Social-Interest Green House Design based in Rapid Product Realization Methodology – Case Study Solar Green House ITESM

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ABSTRACT

In this paper we share our experiences in the methodological design of a green house focused in the Social-Interest Market. The methodology exposed here was developed by the Tecnológico de Monterrey, and is a particularization of a general model. This particularization has the purpose of allowing the rapid detection of housing needs in developing markets and their covertures with emergent green building technologies. One of the main achievements is the generation of a reference framework for the Green Building Designer who wants to explore the low income market. This methodology includes the needs covertures identification, the evaluation methodology of feasible green building technology solutions and the rapid green building realization methodology including the determination of the solar geometry, the architectural bioclimatic and solar passive design, the comfort analysis, the electric and thermal power supply and the sanitary system.

Keywords: green-housing, design methodology, rapid product realization, developing markets, social-interest housing needs detection.

1 INTRODUCTION

Until recent years for the construction industry, the use of bioclimatic design criteria and alternative energy sources had been considered to satisfy necessities and expectations of developed markets. There are numerous examples of buildings planned with an ecological perspective using methodologies of design as Olgyay & Herat [2], Wang et al [3], Siu-Yiu et al [4], etc. But no one covers the diversification and consumers habits of the developing markets that represent the 86% of the world market [5].

The design of green buildings in developing markets emerges as an opportunity area since developing markets are experiencing accelerated growth in populations and income and; they are becoming more important to define the future of the world green building. Is well known that the energetic development of these economies is based on fossil fuels, and is also known that the constructions where people live, work and study consume 40% of the energetic world production [6]. In Mexico, according to the National Balance of Energy published by the SENER [7], 36 % of the electric power generated is consumed by the residential, commercial and public buildings and the 74% of this energy is produced by oil and its derivates [8].

The benefits of the green constructions are innumerable, besides the preservation of the environment for future generations, a general believe exists that the green building involves improvements of productivity and general health of its users [4], an important reduction of construction residues, minor consumption of water and energy, a general reduction in the operative costs and a top quality of interior air [2].

There exists a widespread myth about the expensiveness of ecological buildings. Nevertheless, if the design and the construction plan are developed using a correct design methodology, the green housing does not involve increases in the costs of the construction [3].

There are numerous examples of buildings planned with an ecological perspective that are not more expensive thanks to its strategies of energetic and material efficiency in an integral and methodological design; multiple initial expenses are minimized, and will be pay back before than a traditional building would do, since its costs of operation will be considerably minor. The methodology exposed in this paper focus its efforts in the early developing market necessities determination and the translation of this in best green construction practices that assure a soft implementation due both, to the cost and the integration with the developing local environment.

A developing market economy is defined as an economy with low-to-middle per capita income (a GNP of less than 10000 US dollars). Such countries constitute approximately 86% of the global population, representing about 14% of the world's economies [5].

Some of those countries are making a critical transition from a developing country to an emerging market; the five biggest emerging markets are Brazil, Russia, India, China and South Africa. Other countries that are also considered as emerging markets include Mexico, Argentina, Poland, Turkey, and South Korea. These countries do not share any common agenda, but some experts believe that they are enjoying an increasing role in the world economy and on political platforms. Each developing or emerging market is important as an individual market and the combined effect of the group as a whole will change the face of global construction business and the green industry.

The developing world is not a monolithic market opportunity; there are diverse segments such as the rich and super-rich, the middle class, the poor and the rural [5]. All these segments share a common environment and a general necessity, the sustainable housing. These distinctive characteristics represent challenges for the green construction companies and also represent opportunities in an exiting market.

2 RAPID PRODUCT REALIZATION METHODOLOGY FRAMEWORK

Product development is the transformation of market opportunity and a set of assumptions about product technology into product availability for sale. Different disciplines are strongly related, or were conceived for the global process (or set of activities) required to develop a new product. These disciplines are New Product Development, Concurrent Engineering, Systems Engineering and Project Management. There is a remarkable common purpose between those disciplines of product development within time, cost and quality requirements. Concurrency of activities in a proper manner has been considered as a primordial aspect for the shortening of time, improving quality and avoidance of rework. Considering new manners to describe success for the product development, there is another definition of success of products, where the client satisfaction or perception is the most important concern.

In the new global economy, the tendency suggests that the competitive advantage will be for those companies capable to develop products rapidly with a focus on the client. The economical success of organizations depends on their ability to identify the necessities of the market and the development of products which satisfy those necessities with a low cost and in the lowest time.

Methodologies for product development under green housing special characteristics have been developed. The Methodology Framework for Rapid Product Realization (RPR) (See Fig. 1) conceived at Tecnológico de Monterrey, arranges a set of appropriate tools and techniques for the rapid development of green houses for developing markets throughout the different phases of the global process of development.

In order to efficiently carry on the process of product realization is needed a set of reference models, methodologies, techniques and technologies. An efficient framework for Rapid Product Realization (RPR) must take into account the very rapid evolution of feature and function of products and requirements in developing and developed markets. Some product-design best practices that are useful for the RPR Framework can be classified according to the stage of the product life cycle and the kind of activities they can support.

For necessities detection and their satisfaction using emerging technologies in developing or emerging markets, new best practices are being contemplated in this paper (considering emerging technologies as not the same than those from developed markets).

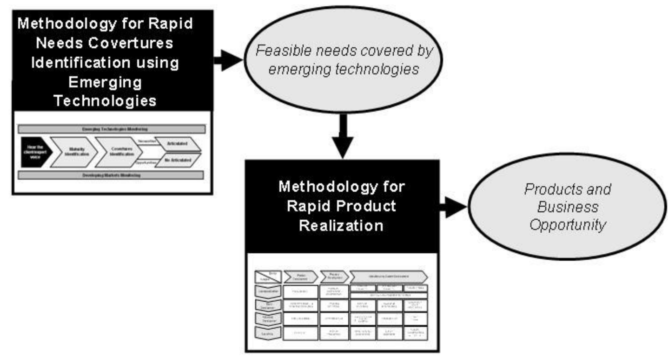

Figure 1: RPR Methodology Framework.

2.1 Methodology for Rapid Needs Covertures Identification using Emerging Green Housing Technologies

This is the phase of the methodology framework and aims to identify the housing necessities of the selected market and the possible necessities covertures by means of green building techniques and emerging technologies, all this into an environment of green building best practices using an integrated methodology named “rapid needs covertures identification (RNCI) using emerging green housing technologies” (See Fig. 2).

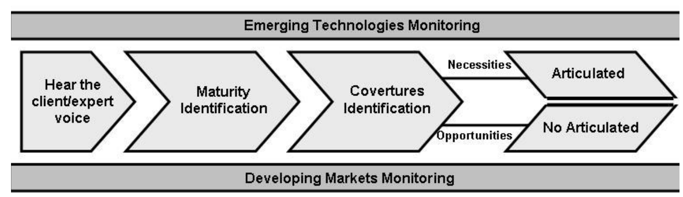

Figure 2: RNCI Methodology.

2.1.1. Hear the clients/experts voice

First it is necessary to identify the opportunity areas of the actor that run the methodology (be it an enterprise or a research organization). A fifteen question document will be sent to the experts in green technologies that collaborate with the actor to identify the advances in green housing technologies (e.g. Solar Passive Heating, Bioclimatic Structures, etc.). The answers obtained with this questionnaire simplify the selection of appropriated information sources of each green housing technology with global acceptance, where the technology prospective and regional necessities are exposed.

Once selected the technology subject to be considered, the study population has to be delimited according to the actor’ interests and scope, the intrinsic characteristics of the subject or the technological development of the subject in regions. Periodical national and international reports, statistics and trends can be founded in literature. The obtained emerging market information is extracted from

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sources and registered. This activity can be made in a data-base which could allow the information search structuring and analysis, as well as retrieval. The obtained information of this section is a preliminary list of feasible green housing emerging technologies and information of their developing trend.

2.1.2. Maturity identification

For each necessity identified in the past stage, it is necessary to evaluate three important factors (Solution, Technology Maturity, and Market Acceptance) that will help the designer to decide which technology best fits the necessity using the information mined before.

Solution (s): A technology is a solution when it covers the specific need studied. The possible values are 1 from a solution and -1 if the technology does not represent a solution for the necessity.

Green Housing Technology Maturity (m): Is a measure of the technology development degree in the organization or in allied organization. This measure is divided in ten points and four critical phases; *Initiation Phase:* A proved phenomena is discovered and reproduced (0-0.1).*Growing Phase:* Computational characterization of the phenomena (0.2-0.6).*High Maturity Phase:* Prototype is developed (0.7-0.9).*Aging Phase:* Proven commercial technology application of the phenomena (1).

Developing Market Acceptance (a): Is a measure of the market's green housing technology acceptance due to the necessity coverage. This measure is divided in ten points and four critical phases. *High acceptance:* Receptiveness to the emerging technologies, no political regulation barriers, no socio-cultural barriers for the necessity cover using emerging technologies and the covered need is a national security issue or national development plan issue (1-0.9). *Medium acceptance:* High acceptance characteristics but it isn't a national security or developing issue and it has some political barriers (0.8-0.5). *Low acceptance:* Medium acceptance characteristics but it has social barriers for application (0.4-0.1). *Null Acceptance:* No receptiveness to the emerging technologies.

2.1.3. Covertures identification and Articulation.

According to the information collected of the first stage, the level of maturity of technologies is identified. For each technology is necessary to put a qualification using the criteria defined in the second stage. The resulting number for each technology-market match is the multiplication of each characteristic (See Fig. 3) and it is proposed a decision grid to simplify the results identification.

It is necessary to choose the best technology to cover the developing market necessity. A positive number represents a technology which covers the specific necessity, while a negative number represents a technology which does not cover that necessity. However, if the final process result is a high negative number (e.g. bigger than -0.8) is convenient to evaluate the possibility of generation or identification of a necessity for the use of that technology (no articulated product or service) since it has enough technical development and acceptance by the market.

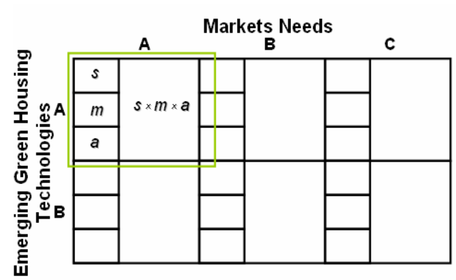

Figure 3: Decision grid.

2.2 Methodology for Rapid Product Realization (RPR)

Molina et al. [1] proposed a reference model that enables the creation of a partial and particular model to set up an Integrated Product, Process and Manufacturing System development processes (IPPMD). The Reference Model structured by Molina et al. [1] is structured in three dimensions: Processes that are a description of the entities that will be developed, it can be a product, process and/or manufacturing system; Stages that are the set of activities, based on the product lifecycle phases that were condensed in conceptualization, basic development, advanced development and launching. For each stage, three kinds of activities can be identified: analysis, synthesis and evaluation. Three phases are proposed in order to configure a particular integrated model: i) Phase I – Definition of the project: identification of the project's scope according to the reference map (see figure 4); ii) Phase II – Partial model definition, from a set of proposed activities, the evaluation and selection of the suitable activities is made; iii) Phase III –Particular model definition, consist on the translation of each one of the activity into the particular case under study. A particularization of the model was developed and integrated to satisfy the Green Housing Necessities(See Fig. 4). A general description of each point is explained next.

Green House Idea – Using the information obtained in the RNCI Methodology it is obtained both technically and economically viable Green Housing idea. The scope of the project and the project plan are defined using a Gant Diagram.

Concept Design & Target Specification - This stage involves the classification of information about constrains and developing markets requirements obtained with the RNCI Methodology to be embodied in the solution it is proposed for this process a Morphological Matrix.

Detailed Green House Design – In this stage is developed the arrangement, form and dimensions of all individual necessities identified with the RNCI Methodology. Drawings and manufacturing documents are produced based in the green building best practices, the design location is defined (solar geometry determination, wind map, precipitation chary, etc.)

Individual Component Specification – House design is received and it is decomposed in order to identify all individual components. Customer requirements are identified plainly in three aspects: function, integration with the architecture and power supply. Finally scope of the project and project plan are defined.

Product Transfer and Component Specification - Product information is collected. Bill of Materials (BOM) is carried out in order to identify materials, standard components, quality requirements and delivery times.

Process Selection - Components are classified as standard parts or manufactured parts.

Supplier Selection - Manufacturing capacities and capabilities from different companies are evaluated in order to integrate their competences to develop the project for each before identified housing necessity.

Prototype - This stage verifies any remaining problems in the product. The formal sketches and the computational model are carried out to check the functionality and potential design modifications.

Operation & Integration Plan - Once the individual components have been purchased or manufactured, it is necessary to define the layout for the production and assembly.

Construction & Quality Control – In this stage the design is constructed by the selected partners. Control variables are defined and monitored.

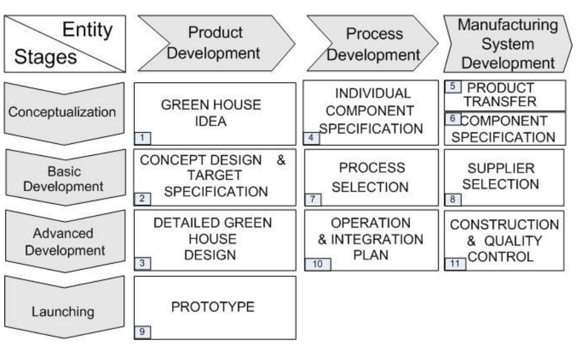

Figure 4: Green Housing particularization of [1].

3 CASE STUDY SOLAR GREEN HOUSE

The development of a Social-Interest Green House is being carried out at Tecnológico de Monterrey. The definition of the client's necessities as well as the identification of technologies has been done as the first part of the methodology exposed before indicates. For the rapid product realization, the second phase of the activities have been performed, this is to say, the partial configuration for a social-interest green house has been developed.

Figure 5 represents the followed methodology since the necessities determination to the final sketch of the house; for illustrative ends in the figure just one functionality.

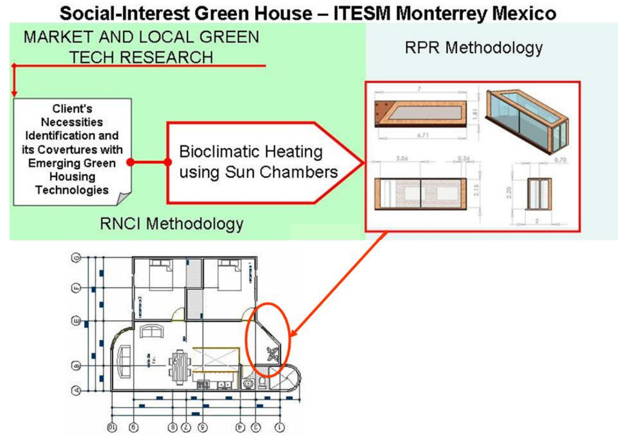

Figure 5: Schematization of the Space Heating.

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