

University campus to become climate neutral

Future designs for the refurbishment and urban development of the Braunschweig campus and its provision with energy



An interdisciplinary research team has developed an energy master plan for the campus belonging to the Technische Universität Braunschweig. Various scenarios for developing the campus as far as 2020 have been created with the aim of reducing the primary energy consumption by 40 % and, in the long term, facilitating the conversion to renewable energy. Planning principles have been developed for the renovation and urban development of the site that can also be transferred to other urban districts.

In terms of their size and structure, the four campus sites belonging to the TU Braunschweig are comparable with inner-city urban districts with a diverse range of buildings that have different usages and ages, including lecture theatres, libraries, cafeterias, offices, laboratories, sheds and administrative buildings. In the first stage, the existing building stock comprising 145 buildings was documented and the buildings' structural and energy characteristics were recorded in an energy register. Based on a district building typology, the researchers selected 19 suitable buildings for a detailed appraisal. Their results can be applied to other buildings of the same type and therefore extrapolated for the whole campus. A major advantage is that the TU Braunschweig comprehensively records the energy consumption of the respective buildings to a high temporal resolution in accordance with the areas, uses and the development of future needs. A centrally operated energy management system enables the monitoring and control of the building services equipment, which is largely integrated into the system using building control technology. The partial energy characteristic values in the buildings can therefore be determined quickly and easily by installing metering and measurement equipment. These characteristic values provide an important basis for optimising the

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Fig. 1 The „Forum“ building on the central campus: A typical functional building from the era when the universities were established again at the end of the 1960s, which was refurbished in 2014/15

energy consumptions. As part of the „energy-oriented operation optimisation“ (EnBop) research initiative, these are being centrally recorded in a database by various research groups and can therefore also be used in campus-based projects. The TU Braunschweig’s building management is also supporting refurbishment measures such as the restructuring of the energy provision in the currently starting implementation phase.

Exhausting savings potential for the campus development

Most of the buildings on the university campus no longer meet current technological standards. The building envelopes display obvious thermal bridges in many places and, as a result, defects and damage. The building system and services equipment is also largely coming to the end of its average useful life or has even exceeded it. Following the appraisal, the researchers have developed refurbishment measures for the selected individual buildings, calculated costs and drawn up savings forecasts. The energy efficiency standard according to the 2009 German Energy Saving Ordinance (EnEV 2009) provides the basis for refurbishing the building envelopes. Further measures encompass the building services technology, the interior lighting of circulation, office and laboratory spaces as well as the technical equipment in the buildings. Extrapolated for the entire campus, about 8 % of the primary energy can be saved by 2020 by improving the energy efficiency of the building envelopes. The research team also believe that much greater potential savings of 14 % can be achieved by optimising the operation of the air conditioning systems (HVAC systems). Up to 18 % could be achieved by installing photovoltaic systems, integrating cogeneration (CHP) plants, replacing obsolete refrigerators and converting the lighting to LED. It is also believed that the user behaviour could achieve additional potential savings amounting to 8 %. Theoretically, the researchers could therefore even exceed their goal of reducing the primary energy consumption by 40 %. For the conversion of the energy supply, they used a model that simulates the integration of CHP systems into the district’s local heating network and the municipal district heating network. The researchers recommend installing a large CHP plant with a thermal capacity of 525 kW in order to supply the East Campus and installing a smaller module with 150 kW in order to supply the North Campus. It is intended that both plants will be

Key data for the TU Braunschweig campus

6 faculties, 140 institutes
3,600 employees, 13,500 students
195 buildings (including new-build schemes)
400,000 m² net floor area
Additional area resulting from new research centres up to 2016: 15,740 m² MUA (6.3 % growth)
Energy costs: Approx. 11 million euros p.a.
Final energy consumption for heating: 109 kWh/m² net floor area p.a.; absolute: 43.5 GWh p.a.
Final energy consumption for electricity: 87 kWh/m² net floor area p.a.; absolute: 35 GWh p.a.

Fig. 2 Indicators for calculations and scenarios, base year 2010



Fig. 3 „Okerhochhaus“ tower block and the „Altgebäude“ building on the TU Braunschweig campus near the city centre

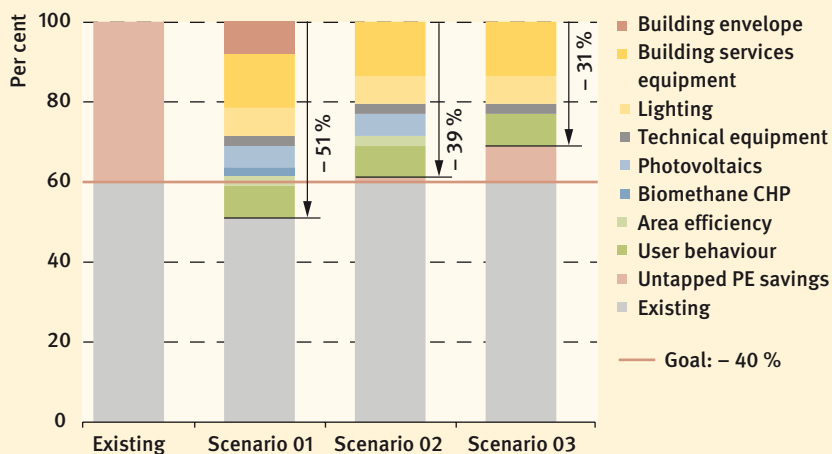


Fig. 4 Scenarios for reducing the primary energy consumption in existing buildings (Scenario 01: „High investment“; Scenario 02: „Medium investment“; Scenario 03: „Low investment“). The project’s aim of „reducing the primary energy by 40 %“ by 2020 can be attained both with scenario 01 and scenario 02.

supplied with biomethane, whose availability and economic efficiency are, however, very much dependent on future funding in accordance with the German Renewable Energy Sources Act (EEG). This investment of around 600,000 euros would save 320,000 euros per year in energy costs – with a roughly 3 % reduction in the primary energy and a 10 % reduction in the CO₂ emissions. Its implementation is currently being examined in conjunction with the local energy provider, BS Energy.

In terms of mobility, the researchers want to reduce emissions and save energy by reducing and shifting traffic and by intelligently designing the transport system. For this purpose, a best practice study on district traffic concepts was carried out and the university staff were surveyed about their mobility behaviour and choice of transport (modal split). In addition, the research team analysed the existing public transport services and the parking situation on the campus. Based on this, the research team created standardised mobility chains and suggested measures to encourage people to switch from using cars to other modes of transport or car pools. These



Multiplier effects for German university sites

The universities in Germany play an important role in achieving the climate protection goals. With their extensive and heterogeneous building stock, they are not only responsible for teaching and research but are also predestined for use as learning laboratories for energy-optimised construction and operation. Together with data from Hochschul-Informationssystem GmbH (HIS) on Germany's existing university building stock, the results from the Braunschweig project will now be prepared for other university sites and supplemented by additional surveys. This will therefore provide an overview of the energy-specific status of the German university landscape (status: 2010) as well as a forecast of its development until 2020.

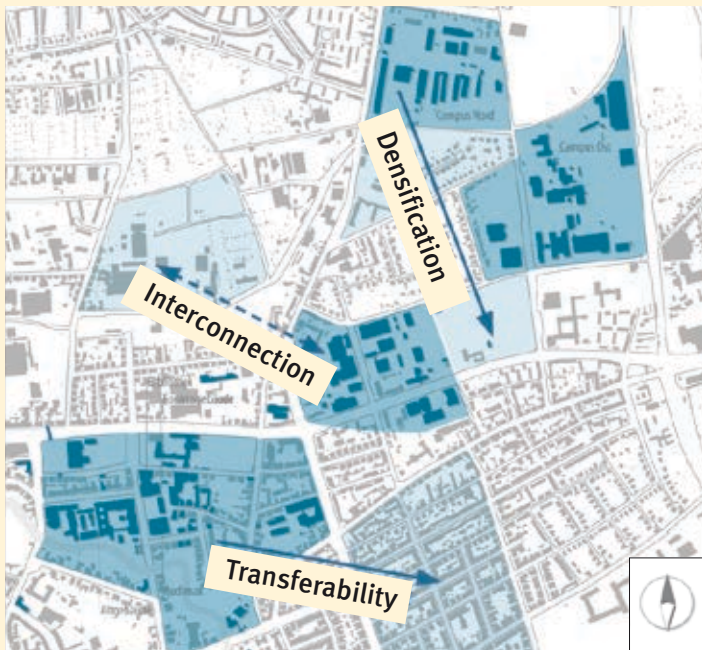


Fig. 5 A goal of the follow-up project: Coordinated urban development strategies for the four campus sites

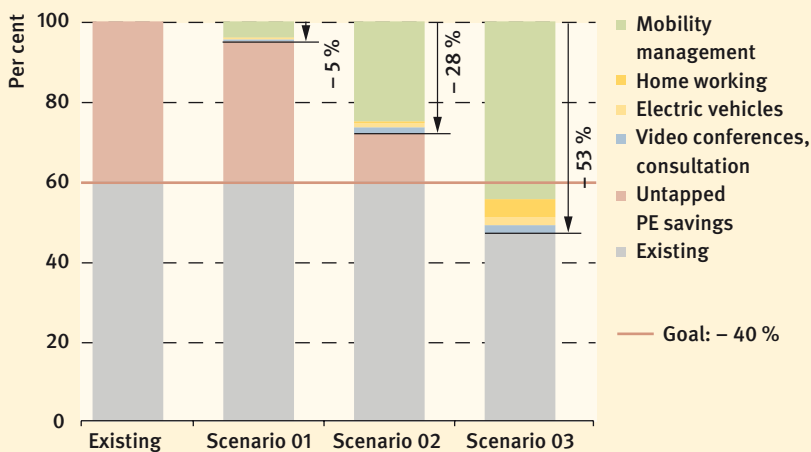


Fig. 6 Scenarios for reducing the primary energy consumption by 2020 in regards to mobility. (Existing status in 2010, Scenario 01: „Small extent“ measures package, Scenario 02: „Medium extent“ measures package, Scenario 03: „Large extent“ measures package)

measures include, for example, an improved infrastructure for cyclists, car sharing and carpooling, parking space management in conjunction with mobility centres (mobility hubs) as well as a campus shuttle.

From individual measures to the integrated implementation concept

All measures are being incorporated into the master plan, which in addition to the use of energy in buildings also includes organisational and infrastructural recommendations. For the period up to 2020, the research team has developed differentiated development scenarios that provide different options for action with regard to existing buildings, new-build schemes, space efficiency, energy provision and mobility. For this purpose, the data from the energy register has been transferred to a calculation model that can take into account various forecasts for the campus development. For example, the „Concentration and reduction“ option assumes that there will be stagnating or even reduced numbers of students and research activity. In this case, the researchers suggest that the North Campus should be relinquished as a

university location. The space made available could be transferred to the city to provide student accommodation. The „Restructuring“ variant presupposes constant development. In this scenario, all four university sites need to be strengthened in terms of their function. The „Campus as an all-day, bustling urban district“ scenario is a development version in which the four sites expand and extend like ribbons through the city. At the same time there is considerable densification of the university properties. For the implementation, the research team has developed a method that enables, for example, the detailed calculations for individual building types to be reliably transferred to similar properties.

As part of the integral master plan, instruments and methods have been developed for processing complex tasks concerned with district development. These include planning tools relating to the building physics, building services equipment as well as the energy management and operational optimisation, methods for calculating the economic feasibility and analysing life-cycle costs, simulation models for mapping development and renovation scenarios as well as instruments for designing service concepts and financing models. The project results will also be communicated within the university.

Perspective 2020 – Vision 2050

In August 2015, the TU Braunschweig wants to begin implementing the master plan with the „EnEff Campus 2020“ follow-up project. This will undertake a diverse range of measures relating to new-build schemes, refurbishment and maintenance, as well as energy supplies, user motivation and urban development. In addition there will be comprehensive monitoring and non-technical measures such as energy coaching and user workshops. Parallel to this, the researchers want to develop a technology platform to facilitate research into urban structures and to develop future strategies for the campus in Braunschweig. The building data recorded using the energy register will be deployed in this platform for the ongoing optimisation of the building performance (Real-life Lab). The long-term goal is to achieve a largely CO₂-neutral campus by 2050. This vision forms the basis for the university's long-term commitment.



„EnEff:Campus“ research focus area

Towns and municipalities are encouraged to implement the German federal government's climate protection goals in their urban development processes. Holistic development concepts for urban districts, the use of innovative planning tools and the networking of diverse experts can make an important contribution in this regard. Thanks to their central administration, technical expertise and heterogeneous building stock, universities and other campus-like facilities can play a leading role and provide important impetus for the respective citywide development. As part of the EnEff:Campus research focus area within the EnEff:Stadt funding initiative, the German federal government is therefore also pursuing new research approaches for achieving greater energy efficiency in these urban sites.

For example, the Leuphana University Lüneburg already decided to achieve a “Climate Neutral Campus” back in 2002 and has developed a sustainability model. Since then the university campus has been further developed in both urban design and energy efficiency terms, whereby an important element is the new-build scheme for the Main Building. The refurbishment of the local district heating network is complete and the building refurbishment is in full swing. Another goal is to convert the energy supply to renewable energies and thereby integrate the low exergy heating systems in the new building and a seasonal heat storage system.

A concept for the energy-efficient development of the Berlin-Adlershof science and business park was developed between 2011 and 2013. By linking energy flows, testing a smart grid and implementing energy planning guidelines, the players combined in the “Energy Grid Berlin Adlershof” are looking to achieve their goal of reducing the primary energy requirement by at least 30 %.

At RWTH Aachen's Melaten Campus and the Forschungszentrum Jülich site, researchers are developing dynamic simulation models for buildings and district heating networks that depict the thermodynamics of the heat supplied to both sites in detail. The research project intends to leverage the potential for holistic energy concepts at campus-like facilities and already significantly reduce the primary energy requirement of the buildings at both sites in the short term.

Project participants

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Links and literature

- » www.tu-braunschweig.de/igs/forschung/eneffcampus » www.eneff-stadt.info/en
- » www.enob.info/en/commissioning/

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