////Title: An Education in Sustainability: Achieving a Climate-Neutral University

////Stand-first: Dr Oliver Opel of the West-Coast University of Applied Sciences in Germany reports on how Leuphana (loi-fah-nah) University was transformed into a climate-neutral and environmentally sustainable campus. In the face of accelerating climate change, this exemplary case-study provides guidance to other universities and institutions that also wish to become leaders in climate action.

////Body text:

Climate change is arguably the greatest threat facing humanity. At the current rate of planetary warming, this growing threat holds the potential to destroy our human civilisations, through increasingly severe drought, mega-storms, wildfires and floods, and the resulting food shortages, water shortages and the collapse of ecosystems we depend upon. The increasing concentration of atmospheric carbon dioxide is the primary driver behind global climate change, released by fossil fuel combustion to meet our growing energy demands.

Carbon dioxide emissions associated with buildings are significant, so there is an urgent need for environmentally sustainable businesses and housing. Sustainable buildings need to be highly efficient, with energy supplied by renewable sources such as solar and wind. Such buildings rely on decentralised smart grids and storage for both power and heat, incorporating energy-efficient heat pumps and next-generation heating networks to minimise losses. However, refurbishing existing buildings is challenging due to economic, legal and social constraints, including cost efficiency and heritage conservation.

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Universities can have serious impacts on the environment, due to their size, population and complex activities. Because they can be viewed as a small city, universities can also act as 'living labs' for sustainability, particularly regarding energy consumption, water consumption and transport, and can play a central role in sustainable development processes. However, universities often lack a systematic, sustainable approach to reducing their own negative environmental impacts.

In a new case-study, entitled 'Climate-neutral and sustainable campus Leuphana University of Lueneburg (loon-e-berg)', Dr Oliver Opel and his colleagues describe how a university successfully reduced its carbon footprint to zero by adopting a whole system approach. Leuphana University currently hosts approximately 9,000 students. Dr Opel was formerly a research assistant at this university, and is now a professor of energy optimised buildings at West-Coast University of Applied Sciences.

The university campus is situated on a former World War Two barracks that is split into two parts, one hosting the campus and the other a residential area called Bockelsberg. Prior to 2006, several small environmental improvements were made to the university, including installation of small-scale photovoltaic solar systems and refurbishment of the heating network. These improvements reduced the university's footprint by approximately 125 tonnes of carbon dioxide per year. Various user-orientated measures almost doubled this value, but this was still only a small proportion of the total 8,400 tonnes emitted, 44% of which was due to commuting. About a fifth of the university's emissions was associated business trips, approximately a quarter from electricity and the remainder from heating.

In 2006, a campus development program was initiated with the strategic goal of making the campus 'climate neutral', that is, emitting zero net carbon dioxide. The university planned to extend the

main campus to provide for future growth and reduce inter-campus traffic, as the university also used other locations within the city. Other plans included refurbishing the existing buildings to make them energy efficient, constructing a new central building adopting modern sustainable architectural techniques, overhauling the heating system and adding renewable electricity generation.

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In their case-study, Dr Opel and his colleagues describe the measures implemented to refurbish the campus buildings, including insulating walls, roofs and cellar ceilings, installing new windows and optimising the heating system. Due to the high costs involved, the planners decided to separate the building improvements and refurbishment of the heating system into two independent tenders. Heating of the residential area in Bockelsberg was also incorporated into the heating system design, doubling the overall heating requirement.

To test different heating system options, the university used theoretical models to estimate the heating and cooling demands, and identified heating storage as a critical component of the system. Oil and gas boilers simply convert high-quality fuel into low-quality heat, whereas combined heat and power (CHP) units produce high quality electricity and useful heat. Therefore, the university replaced the existing heating network with highly insulated pipework in 2010, and installed biofuel-powered CHP units to provide the required heat to both the campus and Bockelsberg. Carefully controlled temperature levels within the system allow for optimal heat usage and storage.

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The Polish American architect Daniel Libeskind designed the new central building, which is characterised by walls without right angels to promote open-mindedness and free thinking, an antithesis to the original rigid barracks design.

In this new central building, cooling was an important consideration, so Libeskind incorporated features such as avoiding a south-facing façade and switchable shade glazing, which allows for solar heating in winter and lower cooling requirements in summer. Insulation, low-maintenance panels and openable windows avoid the need for active cooling and mechanical ventilation, whilst making for a more comfortable indoor climate.

Other modern design features include an experimental temperature control system, materials capable of storing and releasing energy within the construction, vacuum-insulation and LED presence-controlled lighting. Roofs were designed to harvest rainwater for later use and modern materials and construction technologies were used in the structure to partly replace and lower the use of unsustainable materials such as steel and concrete.

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Efficiency upgrades of the existing buildings included refurbishing the heating networks, automation, LED lighting and optimising the ventilation systems. To generate electricity, a large photovoltaic solar system was added to eastern, southern and western facing roofs. All these measures together almost cut the primary energy demand in half. This significant reduction means that the energy demand per square metre in these existing buildings is comparable to the newly constructed central building.

Dr Opel explains that several heat storage concepts are currently being considered by the university. Hot water tanks are in place for short-term storage and research is ongoing to investigate reversible

thermochemical reactions for mid-term storage. For long-term seasonal storage, an aquifer thermal energy storage system would be a very cost-effective technology, particularly in combination with CHP and solar energy.

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After the redevelopment, the university analysed the carbon footprint of the campus. Since the university now feeds surplus renewable electricity into the mains grid, this allows them to offset the carbon emissions associated with commuting, business trips and heating. In fact, their analysis revealed a negative carbon dioxide balance. Based on 2015 data and projected demands of the new building, the carbon dioxide balance was calculated to be negative 1,636 tonnes – a magnificent achievement. Adding a future aquifer thermal energy storage system would reduce this further. Revenue due to electricity fed back into the mains grid makes the whole project cost effective long term.

Dr Opel and his colleagues highlight that Leuphana University's achievements in converting a well-established campus with significant carbon emissions into a cost-effective, climate-neutral development by following a clear and ambitious strategy. The research team's case-study outlines the details of this successful strategy, so that other universities and institutions can also become leaders in climate action.

Meet the Researcher

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