global transformation.

Contribute to the rolling out of the French Climate Energy Strategy

On the mitigation focus area, the results of the CSTB's research are intended to enable the players to identify the sources of GHG reduction, efforts needed in each segment, solutions to effectively reduce emissions and prioritisation of their actions.

When it comes to adaptation, given the scope of this theme at the national and international level, the CSTB will provide and develop its expertise in characterising the vulnerability of the built environment to the effects of climate change. Towards this end, it will rely both on its own resources and on its various scientific and academic partnerships. It will also combine with construction players so that the knowledge and tools produced enable them to spring to action. The R&D results and assets will be developed and leveraged.

Preparing the built environment for climate change

Through its strategic action area "Renovation, reliability assurance in construction, and innovation" and this one, the CSTB is clearly displaying its priority: to enable a massive rehabilitation in the existing stock with a dual objective, namely to reduce greenhouse gas emissions and ensure that, in a context of climate change, buildings ensure safety, health and comfort for their users and occupants.

Focusing our thinking on construction sector players and users

There can be no climate change mitigation or adaptation without a profound transformation of our practices, our design and rehabilitation frameworks and our imaginations. The fight against climate change must be a society-wide endeavour. Residents, users and professionals must be stakeholders of the places where they live and work, and involved in new ways of designing, building, renovating and living. There can be no mitigation or adaptation without their involvement. There will be no results if poor workmanship, rebound effects and collective action are not factored in.

THE KEY STRANDS

The mitigation strand comprises two components: carbon and energy assessment, and carbon strategy. The adaptation component covers three essential areas: characterising the hazards for buildings, their users and their environment; assessing the vulnerability of the built environment and its appropriation by occupants; and solutions for adaptation.

CLIMATE CHANGE MITIGATION

1

Carbon and energy assessment

The CSTB's primary objective is to ensure that all players are aware of the carbon impact of their activities and decisions, using tools that provide a standardised carbon (and energy) assessment from component to territory.

To reduce our carbon emissions, we must first develop a restraint-based approach to the use of energy and non-energy resources, and reduce the carbon, energy and material intensity of products and structures for each use.

The CSTB will continue its work on making available the tools for assessing the carbon impact of products, structures or neighbourhoods.

2

Carbon strategy

The second objective of the CSTB is that each player in the building value chain be able to measure the effort required in the short, medium and long term to achieve carbon neutrality at the national level by 2050. To achieve this, the CSTB will participate in the casting of carbon trajectories for segments of the construction sector and in projects to support construction players in identifying their own objectives and carbon strategy.

It is also CSTB's ambition to contribute to the construction of a global ecosystem that promotes decision-making in favour of climate change mitigation and adaptation.

While the main compass today is carbon, analysis of the other components of pressure on the environment (over-consumption of resources, pollution, destruction of biodiversity) remains essential. .

ADAPTING TO CLIMATE CHANGE

The adaptation area of action covers prevention, preparation for extreme events, protection of people and property during crises and anticipation of post-crisis recovery. The aim is for each player involved to be aware of the vulnerability of their property to future climate hazards and to have the information they need to design, renovate and take action on a day-to-day basis in the context of climate change.

1

Hazard characterisation for the built environment

The aim of this strand is to identify the scenarios and new data on which the design of future buildings, the renovation of existing buildings and, more broadly, urban development and renewal should be based. There is also a need to understand the indirect effects of climate change, which will affect the way we live and build. The future conditions of access to energy resources, water and food, as well as changes in biodiversity, need to be known more precisely so that those involved can design their structures to take account of these new constraints .

As a connector between those who analyse the climate and building designers, the CSTB provides stakeholders with the tools and methods they need to assess the consequences of climate change on structures in terms of safety, durability and impact on indoor environments..

BUILDINGS AND CITIES IN THE FACE OF CLIMATE CHANGE

The fight against climate change must be a society-wide endeavour..

2

Vulnerability assessment at all scales and ownership thereof by occupants

In a context of climate change, construction in the broad sense will be particularly tapped to reduce the vulnerability of the existing built environment. The work carried out must make it possible to characterise the response of the built environment and users to the new climate constraints, and to perform analyses with a view to prioritising the risks. This assessment is key to whether buildings can remain safe havens in the face of future climate change, and if so, in what manner. Their vulnerability is, in part, a direct consequence of design and construction choices, very significantly linked to the "resilience" of their users. This research focus will make it possible to understand the "response" of the latter to changes in climate conditions and open up the possibility for the different players to carry out risk analyses for their activities, the buildings they design, maintain or rehabilitate, or for the cities they plan and develop. The risks at stake here are those arising from climate change and those arising from the transitions that result from mitigation and adaptation processes.

3

Solutions for adapting to climate change

__ What meaning will design, building renovation, land development or post-oil urban renewal have in the future, in a context of + 2°C, against a backdrop of more frequent and more extreme weather events? How will our society adjust its imagination-scape and requirements, and adapt? In particular, how will it protect building users from heat waves or floods? How should the trade-offs between mitigation and adaptation be managed?

The aspiration is to explore each levers for climate change adaptation in the built environment, to identify the most effective, to co-construct operational solutions with the players and to spread the knowledge gained. The aim is to identify the priorities for bringing forward our constructive practices and adopt rehabilitation and usage strategies that will lead to the protection of both the population and property. By anticipating the costs of non-adaptation, misadaptation and adaptation, players will be able to make informed decisions.

OUR PRIORITIES

The CSTB intends to give a major technical and economic boost to the process (calculating the costs of adaptation and non-adaptation), drawing on an approach based on the human and social sciences, and the subject of adaptation to climate change combining, in particular, part of the biodiversity subject.

The CSTB will keep up the efforts already underway for years now on climate change mitigation, all the while redirecting its priorities. The aim is to reinforce the carbon strategy dimension to achieve the objective of neutrality, in particular by facilitating the rehabilitation of the existing stock, using carbon as a prism, but not to the exclusion of all other considerations.

The priority topics are as follows:

- Supporting players so that they can be part of a carbon neutrality trajectory up to 2050;
- Providing players with tools needed understand the phenomenon of urban heat islands (UHIs) and their impact on summer thermal comfort, and assessing remediation solutions for this purpose (qualification and access to data, UHI and urban microclimate modelling, digital modelling, etc.);
- Completing the convergence of methods and tools to bring about a single energy and carbon performance assessment model, valid for both new and existing buildings.

Heatwave anticipation is a topic of central importance

Their increasing intensity, duration and frequency over the next century will have an impact on people, as illustrated by the August 2003 heatwave in Europe. The means for adapting to create a built environment adapted to current conditions are within our reach. However, we must make a qualitative and quantitative leap before we can build and renovate structures that offer higher performance over time than those of current buildings.

BUILDINGS AND CITIES IN THE FACE OF CLIMATE CHANGE

OUR AMBITION

The history of humanity has always been closely tied in with that of the climate. Human beings have perpetually had to implement adaptation strategies. The climate has had and will continue to have effects on economic and political systems. For the first time, humanity is not only tributary to climate change, it is also its main instigator. This collective awareness means that we must take action to change our impact. The construction sector has a responsibility to take up in the process of mitigating climate change. This is why the CSTB wishes to facilitate, unite and accelerate this transformation. While mitigating climate change is the prime objective, adapting to it is just as essential. Through this research theme, which ultimately integrates all the transitions, the CSTB aims to foster the emergence and rapid spread of socio-eco-technical solutions enabling planning and construction professionals, as well as citizens, to prepare for the world of tomorrow.

BUILDINGS AND CITIES IN THE FACE OF CLIMATE CHANGE

Programming up to Horizon 2030

Climate change mitigation

Climate change adaptation

Colibri (Open Source Code for Resilient Buildings):
specially-designed specifications shared with stakeholders to enable joint assessment of the energy and environmental performance of new and existing buildings for the development of a reference tool

New version of Menfis:
a technical-economic model for forecasting investments in energy renovation and assessing the impacts of public policies

Carbon Strategy:
the first chain of tools for determining and managing a carbon strategy at the scale of a fleet. Built on the BDNB

—

Zephyr: a technical-economic model for optimising investments in energy renovation within the French building stock (residential and commercial)

—

Assessing and spreading low-carbon solutions

—

Defining the first carbon budgets at the level of buildings to guide players towards the SNBC's objectives

The roadmap for decarbonising the construction sector:
quantifying carbon deposits, lever by lever

2024

PowerDIS:
Energy simulation platform at the urban level

—

New version of the tool integrating the sizing of urban heat networks and estimating their contribution to decarbonisation
Partner: Efficacity

UrbanPrint:
tool for assessing the environmental performance of development projects, for new build or renovation

—

New version of the tool integrating all tertiary buildings, as well as the issues at stake in the circular economy, biodiversity, and total cost
Partners: Efficacity, BBCA

Ecoscale:
a sign of quality in the eco-design of products, it integrates an environmental classification specific to the circular economy and carbon sobriety, making it possible to position their performance in a standard building

Vulnerability and solutions for adaptation to climate change:
inventory of design rules that is to be developed to enable construction players to adapt new and existing buildings to climate change

—

Inventory of adaptation costs at the building scale

Adaptation to high temperatures and urban heat islands:
urban microclimate modelling and visualisation chain to better identify and treat urban heat islands

—

Set of indicators and methodology to assess the vulnerability of structures to climate change

—

Set of indicators to better assess comfort and health risk arising from heat waves to enable better design for structures

—

Definition, creation and distribution of first weather registries, enabling players to design for future climates

Carbon Strategy:
continued development of a set of tools for optimising, exploring and monitoring the decarbonisation strategies of all the players along the building value chain

2027

Creation of a national observatory monitoring GHG emissions across the entirety of the building sector (BDNB, RE2020 Observatory, DPE, Tertiary Decree, etc.)

Colibri:
development of a reference simulation tool, available in open-source format, to assess the energy and environmental performance of new and existing buildings

PowerDIS:
optimisation of the use of heat networks in decarbonisation strategies

UrbanPrint:
new version of the tool and its developer version, integrating an estimate of the carbon budget available for a development project

Development of homogeneous climate datasets
to enable players to prepare the adaptation of their structures on common databases (wind maps, etc.)

2030

CHALLENGES

RENOVATION, RELIABILITY ASSURANCE IN CONSTRUCTION, AND INNOVATION

Making the act of building more reliable means, all along the life cycle, ensuring the performance and adaptation of the building to the various changes in its environment in the broadest sense, its uses and the expectations associated with it. While new construction potentially responds to this need, the renovation of the housing base - the core of the problem - must be reinvented to achieve this, by calling upon all possible innovations.

OUR CHALLENGES

Adapting buildings and their urban environment to shifting patterns in uses and societal expectations in a time scale now constrained by environmental, social and political realities.

Adapting buildings and their urban environment to shifting patterns in uses and societal expectations in a time scale now constrained by environmental, social and political realities. “Covered enclosure”. This old-fashioned expression, used in relation with buildings, refers to the natural and accidental risks that can befall us, as well as to our ancestral fears. And this has been true since the dawn of time. This is what gives building a certain image of reassuring rusticity, reinforced by a [very] low claims experience, or at least one perceived as such. Aversion to risk, which has strongly surged since the 20th century, amplified by all manner of information in almost real time, thus implies faster adaptation for construction to the ever-increasing expectations of citizens and users.

Because of the place they hold in people’s lives, buildings lie at the core of a complexity often invisible in the everyday, spanning well beyond the subject of risks. It is revealed to us only when crises occur, whether relating to the climate, the environment, energy, demographics, health, social, economic or simply accidents. Our attempts to respond to each, no longer individually but systemically, reveal the antagonisms and contradictions in the solutions offered. This congregate of different responses to major societal issues thus requires that a hierarchy or even priorities be set.

While regulations on new construction partly integrate this approach, in particular through indeed numerous innovations in terms of materials, products, solutions and arbitrations resulting from consultations with stakeholders; this is not the case, however, for the existing base. In the latter instance, the problem remains as a result of production that continues to be unsuited to needs.

The level of requirements, if not standards, that used to apply is no longer enough for today’s needs. They are even less suited to those yet to come, which presuppose taking into account long-term developments encompassing the life of the building, such as climate change and the scarcity of resources, including human, that impact construction as a whole.

Buildings are not autonomous entities. In “theory”, they are part and parcel of the urban environment, part of a symbiosis that avails services needed in everyday life and pillars for “forming society”. New technologies, whether digital and the many contributions it makes to users’ lives, the new ways of working and consuming, mobility revisited or the integration of nature in the city: all of this fosters a re-examination of the existing environment to define and optimise its contribution to the society of tomorrow. And this is being prepared and playing out now.

Consequently, beyond the fact that it concerns almost the entire built base, the subject of renovation is the challenge of the 21st century. In the face of today’s many societal emergencies, and the obligations and hopes they entail, the current construction-renovation process is, due to its characteristic time scale, simply not compatible with the objectives and commitments made, like the financial resources dedicated, up to now, to renovation, especially when one weaves in the concept of urban development.

As reiterated in the introduction, one of the main challenges for the sector will be the ability to house everyone, in spaces appropriate to each type of activity, fulfilling, respectful of health, affordable and fostering social diversity, all throughout life. It is thus important that the evolution of the existing system accompany this ambition through an appropriate renovation. History, however, refers us to the simple past and current reality, holding up an uncompromising mirror as to our ability to redevelop old buildings today, given socio-technical-economic and political constraints that are incommensurate with those of the Thirty Glorious. As the same causes bring about the same effects, we need to approach the built base’s renovation in a different manner, so as to initiate a breakthrough transition that will be lengthy, and necessarily collective..

OUR COMMITMENTS

Given the structural difficulty inherent in meeting the renovation objectives, both in terms of volume and technical and economic quality, it is important to understand and specify the process. It is thus essential to identify each of the components, the interactions between them and the existing or possible obstacles, so as to propose operational solutions that optimise it and significantly improve its reliability. This requires that stakeholders be mobilised in an approach that integrates technical, productive, economic, organisational and legal innovations, to be put in synergy with the solutions resulting from experience that make the building’s robustness.

Seeing with the multiple requests and exposures to which buildings are subject, the CSTB, with its partners, has developed knowledge in a variety of scientific and technical fields, enabling an interdisciplinary approach aimed at providing the most appropriate response to the problems encountered. It results from an optimisation of solutions, depending on the sources of leverage available according to the players and especially the decision-makers involved, taking into account the overall constraints resulting from experience gained, but even more so from political lines and choices.

Buildings are thus at the heart of a complexity that is often invisible in the everyday

In this context, the way forward consists of:

- → determining the process most relevant in meeting the objectives set for the renovation of buildings (annual quantity including energy performance, environmental performance, safety, comfort, well-being, frugality of resources, recyclability, etc.), all in a constrained economic and temporal equation. Identifying the current obstacles;
- → specifying the associated approaches and tools on the basis of more precise knowledge of the existing fleet, in particular to enable multi-physical and socio-economic modelling, and give the various players the ability to understand broach both the imperative need for change, but above all the means to achieve it. This needs to be done by: integrating the levers that innovation enables in the broad sense, whether it concerns materials, products, equipment, but also the organisations, and the production and financing processes, through the prism of the various building scales and its urban environment;
- → leave behind the historical and cultural quarrel between factories and construction sites, particularly with regard to the causes of poor quality work and the sector’s capacity in terms of production. Massification, often understood as industrialisation, refers to the volume of works and not to a standardisation that is roundly criticised by architects and project managers, and incidentally by users. It requires, more for renovation than new construction, tried and true scheduling solutions, as it is generally carried out on an occupied site, and thus often needs to be phased. It must be able to rely on trained operators, aware of the impacts of their work on the overall performance and reliability of construction;

- developing the supporting materials that will be used for these practical training courses, as regards design, construction at the site level, as well as management-maintenance, from a systemic perspective and no longer exclusively produced;
- supporting industrial players in a multi-criteria approach ensuring that the various products and solutions are implemented robustly with respect to performance, in line with their specifications or even their certification, in particular through an extended revision of their integrability and their interfacing within the building;
- repositioning the CSTB as a promoter and buttressing force for innovation, based on the scientific and technical skills it has gained and continues to develop with its partners. The obligation to decarbonise the construction sector implies unprecedented innovation in products and raw materials, whether recycled, derived from biomass, new processes or reinvented processes;
- deploying, taking care with the educational approach, the resources and tools enabling building users to optimise occupancy, according to the constraints that apply to it, drawing on their information and innovations, in particular digital (measurements, steering, communication, user interface, etc.). Indeed, Covid-19 highlighted, and rightly so, the dilemma between health security and energy efficiency for fleet managers, for example, but also for users. The same goes for heat waves, indoor air quality or for instance energy sobriety when taken in association with the comfort, safety and economic equations, not to mention carbon;
- Lastly, revisiting the economic approach needed for faster massification, compatible with national and international policies, as much in terms of production capacity as in their technical and organisational responses, financial systems and distribution of added value, subject to the constraints of construction costs. It should not be forgotten that the construction sector, and particularly renovation, is a major area of activity, a source of skilled non-offshorable jobs and potential for industrial renewal at the European level.

The historical robustness of construction is too often synonymous with a lack of vision of the actions necessary for its optimal use, except, as reiterated above, during a crisis or the failure of a component. However, the manifold expectations and constraints connected with construction today makes it a more complex object, a far cry from the common perception gained from both individual and collective experience. While the technical solutions incorporate this, albeit only in part, the CSTB needs to specify and publicise the conditions for proper use, and the types of action required to deal with the problems encountered, just as it has to do with the players in the sector to ensure quality implementation.

These commitments by the CSTB, its scientific, technical and economic partners and, more broadly, policies, are the necessary conditions if we want to collectively meet the challenges resulting from this societal challenge that is climate change, and in which construction is, if not the only key, one of the primary ones. We are familiar with its «strength», inherent in its current level of performance, which calls for a drastic increase in the volume of renovation to adapt to climate change. However, we also know its weakness: inertia.

THE KEY STRANDS

The strategic action area "Renovation, reliability assurance in construction, and innovation" is structured around coherent and interlinked axes that structure the renovation process with its specificities, in particular for the reliability of innovations and new construction methods, also applicable to new construction.

1
Becoming familiar with the built base

→ **National Building Database (BDNB)**

The first step in any renovation project is to perform a situational "inventory", which makes it possible to establish the project's starting point. This term, which we all associate with housing, at least on account of its often extreme level of detail, does not, however, apply to all buildings, whatever their scale. Quite to the contrary. .

Until now, the knowledge base on buildings was only statistical, and not very detailed, except to a certain extent in the tertiary sector and recent buildings. While this may have been sufficient for general analysis or monitoring, it is no longer adequate in view of the expectations placed on each project - whether renovation or new build - in terms of performance, whatever they may be. This lack of knowledge is potentially the main reason for the current state of the building stock and its inability to support the transformations needed for a dynamic adaptation that addresses the main societal issues at stake.

The recent development, within the framework of the PROFEEL programme, of the National Buildings Database (BDNB) makes it possible, by cross-referencing a growing number of public and potentially private databases, geolocated mapping of each building and its urban environment, with an unprecedented level of information, about: the construction methods, the materials and solutions put to use, the various types of consumption, the ways of occupying the premises, etc.

This opens up prospects previously unimaginable for this sector. In comparison, the automotive sector, which is similar to the housing sector not only in terms of overall figures - there are 36 million private vehicles, compared to 26 million homes - has for many years, through regulated vehicle monitoring, been dramatically improving the reliability and quality of its existing stock, as well as its new production, by incorporating feedback from technical inspections.

The CSTB, behind the major innovation known as the BDNB, and its partners, aim to develop it into a meta-database of reference for all those involved in the construction industry, relating to the 'common public good', and enabling the integration of multiphysical, behavioural or economic approaches, without however precluding a competitive dimension, and while respecting creation and innovation. To describe it more colourfully, and in a way that is relevant to the construction industry, the BDNB is like a reinvented Babel.

Over and above the technical issues, particularly those relating to data, its qualification and interoperability in simulation and optimisation tools, research presupposes structuring both the databases and the chains of players by setting up reference systems (qualification, updating protocols, data extrapolation, using artificial intelligence), within frameworks that are compatible with legal and economic approaches. It is therefore also a subject for the social sciences.

2
Renovation-construction solutions

→ **Multi-criteria assessment of construction products and processes**

Research is aimed at providing the foundation of knowledge and methods needed to qualify all aspects of construction system performance, on the basis of multi-criteria analyses and assessments of existing products and technologies, as well as current and future innovations.

This implies assessing products using a multidisciplinary approach with regard to the various primary requirements (structure, thermal, acoustics, fire, durability, implementation, environmental, health, safety, etc.), in particular in terms of their interfacing with other components for their integration into the building system, and having the ability to qualify and quantify their contribution to overall performance based on those, intrinsic, relating to specific requirements.

This also prompts a reinforcement in characterisation methods, whether experimental, digital or hybrid, including in situ, as well as the associated means of analysis by contributing to the development of the skills of industrial players, companies and professionals in connection with the new challenges of construction. Concurrently, this is expected to encourage the emergence of cutting-edge test platforms for the multi-criteria characterisation of products and solutions, subject to multiple constraints induced by their integration in the building.

Drawing on feedback about products and solutions whether these relate to ease (or technicality) and robustness of installation, in-service performance, maintainability or, in the near future, dismantlability for recycling or reuse, these hybrid approaches will constitute a remarkable body of knowledge serving innovation and reliability, operating primarily on the principle of *reverse engineering.*

3
Production & execution

→ **Multi-criteria rehabilitation**

The aim is to develop an environment that will support contracting authorities and project managers, as well as manufacturers and related players, in the prioritisation essential for optimising rehabilitation strategies and scenarios.

This support process is based on an all-encompassing approach, based on a multi-criteria assessment necessary for the informed consideration of the constraints that apply to the project, whether they result from the project itself, regulatory contingencies, specific interests or economic issues at stake, at the level of the building concerned, or that, more broadly, of its urban environment.

To achieve this, the CSTB and the players involved must pool, via the creation of digitised knowledge bases, all the data associated with the renovation project, relating to the technical characteristics of the building, its uses, its environment, as well as renovation solutions and their multiscalar description. This will make it possible, via appropriate protocols that make use of qualified and shared data, as well as common descriptors and modelling-simulation tools, to converge the multi-criteria approaches – that associated with products, optimising their integration and performance, with those concerning the building integrated into its urban environment.

The whole is underpinned by the capitalisation of expert, cross-disciplinary knowledge of the existing building stock, which has now been "unveiled" and made more accessible by the BDNB. It is also based on information from demonstrators, incorporating feedback and technical, economic and sociological data, the latter field being understood in a very broad sense, from the organisation of chains of players to the uses and perceptions associated with the projects (well-being, comfort, user experience, reliability, etc.), not to mention the ergonomics and robustness of the implementation for and by professionals.

4
Qualifying performance

→ **Ensuring the reliability and guaranteed performance of our products**

ÀThe measurement of the actual performance of a new or renovated building is both the final stage in the renovation cycle and the foundation for overall project improvement, particularly through feedback, and is the "ultimate" indicator that refers back to the project's initial objectives. These are the result of a more or less complex engineering process incorporating different know-how, models, simulations, experiments and innovations.

All too often, however, the reality on the ground is a lack of performance control, with the exception of certain regulatory obligations - whereby these only investigate specific points. The recurring deviations observed on certain points reflect both the relative adequacy of the theoretical models and the technical solutions called upon and their implementation, not to mention their use when it comes to performance in service.

More often than not, performance is measured in relation to a particular indicator, such as energy consumption, air exchange rate, acoustic attenuation, air tightness, etc. Consequently, there is no indication as to the overall performance of the building, whether new or renovated, for which a systemic response is needed to achieve, for example, the objectives of "Designing buildings and neighbourhoods to foster good community living", in the context of climate change".

The CSTB's ambition is thus to build the capacity to assess the buildings' real overall performance in order to better understand their determining factors, improve them, make them more reliable and guarantee them. In conjunction with the other strategic fields of action, it will contribute, together with the scientific community and players in the construction sector, to the definition of global performance indicators that combine and weight the contribution of specific indicators.

RENOVATION, RELIABILITY ASSURANCE IN CONSTRUCTION, AND INNOVATION

This entails, firstly, developing evaluation methods and tools, in particular by measuring actual performance. Secondly, it means putting them to the test on the ground and facilitating their operational deployment. For this, a multi-disciplinary approach is needed, based on technical aspects as well as organisational, governance, legal, economic, insurance and change management issues.

At the same time, arrangements must be made to implement and capitalise on lessons learned on the ground, to shine the light on the best achievements and the pitfalls to sidestep, and thus define best practice. The whole, after consultation, will be made available to the players through broad distribution. This will enhance knowledge of the building stock, encourage exchange between players and facilitate the emergence of innovations in collective and systemic solutions.

Lastly, a building's overall performance is directly dependent on the different types and conditions of occupancy. Users are often very little informed about and involved in designing the fundamentals of its operation, and even less about its specificities under special conditions. Drawing on approaches affiliated with the human and social sciences, extended to the uses of the building and related uses (mobility, work, leisure, consumption, etc.) and mobilising the scientific community, the CSTB will organise appropriate communication to raise awareness and spread this knowledge among users. This is an essential component if they are to actively shape the performance of their homes.

5
Economy & sector

→ **Knowledge and developments in the sector**

All the factors listed above, from knowledge of the building stock to the performance of buildings, make it possible to identify the critical points with regard to the ability of the building sector, both individually and as a whole, to contribute to the societal challenges identified all the while meeting the objectives set.

The key success factors thus defined, which are the focus of research conducted by the CSTB and its partners, imply two prerequisites if implementation is to take place in accordance with the timetable and the various national and international political commitments: funding and the construction industry's ability to respond.

After all, what good is it to have products and the solutions resulting from their optimisation in relation to the rehabilitation project, if the latter cannot achieve an economic balance? Similarly, once the investment has been agreed, what about its feasibility? The contractual level of economic and technical performance, and therefore of expected quality, assumes a certain capacity for production, technical expertise and training for the players involved...

The CSTB will need to answer all these questions, consolidating a whole range of data, building from their current value. This value reflects and integrates the [non]answers to the questions raised, whether they concern the economic data at the macro (statistics, national trends) or micro (project scale) levels, are related to the structures delivered (volume, costs, etc.), the types of financing and support measures, the sector (specificity of the players, including new sectors, value-added chain, productivity, innovations, etc.) or inherent in the production capacity (HR volume, training, qualifications).

Based on the results of the various strategic areas of action, which take into account both the political objectives and the specificities of the projects, the CSTB will need to be able to investigate the alternative models which the sector will have to implement to successfully play its part in developing the response to major societal challenges, at least significantly by 2050.

This will involve studying the synergy between the industrialisation of the process, the co-production of the players (essential in meeting the objectives, in particular to ensure the necessary volumes and quality, at controlled costs) and the appropriate means of financing, in particular through the analysis of the value added chain and its distribution.

The aim of this knowledge base will be to shed light on the sector's ability to integrate the transition solutions developed within other strategic areas of action..

OUR PRIORITIES

Directed towards renovation, but transposable to new construction, our priorities are predicated on the need to mobilise the research community, particularly in the economic sectors. The aim is to identify the causes that brought about the chronic deficits in the renovation sector, and to find solutions that incorporate multi-criteria approaches, thanks to innovation in the broad sense of the term, so as to take a new approach to the construction-renovation process.

Data and knowledge of the building stock

The very foundation of renovation requires first gaining "necessary AND sufficient" knowledge of each building so that, from its initial state, the required solutions can be implemented, subject to technical, economic and sociological constraints.

Statistical and disembodied until now, this knowledge of construction – down to its very components – must now face multiple threats due to its very rapid and promising digital development. Amidst infobesity and the illusion of detail, it is the responsibility of the CSTB and its partners to set out a modus operandi that optimises this information (description, scope of validity, volume, qualification uncertainties, versioning, etc.).

It would be a mistake to produce a description so detailed that it makes each building 'unique', calling for a specific solution for each one. This would run counter to the imperative need for mass renovation, combining quality and performance within a sustainable economic model. This requires the definition of key indicators, which will be the common denominator for those involved in sustainable construction throughout its lifecycle.

Robust solutions

While the mobilisation of existing products and innovations will make it possible, via modelling-simulation-experimentation tools, to respond as best as possible to multi-criteria technical, sociological and economic requirements, it also assumes that this is done with an assurance of robustness and durability [in the strictest sense] in the face of various hazards (integrability, sensitivity to implementation, performance in real-life conditions, flexibility of use, etc.).

The drastic reduction in the non-performance of buildings, specific to the sector, is an unprecedented source of leverage for growth, based on design that incorporates simplicity-of-use requirements to ensure minimum performance of the products and solutions used. In the face of increasing technical complexity, coupled with a decline in the sector's attractiveness, where the training of players is uneven, the characterisation of solutions using hybrid approaches, including experimental data and systems simulation, should make it possible to support and transform innovation.

Whether in a logic of reverse engineering or design thinking, this approach must be a strength of the CSTB, which ensures the continuity of research towards proven operational solutions. Through its technological activities and testing resources, it is at the heart of the evaluation of innovative components and the definition of their optimal integration conditions.

It is expected that artificial intelligence, based on its knowledge of building components, regulations, state-of-the-art rules and standards, will enable the CSTB to support the chain of players from design to installation and maintenance, by revisiting the design of products and systems and optimising them according to the full range of quality-cost-performance criteria.

RENOVATION, RELIABILITY ASSURANCE IN CONSTRUCTION, AND INNOVATION

Players and sectors

At a time when the ambitions of the construction sector have never been so high, amplified by the reality of climate change and the need to reduce its many impacts on society as a whole, the situation is clear: France is not producing enough renovation and new-build to achieve the targets set.

There are many reasons for this: a lack of production capacity, a shortage of trained manpower, a lack of complete industrialisation of products (i.e. ensuring the same minimum performance, albeit a high one, regardless of who implements them), a multi-player construction process that is not integrated, but highly dependent on each player in terms of the overall performance of the project, not to mention the integration of innovations, which are, after all, numerous, but which are finding it difficult to find a market.

The same applies to the organisation of the construction process, whether that of new construction or even renovation, all along its design-construction-management triptych, where information sharing is a major key to the overall quality of construction.

The historical – if not characteristic – or structural non-quality of the construction sector, often mocked for its approximate approach to construction, in the various phases of construction, is an obstacle that absolutely must be removed.

There is therefore an urgent need to (re)reconcile the various players around the ambitions set, drawing on the proven skills of each, but working in particular on their interoperability through the prism of optimisation -- at the risk of never moving beyond the stage of intentions.

It is by developing and optimising the synergies between players that this will be possible, provided that the subject of construction is considered and addressed differently. Industrialisation, whether in production or in the supply chain, while exemplary in terms of consistent quality-performance and lower costs, should not be construed as the only solution. Quite to the contrary. There will simply not be a breakthrough scenario, or the substitution of large areas of activity to its benefit. There is a need for collaboration and optimisation at all stages of co-design, co-creation and co-responsibility, respecting the quality-cost-lead time triptych, building from equally optimal solutions combining different materials, whether new, recycled or from different general, local or alternative sectors.

This approach is therefore a major focus for research. We refer here to applied research, which must have a practical obligation: that of bringing about robust operational solutions, implemented quickly in the light of urgent situations at hand. This will require building new skills on the components not currently integrated by the players in the chain, something which will in turn make it possible to inform the trade-offs of economic and political decision-makers and find new ways to revitalise the sector by bringing it into the twenty-first century

The economic equation

Upstream from the technical and organisational response, the economic factor is an essential component of renovation, in the broadest sense of the term. The improved knowledge of the housing stock shows that more than 5 million homes need to be renovated, with priority given to energy efficiency, to have a definite impact on the 2050 targets, without neglecting the need to upgrade safety, comfort and reduce exposure to risks (climatic, health, poor housing, etc.). It also throws light on socio-economic data, as regards debt capacity, prioritisation of lifestyle choices and awareness of the global nature of building-related issues and the impact they have on everyday life.

The repercussions on deferred public spending on social and health issues, particularly for an [ageing] population, are major and must be seen in the light of the investment needed for these renovations, from a cost-benefit perspective, over longer integration scales. It is therefore beyond the associated models and simulations currently being implemented, in particular by public policies, regulations and various forms of aid, that the CSTB, together with its partners, will need to study the opportunities which the different types of investments, support policies and taxation can cover. It will also need to carry out this exercise at the European level, where all countries are facing the same issues -- climate change, population ageing, international dependence with respect to energy resources, raw materials and products, and insufficient production capacity in non-offshorable activities -- associated with the act of construction.

The second more "microeconomic" subject, for which the CSTB and all academic and operational players are required to provide innovative solutions, is that of "construction costs". In a constrained, potentially inflationary economic context, as a corollary to domestic and international obligations on major societal issues, these costs should – if not to say must – nevertheless reasonably fall, all the while improving the overall performance of the structures delivered. This means combining the know-how and strengths of the various players throughout the design-build-maintain process, which will [undoubtedly] lead to a re-examination of all production and design methods.

For example, it would be of relevance to structure renovation and new-build projects taking inspiration from industrial production, where scheduling and logistics are, like the process and the skills of the people involved, an essential factor in the efficiency and quality of the finished product. The automotive sector has achieved this by revisiting every component of the process, including fleet control, as has the construction sector, which also in its time upended some of its finishing processes with a major innovation: plasterboard.

The combined approaches of these two economic components ought to make it possible to offer new forms of support to the sector in a necessary transition and to ensure, or at least organise it so that it can meet its commitments for 2050 in terms of project volume, quality and performance.

The economy and digital in the broad sense proceed from a necessary cross-functionality between the different strategic areas of action, in particular with respect to the data that serve as the common denominator. These two sectors are respectively subject to a systemic approach aimed at consolidating a common foundation, now essential, in terms of reliability of solutions, efficiency, and robustness of cross-cutting approaches.

RENOVATION, RELIABILITY ASSURANCE IN CONSTRUCTION, AND INNOVATION

OUR AMBITION

Construction is but the reflection of civilisation and its evolution. Exacerbated by new technologies, the growing level of information available to the players and an inflationary aversion to risk, particularly in high-income countries, this change is bringing about a radical change in stance in the expectations of buildings and their urban environment, which people would like to see fall in step immediately. This is not currently the case, even for new construction, and even less so for the existing fleet. The current, sequential and often disciplinary approaches have proved their worth, but are also showing their limitations. If we do not manage to radically change them, all the while being aware that there will not be a sudden break, all the research and knowledge accumulated by the players will remain "theoretical", if not pointless. The different paths which the strategic action area "Renovation, reliability assurance in construction, and innovation" proposes to investigate, co-develop and strengthen are not just a promise. In close connection with the other strategic areas of action presented in this summary, they must, in a systemic vision of optimised co-construction with the players, draw on operational experiments-achievements. Beyond the demonstrative vocation, these will help substantiate the assertions that the objectives set for horizon 2050 are not a utopia, but a reality. An accessible reality that must lead the sector to transform itself in a logic of concurrent disruption and continuity, as other sectors have been and will be required to do.

RENOVATION, RELIABILITY ASSURANCE IN CONSTRUCTION, AND INNOVATION

Programming up to Horizon 2030

Knowledge of built base

Multi-criteria building renovation

Knowledge of sector

Assessment of real building performance

Multi-criteria assessment of products and processes

National Database of Buildings:
the first CSTB tools connect to the BDNB: UrbanPrint (partner: Efficacity), BTPF lux, TyPy, etc..

Establishment of knowledge base by geospatial cross-referencing and integration of national public databases

Development of use cases:
tracking of carbon trajectories and water consumption within a test housing stock
Partner: Action Logement

2024

Occupants at the heart of performance:
"user" pathway and keys to monitoring one's performance from the start to the end of a project

Sharing best practices and key figures with the general public

Objective: to facilitate the involvement of occupants in improving building performance

Reports from the ground on actual performance and associated action plans:
special focus on economic aspects and energy consumption monitoring at all project phases

Methods and tools for performance assessment and reliability assurance:
cases for measuring the performance of building shells, systems and overall performance (energy and comfort aspects)

Multi-criteria diagnostics:
modular protocol for multi-criteria diagnostics of existing buildings applicable to the first demonstration units in the built base (schools, single-family home, residential, collective)

Digitised knowledge bases for rehabilitation:
a newly-initialised database and digitised knowledge about thermal insulation procedures/techniques for renovation

Integrated chain of digital tools to support the rehabilitation process:
rapid energy-cost simulator of rehabilitation strategies (residential sector)

Multi-criteria rehabilitation strategies:
proof of concept of a multi-criteria project management assistance protocol for holistic rehabilitation (schools, residential, collective)
Partners: Var Departmental Council, SPLAIN Marseille

Assessment of technical and economic conditions for the deployment of prefabricated/industrialised renovation solutions
Partners: RESTORE, NOBATEK-Inef4, Greenflex

Consolidation of the multi-criteria diagnostic protocol

Enrichment of the digitised knowledge base on thermal insulation:
façde and building typologies, rehabilitation procedures (in particular energy systems), content of multi-criteria diagnostics

Model building detection module in the BDNB enhanced with associated model renovation projects/actions (residential, educational buildings)

Extension/widening of case scopes for all uses and integration of multi-criteria to have simple and inexpensive methods for assessing actual performance on any type of building
Partners: field surveyors, developer of diagnostic tools, fund providers

Consultations with the stakeholders in the sector concerned with a view to charting out a roadmap for performance guarantee

National Database of Buildings:
integration of BIM digital tools within the BDNB

Integration of public databases available at regional level

Recovery of the sector's costs and volumes at different scales and capitalisation on the sector's key figures, its structuring and the distribution of its added value

2027

Development of a multi-criteria "energy-carbon-comfort-costs" simulator:
an ergonomic digital tool used to define multi-criteria rehabilitation strategies in one or more stages, to assess them by simulation and produce summary reports on the results

Development of a roadmap
for upgrading, convergence between environmental and technical regulations on the existing building towards the multi-criteria performance of the building being renovated

Implementation of the multi-criteria product database
under ATec operational in 2030

Roll-out of multi-criteria measuring kits in our test laboratories

Set-up of an observatory on construction costs and volumes

Creation of the scientific core to strengthen multi-criteria evaluation of products
(mechanical, thermal, acoustic, sanitary, sustainability, implementation, environmental) and develop the framework for expertise (insulation, masonry, water, wood-burning, smoldering, wind)
Partners: Placoplatre, RELINE, HILTI, CTMNC, CNES, LEMTA, CETHIL, CODIFAB, RISE

Provide technical and regulatory information to support selected breakthrough innovations
Partners: ENPC, LaMé Orléans, XtreeE, Vinci, Bouygues, etc.

Develop the test capacities of the CSTB's major infrastructures
(Jules Verne blower, Four Vulcain) and strengthen the expertise and technical analysis backed by the tests

Establishment of a building digital identity card within the BDNB

Regular sharing of knowledge with the general public who will have good control of their buildings

Broad sharing of multi-criteria diagnostic protocols to those involved in diagnostics and renovation support

Comprehensive digitised knowledge base
on the existing built base and technical rehabilitation solutions, connected to the BDNB

Multi-criteria simulator for rehabilitation strategies
at the building and building complex level

Structuring of continuous capitalisation
of reporting on construction costs and volumes

Method for quantifying the impact
of a regulation and its supporting mechanisms on the sector's ability to adapt

2030

RESEARCH DIVISION REFERENCE DOCUMENT

MEANS FOR ACTION

CIRCULAR ECONOMY AND RESOURCES

FOR BUILDINGS

Optimising the use of our resources for construction is essential towards ensuring them a certain durability, as well as for preserving the environment. This means, in particular, extending usage times, turning to re-use options, and massively developing secondary substitute raw materials (MPS), resulting from recycling..

OUR CHALLENGES

To shift from a construction approach currently based massively on the use of new resources, whether mineral or derived from biomass, to an approach that structures the development of reuse and recycling as a conventional approach, based on innovation as much in techniques as in organisation and culture.

Historically, buildings had the virtue, so sought-after today, of being fundamentally sustainable, and were consequently modern in a way that we would describe today as avant-garde. There was no strategy, however, and instead plain and simple use of the raw materials available, most often local, still taking the "covered enclosure" approach, seen as the "fundamental" of the building, coupled with a search for heritage durability.

The various developments in society, industry and the economy have, to some extent, revolutionised the way buildings are used and the services they provide - safety, comfort, etc. - at the same time, however, causing them to lose some of their sustainable character in the current sense, particularly when it comes to raw materials, materials and components. The increasing functionalization of each has led complexification in them, both in terms of the mix of materials used and the way they interface with the other elements that make up buildings.

There are a number of reasons for this, ranging from an increase in the performance perceived by end-users to, more simply, an improvement in the process to make it easier to install and last longer, while at the same time increasing technical and economic efficiency. This performance is needed to meet the challenges of demographic growth, urbanisation and the aspiration to cleaner environments... Unfortunately, the effect is delayed over time, to the detriment of reuse and recyclability, the economic model of which was not part of the collective imagination-scape, being too often associated with poverty...

We have thus gone from structural shells recyclable "ad infinitum" -- which, over the centuries and the vicissitudes of history, made certain constructions nothing more than quarries -- to the technical, but mainly economic, inability to reuse the majority of the components of buildings, and especially those of the interior works. With the latter, the issue at stake is different, beyond the design and construction processes that had little concern for demountability, a necessary condition for re-use.

Due to the continuous improvement in construction products, both under pressure from the markets and in terms of the performance induced by regulations, those of secondary works are, by essence, a social marker directly "in contact" with the user, and thus visible. This, in a re-use logic, calls into play two opposing notions: that of "vintage", which is unregulated and willingly takes on imperfections and relative performance, and that of insertion as a "new" product that has to meet various regulatory requirements, with the need for reintegration into an industrial refurbishment process that is not yet complete, either operationally or economically.

In the case of re-used components, there is a gulf between advocacy and economic realism, the latter being largely conditioned, not to say rivalled, by imports of new components from low-cost countries. In contrast, when it comes to materials and certain structural components, the trend towards re-use is more easily established. At the same time, recycling offers the most operational perspective that can be directly integrated by industry, through the development of the resulting secondary raw materials, and some remarkable industrialisation (planed wood).

CIRCULAR ECONOMY AND RESOURCES FOR BUILDINGS

Thus, re-use and recycling are, beyond technical constraints, fundamentally conditioned by the very fact of deeply rooted cultural logics. Admittedly, the challenge is not only technological, but above all economic, societal and organisational.

Throughout its life cycle, the construction sector is a major consumer of materials (minerals, ores, hydrocarbons, plastics, biomass, water, etc.). In 2018, along with development, it accounted for almost half of the materials used in domestic consumption in France. With around 40 Mt generated each year, it is thus one of the largest producers of waste, compared with the 30 Mt originating from households. Until now, this finding appeared a disadvantage in terms of image, but above all in economic terms, as waste has not yet overcome the traditional opposition between old and new, revealing their positive image as a resource in its own right.

The challenges confronting us in the 21st century - climate change, demographics, changes in lifestyles and production methods, as well as economic and geopolitical issues - mean that building waste is, beyond being a play on words, a mine of "infinite" resources, in the same way as other sectors of activity that are potentially further ahead in their reuse.

If, moreover, we extend the scope of the building to its urban environment, and apply the constraints of climate change to it, then the question of the environmental footprint immediately comes to the fore in terms of natural resources, especially water, not to mention space and the ecological services that come along with it. Another matter is the impact of human activity on these environments and, more broadly, on biodiversity. In view of the unbridled use of both drinking water and land in developed countries, where the population spends more than 80% of its time, and where urbanisation and suburbanisation are soaring, with the attendant artificialisation of land, it is important to re-examine the current approaches to these resources, from the angle of optimisation and restraint.

It is therefore essential that we optimise the use of our resources to ensure their long-term viability - the challenge being to do so at controlled costs - but also to preserve the environment and, to a certain extent, biodiversity. The issues at stake are economic, organisational, environmental and political. To wit, the challenges in recycling and reuse are multiple, and imply changes in behaviour at every level, whether on the part of professionals, users or citizens. Consequently, this should prompt us to think about construction differently.

OUR COMMITMENTS

CSTB is determined to play an active part in the organisation and development of the circular economy in the building sector. On the one hand, and with its partners, by removing the scientific, technical, normative, regulatory, insurance and economic barriers associated with it. On the other hand, by bringing together all the players - businesses, craftsmen, industrialists and users - to ensure that the circular economy becomes a reliable, sustainable, mass-market alternative that creates value and jobs.

The need to make reasoned use of the various resources drawn on directly or indirectly by the construction sector is no longer in dispute, given their impact on different scales, from the local to the global. However, given the speed of change in the sector and the deadlines set by national and international commitments, it is essential that the momentum for the massive development of materials recycling and, to a lesser extent, the reuse of components, be rapidly initiated.

While some technical levers still remain to be developed, particularly as concerns the formulation of products incorporating secondary raw materials to meet current health and regulatory requirements, as well as characterising their performance (the same applies to reused components), the challenge lies mainly in structuring the process.

This implies knowledge of the resource base, both for reuse and, less markedly, for recycling. The same applies to the construction and assembly processes: necessarily aged, they do not always include a dismantlability logic in their design, as a matter of standard practice.

Furthermore, from the perspective of "necessary" industrialisation, the difficulty of this approach lies in the almost essentially diffuse nature of the supply, apart from the major building renovation projects connected with the tertiary or residential sectors. Which brings us back to logistics in the broadest sense of the term, which, over and above the organisational aspects associated with it, will be one of the main keys to the economic model that will need to enable the widespread development of this approach, now more encouraged than ever by the necessary decarbonisation of the building sector.

The CSTB's status, both in its research and in its operational activities, gives it a role as a facilitator on the subject of the circular economy. It will need to encourage and develop the skills of the players involved by building and spreading knowledge, in order to achieve a structured, if not structuring, process for the economy in the broadest sense.

Knowledge and recovery

This requires «precise» knowledge of the resource base, through a detailed understanding of the stock at the level of each building, whether on a statistical basis, on a macroscopic scale, or on the basis of diagnostics on the scale of the deconstruction - reconstruction - redevelopment project. The National Database of Buildings (BDNB), combined with the knowledge bases on construction methods, projects and AQC construction quality audits, form a more than solid foundation for this point.

Over and above the availability of the resource, a fundamental prerequisite, work must be carried out to qualify it, and thus assess its various characteristics with a view to either reuse or recycling. For reuse, this means defining assessment protocols for products/components, with or without integration in a refurbishment process, taking into account residual performance capabilities and ageing in use. As with products derived from virgin raw materials, secondary raw materials derived from recycling will have to meet current standards, particularly as regards health aspects relating to REACH pollutants. As to the physico-chemical properties that may impact formulations, the solutions will range from [over]extending or limiting areas of use, resulting in practices under less severe conditions of use.

Similarly, it is important to have a precise understanding of the material flows involved, as much from a physical as an economic point of view, informed by their location and usage conditions. This will make it possible, first of all, to organise the sector, by creating alternative solutions for both re-employment and recycling, with precise knowledge of the needs and associated trends; and secondly, to make these «new» industrial activities more attractive to investors. As with many subjects, the constraint is above all economic, with the need for a market price equivalent to, or possibly lower than that of the new resource, and the requirement for a growing volume of substitution, in order to reach a profitable economic model, guaranteeing the logic of the circular economy.

Structure

The circularity objective thus requires that we revisit the construction process, with the different components of the value chain, involving new players in the process – logistics, to mention just one in reference to the diffuse nature of the resources – in a building life cycle logic, integrating this change in the medium term towards a high building recycling rate. The economic models, like the sectors, remain to be built and will have to take into account public policies, whether incentive-based (grants, taxation) or regulatory, in a current and forward-looking vision at the national and European level.

With regard to the recycling sectors, the fragmented and highly disparate nature of the products or materials, today seen as arising exclusively from the construction sector, prompts questions about industrial structuring in the light of the abundant innovation today in terms of new materials. Seeing its potential in terms of volume and accessibility, the localism model will have to bow out, leaving the stage to the logic of multinational industries, as is being seen with metal materials or those derived from chemicals. The exemplary nature of the automotive, aeronautics and rail sectors in terms of the transition to industrialised recyclability (recyclability rate and recovery of around 96% for the automotive sector) will be a particularly interesting object for study.

Preserving resources

Resource preservation is to be understood in the general sense, as well as with reference to natural resources, but more particularly to water, the scarcity of which has a direct and very short-term impact on life as a whole (human, animal, plant). The CSTB has long been developing an intermediate approach at the scale of the building and its plot (an essential component of the small water cycle), with regard to the optimisation of water of different kinds: whether natural water inputs, taking into consideration climate-related imperatives; or the optimisation of drinking water and grey water uses, in particular to reduce consumption and withdrawal from the environments. Connecting in with the higher scales, this approach makes it possible to look into the dispersion of pollutants in the large water cycle.

The recent increasingly frequent effects of climate change during summer periods over the last decade have put the scarcity of this resource across the country back in the spotlight, reminding climate sceptics of this simple reality: water is a source of life, and unrestrained access to it is no longer a certainty for rich countries. The various uses associated with it are obviously anchored in construction, although urban development also plays a decisive part, in particular through artificialisation, blue and green belts, etc. The balance between scales, types of water and the associated functionalisation – feeder, energy, thermal, support for biodiversity, etc. – must make it possible, through optimisation and prioritisation of uses, to preserve the resource, relying on appropriate technologies. Revisiting the methods of use and regulations associated with drinking water and grey water in the most stringent light, taking the premise of very profound cultural change, is another necessity, both for safety and health, and for citizens, connecting in with the reintroduction of the dogma "access to water for all, everywhere, without limits and without compensation".

THE KEY STRANDS

This strategic action area "Circular economy and resources for construction" is organised along three lines: :

IDENTIFYING MATERIAL FLOWS AND ANTICIPATING THE MATCH BETWEEN NEEDS AND AVAILABLE RESOURCES ON A REGIONAL AND NATIONAL SCALE

The objective is to be able to drawn on a set of tools (databases, models, experiments) to steer the actions of the CSTB and construction sector players, at the scale of the project and its components, on the most critical and/or high-impact materials, to observe the emergence and efficiency of the economic models associated with the circular economy and to gain forward-looking information to take into account the construction sector's long time-scale.

1

Promoting the circular economy and enabling its industrialisation

For the CSTB, this implies: disseminating knowledge about the materiality of the existing building stock and the flows of materials associated with construction, deconstruction and rehabilitation; informing players about alternatives (in terms of resources and waste management) and thus encouraging them to change their perception (volumes, technical and economic feasibility). Lastly, the CSTB will contribute to fostering the emergence of goods and services offers (services connected with the alternative management of resources and waste).

2

Understanding the issues at stake in the resource economy and the circular economy

The aim of the work carried out is to gain and spread a panoramic view of the criticality of materials and resources (including water) and the impacts associated with their extraction, transformation and end-of-life, so that actions can be prioritised. The CSTB, together with ADEME and a group of stakeholders, wishes to raise the following question: «What are the prospects for the development of the circular economy in construction and what will the consequences be for stakeholders and the environment?" Lastly, the CSTB analyses the sectors' economic models in order to understand, develop and encourage the most efficient model[s].

3

Identifying the flows and stocks of resources and waste on a given territory

The objective here is to gain a better understanding of the stocks of materials and the associated flows (both incoming and outgoing), on a scale ranging from local development operation to nationwide territory. The aim is to anticipate future waste flows on a given territory to enable players to put in place the best solutions for reusing them or managing their end of life. BTPFlux, developed within this framework, models material and waste flows in buildings, using knowledge of the existing stock, a detailed reconstruction of buildings using a macro-component approach, and construction-deconstruction-rehabilitation scenarios in a given area.

REUSING MATERIALS FROM EXISTING BUILDINGS

Buildings are part of a construction, renovation and deconstruction process characterised by slow advancement. As such, the issue of managing the materials from existing buildings will concern multiple generations. The rising cost of raw materials, combined with supply difficulties and greater sensitivity to environmental impacts, highlights the potential and strategic interest of this stock.

1

Encouraging the transition to selective deconstruction and material recovery procedures

The CSTB is focusing its work on upgrading "products, equipment, materials and waste" diagnosis prior to demolition, and on developing tools, methods and metrics to enable project owners to place material recovery at the heart of their operations management strategies.

2

Developing reuse and industrialising recycling

To support the massification of re-use, and the deployment of supply and demand, the challenge is to secure it by supporting players in the institution of common rules. Priorities include topics such as the durability and lifespan of products, materials and equipment, or the assessment of their performance for reuse. The CSTB is also taking up issues of technical and health performance assessment, as well as the sustainability of products made from recycled raw materials, by supporting industrial players throughout the process of changing from virgin to secondary raw materials.

3

Optimising rainwater, grey water, wastewater and process water management

To limit the consumption of drinking water while using water as a means of supporting biodiversity and urban cooling, the CSTB is working on the uses of non-conventional water (grey water, rainwater, etc.) in order to guarantee its technical performance and make it safe from a health point of view. The objectives of the CSTB are to contribute to reducing the consumption associated with the construction process, improving the efficiency of equipment, diversifying the types of water used, in particular by intensifying re-use, improving the quality of water discharged into the environment by analysing the performance of autonomous treatment systems, and supporting innovation enabling alternatives to the use of water itself (so-called reinvented toilets). It is also interested in the assets which the networks form and in maintaining their performance over time.

CIRCULAR DESIGNING

With a renewal rate of less than 1% per year, exacerbated by the challenges of climate change and the associated energy and environmental transitions, as well as by the need to decarbonise, the current status of the building stock is almost ideal, with a very low deconstruction rate, for the transformation towards a circular economy in construction to begin and develop. It draws on a built heritage that has very rarely taken the concept of reuse into account in its design, and just as rarely in its construction, except, as mentioned in the introduction, in a historical reading mainly related to the shell (envelope, columns, beams, roofing, etc.).

The integration of the principles of the circular economy at the design stage of products, structures or development projects offers considerable leverage when it comes to reducing environmental impact and limiting material flows.

Designing with recycling in mind is the key to achieving long-term objectives. It assumes, for any project, and at different scales, making priority and majority use of products derived from recycling and, to a lesser extent, from reuse, particularly in view of certain regulations and obligations. It relies on optimising natural resources, particularly those that are under pressure. It requires revisiting systems, particularly their interfaces, with a view to their eventual dismantlability, as is once again the case for industrial products and their reparability.

We need therefore to work on the pressure indicators and quality indices that will foster eco-design, and address the issue of the lifespan of products and structures. Environmental, social and health criteria need to be integrated from the very design stage of a product or structure. This makes it possible to anticipate multiple life cycles, optimise recovery scenarios at the end of the cycle and limit the impact, particularly on the extraction of non-renewable resources during production. The aim is also, of course, to work on restraint by optimising the consumption of energy and non-energy resources, and to promote the ability of products and structures to adapt to different uses..

We need to integrate environmental, social and health criteria right from the design stage of a product or structure.

CIRCULAR ECONOMY AND RESOURCES FOR BUILDINGS

OUR PRIORITIES

The construction sector is one of the biggest consumers of raw materials, the second biggest emitter of greenhouse gases, and the biggest consumer of energy along with transport. Add to this the sluggish growth in its productivity compared with the major industrial sectors, and the industry could be written off for good.

This chronic difficulty in achieving the objectives set for it, in terms of quality, productivity and quantity of renovations and new builds, is now proving to be, in fact, a tremendous opportunity for drastic change. This is mainly due to the constraints imposed on us by climate change, particularly as regards greenhouse gas emissions and the depletion of natural resources, not to mention the impact on the environment. All of this needs to be achieved within a timetable and with commitments that will not be delayed: the building stock must be renovated in its entirety by 2050.

Beyond the purely technical aspects, from data of all kinds to an inventory of past and current technologies, from innovations to models and simulations of complex cases, and to the formulation of solutions and levers for their optimisation on a case-by-case basis, a simple reality check is in order: What is the reality of the built environment? Do we really know?

Although the answer may seem simple, it is not, by dint of the theoretical and disembodied approaches used. Knowledge of the building stock means first and foremost knowledge of the construction site, with a realistic understanding of the construction methods, the “rules of the trade”, the interfaces between materials and components, the effectiveness and variability of use, etc. While this may be the case for a new-build operation, the problem is more complex for renovation, where the sector is not known for the traceability of projects. In deconstruction, for example, where the process is essentially manual, particularly for products intended for re-use, it is easy to lapse into empiricism, with approaches based on more or less relevant know-how. As a result, operating protocols need to be put in place to ensure a baseline level of quality, so as to ensure the reliability of re-use solutions, whether they are direct or indirect, as they involve refurbishment.

However, when it comes to recycling, which is ultimately more a question of waste treatment and input management, the technical solutions do exist or will exist. They will make it possible, during the process of generating secondary raw materials, to prevent, to a certain extent, imprecise dismantling solutions that result in pollution in future uses (for example, pollution of cement with plaster).

The need for a detailed understanding of the existing project is thus a priority, so as to secure the reliability of the first stage of the circular economy process.

The second priority lies in a detailed economic analysis of the current construction process with products based on virgin raw materials (or including a small percentage of waste from the same manufacturing process). The same applies to products derived from recycling by developing the current circular economy model. With a low to negative impact on the project as a whole as the prospect, the comparison of the two economic realities is intended to shed light on the most relevant avenues for ensuring the massification of the circular economy, at controlled costs. The only prospect for developing the circular economy in the building industry is one that has a minor impact on the cost of construction, without limiting the project’s scope.

Working on the circular economy, we reexamine our relationship with nature, and our existing and future heritage, through our access to resources.

Given the combination of a very low rate of deconstruction of the stock, understood as complete demolition, and a complete renovation of the stock between now and 2050, it is essential that we coordinate a circular economy approach, reinforced by the diffuse and piecemeal nature of the renovation. In the case of recycling, as with any commercial activity, the problem is fundamentally economic, with an equation for closing the loop that is removed from current approaches, except for grants and tax relief. We should bear in mind that the rising cost of electric mobility with iso service performance is impinging on households' ability to pay for home renovation, and even when they can, then at an unattractive rate of return. It is thus important that the secondary raw materials (SRMs) derived from recycling are derived from industrial processes that enable a significant reduction in production costs, so that their integration into current processes has little or no impact on the products replacing those derived from virgin raw materials.

The same will apply to the optimisation of the circular economy process applied to the building industry, in view of the current chain of players, the introduction of EPRs and recyclers, and the sociological approach to organisations under economic and regulatory constraints, where the joint approach, which is certainly the guarantor of major balances, needs to be questioned. This is true whether in the face of the expected transformation of the sector, in terms of volume, transformation kinetics or compliance with deadlines, all of which are subject to severe economic constraints, capacity constraints and the attractiveness of the jobs associated with recycling.

At the same time, performance qualification of SRM-derived products will need to include assessment of health impacts, as already takes place at the declaratory level via environmental product declarations (EPD), depending on whether the sectoral channels come from the building industry or other sectors (electronics, automotive or aeronautics, as far as concerns the presence of carbon nanotubes, for example). The risk of insufficient resources opens up, through innovation, unlimited opportunities for hybrid materials (biomass + MPS). It is thus important that the assessment protocols for these be developed, in conjunction with academic partners, to qualify, beyond their specific performance features, their sustainability under different types of ageing and demands..

CIRCULAR ECONOMY AND RESOURCES FOR BUILDINGS

OUR AMBITION

Similar to the issues at stake in the other strategic areas of action, and more particularly in "Renovation, reliability assurance in construction, and innovation", the circular economy and the resources needed for building place the CSTB at the heart of the socio-technical-economic issues that arise from climate change and the now established awareness about it.
At a time when pressure on natural resources is reaching its limits, and low-carbon construction is becoming a fundamental, reinforced by the need for massive renovation of the building stock, the CSTB is engaging with stakeholders in structuring the circular economy for the construction sector.
As we work towards a circular economy, we are prompted to re-examine our relationship with nature and with our existing and future heritage, through our access to resources. This process also implies radically bringing practices and related professions forward, so that they enter a new dimension.
The aspiration is to challenge our way of considering, using and mobilising natural resources, to revise the construction sector's linear consumption method by optimising the use, at least, of virgin raw materials and by considering any existing material, product or structure as a preferential resource. With the aim of future demountability and recyclability, construction-deconstruction methods, as well as those for the production and assembly of the various components and, in parallel, the industrialisation of secondary raw materials, among others, will need to be revisited.
In this context, the CSTB will have to integrate construction sites even further as an essential component of the circular economy, like logistics, whose impact on the economic equations will be fundamental.
Once marginal and considered minor, the material collection, sorting and reuse activity is now being given a new lease on life, at least in theory. If it is to create value and jobs, a number of very different obstacles must be overcome, ranging from techniques to behaviour, the sociology of organisations and, of course, the economy. Given the importance of the subject and the wide array of issues associated with it, the CSTB has made it one of its research priorities..

THE CIRCULAR ECONOMY AND RESOURCES FOR CONSTRUCTION

Programming up to Horizon 2030

Water management

Secondary raw materials - Recovery of material

Circular product and structure design

Secondary raw materials - Identification of flows

Performance feature sustainability

2024

BTPFlux:
a tool for modelling, at the regional or national level, material and waste flows from buildings. It makes it possible to anticipate MEWP flows to foster the institution of a circular economy

—

Coupling of the BDNB and TyPy,
CSTB database of macrocomponents, used to model the materiality of buildings
Partners: local authorities, cities, metropolises, building stock managers, MEWP surveyors, research players (France & Europe)

PEMD platform:
a digital platform accessible to all, to support the institution of diagnostics about the management of products, equipment, materials and waste (MEWP). Will make it possible to receive, upstream from the site, the MEWP diagnostics and give visibility to the identified deposits and, at the end of the site, to receive the reconciliations
Partners: DHUP, ADEME

Circular economy outlook:
forward-looking approach, primarily qualitative, regarding the formulation of differentiated scenarios for the development of the circular economy on horizon 2035
Partners: ADEME, FPI France, GRDF, EDF, IGNES, GIMELEC

Reuse - guides on diagnostics and performance assessment:
drafting and distribution of methodological guides to support the practice of reuse, for each product family

—

Support and improving reliability in the institution of a circular economy
Partners: MEWP diagnostics specialists, construction companies, project management

Project Spirou:
Securing Innovative Reuse Practices via a Unified Offer

—

Launch of the SPIROU project. Drafting of characterisation protocols for 10 component typologies. Formalization of associated feedback
Partners: ADEME, A4MT/Booster du réemploi, Qualiconsult and Mobius réemploi

Re-use - a sign of quality for reconditioning centres:
developing a quality sign to provide recognition for the processes of reconditioning platforms for products derived from re-use (MGP, CSTB)

—

Projet E2IC :
for a better understanding of impacts in the construction site phase. Improving knowledge of the environmental impacts associated with the construction phase. Developing a configurable decision-making and assessment tool adapted to the new build, renovation and deconstruction scopes

Pathologies due to humidity:
mapping of the risk of water in the building

Use of unconventional waters in buildings:
evaluation of the circularity of water within the building and the plot to demonstrate the feasibility and benefits of technical solutions by securing health risks (housing stock managers, design offices, industrial companies)

—

To support stakeholders in their water use efficiency actions, precise and up-to-date knowledge of buildings' water needs (local authorities, housing stock managers)

APICIPO project:
definition of reference scales for circularity indicators concerning different product families, lots and sub-lots for new buildings

—

EC2 tool:
developing a tool to measure circularity at the scale of structures
Partners: ADEME, Alliance HQE, EVEA

ECOSCALE
a set of indicators that can be deployed at the scale of the components to characterise circular design efforts

—

Development of four indicators that characterize the content of recycled and biosourced materials, dismantlability, recyclability and reemployability of construction products

—

Consolidation of a technical reference base describing the methodology for calculating these indicators

2027

BTPFlux:
opening up codes and databases to academic, then operational players

—

Anticipating MEWP flows with a view to promoting the institution of a circular economy

Re-use:
more diagnostic and performance evaluation guides available for other product families

EC2 tool:
development of a tool for analysing the circularity of components for renovation

Water circularity:
development of technical guides for the implementation of re-use loops and ATEx projects to reduce the water footprint of buildings and help preserve water resources (housing stock managers, industrial companies)

—

Development of tools for monitoring water consumption in housing stock (in conjunction with the BDNB) in order to identify priority maintenance operations (change of equipment, execution of works, etc.) and to institute awareness-raising campaigns on uses (housing stock managers)

Observatory on service life-span
in the field to set up and capitalise on feedback from the field and feed our knowledge of structures' "real" service life-span

—

New accelerated ageing protocols
for building envelope components in the context of climate change

2030

Predicting building materiality:
anticipating the flows of MEWPs in order to promote the introduction of a circular economy in a context of climate change

Re-use:
complete body of methodological guides for diagnosing and assessing the performance of all components that can be reused, in order to support and ensure the reliability of the implementation of a circular economy

THE CSTB'S

PARTNERSHIP

POLICY

As the only French organisation to work on the building system as a whole, the CSTB strives, through structuring partnerships, to involve the big names in French research in order to speed up the production of tangible and credible results.

PARTNERSHIP POLICY

The vision of the building put forward by the CSTB is well established within the scientific community. Today, it is clear to all players in the sector that research in this field must be systemic, scaled and highly interdisciplinary.

Steering this research certainly requires a global approach, but also high-level specific contributions in a wide range of fields, from applied physics to sociology and economics. While the legitimacy of the CSTB is beyond any doubt, it does not on its own have the resources needed to answer all the questions posed to research by the subject of buildings.

This dual necessity – diversity in both disciplinary fields and resources – is substantiation for its policy of resourcing and partnerships.

Developing structuring partnerships

As the only French organisation to work on the building system as a whole, the CSTB strives, through structuring partnerships, to involve the big names in French research in order to speed up the production of tangible and credible results. In the context of meetings and joint initiatives, it gradually establishes a relationship of trust with the latter based on communication and anchored for the long-term.

Over and above the jointly programmed actions, operating as a network is also a means of promoting and strengthening systemic approaches in the sector. To this end, membership in competitiveness clusters or participation in associations are necessary in order to develop knowledge and maintain mutually beneficial relationships.

The emblematic partnerships

Out of the many partnerships which the CSTB maintains, the most emblematic is that engaged with the National Centre for Scientific Research (CNRS). On subjects of academic standing, it consolidates the CSTB's knowledge in disciplines such as the human and social sciences. It is also building up its understanding of cutting-edge materials science.

In addition, together with the French Atomic Energy and Energy Commission (CEA), the CSTB is working on electrical networks. These include the scale of the building as a specific producer and consumer, as well as the management of the energy mix at neighbourhood level.

The French Centre for Studies and Expertise on Risks, the Environment, Mobility and Land Planning (CEREMA), which enjoys a strong regional anchoring and mesh, and the CSTB contribute to a number of research projects, particularly on climate change and its energy issues. In this manner, they are supporting the development of knowledge on in-situ energy performance guarantees for buildings and the creation of innovative approaches to deal with the issue of urban heat islands (UHI).

The needs surrounding UHIs, the redefinition of 100-year crises and the mapping of soil hydrometry, in conjunction with structural risk, have also naturally led to a partnership with Météo France.

Lastly, questions about the nature of the soil at the level of the structures in the districts of Marseille, following the collapse of the buildings in the rue d'Aubagne, illustrate the need for answers and provide ample grounds for a partnership with the Bureau de recherches géologiques et minières (BRGM), extended to the existence of needs in the area of 'low enthalpy' geothermal energy.

This policy of developing structurally-defining scientific partnerships is reinforced by the need for the CSTB to contribute at the highest level to the initial training of experts in the field of building.

THE CNRS

In order to secure its resourcing, contribute to the removal of scientific barriers and meet the requirements of the buildings of tomorrow, the CSTB has consolidated its ties with the French research system and, in 2020, signed an emblematic partnership with the Centre national de la recherche scientifique (CNRS).

Through this partnership, the two organisations aim to consolidate their complementary skills in order to pursue research topics that are in line with the new technical, economic and social challenges facing construction and land development.

The sciences at work for tomorrow's buildings and cities

The two partners' aspiration is to combine their expertise, skills and know-how around three fundamental themes to anticipate the development of the buildings and the city of tomorrow:

- engineering and systems sciences, in particular issues related to energy and sustainable renovation in the broad sense, extending from the existing collaborations that have already brought together the teams at the CNRS and CSTB;
- the digital sciences, more specifically artificial intelligence, 3D modelling, connected objects and the adaptation of digital technologies to the issues at stake in construction;
- the human and social sciences, particularly in connection with shifting patterns in the practices and needs of users and professionals alike. Integrating this concern, right from the structure design phase, is a major challenge for the CSTB, and more broadly for the buildings and the city of tomorrow, which requires adopting a new vision, combining techniques and uses, informed by economic approaches.

Various forms of action are being contemplated, such as research collaborations with shared objectives, information sharing to move the technical debate forward, as well as scientific dialogue, and to promote innovation, the joint organisation of conferences, seminars and colloquia.

Actions undertaken

UA joint call for proposals by CNRS CSTB, launched in 2021 through the Mission for Transverse and Interdisciplinary Initiatives (MITI), has made it possible to support interdisciplinary and innovative research aimed at removing the barriers related to buildings in the sustainable city. "Reducing fluid discharges from buildings by integrating microalgae culture into the facade",

"From mammoths to architecture: the long bones of proboscideans as model pillars» (mechanical tests comparing the resistance of traditional columns and columns inspired by elephant bones) and "Climate risks of territorial and social divides: in search of resilient support" are a few examples.

A workshop, held in June 2022, brought out synergies between the CNRS communities dedicated to the human and social sciences and the players in the different strategic areas of action of the CSTB.

It also helped lay the foundations for a partnership on subjects of common interest:

1. improving the understanding of individual behaviours and practices to promote innovations in the act of building and renovating;
2. broaching digital innovations;
3. understanding the processes for collective action to set the ecological transition in motion;;
4. finding a sustainable business model to promote efficient and inclusive built environments.

In addition to the initiatives already underway, which will be expanded upon in the coming years, new research prospects are being consolidated within the framework of existing partnerships with joint research units, supported by the CNRS, in the following areas:

- circular economy: UMR 5 600 Environment, city, society;;
- adaptation to climate change: Lyon Energy and Thermal Centre (CETHIL), Laboratory of Environmental Engineering Sciences (SIE)
- fire risk: Energies & Theoretical and Applied Mechanics Laboratory (Lemta), Navier Laboratory;
- sanitary quality of water or air: LaSIE, Analysis, Modelling and Materials Laboratory for Biology and the Environment (LAMBE) UMR 8587,
- performance measurements: Building Energy Processes Laboratory (Locie);
- green innovation (Economix).

THE **CERTES**

The Centre for Studies and Research on Thermal Environments and Systems (CERTES) of the University of Paris-Est Créteil Val-de-Marne (UPEC) specialises in the physics of transfers and the modelling of energy and environmental systems.

The cooperation between CERTES and CSTB, which began in 2003 with the study of the transport and survival of bioaerosols in buildings, is continuing on the topic of air contaminants, incorporating their measurement and characterisation, as well as the modelling of their impact on indoor air quality.

Viral exposure at the heart of the project

AIn view of the ongoing pandemic situation, the study of the environmental determinants of viral exposure is of particular interest. The general objectives of this cooperation were to improve understanding of the exposure of occupants to respiratory viruses and to suggest the first foundations for management solutions compatible with the use of enclosed spaces.

Similarly, in association with Université Laval (Québec), the CSTB has adopted a multi-scale approach, studying the behaviour of viruses in the laboratory, then in a controlled environment, and lastly in situ. Through this project, a methodology for measuring exposure to respiratory viruses was proposed and validated for classroom environments during the seasonal flu outbreaks of 2015 and 2016.

As regards the development of solutions to reduce exposure to respiratory viruses, the impact of hygrometry, temperature and various chemical substances was studied in the laboratory. Among the decontamination solutions implemented in a realistic environment, the relevance of controlling ambient hygrometry was confirmed.

Key figures from our cooperation projects

These successful partnerships have resulted in the co-supervision of nine doctorates and five post-doctorates, promotion of research through 12 publications, a patent, and proceedings from 41 international or national congresses. The CERTES Laboratory and the CSTB were awarded five calls for research projects.

These collaborations have also given rise to the development of numerous original experimental benches for the study of bioaerosols, the development of a calculation code on the emission and dispersion of particles emitted during respiratory phases HEEDIE (Human Exhaled Emission and Dispersion in Indoor Environment), and the design of a low-cost microsensor for the detection and measurement of particle concentration in collaboration with the École Supérieure d'Ingénieurs en Électrotechnique et Électronique (ESIEE). .

Pandemic and built environments

On the strength of its expertise in the field of 'bioaerosols and indoor environments', and in response to the indoor air quality issues highlighted during the health crisis, the CSTB launched a 'Pandemic and built environments' research programme in 2021, involving academic partners with strong scientific and multidisciplinary expertise.

To date, the consortium includes the ANSES Laboratory in Ploufragan-Plouzané-Niort, the Research and Study Centre for Thermal Environment and Systems at the University of Paris-Est Créteil (CERTES-UPEC), the Institut Pasteur in Paris (IPP) and the Quebec University Institute of Cardiology and Pneumology at Laval University (IUCPQ-UL). This scientific group, made up of players in human and animal health, brings together the disciplines of aerosol physics, aerobiology, virology, animal experimentation, epidemiology and the study of pathogens in the environment. The complementarity between the partners enables phenomenological study of virus survival and airborne transmission in built-up environments at different scales..

OQAI

Because of our everyday activities, we spend more than 80% of our time in buildings and the built environment. In addition to the health impacts already identified, such as those resulting from exposure to volatile organic compounds, particles, radon, moulds and electromagnetic radiation found in indoor air, pandemics such as the one we have had to contend with raise questions about the essential role of these spaces. Synonymous with shelter and protection against outside attacks, what role do buildings play in the exposure and transmission of airborne pathogens (viruses, bacteria, mould, etc.) found in the indoor air? What are the means for protecting from this? In this context, the CSTB is lending its support to the public authorities and construction professionals to anticipate risk situations and guarantee quality of life in indoor environments.

Prevention and monitoring

Commissioned by the public authorities in 2001, the French Observatory on Indoor Air Quality (OQAI) is a national body set up to gain a better understanding of situations of pollution and discomfort and their origins on a national scale. This work is essential in laying the foundations for public policies and providing appropriate solutions for the prevention and monitoring of indoor environments, as well as for professionals, opinion leaders and the general public. Since its foundation, the CSTB has been the Observatory's technical operator. More than a hundred researchers, professionals and PhD students from various disciplines, belonging to some fifty French and foreign organisations, have been and are associated with the work through partnerships or working groups aimed at planning out the studies and implementing them, then mining and promoting the data. In addition, local technical teams have mobilised for the deployment of national campaigns and specific studies. They are spread across the various survey sites and trained in data collection by the CSTB, which coordinates the campaigns. Laboratories, both in France and abroad, have also been called upon to analyse the air and dust samples collected.

Research actions

The national campaigns already conducted by the OQAI have made it possible to gain knowledge on the population's exposure to indoor air pollution, as well as on the level of comfort of the different living areas. Supplementing this are specific studies, which have advanced the thinking on priority topics: ventilation practices and microbial diversity in nurseries and schools, emissions of maintenance products and school supplies, etc. This work provides data needed for the effective prevention and improvement of indoor environment quality, and enables the development of decision-support tools: predictive models of indoor pollution, indoor air quality indices, measuring systems for indoor air containment, ventilation management, controlling equipment and/or opening windows according to occupancy levels - widely deployed since the Covid-19 pandemic - etc.

The Observatory also raises awareness among professionals and informs the general public to develop practices in favour of better quality of living (public workshops, training, publications).

Outlook

From 2024, the OQAI will develop into a Quality Observatory for Indoor Environments (OQEI). Jointly steered by the Anses and the CSTB, this new body will continue to run an interdisciplinary network of scientific partners: medicine and public health (epidemiology, toxicology, pharmacy), environment (physical chemistry, microbiology, aeraulics), building (ventilation, materials, energy), mathematics (statistics) and human sciences (sociology, environmental psychology).

This multi-scale and multi-physical development of environmental health issues, which is partly underway through the OQAI, is aimed at building a resolutely holistic approach to indoor environments based on all the specific exposure factors. The OQEI will therefore work on concerns around other determinants of the quality of indoor environments, such as thermal comfort, the impact of extreme heat on health and the perception of occupants. Living places are also subject to other exposures – noise, artificial light, electromagnetic fields (EMF), etc. – already studied in some campaigns, but the data of which are still little used. As such, the future OQEI will contribute to the study of the indoor exposome of populations as enshrined in public health policy commitments.

ACTION **LOGEMENT**

Action Logement Groupe, a flagship player in the social and intermediary housing sector, and the CSTB committed to a research partnership in 2022 to improve the environmental performance of the largest social housing stock in France.

With a portfolio of more than one million homes, Action Logement has made ambitious commitments to develop a strategic asset management framework (Cadre Stratégique Patrimonial - CSP). This framework makes it possible to model development, investment and arbitrage scenarios, with a view to improving the strategic management of the Group's property assets as part of its contribution to mitigating and adapting to climate change.

The aim of this research collaboration is to make the Group's strategic asset plans dynamic so that the real estate holdings can be better tracked over time. The existing or reconstructed data are centralised and enhanced to provide the Group with a 360° vision of its assets. By analysing and cross-referencing data at building, portfolio and regional levels, it becomes possible to design and implement optimal solutions, then measure the progress achieved in terms of mitigating and adapting to climate change, quality of use and energy efficiency in housing.

The future CSP focuses on unprecedented use cases that will eventually enable Action Logement to project and monitor the carbon trajectory of its housing stock in "real time", in particular via the energy performance and water consumption of residents, with a view to identifying and correcting any possible excesses.

Use case 1:
Managing water resources
The latest report from the Intergovernmental Panel on Climate Change (IPCC) emphasises the magnitude of the pressure currently placed on water resources, even in the most favourable temperature rise scenario.
The aim of the research partnership is to track and analyse household water consumption. It uses a study of existing housing to establish profiles of typical dwellings and their water consumption 'signature', which is then consolidated by monitoring a representative sample of dwellings. The aim will be to build a database architecture, specific to Action Logement, to capitalise on this contextualised consumption data and to cross-check this private database with other public databases in order to set up the most appropriate technical, organisational and usage management solutions.

Ultimately, the aim is to integrate these water consumption data into the National Building Database (BDNB)[1].

Use case 2:
Decarbonising the housing stock
Action Logement has begun drawing up its roadmap for reducing greenhouse gas emissions, in line with the National Low-Carbon Strategy (SNBC), working on the entire value chain of the building life cycle: design, construction, renovation, deconstruction, operation and use.

Similar to what is proposed for water resources, this part of the research effort is aimed at developing tools for steering the decarbonisation strategy, based on the collection, structuring, cross-referencing and analysis of heterogeneous, multi-scale data. The aim is firstly to convert the data into carbon accounting, aggregate it at the level of the housing stock, quantify the levers available to the Action Logement Group, then define possible trajectories, and finally, manage and monitor decarbonisation.

1 The BDNB is a mapping of the existing building stock, built by geospatial cross-referencing of some twenty databases from public bodies. Structured at the "building" level, it contains an identity card for each of the 30 million buildings, residential or tertiary. It is intended to be shared and to form an open repository, the basis for the development of a wide range of services provided by public and private players, as well as a place for capitalising on knowledge about existing buildings.

CLIMATE ECONOMICS CHAIR

The CEC (Climate Economics Chair1) was launched in October 2010, founded under the aegis of the Fondation Institut Europlace de Finance and the Université Paris Dauphine-PSL, the academic and outreach work of which focuses on the economics of climate change.

This chair is a research platform recognised academically and open on the world of economic and political decision-making. Its research programme, validated by an internationally renowned scientific council, focuses on the economic analysis of all public policies aimed at making the carbon transition a reality in each sector of the economy. It also endeavours to train young researchers by welcoming trainees, doctoral students and post-doctoral fellows from a wide range of backgrounds, and is an important forum for discussion between researchers and professionals.

Promoting energy renovation
Within this context, the CSTB and the CEC have been working together since 2015 on public policy assessment issues with a view to massively increasing energy renovation work within the French building stock. Officialised through a partnership, this cooperation programme enables, each year, a joint thesis or post-doctoral contract, financed by the CSTB and carried out within the two research centres.

Furthermore, it enables the CSTB to benefit from:
- academic supervision capacity for research projects relating to the environmental transition of buildings, thus helping to strengthen the CSTB's scientific positioning;
- the expertise of CEC professors and researchers, who provide scientific support on the most advanced economic and econometric analysis methods, which are then used by CSTB teams as part of its activities.

In turn, the partnership enables the CEC to increase its capacity to propose theses on environmental economics applied to the building sector, to benefit from the CSTB's expertise on energy and environmental transition problematics for buildings, and to gear its work to the concrete questions posed by players in the sector, in particular professionals and public authorities.

To date, this partnership has resulted in the completion of five theses on the evaluation of public policies for mass renovation and on the role and process of spreading innovations within the sector.

Ambition and outlook
Much research remains to be carried out on how to achieve the energy and environmental transition in the building sector. The following subjects will be the focus of particular investigation:
- assessing the impact of incentivising public policies;
- the structuring of the sector and the reduction of faulty workmanship;
- Ithe innovation process, ownership thereof and deployment throughout the industry;
- prospective modelling of decarbonisation trajectories.

In addition, this partnership aims to facilitate the training and skills development of young economists in the field of environmental economics associated with buildings, notably through internships and doctorates that could facilitate the arrival of new employees within the CSTB.

It carries a strategic dimension for the CSTB. It enables its teams to benefit from the support, interaction and academic and scientific collaboration in the field of climate change economics that are essential to its work. It also enables them to be better integrated into the related scientific and professional networks and facilitates the recruitment of young researchers in environmental economics.

1 www.chaireeconomieduclimat.org

EFFICACITY

Since 2014, a group of around ten CSTB researchers have been partly seconded to the Efficacity Institute for Energy Transition to contribute to the construction of common tools, with the aim of spreading reference tools across the operational world.

Efficacity, dedicated to the energy and ecological transition of cities, was created in 2014. Involved from the outset in its creation, the CSTB is a founding member. It sits on the Board of Directors and on various steering committees associated with the R&D programmes.

Efficacity brings together research centres, large corporations and design offices. Efficacity conducts action research in close collaboration with the beneficiaries, users and producers of the tools, the aim of which is to objectivise design choices for development operations.

Neighbourhood energy simulation

The CSTB and Efficacity have made two tools available to the players. The first, PowerDIS, draws on the CSTB's Dimosim urban energy simulation calculation engine. Dimosim is a software tool offering forward-looking depiction of an energy system's organisation (production, networks, consumption) in line with the resources and constraints of an area. It is the result of ten years of R&D on a dedicated project entitled "low-carbon neighbourhoods", within the CSTB's research programmes. Together, Efficacity, its partners and the CSTB designed interfaces and enhancers enabling PowerDIS to produce dynamic energy simulations of neighbourhoods, calculate the needs of buildings and the consumption of the various means of production, including heating grids. PowerDIS offers users the ability to compare different production variants. A joint thesis - "Methodological developments for the validation of urban energy simulation tools" - will have made it possible to build a generic approach ensuring the validity of the results.

Assessment of environmental impacts

The second tool, UrbanPrint, is a software tool for assessing environmental impacts at the neighbourhood level, based on life cycle analysis of a new build, refurbishment or mixed urban development project. It makes it possible to gather information on buildings, as well as on external spaces, grids, waste management, mobility, etc.

Over a period of six years, the CSTB and Efficacity have built a shared and open methodology, through an associated research project via a joint thesis1, an ADEME project expanding the field of stakeholders, an Efficacity project with its partners, a calculation core, an interface designed with user involvement, and an experiment on some sixty operations, before ultimately making the software widely available under licence or providing calculations directly to developers.

For each of these projects, the CSTB co-constructs the methodologies, makes available researchers or co-develops computing cores and databases, participates in deployments, training and capitalisation on feedback, performs calculations in service or support mode and co-distributes software. The issue at stake in making these assessment and design tools available is shared by Efficacity and the "Buildings and cities in the face of climate change" roadmap.

1. Contributing to the development of an environmental assessment methodology at urban scales

AN **INTER-DEVELOPER** APPROACH

For nearly ten years, the CSTB has been assisting a number of developers in mainland France and the French overseas territories with their digital transition, both in the design phase and in monitoring operations.

More recently, some of these partners have pooled their efforts and embarked on a collective approach to understand the issues at stake in the implementation of public policies relating to the environmental and digital transitions. Together, they have identified concrete and realistic solutions to speed up the implementation of these policies in development projects.
One of the aims of this partnership is to pool practices and the results of previous research so that they can be shared as widely as possible. Another aim is to identify the key scientific and technical innovations offered by digital technology for the planning profession, which will enable the various commitments to be met, particularly those relating to environmental performance.

Securing "good community living together"

In this spirit, in June 2022, Euroméditerranée, Euratlantique, EPAMarne - EPAFrance, Grand Paris Aménagement, Paris La Défense, EPA Paris-Saclay, Espaces Ferroviaires and the CSTB set up a collective that helps define and achieve objectives relating to energy restraint, carbon impact, the circular economy and the resilience of urban developments, all the while aiming to secure "good community living". Beyond the creation of working groups and the organisation of practice sharing, the approach is distinctive in that it targets innovations. As a result, developments in the planning profession can be anticipated from a multi-issue (technical, economic, societal, etc.), multi-criteria perspective. It uses a technical and scientific approach to subjects of interest to public developers and, more broadly, to the industry as a whole. It encourages partners to set out shared research and development (R&D) initiatives for the development, testing and pre-operational or operational deployment of specific methods and tools.

A desire to harmonise and improve practices

This collective works via workshops and seminars, dedicated to sharing and analysing reports from the ground, and comparing them with the state of the art, informed by scientific and technical monitoring data, to ultimately bring out common subjects for R&D. The topics already identified for workshops and for sharing feedback include:

- Managing multi-format data (BIM, CIM, GIS, DWG, etc.) to achieve objectives in terms of biodiversity, land conservation, housing quality and reducing the carbon impact of development projects;
- The implementation of a common dictionary covering the data at every level of involvement for monitoring, steering and reporting purposes, and facilitating interoperability with the various tools;
- Change management as a key issue for the ownership by all stakeholders and the successful deployment of data management approaches such as CIM (City Information Management);
- Project management and visualisation tools that are relevant and tailored to land planning practices and new data management methods.

With these two major players in the planning industry coming together, a strong signal has been sent out, telling of a desire to harmonise and improve practices, with a view to disseminating and sharing them with all urban planning professionals.

LEMTA

The CTSB and LEMTA (“Energies & Theoretical and Applied Mechanics Laboratory”) have been working together since 2016 on research initiatives relating to fire safety in buildings. The partnership was born out of the two institutes’ need for complementary skills. LEMTA contributes its expertise in material fire degradation models, smoke extraction and fire propagation modelling, as well as experimental methods (particularly advanced instrumentation for testing). Using its expertise, the CSTB contributes to the development of theoretical approaches and validation tests with a view to their use in engineering, promotes scientific knowledge through the development of guides and contributes to regulatory developments.

A shared ambition
The aim of the research conducted is to round out or improve the reliability of performance-based dimensioning methods used in Fire Safety Engineering (FSE). These methods target the development of fire within a building or along a façade (taking into account ventilation conditions or the contribution of materials) as well as smoke flow. In recent years, the contribution to fire of bio-based materials, particularly wood, has been the subject of several studies to assess their impact on fire development.

Research actions
The joint actions are structured around four themes:

1. Smoke flow, with the aim of using simplified methods to calculate changes in the smoke layer in a room as a function of ventilation conditions. Following on from work initiated in the context of a thesis on analytical methods for quantifying the filling-mixing phenomena in a room with an outlet, a guide to smoke extraction in establishments open to the public has been finalised, intended for designers and engineers.

2. Development of fire in contained environments, the research aim being to quantify thermal action inside a room where gas combustion is incomplete due to lack of oxygen. This phenomenon becomes all the more prominent when there is significant presence of combustible materials (such as wood). The combustion of pyrolysis gases then takes place in an exterior environment (via an opening), thus reinforcing the thermal stress on the façade. The theoretical description of these phenomena via FDS & FireFoam simulations, as well as phenomenological tests on a medium scale, are fully in line with the scientific partnership.

3. The contribution of wood to fire is used to predict its development in the presence of visible wood surfaces. To this end, the ignition/extinction conditions and energy contribution of wood were identified experimentally on the scale of the material through a thesis, and this work is continuing today in order to be able to use this material data in engineering methods in the short term.

4. The propagation of fire along facades is being studied through the ANR FIREWALL project (2020). The aim of the study, carried out by the Centre d’Energétique et de Thermique de Lyon (CETHIL), LEMTA and CSTB, is to understand and describe by simulation the aeraulic, thermal and chemical phenomena taking place on façades subjected to fire (secondary pyrolysis). To this end, full-scale tests are being carried out at CSTB. The LEMTA rounds off the analysis with modelling and numerical simulations, which are used, in particular, to validate the move to smaller experimental scales, carried out at CETHIL.

Conclusions and outlook
Through the work carried out on smoke extraction and the contribution of wood to fire, the CSTB’s capacity for expertise on these complex subjects has been strengthened. The fire doctrine issued by the BSPP (Brigade des sapeurs-pompiers de Paris) in 2021 has, by limiting the use of wood, brought back the need to characterise this risk in order to support the industry with regard to fire. Future topics include the safety of emergency personnel (after the occupants of a building have been evacuated). This theme will require overcoming new scientific hurdles, such as understanding incandescence phenomena to assess the residual strength of a structure in the hours following a fire.

HILTI

Since 2018, Hilti and the CSTB have been collaborating on research activities in order to bring forward the rules for evaluating and sizing fastening products in buildings.

A world leader in fastening systems and anchors for the construction sector, Hilti is a major player in innovation, more particularly in recent years, in the field of structural bondings.

Validating the durability of the performance of these innovative solutions, in terms of the safety of assemblies under various stresses, particularly thermomechanical stresses, and in different conditions of use, is essential for access to the construction market. Specific assessment procedures are then used to ensure that these new products are insurable.

Behaviour of fastening products in the event of fire
The aim of this research partnership is to provide the scientific basis on which these assessment procedures and the resulting sizing methods are based.

Established in 2018, a framework agreement between Hilti and the CSTB formalises establishes the partnership relations to provide the scientific elements for building regulations on the subject of fire, available to international players.

Four joint theses were initiated between 2018 and 2021, on:

- the fire resistance of chemical anchors;
- the post-fire behaviour of reinforcement seals; ;
- concrete failure under thermal gradient by cone pull-out;
- concrete rupture under thermal gradient by splitting.

These studies, based on the various physical phenomena, have resulted for instance in the development of innovative approaches for predicting modes of failure, once the causes have been identified, due to the thermomechanical behaviour of the elements in the fixing system (steel rod, concrete, structural adhesive). This has made it possible to propose rational methods for drafting dimensioning guides.

This code development activity, downstream from research, is also integrated into the partnership and is carried out in Europe and the United States in bodies such as: the EOTA (European Organisation for Technical Assessment), the FIB (International Concrete Federation), the CAMA (Concrete Anchor Manufacturers Association) and the ACI (American Concrete Institute). Over the past two years, several regulatory documents (acceptance criteria, European assessment documents, technical dimensioning reports, US dimensioning code segments) have been approved or are in the process of being validated.

Solid complementarity
The research draws on the expertise of the CSTB and the University of Orléans - which supervises the theses - as well as on tests, mainly carried out by the CSTB. Hilti provides additional input to the work, through its knowledge of products and historical scientific data, particularly those relating to the methods used to draft regulations over the last thirty years. The code writing activity is also supported by knowledge of international regulatory environments, supplemented by Hilti, particularly in the United States, as well as best practices in document development.

Outlook
The partnership with Hilti is structurally-defining through the quality of the scientific and technical stakeholders, the regulatory knowledge, and that of the coding stakeholders, as well as by the regulatory development objectives that determine the research ambitions (over cycles of around three years). Thanks to this collaboration, the CSTB has stepped up its external positioning, particularly in the United States, over the last two years. A large-scale project is underway to adapt and transpose several European methods into the American regulatory context, covering all modes of chemical anchor failure in fire.

THE CSTB'S DOCTORAL POLICY

Training in research is a factor of resourcefulness and visibility for the CSTB. It is for this reason that it is currently developing an active policy in favour of doctoral research. It hosts a steady stream of 50 to 60 doctoral students, who are working on a thesis related to one of the four strategic areas of research.

THE DOCTORAL POLICY

To complement its public service mission of facilitating research in the building sector, the CSTB has been conducting an ambitious doctoral programme for several years.

The main objectives of this doctoral programme are to ensure a privileged relationship with the academic world, from which it draws its scientific resources, to contribute to anchoring academic work in the building sector and to train future researchers and experts destined to work with public and private players in the sector.

An active doctoral policy

Training in research is a factor of resourcefulness and visibility for the CSTB. It is for this reason that it is currently developing an active policy in favour of doctoral research. It hosts a steady stream of 50 to 60 doctoral students, who are working on a thesis related to one of the four strategic areas of research. These young researchers play a fundamental part in the CSTB's upstream scientific resources and in updating the scientific knowledge mobilised by its applied research. They also contribute to more than 20% of scientific publications, resulting from the institution's research work. The PhD students are also strongly involved in the research projects which the CSTB conducts, alone or in partnership with industry players, and are thus drivers in its ability to innovate.

Multi-year framework agreements

To help maintain a recruitment «pool» for future doctoral students and strengthen its ties with certain academic laboratories, the CSTB enters multi-year framework agreements, based on research subjects, co-defined with the laboratory and in connection with its scientific priorities. These agreements include a commitment by the laboratory to launch several co-supervised theses over the period covered, with the latter receiving a mandate, in the event of a patent being filed as a result of the thesis work, to manage co-ownership and exploitation in the best interests of both parties.

Each thesis is the focus of collaboration with two partners: the academic laboratory with which the CSTB co-supervises the doctoral student and the organisation (university or school) in which the student is enrolled. Accordingly, a number of agreements signed with academic laboratories are concluded within the framework of an arrangement with the university. Other partners (public research organisations or the private players mentioned above) are also associated with certain theses.

The CSTB also cultivates privileged relationships, formalised by these framework agreements, with more than twenty academic laboratories, the main ones being affiliated with Université Gustave-Eiffel, Université de La Rochelle, Université des Mines de Nantes, Université de Lyon and Université Paris-Dauphine - PSL.

These relationships not only give the company a high profile in the academic community, but also lend credibility to and spread the results of its scientific research.

The employment rate of young PhDs in engineering sciences at the CSTB, one year after the defence of their thesis, is 100%. These figures, which have been rising in recent years, are higher than the national rate (86% for all disciplines combined, 91% in engineering sciences).

This policy of hiring young doctoral students at the CSTB has always been essential, since it constitutes a preferred means of upstream scientific resourcing. In addition, it is an effective lever for developing scientific partnerships between academia and industry.

WHAT DOCTORAL STUDENTS HAVE TO SAY

MIORA ROBSON, age 28

University of Orléans

Thesis: Resistance of concrete chemical anchors under thermomechanical stress (3rd year)

The CSTB's multidisciplinary environment and state-of-the-art equipment are a real asset.

GABRIEL ROSSIGNOL, age 25

Institut Mines-Télécom de Lille

Thesis: Impact of the presence of formaldehyde releasers in the formulation of household products on air quality in indoor environments (2nd year)

My thesis is co-funded by the CSTB and ADEME. I'm more used to laboratory work and, as a result, my integration into CSTB's Santé Confort Department has been very rewarding in terms of pure research, and particularly in the transmission and sharing of results.

MARTIN RIT, age 27

École des Mines de Saint-Étienne

Thesis: Assessing the energy renovation potential of a territory in the framework of massification processes (1st year)

In the area of construction and renovation, the CSTB remains one of the benchmarks in France. As to supervision, one of the benefits I gain from it is the opportunity to be enriched by other projects related to my thesis topic.

NADA BENDAHMANE, age 26

École des Mines de Saint-Étienne

Thesis: Development of indicators of pressure on mineral and metal resources for a performance-based approach to the circular economy (3rd year)

I served an internship at CSTB Grenoble to produce default environmental data for construction products and building equipment to pave the way for the RE2020. Although I was far removed from the field of research, the talks I had with the other doctoral students and the support I received from the CSTB Environment team during my internship made me want to continue in this direction. Working on a thesis at CSTB means being able to quickly come into contact with the field and be constantly in touch with the concrete needs of the players involved.

MERVEIL MUANDA LUTETE, age 29

Nantes University

Thesis: Assessing measures to adapt the urban environment to the constraints of global warming (2nd year)

Initiated on a proposal by the CSTB, my thesis has attracted the interest of the company Ingérop. As part of this thesis backed by CIFRE, a mechanism that provides a framework for collaboration between public companies and research laboratories, my work aims to advance research directly related to the company's problematics on climate change adaptation in urban development projects.

CONCLUSION AND OUTLOOK

What more could be said, after this fairly exhaustive review of the issues concerning the building in its urban environment, albeit addressing only a limited number of the research subjects associated with it, in an equation involving somewhat restricted resources?

First of all, it is based on a variety of findings and studies from extended collegial bodies, often thematic or disciplinary, too much so, perhaps, shared at national and international level, of which the CSTB has been, and still is, a long-standing stakeholder.

Secondly, it nevertheless takes into account, through its perception and systemic approach, the specificities of construction in France, not to mention its complexities. This is particularly true when it comes to the issues associated with the renovation of the housing fleet, which will be one of the major projects of this century, and certainly that of Europe. More importantly, it incorporates this unique way of life willingly referred to as the "French art of living", both individualistic and collective -- with the aspirations, requirements, and constraints that come along with this.

If the building is a reflection of this, it is at the level of the neighbourhood, the city and land development that this art of living is expressed, with varying degrees of success, not to mention happiness. Thus, the whole of this refoundation of research within the CSTB tends towards the realisation of the stated ambition: buildings and neighbourhoods for good community living.

However, you will note that some major shifts, such as that related to [future] mobility, for example, data, and behaviours in the broad sense, are not precisely identified. This despite the fact that they are in terms of everyday uses "connected" to buildings and their environments, impacting them greatly, very often on safety and security issues, and on the benefits-risks trade-offs. These topics are obviously broached with the specialists in these respective fields.

This last fact highlights the approach that prevails in the CSTB's research approach, based on a systemic vision of the different problematics of buildings in their environment, both multi-scale and multi-disciplinary: that of partnerships.

"Partnership" is, first of all, the key word for ensuring, at least on the priority and major issues, that the community of players, whether scientists, professionals, users or citizens, interact, debate and, ultimately, contribute to the advancement of research in the different areas identified.

This new organisational conception of research is aimed at increasing this collective approach even further, without however being dictated by trends not very compatible with the sector's time-scale for action. The sociology of organisations will help us towards achieving this shared objective: to support the players in their respective approach to solutions for construction, in line with the different multi-scale themes and components, all the while holding on to the innovative character that is specific to them. Ultimately, it is the driver of the activity and of economic growth.

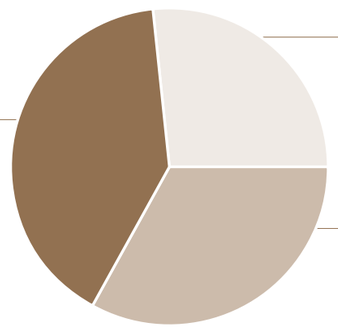
Last but not least, above and beyond the scientific subjects and socio-eco-technical support for operational projects at the level of their life cycle, i.e. by integrating their evolutionary nature, the CSTB has embarked on a process of knowledge capitalisation. This will enable, with the support of digital tools, an increase in collective skills, needed to make the stated ambitions reality.

In conclusion, construction needs to radically change in order to enter the twenty-first century. Join us!

KEY FIGURES

TOTAL RESEARCH AND EXPERTISE

43,92 M€



€16.82 M
Contractual research and expertise with public players

€12.53 M
Contractual research and expertise with private clients

€14.57 Million
Production capitalised on endowment

€3.20 M
sous-traitances externes incorporées aux produits

€1 M
dotation allouée à l'investissement matériel recherche

€6.14 M
contrats avec partenaires

€1.36 M
contrats européens

RESOURCES AND TOOLS

58
doctoral students

217
researchers

100
co-financed projects

1 200
test benches

RESULTS

4
strategic action areas includin
18 projets

+80
referenced publications

4
priority patents filed

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