

Energy and exergy

DEFINITIONS

For the inhabitant, a building has the purpose to provide for a safe and comfortable environment. The building can do so by passive and/or active components. The inhabitant or user of a building, apartment, office space or any other enclosed part of a structure perceives the inner view of a system.

Seen from the outside, a building causes a change to the environment it is constructed in with potential impacts going far beyond the direct vicinity of the building: The change of the Earth's surface on the building site, the addition of water and energy supplies, the production of waste in form of material and temperature directly influences the environmental system.

For the future, it will be crucial that the environmental system in which a building is placed is disrupted as little as possible. In that respect, energy and exergy become key concepts.

Energy and exergy

Most people are familiar with the concept of energy and its uses in buildings. They also increasingly understand and see the relation between their personal energy consumption and the long-term impact on the environment. But few are aware that the environmental system surrounding each building – air, earth, or water – offers many opportunities to make use of the energy contained in this environmental system for increasing the comfort inside the building. The concept of **exergy** thus presents a more appropriate measure of energy consumption.

Hansjürg Leibundgut is professor for building physics at the ETH Zurich, and besides performing fundamental research on exergy, he also teaches the subject and implements applications of it in his own practice. He describes the work and purpose of the Low Exergy Module in the Future Cities Laboratory as follows:

“The building sector places one of the heaviest, and increasingly unsustainable, burdens on the world's energy resources and natural environment. The problems of climate change and finite stocks of fossil fuels will cause severe conflicts in the coming decades if there is no change in the technologies used to construct and run buildings. The supply of energy itself is not a problem because solar radiation exceeds the power requirements of human society by factors of more than 100 at every site of human population. Rather, current technologies inhibit our ability to capture and utilise available renewable energy without negative side effects.

This module proposes, as a consequence, that fundamental changes and innovations are necessary in the way we consider buildings and the flows of energy that they embody. This implies a rethinking of the way in which buildings are designed, constructed, operated, maintained, renovated and, if necessary, demolished. The module is focused on expanding the available range of solutions that can counter the current unsustainable demand that the built environment places on global energy resources. It does so at theoretical, methodological and empirical levels. The module will innovate theoretically around the concept of exergy as a more sophisticated measure of energy consumption in the building sector. It will develop and modify design software, building control and automation systems to optimize the use of renewable energy sources through the operation of low exergy systems. And finally, it will adapt and implement practical solutions being researched in Switzerland in the different climatic and cultural conditions of Singapore. These will take the form of models, pilot projects and at least one full-scaled building project.

The BubbleZERO is the first pilot of low exergy technologies in Singapore. The laboratory contains several technologies including radiant cooling, decentralized ventilation, and wireless sensing and control that will be tested and evaluated for high performance cooling operation in the tropical Singapore climate.

The Low Exergy module researches the development of new low exergy systems for the tropics. The work includes the adaption and performance assessment of existing low exergy systems that have been developed in Switzerland for heating and have been brought to Singapore for evaluation as part of the containers that now form the BubbleZERO laboratory. The research in Singapore is managed by the module coordinator and five PhD students have projects studying different aspects of the low exergy system implementation in the tropics. These topics are:

- radiant high temperature cooling
- decentralized ventilation and indoor air quality optimization
- wireless sensors and control
- low temperature heat rejection
- integrated system design, modeling and visualisation”

(Future Cities Laboratory, *Low Exergy*, 2013)

This example demonstrates, that by focusing on fundamental research, real-world applications can quickly emerge and contribute significantly both to value creation and to the improvement of the environment, by bringing their system back closer to its previous balance.