Living architecture: metabolic programmable Apps as part of Life Support Systems

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University of Trento / University Degli Studi di Trento, Centre for Integrative Biology

AgroSpace-MELiSSA, Rome 16-18 May 2018
17 May 2018, Modelling and system design

FET-OPEN

Living Architecture

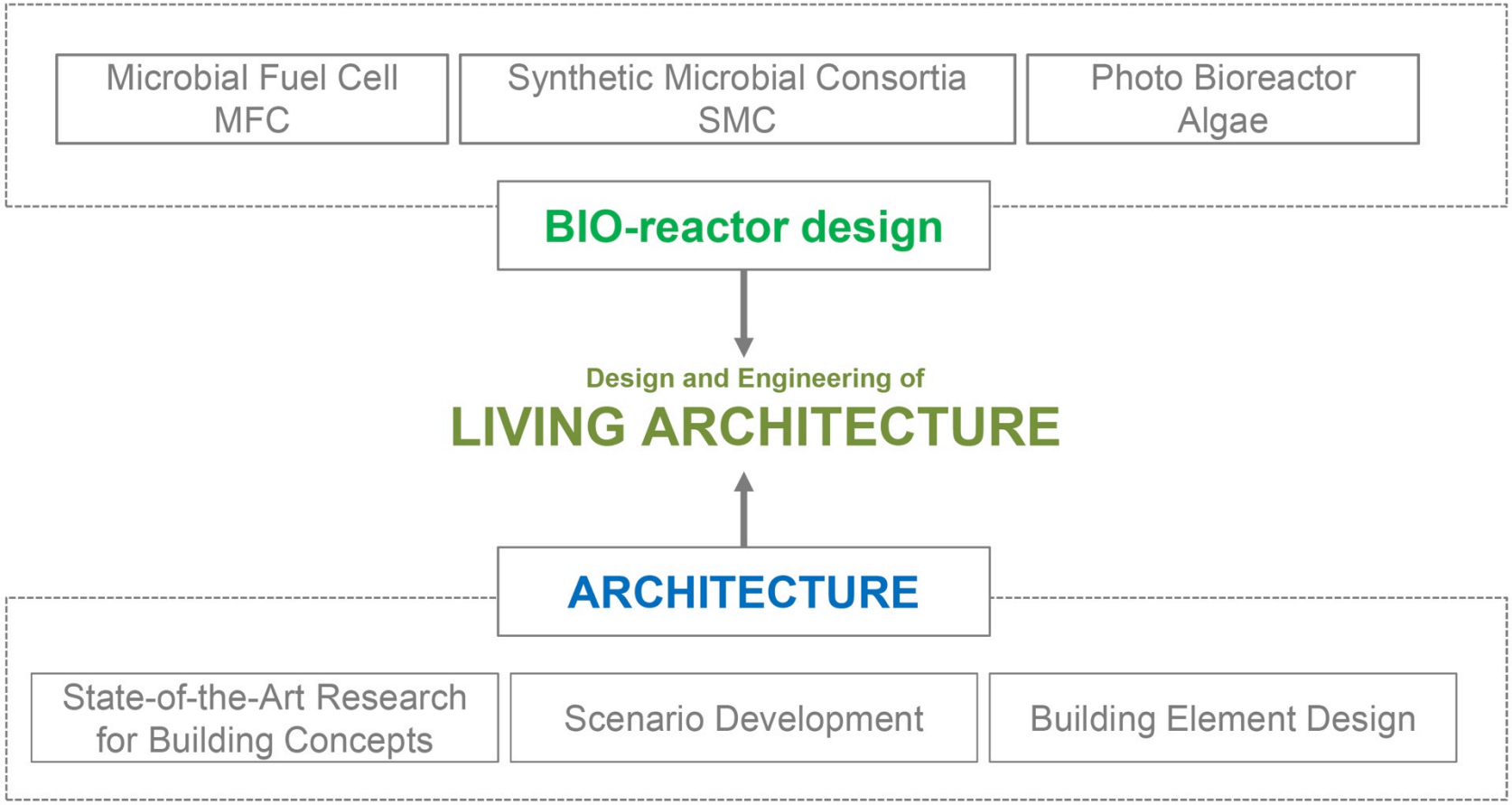
Is a selectively-programmable hybrid partition wall that:

- Produces useable products such as biomass, electricity and polished water
- Uses waste as an energy source
- Recovers valuable resources from waste

Is a collaborative project designed by architects, engineers and scientists incorporating:

- Microbial Fuel Cell (MFC) technology
- Photobioreactors (Algae Lagoon)
- Synthetic Microbial Consortia (SMC)
- Standard building practices
- Building inhabitant / User strategy

Living Architecture



PARTNERS

>>> sustainable practices for smart cities

University of Newcastle Upon Tyne (UNEW)

School of Architecture, Planning and Landscape, Institute for Sustainability

Focused commitment to urban ecology with particular interest in smart cities initiatives that simultaneously advance technological know how and civic engagement

>>> turning waste into energy

University of the West of England (UWE, Bristol)

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

BBiC specialises in Microbial Fuel Cell (MFC) technology, which utilises common waste products generated by society for producing bioenergy (heat, gas, biogas, biofuel, electricity). BRL develops scientific and engineering solutions for the integration of robotics into existing structural systems, both human and infrastructural, for greater efficiency and autonomy of the systems.

>>> metabolic engineering for targeted performance

Spanish National Research Council (CSIC)

The Biological Research Centre (CIBCSIC), Department of Environmental Biology

The Biological Research Centre (CIB) advances knowledge in the growing fields of Biotechnology and Molecular Microbiology and models and engineers synthetic biology, and metabolic applications.

>>> architectural and engineering solutions for future living

LIQUIFER Systems Group (LSG)

LSG specialises in the development of architectural and engineering systems for human utilization in terrestrial and space applications.

>>> synthetic biology - DNA and RNA molecular Biology

EXPLORA Biotech (EXP)

EXP develops technologies for designing, simulating, fabricating and testing synthetic biology parts.

>>> system modelling, photo-bioreactor

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

Centre for Integrative Biology (CIBIO)

CIBIO merges classical cellular and molecular biology with new approaches including systems and synthetic biology, with focused interest in chemistry, physics, informatics, mathematics and engineering.

Living Architecture

Current situation

Resources

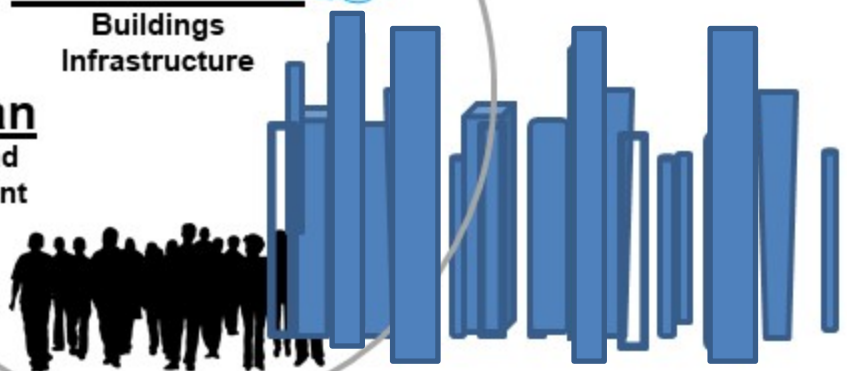
Food
Water
Energy

Static Built Environment

Buildings
Infrastructure

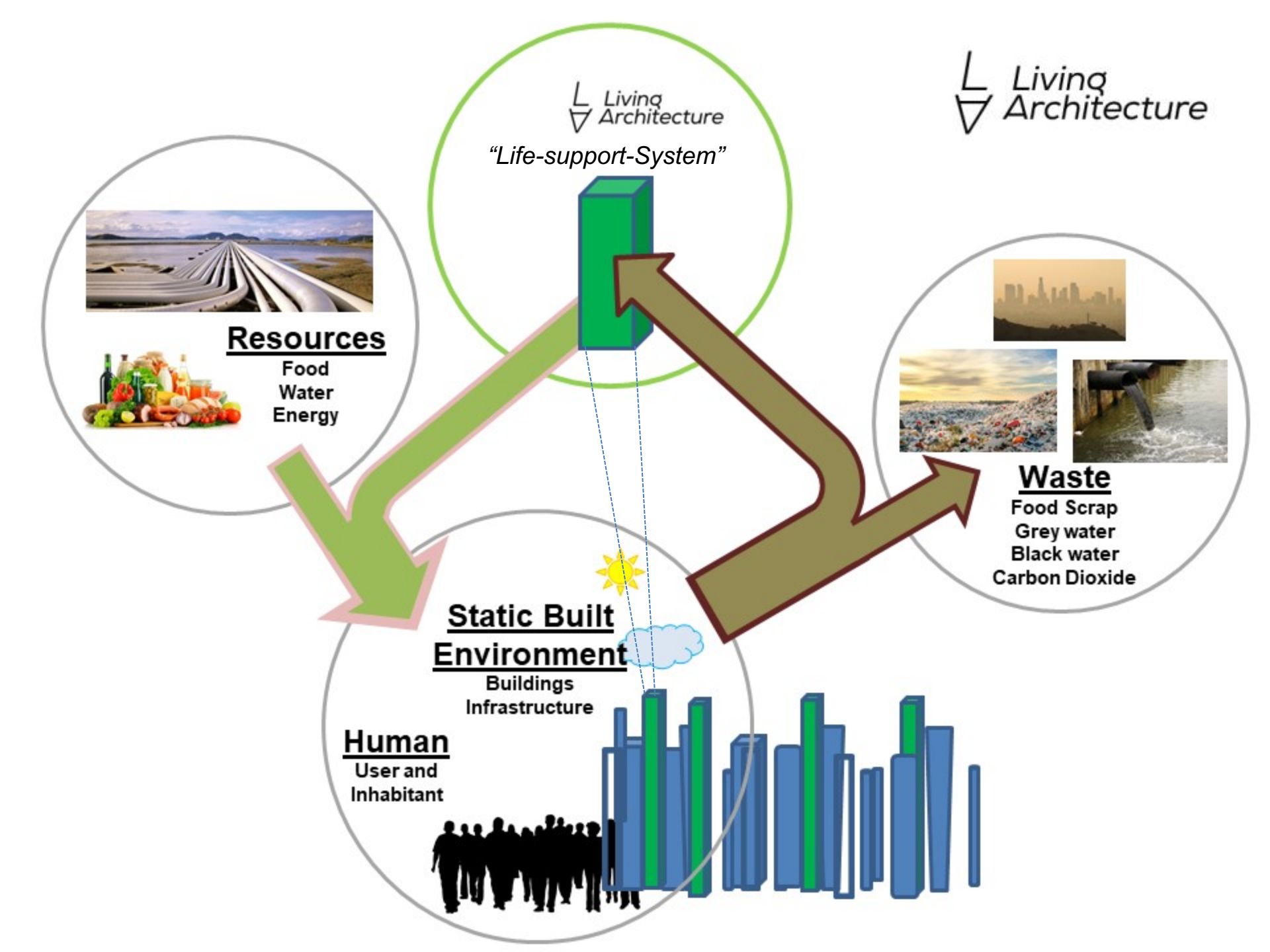
Human

User and Inhabitant

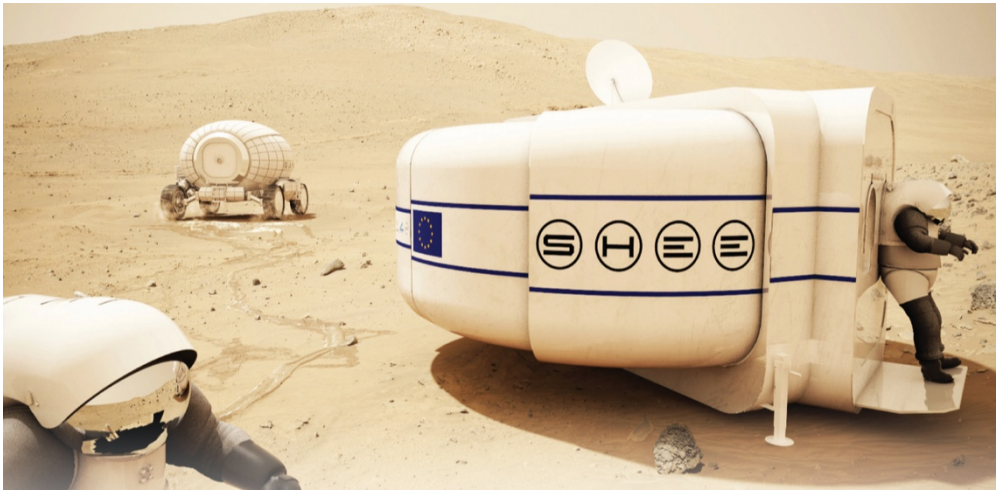


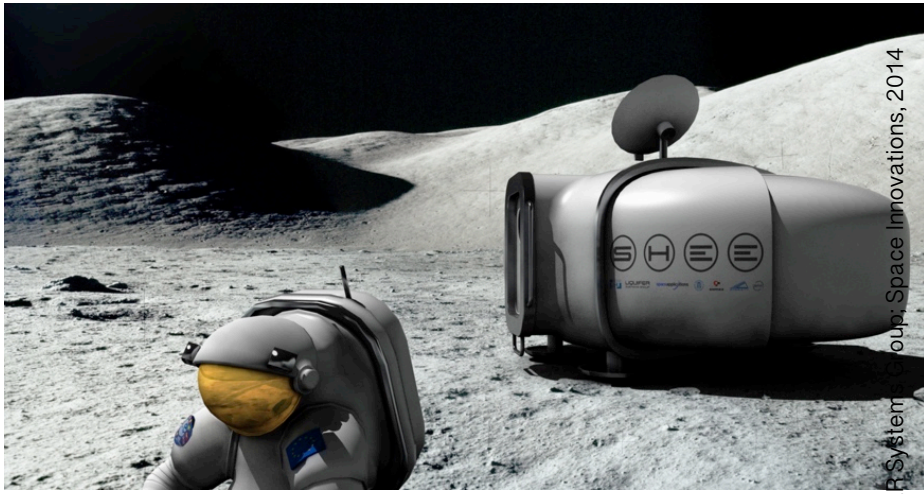
Waste

Food Scrap
Grey water
Black water
Carbon Dioxide


Living Architecture
Living Architecture
“Life-support-System”
Resources
Food
Water
Energy
Waste
Food Scrap
Grey water
Black water
Carbon Dioxide
Static Built Environment
Buildings
Infrastructure
Human
User and Inhabitant

SHEE – Self-deployable Habitat for Extreme Environments 2015





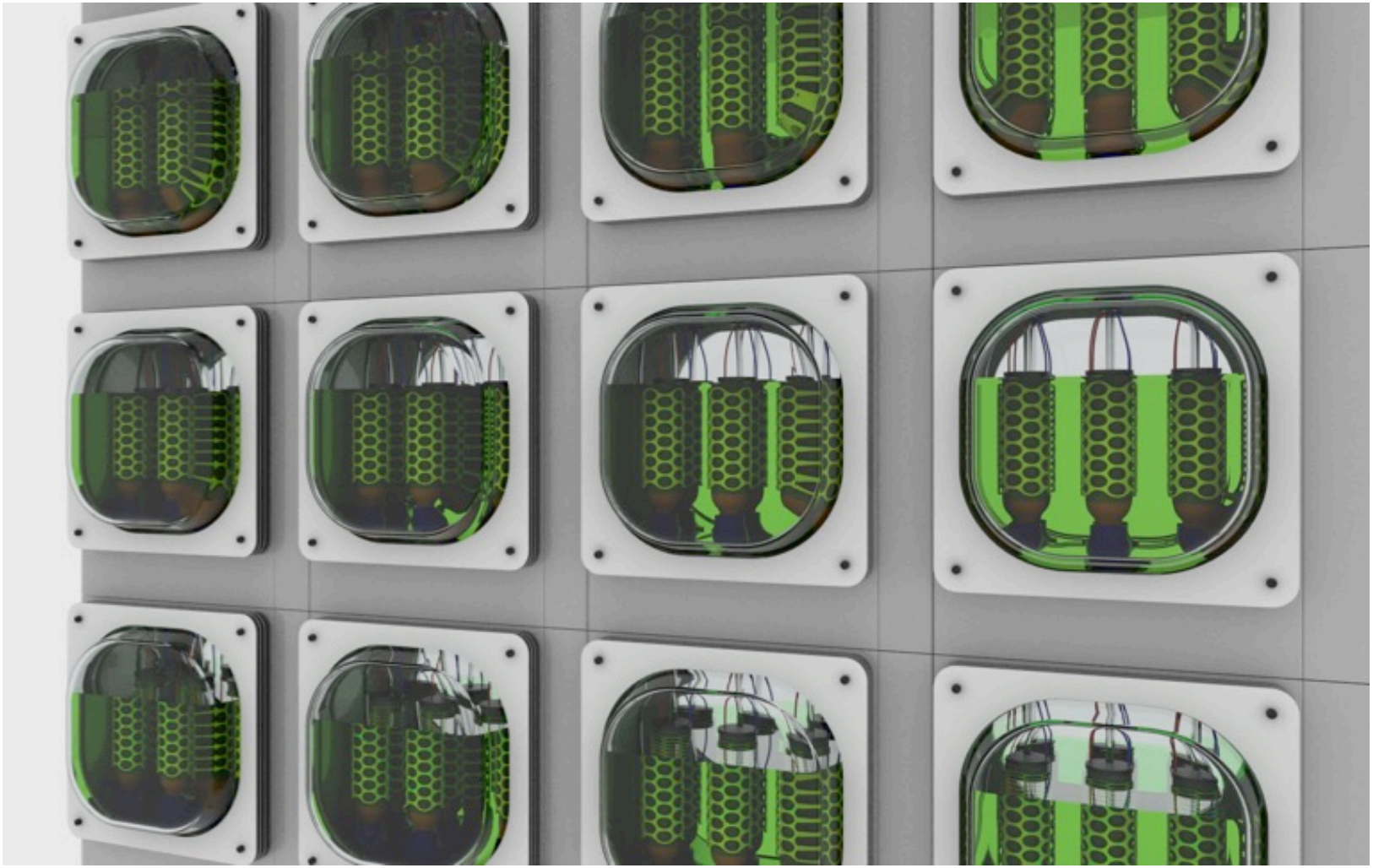
Credit: SHEE consortium, visualization: LIQUIFER Systems Group; Space Innovations, 2014

Process Diagram

Living Architecture Technology

Process diagram, UWE 2018

Living Architecture Partition/Facade Wall



Concept for Bioreactor Wall, LSG 2019

Living Architecture

FRAMEWORK

Considers **EU stats and standards** on EU **resource use, waste production, and housing type and quality**

Investigates EU directives and mandates to inform targeted goals

PARAMETERS

Specific to LIAR technologies & subsystems

SCENARIOS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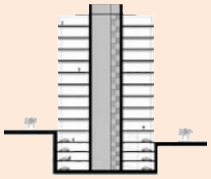
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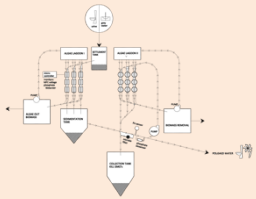
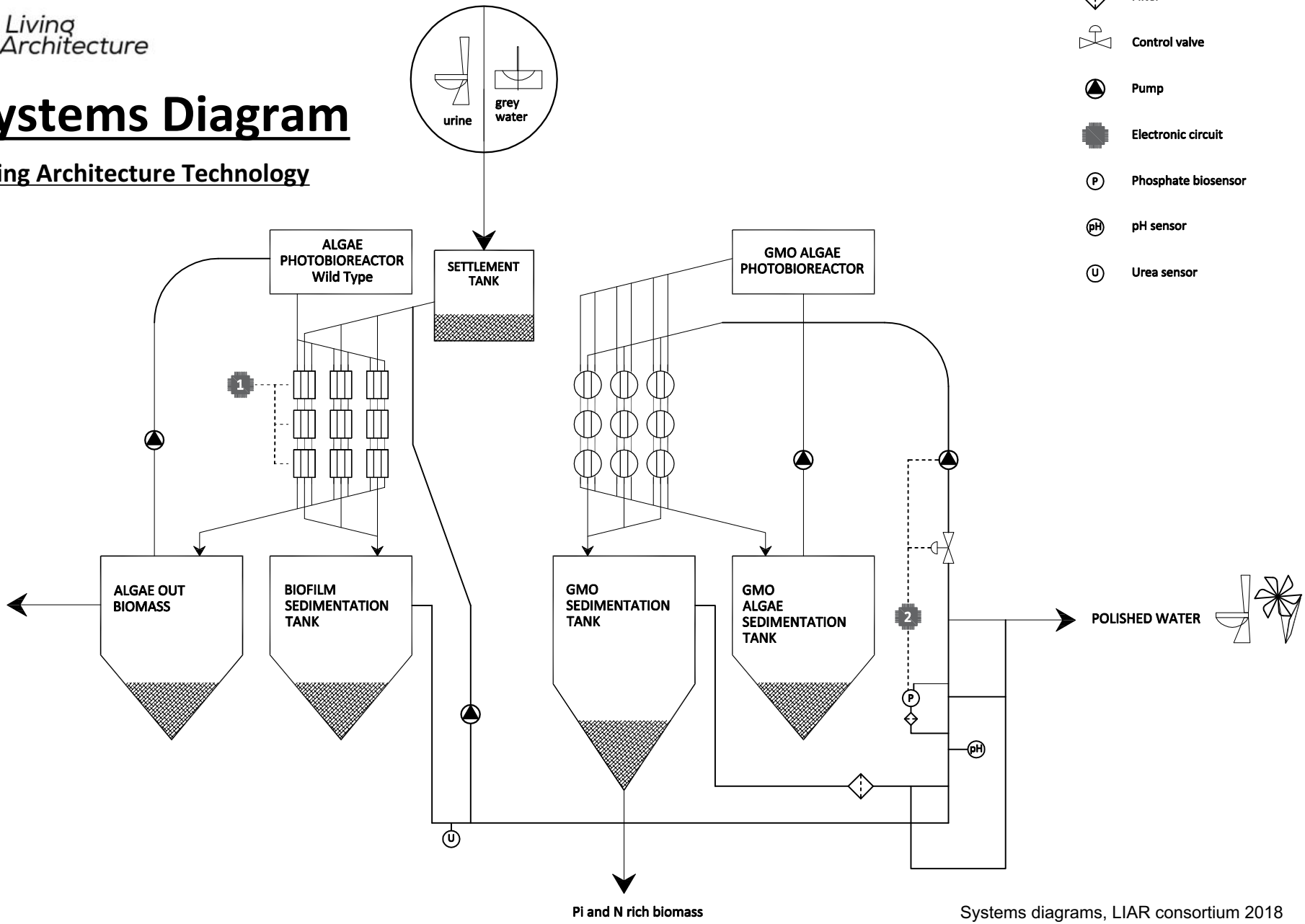


Urban CONTEXT | **USE Strategy** | **BUILDING Typology** | **Technology INTERVENTION / INTEGRATION**

Living Architecture

Systems Diagram

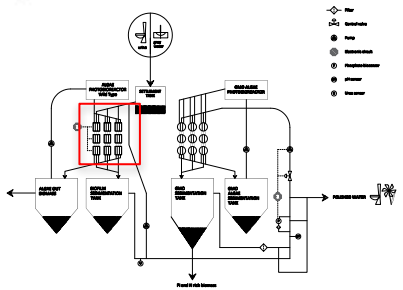
Living Architecture Technology



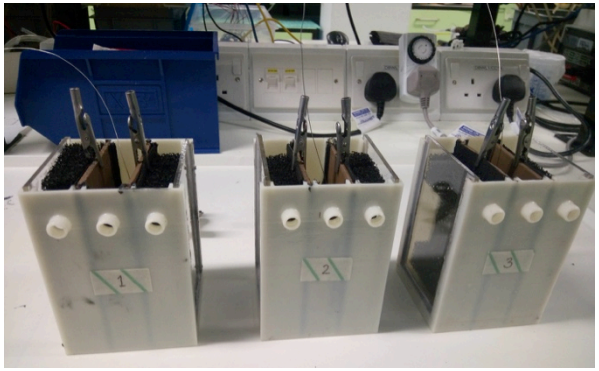
Systems diagrams, LIAR consortium 2018

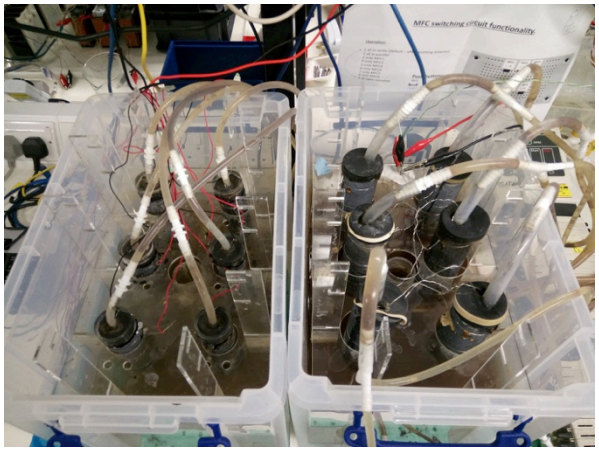
PARAMETERS

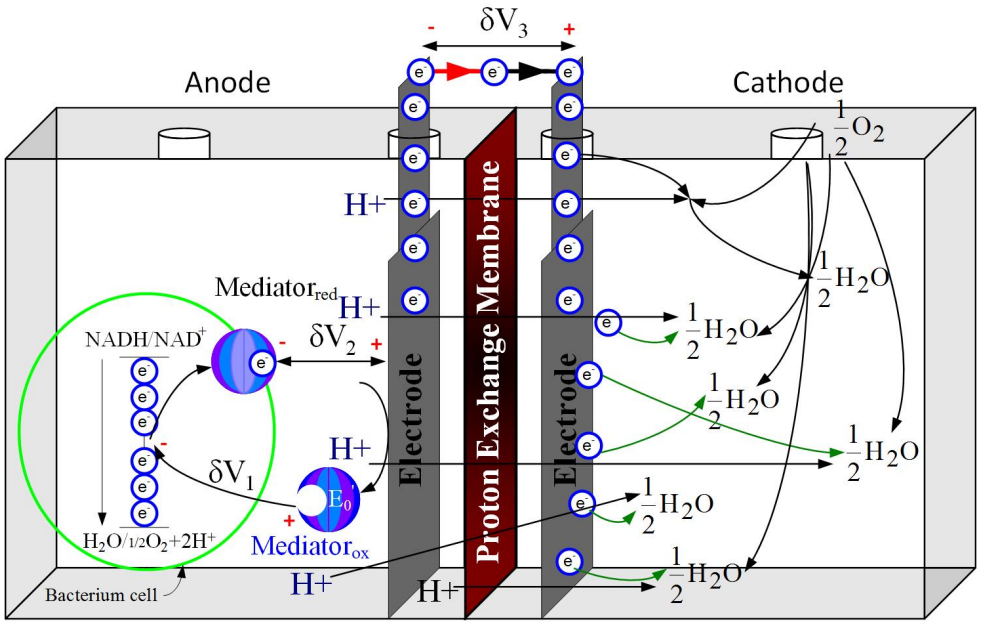
Specific to LIAR technologies & subsystems



Microbial Fuel Cell (MFC)





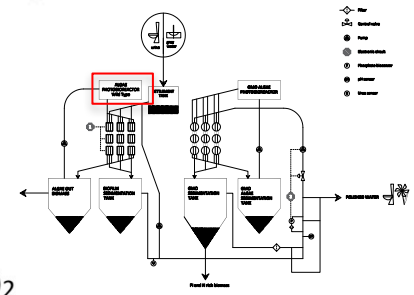


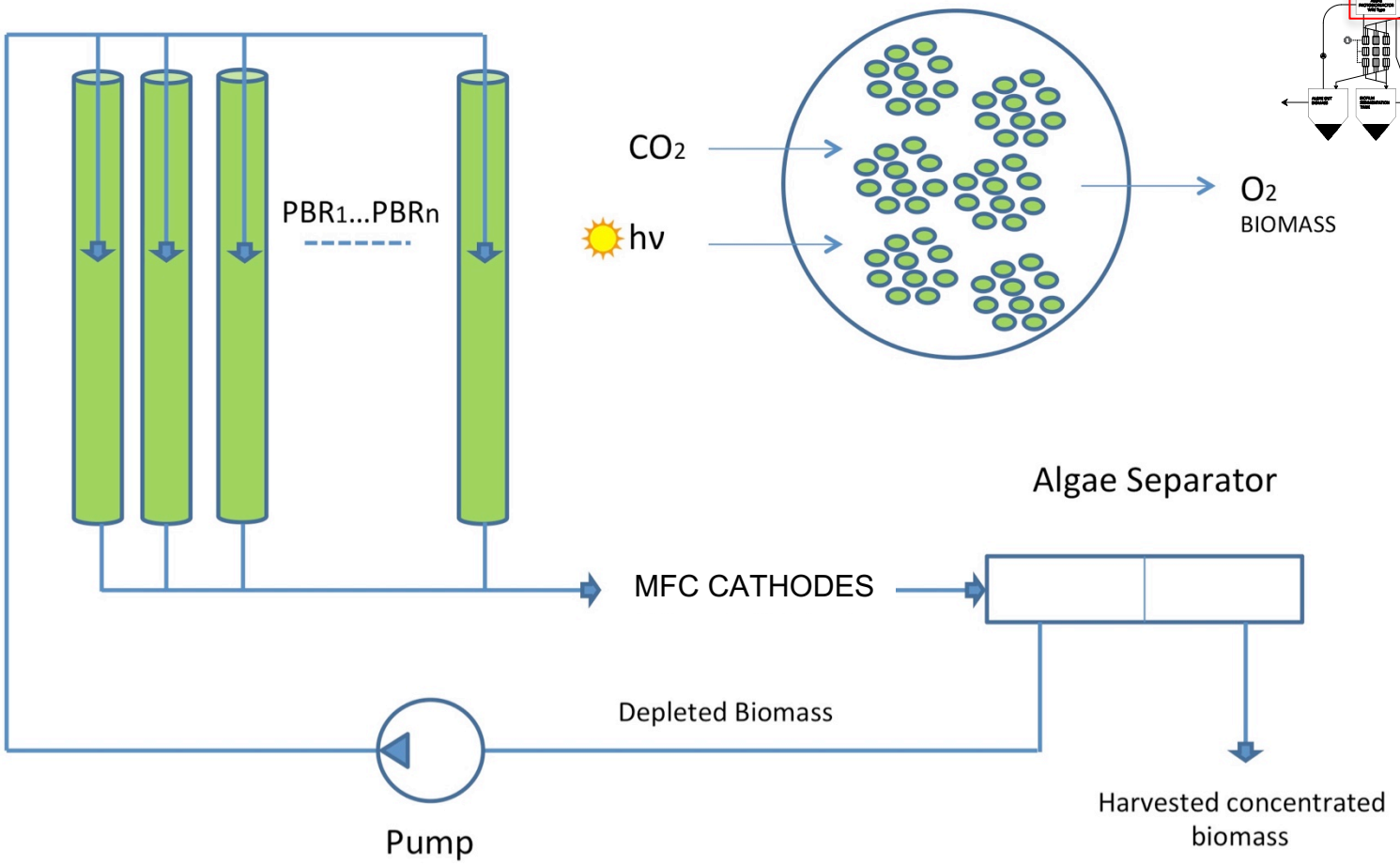
MFC unit concept diagram, Bristol BioEnergy Centre, Bristol Robotics Laboratory, UWE 2016

PARAMETERS

Living Architecture

Algal Lagoon/Photobioreactor (PBR) Section (Wild Type)





PBR (wild type(concept diagram, UNITN, 2018

PARAMETERS Specific to LIAR technologies & subsystems

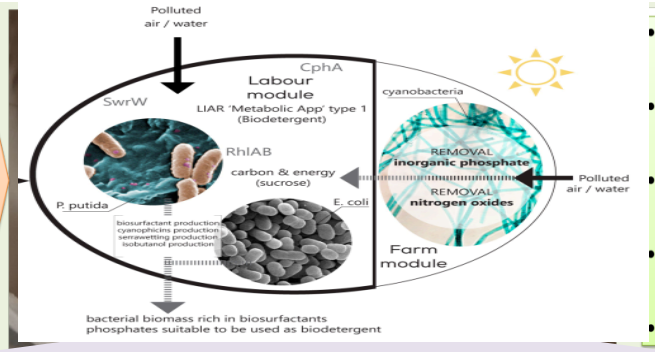
Living Architecture

Synthetic Microbial Consortia (SMC)

GOALS

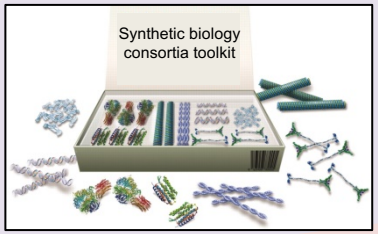
Chemical Engineering

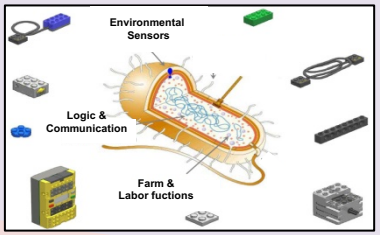
- Gray water
- Polluted air
- CO_2
- Sunlight



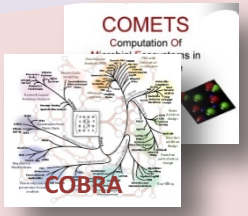
- Clean water
- Clean air
- Biofertilizer
- Biodetergent
- Byproduts

Synthetic Biology





Systems Biology



*i*JB750

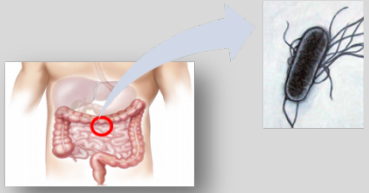
Modeling consortia toolkit

*i*JO1366

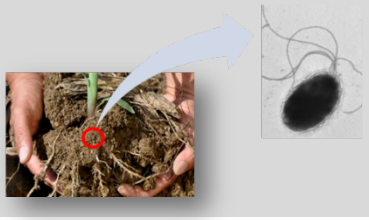
*i*JN1411

Synechococcus elongatus

Escherichia coli



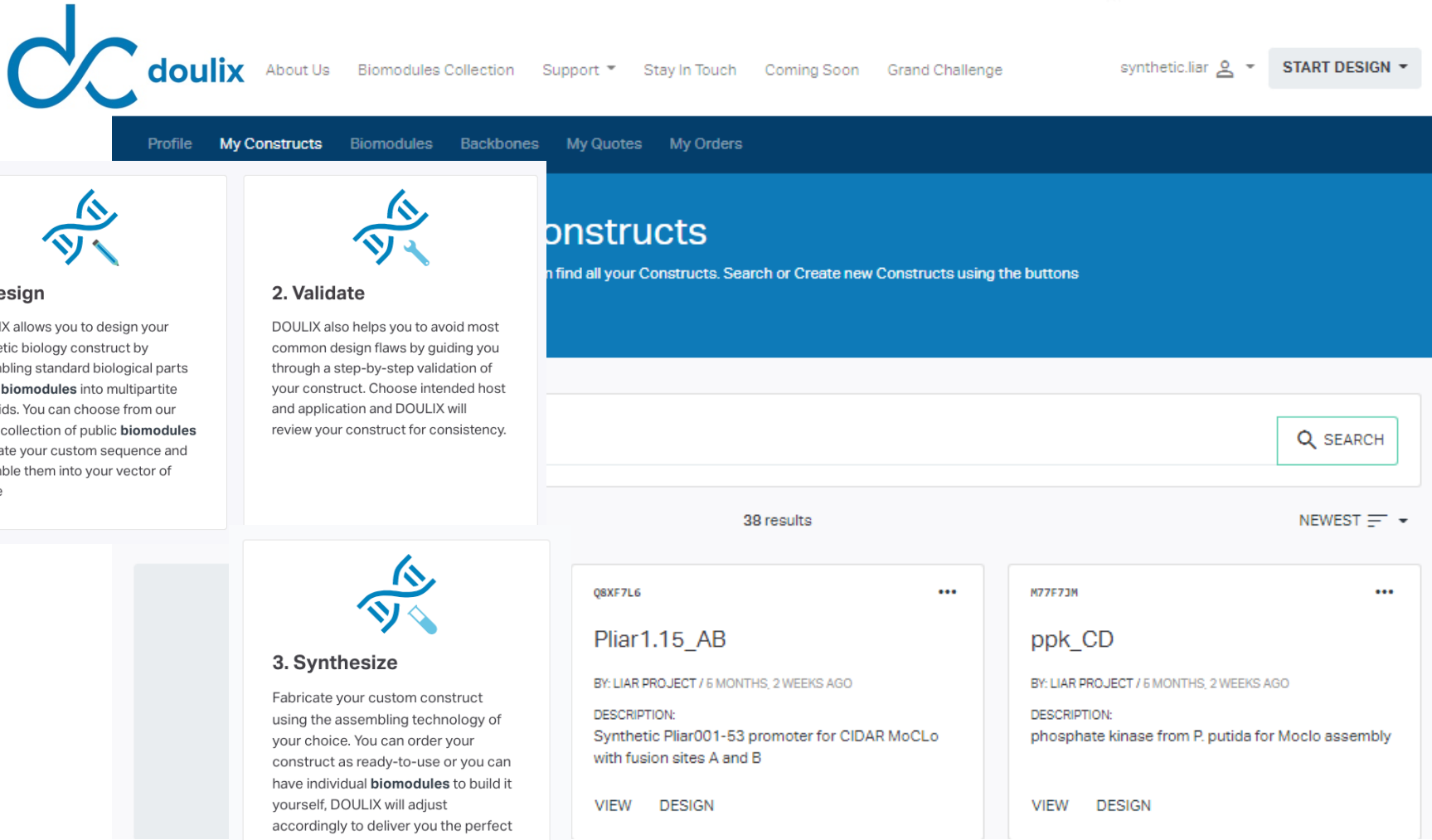
Pseudomonas putida



SMC goals, CSIC, 2017

PARAMETERS Specific to LIAR technologies & subsystems

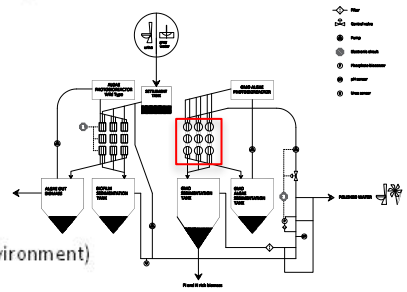
Living Architecture

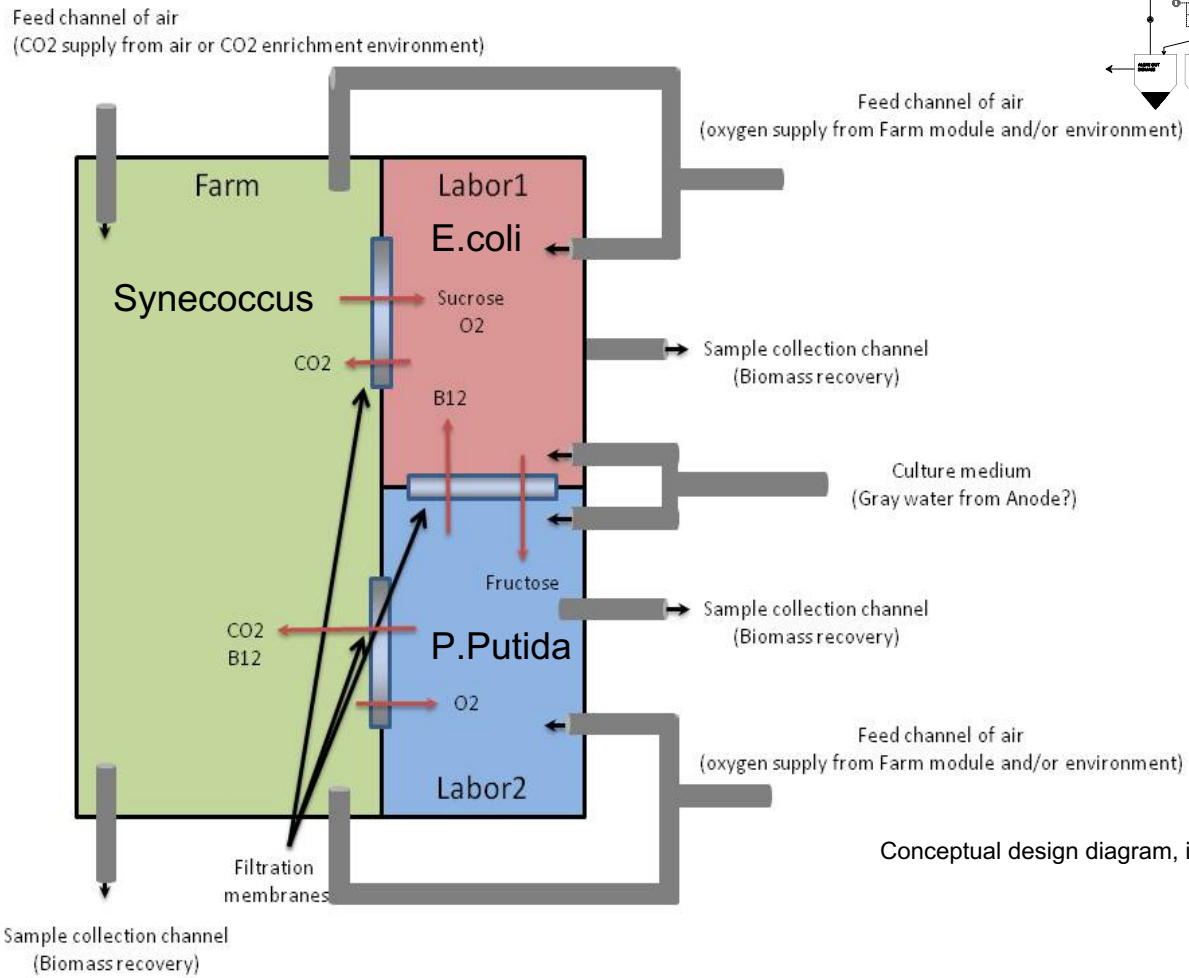


PARAMETERS

Specific to LIAR technologies & subsystems

Synthetic Microbial Consortia (SMC)



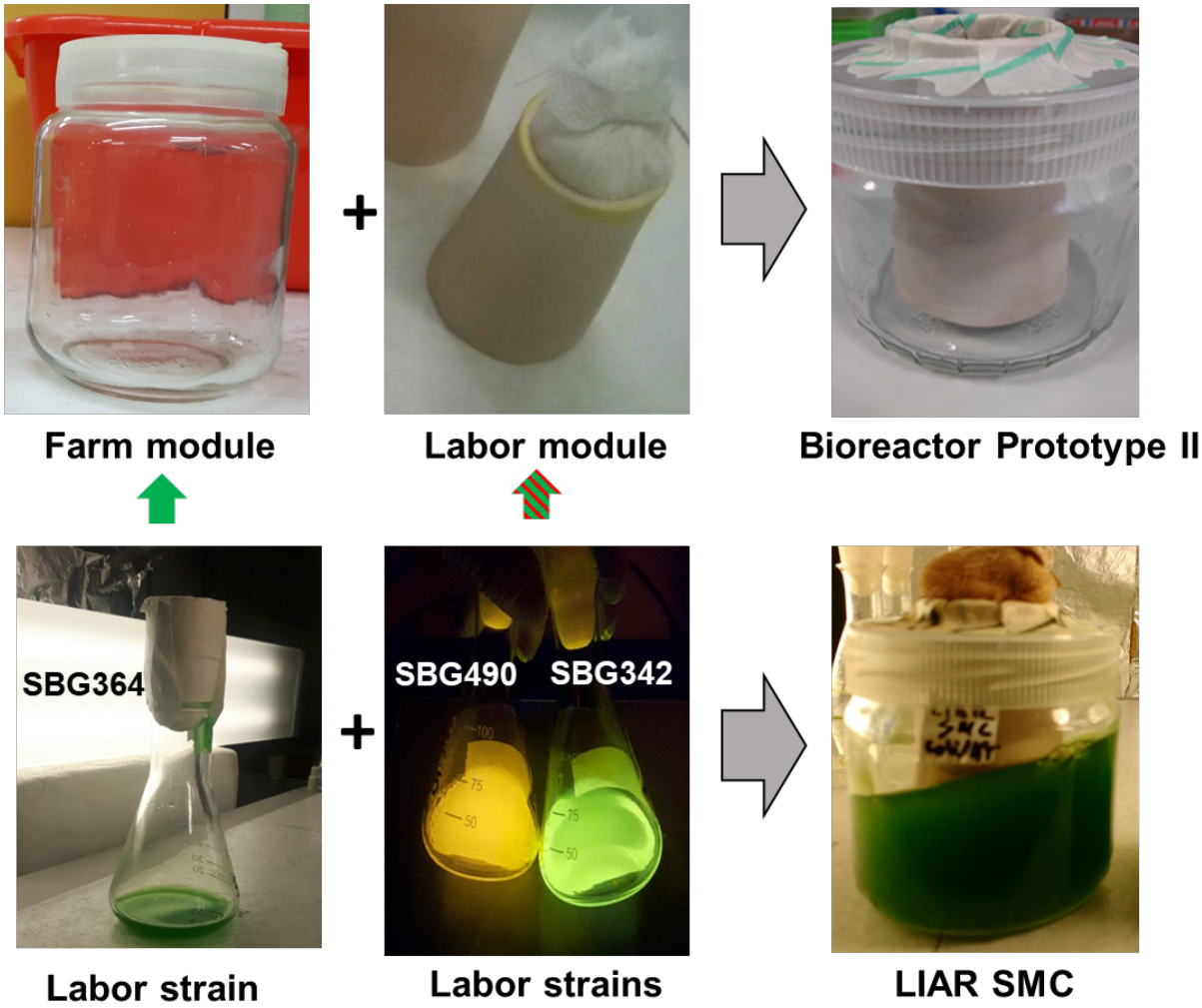


Conceptual design diagram, input / output, CSIC 2017

PARAMETERS

Living Architecture

Set-up for the Synthetic Bioreactor Prototyp (SMC)



Conceptual design diagram, input / output, CSIC 2018

SCENARIOS

Urban CONTEXT

Considers typical urban conditions for building types and uses based on EU statistics

USE Strategy

Scenario / Use Case 1 – Household

3-person, 2-bedroom flat, affluent trend setters for sustainable living, climatic independence - interior applications, active user commitment

Scenario / Use Case 2 – Town House

50 persons – approx. 20 flats, 4 floors – 5 flats per floor, affluent trend setters for sustainable living and others, climatic independence - interior applications, semi-active user commitment

Scenario / Use Case 3 – Office Building

Small and medium-sized enterprises (SMEs), office space, affluent owners /CEOs who build their philosophy and status on sustainable principles, climatic independence - interior applications, low or no active user commitment

Scenario / Use Case 4 – School Building

Public institution, secondary school, 600 pupils, alternative affluent school types which build their philosophy and status on sustainable principles, climatic independence - interior applications, selectively high active user commitment

SCENARIOS

BUILDING typology

from **Existing (INTERVENTION)** to **New (INTEGRATION)**

Visualization, Minovski/LSG, 2012

Outlook – Potentials of Living Architecture

- **Short term: Proof of Concept: December 2018 - Partition Wall in a Laboratory Context**
- **Near term: Creating larger community and economic impact**
- **Long term: Living Architecture Bio-reactor – viable solution for urban and remote contexts**

Semi-autonomous habitat SHEE in a Mars mission simulation, Rio Tinto, Spain, 2016, credit: Bruno Stubenrauch