ZERO KILOMETRE PLANTS PRODUCTION. AN INTEGRATED DESIGN APPLICATION

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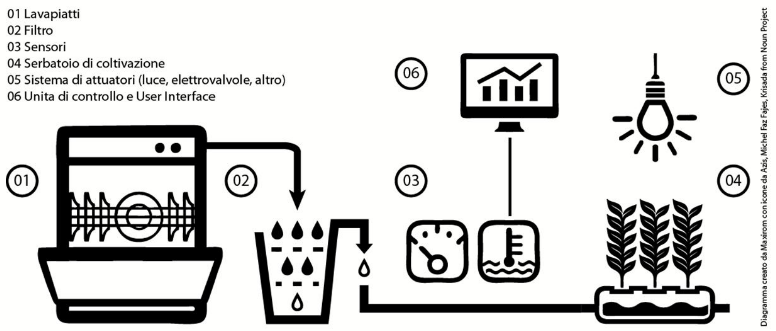
ABSTRACT

Interest in urban agriculture as well as the various forms of zero kilometre production for domestic use, necessarily passes through the redefinition of the parallel system of building components, both regarding technological and innovation level of the built space, towards their progressive integration: from independent solutions or simply superimposed on the building, towards increasingly hybrid forms, as expression of an increasingly integrated collaboration between architecture, agriculture and design. The result is the progressive replacement of traditional products with elements and components directly integrated in construction by composition and technology. The paper presents the first results of the design research whose objective is to experiment the possible applications to the contexts of the built space, to the different scales of the project, of a product system for the recycling of washing waste in a domestic environment for the production of plants. edible products underway at the Design Department of the Milan Polytechnic.
Key Words: sustainable gardening / waste water recovery / green integrated solutions.

1. INTRODUCTION

Environmental or ecological sustainability requires awareness of the natural resources. The impact of human activities and decisions on it is therefore of first interest in sustainability research deals with living spaces (architecture and construction activities). In this context an increasing research area of interest is focusing the consumption of water resources in household appliances, particularly all technological systems and/or solutions able to recycle dishwasher wastewater for the cultivation of edible and ornamental plants. However, there is still a significant gap concerning the possible application of these innovative technologies to the built space context. Therefore, the integration of the wastewater treatment system in kitchen furniture, with green or gardening architectural solutions as first application outcome of the research itself, can push a change in indoor growing modules design, as well as in user behaviours, while improving the domestic water use efficiency.

An in progress interdisciplinary research on Waste Water Food Converter (WWFC) by Department of Design of Politecnico di Milano, aims to study a product system for recycling wastewater in a domestic environment for the production of edible plants through an autonomous cycle, whose preliminary phases were[1]: characterization of wastewater, plant growth and functionality analysis, technical design of the remediation plant, product and user inquiry, participatory design for expert and user involvement in the system ideation and development, followed by the development of a functional prototype designed for indoor installation, equipped with a series of sensors and actuators for the control and regulation of the entire system, as well as a low emission system with low environmental impact [Figure 1]. The paper presents the first results of this system possible application at the built space context, and at the different scales of the project.



[Figure 1] Functional diagram and prototype

2. TOWARDS AN INTEGRATION OF THE SYSTEMS

Foreword to the project research was the collection and critical analysis of case studies on issues of vertical green, urban and indoor gardening, in the search for dependency relationships between application technologies and built space, useful in defining the related application strategies to apply into follow design phase. Two were the references adopted particularly: the development that over the years has taken place in the context of research on photovoltaic components, on the one hand, and the design experimentation of green solutions for roofing systems and façades, on the other.

Over years, their design solutions have experimented a path of progressive integration, from independent solutions and simply superimposed on the building, to increasingly hybrid forms for morphology and construction components, addressing basically three main types of applications, as summarized in the following Table 1 [1, 2].

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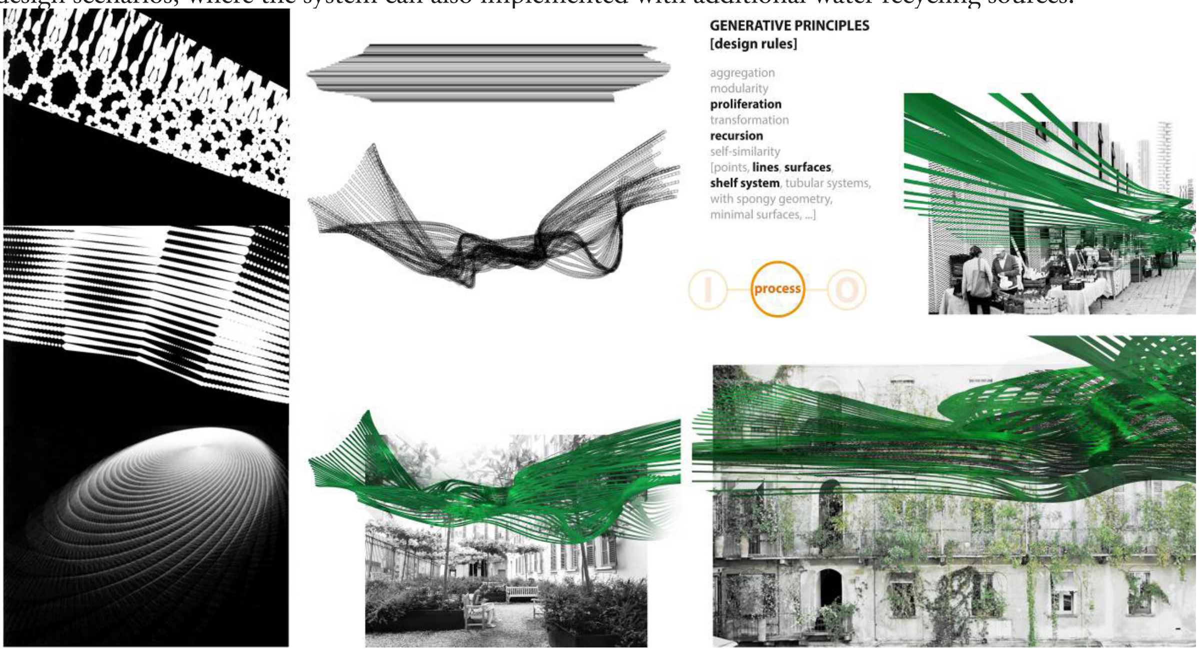
[1] For more information on research see Aureggi, Carboniero, Costa, Perego, Pillan, Vignati "Design for sustainability and ICT: a household prototype for waste water re cycling", also published among the acts of The LeNS World Distributed Conference – Designing Sustainability for All.

[Table 1] Towards an integration of systems - main application types

INDEPENDENT APPLICATION	APPLICATION BY OVERLAPPING	APPLICATION BY INTEGRATION
It does not act as a building envelope and the building presents itself as a simple support of technology (morphology that does not determine the arrangement of the components of the application).	It is characterized by standard technological elements that differ only for the type of support used. The envelope acts as a simple support (technology components anchored to the construction with a parallel and not far structure).	Hybrid nature of the constructive system that arises between architecture, nature, open space and because of a different interpretation of the organization of space in morphological, technological and thematic terms.
The application does not replace traditional building components (both the construction and the technology maintain their autonomy, functional and spatial) and its location with respect to the building partitioning system is closely related to the type of vegetation or technology.	"Superstructure" effect: technological elements that do not substitute envelope parts or sub-systems, but are limited to their overlap (second "skin" strictly dependent, which often contributes to increase the environmental and/or energy performance already achieved by the constructive component).	Technological-constructive components studied ad hoc and able to replace, incorporating, some or all the functions related to the elements of the partitions and the built space. The complex ensemble that results from it is not so easily divisible in its constitutive elements.
Simple, fast and economical solution, suitable for full or partial redevelopment processes.	Simple, fast and economical application, indicated in the retrofitting process.	It is applied in new interventions or in case of replacement of significant portions of an existing building.

The three emerged application strategies were the basis for defining the design hypotheses in which the WWFC system can be applied to the different scales of the project, with integrated solutions both in furniture design and in façade construction components, thus determining a functional and technological reinterpretation. To this goal, meta-design principles and generative rules have been explained [4], which in the form of spatial suggestions, have allowed to direct the design research as integration between architecture, agriculture and design dimensions [Figure 2]. The integration of the wastewater treatment system in kitchen furniture, first, and with the vertical gardening solutions, second, make it suitable for end consumer, giving the research a first application outcome, further developed into design scenarios, where the system can also implemented with additional water recycling sources.



[Figure 2] Generative principles and outdoor scenarios (Font: Authors)

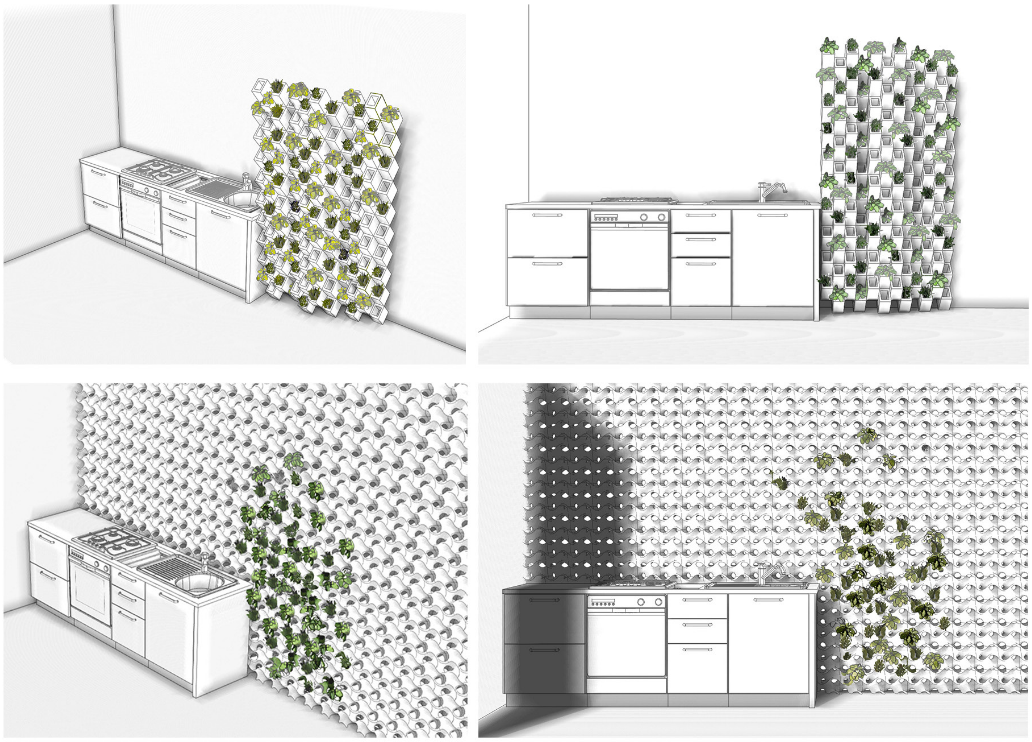
3. SCENARIOS

The industrial and profit-making logic that supported the modern food production system it considers food as a commodity to be produced and sold with the maximum cost-benefit ratio. This process creates situations of natural and energy resources unsustainable exploitation, incompatible with the continued world population growth. The debate has progressively expanded over recent years, involving not only researchers and politicians, but the entire population. The consequence is the emergence of a market promoted by conscious consumers, who buy not only for hedonic purposes, but with the awareness that buying and selling process also has a social and ecological impact. The focus is no longer just the price, but also to healthiness of the purchased food, to influence it has on its own health, to attention for sustainability of the production process in social and environmental impact terms.

From the results of the experimental research[5] a significant amount of useful surface to accommodate the various species of edible plants was emerged. Specifically: 80 lettuce plants equal to a consumption of 3.5 liters of water/day of waste recovered and filtered, equal to a surface of about 3 square meters, which make it possible to use the average waste production of an Italian family.

With the aim to direct the project development towards integrated solutions for technology and construction, the project requirements for the implementation of this phase have been defined as follow:

- modularity of the system _ from the single base unit (in the study prototype represented by simple polystyrene vases of 60x20x18 cm, containing three plants each, mounted on a vertical metal frame) to their aggregation in functional sets;
- differentiation between structure / frame, with the related systems for irrigation and wiring of the sensors, and the modules for the support of vegetation;
- flexibility of cultivation, providing both the possibility of cultivating more edible species, each with a specific consumption of water, and the possibility of integrating the system with ornamental types;
- easy access, maintenance and movement of the elements (single and aggregated);
- implementation of the urban scale system in the redefinition of themes and functions, also focusing on issues of socialization and the redevelopment of living spaces.



[Figure 3] Indoor scenario (Font: Authors)

Those listed are general features of the system which may have different repercussions depending on the implementation scale. In designing a system for domestic use it is necessary to consider food consumption practice as an action of meanings attribution, which contributes to build costumer's personal identity[3]. There is therefore an attention that opens up new trends in domestic environment, in particular for the kitchen area [Figure 3].

Despite the sensitivity of potential consumers it's necessary the new system is independent and functional as possible. Contrary to outdoor vegetable garden, where time dedicated to cultivation is perceived as a hobby, in a domestic interior the system must subtract the user as little time as possible. Electronic devices will monitor growth protocols by regulating luminance, entrusted to particular LED lights (specifically modulated to optimize and accelerate different species life cycle), the temperature and the humidity required, no matter of the real conditions, at any latitude. The vegetables so cultivated do not undergo contamination with chemical substances or potentially polluting soils, allowing the consumption of fresh products that maintain their organoleptic properties unaltered[6]. Form is designed to integrate green in kitchen environment, satisfying the needs of different vegetal species through modularity, in adaptable and reconfigurable morphologies for limited spaces.

On an architectural scale, integration is instead shaped by the rethinking of a traditional module of vertical obscuration of the façade, to integrate the cultivation system of edible and/or decorative plants: a sort of brise-soleil, at the same time a technological element of façade and cultivation. The panels, modular elements equipped with a frame integrated with the irrigation system and a series of vases housing the plants, maintain the kinematic nature of the shading systems and can therefore run on tracks integrated into the façade, characterizing a dynamism appearance, both for the movement of the frames and for the growth cycle of the plants [7]. By exploiting the surface of the panels, this solution allows you to create a small vegetable garden or vertical garden for domestic use and directly connected to it, flexible, implementable (from a few panels to an entire facade solution) and easily compatible with other spaces of the building, even in contexts where it is not possible to realize more traditional urban gardening solutions [Figure 4].

[Figure 4] Architectural scale scenario (Font: Authors)

At the widest scale of the open space, the project finally configures a shelf structure, supporting and housing vases for cultivation, conceived as an element in adherence to small / medium sized commercial activities and aggregative spaces, where to promote an idea of cultivated area not profitable, but open and shared, from which, with a parallel to what was promoted in the naturalistic field, it's name: "vegetable garden to lose"[2]. In addition to encouraging the recovery of more marginal urban spaces and environments, the recall effect of this solution, thanks to the commercial part's lever in the recovery of waste water produced by the established activities and in the more general promotion, cure and basic maintenance of the system, would help to promote socialization and caring of urban space [Figure 5].

[Figure 5] Urban scale scenario (Font: Authors)

4. DISCUSSION

WWFC technology in future could change both building and space factors of green decoration to producing more resilience indoor and outdoor products, also taking into account the legitimate needs of users with regard to the satisfaction of both the food quality aspects and the aesthetics of the system as a whole. The scenarios are therefore not to be read as products to themselves, as suggestions inserted within a broader experimental research and whose goal is to anticipate the results of hypothesizing, in addition to the size of the product, the possible forms of application of the technology itself to the built context. In this sense, they are configured as meta-projects, solutions open to change deriving from what still needs to emerge from experimental research, able to fix some key aspects for the implementation of the system's application strategies, both indoors and outdoors. The design requirements of these scales, in particular, as well as the feasibility and application contexts, and their relationship with the functional as-

[2] Solution implemented in places where the fauna is damaged or in danger, providing the animals with help in the form of food. This form of protection also acts as a lure for other species of animals, in particular small invertebrates, which in a virtuous circle sometimes attract other species. Among the plants the strawberry, in particular, is very sought after and being a perennial plant it is possible to find it in the vegetable garden all year round.

pects of the technology for the recovery and filtration of wastewater, are in fact still configured as critical nodes from solve in the search. A multi-scale approach that considers a contemporary action to the dimensions of the product, as technology, and space, as application output, will then guide the next steps of experimentation.

In addition to the prototyping of the various solutions, development of the design research aims to study a further scenario on territorial scale, as an extension of the principles and requirements defined in introduction, thus moving from a timely dimension that binds the product of the WWFC technology to the building components of domestic space, to a more widespread and networked one, characterized by intermediate dimension between space of the neighborhood and that of interactive connections.

BIBLIOGRAPHY

1. Blasi C., Padovano G. (2003). The challenge of sustainability. Milan, Italy. Foxwell & Davies.
2. Blasi C., Padovano G., Nebuloni A. (2007). Sole, vento, acqua, vegetazione e tecnologie avanzate. Rome, Italy. Gangemi editore.
3. Blay-Palmer A. (2010). Imagining Sustainable food systems. Aldershot. Ashgate Publishing.
4. Buratti G. (2017). Il disegno computazionale, la forma come organizzazione. In Nebuloni A., Rossi A. (Eds.), Codice e progetto (pp. 111-123). Milan, Italy. Mimesis.
5. Costa, F., Amati, A., et al. (2018). Designing the Future: An Intelligent System for Zero-Mile Food Production by Upcycling Wastewater. EIDEC Conference Proceedings, 2(22), 1367. https://doi.org/10.3390/proceedings2221367.
6. Eigenbrod C., Gruda N. (2015). Urban vegetable for food security in cities. A review, Agron. Sustain. Dev. (2015) 35: 483. https://doi.org/10.1007/s13593-014-0273-y
7. Nebuloni A. (2017). L'architettura dell'adattività. In Nebuloni A., Rossi A. (Eds), Codice e progetto (pp. 151-161). Milan, Italy. Mimesis.