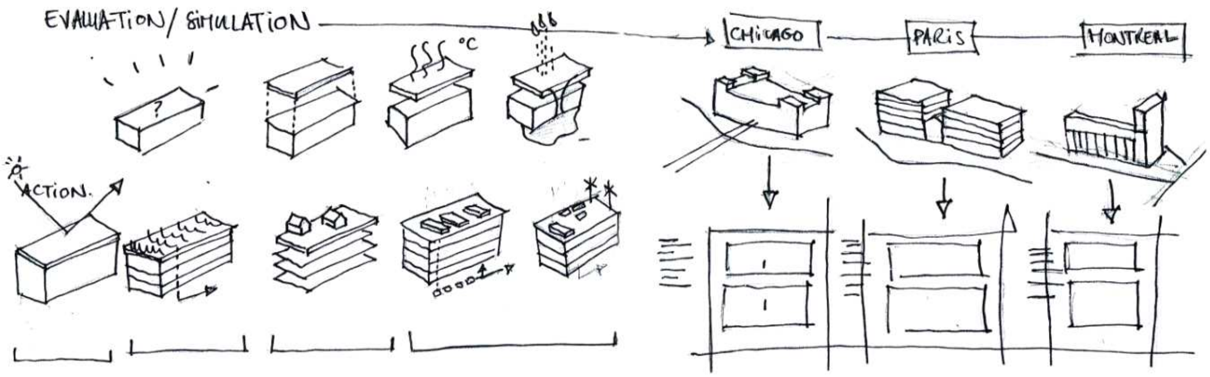

Epidermal Cities : revitalizing the urban roofscape
Learning from Chicago, Montreal, and Paris
An architectural and urban manifesto

Zoubeir Azouz, architect
ZAA - architects

KEYWORDS: roofscape, ecological footprint, digital simulation

ABSTRACT

This paper is part of the interdisciplinary research program *IgnisMutat Res*, regarding environmental issues, energy consumption, and their impacts on the quality of life of citizens. It aims to inform the world of the potential of rooftop architecture to provide innovative solutions in dense urban environments. While urban environments experience an increase in their energy consumption needs, architecture and urbanism researchers are also becoming more and more eager to reduce the city's ecological footprint (Venetoulis and Talberth, 2008) through new architectural and urban development (Barrett et al. 2005). However, the reduction of this footprint has proven to be very difficult to quantify economically using a general approach (Van den Bergh and Verbruggen, 1999). In this instance, the lack of standardized methodology is the main cause of the approach's stagnation at an exploratory phase (Uhde, 2009).

Here, the development of a digital device to evaluate and simulate rooftop potential can serve as a decision-making tool in urban settings. This research has gathered the exploratory studies from the rooftops of three cities: Chicago, Montreal and Paris. In all three, the roof is approached as an area for investigations that would work towards solving urban issues (Prochazka, 2010), specifically, reducing the commonplace of urban heat islands, and managing rainwater. Overall, the strategies found would empower cities and help to reduce their fossil sources dependency.

THREE CASE STUDIES

On June 12th to June 14th 2013, *IgnisMutat Res* (roofscape.org) researchers and professional partners participated in Chicago workshop. The event was organized with the intention of coming up with new ways of integrating roofs as a "fifth façade", and became an opportunity for experimentation, with goals to minimize current urban environmental challenges. This *think tank* workshop brought together a multidisciplinary team: architects, engineers, biologists and public administrators of the city of Montreal and Chicago. To begin exchanges amongst professional groups, several sites located within the area of the Loop in Chicago were suggested by representatives of the workshop host firms (GailBorthwick - Gensler , and Colin Rholfing - HoK). One site in particular caught the researchers' attention: The roof of the old Chicago Post Office, built in the 1930's (Figure 1). Abandoned since decades, it was unable to find a buyer, mainly because its massive structure was incompatible to being converted into a profitable real estate operation. According to the Chicago colleagues, the building was once coveted by several promoters, such as the International Property Developers North America Inc. However, the viability of the promoter's project depended on the creation of a mall and of a high-rise building, juxtaposed to the existing derelict structure, which would subsequently be converted to a residential building. When plans for the construction of the high-rise and mall were dropped, all projects for the old Post Office were also abandoned. Over a period of two days, potential solutions for this space arose from brainstorming at the workshop. Fruitful ideas included upgrading the building's rooftop in order to increase city density, to collect renewable energy, to develop urban agriculture and to work towards autonomizing the city center. At the end of the workshop, researchers reviewed and shared data, information and experiences, while identifying gaps in their strategies and possible constraints to reducing Chicago's ecological footprint.

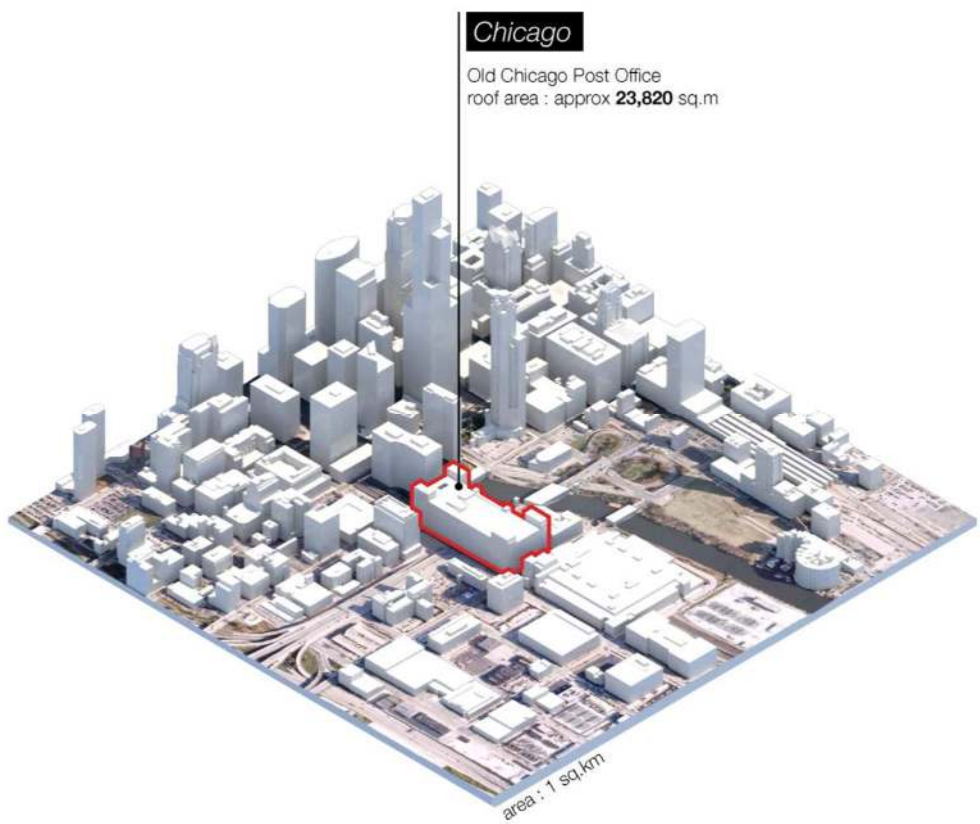

Figure 1. The old Chicago Post Office.
Source: ZAA (2014)

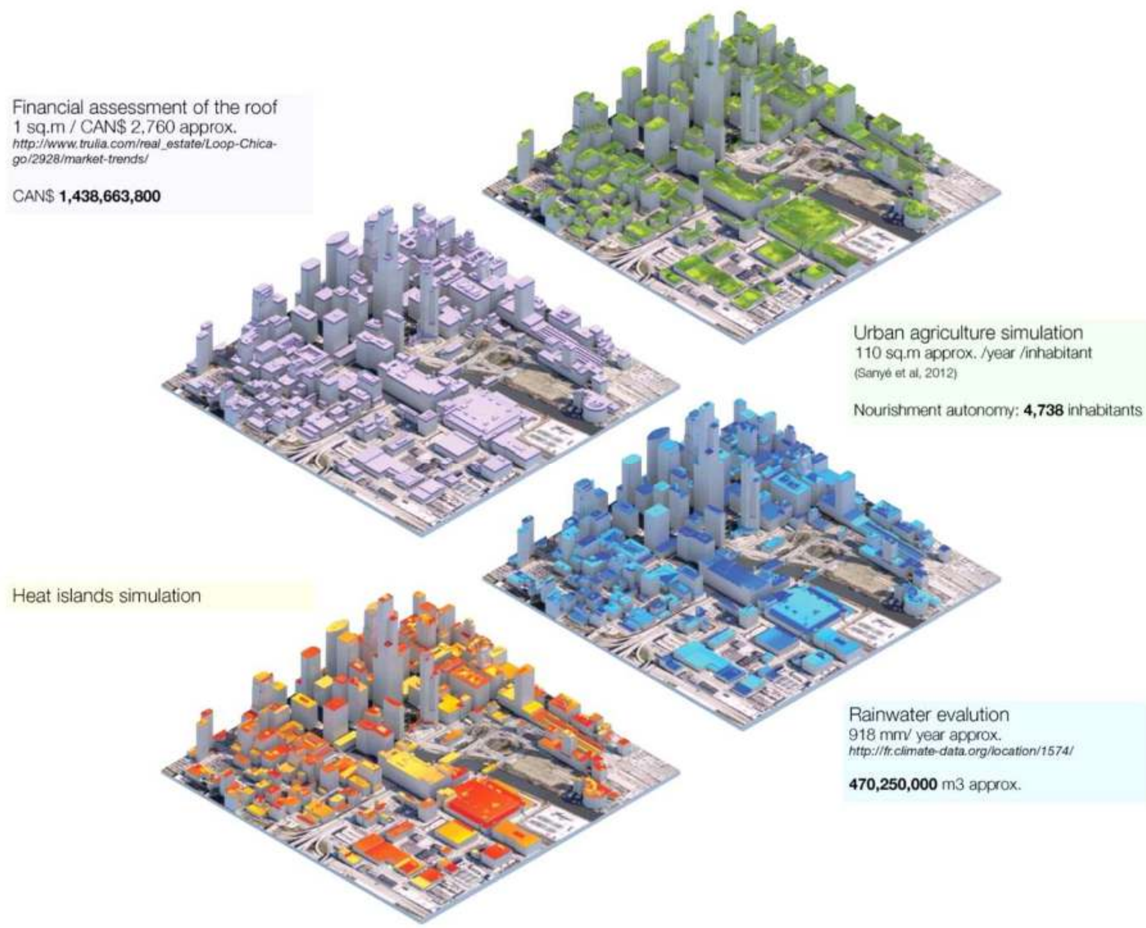

Figure 2. Roofscape evaluation/simulation
Source: ZAA (2014)

Proceedings were sustained in Montreal and Paris to test and confirm urban rooftop potential principles. Once validated, the architectural and urban principles found through the work and research at IMR-Roofscape could be refined through digital tools, and adapted for application to any megalopolis. After the analysis of the Chicago Post Office (Firgure 3), two abandoned buildings were also identified in Montreal and Paris: The former Montreal Old Port granary (Silo No. 5), and Paris' former Chamber of Commerce and Industry situated in Pantin, on the North-Eastern Parisian edge. These buildings, originally built as part of industrial areas, were eventually newly surrounded by expanding city cores. Criteria for selection of the buildings revolved around their symbolic similarities; Both were formerly major facilities, fully involved in the activity of their respective city centers. Aside from their current states as inhospitable buildings, they were also equipped with a potentially suitable area of horizontal rooftop, and dwelled along a waterway.

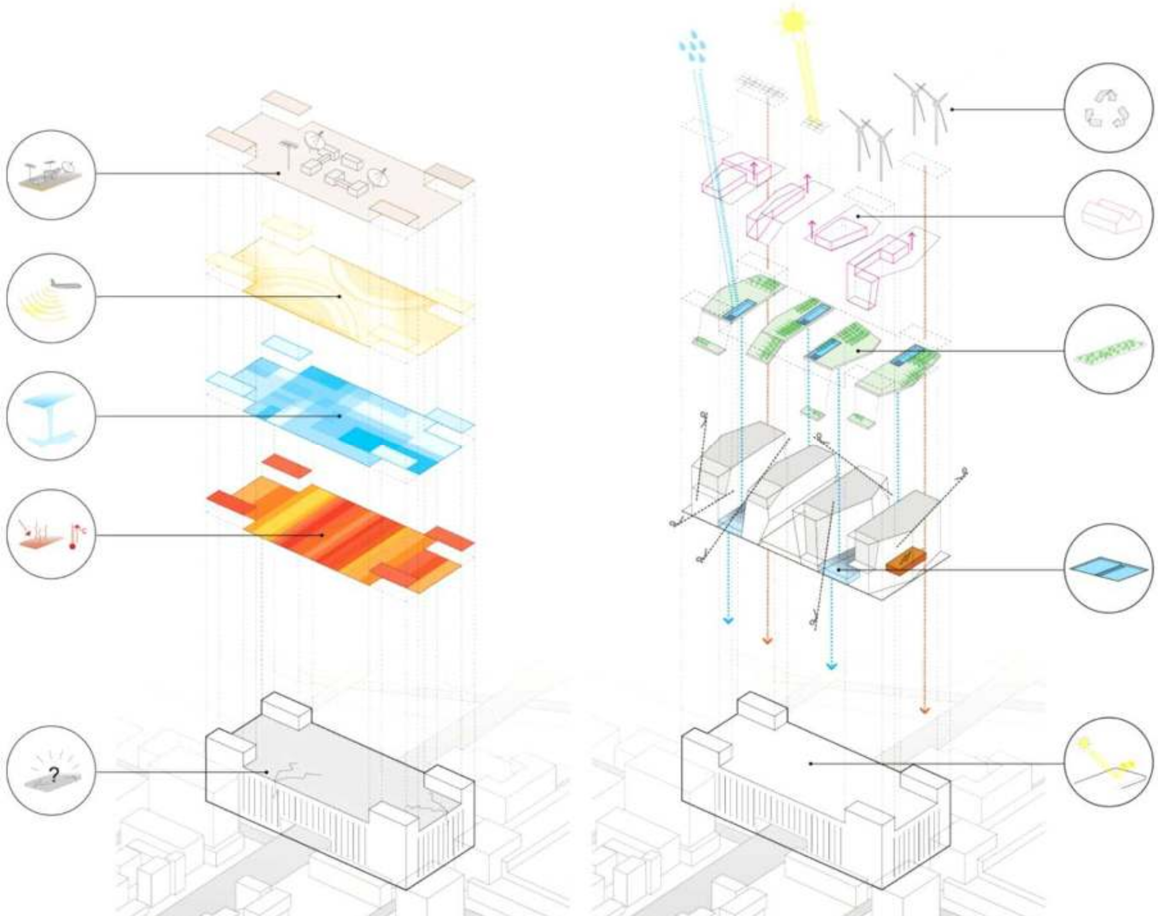

Figure 3. Analyzing the roof potential :
Five negative phenomena vs. five positive interventions
Source: ZAA (2014)

VARIOUS ROOFTOP FUNCTIONALITIES

In the three prototypic projects, the reduction of these major cities' ecological footprints is explored through the potential of these building's horizontal rooftops. Their locations are key: The Chicago, Montreal and Paris buildings are all located at the heart of a 1km2 territory, as shown on three-dimensional models and simulations generated by urban data visualisations systems. A first approach assesses the potential impact of the three buildings' rooftops, both on the scale of the larger city and of their respective neighbourhood. Two environmental phenomena directly related to the rooftops serve as measuring guides: The urban heat island index and the rainwater runoff coefficient. These environmental markers are illustrated by data visualisation tools in Figure 4(a) and 4(b). Indeed, rooftops, when not optimized to respond to these environmental issues, worsen these phenomena. However, the horizontal rooftops identified offer interesting environmental solutions. The first solution involves improving the surface of the rooftops to reflect the sun's rays, which helps reduce urban temperatures. The second approach is to collect rainwater for domestic use, gradually returning it to the sewer systems. Yet a third intervention is to compensate for the lack of green spaces in urban settings by implementing green roofs. Can such measures have an impact on the city at a much larger scale? Could the surfaces collectively be large enough to reduce or reverse the city's negative environmental impact?

(a) (b)

Figure 4. Visualizing heat islands (a) and rainwater capacity (b)
Source: ZAA (2014)

Figure 5. Montreal green roofscape utopia
Source: ZAA (2014)

Yet another option is to undertake practical, overall simulations. Indeed, multifunctional urban rooftops are now considered to be meaningful components of architectural projects and of sustainable urban developments. This is particularly true given the current context of accelerated climate change, of a decreasing biodiversity, of increasingly scarce fossil sources, and of increasing tax burdens. Diversified rooftop practices help reduce the impact of heat islands, reduce the energy consumption of buildings, and manage runoff rainwater. They can also help increase the city dweller's living space, increasing the amount of space available for gardening, for leisure, and for many other imaginable uses and developments.

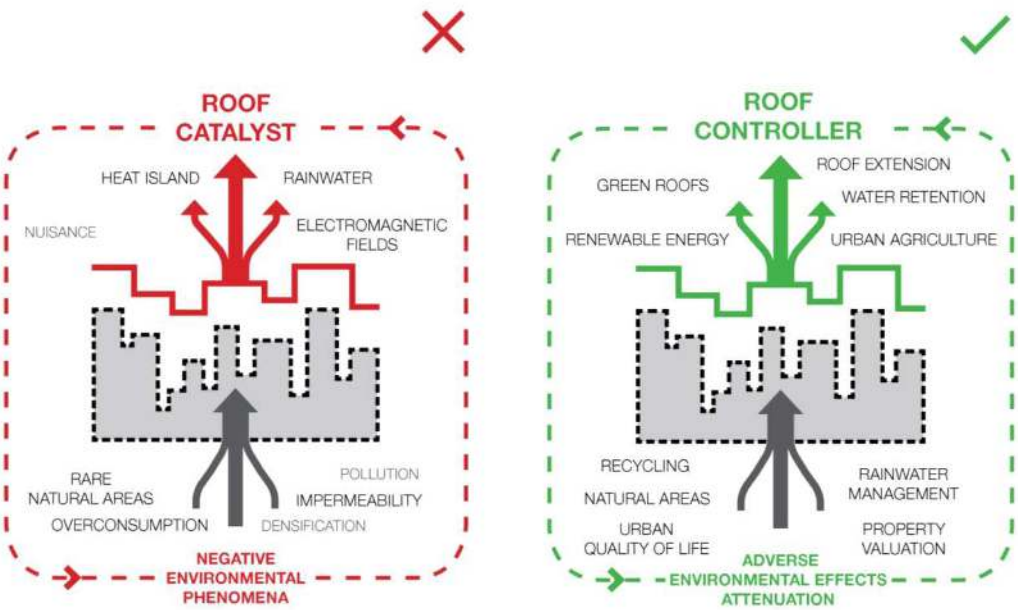

Figure 6. Roof synthesis :
Environmental issues vs ecological potential
Source: ZAA (2014)

Five types of rooftop functions were identified:

- Receptor roofs, to attain optimal energy efficiency: Solar panels, wind turbines, solar chimneys and other devices for natural ventilation, recycling, treatment, pooling of services and other tactics. (Wong , 2006)
- Communal roofs, elevated and inhabited: The combination of functions or making a "city within a city" by adding one or more storeys to a building (MVRDV-ACS for Grand Paris, Simon et Bendimérad, 2010). This is often an option for existing buildings and to add new architectural value to decrepit buildings by increasing liveable space and raising infrastructure height. (Gariepy , 2012)
- Green roofs, as divided into two categories: Extensive roofs, made of a thinner layer of land and of resistant plants (not generally accessible to the residents), and intensive or semi-intensive roofs, made of a thicker layer of earth and often equipped with sophisticated irrigation systems and plants suited for the application.
(Jaquet, 2011)
- Foster roofs, which contribute to urban food markets and agricultural production, with products re-entering the local food chain. This application brings to attention current systems of production and consumption, including the excessive distances traveled by the foods consumed daily in cities. (Trottier, 2008)
- Equipment roofs, laden with antennas, magnetic fields, mechanical systems, etc. These have an aesthetic impact, but also a health impact on urban beings. (Fournier, 2010)

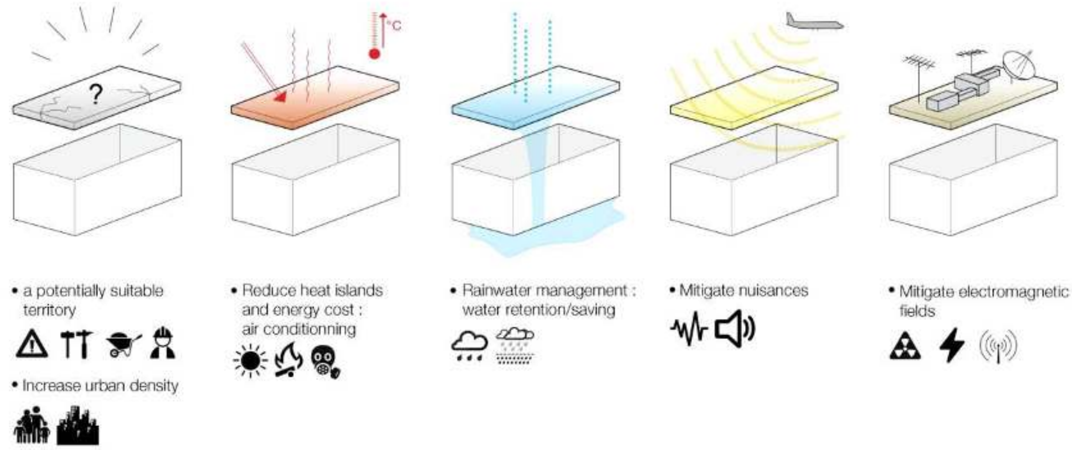

Figure 7. Five environmental issues
Source: ZAA (2014)

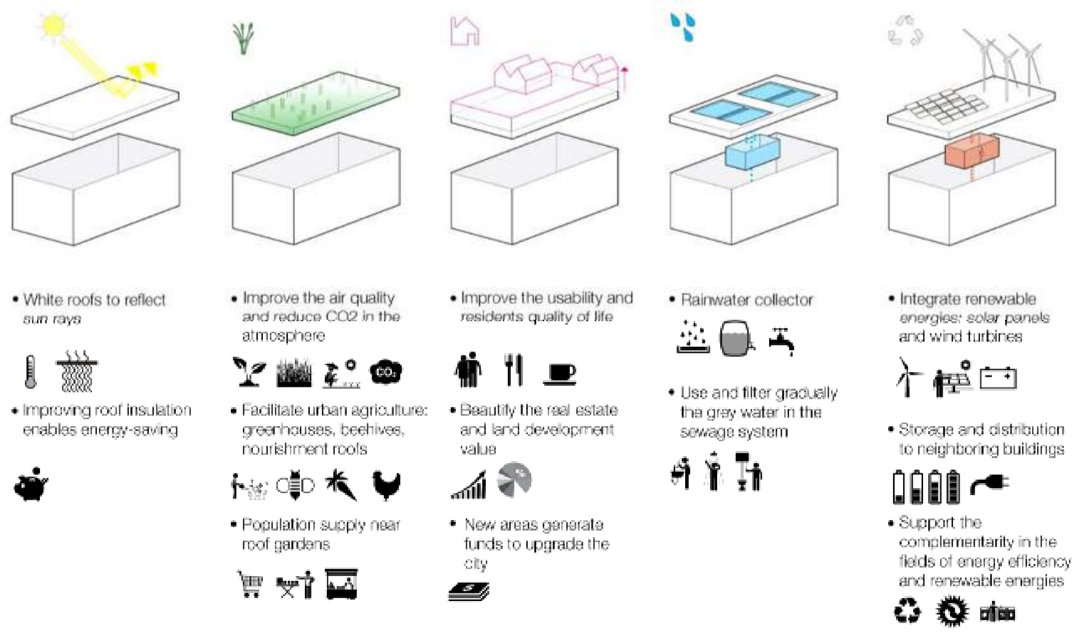

Figure 8. Fiveecological interventions
Source: ZAA (2014)

All of these types of roofs have direct ties to environmental issues: For example, they can influence the balance of city environments by collecting and transforming solar energy and recovering rainwater. Receptor roofs can also contribute to the autonomy of cities by giving it the means to harvest more of its own energy and water. Also, foster roofs can grow flora and produce food in a context of urban density. Vacant land, outside of roofs, is scarce and subject to heavy taxation, leaving no room for the development of new gardens.

EVALUATION / ROOF SIMULATION

Here, a solution is suggested by means of a digital process: a prototype software created to assist urban designers conceive of the necessary storey increases and added roof units or chambers. This software would permit the reconstruction of a portion of the territory in three-dimensional form. The digital model provides an opportunity to visually quantify heat islands and show maximum temperatures of building rooftops, identifying those that skyrocket overall urban temperature. The volume of potentially recoverable rainwater is also evaluated. Additionally, comparing the amount of water accumulated by roofs to the amount of water consumed by the population reveals the amount of water wasted. Utilizing this water as a resource instead could help preserve biodiversity, natural habitats and develop further green spaces. Green roofs can contribute to the development of urban food autonomy in response to the needs of 11,527 inhab. / year. One study estimates the average production of a greenhouse rooftop to at least 15 kg / m² / year (Sanye et al , 2012). Knowing that the average city's caloric need is of 1800-2000/day (4.5kg of vegetables/day) allows us to assume that its yearly needs are of 1.6 ton of vegetables per city, which means 110 m2 of feeder roofs. Developed rooftops could also contribute to increasing urban property valuation. This added valuation would highlight decrepit buildings and encourage the construction of new related facilities. These new constructions could improve urbanite living standards or enable planners to carry out large-scale projects that would offer practical solutions to current environmental problems.

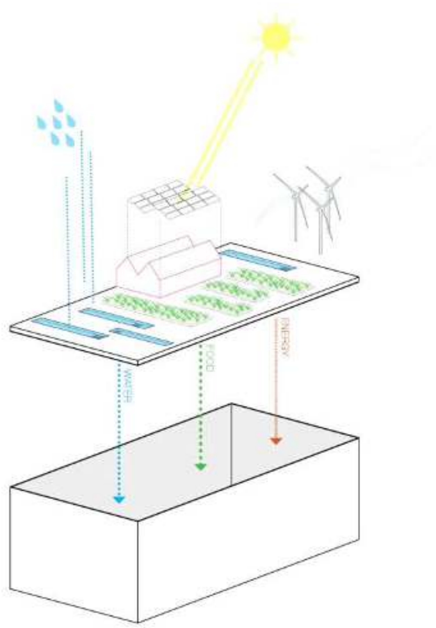

Figure 9. Roof trilogy : water, energy and nourishment
Source: ZAA (2014)

This digital survey suggests that the roof’s impact is not negligible on its host building. The revaluation process needs to take into account the structural integrity of buildings before raising or converting roofs. These residential buildings cannot always bear additional weight without rethinking their structure, generating significant cost. However, elevation of industrial buildings from the early twenty-first century is commonly possible. Structures of this period are often oversized and can support new functions (offices, artist studios , residential lofts). Today, the reallocation of these buildings as condominiums does permit an additional load on the roof, with relatively few structural changes. Also, the digital model is interactive and bases its decisions in part on urban growth models. It facilitates the use of complex urban data, and discourages the overspecialization of designs in favour of more global visions. These methods can also be applied to cities with higher energy consumption rates. Assessment and simulations for rooftops could be presented as an open data, accessible, and interactive map online, such as the interactive map of Chicago Loop green roofs.

ENABLING ROOFTOP ADOPTION

The multiple uses of urban rooftops presented here help upgrade existing buildings by mitigating the impact of heat islands, reducing their energy consumption needs, and participating in the management of runoff rainwater. They can also help increase liveable, garden, and leisure space, or even new space for restaurants or businesses, given the wide potential of rooftop functionalities.

Subsequently, it is necessary to :

- Identify, based on the characteristics discussed and the ongoing projects , what "services" may arise on the roofs of the three city's buildings, with variations in standards, rules, incentives, knowhow, and materials.
- Take into account economic issues of roof transformations, compared to the costs incurred.
- Examine elements that complement and contrarily those that are incompatible with different types of services, and their impacts on the environment.

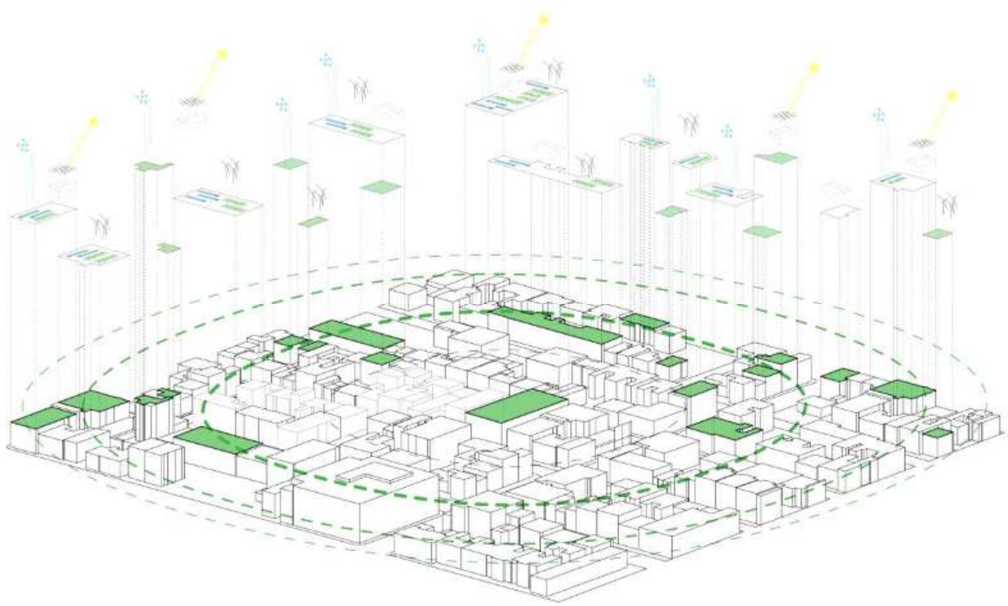

Figure 10. Sustainable roofs Pollinization towards city scale
Source: ZAA (2014)

Overall, the opportunities discussed would empower cities and help them reduce their dependency on fossil sources. In order to refine the data on the integration of nature in urban settings, further avenues of investigation may include identifying the potential of vertical surfaces in much the same way as has been done for roofs. Made into living walls, they could be true vertical ecosystems participating in the delicate balance of urban ecosystems.

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