Bauhaus Structures – Designing Energy Producing Structures for Public Space on the Bauhaus University Campus in Weimar, Germany

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ABSTRACT

Due to its location within the city centre of Weimar and heterogeneous neighbouring districts, the campus of the Bauhaus University is representative for a city quarter. It accommodates not only educational buildings but also a café, laboratories, workshops and studios as well as residential buildings. Facing one of the main traffic routes leading into the historic city centre, directly at its southern border, the campus offers a site for densification and extension of the existing building stock. This site is currently covered with grass and grown trees and forms the end of the internal pathway through the campus. At the same time, it offers great potential to be acknowledged also as an entrance to the campus from South. Students of the Masters course Sustainable Structures were asked to design an energy producer for the campus on this site; to maximize energy production and to minimize the amount of grey energy by material choices; to work with locally available energy resources and materials and choose a building function that will enhance the usability of the site. The studio methodology included four work packages: (A) site analysis, (B) potential analysis and sustainability strategy, (C) implementation in a design proposal and (D) simulation of the proposal and validation. Work package A included an urban analysis of the neighbourhood for topography, morphology, building typologies, traffic and views; a climatic analysis of temperatures, solar radiation, wind, rain and humidity and an analysis of existing energy networks, current energy consumption, local energy production and local energy potentials to identify interconnections and possible synergies between these fields. Work package B continued with an analysis of the potential for active energy harvesting technologies and finally concluded in a sustainability strategy for an energy producer based on the findings of the four different analysis parts. This strategy ideally includes a site-specific approach utilizing locally available energy sources and materials offering a benefit to the campus not only in terms of energy but also for the user. In a first attempt, a site design, a volume, a material concept and a building function had to be defined. In work package C, the sustainability

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strategy had to be transferred into a building/ object design and first calculations evaluate the ratio between the energy demand of the design and possible energy production. Work package D validated the calculations by simulating the site-specific solar or wind energy potential, energy demand of the building and / or thermal comfort within buildings/ underneath sheltering structures. To improve the results, the design had to be iterated to maximize energy production and minimize energy demand to be able to contribute to the energy demand of the campus. The range of design proposal results was manifold. Starting from very sensible small-scale projects like textile pathway cover with PV or a cafè with a wind turbine on top it became obvious that with an increase in energy generation the scale of the project proposals also increased. Sports ground utilizing piezo crystals for electricity generation; a tree house structure with wind turbines, exhibition cubes underneath a connecting wooden PV-covered roof and the re-use of an existing 2-storey steel structure by adding an algae façade display the building scale proposals. The biggest and most ambitious project proposal was a high-rise power plant housing a power2gas generation, a curved PV façade and wind turbines as well as geothermal storage. Resultantly, this proposal was the only project that could significantly contribute to the energy demand of the campus. Hence, the design proposals mirror the intended learning outcomes: Maximizing energy production requires an adaptation of the shape of a building/ structure, i.e. implementing a feasible wind turbine requires a height exceeding the average building height of the city quarter (energy design). Small-scale interventions will only offer small-scale energy production (scale). The contribution to the network is not only depending on the scale but also on the function of the building itself. Many of the proposals eliminated the necessity for thermal condition of the interior spaces after work package C to be able to achieve an energy surplus and asked for adaptation to the climatic conditions by the future users (mix of functions, heterogeneous quarters). Concluding can be observed that the topic of energy producers within the cityscape needs further exploitation. New typologies have to be developed and the proposals of this module only have started to investigate the potential. Having an interdisciplinary group of students with engineering and architectural backgrounds added significant value to the design proposals.

Aim of the paper and urban challenge it addresses:
The exit from nuclear and fossil fuel energy results in a turnaround towards renewable energy sources that are locally available. Facing the challenge of re-integrating energy generation into rapidly growing, high-density cities is strongly linked to the limitation of spatial and temporal availability of renewable energy sources. The design studio “Bauhaus Structures” as part of the Masters course Sustainable Structures at the Frankfurt University of Applied Sciences focussed on the design of energy producing structures within the urban context.

Students were asked to harvest local renewable energy sources to contribute to the energy demand of a university campus. Based on an urban design analysis, a climatic analysis, an analysis of the existing energy network and a potential analysis of renewable energy sources, a site-specific sustainability strategy had to be developed. Subsequently, the design proposal, based on the sustainability strategy, included a surplus energy building or structure embedded in the local context. Utilizing energy simulation tools suitable for basic design decisions during the first phases, i.e. Grasshopper and Ladybug and LCA tools like CAALA the design proposal was refined to maximize energy production and to minimize grey energy demand.

KEYWORDS

Keyword 1	Urbanization
Keyword 2	renewable energy sources
Keyword 3	climatic design
Keyword 4	lifecycle assessment

WORKSHOP

Workshop III: Urban Sustainable Development