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QUALITATIVE ANALYSIS OF SUSTAINABLE VERTICAL DWELLINGS IN NUEVO LEON, MEXICO
(ANALISIS CUALITATIVO DE LA VIVIENDA VERTICAL SUSTENTABLE EN NUEVO LEON, MEXICO)

TESIS

PRESENTADA COMO REQUISITO PARCIAL PARA OBTENER EL GRADO ACADÉMICO DE:

MAESTRO EN CIENCIAS CON ESPECIALIDAD EN INGENIERÍA Y ADMINISTRACIÓN DE LA CONSTRUCCIÓN

POR:

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1 INTRODUCTION

Climate change has become one of biggest concerns in contemporary times since the effects of fluctuations in the weather are more notable every day. One of the many causes to this climatological event is the destructive action of mankind on nature. The environmentally harmful changes are also partly due to different kinds of natural phenomena that occur in different regions of the world. Regardless of the causes, it can be concluded that climate change directly affects the human population.

As it has been previously noted, human action is part of the problem in this matter. The greenhouse effect, which is caused by high concentrations of CO_2 in the atmosphere, is one of the many by-products of human's unconscious interaction with nature. The National Institute of Ecology (INE in Spanish) (2006) states that dwellings contribute 7.64% of the CO_2 emissions in Mexico. Mayagoitia (2006) states that in general, construction generates 33% of the total CO_2 emissions in the country. Given the significance of the effects that construction has on the emission of CO_2, it is more than reasonable to promote the reduction of this adverse activity. One possible solution to this problem is the implementation of sustainable criteria in the designing and construction of new housing developments. This should also be accompanied by the adaptation and refurbishment of current dwellings.

The incorporation of a sustainable vision in housing creation will have a positive impact in the economy, on society, and on the ecology of Mexico. The Mexican economy will be favored under this new housing initiative because it is estimated that dwellings with sustainable parameters represent lower expenses in utilities, mainly in water and electricity bills. The societal factor considered includes better quality and more comfortable homes that will be offered to the Mexican citizenry. Ecological gains will be achieved with the reduction of energy usage subsequentCO_2 emissions into the atmosphere. In addition, if low environmental impact materials are used during the construction process, this will considerably reduce CO_2 emissions to an even higher extent.

Vertical dwelling developments possess a lower environmental impact than horizontal structures due to their reduced footprint, concentration of services, and re-use of land among many others. They are therefore more efficient and cheaper to run during their life cycle.

From 2001 to 2006 the housing production in Mexico has increased approximately 40% (CONAVI 2007), positioning it as one of the most important activities in both the economic and urbanization process of the country. The participation of the public and private sectors has been decisive to the current housing supply. Nevertheless, there are still great challenges that must be addressed, such as providing easier access to mortgages for the lower-income population and linking this effort to the development of sustainable dwellings and suitable technology for Mexican conditions.

According to CONAVI data, between 2006 and 2012 the national housing requirements amount to over 4,427,000 new dwellings and more than 2,930,000 home improvements, indicating an increase in future housing needs. In its National Development Plan (NDP) 2007-2012, the Mexican government has taken into account sustainable aspects in its planning for this massive production. Specifically stated in its second objective is to: "Promote a sustainable housing development", broken down further into strategies including: "Promote the construction of housing developments with sustainable characteristics". This strategy also includes the promotion of certification and registration of emblematic models that enhance verticality, sustainability, efficient equipment, climate change protection policies and the optimum use of current infrastructure, water and energy.

Considering the aforementioned situation, sustainable vertical dwelling is a suitable solution to cover one part of the housing shortage in the country, as well as the land shortage in the urban areas, and at the same time it will provide better quality living quarters to its residents and a lower impact to the environment.

1.1 Problem definition

Climate change is a problem that affects all humankind and the construction sector, being one of the greatest contributors to climate change, accounts for around 33% of green gas emissions (Mayagoitia, 2006). Housing is also a high source of emissions, therefore it is imperative that solutions be found to mitigate housing impact on the environment.

Sustainable living practices seek to reduce the impact of human activities on the environment, promote social equity, provide higher comfort within public and private facilities, and to be a feasible option for constructing and operating facilities due to its cost savings of energy usage and waste management.

The Mexican housing situation (CIDOC, 2008) indicates some issues regarding the construction and urbanization trends, as well as the shortage of housing to satisfy society's needs. Thus, sustainable principles promise suitable alternatives for development and housing construction.

The application of sustainable elements in construction has proven to generally be more expensive than the 'conventional' projects (Lapinski, A, et al, 2006, Jackson 2008), and therefore investors and facility owners are reluctant to invest in the construction of sustainable buildings. This cost increase can be mainly attributed to the high price of technology needed to provide high efficient systems, versus the use of passive or eco-design.

1.2 Objectives

The objectives of this research are to:

- Present the general housing situation in Mexico, and its problems and challenges.
- Assess the awareness of sustainability in the housing sector, which includes construction companies and developers, and government boards and associations or institutes related to the construction industry.
- Perform a qualitative analysis of a traditionally constructed high-rise versus construction of the same building with sustainable features, emphasizing the added value and the potential cost savings.

1.3 Justification

This project is aimed at promoting vertical, sustainable housing construction as a main option of dwelling developments due to the following advantages: increased energy efficiency, lower harmful environmental emissions, decreased energy and water consumption, improved ventilation and indoor air quality, healthier living conditions, longer lifecycle, and less expensive operation (Alnaser 2008, Hikmat 2008, USGBC). With the land for urbanization becoming more difficult to access (CIDOC 2009) and the costs of horizontal housing more expensive and generally increasing in price annually, vertical dwelling developments are a feasible solution to these problems.

As cost is a deciding factor in the question of whether or not to undertake new projects, the proposed qualitative analysis in this research seeks to foster the construction of vertical dwelling developments using sustainable practices, to change the perception that they are more expensive to build, and prove that they are less expensive to operate during their life cycle.

1.4 Research Scope

The scope of this research is as follows:

I. Identify the awareness of sustainability as a means to protect the environment, provide better headquarters to users and confirm lower construction and operation costs. This can be achieved by the use of interviews face to face with key members of representative construction companies and developers, and government boards and institutes related to the construction industry.

II. Perform a qualitative analysis comparison between two alternatives of construction, applied to the same condominium project located in Monterrey, Mexico.

2 CONCEPTUAL FRAMEWORK

2.1 Sustainable Construction and Smart Growth of the cities

All industries, including construction, now face an inescapable challenge posed by the movement toward "sustainability". Business activities of all kinds can be a major impact, both directly and indirectly, on the environment. Until only recently, most developing countries' businesses have given thought to the environmental aspects of their activities and their own sustainability. Alternatively, many developed countries have more recently made great advancements in the implementation of sustainable policies and regulations, and have undertaken further actions regarding sustainable development.

2.1.1 Brief Review of Sustainability

The concept of sustainability in the context of the environment was defined by many leading advocates during the 1980s. One of the most common definitions of sustainability was phrased by Norway's Prime Minister, Gro H. Brundtland as: "Leaving sufficient resources for future generations to have a quality of life similar to ours" (UN Documents 1987). The term was firmly recognized by the global community in 1992 during the Rio Earth Summit when "Sustainable Development" was incorporated in the official documents as a common target to be achieved by the world.

Similar to Brundland's definition of sustainability, the World Commission on Environment and Development of the United Nations states it as: "meeting the needs of the present without compromising the ability of the future generations to meet their own needs" (Tarun, 2008).

In 1991, as the planning of the World's Fair was under way, the city of Hannover, Germany asked William McDonough and Michael Braungart to create sustainability principles that have since become known as "The Hannover Principles: Design for Sustainability", and include directives concerning the use of water. Although these guidelines were created for the World's Fair, they are still a good tool to guide current and future development around the world (Tarun, 2008) and are outlined as:

- Insist on rights of humanity and nature to coexist
- Recognize interdependence
- Respect relationships between spirit and matter
- Accept responsibility for consequences of design

- Create safe objects of long-term value
- Eliminate the concept of waste
- Rely on natural energy flows
- Understand the limitations of design
- Seek constant improvement by sharing knowledge

The Hannover Principles are not “cast in concrete.” They were devised to provide a tangible document that could evolve and be adapted as our understanding of our interdependence with nature changes and becomes more important over time.

Caring for the earth offered a definition for sustainable development: “(development which) improves the quality of human life while living within the carrying capacity of supporting ecosystems” (Wetherill, 2007). However, it’s inevitable that development would deplete some stocks of nonrenewable resources and that development should take account of this by “investing” in other assets (which could include social or manufactured capital) in order to meet the needs of the future.

Triple Bottom Line

With the addition of social and environmental values to the traditional economic measures of a corporation or organization's success, Triple Bottom Line accounting attempts to quantify the social and environmental impact of an organization's activities in order to demonstrate improvements or to enable more in-depth evaluation of its economic performance. The Triple Bottom Line phrase was coined by Elkington (1998), who published a book describing three main sectors interacting together as a desired outcome in reaching sustainability, however there are currently few standards for measuring the impact of these two other values.

Savitz (2006) said that the Triple Bottom Line is the place where corporate and societal interests intersect. It is a new way to measure the bottom line, where profits go side-by-side with environmental and social performance; and an illuminating way to understand the often-fuzzy concept of sustainability. It is a practice that the best-run and most profitable companies have already found. The figure 2.1 depicts this concept of triple bottom line:

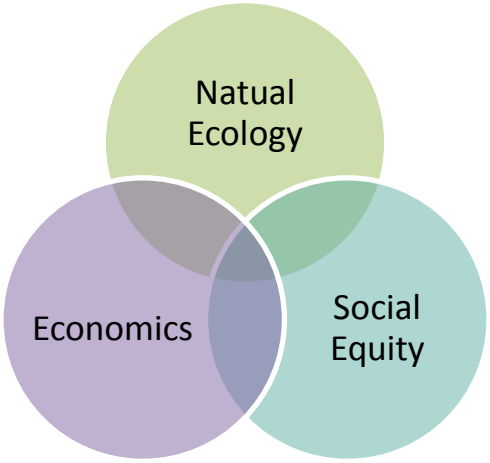


Fig. 2.1. The triple bottom line of sustainable development.

Some authors refer to the 3 parts of sustainable development as: People (referent to Social Equity), Planet (referent to Natural Ecology), and Profit (referent to Economics) (Savitz 2006, Elkington 1998, and Dockside Green). Some considerations within each term are:

Environmental:

- Energy and water
- Materials
- Emissions and waste
- Operational and design efficiencies
- New product, service opportunities
- Life Systems Impact

Economics:

- Revenue growth
- Productivity
- Profit margin
- Return on Investment
- Capital Costs
- Risk Management
- Evaluation of Enterprise
- Appeal to Investors

Social:

- Community and social impact
- Health and safety
- Fair compensation
- Equal opportunity
- Education
- Recognition

2.1.2 What is sustainable construction?

Before defining sustainable construction, we present an overview of the contribution of the construction industry to energy consumption and its emissions to the environment.

In the European Union alone, energy consumption for buildings related services accounts for approximately one third of total energy consumption; although creation and operation of the existing environment, including directly associated transport and processing of materials, accounts for at least 50% of all energy consumption in Europe (Wetherill, 2007).

The global average of the building sector provides between 5-10% of national employment and 5-15% of gross domestic product (GDP). Additionally, the servicing of buildings (including heating, cooling, ventilation and lighting etc.) on average accounts for approximately 40% of the total worldwide primary energy consumption (Thorsten, 2007). The building sector is therefore responsible for a large majority of the global green-house gas emissions, but it also offers potential for a significant reduction of energy consumption and related CO_2 emissions.

Voss and Kramp (2007) said that energy use in buildings worldwide accounts for a considerable part of the primary energy use and the green house gas emissions. The ratio widely varies by country due to climate, population density, lifestyle, building standards, and use of renewable sources. Depending on the building energy standard and the fraction of the energy sources in use, buildings are more a direct (on site use of fossil fuels) or indirect (site delivered electricity, district heating/cooling, building materials) source of emissions..

In Mexico, construction produces 33% of emissions and generates 20% of industrial waste. Graedel's estimates that 80% of the environmental pollution is produced during the life, use, and maintenance of houses (Mayagoitia, 2006).

Sustainable Construction

Sustainable construction involves using best-practices clean and resource-efficient techniques, from the extraction of the raw materials to the demolition and disposal of its components (Ofori, 2000). Sustainable construction is part of sustainable development, and can also be called 'green building'.

Green building has now become a flagship of sustainable development in late last century that takes the responsibility for balancing long-term economic, environmental and social health. It offers an opportunity to create environmentally efficient buildings by using an integrated approach of design so that the negative impact of building on the environment and occupants is reduced (Hikmat, 2008).

The 1992 United Nations Earth Summit was intended to bring sustainability to the forefront of policy formulation. More than 100 nations participated, with the exception of the United States. The result of the Earth Summit was the publication of Agenda 21which highlighted six subject areas of focus for sustainable design (Bunz, 2006). The main recommendations of the Management of Human Settlement section of Agenda 21 are as follows:

1. The use of local materials and indigenous building sources.
2. Incentives to promote the continuation of traditional techniques, with regional resources and self-help strategies.
3. Recognition of the toll that natural disasters take on developing countries due to unregulated construction and use of inadequate materials, and the need for improvements both in the use and manufacturing of materials and construction techniques, as well as training programs.
4. Regulation of energy-efficient design principles.
5. Standards to discourage construction in ecologically inappropriate areas.
6. The use of labor-intensive rather than energy-intensive construction techniques.
7. The restructuring of credit institutions to allow the lower-income class to buy building materials and services.
8. International information exchange among architects and contractors, on all aspects of construction related to the environment, particularly about non-renewable resources.
9. Exploration of methods which encourage and facilitate the recycling and reuse of building materials, especially those requiring intensive energy consumption in their manufacture.

10. Financial penalties to discourage the use of materials which damage the environment.
11. Decentralization of the construction industry through the encouragement of smaller firms.
12. The use of "clean technologies".

These 12 recommendations constitute the foundation for many international sustainable design guidelines and recommendations, and collectively they cover many aspects of the lifecycle of a building project (Bunz, 2006).

In November 1994, two years after the Rio Earth Summit, , the First World Conference for Sustainable Construction was held in Tampa, Florida where the future of construction in the context of sustainability was seriously discussed (Miyatake, 1996). Sustainable construction is a concept for the civil engineering and construction industry denoting its share of responsibilities in achieving sustainable development.

Miyatake (1996) stated: "I believe that realizing sustainable construction is the key for our industry to prosper sustainably in the 21st century, and we should exert ourselves immediately and positively to realize this new concept".

During the 1994 conference in Tampa, several attempts to define the concept of sustainable construction were made. For example, Professor Charles J. Kibert of the University of Florida proposed six principles of sustainable construction:

1. Minimize resource consumption.
2. Maximize resource reuse.
3. Use renewable or recyclable resources.
4. Protect the natural environment.
5. Create a healthy, non-toxic environment.
6. Pursue quality in creating the built environment.

These six principles clearly communicate the essence of what the civil engineering and construction industry should practice in this era of global environmental problems.

Miyatake (1996) also proposed three ways by which the civil engineering and construction industry can act to realize sustainable construction:

1, Creating built environments: Creating better built environments for human lives has always been a core mission of the civil engineering and construction industries. To realize

sustainable building, industries must change the construction processes of creating built environments from the conventional linear process to a cyclical one.
Current construction processes, similar to most industrial processes, are linear. They use energy and materials that are resources from the earth or natural environments and convert them into buildings and structures, then discharge waste. Changing the linear construction process to a cyclical process will mean a significant increase in the use of recycled, renewed and reused resources, and a marked decrease in the consumption of energy and resources.

Restoring damaged and/or polluted environments. Engineering practices for the treatment of damaged and contaminated soil, water, and air are major examples of activities in this area.

Improving arid environments. The civil engineering and construction industries' involvement in the fight against desertification is a straightforward example of activities in this arena.

Green building characterization

Sustainable building design includes formal and informal initiatives advanced by governments, professional organizations, and private industry. These efforts have focused on the development of building design guides, improved energy codes, the use and development of low environmental impact building materials, renewable energy and resources, and the concept of analyzing the effects of design choices over the complete lifecycle of a building (Bunz, 2006).

The typical features of a green building include (USGBC):

- Sustainable sites
- Water Quality and Efficiency
- Energy and Atmosphere
- Materials and Resources
- Indoor Environmental Quality (IEQ)
- Innovative Design

Green building does not only make a positive impact on public health and the environment, it also reduces operating costs, enhances building and organizational marketability, increases occupant productivity and helps to create sustainable community (Hikmat, 2008). Generally, green buildings are:

- Energy efficient
- Water conserving
- Durable and non-toxic
- High-quality spaces which include high recycled content materials

Green buildings also provide many advantages such as marketability value, energy efficiency performance, less emissions, adequate day lighting and good distribution, less glare, low energy and water consumptions, better ventilation, free from high Volatile Organic Compounds (VOCs), indoor air quality, free from sick-building syndromes, better health conditions, less absenteeism, higher productivity, longer lifecycle, and more. (Alnaser, 2008)

In countries where the outdoor temperatures are very extreme, people spend more than 90% of their time indoors. Therefore, green sustainable buildings offer healthier and more efficient solutions to owners, occupants and businesses. It has been demonstrated that energy and water efficient buildings reduce the operating costs by more than 50% by employing well-integrated green design concepts (Alnaser, 2008).

It is notable that in order to move the construction industry forward toward sound sustainable principles, there is a clear underlying need for technical, social, and innovative change. However, there are still barriers preventing sustainable construction from gaining ground in mainstream building processes (Wetherill, 2007). This is due to several factors including:

- Sustainability knowledge in construction is fragmented, diverse, embedded in various documents, and developed in a non-concerted and integrated way across geographical boundaries
- Lack of sharing, exploitation, and reuse of isolated sustainable practices and principles acquired through practice across the industry
- Lack of education and awareness across key construction stakeholders and building end-users
- Lack of access to value-added sustainability information

- Unclear links between sustainability principles and current construction regulations and standards

The concept of green dwelling

The most significant end user demands for energy use in building are the heating of space and water, air conditioning, lighting, refrigeration and the service of building equipment, such as domestic appliances, computers, lifts and office equipment (CONAFOVI, 2006).

A green dwelling can also be called a passive dwelling, for the implementation of passive design and technologies (eco-technologies) to increase the energy use performance and improve comfort (Voss and Kramp, 2007).

A stabilization of green house emissions can only be achieved by the extended use of renewable energies, the construction of new buildings according to passive house standards, and the maximum rational implementation of measures to reduce the energy efficiency of existing buildings (Thorsten, 2007). By the utilization of passive house technology in the natural cycle component, the necessary actions for replacement and building renovation can be realized in an economically feasible way.

The average energy demand for the tempering of passive houses is only about 10% of the existing building stock in Germany and Korea (Thorsten, 2007). Hence passive houses can contribute significantly to the reduction of fossil energy consumption and the related green house gas emissions.

The minimization of the heating and cooling energy demand is achieved by a good insulation of the building envelope, the appropriate use of internal heat sources (i.e. people, lighting, and domestic appliances) and solar radiation, as well as the controlled energy efficient ventilation with high-heat recovery rate. Furthermore, an appropriate surface to volume ratio of the specific building, the avoidance of thermal bridges and the reduction of heat loss by uncontrolled ventilation are crucial for meeting the required low energy demand.

Passive houses are buildings with a very low service energy demand. The total primary energy demand of certified domestic passive houses may not exceed 120 kWh/m^2 per year for heating and cooling, hot water production, and general household energy consumption (Thorsten, 2007).

A large variety of measures to significantly reduce energy use and emissions is known and available on the market. The first option is simply to prevent a building from consuming energy by improving the quality of the building envelope. This is made available through passive solutions such as insulation, cross ventilation for humid climates, the efficiency of the "active" systems (better COP, co-efficient performance, better lighting efficiency etc.) or simply replacing a fossil energy consuming system with a renewable energy driven solution (solar heating or solar cooling etc.) (Voss and Kramp, 2007).

Economic Advantages of Green Buildings

Green buildings have a significant economic advantage; some experiences show that it was possible to reduce both, or one of the capital and operating costs by becoming a green building.

That is the case of Toyota Motor Sales, South Campus Facility, which was labeled a LEED Gold Certified facility without a first cost premium (Lapinski, A, et al, 2006). This is a notable accomplishment compared to an industry average 5-10% cost premium often needed to deliver LEED certified buildings.

This success was accomplished through the implementation of Lean Processes for Sustainable Project Delivery. Advances in manufacturing processes, especially those in lean production, demonstrate the power of harnessing production science to improve product quality (increasing value) and at the same time dramatically speeding production and reducing costs (Lapinski, A, et al, 2006). More detailed information is provided in section 2.2.4 of this document.

Jackson (2008) performed a study of Energy Budget at Risk investment analysis of an energy efficiency option for a five-story, 11,148.3m^2 office building in Austin Texas.. The least-cost baseline design results in modeled annual electricity use of 16.42 kWh/ft^2 and natural gas use of 35.1 kBtu/ft^2. Two efficiency options were considered; the first was a package of lighting technology upgrades and the second was an HVAC redesign including an energy management and control system.

The payback calculation of 2.3 years was longer than the building owner's 2-year requirement; consequently, even though this investment would reduce the building's annual energy cost by 38%, the investment would not be made because it fell short of the payback criteria. From the owner's perspective, investments with expected paybacks greater than 2 years carry too much risk of unacceptable investment returns.

Finally Jackson (2008) concludes that the payback analysis traditionally used to evaluate incremental energy-efficiency investments is designed to avoid investment risk. However, payback analysis does not consider energy cost savings beyond the required payback period, rejecting many profitable building design options that reduce annual energy costs by more than annualized investment cost.

This is one example of the need for the investors to understand that sustainable design could be slightly more expensive at the beginning, but if they consider the Internal Rate of Return (IRR) of the lifecycle of the facility, it could actually be cheaper.

Ofori (2000) stated that construction contractors can derive savings from the minimization of resource use and improve their corporate image. The enterprise's compliance with regulations and codes would be facilitated, and risk and uncertainties reduced.

Measuring Sustainability

Rating systems provide an effective framework for assessing a building's environmental performance and integrating sustainable development into building and construction processes. They can be used as design tools by setting and implementing sustainable design priorities and goals, and determining performance measures to guide the sustainable design and decision-making processes (Yokoo, 2002).

Using a green rating (assessment) system in the design/build process can produce significant benefits that are not likely to result from standard practices (Hikmat, 2008). Assessment measurements based on building lifecycle can produce significant long-term benefits for building owners and occupants; as this system helps for solving existing building problems, limiting environmental impacts, creating healthier and more productive places, and reducing building operations cost. Lifecycle analysis takes into account all costs of acquiring, owning, and disposing of a building system.

We should develop technical services and resources for determining the "green-ness" of a building based on an appropriate green rating system that suits the Mexican local context.

Awareness and alternatives for addressing sustainability

Bakens (1997) conducted an assessment of the research on trends in building and construction and found that for about the last decade somewhat isolated groups of strongly committed experts have been working on sustainable construction. Models have been developed for the assessment of the environmental impact of new buildings, of

building materials and components, and design guidelines.. Thus, things are changing in a fundamental way.

First, the trust of the work of those experts is shifting from developing theoretical models to working towards implementing these models (Bakens, 1997). Their commitment remains just as strong, but their goals are moving from developing new knowledge to trying to convince others that this knowledge has to be applied.

Second, experts in other areas are beginning to realize that environmental aspects have to be an integrated part of whatever they want to develop. As with Information Technology, the principles of sustainable construction are no longer an isolated topic but are an integral part of many other topics of importance in construction.

Sustainable goals can only be achieved if new resources of knowledge and expertise inform construction activities. Some of this comes in the form of good practice and standards, but much will have to come from situated and contextual appreciations of sustainability goals and local practices developed across organizational, professional, and multicultural boundaries (Wetherill, 2007).

Ofori (2000) states that some designers and contractors are now starting to respond to the increasingly stringent demands of their knowledgeable clients. Contractors are paying more attention to corporate environmental strategy, environmental impact assessments, ecological and land-management surveys and evaluations, and waste management. And some of those contractors have already implemented environmental management standards (EMS).

A new challenge, the environment, faces businesses in the wake of regulatory and competitive pressures and growing public attentiveness to the quality of life and conservation of natural resources. As construction activity has a significant impact on the environment there is a vital need for the construction industry to add one more dimension; the environment, to its success paradigm. Construction enterprises should harmoniously utilize resources and minimize adverse environmental impact through organizational changes and targeted investment (Ofori, 2001).

Ofori (2001) has conducted some research of the implementation of some measures to address sustainability among construction companies in Singapore. One of those measures is the implementation of Environment Management Standards (EMS) as ISO 14001.

An EMS is defined as the part of the overall management system which includes the organizational structure, planning activities, responsibilities, practices, procedures, processes, and resources for developing, implementing, achieving, reviewing, and maintaining a company's environmental policy. ISO 1400 provides organizations the framework for managing environmental impacts.

Benefits found from implementing EMS include:

- Reduced operating costs
- Increased access to markets
- Demonstrated compliance with regulations
- Improved environmental performance
- Improved customer trust and satisfaction
- Enhanced corporate image and credibility
- Employee involvement and education
- Potential impact on world trade to allow competition on an equal basis

Evolved from the ISO 9000 QMS series, the ISO 14000 series of EMS makes good business sense. As an enterprise applying an EMS will realize many benefits, one being cost savings. Singapore was the second country in Asia (after Japan) to start certification to ISO 14001. (Ofori, 2001). In Mexico only a few construction companies are ISO 14001 certified, those being the largest companies in the country.

After being ISO 14001 certified, one construction company in Singapore derives cost savings by adopting the following measures (Ofori, 2001):

- Use of materials which can be recycled, such as metal formwork
- Use of a thinner layer of mortar for plastering after improving the quality of structural works
- Use of pre-packed mortar for plastering
- Using rainwater instead of potable water at the washing bay

The National Institute of Ecology (INE 2006) states that dwellings contribute 7.64% of the CO_2 emissions in Mexico. Ideally the current 25.7 million houses in Mexico (CONAVI 2007) should have environmental mitigation and correction practices performed to reduce this amount. This is the challenge for the current sustainable housing. Additionally, moving forward, it implies the need to change the perspective and implementation of planning,

designing, material usage, construction procedures and the trends of energy and water use, to address and capture the economic benefits of new housing construction.

2.1.3 Smart Growth of the cities

Existing patterns of urban and suburban development seriously impair our quality of life. The symptoms include more congestion (traffic) and air pollution resulting from our increased dependence on automobiles, clearing of new areas, need of infrastructure for the new developments (sprawl), the loss of precious open space, the need for costly improvements to roads and public services, the inequitable distribution of economic resources, and the loss of a sense of community (US EPA). By drawing upon the best practices from the past and the present, we can plan communities that will more successfully serve the needs of those who live and work within them. Such planning should adhere to certain fundamental principles.

New Urbanism

In 1991 in Sacramento, California, at the instigation of Local Government Commission staff-member Peter Katz, author of the New Urbanism, the commission brought together a group of architects who have been leaders in developing new notions of land use planning. These innovators were asked to come to an agreement about what it is that the new planning ideas, from neo-traditional planning to sustainable design, have in common and from there to develop a set of community principles. They were then asked how each community should relate to the region and to develop a set of regional principles. Finally, they were charged with defining how these ideas might be implemented by cities and counties (Local Government Commission, Sacramento).

The New Urbanism Organization defines this concept as “Giving people many choices for living an urban lifestyle in sustainable, convenient, and enjoyable places while providing solutions to peak oil, global warming, and climate change.”.

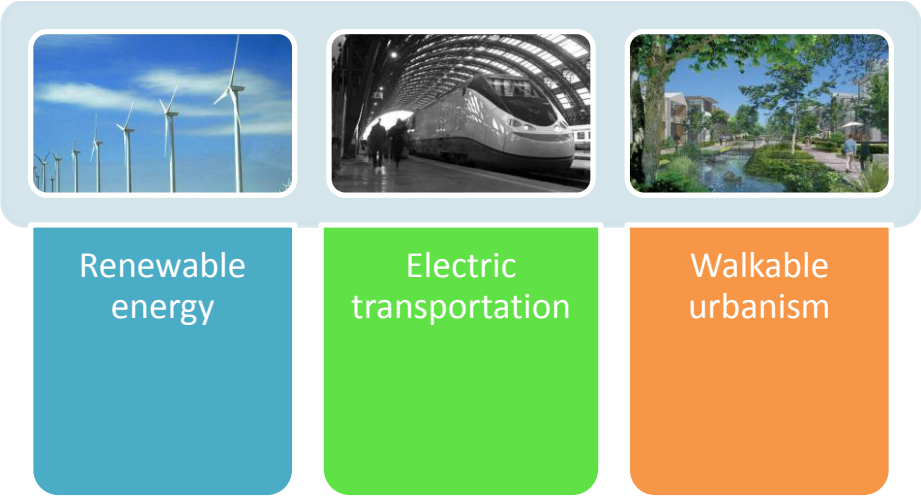


Fig. 2.2. Parts of New Urbanism. Source: Katz 1994.

This means the integration of the concepts presented in figure 2.2: managing growth, reducing traffic, creating sustainable development, and making smart transportation investments are all challenges we face today. New Urbanism is a development strategy that addresses these issues and others by creating communities that are livable, walk-able, and sustainable, while raising the quality of life.

The solution is in rebuilding our existing cities and creating more dense suburbs into compact, walk-able towns and cities connected by extensive train systems. This form of development is known as a Transit Village, or Transit Oriented Development (TOD), and provides a higher quality, sustainable living environment. This gives us the choice of getting around by a number of different means including trains, bicycles, walking, rollerblading, and scooters and is a combination of human scale urbanism, with a mix of uses and services and a range of housing options within compact towns.

In the era of dwindling oil supplies and rising energy costs, the need for low energy lifestyles has never been greater. Urban design principles and practices bring together the ideas and plans to create enjoyable places to live, work and play while greatly reducing energy use. Designing away the need for cars is the most important step in creating sustainable places. This has the triple effect of lowering our energy use (especially imported oil), reducing global warming emissions, and raising our quality of life in cities by increasing mobility and convenience.

Figure 2.3 represents many North American cities, Australia, Asia and Europe in terms of their population density and transport-related energy consumption. It can be noted that

North American cities have low densities and consume lots of energy for transportation due to the prevailing sprawl model of urbanization. European cities in general have high densities and uses low consumption of energy due to the train systems of large range, medium range, and metro systems.

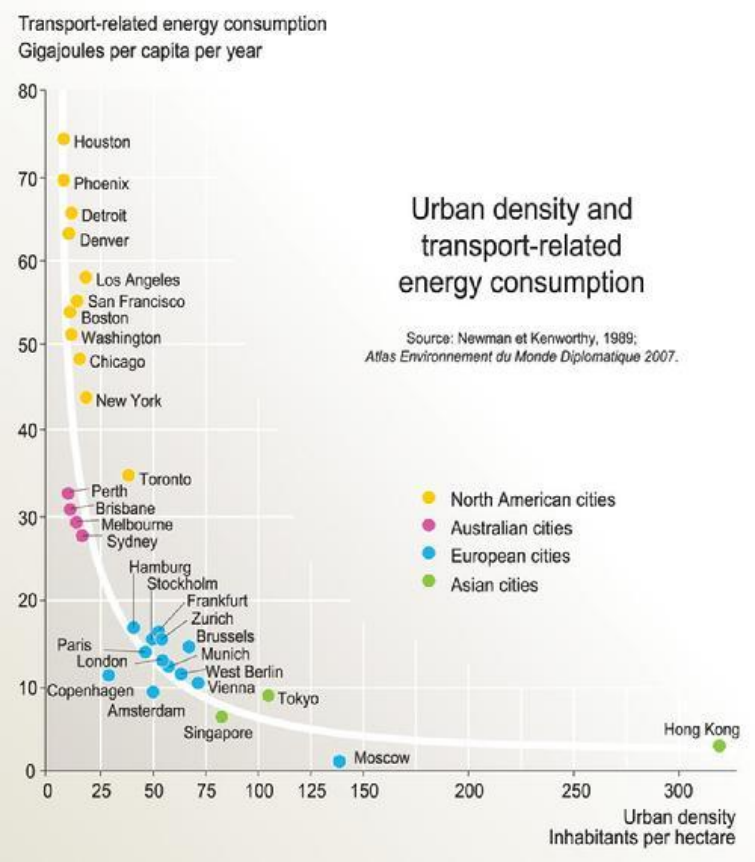


Fig. 2.3. Urban Density and transport-related energy consumption.

The principles of urbanism can be applied increasingly to projects at the full range of scales from a single building to an entire community. Those New Urbanism Organization principles are:

1. Walkability

- Most things within a 10-minute walk of home and work
- Pedestrian friendly street design (buildings close to street; porches, windows & doors; tree-lined streets; on street parking; hidden parking lots; garages in rear lane; narrow, slow speed streets)
- Pedestrian streets free of cars in special cases

2. Conectivity

- Interconnected street grid network disperses traffic & eases walking
- A hierarchy of narrow streets, boulevards, and alleys
- High quality pedestrian network and public realm makes walking pleasurable

3. Mixed-Use and Diversity

- A mix of shops, offices, apartments, and homes on site. Mixed-use within neighborhoods, within blocks, and within buildings
- Diversity of people - of ages, income levels, cultures, and races

4. Mixed Housing

- A range of types, sizes and prices in closer proximity

5. Quality Architecture and Urban Design

- Emphasis on beauty, aesthetics, human comfort, and creating a sense of place
- Special placement of civic uses and sites within community

6. Traditional Neighborhood Structure

- Discernable center and edge, public space at center
- Importance of quality public realm; public open space designed as civic art
- Contains a range of uses and densities within 10-minute walk
- Transect planning: Highest densities at town center; progressively less dense towards the edge

7. Increased Density

- More buildings, residences, shops, and services closer together for ease of walking, to enable a more efficient use of services and resources, and to create a more convenient, enjoyable place to live.
- New Urbanism design principles are applied at the full range of densities from small towns, to large cities

8. Green transportation

- A network of high-quality trains connecting cities, towns, and neighborhoods together
- Pedestrian-friendly design that encourages a greater use of bicycles, rollerblades, scooters, and walking as daily transportation

9. Sustainability

- Minimal environmental impact of development and its operations
- Eco-friendly technologies, respect for ecology and value of natural systems
- Energy efficiency and less use of finite fuels

10. Quality of Life

- Taken together these add up to a high quality of life well worth living, and create places that enrich, uplift, and inspire the human spirit.

Smart Growth

Since the second half of last century, economic control in global urban planning has led to serious and complex social problems of segregation and environmental degradation, whose solution implies a greater social participation in urban planning and management. Our country is no stranger to this problem; in the search for a better, sustainable quality of life, the theoretical, legal, and administrative bases which have so far framed national urban planning must be redesigned (CIDOC, 2007).

Smart growth recognizes connections between development and quality of life. It leverages new growth to improve the community. The features that distinguish smart growth in a community vary from place to place. In general, smart growth invests time, attention, and resources in restoring community and vitality to center cities and older suburbs. New smart growth is more town-centered, is transit and pedestrian oriented, and has a greater mix of housing, commercial, and retail uses. It also preserves open space and many other environmental amenities (Anderson, 1998).

But there is no "one-size-fits-all" solution. Successful communities do tend to have one thing in common - a vision of where they want to go and of what things they value in their community - and their plans for development reflect these values.

Smart Growth is part of New Urbanism and together they seek to create synergy towards sustainable development of cities.

Sustainable Cities must be engines of economic growth through the creation of jobs, housing, and services. Nonetheless, their growth must foresee and ensure their local and even regional environmental impacts are controlled and moderated. For this purpose, they must make sure that their growth dynamics don’t spill over to risky inadequate lands, that there isn’t an urban dysfunction due to lack of infrastructure, and that diseconomies in administrative management are prevented. On the other hand, social equity must be ensured in the distribution of the benefits and costs of development, and in the maintenance of the urban economy’s productivity in the supply of goods and services (CIDOC, 2007).

At the local level, it is very important to keep in mind the concept of “quality of life” to achieve the sustainable development of cities. The achievement of an optimal quality of life poses complex problems involving cultural, political, economic, social, and now in sustainability, education and ecological aspects. Thus, it is clear that urban settlements

with sustainable viability are those with a good quality of life, an equitable society, and economic viability.

In the quality of life, it is also very important to consider the “quality of urban habitat” and of the dwelling itself. This is why, since Habitat II (1996), the “adequate housing together with the sustainability of human settlements” is stressed. This means that it is not enough to fight the lags in housing, but also the quality, as well-being also means having a private place with sufficient room, physical accessibility, adequate safety, secure tenure, structural stability and durability, lighting, satisfactory heating and ventilation, an adequate basic infrastructure including water, sanitation, and waste collection services, appropriate factors of environmental quality and health, and an adequate site with access to work and basic services, all at a reasonable cost. The suitability of all these factors should be determined together with concern for the population and keeping in mind the views of a participative democracy.

The Housing Institute of Nuevo Leon IVNL and CIDOC (2007) presented a model for Smart Growth (Figure 2.4) based on the ‘Development Oriented to the Transportation’ (DOT) which looks to be an emblematic model for the future of the major cities in Mexico.

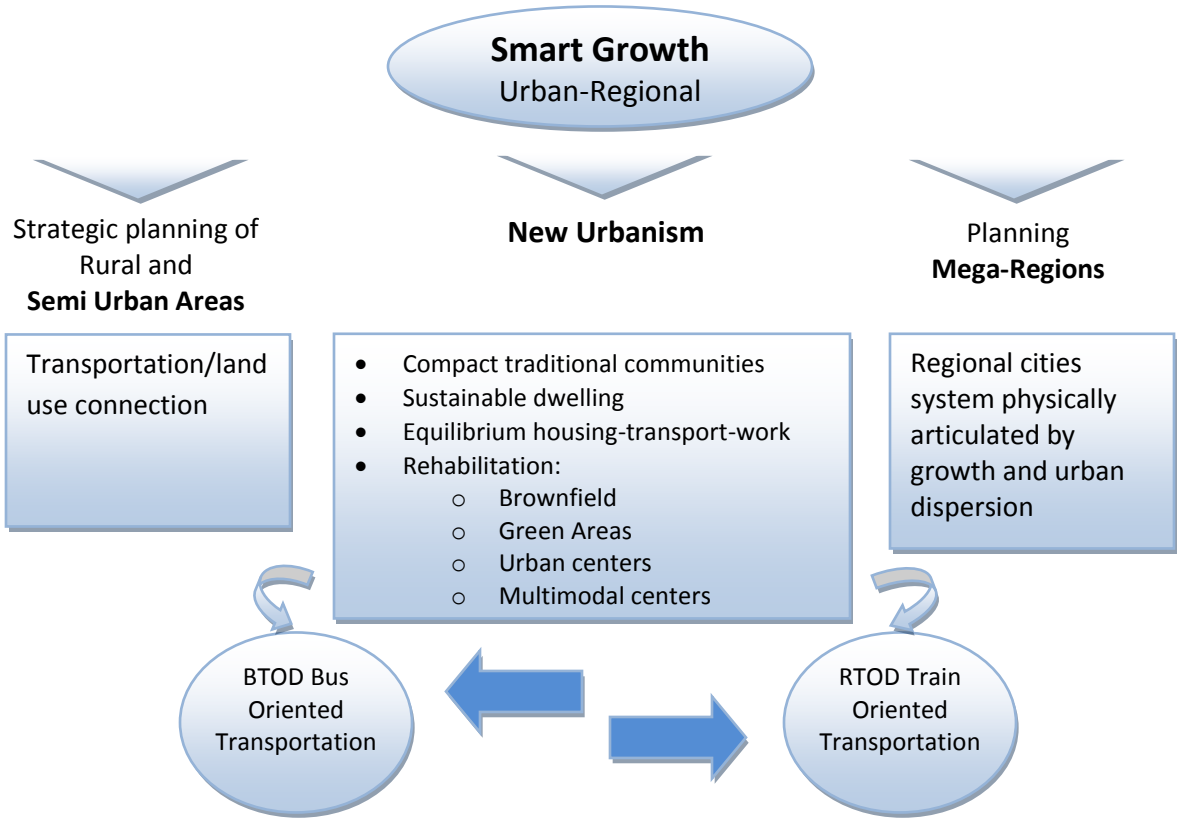


Fig. 2.4. Smart Growth Model for Nuevo Leon, Mexico. Source: IVNL and CIDOC, 2007.

2.2 International Achievements in Sustainable Construction

During the past several decades, many endeavors had been undertaken to address sustainability in construction. The actors had been governments from different countries, private owners committed to the care of the environment, and research institutes. A wide range of actions have been implemented, such as:

- Creation of laws and building codes
- Implementation of Rating Systems to assess sustainability
- Development of eco-friendly materials
- Development of energy efficient system
- Development and implementation of new building procedures and technologies
- Implementation of Environment Management Systems, as part of Total Quality Management
- Construction of sustainable buildings in different cities

We present in this research some examples of these actions taken to address sustainability.

2.2.1 LEED and other Assessment tools

LEED is an internationally recognized green building certification system, providing third-party verification that a building or community was designed and built using strategies aimed at improving performance across all the metrics that matter most: energy savings, water efficiency, CO_2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts (USGBC).

Developed by the U.S. Green Building Council (USGBC), LEED provides building owners and operators a concise framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions. Figure 2.5 presents the types of certifications and the part of lifecycle that they cover.

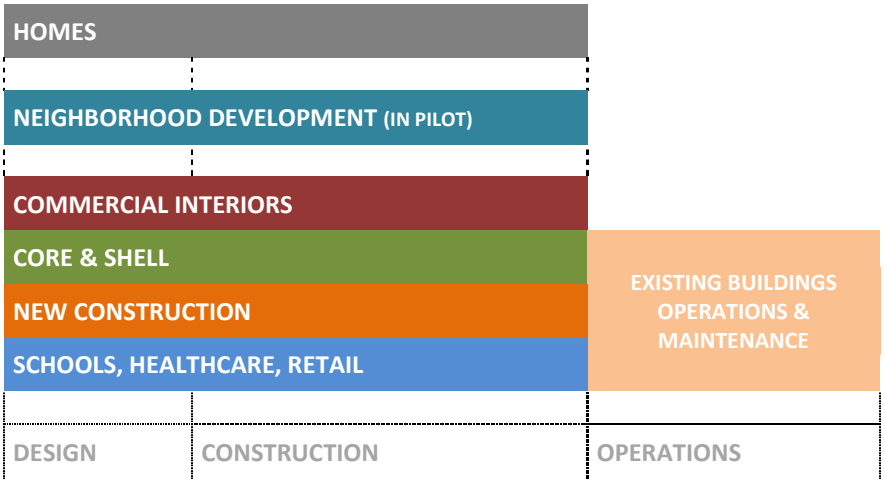


Fig. 2.5. LEED Certifications offered by USGBC.

LEED points are awarded on a 100-point scale, and credits are weighted to reflect their potential environmental impacts. Additionally, 10 bonus credits are available, four of which address regionally specific environmental issues. A project must satisfy all prerequisites and earn a minimum number of points to be certified. Table 2.1 presents the points distribution for the New Construction category.

Table 2.1. Distribution of points for New Construction category. (Source: USGBC)

LEED® for New Construction	
Total Possible Points**	**110***
Sustainable Sites	26
Water Efficiency	10
Energy & Atmosphere	35
Materials & Resources	14
Indoor Environmental Quality	15
**Out of a possible 100 points + 10 bonus points* ***Certified 40+ points, Silver 50+ points, Gold 60+ points, Platinum 80+ points*	
Innovation in Design	6
Regional Priority	4

The building sector has witnessed the development of two types of assessment tools. The first group of assessment tools include those which are based purely on the criteria system. The second group includes tools that use lifecycle assessment (LCA) methodology.

The criteria-based tools can be defined as a system of assigning point values to a selected number of parameters on a scale ranging between “small” and “large” environmental impact (Hikmat 2008; Yokoro 2002). These tools are considered comprehensive environmental assessment schemes. Some of the criteria-based tools are shown in table 2.2.

Table 2.2. Current assessment tools available.

Assessment Tool	Country
BREEAM	Great Britain
GBTool	Canada
LEED – USGBC	United States
LEED – CGBC	Canada
EcoProfile	Norway
HQE	France
Environmental Status	Sweden
Green Housing A-Z	Japan

Since the late 1990's, methods for environmental assessment of buildings based on LCA have been developed for the building sector. Most of these methods aim to be used for selection of building design, building material, and local utility options (energy supply, waste management and transport type) during the design phase. Within lifecycle assessment, different weighting methods based on different basis for valuation are used. Examples of tools of this category are Bees (USA), EcoQuantum (Netherlands) and KCL (Finland) (Hikmat 2008).

It is important to mention that there is not a 'best' rating system; it depends on the local conditions and level of development of the country or region. A comparison analysis should be carried out before choosing a rating system, considering different variables such as implementation cost, climate adaptability, and construction processes.

The following information provides a brief description of some international cases that have implemented sustainable criteria on their projects and the main "green characteristics" employed. These examples can be considered "beacons of hope" for the future as the first endeavors approaching sustainability in construction.

2.2.2 Bahrain World Trade Center

This building boasts innovative features such as three wind turbines to generate electricity, intelligent building technology, and high fire safety standards which make it an interesting environmental construction project on a global scale. Those towers are an addition to an existing development which comprises the Bahrain Sheraton Hotel, the associated single-story luxury shopping mall, an office tower, car parking, services and landscaped areas (Alnaser, 2008).

The twin office towers have a sail-like shape and taper to a height of 240m, the towers and turbines were inspired by traditional Arabian wind towers which harness the wind energy from the onshore breeze. Wind power is expected to produce a sizable portion of the building's power requirements. The project will serve as an environmentally-conscious design model and help pave the way for future projects to also integrate energy from wind power or other sources of renewable energy.

Each turbine spans 29m in diameter and will generate between 1,100 and 1,300 MWh of power per year, which will amount to approximately 11 to 15% of the office tower's electrical energy consumption. In carbon emission terms this equates to an average of 55,000kg of CO_2.

This building is not intended to be a low carbon emission solution by European and otherworld-wide standards. However, aside from the wind turbines, the building does include other noteworthy sustainable design features including:

- Buffer spaces between the external environment and air conditioned areas to reduce conductive solar gain
- Significant proportion of projectile shading to external glass facades i.e. balconies to the sloping elevations with overhangs to provide shading and window glazing, a high quality solar glass
- Enhanced thermal insulation for opaque fabric elements
- Variable-volume chilled water pumping that will operate with significantly less pump power at part loads than conventional constant-volume pumping
- Low pressure loss distribution for primary air and water transport systems that reduces fan and pump power requirements
- Energy efficient, high efficacy, high frequency fluorescent lighting with zonal control
- Dual drainage systems that segregate foul and waste water and allow grey water recycling to be added at a later date
- Dual flush toilets and electronic taps with excess water flow restrictors
- Reflection pools at building entrances to provide local evaporative cooling
- Solar powered road and amenity lighting

Figure 2.6 presents the building shape.

Fig. 2.6. Bahrain World Trade Center.

2.2.3 The Lighthouse Project in Dubai, UAE

The Lighthouse in Dubai is a 400m high, 66-storey commercial office tower with 80,000m^2 of commercial space as well as basement and podium parking, convention centers, retail shops, environmental visitor centre, and a park connecting to the Dubai International Financial Center (DIFC).

It's a unique low carbon commercial tower reducing the total energy consumption up to 65% and the water consumption by up to 40%. The height and shape of the Lighthouse plays an important role in its goal for low energy consumption, allowing for the installation of three enormous 225kV wind turbines, and 4,000 photovoltaic panels on the south facing façade. The developer hopes that this project will serve as a working prototype for future low carbon towers in the region, promoting more sustainable developments. Alnaser (2008) estimates that the 4000PV panels may produce up to a maximum of 700,000 kWh per year, or nearly 200kW per day. Figure 2.7 shows this project.

Fig. 2.7. The Lighthouse, in Dubai International Financial Center.

2.2.4 Toyota Motors Sale's South Campus

Toyota's first LEED certified building was the South Campus facility located in Torrance, California. This three-story office building of approximately 59,500m^2 received Gold certification (Lapinski, A, et al, 2006). Some of the noteworthy sustainable features of this facility include:

- Reclaimed water used for irrigation, toilets, and absorption chillers, eliminating the use of almost all potable water.
- Equipment in heating, ventilation, air conditioning, and refrigeration does not require ozone depleting chlorofluorocarbon (CFC)-based refrigerants by use of a mechanical system which includes absorption chillers and boilers
- Energy performance exceeds California Title 24 State Energy Code by over 42% and American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) standards by 60%. The roof holds the largest photovoltaic array in California providing 20% of the building's total energy (620 MWh annually)
- Over 50% (by value) of materials including all system furniture have incorporated recycled content material to reduce the impacts from extracting new materials

- 97% of construction waste was recycled to avoid landfills and recyclable materials directed back to the manufacturing process, including using tilt-up casting beds as stone steppers in the garden areas

At $87 million USD, this was an unusually large project for Toyota. However, a project cost of $6 USD/$m^2$ lies in the range of $5 to $7 USD/$m^2$ for most of southern California office parks indicating that Toyota was able to obtain an environmental building of very high standard at little or no additional cost over a conventional building (Lapinski, A, et al, 2006). A study by the US GSA (General Services Administration) (2004) of the cost of pursuing LEED on their facilities showed that a modest budget allocation of 2.5% was sufficient for them to achieve Silver Certification.

Process-based theories and modeling strategies can help to understand the delivery attributes of sustainable buildings. The Toyota Production System (TPS) and its lean principles provide insight about the way a process is recognized, documented, and assessed for improvement. The TPS utilizes a process-oriented approach to maximize value generation for the customer by stripping away process waste and enhancing production flow. Thus, applying the lean principles of the TPS to Toyota's capital facility delivery process offered important procedural guidance to capture and understand the enablers of their success as well as opportunities to improve their process further.

Figure 2.8 shows the facility constructed.

Fig. 2.8. Toyota South Campus, LEED Gold Certified.

2.2.5 The Bank of America Headquarters, New York

The Bank of America (BoA) Tower's environmentally sound design aims for big-time return on investment. When its doors officially opened in New York it was the world's greenest skyscraper. Designed by Cook+Fox and co-developed by BoA with the Durst Organization, the $1.3 billion project has set records at practically every stage of its realization.

Debris from demolition and construction was recycled more thoroughly than at any prior major work site. Then there was the pioneering use of recycled and energy-saving materials in construction. And, of course, there is the tower's unprecedented water and electricity efficiency. These innovative features earned the building a Platinum LEED certification, the highest score ever for an office tower.

BoA and Durst estimate the premium to build to platinum certification was about 5%, or around $65 million. But, for all the millions in energy savings the developers anticipate, productivity gains were the bigger motivation. Ultra-clean air and ample sunlight are expected to help cut sick days and boost productivity to the tune of tens of millions of dollars per year.

Water management

The tower has a system to collect all the rain water; even water in the air is harvested by collecting condensation that drips from air conditioning cooling coils. The rainwater reservoir is used to feed the A/C system, flush toilets, and irrigate plants. Not even the steady, if small, flow of groundwater that seeps in through the bedrock in the tower's deepest basement levels is wasted. Before being added to rainwater storage, this cool groundwater emerging at a steady 14°C year-round, is run through a heat exchanger to assist the A/C system.

Daylight Savings

In studies, students' test scores spike by 16% in naturally lit environments. Office workers see similar productivity gains in naturally lit spaces. At BoA Tower, 2.9m-tall, floor-to-ceiling windows are made of “low iron” glass. They are at once more transparent than conventional glass yet still highly insulating.

Transparent walls separating work areas help exterior light flood deeply into the floor plan and give most workers some view of daylight. Ceiling-mounted photo and motion sensors continually adjust overhead lights, turning them down when natural light is bright or when

rooms are empty. The system helps the building cut its demand for electric lighting by 25%.

The figure 2.9 depicts the main sustainable features of BoA tower.

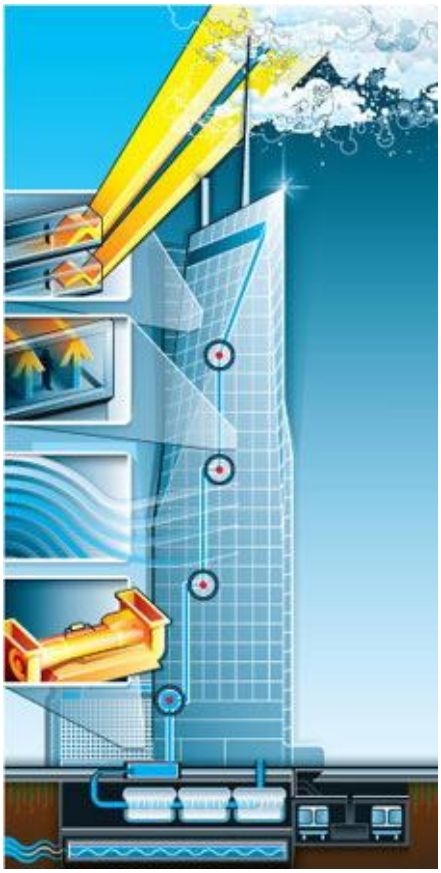


Fig. 2.9. The Skyscraper collects all rainwater, produces its own energy, uses natural lighting, and reduces energy requirements due to its innovative design.

Air Quality and Chill Out System

Clean, oxygen-rich air delivers big productivity gains too. BoA Tower draws in air 10 floors up or higher, far above the stew of tailpipe emissions. Filters catch 95% of particulate matter, allergens, ozone, and other compounds that can cause illness. Oxygen sensors trigger injections of fresh air into crowded spaces to help prevent “meeting room coma”. The tower acts like a 55-story air purifier; when used air is vented back outside it is still cleaner than the street air.

The BoA tower takes a lesson from the past to slash its energy bills. Victorian-era ice houses cut blocks of frozen water from lakes to store and use during the hot summer months. This building will make ice at night, when power prices are lower, and use it during the day to chill the A/C system. In one of the tower's sub-basements there are 44 squat cylindrical ice tanks, 3m tall and 3m across. These promise to help cut the amount of power the building needs to cool itself by 50% during the hottest days, when electricity demand is greatest. Depending on summertime heat, ice storage systems can pay for themselves in three to five years.

Energy supply

BoA Tower will experience huge energy savings by making most of its own electricity. In the tower's podium level a super-efficient 5.1-megawatt power plant, running on clean-burning natural gas, nearly triples the tower's overall energy efficiency. The setup wastes just 23% of the energy from the original fuel used to make the electricity, far better than

the 70% lost at a conventional grid-connected building. Figures 2.10 and 2.11 present the BoA tower.

Fig. 2.10. The Bank of America Tower, a LEED Platinum office building in Manhattan.

Fig. 2.11. The BoA Tower seeks to improve productivity and reduce energy consumption.

2.3 Vertical Sustainable Dwelling

Vertical housing is presented as an alternative for sustainable development, due to its advantage on mitigating environmental impact. Some of those characteristics are:

- Reducing footprint, i.e. less land is required due a higher density
- Use of existing infrastructure, or the new infrastructure required is less and thus cheaper than for a horizontal development
- Utilization of vacant spaces within urban areas reduces sprawl
- The concentration of services in the same building makes its distribution more efficient
- Easy application of eco-design

There are also some disadvantages of living vertical, we can mention some:

- The concentration of services could be a hazard, it something fails, affects to all the tenants.

- The traffic in urban areas increases, especially when urban transportation is deficient.
- The tenant has to adapt to internal regulations, so its freedom is restricted.
- Privacy could be a problem, depends of the kind of neighbors living in the building.

Some global actions regarding the promotion of vertical dwelling have been implemented. However there are some disadvantages of living vertically. One such example is the high-rise apartment buildings in Korea with a compact building shape and have a portion more than 80% of the domestic building stock (Thorsten, 2007). These massive buildings are constructed on site out of reinforced concrete and contain no prefabricated concrete components. Insulation is used (in general expanded polystyrene) with only required minimum thickness of 10cm, fixed to the inner surface of the outside walls and ceilings (cellar and roof).

Another example is the wooden construction sector in Sweden which already dominates the building market share for single family houses by 90%, whereas it represents only a mere niche for the sector of multi-story family houses with around 7% of the market share (Hameury, 2005). The reliance on wood for construction in Scandinavian countries is based on cultural considerations and an almost unlimited access to the raw material, that is the case of other northern countries like Canada and the United States, among others.

One event that fostered the use of timber for multi-story construction was the arrival of the performance-based fire regulation in several European countries during the 1990's. Following up the adoption of the Construction Product Directive (CPD) has provided the opportunity of now constructing multi-story timber frame buildings. Since 1994 in Sweden and 1997 in Norway, there are no further limitations in the number of stories as long as the Essential Requirements (ER) are fulfilled.

A second determinant event for the wood construction sector has undeniably been the global and national sustainability issues addressed worldwide together with the ratification of the Kyoto protocol (1997). These have resulted in the release of national strategies and agenda in several European countries to promote an increase volume of wood used in building (Hameury, 2005). In France, for instance, government and professional organizations did sing the charter "Bois-construction-environment" in 2001 with the commitment to increase the part of wood material in the buildings by 25% starting 2010. This tendency is reflected by the recognition of wood as an environmentally friendly renewable biomaterial.

2.3.1 Dockside Green, Victoria BC

This project is intended to be one-of-a-kind, mixed-use harbour front development supported by unique on-site amenities. It is located in a 15 acre community adjacent to the Upper Harbor and downtown Victoria, British Columbia.

A model for holistic, closed-loop design, Dockside Green will function as a total environmental system in which form, structure, materials, mechanical, and electrical systems will be interrelated and interdependent; a largely self-sufficient, sustainable community where waste from one area will provide fuel for another.

Dockside Green's principles of New Urbanism, smart growth, green building and sustainable community design, are all essential elements for the development plan. It understands the economics of the triple bottom line approach and has the experience, vision, and drive to deliver on it.

Dockside Green Characteristics

Targeting LEED® Platinum certification and striving to be greenhouse gas neutral, Dockside Green will showcase a variety of sustainable innovations including:

- Biomass heat generation
- Onsite storm-water and sewage treatment
- Water conservation
- Energy conservation
- Healthy spaces
- Materials and resources
- Alternative modes of transportation

Harnessing the latest innovations in green building technology, the buildings at Dockside Green are targeted to exceed the level of energy-efficiency required by the Model National Energy Code in Canada by over 50%. Contributing factors include double-glazed, low-emittance windows, high-insulating walls, and external shading devices that also help maintain comfortable indoor temperatures.

Environmental features are focused on health, indoor air quality, urban ecology and energy, and water saving strategies that will save money while helping the environment. Figure 2.12 shows the Dockside Green Master Plan.

Fig. 2.12. Master plan for Dockside Green, Victoria BC.

Landscaping

Cutting-edge landscape design incorporates naturalized water features, vertical green wall elements, green roofs, lush landscaping and numerous green spaces to create a socially and ecologically responsible open space. It also includes a water-front park and access to a public small boat launch and Harbor Ferry stop.

Community Amenities

As Dockside Green community members, residents will enjoy incredible on-site amenities like mini-transit and car-share programs, waterfront walkways, bike paths, and of course, plenty of communal green spaces. Figures 2.13 and 2.14 show some amenities offered by the development to foster healthier lifestyles.

Fig. 2.13. Dockside Green has greater space for pedestrians and bicycles than for vehicular traffic, promoting healthier lifestyles.

Fig. 2.14. Water front park and access to public small boat launch/Harbor Ferry stop.

Dockside Green boasts the following environmental features:

Energy

- 45 – 55% more energy efficient than Model National Energy Code
- 100% fresh air system to each suite with heat recovery ventilator to pre-warm incoming air saving energy
- Energy Star® appliances: refrigerator, range, dishwasher, and washer and dryer
- LED lighting in central corridor and compact fluorescent lighting in suites
- Occupancy sensors or automatic door switches in closets, storage areas, and bathrooms

Water Efficiency

- 55 to 60% less water usage than traditional condo buildings
- High performance dual flush toilets standard in suites
- Sewage treated on site, and treated water is used for flushing toilets and irrigation

Environmental Considerations

- Full cut off light fixtures to prevent light pollution and save energy
- Rainwater collected in onsite naturalized creek and pond features
- Non-potable water used for landscaping and water features
- Majority of construction waste will be recycled
- Bamboo floors (in main living areas) and cabinets with wheat board substrates

Fig. 2.15. Construction of the first phase, July 2008.

Fig. 2.16. Progress of the project by October 2008.

2.3.2 The Solaire, New York

This residential project includes 380 apartments and incorporates numerous sustainable design features. It is located in Battery Park City, New York. This project is considered to be the first high-rise residential building in America to obtain a LEED Gold Rating from the US Green Building Council in 2004. The Solaire sets the standard for green living, reducing the negative impact on the environment while enhancing the lives of its residences by:

Indoor Air Quality

- Fresh filtered air removes 85% of particulate matter, air is continuously humidified or de-humidified depending on climate conditions and is capable of maintaining a minimum 30% relative humidity during the heating season.
- Year-round heating and quiet cooling is controlled by digital programmable thermostats.
- Vapor and air barrier minimize random air infiltration.
- Only building materials and paints with low or no off-gassing and low in VOCs used.
- 24/7 exhaust runs continually in every bath and kitchen.

Water Quality and Conservation

- A central water filtration system used for the entire building.
- Refrigerators contain double-filtered drinking water and ice dispensers with a secondary filtration system.
- A waste water and storm water re-use system provides water for toilet flushing, landscape irrigation, and cooling towers.
- Experiences a 50% reduction in potable water use versus a traditional building of comparable size.

Energy

- Created using an energy-conserving building design that's 35% more energy efficient than code requires, resulting in a 67% lower electricity demand during peak hours.
- Provides substantial utility savings for its residents.
- Photovoltaic panels incorporated into the building's façade convert sunlight to electricity. Those panels will generate 5% of peak electricity for the core-and-shell building.

- Computerized building management system monitors and controls all systems, including wet-bulb temperature reset for a cooling tower.
- Energy Star® appliances are installed in every apartment to ensure maximum energy efficiency.
- Spectrally selective, low-e glass reduces solar heat gain while retaining a high visible transmittance.
- Uses high efficiency lighting throughout the common areas of the building; occupancy sensor-controlled public area lighting including stairs, corridors, storage rooms, offices, public toilets, and garage; and a daylight dimming system in the public lobby.

Other

- Pesticide-free rooftop garden providing natural insulation for building
- Natural gas fed central heating and cooling system free of ozone depleting refrigerants
- On-site bicycle storage area
- Use of materials containing high recycled content, wood materials from certified forests, and/or use of materials from rapidly renewable natural resources
- Large percentage of building materials originate from within 500 miles of the building site
- Environmentally responsible operating and maintenance practices

Figures 2.17 and 2.18 show the characteristics of this project.

Fig. 2.17. The Solaire, to the right, at Battery Park, New York.

Fig. 2.18. The Green rooftop, one Green characteristic of the condominium.

2.3.3 Valdespartera City, Zaragoza Spain

The Eco-city of Valdespartera was designed by the technical services of Urbanism Department in Zaragoza Municipality. It's characterized by the integration of bioclimatic criteria, electric energy savings maximization, and attains a total integration with nature due to the incorporation of multiple green spaces. The project spans 242ha, and has a density of 40 dwellings/ha, but the area allocated for housing is only 103hathe rest is for parks and general services.

The design of Valdesparetera new residential area fully meets sustained development criteria such as:

- Affordable Housing: this is a very important scheme to promote council housing. 9,687 flats, 97% of which will be council units, will be built on transferred land thanks to a town planning agreement.
- Integrating Town Planning: the project is targeted at people coming from different social backgrounds in order to create an integrated urban environment with a varied typological offering.
- Facilities: the residential area will be equipped with a wide range of recreational, sporting, and cultural facilities intended to benefit not only the area itself but the whole city.
- Bio-climatic Architecture: dependency on non-renewable resources is reduced while it is intended to make greater use of alternative energy. Design of ecological corridors to improve the new Eco-city environmental integration.

Town Planning Agreement

The partial plan's aim was based on maximizing energy savings and comfort improvement in regards to the use of solar energy, through passive means mainly. This plan pursues those environmental objectives in three stages of successive and complementary determinations - urban, architectural, and constructive. Some general guidelines for the development of this city are:

- Strategic arrangement of buildings to exploit solar energy; enough distance between the different buildings in relation to their height
- Installation of vertical panels against prevailing winds

- Microclimates - green areas intermingled with the streets and among the houses to create specific microclimates in private spaces and avoiding far road views and instead there will exist large wooded areas
- Vegetation of native species - deciduous trees to provide shade in summer and sunlight in winter
- Water savings throughout the area - the tap fittings of in all units will be equipped with water volume reduction devices and in public areas, the construction of ponds and other similar structures to collect rainwater by means of an independent network that will water the gardens are planned

Architectural Design

- Flat roofs for an efficient installment of solar panels - intended to exploit solar energy, solar panels will cover between 30 - 50% of the energy for hot water for the dwellings (See figure 21). The outer surface of roofs will be painted in light colors.
- Different treatment of façades depending on their orientation - all units will have double façades with opposite orientations to allow crossed ventilation. Bathrooms, kitchens, utility rooms, and stairwells will all face north and no living rooms will face such orientation.
- South facing enclosed balconies - south facing windows and other bigger, glazed surfaces used to exploit maximum solar absorption.

Fig. 2.19. Valdespartera, a sustainable vertical dwelling project in Spain.

Fig. 2.20. South façades with enclose balconies.

Building scheme

- Highly insulating materials: carpentry compactness will be guaranteed, blind slats will have a thermal insulation filling whenever blind cases exist, the finish of their parameters and building arrangement will prevent filtrations into apartments
- Surfaces with enough accumulative capacity: walls separating inner sections of units and enclosed balconies will be designed in such a way that heat absorption will be optimized
- Centrally Heating System for entire blocks of apartments

Ecociudad Valdespartera will be equipped with an automatic system to collect domestic waste. This up-to-date system comprises an underground network of pipes specially designed to carry each type of waste. In each block of units “selective waste collection mouths” will be installed. Disposed waste will be propelled through the pipe network by strong wind currents (reaching 60 km per hour) to a collection centre installed within the system itself.

Design of Blocks and streets

Dwellings are east-west oriented in rectangular blocks; each block consisting of two parallel buildings, 12m deep and spaced 30m apart, with the main façade always facing south. The design of the streets aimed to release the traffic from the interior streets of the neighborhood, which are considered residential with traffic restriction. Those are small streets with dyed pavement, 3m wide and with a winding trace (See figure 22).

Fig. 2.21. Installation of solar panels on the rooftops.

Fig. 2.22. Interior street, winding trace and pathways.

2.3.4 Iconos, Monterrey Mexico

Iconos is a housing project in Monterrey, Mexico, intending to be the first to achieve LEED certification in the country. It's promoted by a new company member of the USGBC, committed to sustainable development through the implementation of good practices and sustainable design and construction in their projects.

This development includes the construction of 4 towers, with 239 apartments in total. The first tower is currently under construction with 63 apartments and is in the finishing phase.

It is located in a lot previously home to old warehouses, so it will regenerate the zone and will use the current infrastructure for communication and services. The design of the project was based on LEED requirements and its aim is to achieve around 32 points.

The apartments will have LED lighting, low pressure shower heads, water saving faucets, and dual flush toilets among other characteristics. In terms of materials, the condo will have Duovent windows (double glass) and Hebel walls (insulated bricks). Every tower will have a green roof that will be part of the rain water management system which will be integrated for 11,000 m^2 of green areas to reduce runoff and filter water to the subsoil.

Fig. 2.23. Iconos includes 4 towers of apartments.

Fig. 2.24. The towers are designed under bio-climatic principles.

2.4 Current Housing situation in Mexico

In 2005, Mexico's population was 103.3 million people and was estimated at 106 million in 2008 (INEGI). There are currently over 25.7 million dwellings in the country; 97% have electricity, 90% have drinking water, and 87% have a sewer system. There is a goal to create over 1 million dwellings per year (CONAVI 2007) to cover the current deficit and serve the demands of the new settlers in high-growth areas. Such is the case of the northeast and the metropolitan areas of Guadalajara, Monterrey, and Mexico City (CIDOC 2007).

We can make the most of current urban infrastructure through urban regeneration projects, densification, saturation, and recycling, with improving programs. Housing is one of the main factors that contribute to social welfare; through a good quality offer we can improve equity among regions in Mexico.

The country has followed a fast trend to urbanization, helping to attend to the housing needs, however the uncontrolled growing of the cities has overtaken the proficiency of water resources, potential for infrastructure and utility, availability of suitable land for this purpose, the capacity of institutions to control habitable conditions, and any sustainability housing principles. (CONAVI 2007).

Concentrated within Mexico's 55 metropolitan areas exists 53% of the population and 70% of the Gross Domestic Product (PIB in Spanish) in the whole country. The demographic growth rate for the period 1990-2000 was 2.3%, one percent more than the rest of the country (CONAVI 2007).

The lack of control of land usage and rules for real estate developments still is encouraging the horizontal expansion in the cities, thus creating the unfeasibility of transportation systems, more expensive utility infrastructure, excessive use of cars, and a shortage of land that directly impacts the house prices and hinders low cost housing accessibility for the demographics in need (CONAVI 2007).

Promoting the creation of sustainable housing development requires actions in three main areas: first, the gradual correction of anarchic expansion, through mechanisms like densification of urban spaces, and the promotion of improved housing and increased housing stock. Secondly, the promotion of new developments that support verticality include the correct use of current infrastructure, rational energy use, water treatment and provision of green areas. Finally, the promotion to new urban centers with full sustainability settled in assigned lands for this purpose through the group participation of

the three government areas and the private and social sectors will allow for the optimization of investments and the use of successful experiences in matters of regional development. (CONAVI 2007).

The single family houses represent 86.5% of the housing stock market in Mexico, whereas only 8% are apartments and the remaining 22.7% are other types of properties such as rooms on rooftops or tenement houses (see Figure 2.25).

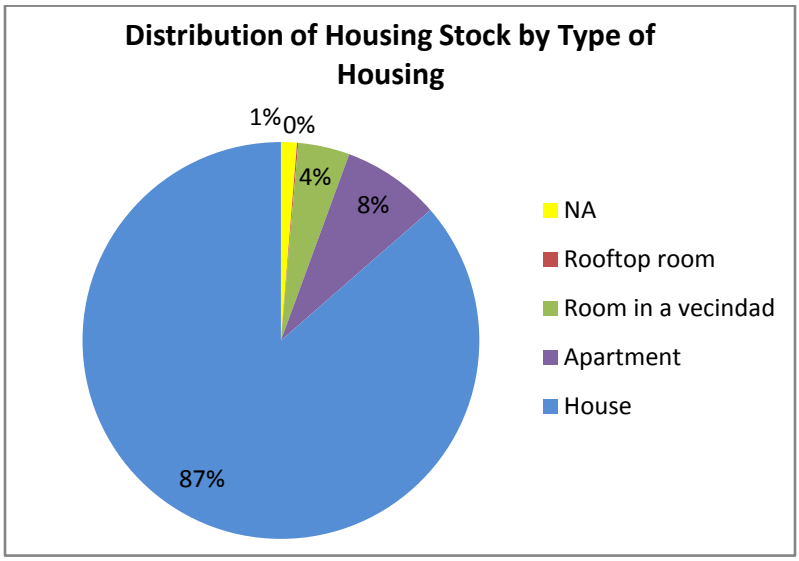


Fig. 2.25. Distribution of the housing stock by type of property. Source: Population and Housing Count 2005, INEGI.

2.4.1 Current situation of the construction industry in Mexico

According with INEGI data (Informatics, Geographical and Statistical National Institute), the construction sector generated close to 6.8% of the GDP in the first quarter of 2008, 0.2% below its share during the same period a year earlier (See Figure 2.26).

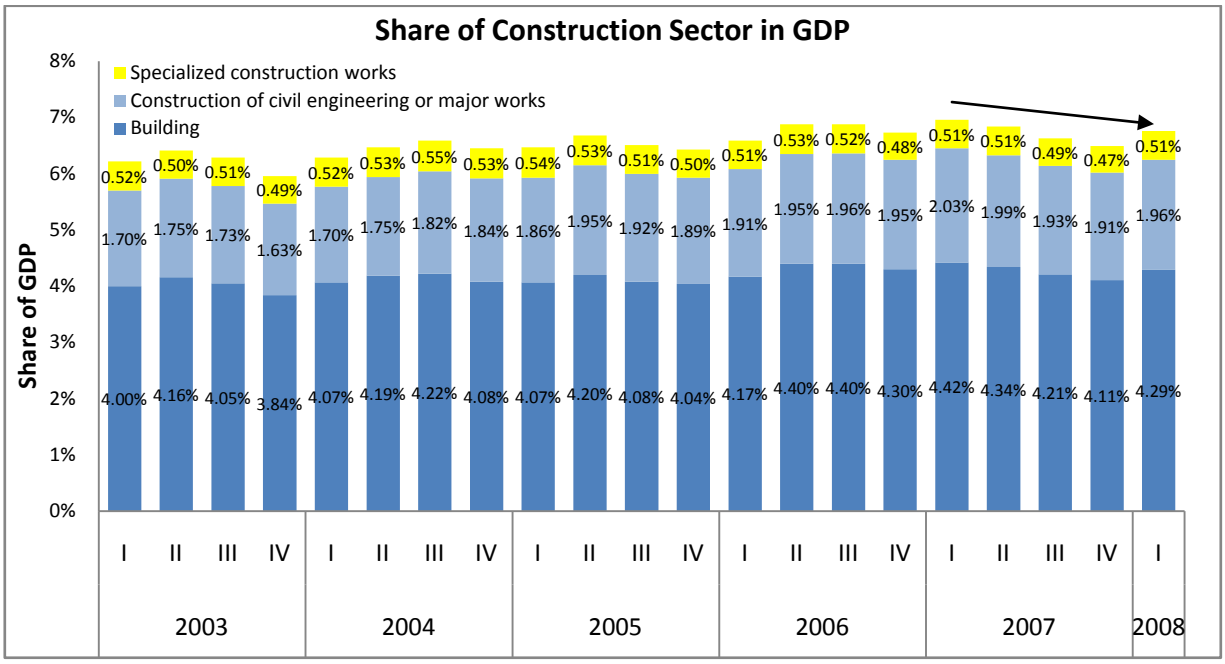


Fig. 2.26. Share of the construction sector in GDP by type of works: 2003-2008

Within the sector, 55% represents building (housing, schools, commerce, hospital, etc), 18.9% is transportation (highways, roads, railways, etc), and 9.6% is oil and petrochemicals (drilling, refining, petrochemicals, storage and distribution, and pipe conduction systems). The remaining is represented by water, irrigation and sanitation, electricity and communications, and others (INEGI data).

US Mortgage lending crisis and the Mexican housing market

The housing market has been significantly affected worldwide by the mortgage crisis in the US. In order to understand its origin, it is necessary to analyze some key facts:

- US financial entities began to grant sub-prime mortgages to individuals with low-quality credit records, charging higher interest rates.
- The possibility to take out a second mortgage, even surpassing borrowers' payment capacity, and the considerable hikes in home prices in the last few years caused a speculative bubble which translated into higher risk for lenders.

Mortgage lending has continued to grow, whereas credit to private companies remained flat in the first months of 2008.

Despite the severity of the problems that the US mortgage market is facing, the effect in Mexico is not directly due to the negligible incidence between the mortgage markets of both countries.

2.4.2 Purchasing power for dwellings

The purchasing power for housing in Mexico has increased in the last five years; currently a borrower with a monthly income of four General Minimum Wages (GMW) can purchase a dwelling worth 39% more than what they could buy in 2002, which means moving up from a social-type dwelling to an economic one (Figure 2.27).

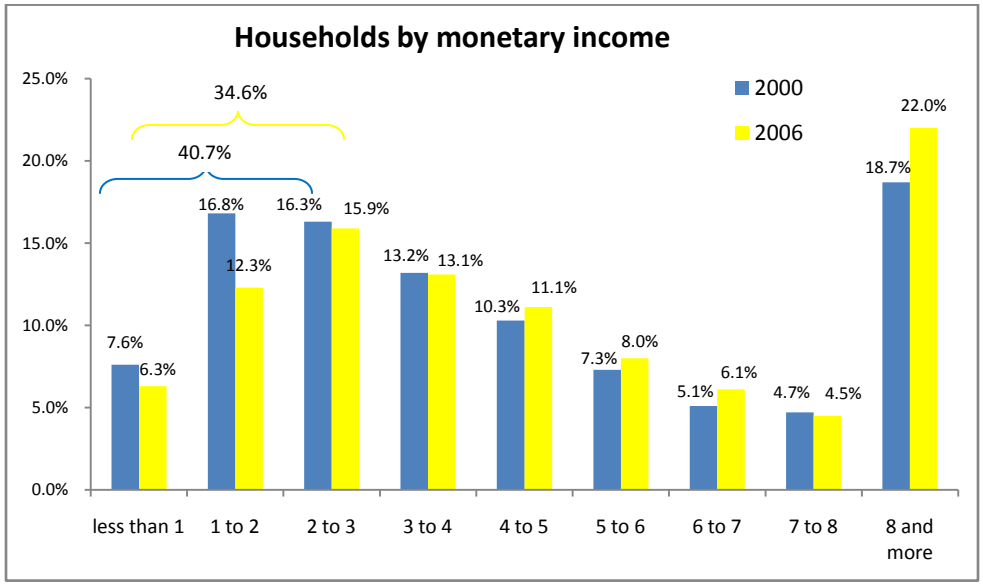


Fig. 2.27. Households by monetary income (based on GMW ranges). Source: INEGI 2006 data.

This increase has come about through several factors:

- Households' income has risen 11% in real terms. In 2000, families who earned under three GMW represented 40.7%, by 2006 this percentage had dropped to 34.5% (see figure 2.33).
- A reduction in the intermediation margins of Banks and Sofols (non-bank banks) as well as in the long-term government interest rates.

Moreover, the price of housing in Mexico has increased in the last few years. Nonetheless, this rise has been moderate compared to what has happened in the US.

2.4.3 Estimates of housing needs and demand

For the 2006-2012 period, the housing needs throughout the country are estimated at around 4 million – 427,000 new dwellings and over 2,930,000 home improvements. On average, an annual 633,000 new dwellings are necessary.

Over the next six years, the population living in urban locations with over 2,499 inhabitants will demand four new dwellings for every one required in rural settlements with under 2,500 inhabitants. The main challenges that our country will face over that period of time regarding housing are:

- Having adequate land reserve to meet the annual needs for the construction of 633,000 housing units.
- Consolidating a housing policy with sustainable spatial planning criteria that will revert the strong urban concentration and rural spatial dispersion trends.
- Ensuring the supply of basic services to the dwellings, such as drinking water, sewage, and electricity.
- Achieving the average goal of building 633,000 new dwellings and carrying out 455,000 home improvements, meaning a greater financial supply to invest in homebuilding, particularly in places where the number of households without a dwelling is more significant.
- Serving the lower-income segments of the population as they require a response that will match their income level related to their saving capacity.
- Considering the trends of potential housing demands, the possible effective borrowers of a mortgage loan (20-59 years old, which has grown about 6% in a 15 years period). Nonetheless, beginning in the 1990's, the growth rate has slowed leading us to estimate that in the years after 2010 the older population will represent a considerable share and demand dwellings with features that will adapt to their needs.

In 2006, the population amounted to 104.3 million inhabitants, divided into 26.5 million households. The total population grows at an average annual rate of 1.02%, whereas households grow at 1.9% and dwellings at 2.0%. Thus, households display greater dynamism than the population due to various factors that influence the decision to form a family.

Of the 26.5 million families in the country, 17.0 million have a suitable dwelling whereas the remaining 9.5 million are concentrated in:

- Low income urban, rural and semi-urban communities
- Households are not affiliated to any social security institute
- Families with incomes below 3 GMW

Table 2.3 shows the market segmentation and the lending and financing agencies serving such markets.

Table 2.3. Market segmentation and underserved markets. Source: CIDOC 2008.

	From 0 to 3	From 3 to 6	From 6 to 9	Over 9	Total
Urban	14.8%	22.1%	11.8%	16.8%	65.5%
Semi-urban	6.1%	4.1%	1.4%	0.8%	12.4%
Rural	13.2%	5.7%	1.8%	1.4%	22.1%
Total by size of location*	34.1%	31.9%	15%	19.0%	100.0%
With social security	23.8%	21.1%	9.7%	12.4%	67.0%
W/o social security	11.3%	10.8%	4.7%	6.2%	33.0%
Total by work situation*	35.1%	31.9%	14.4%	18.6%	100.0%
Monthly income (GMMW)					
Underserved market	Infonatvit/FOVISSSTE		Sofols/Banks		

The demand for housing in 2008 is made up of four elements, which are:

1. New household formation: The evolution of the population has been marked by the two important phenomena, the new household formation and the reduction in fecundity which translates into a slower population growth.
2. Housing backwardness, includes households:
    a. Who share a dwelling with another household.
    b. Whose current dwelling is deteriorated and needs to be replaced.
    c. Who live in dwellings that need expansions or remodeling.
    d. Who live in borrowed or leased dwellings.
3. Housing rotation: Households that already own a dwelling, however they are demanding a larger or higher value one.
4. Origination cures: Households that are turned down for a mortgage loan and are later granted one as a result of an improvement in their credit profile.

Table 2.4. Estimated housing demand for 2008. Source: CIDOC 2008.

Element	Number of units	%
New household formation	299,997	25.8%
Housing backwardness	765,113	65.9%
Housing rotation	71,565	6.3%
Cures	22,724	2.0%
Total	**1,159,379**	**100.00%**

Thus, adding up all four elements, the estimated housing demand for 2008 amounts to 1.16 million units (see table 2.4).

Projected housing demand 2008-2013

The estimated demand for the period amounts to a little over 7 million dwellings (including expansions and remodeling) (See table 2.5). Year over year, demand grows at a slower pace mainly due to the reduction of housing backwardness.

Table 2.5. Estimated housing demand for 2008-2013. Source: CIDOC 2008.

Structure of housing demand					
Year	**New Household Formation**	**Housing backwardness**	**Housing rotation**	**Origination cure**	**Accrued**
2007	24.11%	67.98%	5.99%	1.93%	1,217,515
2008	25.87%	65.99%	6.17%	1.96%	2,376,894
2009	28.11%	63.49%	6.41%	1.99%	3,467,051
2010	30.91%	60.35%	6.70%	2.03%	4,479,940
2011	34.36%	56.49%	7.07%	2.08%	5,411,019
2012	38.53%	51.80%	7.53%	2.13%	6,259,301
2013	43.47%	46.24%	8.09%	2.19%	7,027,484

2.4.4 Main housing builders and developers

Although the number of companies devoted to homebuilding in the country amounts to over 2,600, only Corporación Geo, Desarrolladora Homex, Urbi, Consorcio Ara, Sare Holding, and Consorcio Hogar are traded on the Mexican Stock Exchange (BMV in Spanish); of these, the first four are part of the 35 companies included in the benchmark index (IPC in Spanish) sample and represent 3.4% of its total market cap.

In view of the importance that the housing sector has gained within the country's economy in the last few years, the BMV created the Indice Habita (IH) especially for this sector which includes the six companies mentioned above. This indicator grew 90.5% between the closing bell on February 2, 2006 and April 16, 2007, when it reached its maximum level at 1,051.46 units. From then on, the index declined considerably until January 2008. Nonetheless, between January and June 2008, the IH grew at a rate of 18.33%

Within the IH, the issuer with the largest share is Desarrolladora Homex with 34.44% of the total market cap generated by the six companies, amounting to close to $116 billion pesos. It is followed by Urbi with 32.42% and Corporación Geo with 18.13% (See table 2.6).

Table 2.6. IH companies: market cap distribution. Source: CIDOC 2008.

IH Company	Number of shares (millions)	Price per share (MXN)	Market cap (millions of pesos)
Desarrolladora Homex	335.87	118.90	39,934.94
Urbi	976.45	38.50	37,593.13
Corporación Geo	537.80	39.10	21,027.94
Consorcio Ara	1,311.61	11.23	14,729.41
Sare Holding	382.10	3.736	1,427.51
Consorcio Hogar	370.64	3.38	1,252,78
Total	**3,914.47**		**115,965.72**

With regard to the land banks developers have, there are enough to guarantee production for the next three years at the current growth rate. In the case of Desarrolladora Homex and Urbi, their land banks amount to 6,900 and 5,151 hectares, equivalent to 269,546 and 270,876 dwellings respectively.

Housing type

All six companies are devoted mainly to the construction and sale of housing in the affordable entry-level and middle-income segments. Ara and Sare also build residential housing, and Ara has a significant share in vacation housing as part of its land bank is in tourist destinations in the southeast of the country (see figure 2.28).

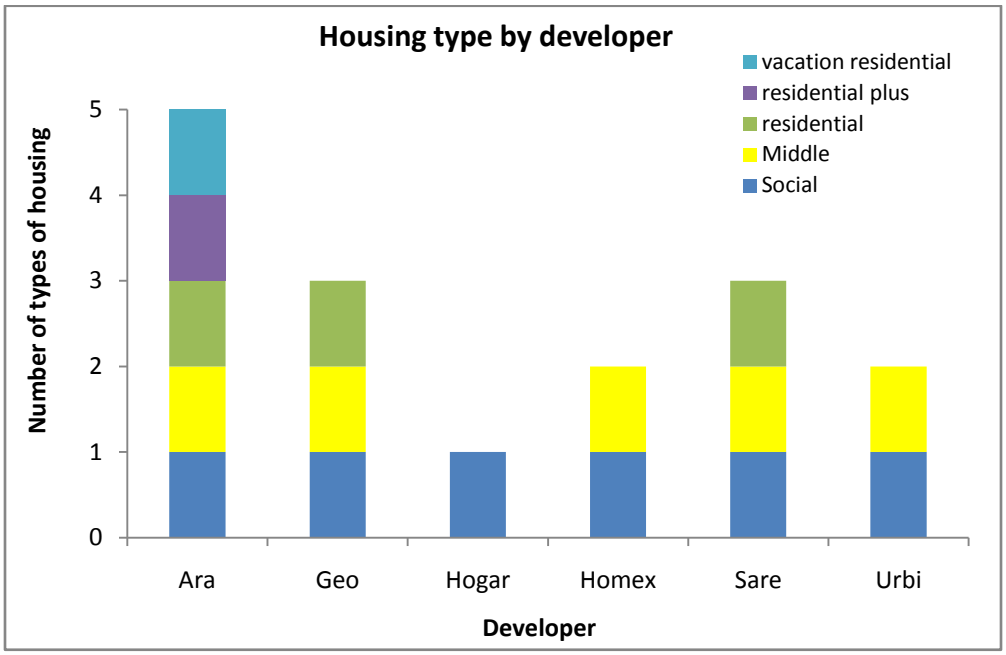


Fig. 2.28. Housing type by developer. Source: CIDOC with BMW and developer data.

Geographic coverage

The map in figure 2.29 shows the states where the homebuilders are present. None of the companies have a share in seven of these States (Aguascalientes, Campeche, Colima, San Luis Potosi, Tlaxcala, Yucatan and Zacatecas).

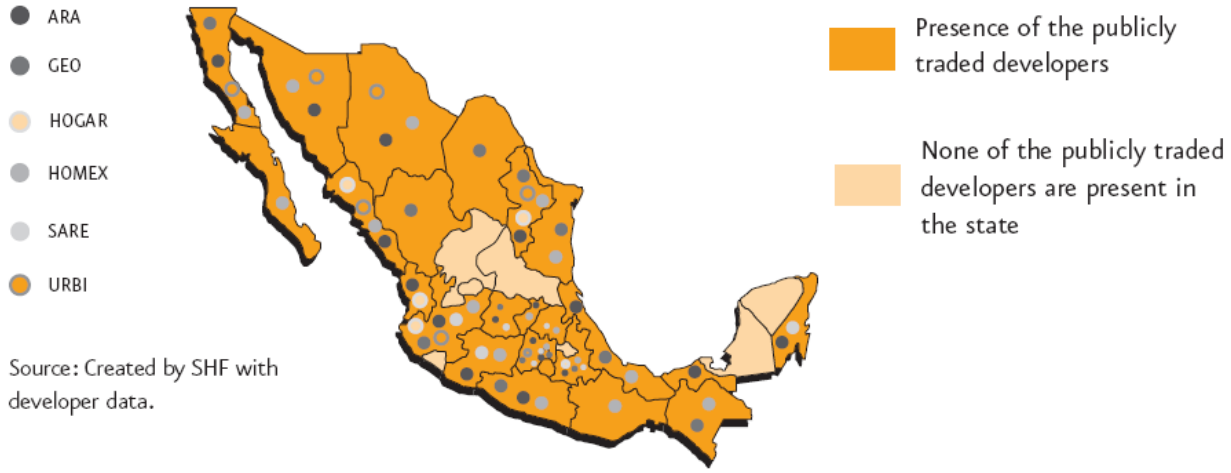


Fig. 2.29. Geographic coverage of the six developers traded on the BMV, 2008

2.4.5 Infonavit and the 'Green Mortgage'

Infonavit (National Found for Housing) is a third-party institute founded in 1972 whose main function is to give workers credit for home acquisition.

Green Mortgage

In collaboration with researchers and various companies, the Mexican government through Infonavit has developed the 'Hipoteca Verde' (Green Mortgage) Project, a plan that would help residents in the country acquire homes with environmentally friendly technologies. In its initial phase, the project has been a success boding well for sustainable living in the country.

According to the data presented previously of housing demand for the coming years, is more than 7 million for the next 5 years and nearly 20 million for the next 20 years, resulting in an exponential increase in the demand for energy and drinking water. According to calculations by the Mexican government, homes consume 16.5% of the energy generated in the country. Due to that, officials and others are betting on building new family homes that save energy and which are environmentally friendly.

The possibility of getting a home with bioclimatic design is a reality today thanks to Hipoteca Verde (Green Mortgage), the instrument through which the Infonavit awards credits to equip new homes with energy saving systems.

It is a loan between 800 and 1,100 USD, in addition to the regular mortgage loan, for the installation of an accessory package with such equipment as solar heaters, low energy bulbs, and low water consumption toilets and faucets. The program began in March 2008 and currently only applies to homes that cost less than 43,000 USD and can be located in any state in the country. However, Infonavit has only identified 10 bioclimatic regions in the country that have suitable characteristics (such as the annual quantity of direct solar energy) for its development.

Currently, 17,240 ecological homes in 22 states are registered and being offered (INFONAVIT). More than 3,000 homes are in the process of being linked to such ecological mortgages and 1,159 operations, homes being used or listed as ready to live in, have been formalized.

The goal is to have at least 1 million sustainable homes by 2012.

Eco-businesses, promoting Green Housing

A group of businesses dedicated to the development of eco-technology are participating in this ambitious but profitable project. To date, homebuilders and producers of certified equipment have invested the equivalent of 1.1 million USD in this program. Fifty businesses have joined Infonavit's green strategy in 77 sets of homes.

Some companies have been certified by the National Commission for Energy Savings (CONAE) to be suppliers of solar heaters for these ecological homes. Their heaters have one-piece thermal tanks made of high density polymers and which can last more than 30 years. They don't have links or welded seams and are free of corrosion and inlays; they don't stain water, don't require plumbing, and last longer than stainless steel. In addition, they can be recycled and reused.

Similarly, other Mexican companies have applied a series of ecological principles in the design of and materials used for faucets and toilets that use less water. As a result, an ecological home from Hipoteca Verde pollutes up to 60% less than a regular home.

But there is also savings for those who live in these green homes. Hipoteca Verde has shown it has a direct affect on a family's pocketbook. In Tecamac, a city in Estado de México which has the largest number of Hipoteca Verde houses, a green home can save up to 70% on gas consumption each year. This is due to the area's solar radiation which permits the use of solar heaters for nine months out of the year.

Parallel to this research, other research to assess the impact of Hipoteca Verde on a family's pocketbook in Monterrey NL is being developed.

Achievements of the Green Mortgage

Sustainability has gone beyond the academic world and integrated itself into everyday life. Hipoteca Verde has become a powerful instrument in transforming the development of homes in Mexico in a way that contributes to counteracting the effects of climate change.

The results of Hipoteca Verde had been successful, and recently the National Housing Commission and Infonavit got an Energy Efficiency Award 2009 from the Energy Star Institute in the United States. The event was held in 17th Annual Evening with the Stars of Energy Efficiency Awards Dinner in Washington DC.

The international star of energy efficiency award recognizes the outstanding contributions to energy efficiency achieved through special projects or activities overseas that are led by

public or private organizations/companies, learning institutions, or government agencies based outside of the United States.

The CONAVI is currently leading Mexico's 2007-2012 national housing program titled "Towards a Sustainable Housing Development." CONAVI has served as a leader in initiating Mexico's energy efficient housing policies. The Commission's main areas of work are: restructuring of the national regulatory framework, research and development of energy-efficient technology, system indicators, certification schemes and financial incentives, and the contribution to mitigating the effects of climate change.

2.4.6 National Program for Urban Development and Spatial Planning

The National Program for Urban Development (PNDUR in Spanish) proposes to reach common goals regarding spatial planning via mechanisms of agreement and coordination. This program establishes general strategies to deal with this complex situation while at the same time offering a broad range of specific lines of action and implementation mechanisms destined to promote and orchestrate the local and state initiatives designed for the urban and regional development of the country.

Ten general goals are proposed in order to achieve the regulatory and budgetary innovations necessary for a democratic management of the territory, considering the need to favor the access to decent housing and orderly and sustainable urban development, and the collaboration of the three levels of government in urban development and spatial planning. In sum, the goals state:

- A new urban-spatial leadership
- Integral territory
- Reduction of urban poverty
- Achievement of the administration’s goal for housing
- Achievement of cities that will find a balance between the intensive use of land and planned growth
- More dense, compact cities, with a compatible mix of land uses
- Use of alternative technologies that will encourage a healthy environment for the cities
- Preservation of the integrity of the population and the common environmental resources

- Achievement of internally united and globally competitive regions
- Inclusion of the social, public, and private sectors in the decisions regarding policies, investments, and projects
- Encouragement of the modernization of the institutional and regulatory framework

With correct actions, the federal subsidy will contribute to sustainable housing development on the side of encouraging emblematic models, either buildings recognized for their sustainable assets or new urban development created with sustainable parameters since the land acquisition (CONAVI, 2007). The Housing Law talks about sustainability when it says that housing must "guarantee the structural safety and adaptation to the weather with criteria of sustainability, energy efficiency, and disaster prevention, preferably using standardized goods and services" (Art.71) (LV, 2007).

It is up to the National Housing Commission (CONAVI) to coordinate the Sustainable Housing Program, which focuses on six goals:

1. Adapt the existing housing regulations to the protection of the environment.
2. Design guidelines that will make it possible to define and qualify a dwelling as sustainable.
3. Encourage the exchange and transfer of technologies with International Institutions.
4. Promote the use of novelty technologies that will guarantee the protection of the environment.
5. Design and develop incentive plans for housing developers and users.
6. Promote the use of eco-technologies.

National Housing Program 2007-2012: towards a sustainable housing development

The program aims toward four goals - increasing the coverage of the financing offered to the population, particularly lower income families; promoting sustainable housing development; consolidating the National Housing System through improvements in public administration; and consolidating a policy of aids from the Federal government which will allow the lower-income population to gain access to mortgage financing and encourage sustainable housing development. As a goal, the program proposes to achieve a total of six million loans throughout this administration. This figure poses a risk for the sector and the chance to achieve it for the financial entities, housing institutions, builders, state and

municipal governments, producers of raw materials, notaries, city planners, designers, and countless other players.

It also considers the achievement of 1.7 million home improvements in the 2007-2012 period; the delivery of 323, 331 federal subsidies for housing acquisition, improvement, or self-production; and the promotion of 144 initiatives, to bolster the government powers on housing development and sectoral coordination.

2.4.7 Normativity in the urban planning system in Mexico

The urban planning system in Mexico answers essentially to various processes of institutional redesign which have been taking place since the enactment of the General Law of Human Settlements (LGAH in Spanish) in 1976.

There are two opinions regarding the current situation of the urban planning system in Mexico; first, that the speed at which the problems of our cities evolve has by far surpassed the capacity of the urban planning system to deal with them in a timely manner; and second, that the distribution of powers on this matter must have a bearing on better processes of governability and follow-up of plans and programs.

Tasks in urban planning are preformed in the national territory with instruments that are out of context, or actions are just taken and not vouched for by legal instruments. 36% of the municipalities have an Urban Development Plan (PDU in Spanish), and of all the cities included in the National Urban System (SUN), only 21% have an updated PDU. Likewise, only 28% of the municipalities have zoning and land use regulations, 23% of which are out of date.

The figure 2.30 presents a scheme of laws and its interrelations between the three government levels. This regulatory framework will seek coordination on sustainable development of the country, states, municipalities and cities.

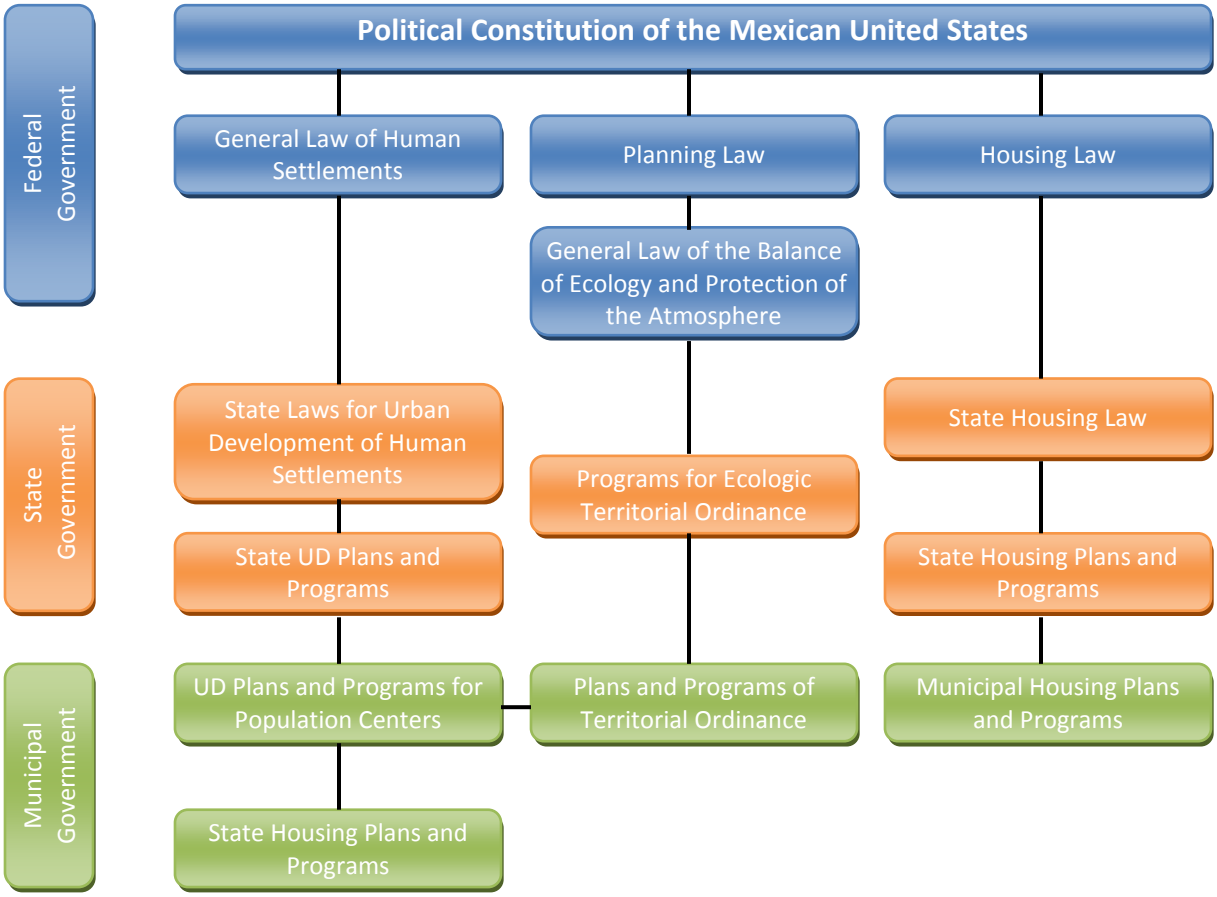


Fig. 2.30. Regulatory framework on housing and special planning in Mexico. Source: CIDOC 2008.

2.4.8 Integrated Sustainable Urban Developments (DUIS).

The boom of the housing sector in the last few years has encouraged very positive economic processes for the country; however, the system for the supply of suitable land has resulted in the creation of developments that are further and further from the consolidated cities, where employment and service centers are historically found.

In view of these problems, different departments of the federal government have created a workgroup that seeks to channel the generation of these large housing developments towards sustainable and integrated plans. Figure 31 shows the main features of DUIS.

The workgroup's specific goals are to:

- Integrate the strategies of the Federal Government into a public policy that will promote the generation of DUIS

- Seek the efficient exercise of resources, stimuli, and incentives from the Federal Government for the development of actions that will affect the sustainability of the DUIS
- Promote the inclusion of plans of equity among the various players (federal, state, and municipal governments, landowners, investors, and housing beneficiaries) in the realization of DUIS
- Work on, and look in depth at instruments and mechanisms of innovation and development of new housing and planning products and instruments.

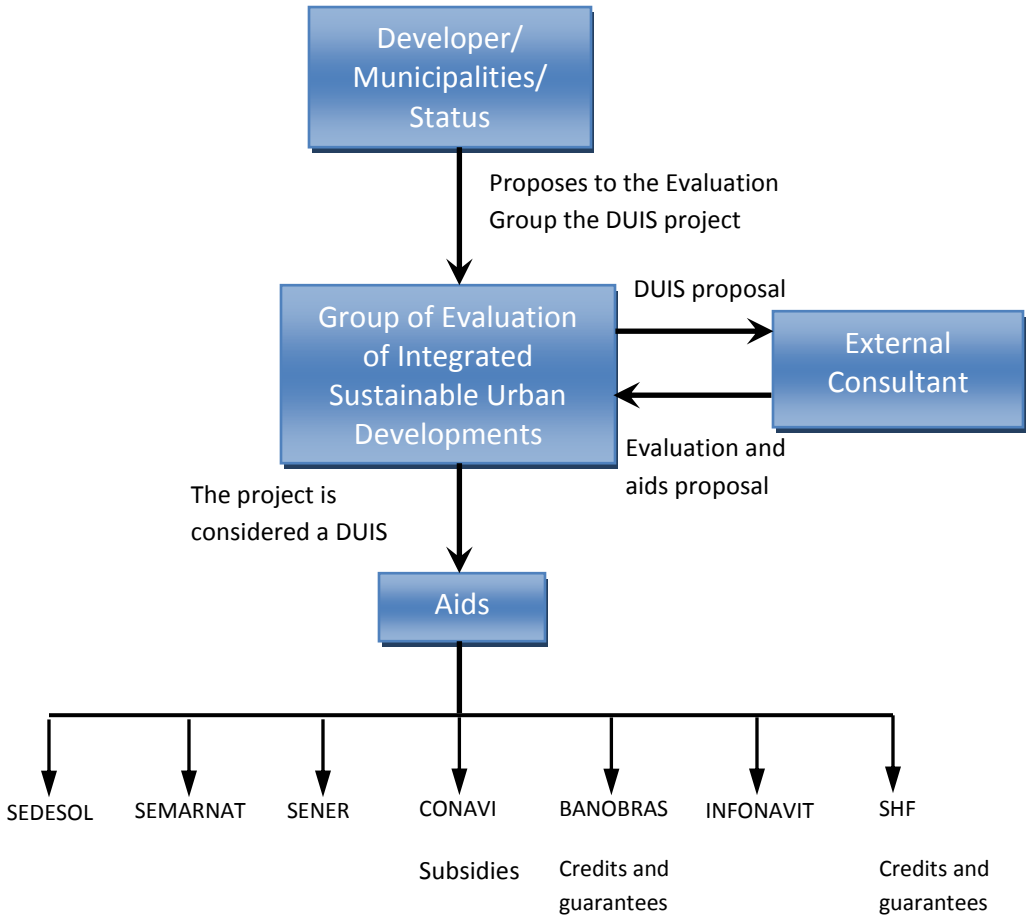


Fig. 2.31. Integrated Sustainable Urban Development (DUIS) diagram. Source: CIDOC 2008.

Recycling and redensification

The average growth rate in Mexican cities is 1.5% per year, in an uneven and unequal way. Although the economic, social, and environmental rationality shows that the exploitation of a space is defined by the potential of the urban land, located in concentric circles around relatively dense urban nuclei.

The irregular settlements tend to be found in spaces that are not acknowledged by the real estate market, generally unsuitable, high risk areas or places with a high environmental value. The cost of urbanizing unsuitable land which must be undertaken by the municipality rises from two to five times, and due to the lack of accessibility, homebuilding cost can increase up to 50%.

Most of the plans and programs for urban development in the main cities are going into stages of revision and updating which makes it possible to introduce new initiatives for regulatory improvement that will promote the re-densification and recycling of large spaces that are currently underused.

There is no better way to practice recycling and re-densification policies than in the consolidated city, where installed infrastructure and equipment, as well as networks, co-exist. It is not limited to re-using the properties or demolishing to rebuild them, urban recycling in the cities recovers the attributes of said cities, following the new economic, social, environmental, and other needs.

Social Development Board (Sedesol in Spanish) is developing a federal initiative that seeks to combine a series of incentives to promote strategies for sustainable urban growth, influencing the reality that determines the behavior of the real estate market through regulatory and fiscal instruments, investments in infrastructure, and financing instruments such as development banking and housing subsidies.

Nowadays within the urban perimeters, there is enough land to house 100% of the population's expected growth without destroying a single square meter more of natural environment and without having to reassign more farmland to the cities (CIDOC 2008).

3 RESEARCH METHODOLOGY

To achieve the objectives of this research, the following methodology was proposed:

3.1 Background Review

In order to know what has been done regarding sustainable construction in the world, a literature review was carried out, addressing the following topics:

- *Sustainable development and smart growth of the cities:* presents definitions about sustainability, sustainable constructions and its benefits. As well as the theories of smart growth and sustainable development.
- *International achievements in sustainable construction:* present actions undertaken around the world to address sustainability in construction, such as assessment tools to measure sustainability and examples of finished or underway projects of buildings around the world that have implemented sustainable features.
- *Vertical housing dwelling:* in this section some case studies of sustainable vertical dwellings are presented from around the world as an example of the application of sustainable concepts in the construction of condominiums.
- *Current Mexican housing situation:* this part presents an overview of the housing situation in Mexico, the actions that the government has implemented to address the current problems, and the new endeavor to promote 'Green Housing', especially for the low-income society.

3.2 Awareness Assessment of Sustainability

To assess the awareness of sustainability in the housing sector two different interviews were designed, one for construction companies and developers and the other for the government boards and institutes related to the construction industry.

Those interviews were intended to know if the interviewees knew about the term 'sustainable construction', its advantages in the application to the construction of vertical dwellings, if their projects (in the case of the developers) have any sustainable characteristics, as well as other open questions such as the acceptance of this kind of construction by society in general.

The questions asked in the interviews were:

Developers and Construction Companies

1. what do yuu know about 'Sustainable Construction'?
2. Do you think the use of sustainable construction criteria is convenient for the construction of vertical dwellings?
3. Do you think that the implementation of sustainable characteristics would make your projects more expensive or less expensive? In the short term, medium term and long term?
4. Is it convenient to build on hillsides and slopes, rather than the spaces defined by the urban areas?
5. Do you consider society ready to live in a sustainable condominium? Which adequacies should be done to the condominium norms and regulations to foster healthy co-existence?
6. Which benefits does your company get from the development of Vertical Sustainable Dwellings?
7. Which is the paper of the government regarding Vertical Sustainable Dwelling? Which are its responsibilities?
8. Do you have a specialized department for sustainability within your company?
9. What is needed to have experts in Vertical Sustainable Dwellings (Government, Developers and Institutes)?
10. Currently, what percentage of your projects have any sustainable characteristics?
11. Have you ever implemented bio-climatic design (passive design) in any of your projects (solar orientation, cross ventilation, natural lighting, etc)? Comment on your experience.
12. Have you ever used any water, electrical energy, gas saving systems, low impact materials, waste management, or other saving and low-impact techniques? Comment on your experience.
13. What is needed to start the implementation of sustainable characteristics in your projects?

Government and Institutes

1. What do you know about Sustainable Construction?
2. Do you think the use of sustainable construction practices are convenient for the construction of vertical dwellings?
3. Do you think that the implementation of sustainable characteristics would make the projects more expensive or less expensive? In the short term, medium term and long term?.
4. Is it convenient to build on hillsides and slopes, rather than the spaces defined by the urban areas?
5. Do you consider society is ready to live in sustainable condominiums? Which adequacies should be done to the condominium norms and regulations to foster healthy co-existence?
6. What benefits does the government have for the promotion of Vertical Sustainable Dwellings?
7. Which is the paper of the government regarding Vertical Sustainable Dwelling? Which are its responsibilities?
8. Is it convenient to have a specialized department on sustainable construction in the construction companies, Institutes or Government?
9. What is needed to have experts in Vertical Sustainable Dwellings (Government, Developers and Institutes)?
10. Is the Regulatory Framework suitable for the construction of sustainable dwellings?
11. From the following sustainable characteristics: water, energy, and land, which is the most important for the government? What is being done to address that characteristic?
12. What changes should be done to the Urban Development Plans?

After the interviews were done, they were analyzed qualitatively and the answers were gathered in a map diagram to identify main ideas and streamlines. This map was the basis for the next step.

3.3 Proposed Guidelines

According to the outcome of the interviews and the analysis, solutions were proposed for each guideline found in the previous step. Some of these solutions were based on the recommendations and comments of the interviewees.

A final map was presented with the key actions that can be undertaken to address sustainability in the construction of the new housing developments in the country, as well as for the spatial growth on the cities of those housing projects.

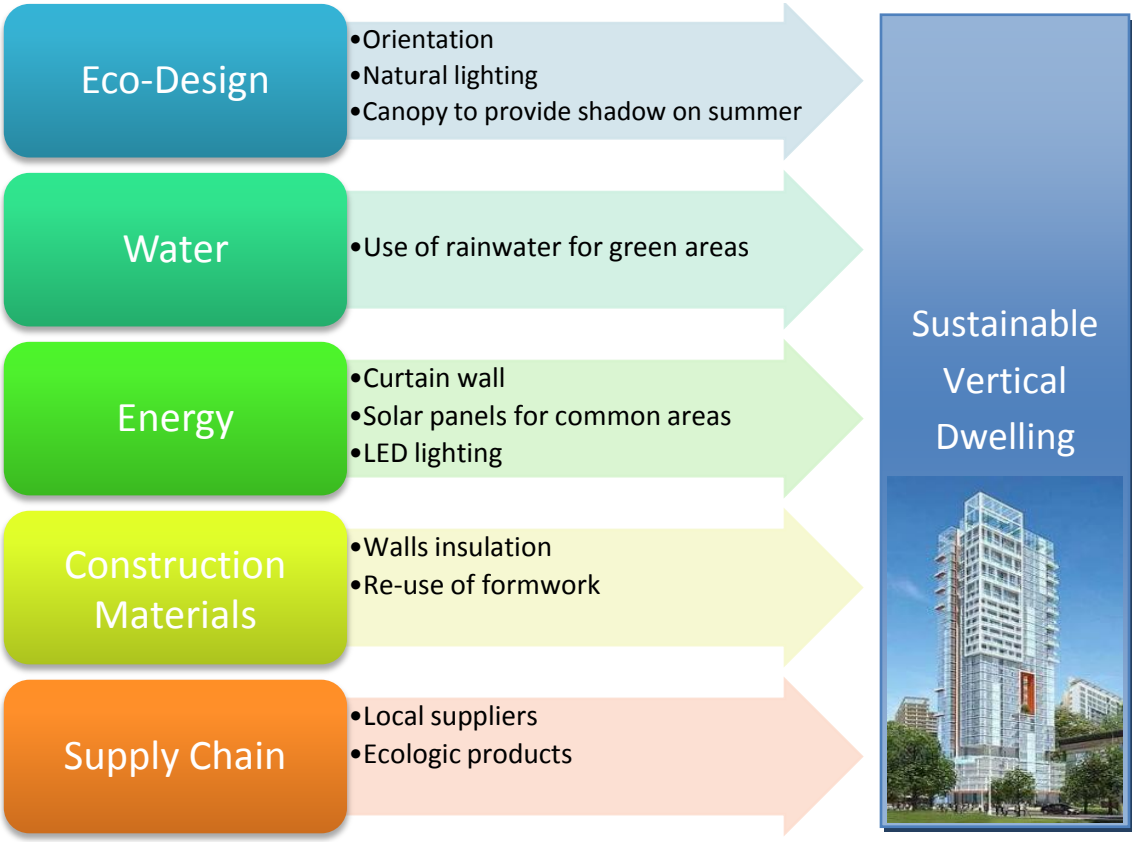
This map is intended to be a guideline for the developers, construction companies, and government boards for the design and construction of the new housing projects that are coming in the following years to cover the current housing shortage.

3.4 Qualitative Comparison Analysis

For the qualitative comparison analysis, a developer was contacted and asked for the implementation of this qualitative analysis in one of their on-going projects.

The main characteristics of the project were identified and then improvements were proposed in order to provide sustainable characteristics, and therefore, a sustainable condominium.

The following improvements were proposed and analyzed:



Subsequently the proposal was analyzed and discussed.

4 INTERVIEWS OUTCOME AND GUIDELINES

4.1 Description of the Interviewees

The interviewees were divided in two groups:

1. Construction companies and developers

Eight construction companies and developers where contacted via e-mail or phone to arrange an interview, only four responded affirmatively representing a 50% response rate.

Two of the interviewees were Project Managers and two were the owners of the company, so the reliability of their answers was considered high. All of those companies are located in Monterrey Mexico; three of them are all building approximately 25-story high-end condominium towers, and one was a consulting firm specializing in sustainable architecture (eco-design) and landscaping.

2. Government boards and Institutes

To cover this part of the research, the main government parties involved in the provision of housing and environmental regulations were identified, as well as some institutes dedicated to the research and consultancy of sustainable construction.

In total, seven institutions were contacted and four accepted the interview, representing a 57% response rate. The persons interviewed were mostly directors and program managers. Table 4.1 shows the government agencies, the position of the person interviewed, and the location.

Institution	Position of person interviewed	Location
Infonavit (National Found for Housing)	Director of Green Mortgage	Mexico City
USAID (United States Agency for International Development)	Director of USAID Mexico	Mexico City
CANADEVI (National Board for the Promotion and Development of Housing Industry)	General Manager	Mexico City
SEMARNAT (Environment and Natural Resources Department)	Federal Representative in Nuevo Leon	Monterrey

Table 4.1. Interviewees from Government Boards.

4.2 Interviews outcome

The answers were gathered in a matrix for each type of respondent to allow for comparison. Only the main ideas were stated in the matrix, the interviews were recorded on tapes and then written in a document to allow for easy sorting of information. The question number was the same as established in step 2 from the methodology.

Developers and construction companies

Question	Company 1	Company 2	Company 3	Company 4
1	In a global approach, including the building itself, energy saving, society and the economics part. A vertical dwelling should offer a better quality of life, appropriate connection with the city, community, transportation, surroundings, and the environment in general. This global approach will provide less use of resources and thus, economic savings, in the short, medium and long term. Sustainable construction seeks to reduce the impact to the environment, though less use of energy and low impact materials.	Is the creation of buildings that harmonize with the environment. Is the coexistence of technology, development, human beings, and nature. Implies the rational use of resources, decreases waste, and the creation of a general awareness of sustainability, in society, in the government and with the families. Government should promote sustainability, therefore, should create suitable regulations and guidelines for the development and construction of new housing projects (horizontal and vertical).	A sustainable construction represents economic saving for the developer, during construction and in the long run. In addition, it respects the environment. It also includes efficient systems, such as air conditioning, lighting, and water treatment. Those systems should represent economic savings in the long run for the resident.	They are buildings that should use available resources, low energy consumption, and take into account position, orientation, topography, etc. Sustainability means creating buildings using common sense. Many concepts can be addressed and be solved by the design, making the use of technology not as important. The bio-climatic (passive design) should be reconsidered, even though this has existed for many centuries.
2	The implementation of sustainable criteria is convenient, but should be applied in a larger scale using a global approach. Not simply by the implementation of low energy consumption lighting or low pressure	The implementation of sustainable criteria must be done in the construction of new projects. And it should be the next step in the construction of new dwellings. Three parties should be involved in	Yes, the implementation of sustainable aspects to construction of vertical dwelling. But technology is still very expensive, and it makes difficult the use of efficient systems that	Definitively, the use of bioclimatic design should be a must for the new developments. In Mexico many new developments are committing mistakes and making high energy

	valves.	this process: the government making regulations, the developer executing those regulations, and the resident accepting the added value of a sustainable dwelling.	allow energy savings, water reuse and other possibilities.	consumption buildings. This should be changed by the implementation of friendly architecture.
3	Currently, in the construction phase these kinds of projects are not more expensive. The major expenses occur at the beginning of the project, in the case of LEED projects, you have to pay commissioning and consulting firms, to design a suitable alternative to reach sustainability. In this specific project, the expected cost was 3-5% more expensive than a conventional project, if the sustainable aspects are planned in the first stages, it will be cheaper than if these are implemented through the construction of the project.	The technology is still too expensive to be implemented in the new projects, so, the construction phase is more expensive, and if we are competing in the market, we can't offer a more expensive product because it would be hard to sell. In the medium and long term, the end user will have economic savings, but those benefits don't apply for the construction company.	The use of technology is expensive, we have done economic analysis for the implementation of sustainable technologies, but the payback period is too long. You can use other kinds of technology, less expensive and less efficient, and it can be suitable to get paybacks in a medium term period.	From my perspective, those projects should not be more expensive. During the design, many sustainable features can be solved and implemented, by using good bio-climatic criteria, thus implementing less expensive technology. Therefore, resulting in less expensive projects with no over cost.
4	Building on hillsides and slopes causes ecological disruptions, and visual impact. One option is to promote vertical developments to use urban land, instead of expanding into productive areas.	It is not convenient to build on hillsides and slopes. Nowadays, the development plans of the cities are very specific and restrictive regarding these issues. In the case of Monterrey, there are parts of the city that are hillsides, but they don't have the grades and ecological characteristics to disrupt the environment, so they are development areas.	This is up to the government and persons who create regulations. They should define suitable places for development, state the use of land and density. They should be the ones to perform environmental impact studies and therefore establish new areas for development. Land reuse is a better alternative; here in this city are many examples of new projects that are under construction.	Slopes and hillsides are the most appropriate place to build, unfortunately media has spread wrong information about this theme. Hillsides are an aesthetic element, but people had opted to urbanize productive land thus reducing the area for food production, and water filtration. Some productive lands are difficult to use for construct due to the big layers of organic soil, making

				compulsory the use of deep and strong foundations which makes the projects expensive.
5	Society is not ready to live in a condominium; there is a lack of education. One way to educate is by having well elaborated rules and an administration office, to impose the regulations, fostering a harmonious coexistence.	Definitely, people are ready to live in a sustainable condominium, especially young people. Condominium living should promote the utilization of sustainable technology and systems, especially in common areas.	People are not ready to live in a condominium. Specific regulations for a condominium regime should be created, and specific fines should be applied.	There is still a lack of culture for living in a condominium. Especially for a harmonious coexistence, respect to neighbors must be fostered.
6	In this project, sales are not as expected, but people who know the advantage and have the conviction of living in a sustainable building are buying. Sustainability is one of the core characteristics of this company, making the difference from other companies.	Seems utopian to think that we can build sustainable vertical dwellings, because if it doesn't generate a profit for the developer, they won't take them into consideration. Sustainable dwelling represents savings in the medium and long term, but those benefits are not for the developer, making it difficult for the implementation of technology and sustainable criteria. But, if there are savings in the construction process, those will be economic savings for the developer, so, this should be considered and analyzed for implementation.	Yes, projects are more expensive at the construction phase, technologies are still expensive and their cost benefits are in the long run. Alternative technologies can be implemented, making more feasible this kind of projects.	Developers don't see any benefit from the construction of sustainable dwellings, and it is difficult to convince them. It is difficult to convince the developer that initial costs are not an expense, but an investment instead. In my case, being a LEED AP hasn't brought many changes, because I've done sustainable architecture for many years, and what I do is just for the fun of it.
7	Promote the development of sustainable construction, through discounts in service fees (water, electricity, sewage, etc).	Government has done something to implement sustainability in housing development, but there is still more to do. Government should promote and reward the implementation of sustainable criteria In housing	Sponsor research, development of technology and new products. It should issue manuals of sustainable construction, showing available technologies, advantages, and suppliers.	To promote sustainable construction, through fiscal incentives, and reductions to services fees.

		projects, such as fiscal discounts, special rates for services, and subsidies in sustainable technology.		
8	No, there are only a few members in the company, we had and outsourcing at the beginning of the project, to help with the design and planning to achieve the LEED certification.	No, we don't have a specialized department on sustainable construction. Because technologies are not still available for developers, and because there is not an adequate promotion of those technologies.	No, we don't have a specialized department. We are a small team, our architects have some knowledge in this regard. We have a network with professionals in the industry, and we use their advice. In the case of specific issues, we hire specialized consultants.	Our company specializes on sustainable construction and design. And the owner is a LEED AP (Accredited Professional)
9	Training, specifically to managers and owners, so they can spread the new culture of sustainability to the rest of the company.	Creating a general understanding of sustainable development. It's also fundamental the existence of experts on sustainable construction. Training of experts is needed in the short term, and they should be the ones to lead the creation and implementation of 'Green Norms'.	Government, research institutes and universities should be leaders on the creation of knowledge and technology regarding sustainable construction. They should have the experts, and then transfer that knowledge to the industry.	It Is a fact that we need experts on sustainability. Current situation will push society to pursue sustainability. Building sustainable developments will reduce operating cost, and in a big scale, that impacts positively to the city. If government understands that, it will make compulsory sustainable development.
10	This is the first project of the company, it was created in 2007. One of the company's slogans is: "building green for the next generation", so sustainability is an important part of our projects.	All of our projects have sustainable characteristics, because the stick to municipal regulations and the urban development plan. The company also has implemented other features not included in the regulations, such as cross ventilation, double glazing, and positioning of the building.	This is the first project for the company; we tried to apply as many sustainable characteristics as we could. But we had building regulation restrictions and budget restrictions as well. The new projects we are working on, they implement more sustainable characteristics.	This company specializes on sustainable architecture, landscaping, urbanization and little construction, and we try to implement sustainable criteria as much as possible in each one of our projects.
11	Yes, the design of the project was based on LEED regulations, aiming to	We have not worked too much on these concepts, he have done some	Yes, in this tower we considered orientation, we perform a sun	As stated before, in all our projects we promote sustainability.

	achieve LEED certification. Building green doesn't mean achieving Platinum certification, is getting the best value and benefit for the end user. The criteria considered in this project are: energy, water, location, quality interior environment, good insulation, sunlight, among other characteristics.	economic analysis for the implementation of these kind of concepts.	pattern study, and the balconies provide shade during summer days. All the rooms in the apartments get natural light. In the west façade had to be concrete, for urban regulations, but we used a prefabricated system allowing good insulation through an air barrier.	We use native vegetation for the landscaping projects, we design taking into account orientation, natural ventilation, lighting, insulation, materials and other sustainable aspects considered in the LEED system.
12	The apartments have LED lighting, low pressure faucets and showerheads. This development has 11 000 m^2 of green areas, which also will work as filtration field. Before there were warehouses, and now this area will help to filter the water to the aquifer. The towers will have green roofs.	We have done some analysis, but nowadays technology is still very expensive, so it makes more expensive the projects. We have not implemented big systems, such as water treatment, but we have use double glazing on windows, low energy bulbs, and canopies to provide shadow on summer.	In this building we have efficient electric boilers on demand. We have a system to intercept and channel a water stream from the hill; we use that water for irrigation. In the construction phase we implemented a materials recycling system.	In our projects we aim to reach sustainability since the conceptual design, making the use of technology not so necessary. However, we use low energy consumption elements and water saving features in our projects.
13	Culture and general awareness of advantages of sustainability. Vertical dwelling' promotion is a cycle. The government should promote sustainability, and then developers should build, expecting fiscal considerations and rewards. The most difficult thing is to convince the society, to make them aware of the economic, social and ecological advantages of sustainable dwelling.	First, that technology can be reached by the developer (less expensive). Make extensive research and cost-benefit analysis to determine feasible implementation of new technologies. Suppliers and companies that sell sustainable technology should promote their products to the developers, and offer deals to them.	Creativity and information, knowledge of sustainable materials, sustainable practices. Technology should be less expensive, and close to the developer. New technologies should be developed, adapted to Mexican conditions.	We already use sustainable characteristics in our projects, but there is still a huge need in the promotion of this kind of construction.

Government Agencies

Question	Agency 1	Agency 2	Agency 3	Agency 4
1	It Is the construction that incorporates concepts for the efficient use of water, energy, and resources in general. This institution considerate a sustainable dwelling as those with a proper location, accessible to services, that facilities dairy activities of the resident; without turning into excessive expenses to cover basic needs and activities.	Sustainable construction is characterized because now and in the future is: Friendly with the internal and external environment, providing comfort and functionality, same as fulfilling the need of transportation, education, health, recreation and services. Flexible to use renewable energy, such as wind, sun, and organic waste. Integrates available technologies to achieve efficiency in resources use and energy saving.	Sustainable construction is friendly and compatible with the environment. Minimize cost and maximize benefits. is not only economically feasible for the users; it also seek the best benefit from the orientation, geography, resources, construction techniques, among others.	Sustainable construction is a practice that should be fostered to face climate change. Sustainable constructions have a low impact on the environment, their location is strategic, they offer comfort to users, and represent low energy consumption. Driving economic benefits, for the builders and users. Social aspects should be taken into account, it means that those construction should satisfy social needs, such as health, shelter, transportation, recreation; thus, improving quality of life.
2	In the development of new dwelling, location has the higher value. So, it should be considered using existing infrastructure, proximity to working centers, schools, hospitals, and other services. For this reason, vertical dwelling has more value than horizontal.	Implementation of sustainable criteria Is not only convenient, but also feasible. Now many construction technologies are available for the commercial and public buildings, those technologies can be applied to the housing projects.	A sustainable criterion is good and should be implemented in the construction of new dwelling. We support smart growth of the cities, where urban planning is implemented, considering environmental issues.	Yes, sustainable construction creates energy efficient buildings, considering bio-climatic criteria for the design. Certification systems should be promoted, and new building projects should be designed and constructed under those regulations. Old buildings in USA used natural ventilation and natural lighting, providing comfort. They used bio-climatic design.

3	To obtain a reliable answer, a detailed analysis should be done. Land in central areas is more expensive than in outskirts, however, if the cost of providing services is considered, it might be cheaper to build in central areas. The cost of a dwelling shouldn't be considered as the construction itself, but considering the integral environment (location, infrastructure, services, transportation). In this regard, vertical sustainable dwelling could be cheaper than conventional dwelling. This agency is working on a vertical model of development, to provide the same revenue to developers than horizontal housing in outskirts, so construction of horizontal and vertical dwelling will compete in similar circumstances.	At the beginning are more expensive, for the implementation of new technologies. In the medium term and long run, there are economic savings for the users, and a better quality of life for them.	The implementation of sustainable characteristics is expensive; we still don't have the proper technology, suitable for our specific conditions. But we can use sustainability in a wider scale, this is, the urban planning and development, we need to take into account suitable areas to development and assess the environmental impact and risks.	Currently, building with sustainable technology is expensive, and only big companies can afford initial costs. Because they know they will get their money back in the long run. Green buildings are also use as a marketing strategy. In the case of housing, sustainable features are being implemented in the construction of high-end condominiums. Having sustainable vertical dwelling shouldn't be more expensive, new technologies should be developed and bio-climatic design should be implemented.
4	Definitively is more convenient to build within urban areas, in first instance, building on hillsides is more expensive (for foundations), in other hand, ecological impact can be avoided if we use current infrastructure, roads, transportation systems, services, etc. Hillsides and slopes can be used as land reserves. This institute fosters the use of	A cost analysis is needed to compare both situations. Urban areas have already infrastructure, but land could be more expensive.	The suitable areas for development are already stated in the UDP, however, there are also areas considered as Parks or Reserves; most of them are part of mountains and hillsides, those areas must be respected and keep natural. If it would be up to this Department to decide areas for development, we would restrict	All the available spaces should be used in the urban areas, before expanding the city. In case that the population continues to grow, the use of hillsides could be an option for development rather than flat productive areas.

	current available lots in the cities (re-densification), in the biggest cities in Mexico.		many areas, because development for itself means the disruption of the environment.	
5	Society is not ready to live in a sustainable condominium, people are not aware of sustainability and they don't know its benefits. Mexican culture is not driven by a coexistence environment, therefore lots of problems arise when living in a condominium, it doesn't matter if horizontal or vertical. We should work hard to promote and generate a condominium culture.	Vertical dwelling is incipient in the country, but I am sure that when this will be an option, it will be widely requested, for its features and because will represent a higher capital gain in the future. The adequacies to regulations should be based on the promotion of correct use of resources and energy. Also a good administration and management of the condominium board should be created.	Unfortunately our society is not ready for living in a condominium scheme, specially older generations. New citizens are more flexible and are more conscious about the environmental, economic and social problems. Culture and education need to be implemented, before applying strict rules and regulations.	There is a lack of culture for living in a condominium, because exist coexistence problems. Those problems could be solved by the implementation of strict regulations. However, new generations seem to less reluctant to live in a condominium, representing a modern lifestyle for them. Vertical dwelling should be promoted in cities with land shortage, making re-densification a suitable solution for that problem.
6	The government will have control over the growth of the cities. It would have adequate planning of services to provide, creating efficient systems. Thus, using economic resources effectively.	The efficient use of current infrastructure. Better planning of the cities, foresee problems, and decrease ecological problems.	For this Department, that would be a dream come true, unfortunately is out of our scope. But from the development of Vertical Sustainable Dwelling the impact on the environment will be reduced, fewer areas to development would be open, and society would be happier and healthier living in a high quality home.	Government will have attended the population with basic needs, so it can focus in other issues. If the government provides of good quality housing it increase the quality of life and social welfare. If coverage of basic needs is secure, it will provide social stability, decreasing social problems.
7	The government determines suitable places for development, through the creation of Urban Development Plans (UDP). UDP should have partial plans, stating land use, densities, restrictions, etc.	To establish norms and regulations based on research from well known institutions. Those regulations should be easily understood and concise, and they should be able to update quickly according with current conditions.	The government in all its levels (Federal, State and Municipal) should create proper UDP, and regulate development of sustainable vertical dwelling, De 'green mortgage' is a good beginning, and it should continue	Government should promote sustainable dwelling, should implement programs to build this kind of housing. It also should support research for the creation of new technologies suitable and adaptable to the

	To promote green hosing, we developed the ''Green Mortgage', and we are working to extend this program for vertical housing. Therefore, promoting Sustainable Vertical Dwelling.		to grow and improve. Government doesn't need to provide fiscal rewards, or other kind of incentives. It should implement strict building codes to be obeyed.	different conditions of the country.
8	There is no need for a separate specialized department; employees should be trained, so they would be aware of sustainability.	Yes, it shows profitability in the medium term and long run. Sustainability is profitable in essence.	We don't need more bureaucracy, we need politic means to create effective laws and obey them.	I am not quite sure if that's the way to go to promote sustainability in the companies and in the government. But I agree that participants and leaders should be aware of sustainable theories. Nowadays, universities and schools are teaching more about those topics, so the new generations of professionals have this knowledge. And I hope they will be the leaders that will make the difference in the near future.
9	Participants in construction industry should be trained, here in Mexico or abroad, in countries that sustainability is more developed. Conventional construction will trend to disappear; it will be replaced with sustainable concepts and practices. It's why we have to update our knowledge, to change towards sustainable construction.	Training, study programs in different levels at school: bachelor, college. The specialist must also be entrepreneur and with a business mindset.	We need people specialized on sustainable construction, what we have now is not enough; there are still many things to do.	Training campaigns should be undertaken, to different levels of the organizations. Research institutes and well-known universities can perform that task.
10	The currently Legal Framework is insufficient and inadequate, UDP should be elaborated consciously and detailed, and its application should be followed up.	The Regulatory Framework is still incipient and requires permanent updating, to be appropriate with current need and technological advances.	There is no a Regulatory Framework for sustainable dwelling, it only exists some guidelines, to foster sustainable housing.	There is a lack of regulations for sustainable development in Latin America. Despite many efforts have been done, there is still lot to do: specific regulation should be

		Specialist should participate in the creation of these new regulations, and they should be kept away from political interests.	A regulatory framework should be created, to rule the construction and design of new housing projects.	creating to address: environmental issues, social welfare, urban expansion, and construction itself.
11	Two are the most critic issues: water and land, because they trend to run out. We promote the efficient use of water on the developments and dwellings. We are trying to foster re-densification, but there is still lot to do regarding development land, UDP should be respected and updated.	The three of them in the same order (water, energy and land). Providing drinking water is everyday more expensive, due to sources contamination. We still can get energy from oil, and renewable energies are underused. We still have enough land reserve within urban areas, suitable for development.	One critical issue for the government is to break the trends on housing development, and foster sustainable vertical dwelling. Government is negotiating with industry chambers, to promote this kind of housing. Energy and water are also important aspects for the government.	Non renewable resources should be of core importance for the government. Water is a renewable resource, but every day is less available, due to its contamination. Land runs out according city growth, so it should be a priority for the government to regulate urban growth, through effective UDPs.
12	In first instance; there are many UDP that are obsolete, so, they should be updated. UDP should be deployed into detailed partial plans.	A re-arrangement of cities, according with current infrastructure, and the adequate land use. Therefore having a planned growth of the cities.	There was no strategic planning for the growth of the city from its origins, leading to urban sprawl. The UDP are specific for each municipality, but we should create plans in a bigger scale, for metropolitan areas and for each state.	The UDP should be more specific in the criteria for the development of new areas, fostering mix-use buildings. Mix-use can be a suitable alternative for sustainable development, where in the same building coexist retail areas, offices, and housing.

4.3 Discussion

Developers and Constructions Company's Opinion

With reference to the awareness of sustainability and green construction, all interviewees coincided on their definitions and their answers were convincing. Thus, it can be summarized that green construction is the creation of buildings which harmonize with the environment together with the coexistence of technology development, human beings, and nature. Green construction should also represent lower use of resources (materials, energy, water, land) and therefore provide economic savings in the short term but even more so in the long run.

According to the answers to the second question, all respondents agreed the implementation of sustainable criteria should be done for the design and construction of new housing developments. First of all, implementing eco-design or passive-design, and then implementing technologies to reduce initial costs. Actions should be implemented on 4 different groups or stakeholders:

- Government: by the creation of a suitable regulatory framework, and implementation of plans for the provision of green housing to the population.
- Developers: to obey green housing laws and invest in the construction of new green vertical dwellings.
- Universities and Research Centers: conducting research for the development of new efficient technologies adapted to regional conditions. Promoting the new advances and providing training to the construction companies, developers, government members and anyone interested in sustainability.
- Population: changing the culture and educating society towards sustainable development, and recognizing that living vertically is more sustainable.

The answers to the third question revealed that as a general consensus green buildings are more expensive at the building phase, but they represent important savings during their life cycle. This additional cost is due to the use of new technology. Nonetheless, two respondents said that this initial cost could be dropped and equal traditional construction costs by using natural resources available in the environment. This is the implementation of eco-design.

Regarding the issue of building on hillsides and slopes, the respondents have different opinions, some of them contrasting. Certainly building on slopes causes ecological

disruptions, but some areas on hillsides on the cities are intended to be development areas due to previous ecological impact studies and building characteristics. In the case of sprawling to productive areas, it's better to urbanize suitable areas on hillsides than changing the use of productive lands. And the best alternative is to use up all vacant lots in the cities, before moving to hillsides or to productive areas.

There is a general consensus that the majority of the population are not ready to live in a condominium. There is a lack of condominium culture and education is needed for a harmonious co-existence in this new environment. Also, a regulatory framework should be developed to control the administration of the condominiums. However, there's one segment of the population composed of young professionals that are looking for this kind of dwelling.

If we talk about the benefits that developers would expect for the implementation of green characteristics and technology on new developments, they are aware of the advantages of this kind of construction but they don't see any direct benefit for them because the payback is often in the medium and long term, so the benefits are mostly for the end user. One developer said that sustainability is part of their marketing strategy but sales were not as high as expected.

A paper by the government promoting green housing is sponsoring research for the development of new technology to promote a green culture in society. Also, the government should reward the implementation of sustainable criteria in housing projects, such as fiscal discounts, special rates for services, and subsidies in green technology.

Regarding the need for a specialized department within construction companies, respondents said their teams are not large enough and creating a new department would not be cost effective, but they consider that it is important to have the knowledge of sustainable criteria. Some developers building a green project hired consultants to help them with the sustainable aspects of the project, and other developers considered it important to train their current employees.

Experts on green construction are needed to boost the development of green housing. It should be the work of research institutes and universities to create and promote the knowledge and technology. Experts should be the ones to lead the creation of green regulation in the construction industry and training should be provided to managers and owners so they can spread the new culture of sustainability to the rest of the company.

It is surprising that developers are already implementing green characteristics in their new developments. They are doing so to fulfill municipal regulations and secondly as a strategy to offer a different product from the rest of their competitors. Two of the companies used green design as a base to develop their projects. However, even though there has been something done to address sustainability on projects, there is still a big need for the implementation of those characteristics on a larger scale.

Some of the green characteristics the industry has implemented are: double glazing windows, green roofs, eco-design, wall insulation, balconies to provide shadow in summer, cross ventilation, and the use of native vegetation. Industry also has implemented energy saving systems such as electric heaters and LED bulbs, and water saving elements such as low pressure showerheads and faucets.

Finally, to set off the construction industry towards sustainability, we need to change the culture and foster respect for the environment and spread the advantages of green construction. Two developers said that for the implementation of sustainable technology in their projects they need it to be less expensive and readily available to them. This means suppliers should promote their ecologic products and offer special rates to the developers.

Government's Opinion

Government agencies' respondents gave the same kind of answers about defining sustainable construction which lead to the conclusion that Mexican construction industry professionals acknowledge sustainable terms and criteria.

These respondents also considered the implementation of sustainable criteria in the development of new vertical housing very important. One person said that in real estate, location has an important value so re-densification in the city center should be fostered using current infrastructure. Therefore, vertical dwelling has more value than horizontal.

Regarding the cost of green housing, the respondents agreed that initial costs are still higher than conventional construction. But if we consider sustainability on a higher scale it could be cheaper. This means, if we considered a lump sum cost including land, infrastructure and services, vertical dwelling in central areas could be cheaper than vertical or horizontal dwelling in the outskirts.

Now if we consider building on hillsides and slopes rather than in urban areas we benefit by using the same infrastructure, roads, transportation systems, services, and severe ecological impact is avoided. On the other hand, suitable areas for development are already stated in the UDP, also where parks and reserves are defined.

Society is not ready to live in condominiums, vertical dwellings are incipient in the country, and coexistence regulations need to be developed. The advantages of a green condominium should be promoted, especially in cities with land shortage where re-densification could be a partial solution of the problem.

The benefits that the government would expect from the implementation of green vertical dwelling are, in the first instance, the control over the growth of the cities; it would have adequate planning and efficient provision of services and the ecological impact would be lowered. It is also interesting to note the point of view of one respondent who said that with the development of green vertical housing government will have managed the population's basic needs by providing social stability and a decrease in social problems.

The government's responsibility regarding sustainable dwelling is: determine suitable places for development through the creation of UDP which should have partial plans stating land use, densities, restrictions, etc. Government should promote the construction of green housing and the 'Green Mortgage' as a good beginning. Government also should support research for the creation of new technologies, adaptable to the country's conditions.

Having experts on sustainable construction is necessary to have the expertise to make a difference. However, the creation of a new department specialized in sustainability would not be the best solution, instead we need to train the current personnel, especially leaders and regulatory makers.

Conventional construction will tend to disappear and sustainable concepts and practices will become more common. For that reason is important to update the knowledge, to change towards sustainable construction. These days universities are training new graduates in sustainable concepts so the new generations of professionals have this knowledge and they will be the ones to lead for a change and make the difference in the near future.

The answers about the suitability of the current regulations to address sustainability revealed a general consensus that the actual legal framework is insufficient and

inadequate and that regulation should be kept away from political interests. This new regulation should address environmental issues, social welfare, urban expansion and construction itself.

For the Government, land seems to be the most important issue, therefore re-densification is one alternative that government looks at to implement change. Water is other important resource. This is running out due to pollution and the growth of the population, so the implementation of efficient system is needed in the development of green housing. Energy is another resource, and in this regard the use of renewable energy should be promoted to change our reliance on oil.

Finally, the changes that need to be done to the UDP are, in first instance, updating many of them. Such updating should consider the deployment into partial plans where detailed information of use, densities, and special considerations must be stated. Mixed-use buildings should also be fostered in the new UDP and the creation of larger scale plans could be implemented to consider not only the municipality, but the whole metropolitan area.

From the previous discussion, the following general issues regarding the implementation of sustainable criteria in the construction of vertical dwellings were summarized:

Developers	Government	Research Institutes	Society
•There is a lack of investment on green projects. •Construction phase is still expensive. •Lack of fiscal incentives. •Green techology is not available and is expensive	• 'Green Mortgage' only available for horizontal housing. •Lack of proper regulation for green condominiums •Lack of a remuneration system to foster sustainability. •Obsolete UDP, need to adjust to the new conditions.	•Need support for research •Low development of new technologies •Lack of training and knowledge of sustainability.	•Coexistance problems •Rejects to live in condominium •Is unaware of green housing advantages.

4.4 Proposed guidelines

Based on the main issues found in the previous discussions, some guidelines or actions to address these problems were proposed as follows:

Developers	Government	Research Institutes	Society
•Implement eco-design in their projects. •Implement construction methods to generate savings for the company (Lean Construction) •Promote sustainability as a marketing strategy. •Look for training to their employees on sustainable construccion.	•Needs to expand the 'Green Mortgage' to vertical dwelling. •Create proper regulation for green condominiums •Implement a remuneration system to foster sustainability. •Update UDP, making concious studies for new development areas .	•Offer training courses on eco-design. •Develop suitable technology according to the country's conditions. •Transfer the knowledge and technology to developers and government.	•Education programs to change the overview of living in condominium. •Implement coexistance codes. •Promote green housing and its advantages. •Offer them high quality developmetns.

With the aforementioned actions, the development of green vertical dwellings could be addressed in Mexico.

5 QUALITATIVE ANALYSIS

To carry out the qualitative analysis, a current project was selected in the city. It was analyzed to identify its main characteristics and define possible improvements to become a sustainable high-rise. The green improvements were based in the characteristics of the green condominiums presented on the framework review and passive features were given preference. The green improvements were also chosen according with the added value to the project.

These improvements were discussed with the Project Manager of the development and the suitable ones were selected and formed part of the improvements proposal. Then, the developer provided the needed information to perform the characteristics comparison.

Table 5.1 shows the sustainable elements that were analyzed, some of them where already present on the tower and they are shown in column 'Status' with the legend: Available. The rest of the elements where proposed as improvements and their contribution to the greenness of the tower was discussed.

Characteristic	Status
Orientation	Available
Natural Lighting	Available
Canopy	Available
Collection of rainwater for irrigation	Not available
Solar panels for common areas	Not available
Hot water recirculating system	Available
Insulated walls	Available
Re-use of formwork	Not available
Local suppliers	Available
Ecologic products	Not available

Table 5.1. Improvements proposal.

We present the following description of the improvements:

Orientation

In this case a proper orientation of the building was used by the developer, having no effect on the cost of the tower. This helps to reduce isolation and provide comfortable temperatures in most of seasons, thus the energy consumption is reduced. The region of Monterrey gets very hot on summer and it gets cool in winter, therefore, a suitable solution to provide natural light without gaining heat was used, it is discussed in the next improvements.

Natural lighting

The apartments were provided with curtain walls to allow for natural lighting, and all the rooms in the apartments were designed to receive natural light. Therefore a reduction in energy consumption was guaranteed. The living areas were located facing south, and as in summer the isolation is high, the provision of overhangs to provide shadow was needed

Canopy

As a result of having curtain walls, canopies were needed to provide shadow in the living areas of the apartments, reducing isolation and fostering energy savings. In this case, the canopies are currently available on the towers but were considered as a proposal.

Rain water collection system

A rain water collection system was proposed for irrigation of the landscaped area. It consisted of collecting pipes from the rooftop of the building and the impermeable areas, and a concrete holding tank of 75m^3 (5x5x3m). This tank will supply water during some of the dry months, representing savings in use of potable water. The draft of the system to provide irrigation to the landscaped areas is shown in figure 5.1, also figure 5.2 depicts the sprinkle irrigation that can be used in the grassed area.

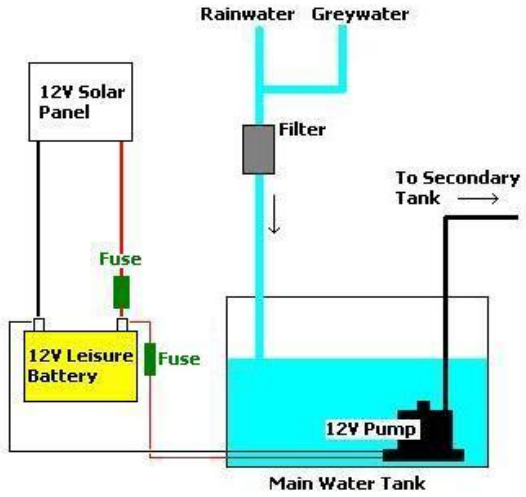


Fig. 5.1. Water storage and irrigation supply system.

Fig. 5.2. Sprinkle irrigation for grassed areas.

Solar panels

A Grid-tie Solar System (GST) was proposed, with an 8 modules array capable of producing 1400Watt. LED lighting was proposed for the common areas and landscaped areas, thus a reduction in the energy consumption for those items is guaranteed representing no cost for the next 25 years (GST warranty). Figure 5.3 depicts the function of the GST system, and figure 5.4 shows the type of lighting that will be used for common areas in the tower.

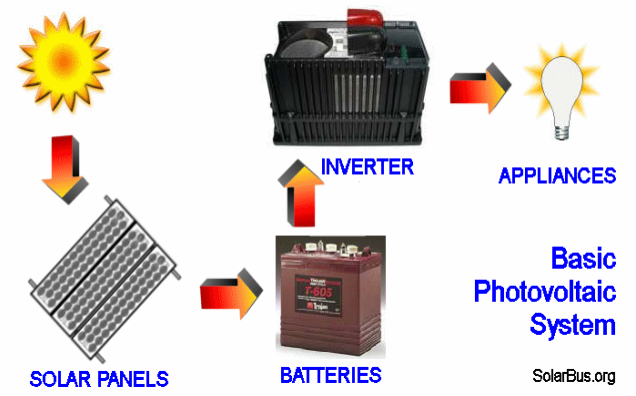


Fig. 5.3. Diagram for the GST system.

Fig. 5.4. LED lighting for pathways and landscaped area.

Hot water recirculating system

A hot water recirculating system is currently available in the tower, fostering energy savings and water use reduction. In terms of this study, this item was considered as a proposal for being a sustainable characteristic. Figure 5.5 shows the recirculating valve, which works with a thermostat where a temperature is set, when the water gets colder, a pump is activated to recirculate water through the pipes, providing hot water at all times and reducing water consumption.

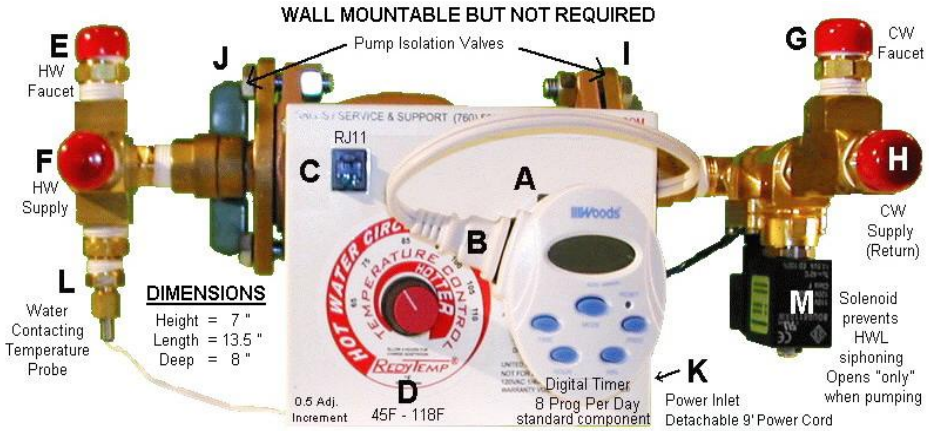


Fig. 5.5. Recirculating valve, to provide hot water at all times.

Insulated walls

Pre-cast concrete walls were used for the building which provides some insulation. However, a layer of polystyrene insulation was proposed to reduce heat transmission (especially during the hot summer months.). Having a comfortable temperature in the apartment reduces energy use from cooling.

Re-use of formwork

During the construction of the tower conventional wood formwork was used, because a reasonable supplier was not found that would meet the sought after specifications and cost. However this technology is evolving constantly and is currently more accessible. Therefore a metal form was proposed for pre-casting exterior walls on site and for pouring columns and beams. In this case, the initial cost of acquiring this technology is expensive but is cheaper than using wood forming, if the whole building process time is considered.

Local suppliers

In this case local suppliers were used to provide all the most important materials, taking into consideration the delivery times. An integration of the supply chain means acquiring all materials from local suppliers, reducing transportation cost and gas emissions. It also means helping local markets, thus local welfare and development.

Ecologic products

In that tower, ecologic products were not used in any phase of the project. Therefore, the use of ecologic and recycled products was proposed such as recycled PVC for piping, recycled metal and glass. Those improvements don't represent a consequential increase in price, and despite their rare use they will soon be considered a need in the country and use will increase.

In Mexico there is not a wide spread of production of recycled materials. Despite the lack of recycling culture, in the country are already some companies that manufacture their products based on recycled materials, but in general they are small companies and don't have the money to invest on advertisement and promotion.

In Mexico now exists a catalog of companies that supply ecologic products and services, it's called 'Las Páginas Verdes' (The green pages), where people and companies can look for a wide range of ecologic products, and construction materials and services are also included.

6 CONCLUSIONS

Sustainability is becoming a focus of attention in the Government, Research Institutes and Education Centers in Mexico. The National Development Plan 2006-2012 contemplates a sustainable development of the country.

The Mexican government has launched the 'Green Mortgage' program to address sustainability in the construction of new housing for the low income class, however this program needs to become broader and include vertical housing and other income levels.

To fill the housing shortage in Mexico the Vertical Dwelling is a feasible option, especially in big cities where the availability of land for horizontal developments is very far from the city center and services.

Vertical dwellings represent a greener way to build by the simple fact that it requires less land space. Vacant lands within urban areas can be recovered, thus the use of existing infrastructure and services make the projects less expensive.

There is not a proper regulatory framework for the condominium regimen or for the construction of green dwellings. Therefore, the government should create a regulatory framework with the help of the Research Institutes and other experts.

The Mexican population is not ready to live in condominiums, but there are some exceptions, like in Mexico City, where the lack of land has privileged vertical living. However, a culture of condominium and coexistence should be fostered. Nonetheless, new generations are open and adaptable to different conditions; they are the key for success of sustainable development of the country.

If we take into consideration the overlook of government and developers of sustainability of the site, government consider the whole city and developers are focused in their developments only. Therefore the actions implemented are according to those scales.

The current green technology is still too expensive to be implemented massively in construction projects, therefore new research and development should be done to create suitable and reliable technology adapted to Mexican conditions.

Developers should foster sustainability in their projects, adding value to their clients through efficient and well constructed homes. They can also get benefits through the implementation of Lean Construction techniques and a good supply chain management.

In the cost analysis, the result showed that a Sustainable Dwelling is still more expensive to build in Mexico. However we tried to show that sustainability can be addressed using passive techniques, such as bioclimatic design, use of ecologic materials, and integration of the supply chain.

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