TU9
GERMAN UNIVERSITIES OF TECHNOLOGY

Policy Briefing 1

Sustainable Building as a Contribution to Climate Reversal

Impulses and Innovations from Germany's leading Universities of Technology

We, the Alliance of leading Universities of Technology in Germany, bear special responsibility for the productive and innovative power of our society and economy.

To this end, we combine our specific expertise in basic research, particularly in the natural and engineering sciences, with application-oriented research and innovation.

We are shaping the future by making a significant contribution to solving the major challenges facing society and thus to achieving the UN's 17 Sustainable Development Goals.

Our new policy briefing series provides an insight into a range of topics and examples.

The Challenge

Climate-neutral living and sustainable management by 2045

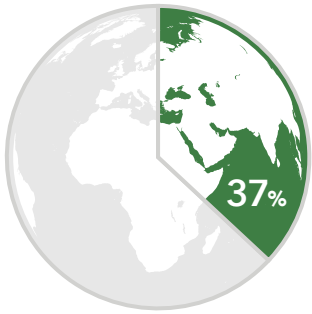
By 2045 at the latest, we want to live and operate in a climate-neutral way in Germany. A gigantic project with many challenges. Discussions about the use of fossil fuels in relation to passenger and freight transport, heating systems, and industry are omnipresent. So far, relatively little attention has been paid to one of the biggest CO_2 emitters. **According to a United Nations report, the construction sector is responsible for around 37% of CO_2 emissions** (Fig. 1). Major drivers are materials such as concrete, steel, aluminum, and glass.

According to current forecasts, raw material consumption in the construction industry will have doubled by 2060 worldwide – with consequences for raw material requirements and production-related greenhouse gas emissions. A reduction to net zero emissions is possible if the right and reliable political incentives are put in place that will lead to a paradigm shift in the construction industry.

Research at our Universities of Technology can already offer approaches and technologies for the construction sector to become more climate-neutral:

- Sustainable and resource-saving building materials
- Living labs for the integration of state-of-the-art energy efficiency technologies
- Concepts for the innovative renovation of existing buildings
- Strategy concepts to promote energy-efficient construction in the context of sector integration
- Use of digitalization tools and methods

Every day, we are researching innovations for the future.



1 | The construction sector is responsible for 37% of CO_2 emissions.

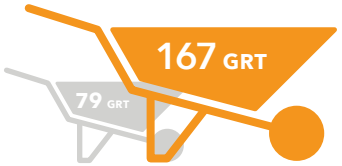
Building Materials

Sustainable, innovative and resource-efficient

Today, building materials need to offer more than the bricks, stones or plain concrete of the past. They are sustainable and resource-efficient materials (Fig. 2 & 3) – a fundamental change. **Universities of Technology are deeply involved in the research and development of new building materials. They not only guarantee maximum energy efficiency, but are also produced in a more energy-saving manner and are long-term ecologically compatible.** The laboratories of Universities of Technology in Germany produce innovations ranging from intelligent insulation and building materials that can adapt to external environmental influences to novel, energy-efficient composite materials. Thus, research at universities is helping to put the construction industry on a sustainable and economically viable footing for the future.

Research activities cover the entire value chain of building materials. The focus is not only on production and resource-conserving processing and use, but also on recycling and re-use. The innovations of Universities of Technology contribute to the emergence of a circular economy and also to new, contemporary standards and norms. As a result, construction projects in Germany can be even more aligned with ecological and cost-reducing aspects in the future.

© Sylke Scholz



2 | Doubling of the material use from 79 GRT [2011] to 167 GRT [2060]

3 | Building with carbon concrete instead of reinforced concrete allows for significantly thinner constructions. Depending on the component, savings of up to 80% are possible.

Carbon Concrete – Rethinking Concrete as a Building Material.

New materials allow for new construction designs and structural shapes. It may sound simple, but in reality, it often takes a long time. In the construction industry, innovation processes are particularly time-consuming due to high safety and durability requirements as well as complex standardization and approval procedures. This also and in particular applies to high-performance building material combinations such as textile and carbon concrete, which will bring about a revolution in building with concrete. Concrete is the most important building material worldwide in terms of quantity. Carbon concrete can significantly reduce the enormous consumption of resources and CO_2 emissions of the construction industry, but also opens up additional functions. And in conjunction with intelligent construction strategies, the full potential of the innovative material carbon concrete can be exploited.

A project of TU Dresden, RWTH Aachen University and the Leibniz Institute for Polymer Research Dresden

» https://tu-dresden.de/bu/bauingenieurwesen/imb/forschung/sfb-trr-280?set_language=en

New Buildings

Integration of state-of-the art technology for energy efficiency

Whether a private home or a major municipal project: Anyone planning a new building can and must rely on state-of-the-art technologies from the outset to ensure maximum energy efficiency. Universities of Technology are paving the way by researching and promoting the **use of new energy systems and intelligent building control systems**.

Scientists at Universities of Technology are conducting intensive research into ways of making **buildings "energy self-sufficient"**, i.e., almost completely independent of external energy sources (Fig. 4). High-performance photovoltaic systems, for example, can contribute to this.

At the same time, greater self-sufficiency minimizes the need for infrastructure. Rainwater can be managed locally and no longer needs to be drained into the sewer system. Renewable energies can be used intelligently through the effective use of technology. **These developments, in which the TU9 Universities are playing a key role, have the potential to revolutionize the entire construction sector and lay the foundations for an energy self-sufficient future.**

4 | There are currently only 500 net-zero commercial buildings and 2,000 net-zero residential buildings worldwide – this is less than 1% of all buildings.

Green Infrastructures for the City of the Future.

Green infrastructures for the city of the future – realized on existing buildings! The living laboratory and demonstration project at TU Berlin shows how it's done: By using photovoltaics on roof, front and window surfaces, energy is generated regeneratively in the existing building and net energy demand of the building is reduced. Rainwater is actively managed and not discharged into the sewer system. Instead, front greening and technical systems on the building enable the storage and use of precipitation water and its use as service and cooling water. The necessary technology is supplied with renewable energy by the building's photovoltaic system. Building shading and transpiration cooling by vegetation and rainwater management increase climatic resilience, reduced cooling, and heating demands lead to CO_2 savings. In designing and setting up the living lab, the researchers are drawing on results and experience from previous research projects.

A living laboratory of TU Berlin

» **https://stadtmanufaktur.info/en/living-labs/climate-energy-water/**

Renovation

Innovative concepts for existing buildings

A look at cities, municipalities and settlements shows: The intelligent energy-efficient renovation of existing buildings is one of the greatest challenges in the context of the energy transition and is becoming an increasingly urgent task for the construction industry and society. Universities of Technology are developing methods and technologies that can sustainably reduce the energy consumption of existing buildings. Supplemented by innovative renovation concepts and the use of state-of-the-art technology, the researchers' work not only helps to improve energy efficiency, but also **contributes to the revitalization of existing buildings and the preservation of older town and city centers – with the inner workings of the 21st century.**

The TU9 Universities' research projects not only include new approaches to construction measures, but also the integration of renewable energy systems into existing structures. Because every existing building is unique, there can be no ready-made solutions here. The focus of the research work therefore lies on adaptive renovation technologies. This allows energy-efficient renovation to meet the individual needs and conditions of existing buildings.

© Rathgen-Forschungslabor, Stiftung Preußischer Kulturbesitz

5 | The ReKult project accompanies the construction of the museum "berlin modern". The largest ongoing project of the Prussian Cultural Heritage Foundation is representative of current museum construction.

Sustainable and Resource-Optimized Cultural Heritage.

The climate and energy crises require more sustainability in the operation and maintenance of cultural heritage buildings as well as in the planning and construction of new museums, libraries, archives, and depots. The research project "Resource-Optimized Memory Institutions – ReKult" is developing assessment and planning approaches for the sustainable maintenance and construction of these valuable buildings (Fig. 5). The focus is on the interaction between objects, buildings, visitors and other users. Museums and collection facilities should reduce their comparatively high carbon footprint in order to counteract the effects of the global climate crisis and reduce resources. The protection of exhibits in particular has so far required a high energy input for ventilation, temperature, and humidity.

A project of Rathgen-Forschungslabor of the Staatliche Museen zu Berlin, the Natural Building Lab of TU Berlin, Technical University of Munich (TUM) and TU Braunschweig

» https://www.nbl.berlin/projects/rekult-ressourcenoptimierte-kulturerbebauten/

Construction in the Municipality

Knowledge transfer and local networking with regard to sector integration

Municipalities are key players in the implementation of energy-efficient construction projects. At the same time, they need to think one dimension bigger and beyond individual buildings. To give one example: the current, mandatory challenge of creating municipal, neighborhood-based heating plans. Universities of Technology, with their research expertise in this area, are becoming important partners. They themselves are pioneers on their campuses. With their living labs (Fig. 6), they play a key role in knowledge transfer and supporting municipalities in making entire neighborhoods or cities ready for an energy-efficient future.

Research results support the development of concepts that enable the efficient linking of different sectors such as buildings, transportation, and industry. Through the integration of intelligent energy and heating networks and the use of surplus energy from renewable sources, Universities of Technology are contributing to ensure that municipal construction projects are not only optimized in terms of energy, but also integrated into a comprehensive, sustainable energy concept.

Universities of Technology in Germany thus play a decisive role in the development and implementation of strategies to promote energy-efficient construction in the context of sector integration. The way in which Universities of Technology work is crucial: Not only the research activities themselves, but also the close contact with practical application and society as well as broad networks contribute to the development of innovative solutions.

EnEff:Stadt Campus – Energy Transition in the Neighborhood.

TU Darmstadt is turning an entire campus into a laboratory, researching and demonstrating how the energy transition can work in an urban district. In the "EnEff:Stadt Campus Lichtwiese" project, scientists from the fields of electrical engineering, mechanical engineering, architecture, and computer science are conducting interdisciplinary research into the energy transition in the district. The researchers are looking at the university's electrical energy supply as well as its heating and cooling requirements. Comprehensive monitoring of the energy flows on campus forms the basis for a fundamental modernization strategy.

A project of TU Darmstadt

» **https://www.tu-darmstadt.de/eneff/eneff_campus/index.en.jsp**

6 | Characteristics of Living Labs

Sustainable Design and Construction through Digital Technologies

Transforming the construction industry to increase sustainability and productivity

Digital technologies in design and construction offer further new solutions for sustainable construction as a contribution to climate reversal. They complement the development of resource-saving and sustainable building materials, the development and integration of energy control systems, sector integration in the construction industry, and the development of renewable energy sources.

However, due to the small-scale nature of the construction industry and a fragmented research landscape, the digitalization of the various sub-sectors of construction is largely decoupled from one another and very slow. In most cases, this only leads to incremental improvements and isolated findings. The full potential of digital technologies remains untapped, even though this is a key economic factor. More resource-efficient, material-saving construction with significantly increased productivity is possible if different disciplines are integrated and radically rethought in an interdisciplinary way.

Artificial intelligence, robotics, automation, digitally based manufacturing processes, adaptive buildings, but also sociology and economics are fields of action in which **Universities of Technology are making wide-ranging contributions to the transformation of the construction industry.**

© ICD / ITKE / IntCDC, University of Stuttgart (left photo: Connie van d'Grachten)

7 | The livMatS research building of the Cluster of Excellence was realized through integrative, computational design, robotic prefabrication, and automated assembly. It is an exemplary demonstration of the cyber-physical construction of tomorrow which reduces the amount of required materials by 50% and the global warming potential (GWP) by 63% compared to conventional timber constructions.

Computational Planning and Construction

Cluster of Excellence IntCDC

Founded in 2019, the Cluster of Excellence "Integrative Computational Design and Construction for Architecture" (IntCDC) is the first Cluster of Excellence in the field of Architecture in Germany. IntCDC seeks to harness the full potential of digital technologies in order to rethink design, fabrication and construction. The aim is to lay the methodological foundations for a comprehensive modernisation and sustainable transformation of building design and construction.

A project of the University of Stuttgart

» https://www.intcdc.uni-stuttgart.de/

TRR 277: Additive Manufacturing in Construction

The aim of the Transregio is to shape the transformation of the construction industry into a digital and sustainable future. The focus is on the use of 3D printing technology to develop resource-saving, low-emission and economical construction methods.

A project of TU Braunschweig and TUM

» https://amc-trr277.de/

**RWTH Aachen University | Technische Universität Berlin | Technische Universität Braunschweig
Technical University of Darmstadt | TUD Dresden University of Technology | Leibniz University Hannover
Karlsruhe Institute of Technology | Technical University of Munich | University of Stuttgart**

**TU9 – German Universities of Technology
Contact: » office@tu9.de**