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Current Developments and Examples of Sustainable Energy Technologies

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Federal Ministry
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Innovations for cool urban oases
Smart ideas for green infrastructure and against urban overheating

Given their consumption of energy and other resources and their considerable emission of pollutants, cities contribute significantly to climate change. At the same time they are the places hardest hit by its effects. Alongside air pollution, dust and noise, rising temperatures and extreme weather events such as heavy rain in cities impair the health of the inhabitants and their quality of life. To counteract these tendencies, pioneering approaches and technologies for greening buildings and implementation of green open spaces in cities are being researched and set into practice in Austria.

Biotope City
Architects: RLP Rüdiger Lainer & Partner
Rendering: schreinerkastler

Greening buildings and laying out open spaces in cities
for climate adaptation and improved quality of life

In future more and more people will inhabit urban areas around the world. Whereas roughly half of the world's population lived in cities in 2005, the current forecast is that by the year 2050 the proportion will be about two-thirds (World Urbanization Prospects UN 2018).

Urbanization and global warming are linked closely. For one thing, urban areas consume a great deal of energy and other resources, and – with their traffic levels and their concentration of industry and commerce – are among the main emitters of carbon dioxide. Then again, the effects of global warming are more drastic in cities than in less densely populated areas. The microclimate in a city is noticeably different from the climate in its surroundings. Building density, a very high percentage of impermeable surfaces, limited vegetation and substantial air pollution cause temperatures to raise. Extreme weather events such as heatwaves, strong winds, storms and torrential rain, which occur more often due to global warming, cause alarming climatic conditions and impair many citydwellers' health and quality of life.

Green urban oases

Green and open spaces can really help to adapt urban systems to global warming and permanently improve living conditions in cities. Vegetation in densely built-over zones, such as greenery on buildings, parks, green corridors, rain gardens, functional tree-planting, roadside greenery, community gardens, etc. have several positive effects: they counteract the spread of buildings and impervious surfaces, improve the microclimate and hydrological balance, mitigate the heat-island effect and help to cope with extreme weather events.

Interlinked green infrastructures in cities help to preserve biodiversity, diminish air pollution, dust, noise and carbon dioxide emissions, and save costs and energy for air-conditioning buildings. On top of this, green open spaces are important for social interaction, provide some experience of nature and encourage public initiatives and activities among citydwellers, such as "Urban Gardening" or "Urban Farming" to produce fresh and local food for one's own use.

Within the framework of the programmes City of Tomorrow (Federal Ministry for Transport, Innovation and Technology/bmvit) and Smart Cities Demo (Climate and Energy Fund) new technologies and approaches for the "green city" are constantly being developed and demonstration projects evaluated under real-life conditions. The topics range from pioneering technologies for vertical greening of buildings, via comprehensive approaches to greening existing building stock and new neighbourhoods, all the way to vertical farming strategies for growing food in cities while economizing on resources. ◘

Urban heat islands

The number of "tropical" nights in which the air temperature does not go below 20 °C is expected to increase in the next few years. In densely built-up areas the Urban Heat Island (UHI) effect – causing the air temperature within cities to rise significantly higher than in its surroundings – will become more frequent.

A number of different impact factors act as negative drivers: buildings with large flat surfaces absorb a high percentage of solar radiation, the materials used in buildings and roads act as heat storage media releasing radiant heat only very gradually, and many urban processes (involving industry, power stations, air-conditioning equipment and road traffic) emit another great quantity of waste heat.

Cities' capacity for cooling is much lower than that of peri-urban or rural areas: with little permeable surface area, rainwater soon runs off into the sewers, therefore the natural cooling caused by evaporating surfaces is not available. And an exchange of air with the city's cooler surroundings is impeded by a dense agglomeration of buildings.

On left: green roof / urban gardening, Sargfabrik
On right: best-practice example of façade greening in Vienna
Photos: GRÜNSTATTGRAU

GRÜNSTATTGRAU
The innovation laboratory for green cities of tomorrow

MUGLI, Photo: GRÜNSTATTGRAU

GRÜNSTATTGRAU is the Austrian coordinator for public and private-sector greening on buildings, linking more than 300 partners from business, science and administration together. The Austrian Association for Greening buildings (Verband für Bauwerksbegrünung / www.gruenstattgrau.org) forms the basis for it.
GRÜNSTATTGRAU was launched as the first innovation laboratory within the framework of the bmvit programme "City of Tomorrow", to promote collaboration and synergies in the research sector "Green City" and support implementing cutting-edge projects. Its activities are currently focussed on the Kretaviertel (Favoriten) neighbourhood in Vienna, and on other target areas for synergies in Graz, St. Pölten, Linz and the province of Vorarlberg. Cross-linking and collaboration between business, research and the public sector give impetus to greening buildings and urban districts throughout Austria.

The innovation laboratory is intended to:
> research and realize ways of implementing pioneering greening measures over large areas
> improve the amenity of public space by means of greening adjacent buildings
> create new plant structures in densely built-over areas
> expand the social functions of intelligently used greened building complexes and open spaces.

The innovation laboratory emphasizes shared, interdisciplinary learning and development, employing open-access methods, the mutual exchange of best-practice examples and active participation by residents. The aim is to identify new topics and strategies for green cities, and to develop these further in co-creation processes together with citizens, the administration and policymakers.

The GRÜNSTATTGRAU instruments

The greened shipping container **MUGLI** (mobile.urban.green.living.innovative) serves as a mobile experimental unit and makes the laboratory's activities and the network partners' technological innovations in a roadshow visible throughout Austria and abroad.

As a site of learning, stakeholder activation and data generation it is a key feature of the innovation laboratory.

The innovation laboratory supports various groups of stakeholders with customized **service facilities**. These include project-related services for demonstration and R&D projects, initial guidance, an exhibitor-, experts- and technology platform, certification procedures, project development, advanced training and the development of business models.

The **GRÜNSTATTGRAU online portal** is intended to serve as a platform and interface for green facilities in urban space. The website helps the network partners to exchange information, and also functions as a central reception point for the public at large.
https://gruenstattgrau.at

On left: green roof with PV in London; on right: PV over roof garden, BOKU in Vienna
Photos: GRÜNSTATTGRAU, Dusty Gedge

Green roofs and photovoltaic (PV)

New technologies make it possible to combine light-permeable PV equipment with plants. Roof greening is used throughout Europe to cool PV modules, which thus deliver more power. To research the potential of these pioneering technologies GRÜNSTATTGRAU collaborates with the **innovation laboratory act.4.energy**. The aim is to take more advantage of the synergies between roof-greening and PV in future. ◘
www.act4.energy

Biotope City
Architecture: RLP Rüdiger Lainer & Partner
Rendering: schreinerkastler

Biotope City
The city as nature

On a 5.4 ha industrial site previously used by Coca-Cola in Vienna (Favoriten) a new green neighbourhood is taking shape, with roughly a thousand flats, retail outlets and educational facilities, modelled on the Biotope City concept. This strategy developed in the Netherlands by Helga Fassbinder sets on greening cities comprehensively, so as to utilize the regenerative mechanisms of nature there as well. The aim is to improve the quality of life permanently and cost-effectively, and to enable cities to cope better with the effects of global warming.

The Vienna project is focussed on implementing a variety of pioneering greening measures that will add up to a systematic, coherent overall strategy for the very first time. Planning was carried out in a cooperative process. All the stakeholders (planners, implementers and subsequent users) share the aim of following the Biotope City model. The project can be seen as a continuation (adapted to today's circumstances) of the intentions of the Viennese architect Harry Glück, forming a model for sustainable living in urban areas.

Scientific supervision

The Biotope City site serves as an urban laboratory, research zone and field for experimenting, to investigate a variety of technological and social issues for the green city of the future and to develop pioneering approaches here. The entire process of planning and implementation has been supervised by an interdisciplinary research team headed by the University of Natural Resources and Life Sciences, employing qualitative and quantitative methods from architecture, urban development, landscape management, biological engineering, project development, assessment of buildings, resource management, social sciences and participation in combination. The research topics included new methods of estimating the effects and costs of greenery, how to adapt urban and architectural planning to living elements, or approaches to the upkeep of urban greenery involving residents. As part of supervision all steps and phases of the project were comprehensively documented.

An inhabited park

The Biotope City model is designed to transform a densely built-up city into a part of nature. On the Wienerberg site the planted surface area will be considerably larger than before, in spite of the high building density. Vertical green façades, green roofs and terraces turn the neighbourhood into a green urban landscape.

Numerous green and open spaces with planted trees, lawns, ponds and areas for allotments and communal urban gardening are being implemented between the construction sites and in the courtyards. By using a wide variety of plants and animals, biodiversity is sought. Active deployment of flora and fauna is intended to benefit the residents' health and sense of wellbeing. The wide view and the unrestricted access to the adjacent Wienerberg recreational area are an integral part of the overall strategy. ◘
www.biotope-city.net

Photo: Mischek

"We are especially proud to become part of Biotope City Vienna with our project 'HOCHH(IN)AUS – a green jewel at Wienerberg', and to play a significant part in landscaping this new district. Our project features 117 unsubsidized freehold flats right next to the Otto Benesch Park with its numerous open spaces it fits into the overall green design very well. This unique location provides the future residents with a breath-taking vista all the way to Schneeberg."

Stephan Jainöcker, CEO
Mischek Bauträger Service GmbH

STADTOASE
Urban Green and Open Space Design in “Smart Pölten”

The civic participation project STADTOASE, part of the “Smart Pölten” initiative, was launched by St. Pölten’s town council in 2017, with the aim of developing intelligent approaches and visions for designing green and open spaces ecologically and socially. The intention is to permanently safeguard the quality of life, health and wellbeing of the residents in the provincial capital of Lower Austria with technical and social innovations. Within the framework of STADTOASE the whole of St. Pölten is being transformed into an extensive testbed for pioneering greening experiments in urban space, with 15 teams of experts and 19 local firms and institutions working on this in close collaboration. Numerous green open spaces and meeting-places will take shape in different parts of the town, to facilitate experiencing nature and new green technologies:

> Mobile Urban Pocket Gardening, Floating Gardens
> demonstrations of the “edible town” (e.g. Mush.Room – growing mushrooms in the dark, a raised bed utilizing natural cycles, edible baroque garden with four-field rotation, fruit paths)
> green walls/green street furniture (e.g. living-room gardens in the form of furnished timber decks under awnings with edible plants and a drinking fountain)
> climate research laboratory for children

Multifunctional green spaces

The actual design of the STADTOASE will be worked out by the project partners in a participative process with residents. For this the council provide so-called “multifunctional green spaces”. Interdisciplinary project teams generate exemplary prototypes which are then discussed in citizen workshops, assessed and finalized for subsequent implementation. Among them are routes leading through the town from one demonstration green stepping-stone to the next. Here new green techniques of protecting against wind, dust and noise will be demonstrated, along with cooling green structures and vegetation to illustrate the idea of the “edible town”. At the same time these demonstration green zones should serve as places to meet and communicate.

Climate research laboratory

A site container with outside greenery to improve the microclimate and with climate monitoring instrumentation serves as a research laboratory for green structures in urban areas. Here mobile instruments, experiments and climate games are provided specially for children and young people.

Monitoring & Social Impact

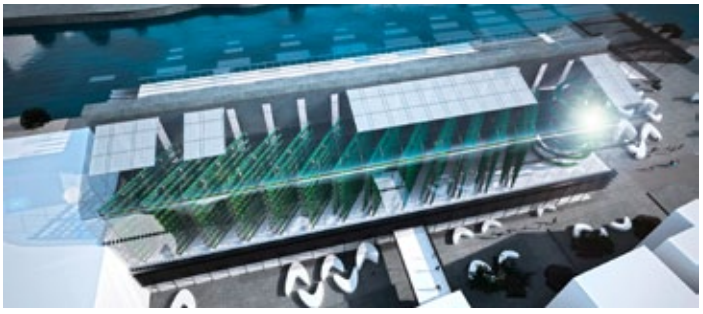
To measure climate indicators such as air temperature and humidity, monitoring stations are set up at various points in town. The aim here is not just to document the effects of green structures on the microclimate, but also to identify social factors and causal interrelations. To do this, sociological surveys are carried out, particularly with the target groups most affected by the Urban Heat Effect, i.e. children and elderly residents. In the course of the project a model for discussing and assessing the social impact of measures to shape green and open spaces and their social return on investment (SROI) will be developed. ◘

www.stadt-oase.at

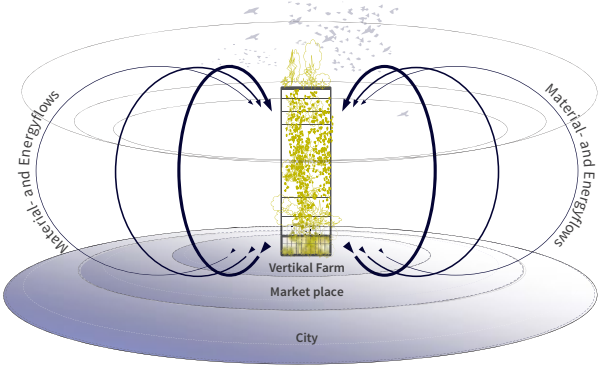
All photos: STADTOASE – on the way to Smart Pölten

Neue URBANE FREIRÄUME Stadtoasen

Further information on “urban oases” can be found on a new website sponsored by the Climate and Energy Fund: **www.slaw-smartcity.at**



Both renderings: vertical farm planned in Innsbruck, source: vertical farm institute



Source: vertical farm institute

Vertical Farming
Sustainable food production in urban areas

How will the cities of the future be supplied with fresh, high-quality food in a sustainable way? It takes about 2,300 m^2 of cropland to feed one person for a year, equivalent to 10 m^2 of cropland per each square metre of the city. Producing food is energy-intensive and relies today mainly on fossil sources of energy. As populations increase and cities grow, we shall need new ways of producing food in a sustainable way, to counteract the exploding consumption of land and energy. Part of the solution is to produce food where it is consumed.

Growing vegetables in cities

Vertical farming is a pioneering technique of producing food locally in densely built-over areas. Cultivating crop plants arranged vertically could help to reduce the area of land needed to produce food for cities and to make cities more energy-efficient overall. Vertical farming buildings are closed systems in which fresh products are cultivated in stacks with various different methods of production. Yields from levels one above the other can be higher than from a comparable area on the ground.

Several climate zones develop in these vertical stacks, and the distribution of daylight is not uniform; so suitable conditions for different crops can be created in a confined space throughout the year. However, state-of-the-art technology is essential for this. To achieve energy and resource-efficient production, the various cycles of use must be adjusted to each other and fine-tuned.

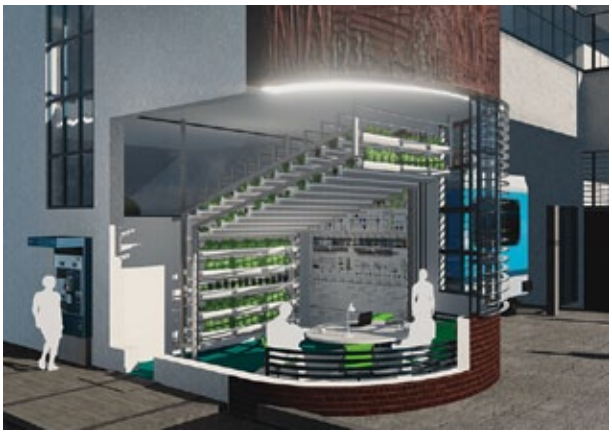
Space and energy requirements

Recent research findings show that vertical farming leads to drastic reductions in land use. Theoretically, one square metre of

„We stand for food production within urban spaces, independent from fossil fuels. With vertical farms we see the possibility not only to reduce the consumption of resources but also to close energy loops. Regional, organic products have to be produced next to the consumer. Food production within cities will become a part of daily urban life again."

Daniel Podmirseg
CEO vertical farm institute

Photo: vertical farm institute



Both renderings: vertical farm "Pixel" planned in Tabakfabrik Linz , source: vertical farm institute

ground can be used for a large multiple of this area. Per square foot of vertical farm area, 50 square foot of cropland outdoors could be replaced. Vertical farming needs energy for light, warmth and cooling. The aim is to operate the farms with renewable sources of energy, thus achieving a closed cycle. Energy consumption can be reduced if suitable crop plants are combined and suitable crop rotation sequences are developed.

If the type of building and the plants selected do not match properly, though, energy consumption will be far too high and it will not be possible to cover requirements with renewable sources of energy. For instance, it turns out that it does not make sense to provide artificial light for tomatoes in a vertical farm, even if ultra-efficient LEDs are used.

R&D for the vertical farm

In Austria the trailblazer in this sector is the vertical farm institute, that is linked in an international research network. In Austria it works on feasibility studies for vertical farms. In an exploratory project the fundamentals for developing a prototype vertical farm for Vienna are currently being worked out; here the vertical farm institute is collaborating with the Institute of Buildings and Energy at Graz University of Technology, the Department of Crop Sciences at the University of Natural Resources and Life Sciences in Vienna, and with SIEMENS as a partner from industry.

Issues to do with plant physiology and types of architecture are being investigated, the potential of climatic conditions analysed and answers to questions in the fields of building, communications and control engineering found. The aim is to develop a hybrid building design combining vertical farming with accommodation and office use. The important question here is to what extent the energy flows involved in these three functions can complement each other, and how large the resulting synergies are. ◘

www.verticalfarminstitute.org

URBAN COOL DOWN

Cool spots in densely built-over urban neighbourhoods

When the city really overheats, what can help to cool down? In the project Urban Cool Down ways to help citydwellers suffering from heat and new ideas for cool spots in densely built-over areas were developed. The project team concentrated on Innerwähring, a Viennese district dating from the late nineteenth century with not much green. Here cartographic methods were used to display the findings from sociological surveys of the residents' subjective sensation of heat.

A variety of approaches for cooling were discussed in the district, and new and old cooling technologies (such as green shade roofs for markets, green awnings for shops, living façades, green paravents, etc.) were presented. In the summer of 2017, 13 actions and awareness-raising interventions in Vienna and in Wolkersdorf/Lower Austria took place. Interested dwellers were able to get to know the approaches, take an active part and table own ideas for innovative urban greening. ◘

http://urbancooldown.mk-landschaftsarchitektur.at

Photos: Mira Kirchner, MK Landschaftsarchitektur

Susanne Formanek and Vera Enzi
Innovation laboratory GRÜNSTATTGRAU

You are both experts on green infrastructure and nature based solutions. Are pioneering approaches to greening suitable for widespread use in new buildings and renovation projects?

Yes indeed, particularly with new buildings there is a comprehensive range of standardized technologies for greening both roofs and façades. And provided that they are tied into the planning process early enough, an excellent cost-benefit ratio can be ensured, since greened façades can be cheaper to maintain than glass façades. Quality control is vital here. We're putting increasing effort into the much more complex structures involved in retrofit. To green an existing building one has to adapt the ideal technological solution to the specific project framework; obstacles must be overcome in the fields of connecting technologies, law, permits, keeping costs down and funding.

What effect does greening façades and roofs have on the quality of buildings and of living in them?

Living buildings offer positive effects in the fields of energy, water, microclimate, economy, ecology, quality of life and the environment. Buildings gain from greening because it can act as a protective skin and provide thermal insulation. The building's life span is extended, and the cooling ratio needed can be reduced and maintenance costs lowered if greening is combined with providing shade. A look ahead into the future: more and more use is being made of smart technologies and components with digital functions in buildings (cf. "Smart Readiness Indicator (SRI)" as per the new EU directive on buildings).

How much potential do you see for greening façades and roofs in Austrian towns and cities?

In Austria more than 40 % of the building stock dates back to before 1930, and 35 % was put up in the 1960s to 1980s. Renovation projects are essential to reduce carbon dioxide emissions, and greening structures will play an important part in saving and providing energy, and in improving microclimates. From an economic point of view greening is very attractive, particularly as combining it with PV or solar panels can boost energy yields while lowering ambient temperatures and retaining water in a town or city. Together with the University of Natural Resources and Life Sciences, AIT, the City of Vienna and our partners in the Austrian Association for Greening buildings we are currently investigating the potential for greening buildings in reference areas, with the long-term aim of developing new public cadastre systems for potential and existing buildings for Austria.

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