BIOPOLUS Technologies & Consulting

Company Introduction

The Biopolus Institute is a privately owned nonprofit research and development company limited by shares and based in Budapest, Hungary.

The primary focus area of the Institute is the development of integrated smart nature-based technologies and solutions for improving the circularity, efficiency, and climate resiliency of cities. Biopolus urban planning and consulting integrates existing infrastructure with high-tech urban circularity infrastructure and NBS-nature-based solutions for beautiful, climate-resilient sustainable cities.

Biopolus has developed a range of its own technologies and solutions for addressing the typical challenges of a circular and resilient economy. These developments range from innovative nature-based water treatment technologies to biological production systems and urban farming methodologies. **The solutions are based upon the principle of water-based urban circularity, where energy, food, and waste systems are built around a regenerative and sustainable water cycle.**

Figure 1. Water-based Urban Circularity

Biopolus is proud to be a part of an extensive network of development partners working together to integrate technologies and knowledge in order to develop intelligent water, energy, waste management and biological production systems that make the operation of cities cheaper, safer and more efficient. **The tested and market ready technologies that we develop, which have been proven in full scale, are built and operated through our strategic EPC, construction, and operational partners. Biopolus supplies specialty equipment and technology, and provides design and on-going expertise throughout the project lifetime.**

Biopolus Circular Urban Infrastructure & Technology

As a technology provider, Biopolus provides preliminary engineering services during the design phase. We deliver key technology related components for construction, and provide technology consulting throughout the process. We perform inspections for start-up and commissioning, and provide training and troubleshooting for long term smooth operations.

1. Technology Module(s)

Biopolus offers the following stand-alone individual technology solutions:

Metabolic Network Reactor (MNR) Water Treatment

Biopolus' primary technology is our reactor-based, biological water treatment and recycling technology, which is comprised of a completely enclosed engineered ecosystem, using 2,000 to 3,000 species including plants, microbes, and other higher-level organisms for high level nature-based water treatment.

Figure 2. MNR biological water treatment uses natural & synthetic plant roots to provide optimal surface area for attached biofilm microbial growth.

The full treatment process takes place in a cascade of aerobic and anoxic bioreactors (typically consisting of 6-9 segments). As the water flows from one reactor to the next, it is continuously cleaned, as the different microbial communities in each tank break down remaining contaminants, with the highest efficiency. Our patented Metabolic Network Reactor (MNR) technology is odor free, very compact and modular, with high efficiency, resulting in better treatment (reuse quality) at a lower cost.

The decentralized water treatment facility can range in capacity from 5 m3/day to 50,000 m3/day and can be completely integrated into any kind of building space, with potential to be highlighted as an attractive palm house botanical garden. The water treatment reactors can be arranged in a vertical or horizontal layout, resulting in an abundance of architecture possibilities. The major advantage of decentralized wastewater treatment, means that the treated, high-quality water can be recycled or reused locally.

Figure 3. Interior view of the award winning Koningshoeven Trappist Abbey & Brewery wastewater treatment facility. The 11,000 PE industrial facility was the first in the Netherlands to use MNR technology, it has heat and nutrient recovery, with options for water recycling.

Rapid Composting Unit

We offer engineering consultancy and technologies for upcycling organic wastes via controlled and compact in-vessel bioreactor composting. Through solid-phase bioreactor design, the composting process can be conducting in-vessel, within a small footprint, creating a highly efficient, completely controlled environment, for maximum control. The raw materials are continuously fed into a solid phase bioreactor, inoculated with selected microorganisms, and continuously mixed and aerated, while the operating parameters (temperature, humidity, oxygen content) are properly measured and controlled.

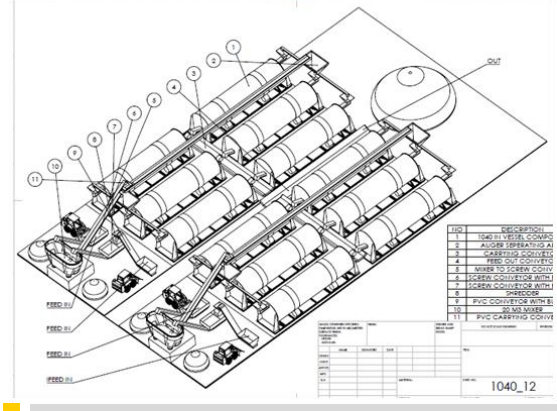


Figure 4. In-Vessel bioreactor composting drum (top); Large-scale in-vessel composting production site (bottom).

This means that a high-quality bio-fertilizer product can be consistently produced (within 5-15 days), in a reliable industrial setting. The nutrient-rich bio-fertilizer can be used to create, maintain, and regenerate our badly damaged soil systems producing high quality topsoil for use in both urban green areas and in agriculture.

Bioreactor composting is available from pilot sized to full scale production. Each reactor can be specialized through a healthy balance of the individual input components (from various organic waste streams such as sewer sludge, food waste, green waste and/ or woody waste) to produce the desired outputs (specially formulated compost products).

Energy Recovery Unit

In designing circular infrastructure, Biopolus performs the metabolic mapping of material and energy flows for each development, specifically looking for waste to resource opportunities, synergies within the system/ facility and with outside neighboring areas, and opportunities for innovation and optimization.

It is well known, that municipal sewage contains a considerable amount of thermal energy; typically, the wastewater from approximately 10,000 people carries a calculable estimated recoverable thermal energy of approximately 0.5 - 1.0 MW. Therefore, our wastewater treatment solution, lends itself to thermal energy recovery through heat pump technology.

Figure 5. An ultra-low temperature hot water chiller, an energy-efficient solution to repurpose ultra-low temperature waste heat to meet cooling requirements.

Thermal energy can be recovered from raw sewage or it can be recovered from the treated water, as a part of the wastewater treatment process. The thermal energy can be used for general purposes (like the heating and cooling of spaces, warm water for showers) and also for technology purposes, like boosting rapid composting during start-up and spring/autumn time, or in the vertical farming process. The thermal energy recovery unit can also be combined with solar voltaic or solar thermal collectors to make the wastewater treatment process even more energy efficient.

Vertical Farming System

With decades of experience in ecosystems engineering and nature-based solutions, Biopolus has developed plant and biological systems knowledge, especially through their engineered hydroponic water treatment system. Biopolus has expanded upon this knowledge with over ten years' experience in plant biology through several plant factory demonstration and R&D facilities. Hundreds of plant types (including microgreens, salad types, herb& spices, medicinal plants) were tested for quality, yield, economy, and growth profiles in order to develop the ideal plant growth recipe (light, nutrient composition, temperature, and humidity requirements).

Figure 6. Vertical farm at Biopolus Pilot facility with mobile racking system for space saving design (left); optimized Bok choy production for desired characteristics and consistent quality (right).

During this time, Biopolus has integrated various urban farming techniques such as aeroponics, hydronics, and nutrient film technologies (NFT) to a create circular vertical farming systems methodology. Plant production can be perfected and maximized in order to produce the desired color, taste, size, and active substance for efficient and consistent production. The production process is part of a larger circular energy, food, water and waste nexus.

Green Wall / Roof

Sustainable urban planning involves systems integration, circular metabolic pathways, and blue/green nature-based solutions to create spaces that are efficient, sustainable, healthy, and beautiful. Biopolus water treatment technologies provide solutions for water treatment and recycling that can be used in blue and green urban spaces.

Green walls and green roofs can reduce heating and cooling requirements in buildings, improve sound insulation, reduce stormwater runoff, sequester carbon, capture pollutants, alleviate urban heat island affects, and increase biodiversity. Biopolus urban planning integrates blue and green solutions at the building level (via architectural integration and via building facility management for smart and efficient operations) and at the neighborhood level for maximized circularity of energy, water, and waste integration.

2. Combined & Integrated Technologies and Solutions

Our individual solutions can be applied separated or combined and integrated with new and/or existing infrastructure.

For example, a decentralized wastewater treatment system can be designed with energy recovery for maximized efficiency. The facility can treat the water for reuse, to irrigate surrounding green spaces (including an integrated vertical farm or green wall) or for local process or display water. The sludge waste produced during water treatment can be upcycled in an in-vessel composting unit (along with other green/ organic wastes) to produce a high-quality fertilizer for soil regeneration.

We optimize our circular engineering design to seamlessly integrate one or more nature-based infrastructure and technologies into the local built urban environment.

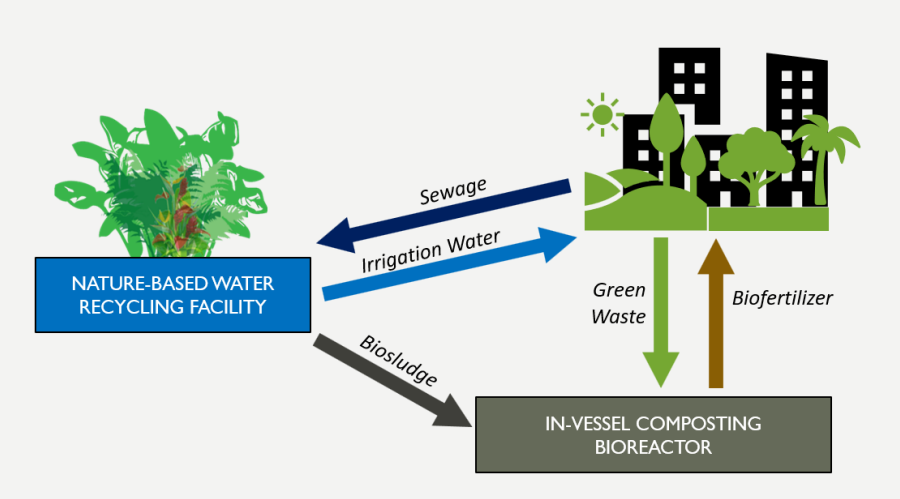


Figure 7. In-Vessel Composting Bioreactor can work alongside a Wastewater Treatment facility to create a sustainable and resilient source of water and biofertilizer (healthy top soil) for urban green and blue spaces.

Biopolus Nature-Based Urban Planning and Consulting

We provide knowledge on how to map and analyze target urban areas and how different technologies/solutions can be most effectively integrated into urban environments in specific locations. We do this by the assessment of urban needs and simulating / modelling complex systems. Also, we make suggestions on how to integrate these solutions and processes into urban planning and how to link them with community spaces and/or educational systems.

3. Metabolic Pathways Integration through Analysis and Dynamic Simulation

A systematic process of metabolic mapping including dynamic computer simulation is completed, whereby urban metabolic flows (water, energy, food, and waste) are mapped and analyzed for synergies and waste to resource opportunities. The main objective of this step is to ensure that the wastes and needs generated are properly analyzed both in terms of time and location, and synergies are exploited in order to provide a comprehensive solution that can address all 'sub-solutions' at the same time. Technological and natural design solutions are analyzed for

efficiency and application, and the overall system is designed to fit culturally- technologically- architecturally into the local urban environment.

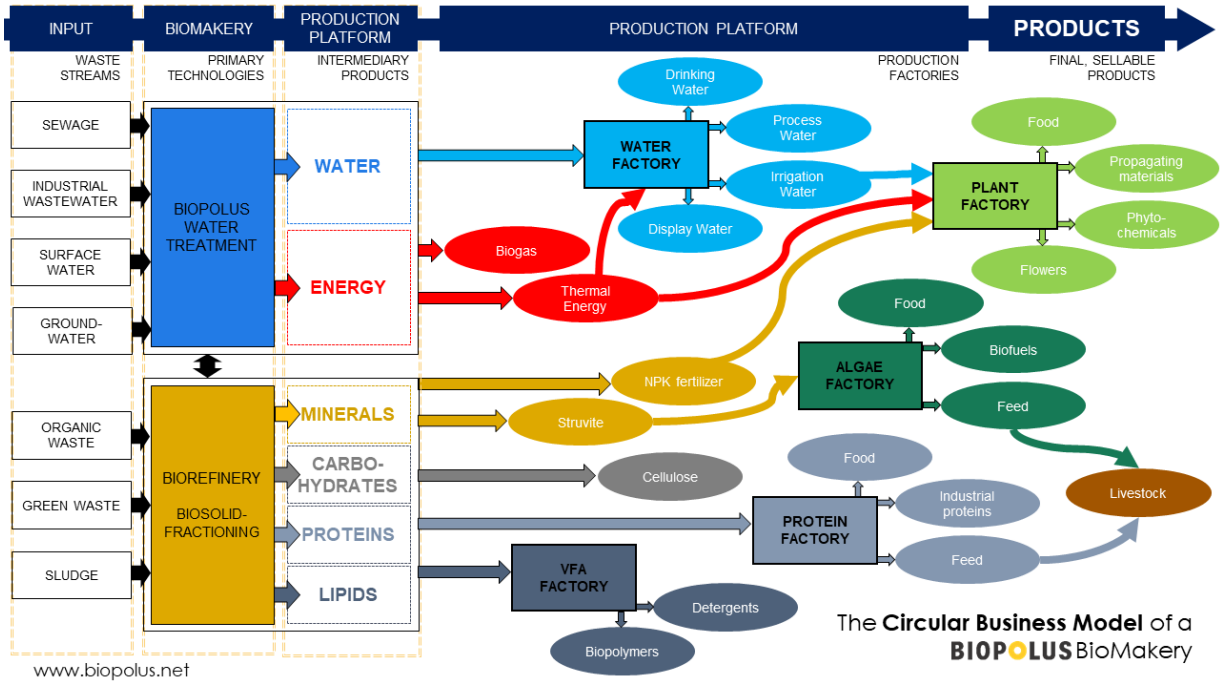


Figure 8. Integrating technologies and metabolic pathways for a resilient and circular model.

4. Architectural and Community Integration

Biopolus works with architects and project stakeholders to integrate new and existing technologies and infrastructure into varying architectural solutions designed specifically for the local urban environment. The existing urban architectural characteristics and/or limitations are considered, while local HVAC and water/wastewater systems are integrated into the overall engineering design. **In alignment with the European Bauhaus initiative, Biopolus designs and solutions work through co-creation to transform society along the three values of aesthetics, sustainability, and inclusion. Solutions go beyond functionality, as they work in harmony with nature and community, creating spaces for community interaction, circularity demonstration, R&D, and education.**

Figure 9. Beautiful architecture and smart design for successful communal and architectural integration.

5. Living, Learning Laboratory for Circularity

Biopolus and partner solutions can be housed together within a circularity hub, which integrates the latest high-tech circular technologies and nature-based solutions (NBS), making it ideal for demonstrating the interconnectedness of circular economy, while also showcasing the benefits of NBS within a community. The space can provide opportunities for innovative, multi-disciplinary, hands-on education and development, which can be tied to nearby institutions of higher education. Students and researchers can use the space as a living, learning laboratory to study engineered ecosystems, resource recovery, and the principals of a water-based circular economy.

Figure 10. A brand-new state-of-the-art wastewater treatment facility is currently under construction in Sharjah, UAE, which will treat and recycle 100% of the wastewater using Biopolus MNR (Metabolic Network Reactor) technology. **A separate R&D facility will be built alongside te municipal facility, which will house a living, learning laboratory where students and researchers can study ecological engineering and circular economy**, including resource and energy recovery.

Experience / Case Studies (Highlights)

BIOPOLUS NATURE-BASED URBAN PLANNING AND CONSULTING

I. GRANTS

Danube Region Water Lighthouse Action / DALIA 2023-2027; Research & Innovation action at 9 demo sites; ecosystem restoration of EU freshwaters. 22 partners; Total Budget: € 8,627,861

H2020 euPOLIS Integrated Nature Based Solutions (NBS) 2020-2025;
Urban Planning Methodology for Enhancing the Health and Well-being of Citizens. Biopolus surface water treatment installation in Gladsaxe, Denmark. 27 Partners; Total Budget: € 11,245,408

H2020 NextGen Circular economy solutions in the Water Sector 2018-2022; Technical, business, & governance advancement at 10 full scale EU Sites. Biopolus Wastewater Treatment Technology at facility in Koningshoeven, Netherlands and Rapid Composting Technology installation in Athens Greece. 30 Partners; € 11,389,106

INTERREG Central Europe / CIRCE2020; Facilitate the uptake of integrated env. management for enhanced industrial symbiosis via circular economy.

II. COMPLEX TECHNOLOGY & MORE

BIO4 Campus Decentralized Wastewater Treatment & Recycling Plant / R&D Lab: A Living, Learning, Laboratory (Concept Design, Currently in Pre-bidding Phase); For a 413-million-eurosa B104 project, to be built as one of the most prestigious bio-based platforms in Europe, combining R&D, academic education and business innovation in bioscience and bioeconomy.

Al Jada, Sharjah, UAE, Nature-based Water Treatment & Recovery in the Desert, State-of-the-art R&D facility for Next Generation Water Treatment Technology (Under Construction); A brand new state-of-the-art wastewater treatment facility is currently under construction that will treat and recycle 100% of the wastewater; a separate R&D facility will be built alongside the municipal facility, which will house a living, learning laboratory where students and researchers can study ecological engineering and circular economy, including resource and energy recovery.

Flåm Wastewater Treatment and Ecotourism (Concept Design); Wastewater Treatment System capable of handling extreme fluctuations in wastewater (winter: <150 m^3/d, summer: >1100 m^3/d) with optional rapid composting and eco-tourism / community space.

Florida A&M University EnergyWaterFoodNexus Hub (Concept Design); New sustainable infrastructure HUB for complex systems integration alongside Circular Economy Graduate Program.

III. URBAN FARMING FACILITIES

BIOPOLUS – TUNGSRAM Cooperation (2019 – 2022) Biopolus partnered with Tungsram (formerly GE) Agritech to build a **2+ million EUR commercial demonstration plant factory (150 m2) with a designated R&D center**, within a previously used GE factory hall. The project was an ideal example of how cities can reinvent urban spaces, integrating food production into unused areas, creating a more resilient and self-reliant food chain. The primary task of the demonstration plant and development center was to create the technological bases of a standardized and modular system, including hardware, software, and cultivation technology elements, as well as the operation and maintenance support services of future systems.

LIVINGISLAND PLANT FACTORY (2016 – 2018) Biopolus – in a strategic cooperation with the Budapest Waterworks – built a **1 million EUR R&D facility in the form of a modular, container farm** (consisting of 12 shipping containers) **in central Budapest with a 70 m2 net cultivation area for experimentation and demonstration**. A controlled urban farming factory system, called aero.green was developed, which integrated a mixed system of three primary urban farming techniques: hydroponics, nutrient film technology (NFT), and aeroponics.

IV. Biopolus WASTEWATER TREATMENT Technology

Residential Megaprojects focused on Human Health & the Environment

VINHOMES PROJECTS

Tai Mo, Smart City
CAPACITY: 17,000 m³/d

Dai Mo, Smart City
CAPACITY: 10,800 m³/d

Grand Park
CAPACITY: 13,500 m³/d

Dream City, facility 1
CAPACITY: 17,900 m³/d

Dream City, facility 2
CAPACITY: 14,500 m³/d

Vinhomes is the No. 1 real estate development and management company in Vietnam. Their mission is to pioneer an ideal living experience within Vietnam's urban locations, by harmonizing modern facilities within a green environment.

Since 2020, Biopolus has been continuously working with Vinhomes on their latest urban development projects, with MNR wastewater treatment technology now installed at five facilities located within three developments.

VINHOMES

Dai Mo, Smart City, Vietnam

Facilities Around the World using MNR Wastewater Treatment Technology

CAPACITY:
20,000 m³/d

MUNICIPAL WW

RETROFIT & NEW ADDITION

Bac Giang, Vietnam

The Bắc Giang Wastewater Treatment Plant was redeveloped in two phases to increase the capacity of the existing facility from 6.000 m³/d to 20.000 m³/d.

CAPACITY:
5,000 m³/d

MIXED MUNICIPAL & INDUSTRIAL

RoYu, Shenzhen, China

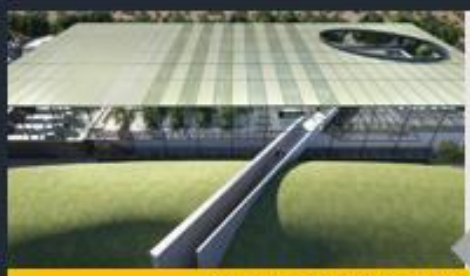
Mixed industrial and municipal Wastewater Treatment Plant for an industrial park housing China's largest foldable flatscreen manufacturer.

CAPACITY:
440 m³/d
11,000 PPE

MIXED MUNICIPAL & INDUSTRIAL

Tilburg, The Netherlands

Industrial and municipal WWTP with heat and nutrient recovery at the Koningshoeven Trappist Abbey & Brewery and visitor center.



CAPACITY:
16,500 m³/d

MUNICIPAL WW and R&D Center

Under Construction

Al Jada, Sharjah, UAE

Municipal WWTP to serve new Real Estate Development and Technology Park. The facility includes an R&D center based on Biopolus water and circularity technology.