CRADLE TO CRADLE IN THE BUILT ENVIRONMENT - CASE STUDIES IN THE NETHERLANDS AND BRAZIL

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ABSTRACT

This work deals with the role of the built environment in relation to the resources it relies on. It reflects and designs urban systems towards closed cycles of energy and water. Moreover, it takes into account the buildings integration to its local biodiversity and material cycles. All these issues, when planned for an urban area, will bring up an effective design through a strategic management of resources. To create such effective design, the 'Cradle to Cradle®' (C2C) (McDonough *et al*., 2002) theory is embraced as the theoretical background for the design criteria. The three tenets of the book are used for the design of two case studies.

The first building design chosen is the industrial *Sunrise Campus*, located in Venlo, the Netherlands, where a building called *Biotope* is to be built. The second is a restaurant building called Casa Jaya, located in Sao Paulo, Brazil. The case studies are designed managing different technologies that are seen as a connection between the human functions of the buildings and both the renewable sources such as the Sun and the rainwater and the non-renewables such as construction materials from the technical cycle[1]. Different technologies that reduce the water and energy demand, and others that enhance their multisource are implemented. At the same time, green areas are also added to the program with the intention of increasing the biodiversity in the building and the city. According to each building design and chosen technologies, their demand and self-sufficiency vary. Furthermore, the amount of green area in each design, as well as the local species that would live there, will differ. For the second case study, a market research was done concerning the security of the chosen construction materials and the amount of recycled and recyclable materials.

Keywords: built environment, Cradle to Cradle, water cycle, energy cycle, materials health, biological and technical cycle, construction materials

1. Introduction

Sustainable buildings have been designed with the intention of a better care towards the environment, however they are still being planned to be efficient, based on impact reduction, emission minimization, and mitigation of environmental damages. Although efficiency is necessary as a first step, it only retards the unwanted effects on the environment. The main objective of this work is to study building designs that can cause positive impacts to its users and surroundings. It is therefore motivated by the search for innovative values and methods for the development of built up areas, that are able to make use of renewable resources that will bring up diverse, clean, safe and healthy environments.

[1] Cradle to Cradle® distinguishes biological and technical materials, so they can re-enter their cycles indefinitely. Biological materials are those made from renewable resources, and can be safely returned to the biosphere. Technical nutrients, such as metals and plastic are made from non-renewables sources and are unsuitable for the biosphere, and they should be designed for reuse can circulate in the technical cycle, and are nutrients for the production of new products of same or higher quality in the industrial flow (McDonough *et al*., 2002).

Two cases of building design are exhibited, one in the Netherlands and another in Brazil. The first building, the Biotope in the industrial Sunrise Campus, situated in Venlo, NL, was designed in 2011 as a result of the authors' Master thesis from Wageningen University (NL). It is an industrial campus that serves as an open innovation place for companies and institutes that have their main focus on glass and energy. The Biotope will serve as a meeting place for all workers of the companies. The Biotope is to create an identity in the campus while it stimulates the working environment (Gemeente Venlo, 2010).

The second building, called Casa Jaya Restaurant Building, located in Sao Paulo, Brazil, was developed in 2014 by the author, together with a team of architects and engineers[2], in her work as an architect and urban environmental manager. Casa Jaya is a cultural center in a busy area of the city and a new restaurant of organic food is being constructed. The community is involved in the project that started with a workshop where the C2C parameters were presented and the future goals (for the next 30 years) of Casa Jaya were determined. The main objective of the community is "to create a beneficial island to Sao Paulo city".

Therefore, the design developed for the case studies works toward the development of innovative strategies to the development of built up areas, through spatial planning strategies and resource and technology management. The Cradle to Cradle® framework advocates for an effective design where all wastes are to be reintroduced to the building area and the design is able to generate beneficial impacts. The three tenets of the book, 'waste equals food', 'use solar income', and 'celebrate diversity', are used as guidelines for the development of the buildings design (McDonough *et al*., 2002).

Although the two projects take into account C2C concepts, the parameters used are distinguished due to legislation, market conditions, client necessity and decisions of the design teams. However, both building designs are motivated by the production of design models that can be scalable and replicable to other urban settlements, and that, at the same time, can make use of local natural wealth and community features.

2. Buildings assessment

For both designs, the first and second C2C principles – 'waste equals food' and 'use solar income' were evaluated through the urban harvest approach (UHA) criterion, developed by Agudelo-Vera *et al*. (Agudelo-Vera *et al*., 2011). This method assesses energy and water balance flows through three different indices: demand minimization, self-sufficiency and waste output. The UHA always starts with a baseline assessment, followed by the evaluation of strategies to harvest resources. According to Agudelo *et al*., it consists of three bases for calculations. First, the demand is minimized. Second, it is necessary to reduce waste outputs by cascading and recycling. Last, renewable and local sources are used for the remaining demand (Agudelo-Vera *et al*., 2011).

A second methodology was used for both case studies in order to cope with the C2C design criteria of 'celebrate diversity'. It is focused on biodiversity in the built environment. Its assessment comprehends two different calculations: green area and local species indices.

The baseline assessment, the starting point of the UHA, is a mass flow analysis for the Business as Usual (BAU) Scenario. The aim is to identify all the external inputs and outputs of a defined urban system and to understand the situation of the development of the area in the case of absence of any concern to urban harvest and biodiversity issues. A demand and an output inventory are covered in this analysis. The demand inventory quantifies the activities that consume resources and studies the qualities required for their uses. The output inventory describes the outgoing resources of flows, their quantity and quality (Agudelo-Vera *et al*., 2011).

Besides closing the water and energy cycles and creating conditions for biodiversity, when working with Cradle to Cradle® in the Casa Jaya project, it was taken into consideration that the materials chosen for the constructions should be safe for human and environmental health. A building is understood as a material bank, wherein each material used has a high resource value that must circulate indefinitely. Each construction material, as well as the materials used within

[2] The project was design in partnership with Ecosapiens Soluções Ecológicas and Flock.

the buildings, should be non-toxic and designed to be disassembled foreseeing a further use, with respect to biological and technical cycles. A product's reutilization score was calculated according to Cradle to Cradle Material Reutilization Equation (C2C Product Innovation Institute, 2015). This formula combines the percent of recycled or rapidly renewable material in the product during the current life with the percent of material that will be recycled or composted into its next life.

3. Case studies

3.1. Biotope in the Sunrise Campus, the Netherlands

The Biotope building is shaped into seven sub-blocks that are used for human function, greenhouses and gardens. This design enables passive lighting and ventilation. This plan was solved with the purpose of achieving the maximum sunlight in the greenhouses and human functions sub-blocks. The length of each sub-block is more than three times the height of the building for the optimum use of direct sunlight and heat.

Greenhouses that produce food and heat for the human function blocks are implemented in the extremities of the Biotope. The greenhouses and garden blocks will be covered with PV windows on their roofs, as well as the South façade. An Aquifer Thermal Energy Storage (ATES) FiWiHEx System is to be installed and is responsible for heat exchanges between the greenhouse, gardens and human function blocks. The rainwater is harvested and used for irrigation in the greenhouses. It is pre-treated in constructed wetlands and stored in retention ponds, together with the cleansed grey water from the human functions that is treated in a bioreactor. This water irrigates the greenhouses, which after water condensation, is collected and reused. It becomes drinking water and is reused in the Biotope. From there, the grey water is treated and enters back to the cycle. The black water is collected from vacuum toilets and sent to a UASB (Upflow Anaerobic Sludge Balnket) reactor (Graaff *et al*., 2010), where it is digested and energy is produced.

3.2. Casa Jaya Restaurant Building, Sao Paulo, Brazil

The Restaurant building is located in a building block behind the Cultural Center Building and connected to the hall block, which will also serve as a restaurant hall. A vegetable garden is installed on the roofs, providing food that is to be used in the restaurant. Food wastes become nutrients to the garden and the excess is collected by a cooperative that composts organic waste.

The energy efficiency is increased with the use of passive lighting design and ventilation techniques. Although the idea of producing energy with PV cells was well accepted, the cost-efficiency was not attractive enough for the owners of the building – the payback would be in 10 years, and it would cost approximately 50% of the whole construction. However, they have the intention of installing PV cells when it becomes financially attractive.

The rainwater is collected from roofs and permeable pavements and stored in water tanks. It is used for flushing toilets and irrigation. The rainwater that is not used within the building is returned to the groundwater via soakways, preventing floods. For other activities that require a better water quality, drinking water is supplied to the building by the local public water company. The Casa Jaya's wastewater is discharged into the sewage system and treated by the local public utility.

4. Results

4.1. Energy results

The Biotope has considerably minimized its energy demand, achieving 58% of demand minimization when compared to the BAU situation. Casa Jaya achieved 61% of reduction of consumption. These result in both cases from the combination strategies of passive design, that avoids the use of air conditioning and heating systems, and the implementation of efficient lighting and electrical gadgets. Besides that, the percentage of energy that the building is able to produce itself is assessed to determine its rate of self self-sufficiency. While Biotope produces 76% of its own energy, Casa Jaya does not produce energy. In the first case, the building is to produce energy from the highest technologies in the Dutch market. In the second case, this will not be possible due to elevated costs of the Brazilian market.

4.2. Water results

The Biotope building decreased its water demand in 44%, while the Casa Jaya has reduced in 39%. This difference occurs first because of the use of vacuum toilets and dual-flush for the toilets, and second because the drinking water consumption for cooking is proportionally higher for the second case. The Biotope is able to recycle and produce 100% of its water consumption, and 80% of the wastewater is re-introduced to the system. In Casa Jaya, there is no water recycling. However, as a first step, the building is going to harvest rainwater and use it for non-drinking purposes. In this sense, it becomes 30% self-sufficient.

4.3. Green areas

In the Biotope and Casa Jaya restaurant Buildings, green areas are present in the form of green roofs, green walls and internal gardens. As a result, the total green area corresponds to 76% of the Biotope's area and 75% in Casa Jaya. From those areas, not controlled green areas comprehend on 49% in Biotope and 34% in Casa Jaya. The higher amount of controlled green areas in Casa Jaya occurs because of the interest of producing food for the restaurant locally.

4.4. Building materials

In order to choose the appropriate materials for Casa Jaya construction, the C2C framework was also taken into account. The use of glue and other additives was avoided so that the building can be dismounted and its parts can re-enter their cycles in future materials uses. Hybrid materials between biological and technical cycle were also avoided. Although one of the main constrains of this research was to get information about the chemical composition of materials, the main homogeneous materials of the construction were assessed by its toxicology according to its Material Safety Data Sheets (MSDS), and the Brazilian version Ficha de Informações de Segurança de Produto Químico (FISPQ - the Brazilian Chemical Product Safety Data Sheet). These sheets list the NFPA (Standard System for the Identification of the Hazards of Materials for Emergency Response) or describe the materials as biologically inert.

The lack of healthy materials available in the Brazilian market proved to be an obstacle, especially for the technical cycle, such as additives for concrete blocks (walls), paintings, roof tiles, etc. For this reason, the materials chosen were either C2C certified materials – whether they exist in the Brazilian market, or biological materials such as certified wood, biological resin and bamboo floor. Moreover, less toxic or hazardous materials with the best functionality were chosen for the technical cycle.

5. Conclusions

In the Dutch scenario, the building goes further with the passive techniques and is able to produce its own energy and water. However, in the Brazilian context, further development on research of new technologies that can be locally cost efficient and a stronger support from the public sector are still necessary. Moreover, this study brings forth the need for the civil construction products industry to be more transparent in the composition of its products as well as their safety. This can help architects to make more effective choices related to material cycles. Local waste management combined with industry reverse logistic is also to be better implemented, aiming that construction materials enter into a closed loop system.

Although the scenarios developed have different characteristics, all of them represent a step towards a more efficient design according to the three criteria stipulated. Moreover, the intention of both communities is the same: to create a positive impact to their surroundings. However, local cultural, market and legislation conditions affect directly the integration of the society with its supporting environment.

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