ENBRI European Network of Building Research Institutes

Member of ECTP INNOVATIVE BUILT ENVIRONMENT

Building for Society

Future Research and Innovation needs

The European Network of Building Research Institutes (ENBRI) and its members in 20 European countries aims to support the development of a sustainable built environment through multi-disciplinary research and innovation actions and collaborations with various stake-holders (municipalities, infrastructure etc.) of the construction industry.

This document outlines a strategic vision for the Research, Development and Innovation needs in **six strategic priority areas** to support the ENBRI institutes developments over the next 10 years.

1. BACKGROUND

The European Network of Building Research Institutes (ENBRI) was founded in 1988 bringing together dedicated Principal Construction Research Institutes in Europe. It was an important period in the development of the European Union; the Single European Market was being implemented and the Construction Products Directive (CPD) was being drawn up. According to the Memorandum of Understanding drafted in 1988, the network was set up to "enable its member institutes to contribute more effectively to the implementation of the European "single market objectives" [1]. This achieved through:

- *advising* the European Commission on strategic decisions in terms of legislation, research, innovation, standardisation and subsidies related to technical, functional and environmental aspects of buildings and their constituent materials, components and systems,
- *advising* the construction industry including suppliers and the industry's representative bodies.
- *advising* owners, operators and users of buildings and infrastructure.
- *undertaking research and technical studies to support such advices*.

Currently, the network, which was established by 7 institutes has grown to 20 members, each being the sole representative of its country in ENBRI. Today ENBRI groups resources of over 8000 people in various disciplines most of them researchers, skilled engineers and laboratory technicians.

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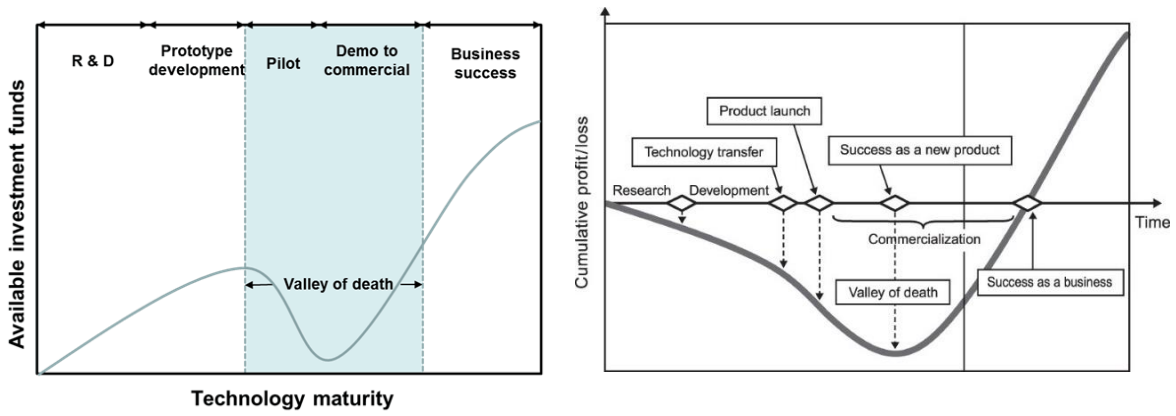
Today, ENBRI and its member institutes continue to be true to the original mission. However, the activities have been increased as have the ways they are conducted. With the European Single Market, many common mechanisms and procedures have been adopted by the Member States. The influence of European strategies, agendas and directives is overwhelming in topics such as energy-efficiency, chemical safety, waste usage. ENBRI and its member institutes regularly input information to the European Commission on research and innovation needs. ENBRI has been performing leading edge work which has supported the European Council for Construction Research, Development and Innovation (ECCREDI www.eccredi.org) and the European Construction, built environment and energy efficient building Technology Platform (ECTP www.ectp.org), both organisations to which ENBRI was a founding member. This has effectively broadened the agenda, moving from products and materials to buildings and District (level).

Overall, the actions from ENBRI members can be summarized as follows:

- Managing a wide range of research and innovation capabilities and unique research facilities relevant to the construction industry and its stakeholders;
- Performing projects at different levels of Technology Readiness (TRL's), by offering services across the whole of the technology levels, concept development, performance and process simulation, laboratory and in-situ testing, the setting up of demonstration projects, up-scaling technologies and monitoring.
- Assisting the development of strategic programmes, regulations, standards and codes of practice and quality and performance assessment schemes at regional, national, European and global levels.
- Communicating research findings with real scale demonstration projects and providing information and training sessions, publications, seminars and mechanisms for Technology Transfer
- Certification and quality assessment approaches.

Considering the above, ENBRI members occupy a distinctive position in the promotion of innovation in building and construction as intermediaries and brokers between academia, researchers, industry, public authorities and the civil society. Each ENBRI member is closely linked with national stakeholders in the construction sector and has its own distinctive profile of multi-disciplinary research competencies. Over the past decade, many ENBRI members have developed close collaboration with universities and other 3rd level institutes and by doing so, ensure an applied focus by researchers in these institutes for working with companies. .

The members initiate collaborative research and contribute to innovation activities of public bodies/actors and private companies, from long-term road mapping to market access and standardization. ENBRI members are thus very well placed to bring companies through the traditionally called "valley of death", in moving products and services up the technology readiness level scale.



Technology development to maturity

Overall, the ENBRI provides far reaching competencies relevant to the development of a sustainable built environment and guarantees a steady up-dating of international knowledge and experience for the construction industry and its stake-holders. ENBRI, targets the broad construction Industry and the needs of society by delivering, maintaining and improving the built environment. This supports the development of construction materials, manufacturing of construction products and components, building construction activities and processes on site, operation and maintenance, facilities management, architecture and engineering designer services, owners and developers and other related companies. ENBRI works with and additionally recognises the importance of regulatory bodies influencing performance characteristics and the state bodies supporting the financing and building of housing, infrastructure etc.

"ENBRI's vision is to contribute to the development of a sustainable built environment and competitive construction industry through technology and innovation for the benefit of society"

2. CHALLENGES

The construction industry is often defined as embracing all the activities that contribute to the creation, operation and maintenance of the built environment. It includes the whole life cycle of buildings and infrastructure works, including not only manufacturing of products, design and execution but also their operation, maintenance, repair, refurbishment and ultimate demolition and recycling.

The construction industry is a significant economic sector. It accounts for well over 10% of Europe's GDP. It employs about 15% of all persons employed in European industry and business, accounting for some 20 million people [3] under the NACE trade classifications which take into account on-site construction, professional services and manufacturing sub-sectors that can clearly be identified to be related to on-site construction. The indirect impacts of the construction sector however, extend much further, with some of the principal challenges to be addressed by construction set out below.

The quality and usability of the built environment influences the wellbeing and performance of individuals, organisations and society in general. A commonly quoted figure is that the cost of activities taking place within a commercial development over its lifetime may be up to 200 times that of the initial cost of construction and so a small improvement in productivity achieved through better design can be repaid many times. Additionally, it is well known that the design of urban areas can promote wellbeing while discouraging crime and anti-social behaviour. Overall, through these indirect effects, the built environment exerts a leverage on economic and social development which far exceeds its direct economic contribution. The construction sector impacts significantly on the competitiveness of the European economy and social welfare and job creation at large.

Additionally, the construction industry is central to achieving sustainable development. The sector accounts for some 40% of energy and resource consumption (raw materials and water) and 50% of solid, liquid and gaseous emissions. Thus, environmental issues faced by the sector include the need to: reduce greenhouse gas emissions through enhancing energy efficiency, restoring sites affected by industrial pollution, conserving natural resources such as raw materials, development of greenfield sites and water supplies, and creating urban areas and infrastructure in strict balance with local and global eco-systems. In particular, construction has a crucial role to play in reducing overall use of energy and creating the means to harness natural energy sources, facilitating reduction in fossil fuel consumption and their associated emissions. Because of developments over the past decade it is now common to speak of not only Nearly Zero Energy Buildings but also Nearly Zero Energy Neighbourhoods [5].

Expectations continue to change, as our knowledge of climate change increases we shift from mitigating to adaptive actions. We become equally aware of the effects of flooding, earthquakes, storms, fire and even issues around security in the wake of terror attacks.

The effective creation, management and improvement of the built environment requires the synthesis of a wide range of social, environmental and economic issues, reflecting both immediate and long-term problems and opportunities. Addressing these issues is central to achieving economic development and sustainable growth as well as enhancing the quality of life for all Europe's citizens.

The need to plan, and create the built environment for 21st century society is a multi-faceted challenge. Around one third of the European population will be aged over 60 years by 2020. Significant time is spent by people indoors. Therefore, buildings should provide an indoor environment where people can comfortably live, be protected and carry out business and leisure activities. This highlights the urgency to improve the built environment for all citizens through implementing a 'design-for-all' approach.
Today, 80% of Europe's population live in cities and the migration between EU Member States and from countries outside of Europe causes new challenges to inclusive urban planning allowing Europe to develop as a multicultural region.

A significant part of urbanisation is taking place on the periphery of urban areas. This phenomenon of 'urban sprawl' requires innovative solutions, with the development of mixed communities that reduce the need for daily travel and new means of renewing and revitalising the buildings and infrastructure of older city areas. For the EU to live up to Conference of Parties (COP 21) commitments to reduce substantially its greenhouse gas emissions, an enormous challenge is ahead implementing energy efficiency measures for the current building stock.

Society is becoming more mobile as a consequence of globalisation of manufacture and business, while tourism requires increased flight connectivity, better train networks and roads. This infrastructural investment together with safety and security concerns have to be married with the wish to preserve the character of Europe's historic towns and countryside. Reconciling these modern requirements will be though new technologies and design, which respect traditional values and cultural heritage.

In addition to social and economic challenges and those posed by environmental demands; the construction industry and the sector at large faces internal challenges. It currently forms the largest industrial sector in the EU, representing one quarter of the total industrial output. However, it tends to have low profit margins, is dominated by small firms and the sector faces increasing global competition.

In most of the EU Member States, more than 90% of construction employment is accounted for by small firms with fewer than 10 employees. This industrial feature alone presents barriers to the communication and assimilation of new developments and inhibits investment in the creation of new knowledge. New structures, processes and relationships are required to create business environments that promote innovation, so that the industry meets the needs of clients, users and society more effectively and makes a full contribution to the sustainable development in Europe. It is also worth noting, that the supply chain often extend beyond Europe so global competition will continue to increase and all contractors have to adapt accordingly.

3. ENBRI'S PROPOSAL

Since ENBRI's establishment in 1988, business conditions for research have changed considerably. Competition for both national and European research funds has increased significantly and the financing of "collective" research projects have reduced substantially. Focus has shifted to leading edge private projects as well as Public-Private-Partnership (PPP) projects. In the wake of these changes some ENBRI members have gone through radical changes to their status, with some being privatised and in many cases, seen significant reduction in research incomes from their national governments.

A positive sign however, is the fact that the strategic importance of the construction sector is increasingly gaining the interest of industry, society and government. Following the global financial crisis, the importance of the sector was recognized in the recovery plans, adopted by the European Commission and the Council late 2008 with the construction industry playing an important role in discussions on the Horizon 2020 research agenda.

With these major changes in business conditions and status for many ENBRI Members, there is a need to constantly revisit ENBRI's strategy to ensure ENBRI maintains its leading-edge position in European Construction Research.

Pooling their multidisciplinary teams and capabilities, ENBRI Members can provide knowledge and expertise needed to respond to the challenges associated with the development of a sustainable, attractive and knowledge-based European construction sector. They also have close links with all stakeholders involved taking account of the different perspectives involved i.e. customer requirement, societal needs and commercial interests.

The approach driving innovation is double stranded, (a) concentrating on a number of well selected horizontal targets while at the same time (b) relying on a proven approach of translating research into practise. In this way ENBRI members have been making a major contribution to research and innovation in construction, economic competitiveness and social progress across Europe.

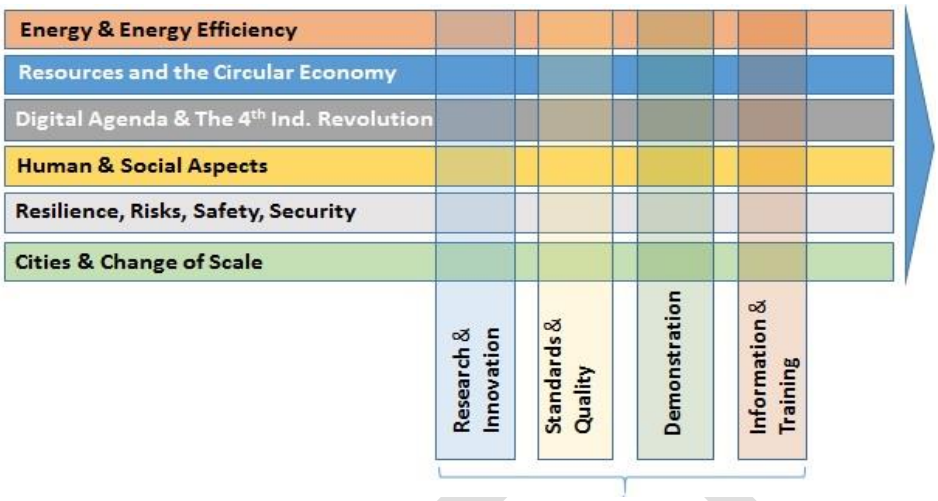
Realising competitiveness and value for customers and society requires efficient and effective knowledge sharing and transfer of new technologies into market. ENBRI went through an exercise in 2015 which identified 6 horizontal priority areas in discussion with its members and the ENBRI EC Research group. These were:

- **Energy Transition and Energy Efficiency** (energy performance, energy transition, renewables)
- **Resource Efficiency and Circular Economy** (Water, Materials, Design and Recycling)
- The **Digital Construction Agenda** and the **Industrial revolution 4.0** (Smart building processes and smart built environments with support from ICT, GIS, BIM etc.)
- **Human and Social Aspects**
- **Resilience** of our **Built Environment** (Risks, Safety, Security, together with adaption for Climate Change
- **Cities and urban areas**. Sustainable attractive cities of the future encompassing a clear move from technical studies on single structures to emphasis on integrated considerations on buildings and districts.

ENBRI focuses on four main cross cutting areas through all technology developments:

- **Research & Innovation**. Professional inter disciplinary staff and advanced large scale testing facilities constitute major key strengths.

- **Standards & Quality**. Translating research results into standards and quality and performance assessment procedures continues in this much regulated sector
- **Demonstration and Living Labs**. Recognising that results in the laboratory need on site experimentations and demonstration to build confidence.
- **Information & Training**. Training and Information workshops to reach out to SME's in the sector.



Priority areas of ENBRI Strategy 2016+

Special attention has to be given to pilot demonstrations, standards, quality and performance assessment. In particular, given the significant investments linked to construction, durability testing to ensure long life is a must.

The table below shows how the different challenges relating to different objects within the built environment should be addressed at all levels; buildings, infrastructures and cities.

Challenge	**Environmental impact** and use of Resources incl. energy	**Climate change** (Mitigation and adaption)	**Social issues**, accessibility, wellbeing, safety and security, dignity resilience	**Digitalization** of the built environment and the construction industry
Materials	Depletion of non-renewables Risks of extraction to local eco-system Services; Energy consumption Emissions Waste Recycled materials	Energy consumption Cradle to Cradle rather than cradle to grave	Location of extraction sites (noise, recreational areas)	Automated extraction Automated refining processes
Products	Energy and material consumption Emissions from materials Chemical contents Transportation Recycled materials	Life cycle energy consumption Design for re-use Durability Safety	No harmful substances, Workability/buildability Occupational health	Automated process lines Customisation e-product libraries e-commerce BIM Embedded sensors
Buildings	Land use (occupancy, transport, Services) Operation of buildings Demolition Recycling	Energy consumption Service life in taking account of increased moisture and rains Safety against increased impacts	No harmful emissions No moisture problem Thermal comfort Acoustics Accessibility (vertical circulation, indoor design, lighting) Support to independent living Privacy Security / Safety	Digitalisation in construction processes (BIM, product libraries) Integrated management of service systems (heating, cooling, lighting, detectors of presence, moisture etc., 'intelligent buildings') Integration of buildings to energy networks; internet of things incl. buildings
Infrastructure	Land use planning Demolition Recycling Maintenance	Safety against increased loadings Service life	Protection against Noise, vibration et. Access to travel	Sensors embedded
Cities	Land use (occupancy, needs of networks and logistics, eco-system services) Waste Systems Energy Systems Water Systems	Energy-efficiency of buildings, cities. Integration of renewables Resilience	Security / Safety Resilience Inclusion Functioning everyday life	Smart cities, incl. service applications like BEMS

Table 1: The Built environment and its different challenges

3.1 Energy Efficiency

Buildings constructed today are significantly more energy efficient than those built even 20 years ago thanks to new technologies and systems which can lead in practice to nearly zero energy and positive energy buildings. In some cases, careful design, technology selection and build quality can lead to buildings which produce more energy than they consume. However, addressing the refurbishment of existing buildings (including historic buildings) is particularly critical in order to achieve Europe's decarbonisation goals, particularly if we consider that by 2050 more than half of the current building stock will still be functional. This poses tough technical challenges requiring innovative approaches and solutions. Many aspects need considering: renovation or demolition, recycling and/or rebuilding…

Developing breakthrough affordable technical and business driven solutions at building and district scale is a significant challenge facing the building sector.

There are three main objectives:

- **Accelerating building stock renovation**: Through breakthrough research in systematic, cost effective, mass-customised, prefabricated, high-performing, geo-clustered and minimally invasive solutions it will be necessary to increase the current building stock renovation rate. In Europe, this currently is estimated at an annual rate of 1.2% of the overall stock. This needs to be increased to 3% by 2020 [(6)].
- **Embedding interactive and sustainable buildings** at district and city scale for energy neutrality/positivity.
- **Ensuring consistent energy performance** during the building's service life as predicted at the design phase.

This requires parallel and integrated activities in several technology areas such as:

- **Design**: where significant efficiencies in building performance can be achieved at the design stage.
- **Technology Building Blocks**, where key technologies, such as advanced materials and nanotechnology, are applied to building structures for sustainable, adaptable and affordable structures.
- **Building envelope and energy systems**, going beyond existing technologies, breakthrough solutions can be expected in heating/cooling systems combining with renewable energy sources, storage (both heat and electricity) and building or district integrated solutions in combination with smart grid technologies.
- **Construction Process** ensuring final energy performance: Every step of the construction process requires planning to ensure buildings performance.
- **Energy performance monitoring & management**, which allows users to oversee and control their own consumption, allows detection of inappropriate operating conditions and uses algorithm and trend modelling to optimise this.
- **BIM, Data, and Integration,** enabling a data ecosystem that will support the multifaceted construction process and final solution through to the end user (see 3.3 below).

Energy Efficiency:

ENBRI will support and lead with the Construction Industry in the areas of:

- *Acceleration of Building stock renovation*
- *Embedding energy neutral/positive buildings within cities*
- *Supporting standards to ensure energy use in buildings is consistent with the design*

3.2 Resource Efficiency and the Circular Economy

Humanity is currently using resources well beyond the rate that they can be replenished naturally by the earth. The Building Industry is a major contributor to this directly through the use of these resources in design, but also by association in the way the building functions (heating, ventilation, technology).

The existing linear economic approach of 'Take, Make, Consume and Dispose' has negative effects on the environment, on economic resilience, and consequently on the quality of life of European citizens. **The circular economy approach** on the other hand, is based on maintaining the value of materials and energy used in products for as long as possible and on minimising waste and consumption of resources. It promotes competitiveness, innovation and greater resilience for man and the environment, while providing major economic benefits, which contribute to growth and job creation. Due attention needs to be given to 'affordability'

and ‘business models’, ‘profit and finance’, ‘return on investment’ as well as ‘design for deconstruction’, but must do so on the back of a value being placed on the environment.

The circular economy model requires the application of systemic approaches and interventions at several levels:

- new methods to reduce the quantity of materials produced and the amount of energy used in their production.
- new thermal insulation materials and technologies requiring lower thickness, saving volume and energy
- new methods to extend the use phase of products. This includes redesign of products for easier maintenance, repair, upgrading, remanufacturing or dismantling, and recycling (a cradle to cradle approach);
- reducing the use of materials which are hazardous or difficult to recycle and supporting the development of markets for secondary raw materials.
- incentivising and supporting waste reduction and high-quality separation by consumers; incentivising separation, collection systems that minimise the costs of recycling;
- improving cross-sectoral cooperation and facilitating clustering of activities to prevent by-products from becoming wastes (waste use through industrial partnering).
- the development of new business models (e.g. renting or sharing versus buying).

The building and construction sector is ideally placed to address elements of the circular economy; already large quantities of benign materials are reused, while it is also possible to stabilise hazardous components prior to reuse. Partnering with waste owners and collectors of waste to produce good-quality construction products needs particular attention to ensure a second life cycle for these recycled materials. Regulation should support this approach requiring recycled materials and products whose performance characteristics are not compromised to be used during the building cycle, thus reducing the overall building’s environmental footprint.

In 2013, in support of this, ‘Clause 7’ was introduced in the revised version of the *Construction Products Act*, which promotes the efficient and sustainable use of resources. Additionally, the *Waste Framework Directive 2008/98/ES* introduced a new waste management hierarchy, where reuse and recycling are the priorities.

Areas where the construction sector could become a role model in the circular economy:

- *Energy and Material efficient buildings which are easy to build, use, maintain, dismantle and recycle, which capture or produce energy and water.*
- *New business models based on the renting and sharing of systems without jeopardising consumers' costs, protection, information etc.*
- *Improvement and implementation of green public procurement principles,*
- *Improving information about the sustainability of construction products based on Life Cycle Assessment (LCA) and Life Cycle Cost (LCC). This could be achieved through Environmental Product Declarations.*
- *Life cycle thinking in building design (e.g. design for de-construction)*
- *Awareness raising about flexible and adaptable buildings,*
- *Improved techniques for selective demolishing,*
- *Improvement of health and safety in the construction sector,*
- *Easy access to buildings for all people,*
- *Sustainable use of water,*
- *New modular and 3D-construction technologies,*

Resource Efficiency and the Circular Economy:

ENBRI will support and lead with the Construction Industry in the areas of:

- *Regulation for material and resource reuse*
- *Development of methodologies and processes to promote the circular economy*
- *Life Cycle Assessment (LCA) and life Cycle Cost (LCC)*
- *Development of new energy and resource reduced materials*
- *New business models for reuse, renting and sharing*

3.3 The Digital Agenda within the Construction Industry

The next stage in the digital revolution has begun. Having transformed publishing, travel, financial services and retailing, digital technology is changing the way we plan, build, maintain and use our Built environment (buildings and districts) as well as the transport networks and infrastructure. This next stage will rely on two fundamental cornerstones:

- ***BIM, Big Data, and Interoperability***, enabling a new data ecosystem to support the interoperability and exploitation of resource-related data. This will promote the development of new methods to improve the accessibility, interoperability and integration of information which are required across the design, implementation and operation of buildings and districts.
- ***New Technologies and Sensors***, robots and data management that become part of, or are embedded in our tools, equipment and assets enabling performance to be constantly monitored and adjusted, driving efficiency gains in facilities and asset management.

Building Information Modelling (BIM) has emerged as a means to store all relevant data generated during the life-cycle of the building and its facilities: BIM today provides all the appropriate methodologies, models and supporting tools to record and analyse building-related information. BIM uses computer systems to build 3D models of infrastructure and hold large amounts of information about its design, operation and condition. At the planning stage it enables designers, owners and users to work together to produce the best possible performance driven designs and to test them in a virtual state before they are built. At the construction stage, it enables engineers, contractors and suppliers to integrate complex components, cutting out waste and reducing the risk of errors.

This upstream view of the built environment, its design and construction stages, naturally extends to downstream operations where building and industrial facilities appear more as huge dynamic data producers and concentrators whilst operating. This creates new challenges, leading to what is referred to as Intelligent and Smart Constructions (ISCs). It can only be delivered through enhanced standardisation of models, representations, services and operations.

This evolution towards ***Building Information Modelling and Management*** (BIMM) will change the construction industry through the next decade – supporting the overall process for components and buildings life-cycle management.

- It will combine with the Internet of Things (IoT) allowing integration of dynamic data and information provided by sensors, components and buildings to the various stakeholders of the Construction process to plan new buildings and infrastructures more effectively.
- It will also provide the potential to build at lower cost, using less material and resources, relying on less labour and workers with enhanced skills
- allow the building to operate and be maintained more efficiently having a lower carbon footprint.
- It will enable citizens to make better use of the infrastructures we already have and are building, and to consider a global user-centric design for all.

The changes ahead of us will be dramatic, with global data traffic increasing almost logarithmically with more and more data moving to the ‘cloud’ in the next few years. Through robotised systems and the Internet of Things, physical objects (HVAC systems, safety systems, doors, windows etc.), whole buildings, districts and infrastructure will be able to interact with humans and each other. These digital interactions are expected to grow to 44 billion by 2020.

Already, the built environment is becoming a big data provider and this opens the road for new uses and services, completely changing the relationships between what used to be passive construction with inhabitants or occupants into living symbioses of high tech hosting facilities with consumers of new services.

This ***‘Big Data’*** phenomenon will generate huge volumes of unstructured data, with a need for cleaning, categorising, contextualising and analysing this data and information. This will require multi-dimensional decision-making frameworks and tools able to perform simulations based on information retrieved from the BIM, such as active nodes in the energy grid and evaluating the impact of such nodes in its area and the impact of the area on the building itself. This revolution will leverage on the newly interconnected built environment with various technologies such as ubiquitous information gathering, cloud computing, robotics (robots, drones etc.) and collaborative robotics (cobotics).

In construction processes; with new approaches related to manufacturing (including 3D printing and additive manufacturing), the circular economy and the integration of new active materials and nanotechnologies, technologies are expected to play various roles in the four key phases of the life-cycle of built facilities, ***Acquire, Operate, Maintain and Dispose.***

Opportunities associated with the Digital Construction agenda:

- *Use of embedded sensors, remote monitoring, telemetry, control systems and other features of the IoT to monitor the condition of infrastructure, to understand asset performance in real-time and to predict the need for maintenance interventions. This creates a feedback loop to the asset brief, enabling the opportunity to invoke performance contracts and reporting.*
- *The enabling of the Internet of Services (and Construction) as well as associated value chains, to allow cross sector collaboration enabling best use of capability in the supply chain to deliver value to customers.*
- *Development of standards & Application Programme Interfaces (APIs) for Smart Buildings and districts Data (including open data and Linked data) – along with experiments on the generalisation of Open Data integrated portals & frameworks.*
- *Integrated and intelligent smart systems and associated "big data" concepts to deliver vital public services, including healthcare and assisted living, patient monitoring, digital records and administration, Smart Energy Grids, demand management and renewable source integration, transport, traffic and congestion management, road charging, emergency response, public information, managed motorways and smart parking, indoor navigation, water and waste management.*
- *Use of 3D printing and other robotised local fabrication techniques to provide components for infrastructure projects as well as Smart factory and site automation.*
- *Development and deployment of large-scale digital mock-ups for optimal operation of all buildings and districts, as well as the optimal planning of sustainable urban systems in a holistic and integrated fashion – examples of targets are:*
    - *Designing innovative constructions/material selection frameworks for new buildings;*
    - *Refurbishment, renovation and insulation of existing buildings;*
    - *Improving performance of buildings through smart monitoring/ control;*
    - *Deployment of new technologies for the efficient supply of buildings.*

The Digital Agenda within the Construction Industry:

ENBRI will support and lead with the Construction Industry in the areas of:

- *integration and development of protocols,*
- *integration and development of sensors, tools and control systems*
- *big data analytics, interaction between IoT components and humans*
- *3D printing and robotized fabrication*
- *demonstrators and pilot development*

3.4 Human and Social Aspect in Sustainable Construction

Sustainability is crucial for a democratic society and is essential from an economic perspective. A socially sustainable society is resilient, change-inclined, and a society where people live with good health and medical access and without unjust differences. It is a society with a high tolerance where human equality is at the center, which requires that people feel trust and confidence in each other and involvement in community development. Factors influencing social sustainability include democracy, education, health and quality of life, affordable housing, equity, equality and freedom, together with access to information and the possibility to influence and express opinions.

Members of the ENBRI network are pioneers in the development of principles and methods of sustainable construction at all levels from products to buildings and the entire built environment. In 1994, the International Council for Research and Innovation in Building and Construction CIB defined the goal of sustainable construction as "…*creating and operating a healthy built environment based on resource efficiency and ecological principles*". Since then, sustainable construction has matured and partly become standard practice

through CEN work. Several Members have also developed voluntary certification schemes for sustainable buildings, often at national level but also working for harmonised European methods or internationally competitive assessment services. Despite these remarkable achievements, in particular the social and cultural historical dimensions of sustainable construction, these are still underdeveloped compared with methods of environmental assessment. Furthermore, there is a need to understand the interdependence of global, regional and local indicators.

The human and social aspects of planning, designing, producing, maintaining and renewing the built environment includes issues that influence safety, health and comfort of users; this includes indoor air quality, acoustics and evacuation routes. Construction Product Regulations show a great variety of engineering disciplines are involved at the Research and Innovation stages. Any producer within the supply chain provides information about basic requirements that are connected to the life-cycle performance of the building or infrastructure. ENBRI members have long-term expertise and excellent facilities to provide testing and verification services to manufacturers, designers, contractors and administrators. Member have laboratories (or access to laboratories) to research materials, products, components and even building systems

Europe's ageing population profile has highlighted difficulties regarding usability of the built environment Barrier-free design has been gradually maturing with greater accessibility and suitability for all. Together with elderly and disabled people, pregnant women and children are often identified as "weak groups in design". In 'Design-for-All', the different needs of all persons are central. This process involves creating products, services and systems, which are usable by people with the widest possible range of abilities and operating within the widest possible range of situations. As an area for research and innovation activities, accessibility and design for all calls for methods and approaches that are non-traditional R&D activities in research institutes and companies. Many of the ENBRI members have capability in this area involving multidisciplinary teams to investigate performance of new developments in accessibility and liveability (e.g. air quality, natural lighting, sustainable materials) that ultimately influence human comfort and health.

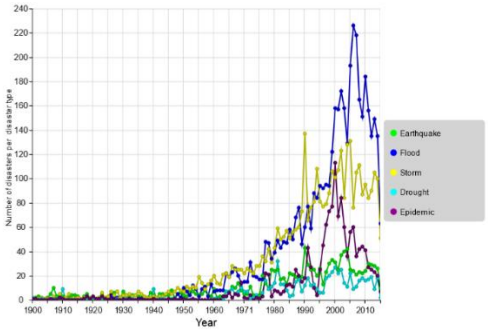
Human and Social Aspects in Sustainable Construction:

ENBRI will maintain and develop support to lead the Construction Industry by:

- *Continuing to develop principals and methods of sustainable construction that provide for the vulnerable and marginalised in our society.*
- *Continue to promote and develop the management of multidisciplinary teams necessary to achieve this.*
- *Undertaking efforts leading to democracy in decision making and users involvement in planning and design*

3.5 Resilience of our Built Environment (Risks, Safety, Security, Climate Change)

Globally, the recorded number of hazardous events that adversely affect the human population is on the rise and made obvious from the data provided by the 'Centre for Research on the Epidemiology of Disasters (CRED)' who have been maintaining an Emergency Events Database EM-DAT for many years (see trends in the figure below). The figure indicates that the number of recorded seismic events (deadliest in terms of loss of life) is relatively constant, but points to an increase in the reported number of storms and floods. In many parts of the world, the risks associated with weather-related hazards are on the rise as are the risk of economic losses although fewer deaths have been recorded). The number and intensity of floods, droughts, landslides, and heat waves can have a major impact on urban systems and resilience strategies. Depending on the location, climate change is likely to increase the frequency of precipitation in many regions. This will imply changes in flood patterns and contribute to upward trends in coastal high water levels.



CRED International Disaster Database http://www.emdat.be

In recent years, we have become increasingly aware of the significant risks that climate change poses to our cities and urban infrastructures. Premature material and equipment failure, higher peak electricity loads and voltage fluctuations, transport disruptions, and increased need for emergency management are becoming more common.

Strategies and policies can be developed to address these issues, as part of an overall vision to make cities of all sizes and profiles more resilient and liveable.

The following issues are, according to the United Nations among the most significant ***risk drivers*** *(ref x45):*

- *Growing urban populations and increased density, which put pressure on land and services, increasing settlements in coastal lowlands, along unstable slopes and in hazard-prone areas.*
- *Concentration of resources and capacities at national level, with a lack of fiscal and human resources and capacities in local government, including unclear mandates for disaster risk reduction and response.*
- *Inadequate water resource management, drainage systems and solid waste management, causing health emergencies, floods and landslides.*
- *The decline of ecosystems, due to human activities such as road construction, pollution, wetland reclamation and unsustainable resource extraction, that threatens the ability to provide essential services such as flood regulation and protection.*
- *Decaying infrastructure and unsafe building stocks due to lack of maintenance or the impact of manmade hazards (terrorism, accidents), which may lead to collapsed structures.*
- *Uncoordinated emergency services, which decreases the capacity for swift response and preparedness.*
- *Adverse effects of climate change that will likely increase or decrease extreme temperatures and precipitation, depending on localized conditions, with an impact on the frequency, intensity and location of floods and other climate-related disasters.*

In recent years, security and resilience have become increasingly embedded in urban planning. In national security and energy policy, attempts have been made to make the built environment and critical energy infrastructure more resistant to disruptive challenges. This against the background of threats from climate change and in more recent times, terrorism have highlighted the need for effective maintenance programmes.

A well-maintained database of disaster losses and a Geographic Information System (GIS) to map hazards, vulnerabilities, exposure of people, assets and capacities will provide the foundation for risk assessment. Risk is a function of the exposure of people and assets to the hazard (a hurricane, earthquake, flood, or fire for example) and the conditions of vulnerability of the exposed population or assets. These factors are not static and can be improved, depending on the institutional and individual capacity to cope and/or act to reduce risk. Societal and environmental development patterns can increase exposure and vulnerability and therefore increase risk.

Climate change will also have an impact on the environmental loads (wind, snow, etc.,) on the built environment, and consideration needs to be made within the building codes. Part of this consideration would be the monitoring of structural behaviour during the build and use phases to reduce risks, by applying geotechnics studies for example.

Resilience in our built environment:

ENBRI can support and develop the Construction Industry by:

- *Supporting the development of materials and buildings that can cope with the threats associated with Climate change*
- *Supporting know-how and capability to cope with inadequate water resource management and declining eco systems*
- *Providing know-how and capability in the monitoring of buildings during the build and use phases*
- *Providing support and capability in the development of buildings in vulnerable areas that may be subject to natural disasters and security threats*

3.6 Planning for Smart Cities

Urbanisation is a world-wide phenomenon in the growth of population that is rapidly taking place around cities in developed and developing countries. Cities are hubs of economic activities that are connected through transportation routes on land, air and water. They have to be supplied by communications electricity, water, sewage and waste services often from a long distance. Apart from the management of the physical infrastructure management of these systems from a technological viewpoint, is truly complex. Objectives of sustainable urban and land use planning add to this complexity various social, cultural, environmental and economic aspects.

Transforming existing cities with respect for their cultural heritage and constructing new urban areas cognoscente of the principles of smart city design are world-wide seen as a process toward better management of urban planning, building stock infrastructures and better services to the citizens. Countries like India, China, Japan, South-Korea and USA have adopted programmes and action plans for smart cities. There are also many activity running in Europe, initiated by cities themselves and by public agencies whose aims are to develop resilient urban environments through uptake of best available technologies and prioritising people's well-being.

The changes are reliant on digitalisation and big data. Smart economy, smart people, smart governance, smart mobility, smart living and smart environment are but some of the indicators that the digitisation of our world offer. Objectives are however set differently in different countries and cities depending on prioritization of the challenges to be solved. Often, the objectives are similar as in sustainability action plans. Thus, understanding the mixture of urban challenges and potential responses has become a set of demanding research, communication and decision-making issues.

Innovation and paradigm changes in the building sector can no longer be approached without considering the fundamental change of scale. Buildings have to be considered as one of the basic elements of the "built environment" system, including constructed elements such as transport and other infrastructure, which supports a cities function and its natural cycle. The emergence and development of sustainable cities is thus based on the performance of the built environment servicing of the citizens and promoting integration, interaction and meetings, identity and experience, functioning everyday life, security, and openness requires an integrated approach to the scale of the cities and territories.

Thus, for sustainable cities and communities in the future, intelligent integrated solutions for mobility, communication, energy supply and energy efficiency of the built environment will require a circular economy based on the reuse, recycle and the treatment of waste as a resource. It will also require green and blue surfaces that attenuate the impact of large amounts of water, contribute to biodiversity and better sound environment, health and a green urban environment.

Renewable energy, storage and emission of greenhouse gas emissions will depend on particular sites and well-designed transport systems which operate at a district and city wide level.

These complex issues must be integrated into the planning and building of cities or development strategies for territories. The projects must then be subject to regular evaluation, to ensure that the initial objectives have not been overlooked and that they respond dynamically to changing requirements.

Planning for Smart Cities:

ENBRI, through its unique position at international level, will support the development of the Smart City and Smart Community by:

- *Supporting the Smart City and related Smart applications for the betterment of the citizen.*
- *Develop with promoters and industry the necessary tools to integrate the various technologies to support Smart related City development.*

4. CONCLUSION

Society is moving towards large conurbation living and these social movements demand an interconnected approach to design, planning, building and maintenance. Large scale planning, infrastructure and supporting technologies require support in their development. ENBRI is ideally placed to support the Construction Industry by facilitating ready access to knowledge, testing, piloting and product development. Its members, provide the opportunity to develop inter and multi-disciplinary

teams to support this dynamic movement. It also works with Governments to provide a ready route to the development of standards that work with society to integrate marginalised communities.

Innovation in the construction sector demands a capability in research and technical development which is capable of solving complex and multidisciplinary problems. The principal building research institutes in Europe, represented by the institutional network ENBRI, offer comprehensive experience and capability in a wide range of disciplines, with in-depth knowledge in specialist fields at different locations, which can be combined for solving particular problems with high scientific input and the use of often unique test facilities. The ENBRI institutes are involved in numerous EU projects, as well as those of national research programmes. The institutes have excellent experience in the management of large research projects, networks and programmes at European, national and regional level with involvement from a wide group of stakeholders.

Furthermore, the institutes are well established within the scientific community. They are partners to industry, authorities, users and standardisation bodies. All this provides significant potential to the construction sector and policy bodies and ensures clear mechanisms for support of the development of sustainable societies around Europe.

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REFERENCES: *to be completed*

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