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EVAPO+ Transpiring Green Walls – a Demonstration on How to Maximise the Evapotranspiration Effect to Cool Down our Microclimate

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1 ABSTRACT

It is undeniable that climate change effects are impacting our daily lives and need to be considered when shaping our living environment and therefore also included in matters of spatial and landscape planning. Climate change adaptation measures mostly address climate change effects in large cities – such as overheating and urban heat islands. New approaches and solutions to improve liveability and to act against the consequences of climate change are required – not only in big cities but also in smaller towns and rural communities.

Nature-based-Solutions (NbS) can tackle some of the most pressing urban environmental and societal challenges such as urban heat islands and by fostering adaptation to climate, halting biodiversity loss and promoting public health and social cohesion. Green and blue infrastructures are considered to be a form of urban sustainability as they not only reduce temperatures and other urban environmental effects, but also improve air and water quality, reduce stormwater runoff, and attract pollinators. Vertical greening and green walls have many advantages and combine a positive effect on the environment and microclimate with an improvement in the quality of life in urban areas.

During the research project “Strasshof. Klimafit!” a concept for “EVAPO+ transpiring green walls” was developed. In comparison to other forms of vertical greening, the EVAPO+ transpiring green walls have a particularly high cooling effect and primarily serve as natural air conditioning in the outdoor area. The name “EVAPO+ transpiring green wall” is derived from the term evapotranspiration, which is the evaporation from plants, water, soil and substrates. EVAPO+ green walls increase and maximise evapotranspiration and thus contribute more effectively than other green wall systems to cooling the microclimate surrounding us.

With the EVAPO+ transpiring green walls which have been innovatively developed, the quality of stay can be improved at many locations in microclimatic areas. Essential functions of green infrastructure and nature-based solutions, such as creating shaded spaces as well as reducing the reflection of incoming solar radiation and cooling of the surrounding environment through evaporation can additionally be strengthened.

Keywords: urban heat island, example, green infrastructure, microclimate, evapotranspiration

2 BASELINE

2.1 Climate Change and Urban Heat Island Effect

It is undeniable that climate change effects are impacting our daily lives and need to be considered when shaping our living environment and therefore also included in matters of spatial and landscape planning. Climate change adaptation measures mostly address climate change effects in large cities – such as overheating and urban heat islands.

The urban heat island (UHI) effect is a phenomenon in which urban areas experience higher temperatures than surrounding rural areas due to urbanisation and human activities. It mainly occurs due to the high percentage of sealed surfaces, asphalt roads and the density of high buildings. These surfaces heat up a lot when exposed to sunlight, and the lack of plants, green areas and unsealed ground means that little water can evaporate to cool the surroundings. Due to the high percentage of sealed surfaces, evaporation is reduced while the solar irradiation on building and road surfaces is stored at the same time. With climate change, the number of very hot days (temperatures exceeding 30°C) increases, and the heat island effect additionally causes an increase in temperature. The UHI effect can cause significant warming of the local climate and can

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be especially troubling during summer heatwaves when temperatures are particularly hot. It is therefore necessary that we adapt our urban construction methods to keep the UHI effect as low as possible. This can be achieved, among other things, through shading, planting and evaporative cooling.

Due to the fact that the population in communities surrounding large cities is constantly growing, small towns and rural communities are burdened with severe influx and, as a consequence, densification and a growing percentage of sealed surfaces to create housing and infrastructure. This causes a loss of green areas which in turn intensifies the consequences of climate change. For this reason, even, in small towns and rural communities, there is a need to take measures to counteract climate change effects, such as heat waves, drought and heavy rain.

New approaches and solutions to improve liveability and to act against the consequences of climate change are required – not only in big cities but also in smaller towns and rural communities.

2.2 Nature-based Solutions and Green Infrastructure

Nature-based solutions (NbS) and green infrastructure (GI) are both approaches used to address environmental challenges and promote sustainability. While there is some overlap between the two concepts, they have distinct characteristics and areas of focus.

Nature-based solutions (NbS) refer to the use of natural processes and ecosystems to tackle societal and environmental challenges. NbS leverage the power of nature to provide sustainable and cost-effective solutions. They involve the conservation, restoration, and management of ecosystems and biodiversity to deliver multiple benefits, including climate change mitigation, adaptation, and disaster risk reduction. NbS can take various forms, such as reforestation and afforestation projects, wetland restoration, coastal management initiatives, and urban greening efforts. These solutions often mimic or restore natural processes, enhancing ecosystem services like water purification, flood regulation, carbon sequestration, and habitat provision. NbS are designed to be resilient and adaptive to changing conditions, providing long-term benefits for both humans and the environment. NbS can tackle some of the most pressing urban environmental and societal challenges such as urban heat islands, fostering adaptation to climate, halting biodiversity loss and promoting public health and social cohesion. Over the last decade, NbS have increasingly been promoted as cost-efficient, no-regret solutions to address urban challenges in cities. The benefits nature delivers have been highlighted in European and international frameworks such as the EU Biodiversity Strategy for 2030, the Urban Agenda 2030 or others. The successful implementation of NbS depends on a sound knowledge and understanding of NbS, the complex processes of natural systems and NbS design features and options. Whilst scientific evidence of the multifunctional benefits of NbS is plentiful and well-documented, and technical knowledge on NbS design and implementation abundantly available, there is a lack of coherent, market-orientated and scalable models for local NbS design and implementation.

On the other hand, green infrastructure (GI) refers to a strategically planned network of natural and semi-natural spaces that conserve ecosystem values while also supporting human needs. It is a systematic approach to land use planning and design that incorporates natural elements into urban and rural areas. In the context of EU policies, GI is defined as "A strategically planned network of natural and semi-natural areas with other environmental features, designed and managed to deliver a wide range of ecosystem services, while also enhancing biodiversity." (Directorate-General for Environment) GI aims to create a multifunctional network of green spaces that provide various environmental, social, and economic benefits. GI includes features like parks, forests, wetlands, green roofs, urban gardens, permeable pavements, and green corridors. These elements help manage stormwater, reduce urban heat island effects, enhance air quality, provide recreational opportunities, support biodiversity, and improve the overall quality of life in cities and regions. Green infrastructure is often integrated into urban planning processes to create more sustainable and resilient communities.

GI also includes vertical greening, such as complex façade-bound greening or ground-bound greening in outdoor areas, which are effective countermeasures. Because vertical greening hardly requires any additional space, it offers great potential for further application, especially against the background of urban densification. Green walls have many advantages: as a "natural air conditioning system", they cool the ambient temperature, absorb rainwater (water retention), improve air quality (pollutant filtering, fine dust binding, air purification, oxygen production, CO2 binding), reduce noise, create habitat for birds and insects

(biodiversity), protect buildings from negative external influences (weathering, heat, cold, UV radiation, rain), energy costs for air conditioning in summer and heating in winter can be saved. In addition, the aesthetic value of green walls has multiple positive effects on our well-being. The quality of life and housing of the urban population in their direct living and working environment is increased. Vertical greening therefore combines a positive effect on the environment and microclimate with an improvement in the quality of life in urban areas.

Both – NbS and GI – are a form of urban sustainability as they not only reduce temperatures and other negative urban environmental effects, but also improve air and water quality, provide space for recreation, reduce stormwater runoff, and attract pollinators – all in all they help greatly with climate mitigation and adaptation. For the sake of completeness, blue infrastructures are infrastructures with visible “blue” in the form of water. This can be e.g., artificial, newly created ponds, water areas or water features. On the other hand, this also includes existing natural bodies of water. The connection of green (land) and blue (water) infrastructure has many advantages for the quality of the environment and natural areas and improves people’s health and quality of life. In view of the constant loss of inner-city green spaces with increasing global climate change, which leads to urban heat islands, especially in cities, greening of buildings is becoming increasingly important. While nature-based solutions and green infrastructure share a common goal of utilising nature for environmental benefits, the main difference lies in their scope and focus. Nature-based solutions encompass a broader range of approaches that can address diverse environmental challenges, including climate change and disaster resilience. Green infrastructure, on the other hand, primarily focuses on urban and regional planning, emphasizing the integration of natural elements into human-made environments. Nature-based solutions and green infrastructure are complementary approaches that leverage the power of nature to promote sustainability. Nature-based solutions encompass a broader range of approaches for addressing environmental challenges, while green infrastructure primarily focuses on integrating natural elements into urban and regional planning to create sustainable and resilient communities.

3 STRASSHOF. KLIMAFIT! – A LIGHTHOUSE DEMONSTRATION PROJECT

3.1 About the project

“Strasshof. Klimafit! Strasshof as a lighthouse: EVAPO+ green walls, green infiltration troughs, empowerment and practical transfer” is a lighthouse demonstration project that stimulates processes for climate change measures by empowering other municipalities and small towns. The project aims to implement resilient, multifunctional and "climate-fit" solutions that respond to heat and heavy rain, improve the microclimate, increase the quality of life and living while promoting biodiversity in existing areas of the municipality Strasshof an der Nordbahn in Lower Austria. With these measures, the municipality of Strasshof can act against climate change consequences and improve the liveability of the population. The transferability of the demonstrations will be guaranteed with the help of various regional, national and international exchange forums. In cooperation with other Austrian municipalities, the lessons learned from Strasshof will be reflected and transferred to the regional network "Climate-Fit Small Towns and Municipalities" along with step-by-step instructions for climate-fit municipalities.

The project is funded by the Austrian Climate and Energy Fund, Klima- und Energiefonds, under the Smart Cities Initiative in Austria, from April 2022 to March 2025.

3.2 About the municipality

Strasshof an der Nordbahn is located about 25 km northeast of Vienna (Austria) in the political district of Gänserndorf and is part of the northern Marchfeld region in the province of Lower Austria. Originally planned and laid out as a Viennese suburb as a kind of "garden city", the settlement had only about 50 inhabitants around the year 1900. With the construction of a marshalling yard of the northern railroad in Strasshof, the economic upswing began in 1906. In recent decades, the town has developed rapidly, and, with 11,786 inhabitants (as of January 1, 2023), it is by far the largest town in the Marchfeld region. With an average population density of 1,012 inhabitants per square meter, the municipality has a compact settlement area. With the help of construction bans, Strasshof has already been taking on municipal tasks that have become pressing in recent years due to enormous population growth. Equally urgent still is the development of climate change-adapted strategies, through which the community can prepare for changing climatic conditions. Since 1999, Strasshof an der Nordbahn has been an active climate alliance municipality with the

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goal of continuously reducing greenhouse gas emissions because it is becoming increasingly important for municipalities to improve the quality of life and standards for their citizens by running projects that fulfil their targets.

4 EVAPO+ TRANSPIRING GREEN WALLS IN STRASSHOF

In the course of the project Strasshof. Klimafit! a concept for "EVAPO+ transpiring green walls" was developed. In comparison to other forms of vertical greening, the EVAPO+ transpiring green walls have a particularly high cooling effect and primarily serve as natural air conditioning in outdoor areas. EVAPO+ transpiring green walls consist of a horizontal vegetation carrier with a continuous vertical substrate body that increases evaporation of the substrate, provides more root space for plants and thus more leaf mass and transpiration. The substrate in the vegetation carrier in addition to the plants causes higher evaporation rates. This technique in combination with automatic irrigation systems leads to greater leaf mass of the plants and therefore higher transpiration. Overall, they increase evapotranspiration, which serves to cool the surrounding area. The irrigation system of the vertical substrate level has a relatively high-water absorption capacity and releases the water slowly. Automatically weather-controlled, this level is watered more on warm and hot summer days. To reduce the top-bottom gradient of green walls, where top and side areas tend to be too dry, a special version of the automatic irrigation system is used. EVAPO+ transpiring green walls make a significant contribution to the adaptation of urban spaces to climate change.

The name “EVAPO+ transpiring green wall” is derived from the term evapotranspiration. Evapotranspiration is the transpiration from plants and evaporation from water, soil and substrates. EVAPO+ green walls increase and maximise evapotranspiration and thus contribute more effectively than other green wall systems to cooling the microclimate surrounding us.

The EVAPO+ transpiring green walls fulfil multifunctional effects on different levels. In addition to microclimatic effects, these effects are in particular:

- As a space-dividing element, the green wall (in a free-standing variation) can counteract conflicts of use at busy open spaces and create protected areas.
- Due to the continuous vertical substrate layer and plant cover, the green wall absorbs sound and can provide low conflict use and pleasant quality of stay as noise protection is provided along roads or playgrounds and sports fields.
- The plants and the moist substrate surface bind dust and harmful air particles and thus increase the quality of stay in the vicinity.
- Plants have a calming psychological influence on people and thus increase well-being and the quality of stay in the open space.

Three different types of EVAPO+ transpiring green walls have and will be implemented as demonstration objects in Strasshof an der Nordbahn as microclimate-improving measures which have been further optimised with regard to evapotranspiration cooling effects, leading to a better quality of life and supporting biodiversity:

- Public buildings: The first EVAPO+ green wall was implemented on the east-facing roof terrace of the municipal office in Strasshof.
- School/outdoor classroom: The implementation of another green wall is planned in combination with a pergola at a school site in Strasshof.
- Central public area: The implementation of a free-standing green wall in combination with seating in a central public area in Strasshof is currently being discussed.

4.1 Construction details

EVAPO+ transpiring green walls belong to the wall-bound façade greening categories. Compared to ground-based and trough-based vertical greening with climbing plants, wall-bound vertical greening can increase microclimatic effects.

The special characteristic of the innovative EVAPO+ transpiring green wall is a horizontal vegetation carrier with a continuous substrate body. This enormously increases the evaporation of the substrate. In addition, the

larger root spaces in EVAPO+ transpiring green walls allow for more developed plants, which leads to greater leaf mass and thus increases the transpiration of the vegetation. This results in the effect of an overall increased evapotranspiration, which cools the surrounding area.

To increase evaporation, the EVAPO+ transpiring green wall has a special design with two different substrate levels and two separate water circuits. The substrate, which runs vertically through the entire construction as a base for the greening, is designed like a gabion wall with a technical, structurally stable, and humus-free substrate in a grid structure and provided with its own irrigation circuit.

The actual plant and substrate level in front is lined with a knobbed layer made of HDPE plastic as constructive wood protection and a layer of geofleece on top. It is filled with a substrate mixture for intensive roof gardens. Watering is automatic via drip hoses running horizontally in the plant troughs.

The following visualisation shows in detail how the EVAPO+ transpiring green wall is constructed and layered. To highlight is the continuous substrate body at the back of the green wall.

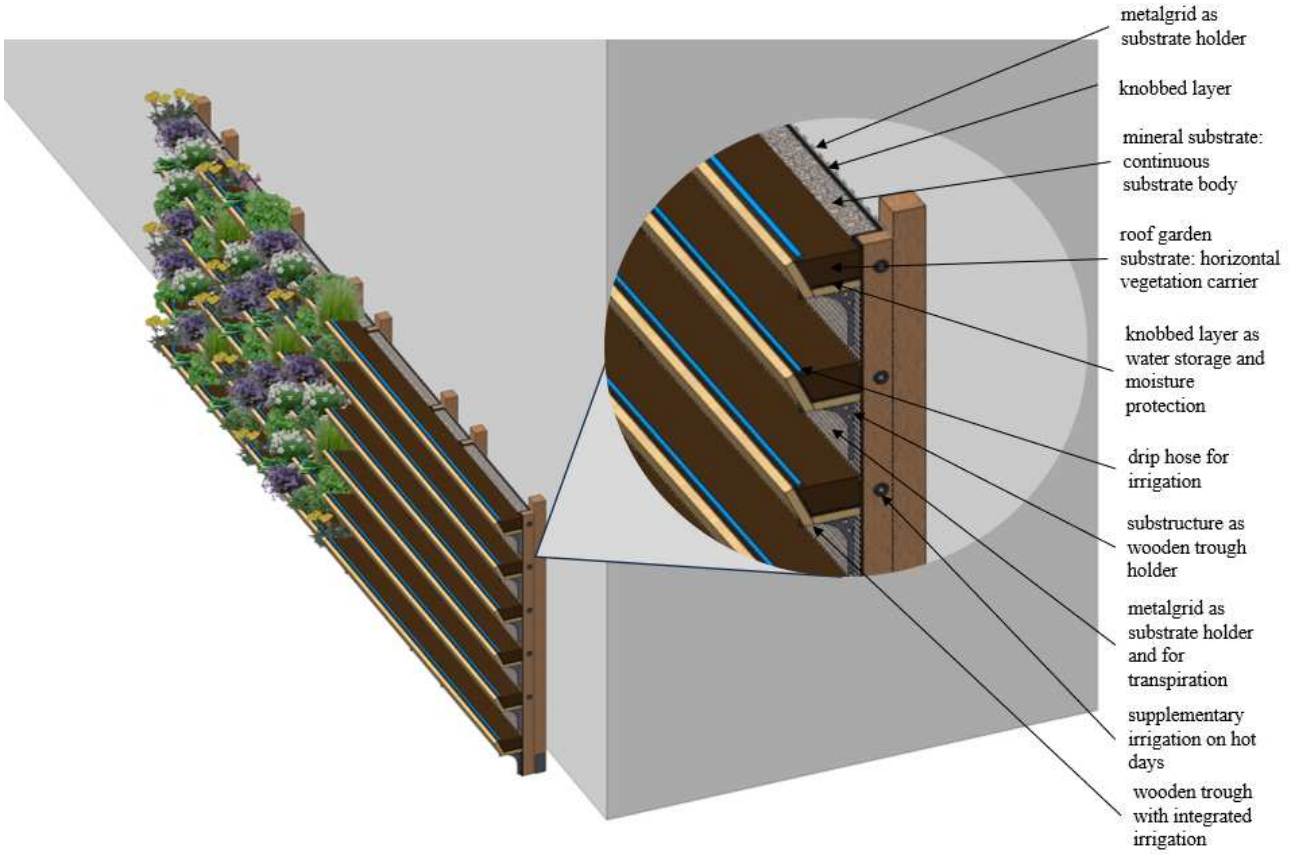

Fig. 1: Illustration of the EVAPO+ transpiring green wall on the roof terrace of the Strasshof municipal office building

4.2 Plants and rhizosphere

The root area is a crucial growth criterion for the plant. The planting is carried out with robust, perennials and herbs. A root space of 1.5 litre of roof garden substrate is available per plant in the vegetation level with the plant troughs alone. In the underlying, vertically continuous substrate level, additional root space can be developed by the plants. According to the standard (ÖNORM L 1136) for full-surface wall-bound green roofs, the minimum dimensions of one litre of available root space per plant is required which is thus well surpassed. The plant substrate consists of a mixture of organic or mineral components that form the vegetation layer. A combination of ready-to-use materials such as crushed bricks and pumice, and filling materials such as sand and compost with an admixture of perlite, is applied.

4.3 Irrigation system

To optimise the performance of EVAPO+ transpiring green walls in dry periods and hot summer days two automatic irrigation systems for the rear substrate are designed. The first type of automatic irrigation system has a relatively high-water absorption capacity and releases the water slowly. The other type of irrigation

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system is automatically weather-controlled. This means, the substrate is watered more on warm and hot summer days. This special irrigation system causes an increase in evaporation via the substrate surface on hot days and a reduction in the top-bottom gradient of green walls where top and side areas tend to be too dry on hot days. The substrate consists exclusively of mineral fractions with a grain size of 2 to 8mm, a maximum water capacity of 40% by volume and a water permeability mod. Kf of 0.68 cm/s.

The following illustration shows the two automatic irrigation systems: the main irrigation system for plantgrows in the horizontal vegetation carrier respectively the front substrate level and the additional irrigation system for hot summer days integrated in a continuous vertical substrate body (rear substrate level).

Fig. 2: Separate water circuits for watering the EVAPO+ transpiring green wall on the roof terrace of the Strasshof municipal office building

4.4 Demonstration 1: EVAPO+ transpiring green at the terrace of the municipal office

The EVAPO+ transpiring green wall is built on the east-facing roof terrace of the Strasshof municipal office and attached to the façade. The green wall is 6m long and 2.40m high. The frame construction for the green wall is made of larch wood, which forms the substrate and plant carrier in the form of rows arranged one on top of the other. Over 300 plants were used. The following plant species (perennials and herbs) where planted in the Demonstration 1 EVAPO+ transpiring green wall: Alchemilla sericata, Allium schoenoprasum, Armeria maritima, Aster ageratoides, Bergenia cordifolia, Dianthus deltoides, Geranium wallichianum, Geranium x cantabrigiense, Geranium sanguineum, Geranium pratense, Iris x barbata-nana, Levisticum officinale, Melissa officinalis and Thymus x citriodorus.

Fig. 3 and 4: EVAPO+ transpiring green wall on the roof terrace of the Strasshof municipal office

Most perennials are deciduous. About a third of the perennials are evergreen so that a relatively green wall can be seen, even in winter.

Fig. 5: EVAPO+ transpiring green wall on the roof terrace of the Strasshof municipal office building

4.5 Demonstration 2: EVAPO+ transpiring green as part of a newly built outdoor classroom

In the Middle School in Strasshof, an outdoor classroom is currently under planning. This design will combine an EVAPO+ transpiring green wall with a pergola construction providing additional shade through climbing plants. The climbing plants form a ground-based vertical greening with climbing frames and aids.

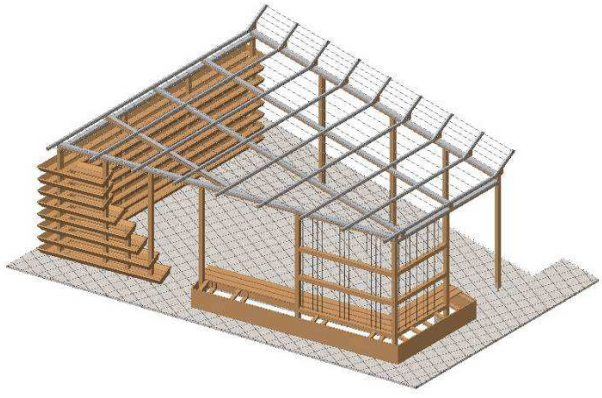

Fig. 6 and 7: Construction details and visualisation of a draft of the outdoor classroom with EVAPO+ transpiring green wall

The EVAPO+ outdoor classroom will be set up near a south-east-facing large window area of the school building to produce shade and a cooling area for the school library, while creating a cool outdoor lounge for school lessons and breaks. In addition to the microclimatic advantages of the EVAPO+ green wall, climbing plants will be applied to the pergola on stainless steel cable elements and thus reduce the solar input into the school building. The deciduous climbing plants shade the library in summer and let the sun through in winter after the leaves have fallen.

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Compared to the wall bound EVAPO+ transpiring green wall at the Strasshof municipal office, the EVAPO+ transpiring green wall within the outdoor classroom will be two-sided, meaning that both sides of the free-standing wall will be filled with plants. For that purpose, wide plant troughs are embedded in the pergola construction, which creates the possibility of two opposing vertical vegetation areas. Partitions with structurally stable technical substrates in grid structures are also installed in the middle of the plant troughs to increase evaporation.

The following visualisation shows in detail how the EVAPO+ transpiring green wall within the outdoor classroom at the Middle School in Strasshof is constructed and layered. To highlight is the double-sided design of the free standing wall.

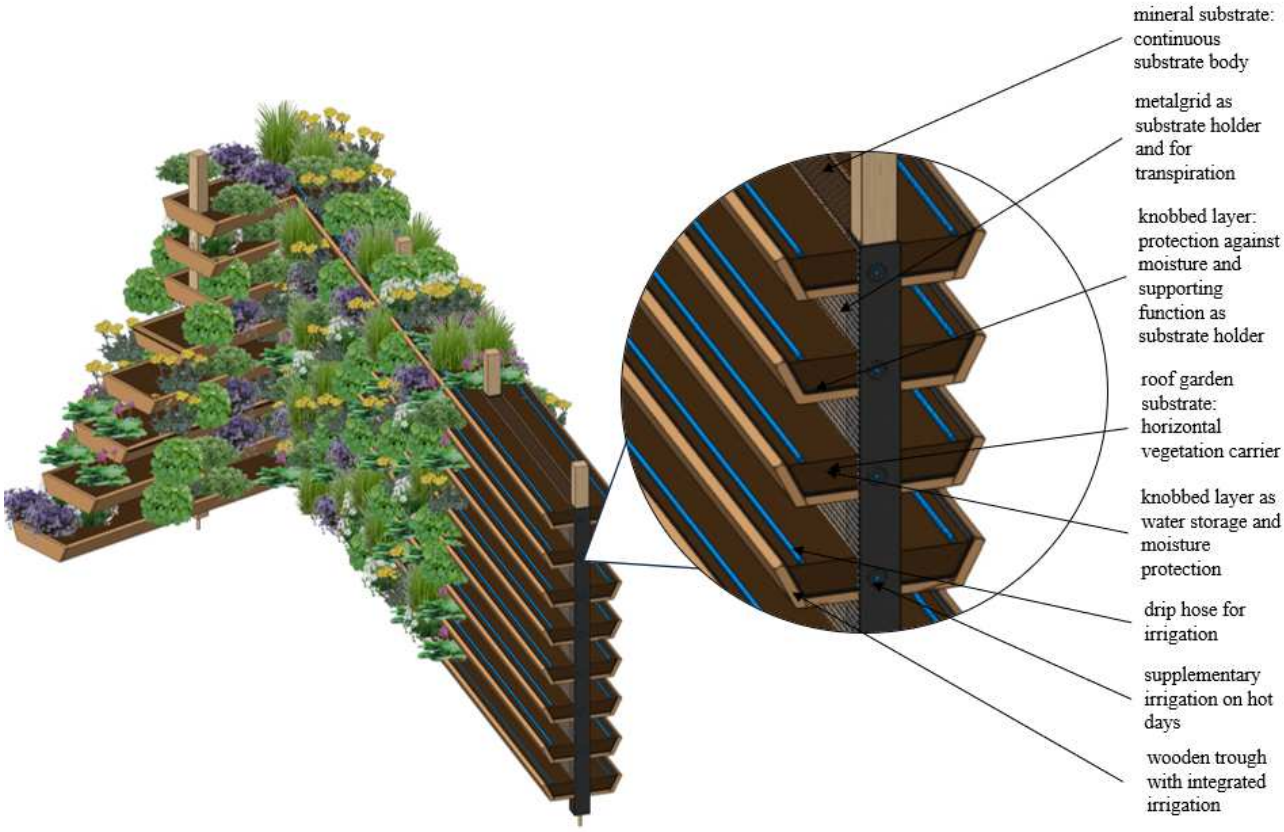

Fig. 8: Construction of the EVAPO+ transpiring green wall within the outdoor classroom at the Middle School in Strasshof

The EVAPO+ outdoor class will be designed using versatile perennial planting that will be home to a wide variety of flowering and fragrant perennials as well as herbs and, if desired, fruit or vegetables for cooking classes.

The outdoor classroom includes several categories of vertical greenery. The EVAPO+ transpiring green wall is a combination of wall-bound vertical greening with partial vegetation and wall-bound vertical greening with full-surface vegetation supports. The vertical greening with climbing plants is surrounded by a wooden border respectively a trough without a bottom. It is only recognisable as ground-based vertical greening at second glance.

The excess irrigation water of the EVAPO+ transpiring green wall is directed into the root area of the climbing plants via an underground supply pipe. Generally, there is a natural irrigation through rainwater and groundwater extraction in the case of ground-based vertical greenings.

The irrigation of the EVAPO+ transpiring green wall will be combined with rainwater harvesting (sustainable rainwater management, careful use of potable water). To save tap water for watering the EVAPO+ transpiring green wall, the installation of a rainwater tank is planned. The rainwater storage tank will receive the precipitation water from the roof of the school building. With the potential to use rainwater for irrigation, the goals of sustainable rainwater management and more careful use of drinking water can be achieved. Irrigation is carried out with low pressure and drip hoses and can thus also be fed with rainwater in public spaces.

Construction work started during the school summer break 2023. With school starting again in September 2023, the plants will be added with the participation of students, so that the EVAPO+ outdoor class will be ready to use starting in autumn 2023.


Fig. 9 and 10: Ground construction/substructure of the EVAPO+ transpiring green wall within the outdoor classroom at the Middle School in Strasshof

5 CONCLUSION AND OUTLOOK

EVAPO+ transpiring green walls are a version of vertical green walls that can be seen as nature-based solutions and form a part of green infrastructures. Through the increased evapotranspiration, essential functions and benefits of green infrastructure and nature-based solutions are enhanced. EVAPO+ transpiring green walls are an easy solution to improve microclimates by cooling the surroundings, improving air quality and quality of stay for different users in urban open areas. They also lead to improvements in urban infrastructures, and in the settings of living and working spaces, etc. The innovatively developed EVAPO+ transpiring green walls can improve the quality of stay for many varying locations: they come in different shapes and sizes and can be combined with other built infrastructures (see outdoor classroom). EVAPO+ green walls can be used e.g., as wall-bound vertical greenery on buildings, in combination with pergola constructions to produce shade, or as free-standing room dividers, for example for terraces and seating areas. Furthermore, the choice of plants can be adapted to individual needs and situations. The evapotranspiration effect increases of course with the size of the EVAPO+ transpiring green wall. Generally, the team aims for construction heights of a maximum of 4 to 5 meters.

The developments around the EVAPO+ transpiring green walls aim to create the most robust, resilient vertical greenery possible in the immediate living and working environment and have exceptional microclimatic advantages. To prove these advantages, the EVAPO+ transpiring green walls will be monitored throughout the project. Measurable goals include microclimatic effects and positive effects regarding rainwater management. Further, it will be important to monitor the quality of stay for the immediate users. The following measurements will lead to a monitoring of the anticipated effects:

- Microclimatic effects through shading and evapotranspiration of the plants and the substrate body. Measurement sensors have been and will be installed and will measure temperature, humidity, and solar radiation through the entire duration of the project for monitoring. The results will be compared to reference measurements.
- To monitor the use and impact on the users, surveys will capture discernible effects of the EVAPO+ transpiring green walls on summer/heat days. Various needs and possible uses and applications of the green wall will be considered. Attention will also be paid to different needs and possible conflicts of use and interest.

Overall, the EVAPO+ transpiring green walls demonstrate an easy way to cool down microclimates with aesthetic effects. The increased and resilient transpiration effect of the plants, together with the evaporation over the extensive substrate surface, creates a particularly efficient evaporation coolness. Further, the vegetation develops much better and is many times more resilient than all wall-bound vertical green walls

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available on the market, even in the event of disruptions or failure of the irrigation system. The demonstrations in Strasshof an der Nordbahn provide a good example for other municipalities or locations.

6 REFERENCES

DIRECTORATE-GENERAL FOR ENVIRONMENT: Green infrastructure. Available online at https://environment.ec.europa.eu/topics/nature-and-biodiversity/green-infrastructure_en, checked on 06/23/2023.

FECHNER, Johannes; Mayr-Ebert, Michael (2020): Regenwasser in der Stadt. Technologie Report. Edited by Wirtschaftsagentur Wien. Wien. Available online at https://wirtschaftsagentur.at/fileadmin/user_upload/Technologie/Factsheets_T-Reports/Technologiereport_Regenwasser_in_der_Stadt_DE_WEB.pdf, checked on 10/13/2021.

KNOLL, Bente; Renkin, Agnes; Fleischmann, Michael; Knasmillner, Elisabeth; Hiller, Andreas; Dopheide, Ralf; Schiefermair, Fabian (2022): Spatial and Settlement Development Adapted to Climate Change in Strasshof an der Nordbahn (Lower Austria). In: 27th International Conference on Urban Planning and Regional Development in the Information Society GeoMultimedia. Unter Mitarbeit von Manfred Schrenk und Clemens Beyer. Real Corp. Airportcity Space Vienna International Airport, 14.-16.11.2022. Available online at https://www.corp.at/archive/CORP2022_140.pdf, checked on 06/23/2023.

KNOLL, Bente; Renkin, Agnes; Fleischmann, Michael; Knasmillner, Elisabeth; Sisko, Klaudia; Karner, Markus et al. (2022): Klimawandelangepasste Raum- und Bebauungsplanung. Am Beispiel der Marktgemeinde Strasshof an der Nordbahn. In: IBO - Österreichisches Institut für Bauen und Ökologie (Hg.): BauZ! Wiener Kongress für zukunftsfähiges Bauen. BauZ! Wien, 11.-12.05.2022.

KNOLL, Bente; Renkin, Agnes; Ralf Dopheide; Knasmillner, Elisabeth; Karner, Markus; Fleischmann, Michael et al. (2022): Raum & Grün. Möglichkeiten zur Integration von Begrünung ins Regelwerk der österreichischen Raumordnung. Edited by Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (BMK) (Berichte aus Energie- und Umweltforschung, 45). Available online at https://nachhaltigwirtschaften.at/resources/sdz_pdf/schriftenreihe-2022-45-raum-und-gruen.pdf, checked on 06/23/2023.

KRAUS, Florian; Fritthum, Roman; Robausch, Eva; Scharf, Bernhard; Preiss, Jürgen; Enzi, Vera et al. (2019): Leitfaden Fassadenbegrünung. Edited by MA 22 - Wiener Umweltschutzabteilung. Available online at https://www.wien.gv.at/umweltschutz/raum/pdf/fassadenbegruenung-leitfaden.pdf, checked on 1/30/2020.