Low Consumption Architecture: Energy reduction models trough design

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Introduction

"For most of us, design is invisible. Until it fails."
Bruce Mau from the book Massive Change[1]

Energy reduction strategies in buildings are becoming standards of our practice. However, is important to question our concept of energy. Are we considering by Energy consumption only when we turn on a light switch? If that is the concept, that will be an easy tasks to accomplish, but in reality, is not the case. Energy consumption and their reduction is a broader concept and their impact could reach global issues easily. Energy is virtually everything in the construction industry, from the transportation, electrical design but also material use, efficient methods of construction. This is our understanding as architect of energy, a theme that goes beyond the grid and power systems, currently under re-design and evolving away from the fossil fuels.

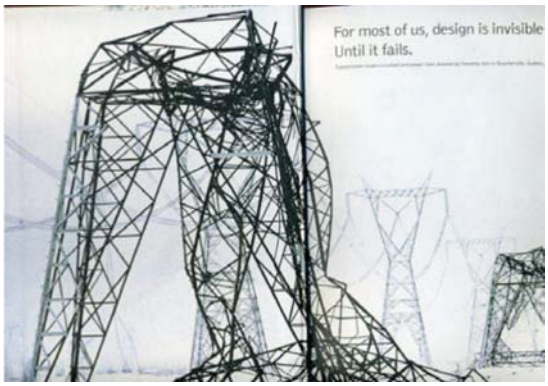

Figure 1: Trabsmission towers crushed and power lines downed by freezing rain in Boucherville, Quebec, January 1998 / Massive Change

Constantly the construction industry approaches the ecological theme as the strategy that will improve business. Available equipment that could reduce energy consumption, like photovoltaic modules, is interpreted as the added value that we must pursue. In fact, construction industry is approaching energy consumption alternative as a purchase issue, more than an integrated design process.

For example, the paradigm of the architect role in the construction industry to be only a designer for the seek of beauty is an error to the project. The result is architecture limited to a designed object. After that, the industry present us plenty of options to purchase an "over-the-counter" solution that could be attached to the structure in many ways. This example, shows that exist a huge difference between architecture and engineered products for energy reduction and sustainability that must be fixed. Architectural design is more than drawings or creativity. The way we, as young architects look at design is how to integrate all the information, technology, existing conditions and environments in a single product to improve people lives. This approach could revolutionize the preconception of the architect with the objective of change and expand his role to a more research driven design methodologies, rather than a intuitive solution or as Sousa says: resulting in "weak architecture"[2]. The enforcement of energy reduction politics based on the forced implementation of technology means we are going to continue creating design destined to provide poor performance and sacrifice the scarce budgets.

A simple example is the design of a building without any environmental considerations at all. Big curtain walls facing south, not cross ventilation strategies and so on. Our tropical climate will require to cool it down, so designer will send to his mechanical consultant and he will provide a solution for that particular case. What happened? An expensive electrical Bill is about to happen. To mitigate the "disaster" we approach the problem with "commercial sustainability". The problem; any solution we search for, will be even more expensive since the consumptions are already high. What we could do then? Find cheap solar panels for example? When we, the construction professionals tries to dampen the consumption with sustainable systems is the worst error we could make. The problem is that the shipping expenses,

[1] Bruce Mau, "Massive Change" 2004 Preface
[2] Ignasi de Sola Morales, "Differences: Topographies of Contemporary Architecture" 1996 p.56

excessive use of the indirect energy to mitigate our poor design problems are even much worst due to a high greenhouse gas generated in the movement of our "solution". Not considering an Energy Efficient Product Procurement[3] will be major a setback when we apply consumerist's rules who affect the performance of our buildings. The last 25 years, has suffered this situation, even tough, several typologies of buildings has been trying to design efficient methods to increase their efficiency in terms of construction time but did not assess the efficiency of the use of materials and the adaptation of the design to the climatic conditions of the place. In our times, the building turns out to be more expensive, more if we add additional lighting and air conditioning to the design not previously optimized. The result is the increase of the cost up to 25% on a yet increased construction cost. We see these rules on our daily life; for example, if we want to lose weight we buy the pills instead of keeping a diet or a healthy lifestyle.

Energy reduction required an increased role of design

The application of "green products" without having a business model or design criteria consistent with ecological initiatives, may affect the cost-effectiveness of the work. Also could affect our life style for the seek of sustainability. This is a huge problem that affects the green community, how we could reduce more energy without changing our lifestyle and comfort?

That's the role of the architect, in order to design more energy efficient, we need to design it integrated to the proper research of the existing conditions and environment. That's take architecture to a broader level of not limit itself to design buildings, we design ecosystems. How we could help technology improve consumption and life, without affecting our way of life or the property aesthetics and possibilities? This make a low energy consumption architecture to approach buildings as organism, where the design improves how the flow of resources like energy, water, even data are more efficient as a biological organism. These analogues are defined by biomimicry[4], which means the evaluation of nature, its models, systems and processes to take inspiration from in order to solve human problems. Our design initiative are profoundly inspired in the best mentor of energy reduction and efficiency: Mother Earth. Diverse studies present design strategies and their capability to adapt, communicate and interact with their environment. We see the design of building components as the human body, capable to adapt to the conditions and functions necessaries to their services and environment efficiently. The design analogues between nature and architecture of low consumption can interact with their commercial counterparts. The design is based in holistic efficiency, construction feasibility and structural resiliency will result in affordable construction cost and less invasive effects when changes and expansions are needed. Also, the concept doesn't relate exclusively to new construction. The adaptation of existing buildings and spaces is possibly the key of reducing construction cost

We must move away from the pre-conception of "ecology" as the acquisition of "green" products. Professionals in the industry should begin to work in an integrated manner. Unfortunately, whether by ownership or trying to emulate bureaucratic systems, confined the work to "do only what matters to me" and not to promote the discussion of ideas. Recent initiatives as raised in order to promote efficiency in construction and design thru IPD or Integrated project delivery[5].

The power to do an efficient project from its development until the construction, in order to obtain an ecological solution requires the evolution of the current business model. Each office project requires

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[3] Environmental Protection Agency, "Energy Efficient Product Procurement: Guide to Developing and Implementing Greenhouse Gas Reduction Programs", 2011
http://www.epa.gov/statelocalclimate/documents/pdf/energyefficientpurchasing.pdf
[4] Benyus, Janine M., "Biomimicry: Innovation inspired by Nature." Harper Perennial Ed. 2002
[5] The American Institute of Architects, AIA National and AIA California Council, "Integrated Project Delivery: A Guide" Ver. 1, 2007

becoming a space of research based on the efficiency and social responsibility. What would you think if the research can optimize the use of its materials, resulting in a more economic work? How about by expert integration, reducing the consumption of concrete we succeeded up to 15%? This reduction amounts to 20% savings in comparison with the total cost and would reduce the footprint of carbon monoxide up to 3 tons. Articulate the business in an integrated manner would add value to our services, improve performance and keeps the cost within the parameters of the market.

Design models based on energy reduction

What we are going to show is work and research that our office has been working in the past 2 year. We will like to show you that energy reduction is part of various design models that could be done rather the construction budget or the local limitations we believe architecture is part of the research cycle to develop even more low energy consumption environments.

ECO-Sport Facility for Puerto Rico and the Caribbean

ECO-Sport Facility is a novel design, which accomplishes the re-engineering of the typical basketball court architecture in Puerto Rico into a sustainable building. The concept was based on the firm's own philosophy by conceiving 'Architecture as an Adapted Product or Organism' which permits design an improved structure within cost-efficiency parameters from early stages of the design development.

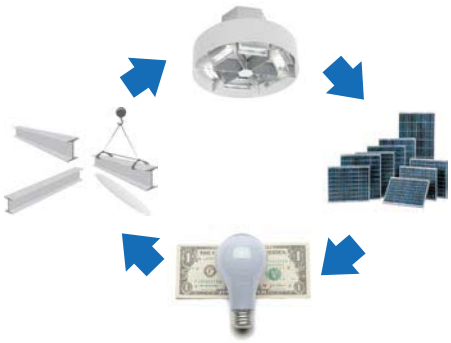

Figure 2: Cycle concept of design and business model of the court.

The basketball court was conceived to be the next step of evolution for this typology. A combination of sustainable system components in relationship with a passive design strategy achieves net-zero power use and low cost maintenance. Furthermore, all material selection was made considering local availability, easy construction methods and cost-efficiency. The design feature LED lighting and high-effici ency fans to cool athletes during the game. The budget required for the development of the proposed basketball court was not radically different from the current cost of the paradigmatic but inefficient design.

In Puerto Rico, such as so many other countries in Latin America, government fosters the construction and inclusion of this type of sport facilities as a social project. This proposal takes advantage of this trend in order to present an architecture initiative with a relevant environmental impact on society. Moreover, the firm's design accomplishes the stringent codes and regulations for Puerto Rico seismic zone and weather and atmospheric conditions. The potential of this kind of project proposal could become the next paradigm of such typology design for the Caribbean and Latin America. In fact, the concept groups all environmental adaptability features of such regions within the current budget boundaries.

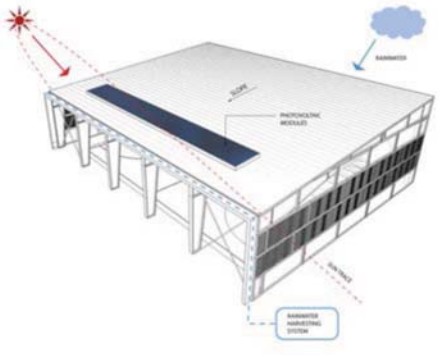

Figure 3: Sustainable features of ECO-Sport.

Figure 4: Artistic representation of ECO-Sport

Healthcare Facility Model

Healthcare facility, one of the most dynamic building type. The interaction of a great amount of patients, services and administrative personnel makes this building a complex organization of spaces and utilities. Historically, designs like this building have been made by the approach of creating profitable business in medical real states. However, some strategic mistakes of this model results in the construction of huge monolithic buildings with lots of lost space, based on the paradigm, *"more space, means more money"*.

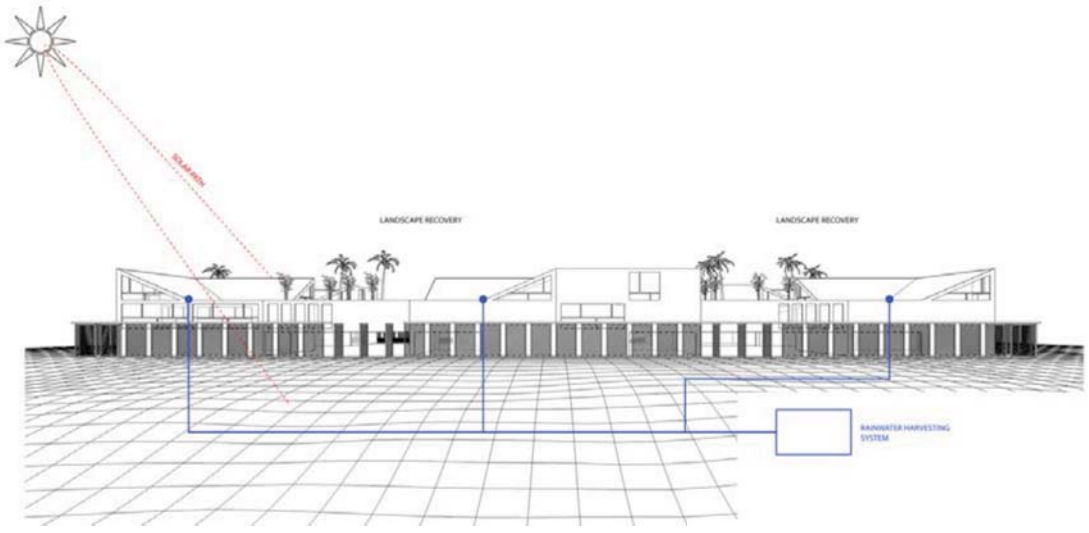

Figure 5: Sustainable features of the Healthcare Facility.

The complex nature of these buildings requires an integrated and efficient design for its optimum operation. The program and medical interventions help us to understand the built environment of care as a living organism. These analogues are defined by transtectonica, which develop a series of models, systems and processes in co-relation with nature.

We see this building design as a body structure capable to adapt to the conditions and functions needed for the services and environmental parameters. Contemporary building design is not contemplating the rapid evolution of the services housed by these structures. A good example is the constant change of bio-medical equipment. This changes, sometimes needs infrastructure improvements, space requirements and service re-organization. Not designing for the nature of the space will affect the improvements delivery and their budget.

Figure 6: Night view of the Healthcare Facility

Various biology studies present the powerful design strategies of living forms to adapt, communicate and interact with the environment. The adaptability of the building to the complexity of healthcare could be compared to Charles Darwing's theory of evolution: "it is not the strongest or the biggest of the species that survives, but the one most adaptable to change"[6].

Our healthcare center project has been architecturally designed to proportionally expand and adapt to determined further needs of this kind of structures. This becomes possible by a series of modular space-frames volumes which basically acts as the framework or the building skeletal structure. The volumes arrangement is determined by the building function and its context. Hence, instead of a free plan, we have contemplated a free volume space with endless configurations, whilst integrated to both environment and performance.

These articulated modules would have the ability to communicate between them as a body communicate and interact with their organs. Utility connections essentially needed like water, electricity, data and also medical gases and oxygen could have proper space to interconnect the needs of various spaces as a nervous or vascular system. This flexibility foster many and different building layouts.

All this analogues interact with their business counterparts. Like an organism shall relate with the environment to survive, our concept is no exception. Because the design is based in holistic efficiency, the modular construction and structural resiliency will result in feasible construction cost and less invasive effects when changes and expansions are needed.

[6] Bjarke Ingels, "Yes is More: An Archicomic on Architectural Evolution", 2009

This entire design concept shall be detailed to have spaces with an identity and spirit. In fact, the design qualities of adaptation with the environment could be made in such way to promote the cultural and climate parameters within the site. Understanding the analogy between architecture and biology should serve to understand the user psychological approach to this built environment. Providing a closer look to the details and finishes will be the opportunity to make a celebration of the life and culture with spaces worthy for quality of care.

Figure 7: Interior Patio of the Healthcare Facility

Bio-Structural Research

How can the structural design foster performance in order to decrease our current energy addiction? We gathered such question from a bio-structural analogue which actually permits to improve the energetic outcomes for cement-based structures fabrication among other adaptive features. We're based on bones as our ecology models. But bones are both structurally-efficient and sustainable due to its material optimization within the form.

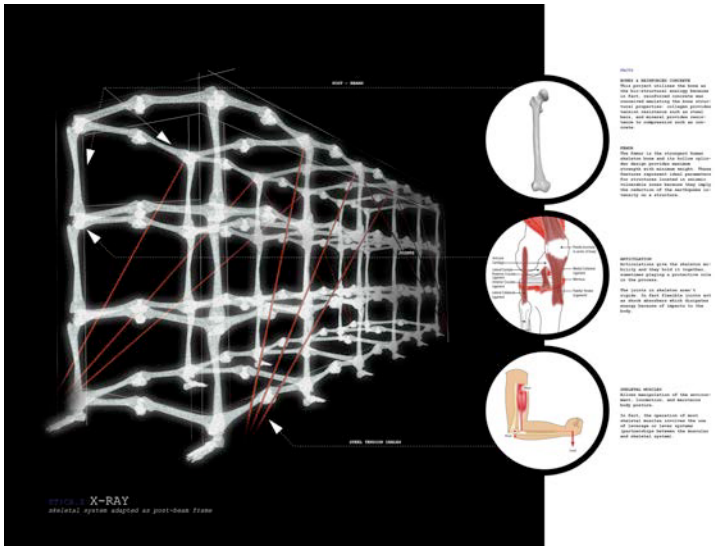

Figure 8: Analogies between structure and the human body.

Some major concern for building professionals in the Caribbean context is the topic of earthquakes due to the current disintegration of most functional buildings with such natural hazard's dynamics. Moreover, there is a lack of adaptation to such hazards in our current design paradigms. In our research, bones have provided some valuable insights in order to improve such design standards.

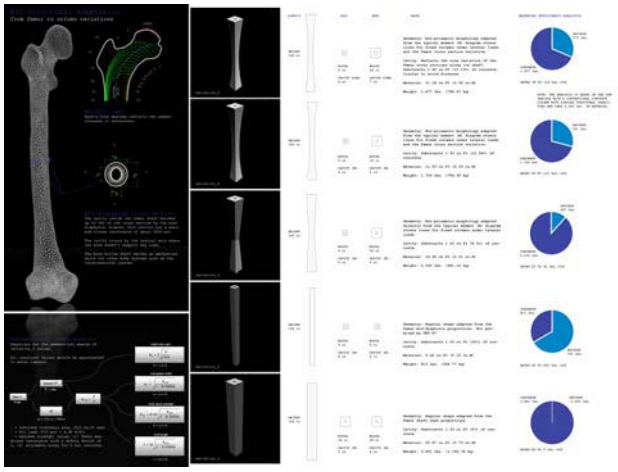

Figure 9: Femur structural properties evaluation.

The femur, for instance, is the strongest human bone and its hollow cylinder design provides maximum strength with minimum weight. Those essential features represent ideal parameters for the reduction of earthquake intensity on a building structure. In addition, the bone's anatomy reflects the common stresses it encounters in order to adapt its morphology to its common mechanical stress. Equally important to such structural output, the hollow-shaft parameter serves to reduce about 30 percent of reinforced concrete by structural component.

Inspired by the bones in the human skeleton, a novel column and beam could be precisely designed according to its specific load condition. The hollow-shaft parameter reduces about 0.32 cubic meters (11.18 ft3) of reinforced concrete, furthermore it reduces 761 kg and up to 118 lbs of CO2 by structural component (column or beam). Also, because the concrete frame is adapted to its common stresses by lateral loads, the deflection was greatly reduced in comparison with a conventional concrete frame under same load conditions. The form, as the result of the diagram of force, directly abstracted from the bones morphology paradigm, makes the proposed frame almost 3 times stiffer than a conventional one. In further analysis, the frame base shear (seismic intensity) was greatly reduced by 35 percent. Therefore, it means that because of the human skeleton parameters were adapted to the conventional structure system, which encourages the efficient concrete utilization and the building weight reduction, the building seismic vulnerability was significantly reduced, increasing its adaptation to the site characteristics. Adaptation reflects in efficiency which becomes the key to better structural performance and the building relevant sustainable output [7].

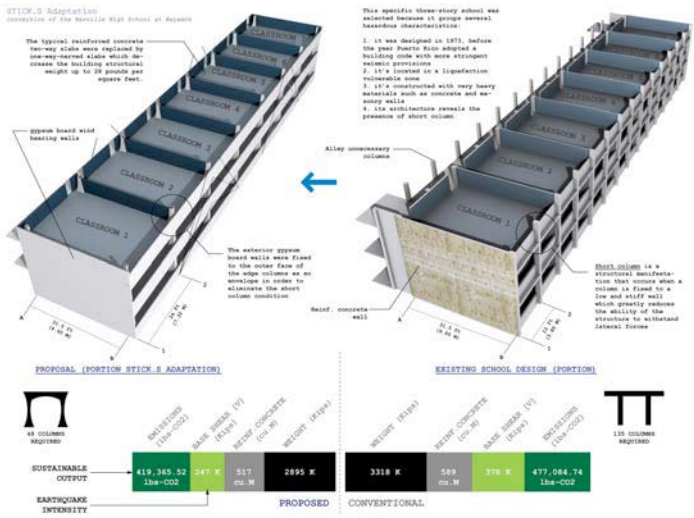

Figure 10: Structural adaptations and their sustainable output documented.

[7] Excerpt from Wilfredo Mendez M.Arch thesis, "Principles of a BioTectonic Culture." University of Puerto Rico, 2010

Conclusion

In conclusion, we have a great field to go where the efficiency and the inclusion of the appropriate expertise, can achieve the viability of projects with sustainable results. We are evolving in a more sensible practice which the challenge is not a visual heroism, instead is a performance driven solutions thru research. As architect Joshua Prince Ramus said: "It's time for architecture to do things, not just represent things". The ecological discourse sounds good, but if not built we will never enjoy the future that we seek without forgiving the following:
"hyper consumerism is what is assaulting our planet." "When we fight for the environment we have to remember that the first element of the environment is called human happiness."[8]

[8] Excerpts from the discourse of Jose "Pepe" Mujica, President of Uruguay at Rio+20, June 30, 2012.