Executive Summary

Living Architecture

metabolic apps for transforming our habitats from inert spaces into programmable sites

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No single technology can solve the environmental challenges we face today – however, Living Architecture offers a careful orchestration of complementing technologies for integration into the built-environment, capable of delivering us to a sustainable future; a future using renewable resources rather than fossil-fuel for generating energy, and therefore defining a high-quality urban living for all inhabitants. Living Architecture combines technologies at various scales; from the micro-scale, where microbial communities are engineered to perform desired tasks; to a systems-scale, where Microbial Fuel Cell (MFC), Photobioreactor (PBR) and Synthetic Microbial Consortia (SMC) technologies are integrated to maximize system outputs (electricity, clean water, usable biomass and phosphate); and also includes the macro-scale, which addresses a large range of building typologies and city infrastructures.

Contents

RADICAL VISION

credit:
Living Architecture Consortium
photo: UWE Bristol

The crises that characterise this millennium have far-reaching effects across a spectrum of human activities, ranging from political systems, to social development, economic growth and environmental health. Despite many of us living longer, healthier and wealthier lives than ever before, these predicaments are symptoms of the dark side of our industrial development, which is shaped by our fossil fuel dependency and voracious consumption of natural resources. Such activities are most concentrated within our expanding cities, where the buildings we live and work in are supposedly apparatuses for everyday living which help us live better modern lifestyles[1] and contribute substantially to the negative impacts of industrialisation. Underpinned by the conceptual framework of modern architecture, they are responsible for half of all global energy use, half of all greenhouse gas emissions, consume a sixth of all freshwater, a quarter of world wood harvests and two-fifths of all other raw materials, while the construction and demolition cycles of buildings generates two-fifths of all our waste[2].

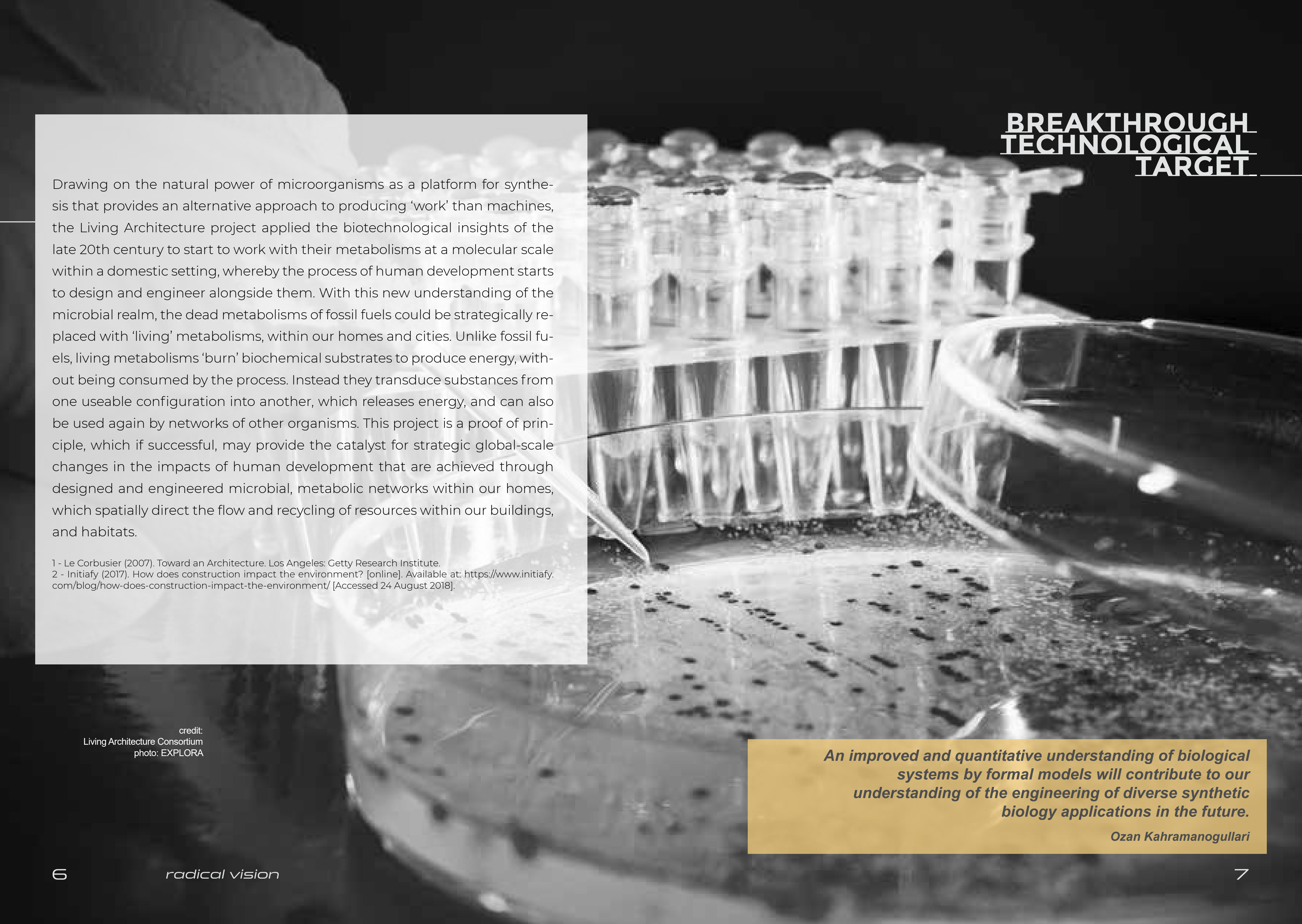
While our building practices and technologies were perfected to deal with the opportunities and needs of the industrial revolution, millennial society faces qualitatively different sets of concerns – where ecology, global development, artificial intelligence, increasing inequalities, ecocide, energy, rapidly swelling urban populations, dramatic loss of biodiversity, environmental pollution, global warming, multiple mass extinction events, fit for purpose political systems, advanced communications, and inhabitation – are inadequately dealt with by our present approaches, so alternative frameworks for the conception and evaluation of architecture are needed.

To enable a necessary shift in perspective and practice from upholding the principles of an industrial age and to take steps towards an ecologically-engaged era of human development, this project explores an expanded toolset for the choreography of space, so that the process of human inhabitation has a qualitatively different impact on planetary infrastructure.

BREAKTHROUGH TECHNOLOGICAL TARGET

Drawing on the natural power of microorganisms as a platform for synthesis that provides an alternative approach to producing ‘work’ than machines, the Living Architecture project applied the biotechnological insights of the late 20th century to start to work with their metabolisms at a molecular scale within a domestic setting, whereby the process of human development starts to design and engineer alongside them. With this new understanding of the microbial realm, the dead metabolisms of fossil fuels could be strategically replaced with ‘living’ metabolisms, within our homes and cities. Unlike fossil fuels, living metabolisms ‘burn’ biochemical substrates to produce energy, without being consumed by the process. Instead they transduce substances from one useable configuration into another, which releases energy, and can also be used again by networks of other organisms. This project is a proof of principle, which if successful, may provide the catalyst for strategic global-scale changes in the impacts of human development that are achieved through designed and engineered microbial, metabolic networks within our homes, which spatially direct the flow and recycling of resources within our buildings, and habitats.

1 - Le Corbusier (2007). Toward an Architecture. Los Angeles: Getty Research Institute.
2 - Initiafy (2017). How does construction impact the environment? [online]. Available at: https://www.initiafy.com/blog/how-does-construction-impact-the-environment/ [Accessed 24 August 2018].



credit:
Living Architecture Consortium
photo: EXPLORA

> ***An improved and quantitative understanding of biological systems by formal models will contribute to our understanding of the engineering of diverse synthetic biology applications in the future.***
>
> ***Ozan Kahramanogullari***

3-IN-1 BIOREACTOR

Technical applications for microbial communities already exist in modern society from the processing of waste water in large scale sewage plants, to the laboratory production of antibiotics and food additives.

The Living Architecture project is a building technology prototype that extends these principles into the realm of design, by working with the adaptive, processing power of microbes to coordinate the actions of a designed metabolism within a domestic space.

Taking the form of an interior partition wall that is about the size of a large bookcase and suitable for installation in a bathroom or kitchen, it is composed of modularly-stacking 'brick-like' components, which gurgle like a stomach, can be stacked together in different ways (as modular units), and are individually programmed (as metabolic 'apps'). As a 'living' structure however, the wall's operations can be likened to the workings of a cow's stomach that differentially processes organic matter through different chambers of the 'gut'. Its liquid feedstocks – grey water and urine – initially pass into a sedimentation chamber from which they pass into a combined processing unit, where specific resident microbial colonies within the 'bricks' turn their nutrients into useful domestic products specifically – electricity, inorganic phosphate, polished water, oxygen, and biomass which can be used as compost. Since microbes have extremely adaptable metabolisms, selected species process the various fractions of liquid waste in various ways to make a range of substances. The plasticity and robustness of microbes means they can perform lots of different kinds of functions and under varying conditions, with the whole process being regulated by a low-power electronic controller that is energised by the constituent Microbial Fuel Cell elements. Algal liquid streams are recycled into the bioprocessor complex to provide oxygen to metabolising microbes, while fresh water is tapped out of the system and solid matter is passed to settlement tanks.

SCIENCE TO TECHNOLOGY

transforming urban and domestic approaches to water, waste, and resources into a circular systems approach

Two basic types of metabolism are employed in Living Architecture. The anaerobic process is housed in the anode of the MFC and is used to breakdown organic waste[1]; and aerobic metabolism, present in the photobioreactor and cathode chambers of the MFC, uses tiny green organisms (algae) to trap sunlight and carbon dioxide to produce solid biomass and oxygen. The main challenge of the project is how these systems can be brought together, so their products mutually support each other through various forms of exchange. This integration changes the very notion of 'waste' because the outputs of one system can be used directly by another, generating a 'cyclical economy' of matter powered by metabolism. However, this is very different from a closed-loop system of exchange, as living processes need to be 'open' to receive energy, resources and remove by-products. The iterations of these processes are not entirely 'circular' but 'corkscrew' through iterations of metabolic exchanges so they can continually respond to changes in the systems input through their growth, development and decay. The significant advantage of this process is not its mechanical 'efficiency' in extracting all the various nutrient fractions but its material robustness that arises from its programmability, integrability and sensitivity to environmental and internal changes[2]. Marking a step-change in integrating household resource and waste streams, the Living Architecture prototype is extremely robust, flexible and able to deal with fluctuations in the metabolic waste streams of individual households, as well as responding to the specific needs of inhabitants.

Organic waste is generated in all buildings as a by-product of human activities; separating these waste streams on-site is critical for Living Architecture technologies and contributes to a circular economy.

Waltraut Hoheneder

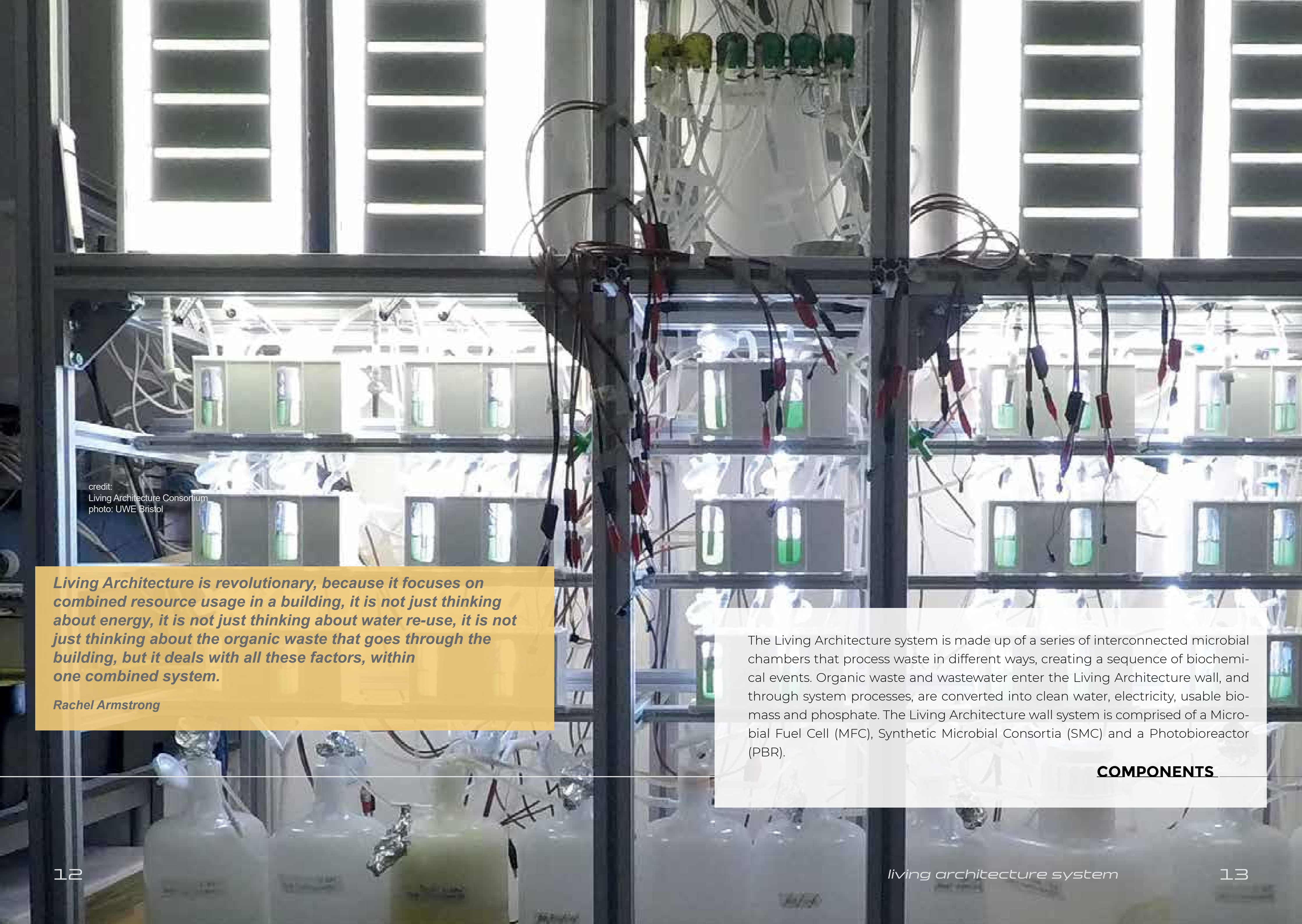
1 - Ieropoulos, I. A., Stinchcombe, A., Gajda, I., Forbes, S., Merino-Jimenez, I., Pasternak, G., Sanchez-Herranz, D. and Greenman, J. (2016). Pee power urinal – microbial fuel cell technology field trials in the context of sanitation. Environ. Sci. Water Res. Technol. 2, pp. 336–343.
2 - Thompson, S. (2018). Living Architecture: Investigating the interface between biology and architecture – a new vision for homes and cities, The Irish Times, 27 December. [online]. Available at: https://www.irishtimes.com/news/science/living-architecture-investigating-the-interface-between-biology-and-architecture-a-new-vision-for-homes-and-cities-1.3733994. [Accessed 2 January 2019].

credit:
Living Architecture Consortium
photo: Bruno Stubenrauch

SYSTEM DESCRIPTION

The Living Architecture project demonstrates that microbial communities can be coupled together by the way they share and process resources. Using spatial protocols and liquid flows to facilitate the combined resource utilisation of domestic substrates, the overall approach of harnessing microbial metabolism marks a radical departure from the central dogma of gene-centric thinking in innovation. Replacing genetic modification of individual cells with the outputs of programmed metabolic 'apps' that are generated by microbial communities achieves a fundamentally different metabolic approach towards engineering and designing with natural systems. Relating through their shared biochemical events, microbial communities make 'decisions' about the combined processing of substances within the interconnected bioreactors. This practice also opens up new frontiers in low power electronics that can be run by bioelectricity produced by the system, as well as the science of programming microbial consortia, which establish the principles for designing metabolic 'apps', where microbes that do not normally work together are able to collaborate for the first time, enriching the potential for metabolic design. One approach is to artificially create a metabolism that releases sucrose, so that new combinations of bacteria can work together in ways they do not in the wild.

Living Architecture's combined effects can alter the character of our living spaces – from environments that merely consume resources – to spaces that link the webs of life and decay to provide for our needs, refresh our atmosphere and reduce the circulation of toxic compounds, such as detergents in our waterways. Like the exchanges between the first forms of life, the way that webs of biochemical exchanges are orchestrated, can increase the liveability of a space by, for example, sequestering heavy metals and breaking down nitrous oxide. Beyond their capacity to act as remedial systems by actively transforming domestic wastes into useful outputs, they generate resources which enables them to be accordingly revalued within the domestic economy.

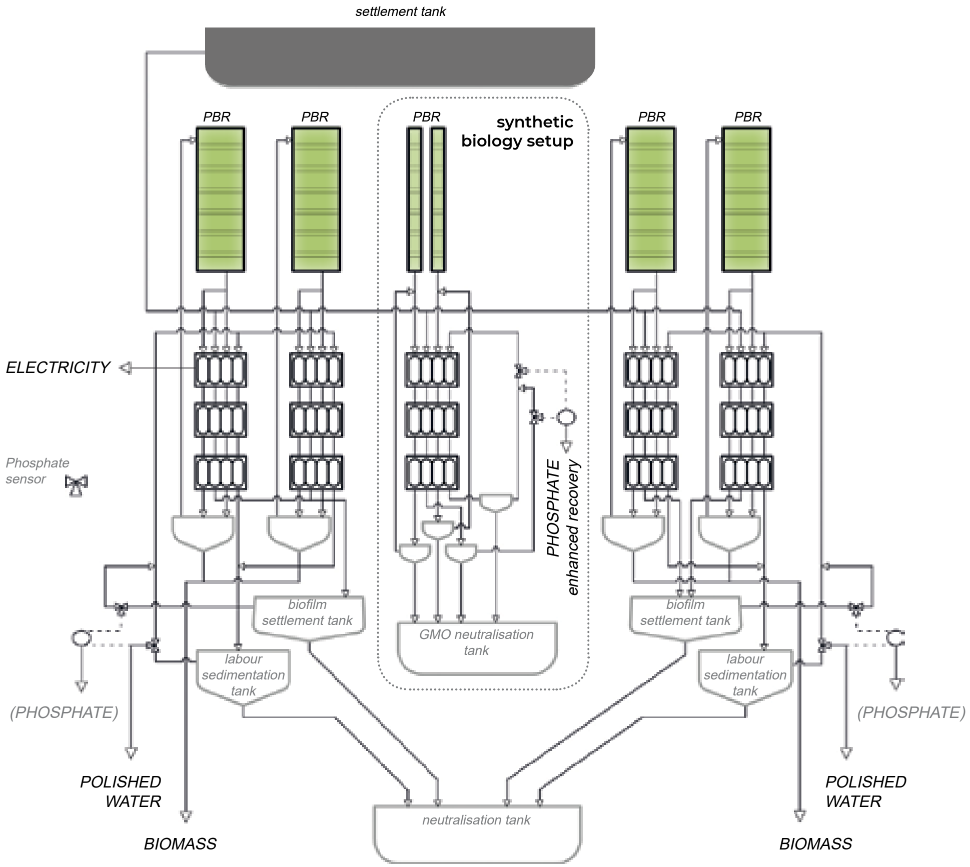


credit:
Living Architecture Consortium
photo: UWE Bristol

> ***Living Architecture is revolutionary, because it focuses on combined resource usage in a building, it is not just thinking about energy, it is not just thinking about water re-use, it is not just thinking about the organic waste that goes through the building, but it deals with all these factors, within one combined system.***
>
> ***Rachel Armstrong***

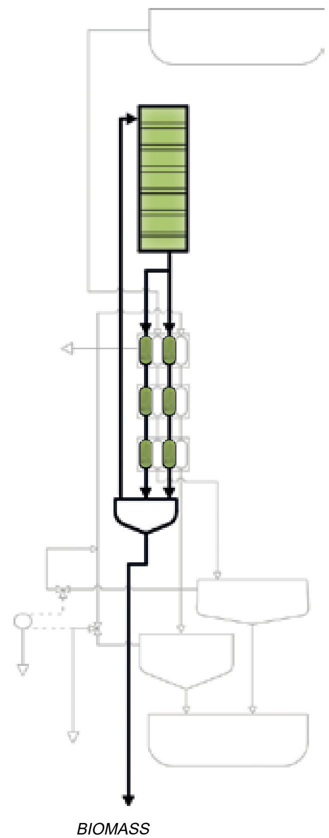
The Living Architecture system is made up of a series of interconnected microbial chambers that process waste in different ways, creating a sequence of biochemical events. Organic waste and wastewater enter the Living Architecture wall, and through system processes, are converted into clean water, electricity, usable biomass and phosphate. The Living Architecture wall system is comprised of a Microbial Fuel Cell (MFC), Synthetic Microbial Consortia (SMC) and a Photobioreactor (PBR).

COMPONENTS

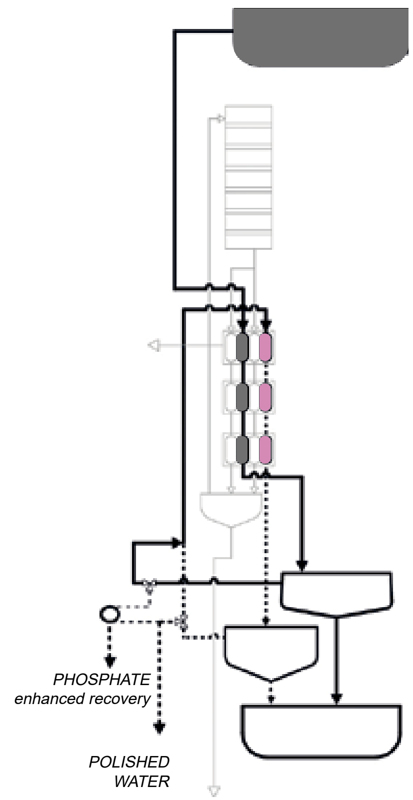


Living Architecture Laboratory Systems diagramme

cathode & farm module flow



anode & labour module flow



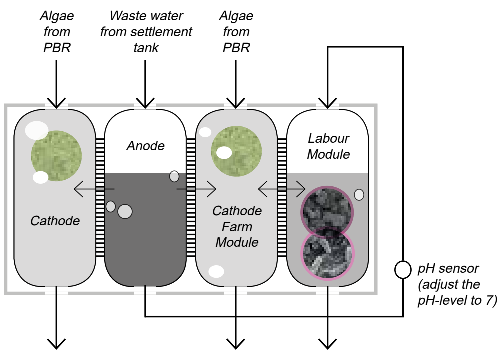
Module configuration

CATHODE
O_2 is produced by algae in the cathode

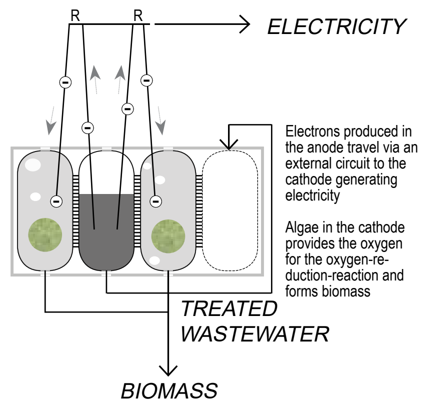
CATHODE / FARM MODULE
Sucrose is produced by genetically engineered *Synechococcus* which passes through the semi-permeable membrane from the farm module to the labour module as food source

ANODE
Living bacteria break down organic waste from waste water
Positively-charged hydrogen passes through the semi-permeable membrane from the anode chamber to the cathode chambers

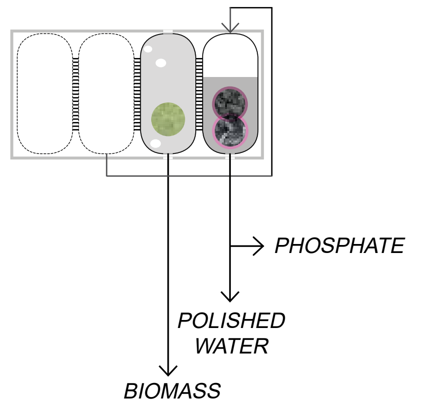
LABOUR MODULE
Adaptive Laboratory Evolved (ALE) *P.putida* recover phosphate from wastewater



Microbial Fuel Cell (MFC) / PBR *outputs*



Synthetic Microbial Consortium (SMC) *outputs*



Living Architecture can revolutionize the way we build our homes for the future, to become truly self-sustainable in terms of waste water treatment and electricity.

Ioannis Ieropoulos

credit:
Living Architecture Consortium
photo: Bruno Stubenrauch

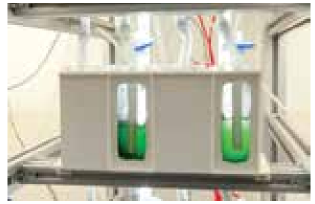
MICROBIAL FUEL CELL (MFC)

A Microbial Fuel Cell is a bioelectrochemical transducer which consists of a positive cathode and a negative anode.

Living bacteria in the anode break down organic waste as they consume it for their growth and maintenance, and in turn excrete electroactive by-products. Live algae are bred to produce oxygen (O_2) in the cathode chamber, which serves as a terminal acceptor of the electrons coming from the anode chamber. Electrons travel from anode to cathode via an electrical circuit. First, they are transferred to an electrode surface within the anode chamber, then travel via the circuit wire directly to the cathode, where they react with protons and O_2 to form a closed circuit.

In the Living Architecture wall, an anode chamber is configured between two cathode chambers; and a fourth chamber, containing the Synthetic Microbial Consortia, is positioned next to one of the cathodes. Chambers are separated from one another by permeable ceramic membranes. In order to specify the most efficient clay type for the membranes, hundreds of ceramic samples were made and tested with a specific focus on clay porosity and form.

Together this configuration constitutes a living brick. Living bricks can be stacked one upon the other, allowing liquid to flow through the configuration as a cascade with the help of gravity.



credit:
Living Architecture Consortium
photos: UWE Bristol

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Living Architecture Consortium
photo: UWE Bristol

credit:
Living Architecture Consortium
photo: LIQUIFER Systems Group

The prototype built by the Living Architecture consortium is controlled by a custom-built electronic circuit, capable of keeping itself in operation through the energy it helps to self-generate.

The system is composed of an energy harvester, which extracts energy from the wall components, and low-power micro-controllers and peripherals, that enable the system to be autonomous in terms of energy. Another key component of the circuit is the latch-and-release grid, which can dynamically change the electrical connectivity of the components of the wall in order to maximize their performance.

The ability of the system to sustain the electrical circuit, while performing computation and self-adaptation to improve system performance, is an innovation arising from within the project.

SYNTHETIC MICROBIAL CONSORTIA (SMC)

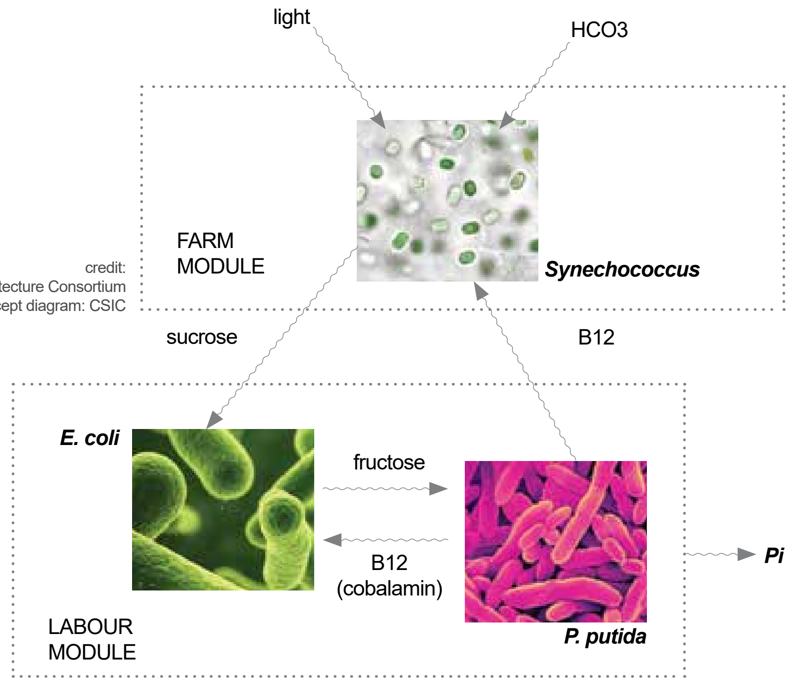
The Living Architecture vision is the on-site deployment of genetically engineered bacterial communities, or Synthetic Microbial Consortia, that are programmed to treat different household waste streams.

SMCs are new-to-nature bacterial associations, engineered by assembling single elements (cells) to follow a standardized synthetic-biology design, in order to perform highly specific tasks, otherwise unachievable by a monoculture of microorganisms. From an industrial point of view, a SMC constitutes a living “assembly plant,” where a high value bioproduct and/or bioprocess is carried out in successive steps by a set of microorganisms engineered to live together while performing a distributed catalysis.

credit:
Living Architecture Consortium
photos: top: EXPLORA,
middle/bottom: CSIC

credit:
Living Architecture Consortium
photo: CSIC

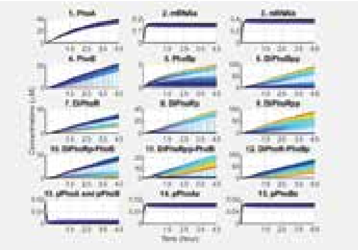
> ***Living Architecture is the first proof-of-concept of how we can combine and pre-program different microbial communities.***
>
> ***Juan Nogales***

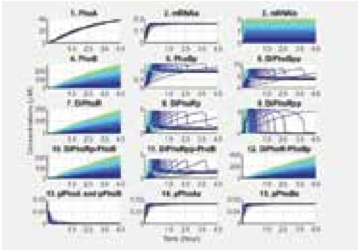


credit:
Living Architecture Consortium
concept diagram: CSIC

The concept of the Synthetic Microbial Consortia in Living Architecture is based on the interactions that occur between two living modules, a farm module and a labour module, separated by a permeable ceramic membrane. The farm module, also functioning as one of the cathodes, is composed of a cyanobacterium (*Synechococcus elongatus*) that uses a dilute-form of waste water, carbon dioxide (CO_2) and sunlight to produce sucrose, which is used in the labour module as a food source. The labour module, compounded by the two workhorse bacteria *Pseudomonas putida* (*P. putida*) and *Escherichia coli* (*E. coli*), produces the functional ability of the consortia, recovering phosphate from waste water.

To auto-control the function of the Living Architecture SMC, a phosphate biosensor is genetically created, capable of sensing the amount of phosphate present in the medium and activating the phosphate-removal function when the levels are high. *E-coli* has one of the most efficient regulatory response mechanisms to phosphate starvation and Living Architecture helps identify which phenotypes would enhance the absorption capacity of inorganic phosphate in the *E. coli* bacteria.





Phosphate modelling

Computational modelling in Living Architecture is used to quantify the dynamic behaviour of a designed synthetic microbial consortium as it is exposed to varying levels of phosphate in its environment. The model is a precise mathematical description of the biological micro-processes that occur inside a cell. The model is extensively interrogated by means of computer simulations, and this way, serves as a virtual lab.

Results of these simulations are filtered and refined. They are then verified by comparing with experimental observations to gain knowledge on the biological processes that occur inside the cell under varying environmental conditions. By using these observations systematically, these bioprocesses can be genetically modified to provide the desired response.

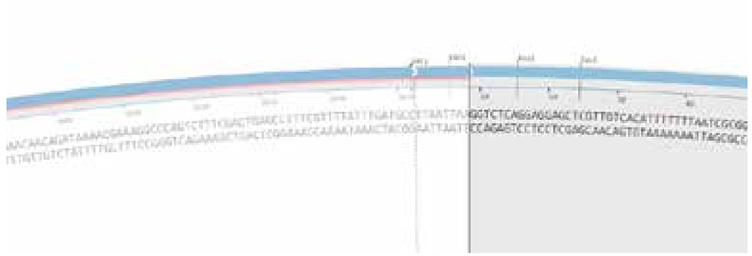
credit:
Living Architecture Consortium
image: UNITN

Doulix

One of the central components of the Living Architecture project concerns the development of foundational concepts and transferable principles rooted in quantitative biology for synthetic biotechnology applications.

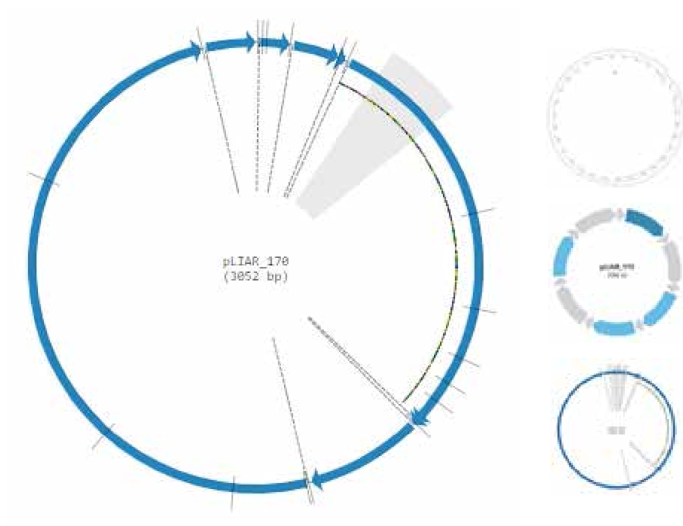
Doulix, a computer-assisted design software, has been advanced during the project bringing together data, software and reagents, to tackle biological complexity. It is a resource and tool for the effective engineering of complex pathways through the assemblage of standard biological parts into multipartite plasmids.

In Living Architecture, a new synthetic metabolic pathway to collect and remediate phosphate is designed, by splitting the pathway into modular units and deploying them into different host organisms to reduce the stress put on any single organism. Rather than engineer a single strain to carry out all the tasks, Living Architecture engineers an SMC to carry-out the tasks collectively.



For Living Architecture, the metabolic pathways of phosphate and nitrogen oxide removal are decomposed and standardized for optimized performance results. The effect of the synthetic pathways on the central metabolism of the different hosts are characterized using RNA sequencing as a proxy for metabolism, in order to minimize the withdrawal of resources.

Living Architecture SMCs account for strain-specific functions (i.e., carbon source production, carbon source pre-processing and energy generation), allowing the emergence of consortium-specific functions such as phosphate removal and added-value metabolite production.



credit:
Living Architecture Consortium
image: Doulix platform stills, https://doulix.com/,
EXPLORA

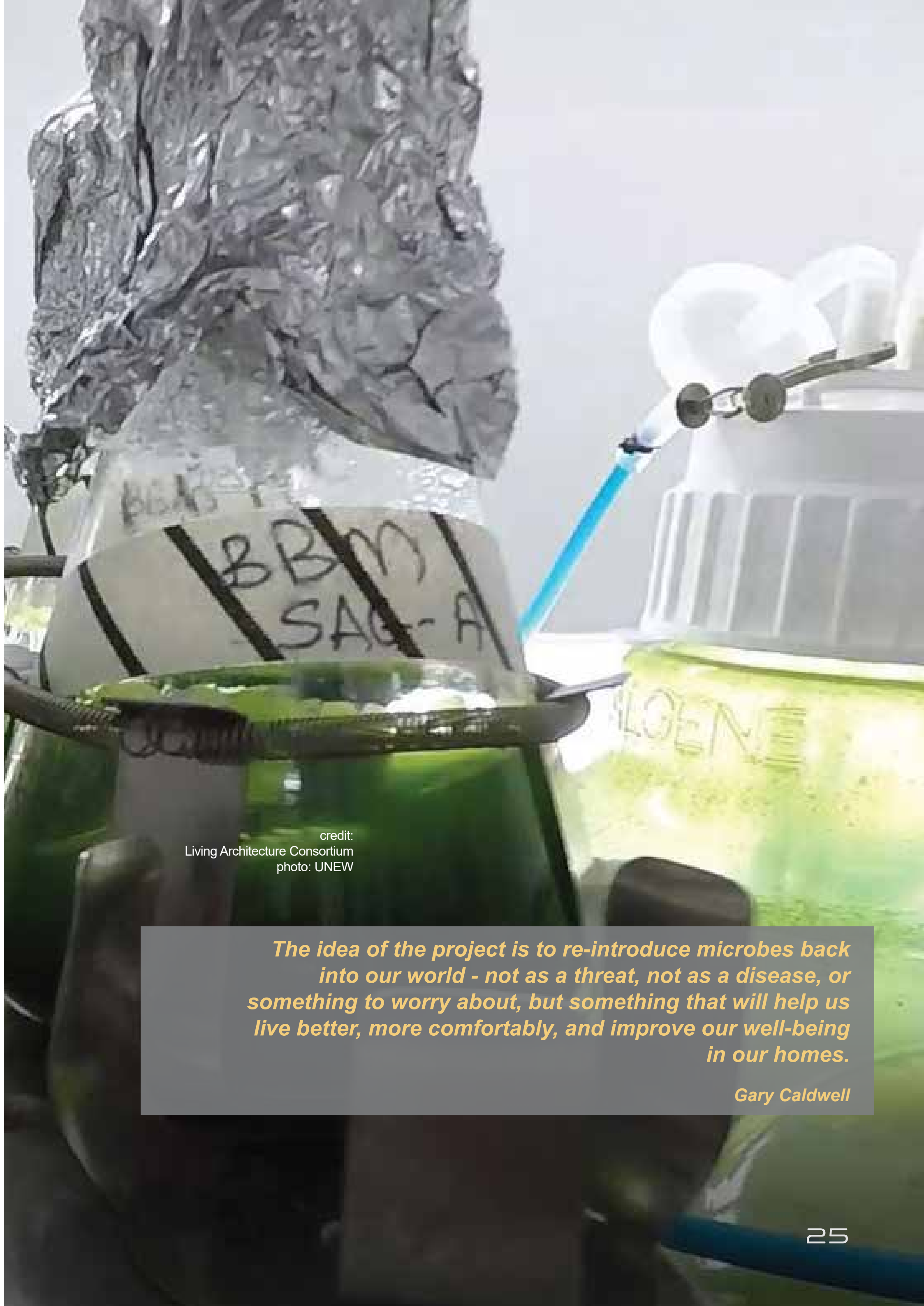
PHOTOBIOREACTOR (PBR)

The photobioreactors deliver a highly controlled environment that drives the growth of cyanobacteria, a photosynthetic bacterium, also known as blue-green algae, or *Synechococcus*.

The cyanobacteria capture nutrients in domestic wastewater, and remove CO_2 from the atmosphere during photosynthesis. In capturing the CO_2, the cyanobacteria releases O_2, which partly dissolves in the wastewater and partly returns to the atmosphere. The dissolved O_2 is fed into the cathode of the MFC where it is consumed by bacterial biofilm, contributing to the production of electricity in the process.

The PBRs have been designed to maximise the amount of dissolved O_2 using minimal energy input. To achieve this, the area and time that the cyanobacteria solution is in contact with atmospheric gases have been extended. The flow of liquid through the reactor creates turbulent mixing driven by gravity, encouraging the saturation of O_2 in the water and consequently increasing the performance of the MFCs.

credit:
Living Architecture Consortium
photos: top, bottom: UNEW, middle:
Bruno Stubenrauch



credit:
Living Architecture Consortium
photo: UNEW

The idea of the project is to re-introduce microbes back into our world - not as a threat, not as a disease, or something to worry about, but something that will help us live better, more comfortably, and improve our well-being in our homes.

Gary Caldwell

credit:
Living Architecture Consortium
photo: UWE Bristol

TRANSDISCIPLINARITY

BREAKTHROUGH

This project aims to catalyse ways of generating new architecturally-concerned, scientific and technological practices that are pertinent to current challenges. It takes the form of a series of high-risk challenges, which are individually addressed by the various expert fields of knowledge in the project (architectural design, bioenergy, robotics, synthetic biology, information technology, unconventional computing and microbiology) and then are brought together through the Living Architecture apparatus, embodying the transdisciplinary nature of the project, which has resulted in breakthrough innovations in information technology, synthetic biology and bioreactor design.

NEW AREAS OF INVESTIGATION

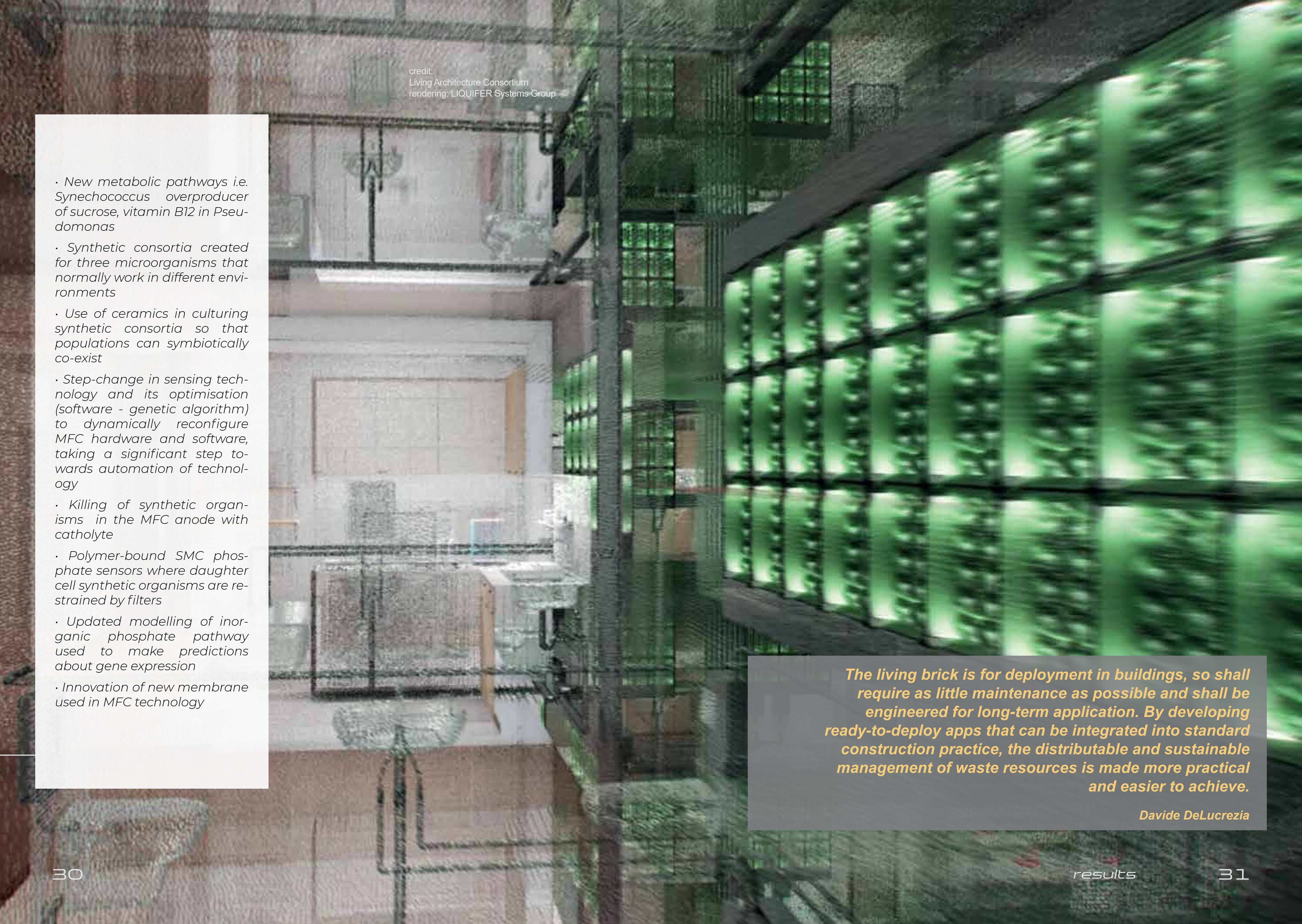
The visionary nature of the original proposal required outstanding originality and experimental approaches to the ‘sustainability’ agendas encoded in the production of ‘metabolic apps’, where the collective explorations are united by the concept of experiment, not in its classical manifestation within a modern scientific laboratory, but as an exploratory engagement with architectural ideas that arise from many different kinds of research environments. Each contributing group addressed various concerns within the project to contribute overall to the potential exchange of ideas that is relevant to the current agendas implicit in dwelling in our homes and cities at a time of ecocide. When considered collectively, the contributions by the various partners generate a portfolio of possibilities and exemplars for experimental practices from which a toolset of approaches for future explorations for human development in concert with the microbial realm (through the further development of ‘metabolic apps’ as hardware, software and interfaces with the public) can be synthesised. Living Architecture is not an ultimate synthesis of the ideas and proposals contained within the project, but a start towards enabling architecture, scientists, technologists and the public to experience alternative ways of performing useful ‘work’ and inhabiting our planet rather than through the technology of the ‘industrial machine’ associated with alternative impacts.

credit:
Living Architecture Consortium
rendering: LIQUIFER Systems Group

RESULTS

Living Architecture key contributions to new scientific knowledge

- *Dynamic reconfiguration of MFCs stacks*
- *Construction of integrated MFC and algal PBR hardware*
- *Ceramic hotspots using additives such as manganese dioxide allow for more efficient MFC systems*
- *Energetically self-sustaining diversion of nutrient stream within an MFC*
- *Development of the computational framework (FLYCOP) for the optimisation of microbial communities with metabolic models*
- *New data about domestic feedstocks and the resilience of MFCs when exposed to common household cleaning products*
- *Integrated anaerobic and aerobic systems*
- *Advanced development of Doulix, an easy-to-use DNA designing technology*
- *Yeast biosensing mechanism using glycolytic oscillations*
- *Symbiosis of different consortia e.g. E. coli and P. putida in the labour module*



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Living Architecture Consortium
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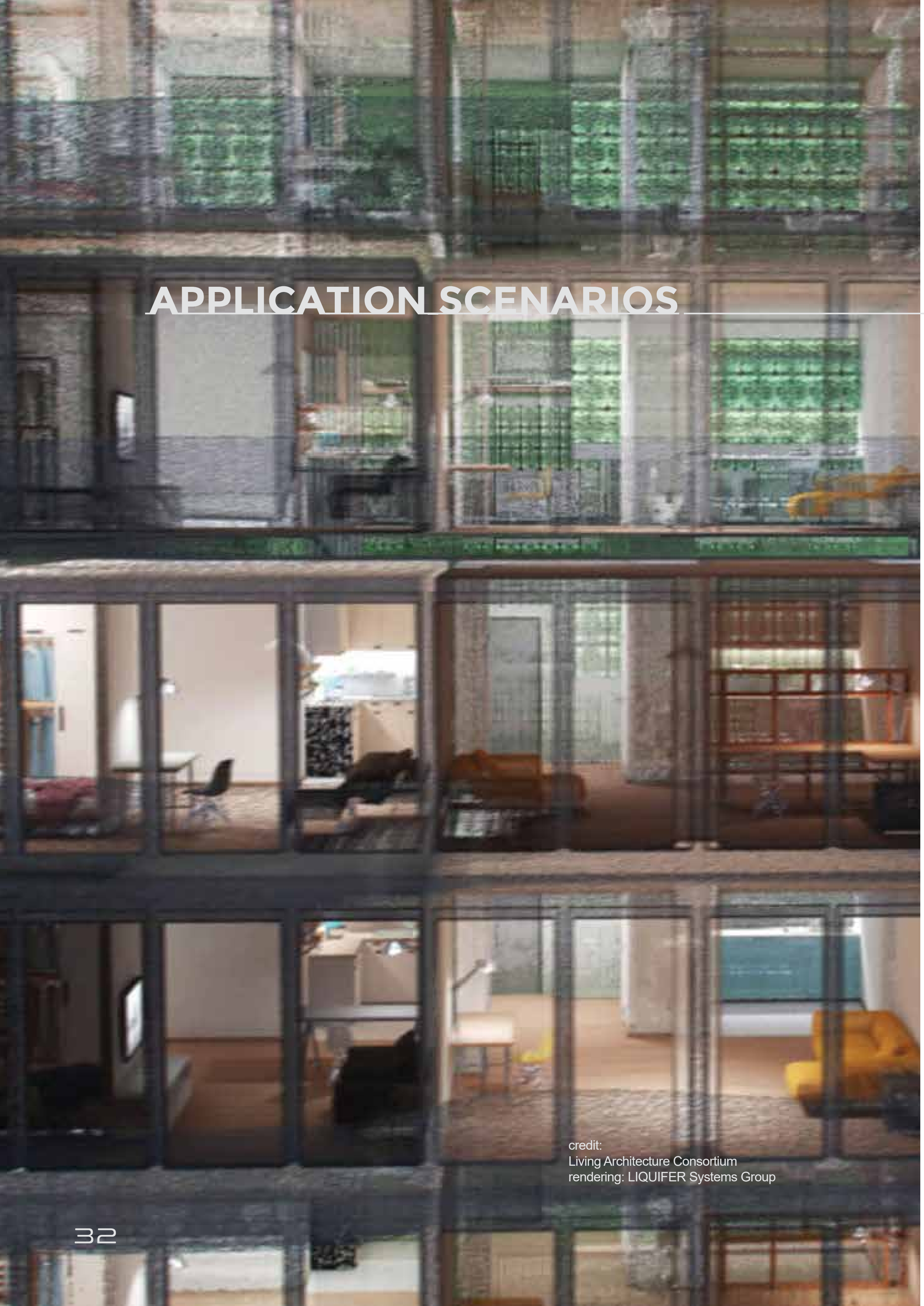
- *New metabolic pathways i.e. Synechococcus overproducer of sucrose, vitamin B12 in Pseudomonas*
- *Synthetic consortia created for three microorganisms that normally work in different environments*
- *Use of ceramics in culturing synthetic consortia so that populations can symbiotically co-exist*
- *Step-change in sensing technology and its optimisation (software - genetic algorithm) to dynamically reconfigure MFC hardware and software, taking a significant step towards automation of technology*
- *Killing of synthetic organisms in the MFC anode with catholyte*
- *Polymer-bound SMC phosphate sensors where daughter cell synthetic organisms are restrained by filters*
- *Updated modelling of inorganic phosphate pathway used to make predictions about gene expression*
- *Innovation of new membrane used in MFC technology*

The living brick is for deployment in buildings, so shall require as little maintenance as possible and shall be engineered for long-term application. By developing ready-to-deploy apps that can be integrated into standard construction practice, the distributable and sustainable management of waste resources is made more practical and easier to achieve.

Davide DeLucrezia

APPLICATION SCENARIOS



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Living Architecture Consortium
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In the scenarios, alternative ways to integrate the Living Architecture system into the urban-built-environment are explored. It is envisioned that Living Architecture technologies shall be progressively developed and implemented, in alignment with the established frameworks and benchmark targets for a Sustainable Future formulated by the European Union, for ten, twenty, and thirty-year outlook periods. By 2050, the Living Architecture system is envisioned as an integral component of waste management and energy production at the city scale, fully embedded in a circular economy, based on renewable resources.

For scenario development, different factors are considered for the successful implementation of Living Architecture into the urban environment over time, including; existing building stock and building typology in the EU, architecture design and visionary futures, stakeholders, resource use, and EU regulatory framework.

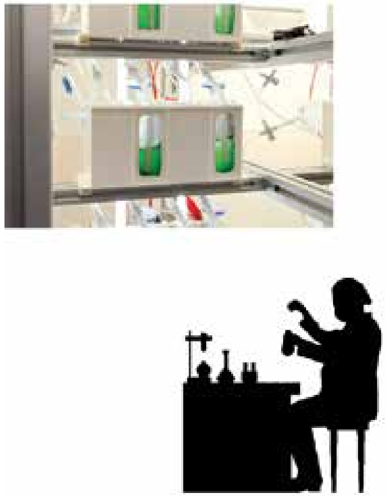
The Living Architecture project uses living things and their regenerative powers to process waste material in homes. A wide range of organic waste streams that are generated in buildings as by-products of human activities are considered as potential feedstock, or resource for the system.

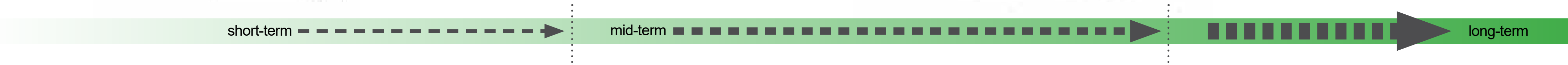
A specific challenge to the application of Living Architecture into buildings is the integration of living microorganisms. Humans are in fact animals, living in a microbial world however, and for far-too-long, we have fought against the same microbes we have evolved with through the sterilization of our environments. The idea of the Living Architecture project, is to re-introduce those microbes back into our world to help us live better, more comfortably, and to improve our well-being. The scenarios aim to illustrate the simultaneous changes that shall occur in the social, economic, technological and political spheres to facilitate the use of living microorganisms in our built environments to process waste.

The most prevalent urban building types in the EU are residential, commercial and public building types. Concept design studies are developed to illustrate the integration of the Living Architecture system into new and existing buildings, specifically targeting single-family-homes, multi-family homes, office and school buildings.

LONG-TERM PLAN ENVISIONED FOR LIVING ARCHITECTURE

Living Architecture is a robust system capable of turning different building waste streams into valuable resources. The development of Living Architecture technologies is planned over the course of thirty-years, targeting different users and scales of application.





2019

Proof-of-Concept Living Architecture prototype demonstrates system requirements and baseline measurements for reducing household wastes, producing electricity, biomass, polished water, and phosphorus.

2020s-**2030**

In the short-term, Living Architecture moves beyond the laboratory context and is installed as a wall system to perform selected building applications. During this phase, scientists, engineers and experimental users collaborate to raise the Technology Readiness Level from TRL4 - technology validation in laboratory, to TRL9 - actual system proven in operational environment.

2030s-**2040**

In the mid-term, Living Architecture technologies are expected to have reached a level of technical sophistication enabling the semi or fully automated system to process all different forms of organic waste and waste water that is produced in buildings. MFC technology is now scalable to building size, and architectural design practices use the Living Architecture technology for providing building services. Different 'metabolic apps' are available on the market for treating different waste types. Biological processes create positive effects on local climate and social cohesion.

2040s-**2050**

In the long-term, Living Architecture technologies are envisioned as sprawling infrastructures, where multifunctional buildings merge with city services to process waste-inputs and produce resource-outputs. Generated resources are owned by governments, municipalities, communities, and/or individuals, and can be sold in the secondary raw materials market place, indication of a thriving circular economy. The system is fully automated and sensing technology keeps the system in balance.

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Living Architecture Consortium
rendering: LIQUIFER Systems Group

The Living Architecture project has the potential to empower individuals and communities to reconstitute the way they value the environment, the way they inhabit living spaces, and the way their homes impact the world.

Rachel Armstrong

Integrating vegetation into the urban fabric is a dedicated goal of the European Union to improve the quality of life in cities. In dense urban areas, vegetation can be accommodated on facades, roofs, along city infrastructure and inside buildings. Vertical farms add to food security, improve air quality, help to reduce the urban heat island effect, insulate building envelopes, provide psychological benefits for city inhabitants, act as natural filters for cleaning water, and contribute as feedstock to the Living Architecture system performance.

Consecutive enhancement of system robustness during the short, mid, and long-term intervals is of highest priority. The integration of living organisms and their capacity to grow, regenerate and reproduce are features that far exceed capacities of existing mechanical technologies. To enable the continuous development of Living Architecture technologies, financing strategies and policy measures must be considered.

University of Newcastle Upon Tyne (UNEW)

School of Architecture, Planning and Landscape
Institute for Sustainability

The University of Newcastle, UK (UNEW) is a Russell Group university that has a constitutional commitment and an international reputation in the field of urban sustainability. Within the context of exploring our urban futures, the School of Architecture, Planning and Landscape established a new field of Experimental Architecture that looks for new paradigms for sustainable urban practices through: modelling, prototyping, designing installations and by trialling cutting edge technologies.

University of the West of England (UWE)

Bristol BioEnergy Centre (BBiC)
Bristol Robotics Lab (BRL)

The Bristol BioEnergy Centre (BBiC) is a newly formed UWE Centre of Excellence (CoE), which specialises in waste and wastewater utilisation as a source of bioenergy for practical applications, and in ultra-low-power electronics ,and smart energy harvesting. The Bristol BioEnergy Centre sits within the Bristol Robotics Laboratory (BRL), which has a mission of understanding the science, engineering and social role of robotics and self-sustainable systems.

Spanish National Research Council / Agencia Estatal Consejo Superior de Investigaciones Cientificas (CSIC)

National Center of Biotechnology (CNB)
Department of Systems and Synthetic Biology

The National Center of Biotechnology is a publicly-funded national research institute that belongs to the Spanish National Research Council (CSIC). The Systems Biotechnology group is part of the Department of Systems and Synthetic Biology. The group explores and exploits, from a systems perspective, the metabolic capabilities of bacteria and how they can be used as standardized building blocks in order to construct new-to-nature metabolic pathways that can contribute to planet sustainability in the future.

LIQUIFER SYSTEMS GROUP GMBH (LSG)

LIQUIFER Systems Group (LSG) is a SME and transdisciplinary platform engaged in the design of future systems for Earth and outer space. The LSG team comprises of experts in Architecture, Design, Systems Engineering and Human Factors. LSG excels in designing advanced concepts for habitation in space and scenarios and spatial environments for urban futures on earth.

EXPLORA BIOTECH S.r.l. (EXP)

Explora Biotech is a privately owned SME established in 2006 in Rome by a pool of young researchers with support of the French seed capital organization INVENT SaS. EXPLORA is committed to the development of enabling technologies for biological engineering. Its mission is to develop a comprehensive bioengineering platform to unlock the full potential of forward biological engineering.

University of Trento / University Degli Studi di Trento (UNITN)

Centre for Integrative Biology (CIBIO)

The Centre for Integrative Biology (CIBIO) is the new initiative in molecular medicine and biotechnology within the University of Trento. CIBIO promotes the idea of merging the classical cellular and molecular biology perspective with the new powerful approaches made available by systems and synthetic biology, giving also strong emphasis on integration with chemistry, physics, informatics, mathematics, and engineering.

Scientific Advisory Board:
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This booklet was prepared as a part of the dissemination activities in the Living Architecture project.

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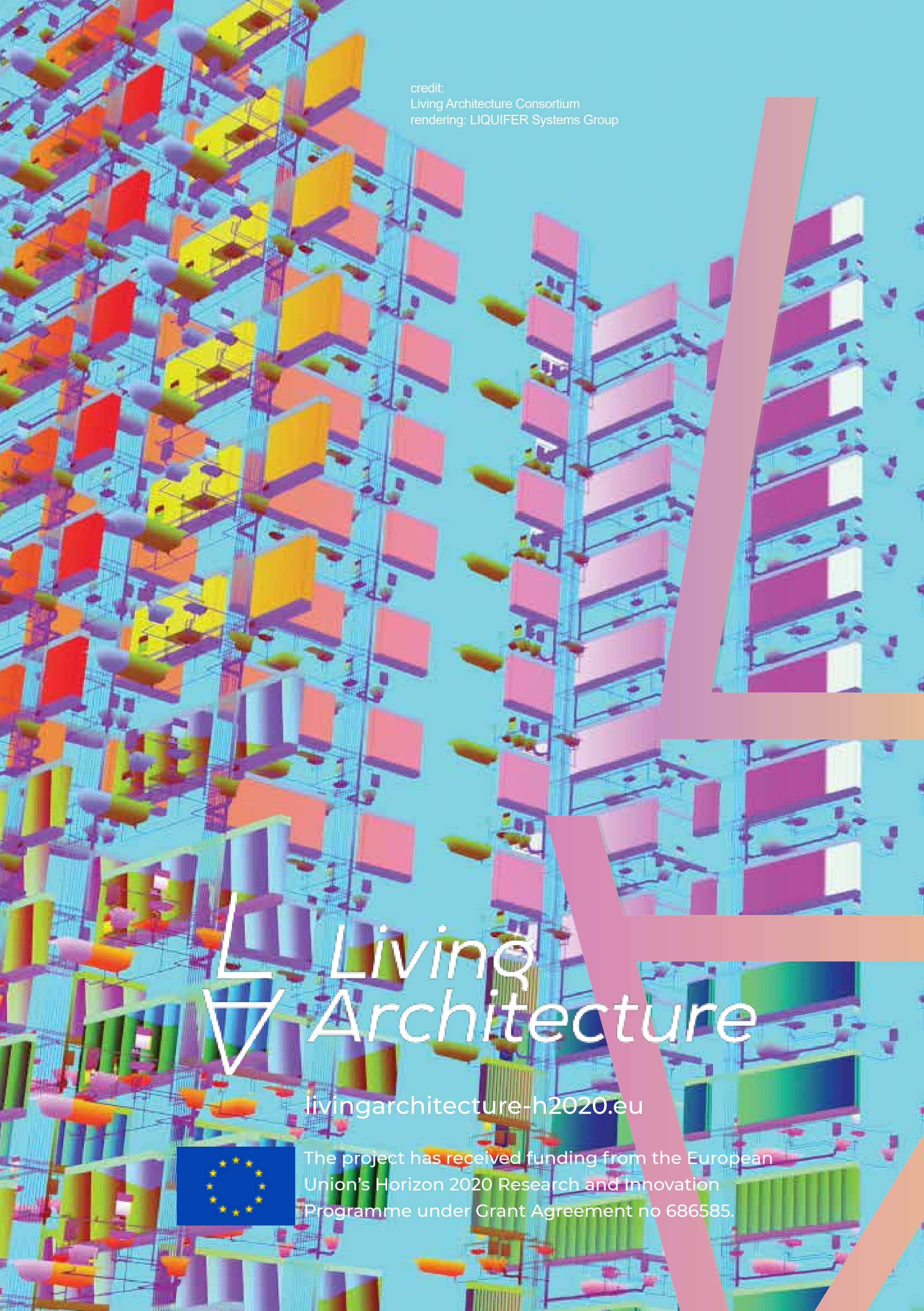

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