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Current Developments and Examples of Sustainable Energy Technologies

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Federal Ministry
Transport, Innovation
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Digitization in the construction industry

Research and technology development in Austria

Digitization will permanently alter how buildings are planned, constructed and operated. With the aid of digital Building Information Modelling quality and planning dependability can be improved and costs and risks involved in implementing structures can be diminished. Interlinking the entire value-creation chain digitally also opens up considerable potential as regards improving energy and resource flows throughout buildings' life-cycle. Pioneering strategies designed to optimize construction processes by means of new digital technologies are being researched and tested in Austria.

Photo: sasinparaksa - stock.adobe.com

Digital change in the construction industry
Challenges and potential

The use of digital technologies results in major changes in all sectors of our economy and life. On one hand digitization opens up huge opportunities for growth, employment and prosperity; on the other hand it confronts us with real challenges. The "digital revolution" requires new types of workflow and production methods, as well as the development of innovative business models in all sectors of the economy.

For a given project the building's structure, the duration of construction and the costs incurred in construction and operation can be simulated in detail well before the implementation phase. Sharing a common database improves collaboration between various participants in all phases of construction and helps to save time, costs and resources.

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In future other technologies related to digitization, such as robotics, 3D printing, sensor technology, augmented and mixed reality, plus employing drones, will permanently alter how buildings are planned, erected and operated.

The digital transformation will also involve changes in job descriptions and in vocational training within the construction industry, and will require a new legal and organizational framework (e.g. for handling planning permission procedures on a digital basis).

In the future, digital transformation will have an increasing impact on the construction industry, too. With roughly 175,000 employees the construction industry achieved a turnover of around 33 thousand million Euro in Austria in 2017. The sector thus makes a significant contribution to GDP.[1]

New technologies make it possible for the construction industry to interlink the entire value-creation chain, from planning via construction and operation to demolishing structures. This opens up significant potential for improving buildings' quality and cost-effectiveness and optimizing energy and resource flows throughout the entire life-cycle.

Pioneering technologies in construction

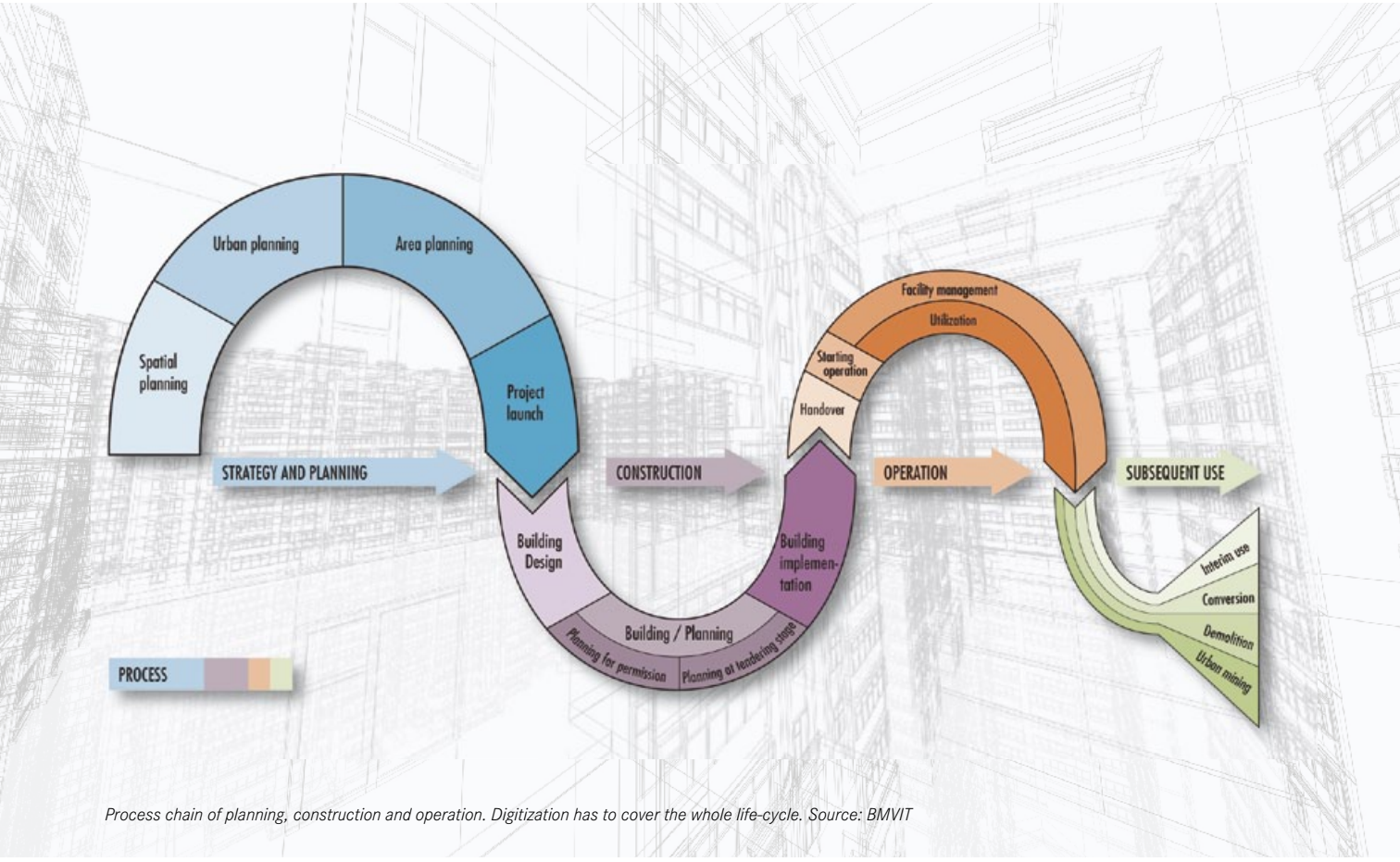
One important stimulus for digitization in construction is **Building Information Modeling**, or BIM for short. This method involves drastic changes to how construction projects are planned and implemented. For the construction industry Building Information Modelling is a pioneering interdisciplinary tool applying to the phases of planning, constructing and operating buildings and infrastructure. The basis is provided by an open digital building information model, actually a complex database containing both geometrical information and non-graphic data.[2]

Research and technology development

As part of programmes supported by the Federal Ministry for Transport, Innovation and Technology (BMVIT) and the Climate and Energy Fund, pioneering strategies, technologies and solutions for cities and their inhabitants are being developed for years. The goal is to enable the transition to energy-efficient, climate-friendly ways of life and work and to improve the location quality as well as the individual quality of life. The topic "Digitized planning, construction and operation of buildings" is a current focus of the research and technology programme "City of Tomorrow" (BMVIT).

In this issue we present various projects in this field that have been carried out within the BMVIT programme or are in process of being implemented. Here the focus is on the planning phase, on developing BIM further and on new digital methods of analysing the existing building stock in cities. Further thematic aspects on this topic are planned for forthcoming calls. ◘

[1] *Source: http://wko.at/statistik/jahrbuch/bau-produktion-2017.pdf*
[2] *Source: Studie: Potenziale der Digitalisierung im Bauwesen, on behalf of bmvit, TU Wien 2017 (in German)*



Process chain of planning, construction and operation. Digitization has to cover the whole life-cycle. Source: BMVIT

Survey
The potential of digitization in construction

As part of a recent survey by TU Wien (on behalf of BMVIT and the Austrian Economic Chambers) the opportunities and challenges presented by digitization in construction were analysed and a roadmap drawn up for implementing digitization and cross-linking processes step by step in every phase of construction projects. A list of recommended measures was assembled in close collaboration with relevant stakeholders from the construction industry and public institutions. Special attention was paid to Austrian SMEs' needs.

The vision of a "digitized construction project" goes well beyond employing a BIM. Whereas BIM refers to an interdisciplinary process based on a digital building model (up to 7D), a digitized construction project covers the entire process of implementing and operating a building in digital form. Amongst other things this involves real-time data recording, automated invoicing and controlling, tracking components, documentation and recording operating and service data continuously. The goal is to interlink all aspects throughout a construction project's entire life-cycle.

Strategies and measures

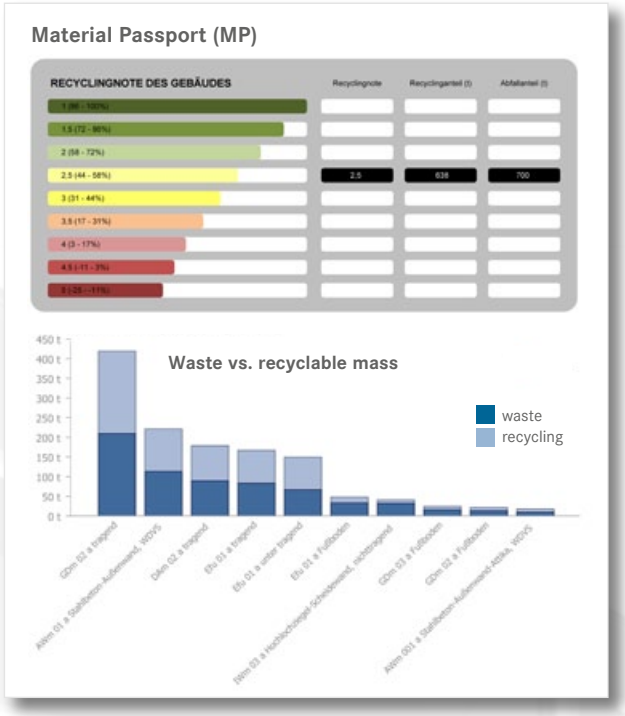
On the basis of the investigations, and with consideration of international developments, various measures for digitizing the construction industry step by step were identified in the survey. For instance:

- > Developing a digital application for planning permission via an open data format for public construction projects
- > Introducing open BIM in public construction projects
- > Funding pilot projects on construction sites, e.g. to try out automated invoicing on site or installing sensor technology and using IoT systems for cross-linking and centralized control
- > Drafting a digital building pass
- > Standardizing data traffic, e.g. to IFC Standard
- > Developing the feature server further, to improve software/model interoperability*
- > Certification programmes for SMEs (e.g. BIM site manager) and funding cross-linking

https://nachhaltigwirtschaften.at/de/publikationen/schriften-reihe-2018-02-studie-potenziale-der-digitalisierung.php (in German)

** Unique in Europe – the ASI feature server developed in Austria as part of ÖNORM A 6241-2, an online database for multi-trade collaboration (http://db.freebim.at) which defines how structural elements and materials are to be described.*

Source:
TU Wien



BIMaterial
Process design for a BIM-based Material Passport

Buildings and infrastructure make up the bulk of the material stock in an industrial economy. Given the growing consumption of primary raw materials worldwide, the existing building stock is of vital importance as a future source of material resources. The long-term maintaining of these urban stocks and the recycling of existing materials is referred to as "urban mining", through which the consumption of primary resources can be minimized. However, the exact material composition of the existing building stock is a knowledge, that still does not exist, wherefore it is not possible to estimate the future material consumption.

Identifying and analysing materials

A "BIM-based Material Passport (MP)" is a digital tool which provides information about the materials incorporated in buildings, as well as their quality and quantity. New digital planning tools such as Building Information Modelling (BIM) enable data management throughout the entire life-cycle of a building and show great potential in the digital generation of a Material Passport.

In a project headed by TU Wien (Institute of Interdisciplinary Construction Process Management)* the framework for generating a Material Passport has been drawn up. The project team developed a workflow which is based on coupling of BIM with the material inventory and analysis tool (BuildingOne) as well as with eco-databases. This workflow enables the evaluation and analysis of the material composition of buildings. Thereby the quality of the materials, the share of mineralic, metallic and organic substances and shares of recyclable and waste materials can be assessed.

Optimization in the planning phase

Architects play a crucial role in the reduction of waste and improvement of recycling rates, since they are responsible for the choice of materials in the early design stages. The MP, developed at TU Wien, has been created as optimization tool in early design stages, for carrying out variant studies and to generate an extensive material documentation. In future the MP could become a standard for building certifications and can also serve as a basis for a secondary raw materials cadastre. ◘

** Project partners: Institute of Water Quality and Resource Management / TU Wien, ATP Sustain, A-NULL Bausoftware GmbH*

SCI_BIM

In the follow-up project SCI_BIM (Scanning and data capturing for Integrated Resources and Energy Assessment using BIM), now in progress, researchers from TU Wien are investigating ways of using digital scanning and modelling technologies to record the geometry and material composition of buildings, taking a building in Aspang (Vienna) as an example. Here five TU Wien institutes are collaborating with the Zentralanstalt für Meteorologie und Geodynamik (ZAMG) and other specialists*.

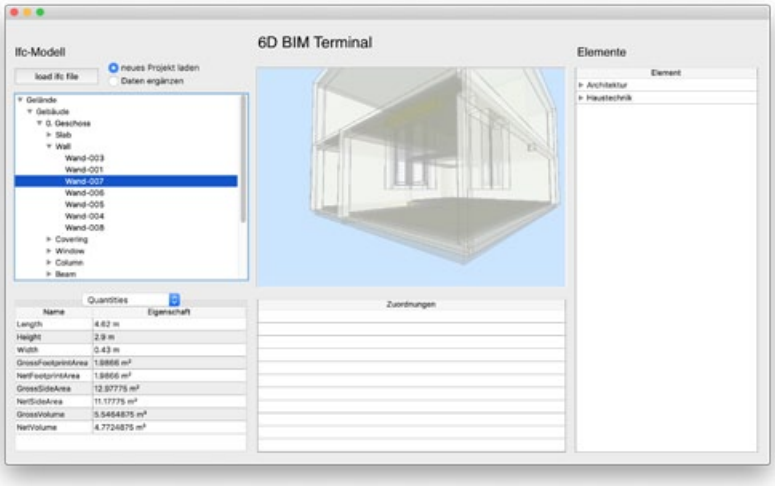
It is planned to employ georadar to establish material composition; laser scanning und photogrammetry will be used to establish geometry. As regards improving energy efficiency, and to document physical alterations, the project will test new digital methods such as gamification strategies. Users receive an application, and use a smart phone to document how the building in question is used (open windows, lightning). These data are uploaded to the gamification platform and incorporated in the BIM model. In this way the as-built BIM is intended to be maintained semi-automatically, providing a basis for BIM for Facility Management (BIM4FM).

** Project partners: TU Wien – Institute of Water Quality and Resource Management / Institute of Visual Computing & Human-Centered Technology / Institute of Architectural Sciences, Department of Building Physics and Builkding Ecology / Institute of Architectural Sciences, Digital Architecture and Spatial Planning, plus Vermessung Meixner, RM Umweltkonsulenten ZT GmbH*

6D-BIM-Terminal
Missing link in planning carbon-dioxide-neutral buildings

Building Information Modelling (BIM) makes it possible to take environmental and sustainability aspects into account as early as the phase of planning a building, so as to achieve zero-carbon buildings. Along with minimizing carbon-dioxide emissions, life-cycle costs (LCC) and other ecological (life-cycle assessment) indicators also play an important part in integrated planning.

While the 3D-BIM approach is already a standard feature of planning in Britain and Norway, the method has only recently started to be implemented in German-speaking Europe. There are hardly any examples of BIM being extended to include the dimensions time (4D), cost (5D) and sustainability (6D) to date. The Austrian Institute for Healthy and Ecological Building (IBO)* is carrying out a project aimed at closing the gap between BIM-based design processes and specialized planning, and aiding cradle-to-grave life-cycle analysis hand in hand with planning.



Prototype 6 D-Terminal, Source: IBO

Complex data exchange

The 6D-BIM terminal is being developed as a tool for collaboration between organizations; it makes data exchange possible between 3D planning programmes and complex BIM systems by converting relatively simple 3D elements into complex 6D BIM elements. Data that go beyond geometrical and representational information and are needed to take costs, deadlines and sustainability aspects into account are automatically added by means of predefined BIM elements. The data structure of these BIM elements is based on (inter)national standards (IFC, bsDD, ASI property server) as far as possible. The 6D-BIM terminal is the central platform used for data transfer. The construction management software ABK is upgraded for more complex computation, so that it can read in the relevant data in IFC format from the BIM architecture model and return them in suitable formats (e.g. as BCF, BIM Collaboration Format). LCA data, life-cycle costs and specifications can be derived from the building models.

Project goals

- > Identifying the properties required for life-cycle analysis, including a manual for planners and functional specifications for software companies
- > Catalogue with 6D-BIM structural elements and building service equipment that can be used as a sample element and adapted to a specific project
- > Prototype of 6D-BIM Terminal with functional user interface, APIs and reference catalogue
- > Adapting the specific sectoral planning tools to integrate the 6D-BIM data model, including interface to BIM terminal

Applying the new planning tool

Using the 6D-BIM terminal helps planners to consider ecological improvements and life-cycle perspectives right from the start of a BIM process. The new tool can thus contribute significantly to achieving carbon-dioxide-neutral buildings. This new technology is intended to benefit SMEs in particular, facilitating first steps in the complex world of BIM planning. ◘

** Project partners: ib data, baubook GmbH, Güssing Energy Technologies (GET), AEE INTEC, A-NULL Development GmbH*

RGB orthophotos and thermal recordings, Source: Project HOTSPOTS

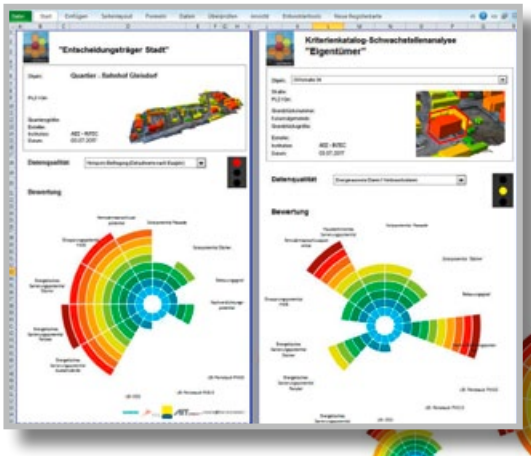
HOTSPOTS
New tools for thermal analysis of urban districts

Improving energy efficiency is an essential part of a forward-looking urban planning. To identify energy losses and potential for improvements, cities need suitable data on the existing building stock. Currently the relevant data are scattered among various different institutions; quality, degree of up-to-dateness and spatial resolution vary. In the HOTSPOTS project new technologies and methods were developed in order to analyse the current state of the existing building stock in an entire district as regards energy efficiency and microclimate. The project was carried out by researchers at Siemens' Graz branch in collaboration with the Austrian Institute of Technology, AEE INTEC and the municipal utility company in Gleisdorf.

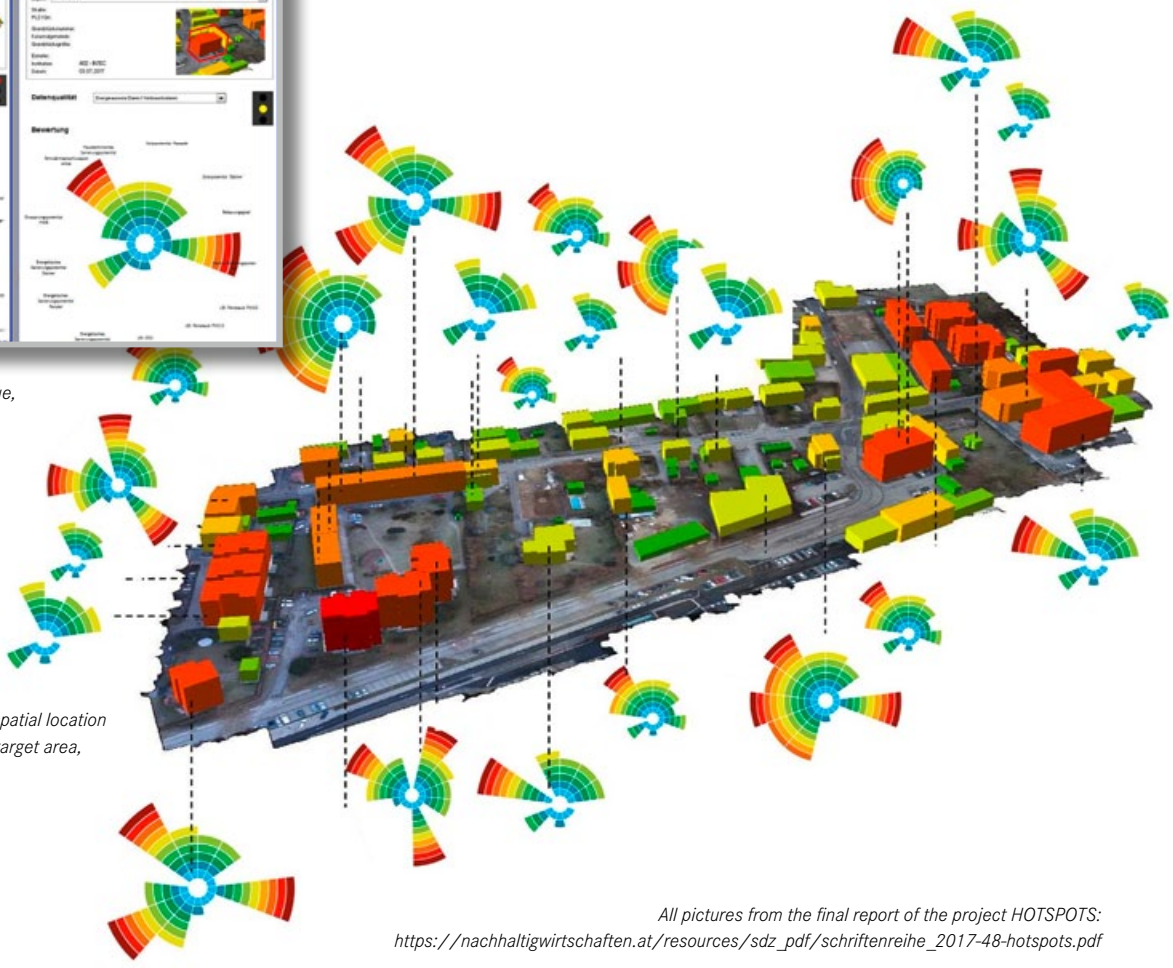
With the aid of new technologies to collect data on energy losses and air quality, and to process them digitally, cities should be provided with the necessary basis for planning modernization and renovation projects effectively. Urban planners thus obtain a tool with which to compute the effects of various different improvement measures and to select suitable steps to be taken in their city's problem zones.

3D aerial photographs reveal energy losses and air quality

Up to now energy and heat losses from individual buildings have been viewed in isolation. With the new methods small urban districts can be reconstructed in three dimensions and cross-linked to thermal data. The data basis for the project is a 3D thermal register generated from aerial photographs. The aim here is to

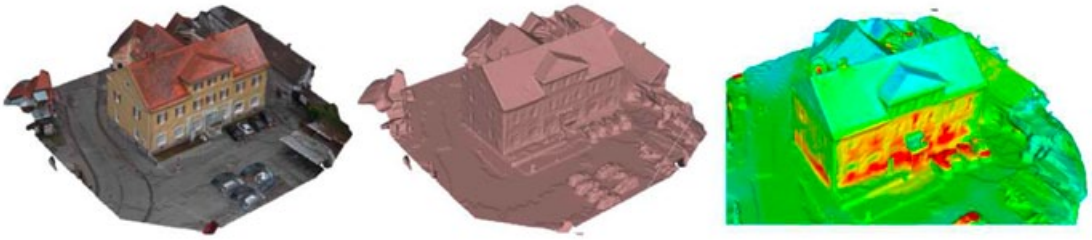


Assessment of criteria catalogue, Source: Project HOTSPOTS



Analysis of critical points with spatial location of the results in the HOTSPOT target area, Source: Project HOTSPOTS

All pictures from the final report of the project HOTSPOTS: https://nachhaltigwirtschaften.at/resources/sdz_pdf/schriftenreihe_2017-48-hotspots.pdf



Aerial view and modeling of a single building, Source: Project HOTSPOTS

collect thermal data covering the whole city area. Low-level aerial photographs are taken with drones or hot-air balloons equipped with thermographic cameras and special sensors; then the data from the individual photographs are interlinked to form a holistic database. From the photographic data 3D building models can be derived, making the energy losses in a given district visible. In this way buildings or groups of buildings with exceptional potential for energy-related improvement – so-called "critical spots" – can be identified.

In Gleisdorf, a small town in Styria, the method was tested for the first time in 2015, and a whole district investigated from the air. As part of the project a three-dimensional model of atmospheric layers was set up, to provide information on air quality and possible causes of air pollution in the neighbourhood in question. Specially equipped drones were employed to collect data.

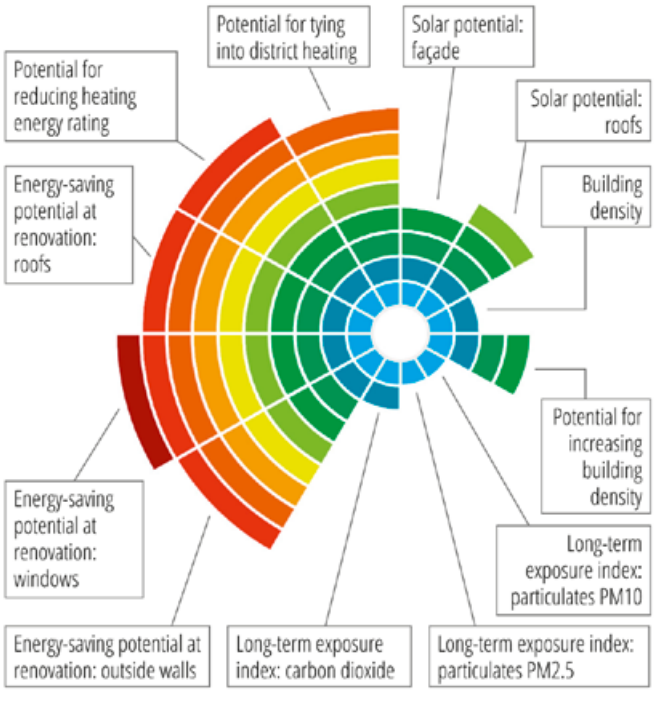
The data obtained with the new methods form the basis for analysing local trouble spots systematically, and make it possible to identify and locate suitable energy-efficient measures. ◘

Smart City Sensing

In a follow-on project now being carried out by AEE INTEC together with the South China University of Technology, four to eight inner-city hotspots are being investigated and analysed by means of the new methods, in Austria and the Chinese province of Guangdong.

The investigations are focussed on urban heat-island effects and on identifying very local concentrations of pollutants. Air and surface temperature data and air quality data in atmospheric layers are used to model microclimate and air quality in three dimensions. It should also be possible to apply the new methods to other cities of differing size in Austria and China.

www.aee-intec.at/smacise-smart-city-sensing-n-thermal-screening-of-physical-objects-and-air-quality-at-urban-scale-p230



Potential evaluation at building level, Source: Project HOTSPOTS

Photo: Siemens AG

"The consortium line-up was ideal for implementing the project. With Siemens' know-how in recording technology, 3D reconstruction and visual data analysis, AIT's expertise in data modelling in energy/urban contexts and AEE INTEC's technological competence and experience in cataloguing weaknesses and efficiency-boosting measures, a pioneering, practical process chain was successfully developed. Benefits for communities, utility companies and property owners were demonstrated on the spot in the town of Gleisdorf."

Claudia Windisch
Project Leader HOTSPOTS, Siemens AG Österreich

Univ.Prof. Gerald Goger
TU Wien, Institute of Interdisciplinary Construction Process Management

Photo: TU Wien

You research data-based modelling, simulation and improvement of construction processes. In the planning and erection of buildings, which steps benefit particularly from digitization?

Planning benefits in particular from the better coordination between the specialist trades and the possibility to solve conflicts on their interfaces in digital building models. But the detailed models not only help to resolve conflicts during the planning process and later during construction, but also make it possible to simulate the entire life-cycle. As a result the energy efficiency of buildings can be greatly improved. In my view the main advantage at the implementation stage is that digitization makes it possible to improve how resources are used, to plan a chain of processes right through, to document transparently and to achieve a better standard of implementation.

How will digitization affect the entire life-cycle of buildings?

Because of digitization, operation (including differing strategies of use) can be taken into account as early as the planning stage; so the life-cycle of buildings can be optimized. Employing sensors, linking them up to a comprehensive database and analysing the data collected opens the path to predictive maintenance, which I see as a key innovation in operating buildings. With continual measurement and data evaluation, forecasting how long technical facilities will stay operational becomes possible. Critical operating variables are presented as key performance indicators and help to make decisions on the most suitable maintenance schedules and operating constellations.

What are the biggest challenges in digitizing construction projects step by step?

Apart from the lack of standardization in the software field, and unresolved interface problems in data traffic, I see a reluctance to depart from traditional ways of thinking, and to some extent a lack of interest in implementing projects in a cooperative way, as the main obstacles to digitization. It turns out that the benefits to be gained from disruptive innovations are hard to quantify in the short term. From recent surveys, though, we know that (for instance) partial digital approaches to documentation processes pay for themselves within a short time. From this we infer that interdisciplinary research efforts need more time for implementation and acquiring funds. ◘

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INFORMATION

BIMaterial – process design for a BIM-based material building pass / SCI_BIM
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6D BIM-Terminal – missing link in planning services for carbon-dioxide-neutral buildings
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HOTSPOTS – holistic thermographic screening of urban physical objects at transient scales
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Survey "Potential of digitization in construction" (in German)
G.Goger, M.Piskernik, H. Urban, Vienna 2017,
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