BIRKHÄUSER

MATERIALS IN PROGRESS



Innovations for Designers and Architects

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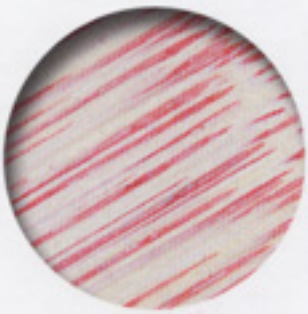
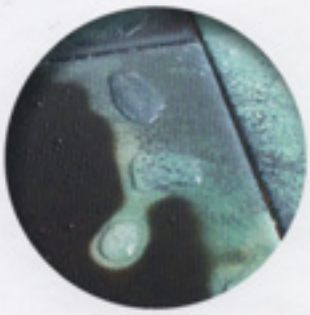



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RENEWABLE ENERGY AND ENERGY PRODUCTION

Moss cells that generate energy
Source: Fabienne Felder

In many large cities, small, periodically blinking boxes have begun to appear on street signs, traffic lights, in public transport, on lanterns or facades. These sensors collect vast quantities of data from their surroundings and constitute a fundamental building block for the smart city of the future. They measure temperature, humidity, noise levels, signals from communication devices and light levels, and relay any relevant changes to a smart system. Intelligent sensor technologies will become increasingly widespread in Europe as smart systems for regulating traffic, intelligent parking, adaptive lighting, signalling systems and waste management are put into practice. Throughout Europe, vast sums have been invested in smart city concepts and research into artificial intelligence and industry observers predict that new business segments will emerge over the next seven years with a market volume totalling some 1.6 trillion euros.

With increasing digitisation and the accompanying widespread adoption of networked devices as part of the Internet of Things, it is becoming increasingly vital that these small data collectors function reliably. They need to be able to transmit data independently, be maintenance-free and also energy self-sufficient, as the devices are often difficult to reach and cannot always be connected to a power supply. For this reason, applications such as those monitoring agricultural land for efficient water use or seamlessly tracking goods have until now been problematic.

Successful advances in semiconductor technology have heralded the advent of integrated circuits with extremely low power consumption that can be supplied by so-called

energy harvesters that capture energy from the immediate environment. The energy sources are as diverse as they are abundant and illustrate the wealth of such untapped sources available on the planet. Alongside sunlight, heat and wind, further renewable energy sources include vibrations from machines, temperature differences in pipelines and even biochemical processes in living organisms such as plants, animals and bacteria. Humans themselves, as active organisms, are likewise a potential source of energy. Energy converters incorporated into textiles or shoe soles will soon be available that provide sufficient energy to power wearables such as fitness trackers, digital glasses or smartwatches. Energy harvesters look set to be a promising technological building block for the development of future smart cities.

It is envisaged that by 2050 Europe's electrical power will be supplied entirely by renewable energy sources such as solar power, wind energy and biomass. According to experts from the LUT University of Technology in Finland and the Energy Watch Group, this goal is both realistic and economically competitive compared with today's conventional fossil fuel and nuclear energy-based systems. However, power generation from sun, wind and water is subject to natural fluctuations, which is problematic for industrialised nations with varying climates such as Germany. To ensure a constant supply of energy across Europe, scientists and engineers are working on new energy storage and battery systems. Electricity can also be stored in pumped-storage plants and converted into hydrogen for distribution on demand via an intelligent networked system.

Current Window
Source: Marjan van Aubel

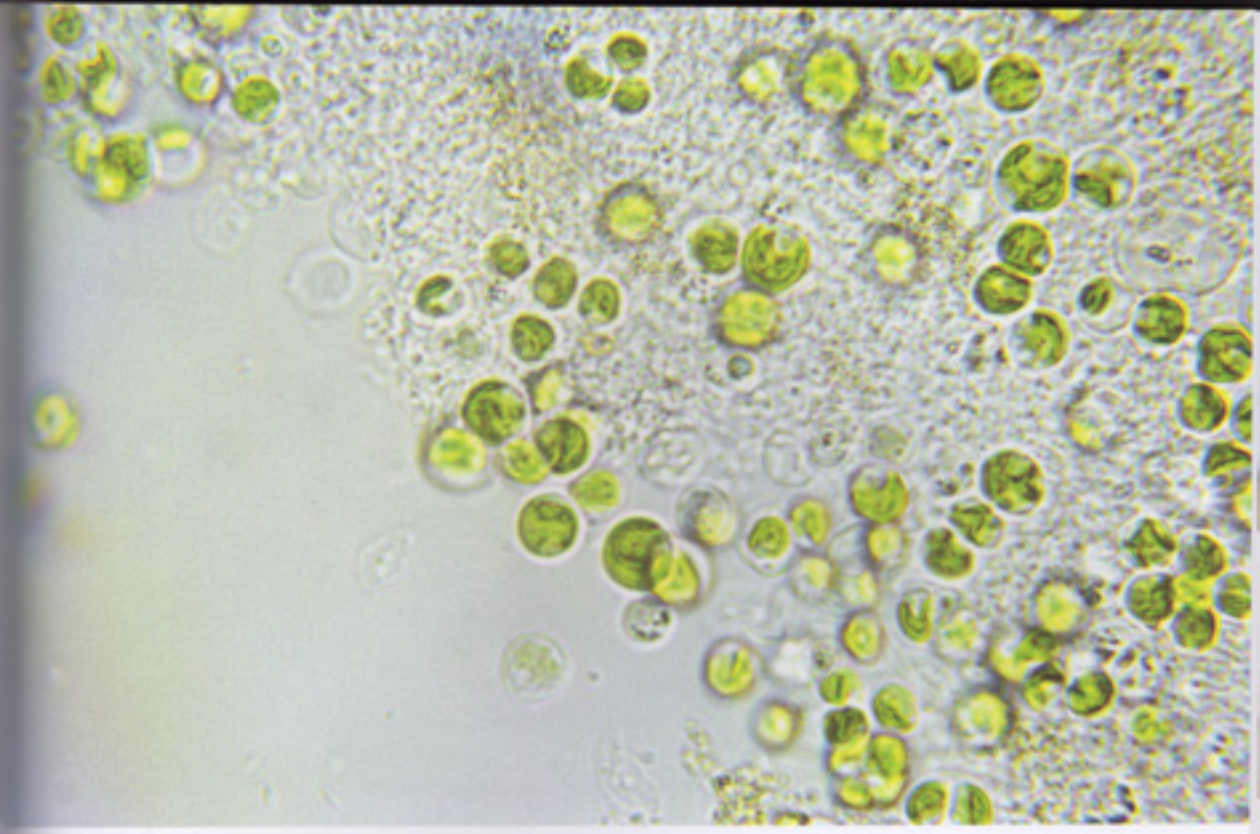
A further factor that will contribute to the successful transition to renewable energy sources will be technological advances in key components of these systems. Making solar cells more efficient, thermogenerators more cost-effective or batteries without heavy metals will provide politicians with ever stronger arguments to push forward changes to energy policies. In January 2019, for example, a commission recommended the phasing out of Germany's coal-fired power stations.

Moss FM radio
Source: Fabienne Felder

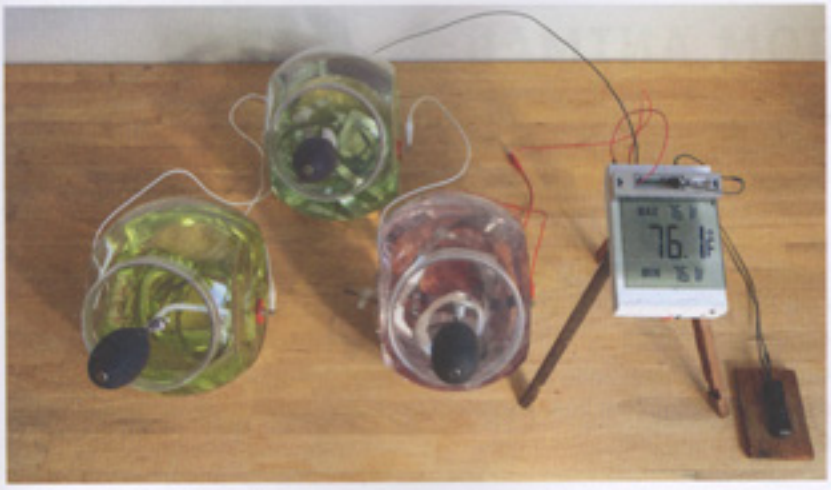
Alternatively ten moss cells can be used to power a digital clock
Source: Fabienne Felder

MOSS FM RADIO

In collaboration with scientists from the University of Cambridge in the UK, Fabienne Felder developed the world's first moss radio powered by photo microbial fuel cells (Photo-MFCs). To ensure a constant supply of energy, Fabienne Felder uses the output of photosynthesis during the day and the naturally occurring bacterial processes of plant respiration at night. Additional bacterial processes in the Photo-MFCs enable the cells to produce electricity in the dark. To generate power, an array of ten moss cells are used, equipped with a composite of water-storing, conductive and vegetable materials. To ensure a constant stable power supply, the moss cells charge a battery that powers the radio. For continuous operation, all moss cells must always be kept moist and placed in a sunny location. This is the first time an electrical device has been supplied solely by the use of plants.



Chlorella vulgaris algae under the microscope. Algae have great potential in the fields of bio-energy and health
Source: Fabienne Felder



Algae thermometer
Source: Fabienne Felder

ALGAE-OPERATED THERMOMETER

Fabienne Felder's exploration of photo-microbial fuel cells continued at Rhode Island School of Design, where she developed the world's first household electrical appliance driven by Photo-MFCs in the form of a thermometer. Microalgae are used to power a commercially available temperature sensor and LCD. It ran continuously for several months as part of the exhibition "Biodesign: from Inspiration to Integration" in the USA and was the only living exhibit.

New materials and technologies play an important role in architecture and design. Alongside environmentally friendly materials and production processes, recyclability and the circular economy are now increasingly important aspects. In addition, trends such as digitalisation, 3D printing, intelligent systems and smart materials are transforming material innovations.

In eight chapters, this book bridges the gap between science and industrial research and applications in architecture and design. It provides a compact and authoritative overview of current material innovations ranging from edible packaging or liquid light to smart natural materials. At the same time, the social dimension of such developments is taken into account.

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