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REGULATORY FRAMEWORK ABOUT CLIMATE CHANGE DUE TO GREENHOUSE GAS EMISSIONS IN MEXICAN CITIES: URBAN-ARCHITECTURAL APPROACH

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Abstract
The present paper is a review article for the regulatory framework about climate change focus on reduce the gas emissions on the greenhouse effect of the Mexican cities under an urban-architectural perspective, and from this revision the authors propose a guide (ten points) that can be helpful to take in consideration for planning and pre-designing of cities and components, such as urban infrastructure and equipment. Mainly this is a revision of the documents of the different general law of ecological balance and protection of the environment in its section of the environmental impact as well as the revision of the national agreement of climate change based on the same law about the climate change in Mexico; Also the models and methodologies about sustainable of buildings and built actives, would be revised all together with their laws and regulations. It is concluded that in Mexico it is of the utmost importance to reduce environmental impacts caused by building and planning cities from an urban and architectural approach, and what better than from the planning and design phases of urban infrastructure.
Keywords: Carbon footprint; Environmental impact; Sustainable design; Sustainable planning, Green cities.

1. INTRODUCTION

It is necessary recognizing the main actions that can be taken in order to adapt a climate change caused mainly by the gas emissions of the greenhouse effect in the cities (Kennedy, 2011). This article presents the basic terminology used in environmental impact, climate change and sustainable urban planning followed by a revision of the regulatory framework about the topics, and in the end, a revision

for the main actions that are being considered at national level to face the climate change in Mexico, including a proposal in form of a guide (ten points) from the authors. This paper contains the emphasis of urbanism and architecture under an environmental approach that allow us to have access to the knowledge that can be used to resolve complex problems in different cities.

2. REDUCTION OF THE CARBON FOOTPRINT ON CITIES UNDER THE URBAN ARCHITECTURAL APPROACH

The previous basic terminology allows the introduction of the main topic, the reduction of the footprint in cities under the urban architectural approach. The way to reduce the carbon footprint from this approach is, first, by reducing the environmental impacts created mainly by the effects of the energy and the use of the resources during this process, operation and maintenance (what is essentially the service life of the urban infrastructure and equipment); Second, by reducing the carbon footprint of the construction materials that are used to build the cities (Lockie and Berebecky, 2012); understanding the carbon footprint of the materials like all the gases from the greenhouse effect and the emissions of CO2e that were released to the atmosphere the moment the product was extracted,transported and manufactured, this is called “from the cradle to the door”.

Another period of the life cycle of the materials could be called “from the cradle to the construction site” and in this case the emissions of CO2 generated from the moment of the extractions of the materials are measured. When the carbon emissions are measured from the moment of extraction of the materials, during the process of manufacture, the end of the construction, use, maintenance and operation of the constructions in the different stages like remodeling, demolitions, etc. until the treatment of the waste and all remains of the building it´s called “from the cradle to the grave”. It exist another similar concept from the previous and it´s called “from the cradle to the cradle” which is practically all the cycle until it becomes a new product or material with similar characteristics (For example: the manufacture and recycle of aluminum).

It´s important to mention that talking about environment that are a series of regulations ISO 14000 that talked about the environmental management of all the processes in production that is very useful for the enterprises and institutions that want to adopt politics of protection for the environment.

Talking about the reduction of the carbon footprint on materials and processes, the regulation ISO 14040 about life cycle Evaluation,it is a methodology that helps directly on the processes of reduction of environmental impact, among them, the carbon emissions. This methodology is resumed in figure 1

Theoretical and Empirical Researches in Urban Management
Volume 11 Issue 2 / May 2016

where you can observe that during the life cycle of any product there is always inputs of raw material and energy and outputs of waste, and emissions that always pollute and can be measured.

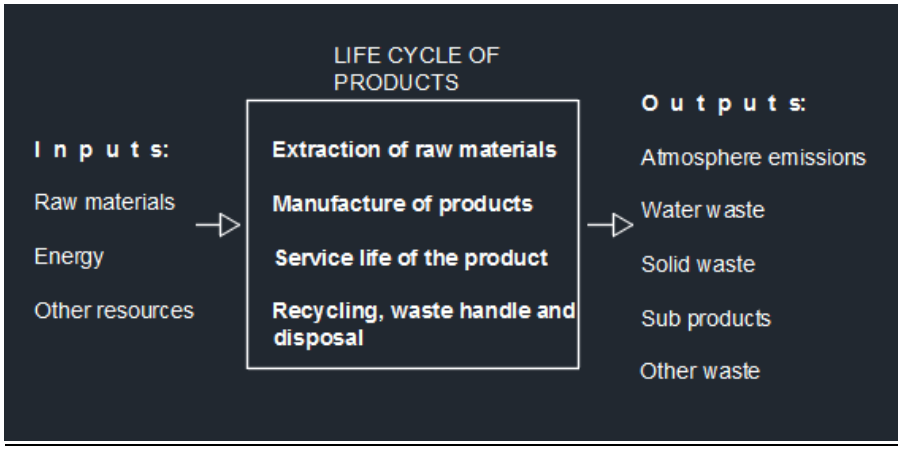

FIGURE 1 - INPUTS AND OUTPUTS DURING THE LIFE CYCLE OF A PRODUCT ACCORDING TO REGULATION ISO 14040 (INTERNATIONAL STANDARDS ORGANIZATION, 1997).

By other hand, equivalent CO2 emissions can be exemplified as: 1 Kg of methane is the same as 25 Kg of CO2, therefore 1 Kg de methane = 25 Kg of CO2e. Table 1 presents some instances of greenhouse effects and their CO2e.

TABLE 1 - GLOBAL WARMING POTENTIALITY FOR SOME GREENHOUSE EFFECT GASES AND THEIR CO2E.

Greenhouse effect	CO_2 e	Source
Carbon di-oxide(CO_2)	1	Energy combustion bio- chemical reaction.
Methane (CH_4)	25	Decomposition.
Nitrous Oxide (N_2O)	298	Fertilizers, car emissions and manufacture products.
Hexa-fluoride of sulfur (SF)	22, 800	Electrical Sub-stations, switches and gears.
Per-fluoride-carbons (PFC)	7, 390-12, 200	Aluminum melting.
Hydro-fluoride-carbons (HFC)	124-14, 800	Refrigerants and industrial gases.

(Source: Lockie and Berebecky, 2012).

The quantity of carbon contain in materials are all those carbon emissions to the atmosphere, associated to the consumption of energy and the chemical processes during every life cycleof materials or products, express in Kg of CO2e by Kg of material. Another important concept “the operational carbon” that refers to the carbon emissions that are generated during the servicelife of buildings, this is the phase of use, maintenance and operation of the buildings. This carbon emissions from the energy that is used by the building, such as artificial lighting, air conditioningand heating, water heating, refrigeration, use of appliances and electrical equipment in the building, etc. in fact this is the part of the life cycle of the buildings that impacts the most,from there, the importance to estimate the service life of construction components and it´s parts (Hernandez, 2015) to be able to calculate the carbon footprint thus the global warming potential is a relative measure of the quantity of the greenhouse gas that is

estimated to contribute to the total global warming atmosphere measured in CO2e. Another concept, that is important, is to understand the measure of the carbon footprint in the materials, "recycle content of a product", that is defined like the portion of a product that contains materials that had been recover (solid wastes) and integrated to the processes of manufacture of such a product. The study of the footprint in buildings is a relatively new field and contains many situations still under experimentation and development. In Mexico exist little information generated that can be used as practical information and statistical in the matter, this is why if we want to experiment or make simulation analysis of the life cyclein materials and buildings and it´s parts we have to use the Software and information that comes from different countries. This information is useful but it has to be adapted to the Mexican context in order not to make measuring errors. This Software and tools (table 2) are useful as models to apply in Mexico but aren´t exact for studies and particular cases due to the differences in the processes of the designing and building that are peculiar in Mexico.

TABLE 2 - SOFTWARE FOR LIFE CYCLE ASSESSMENT (LCA).

SOFTWARE TOOL	DESCRIPTION
BEES® 3.0	Construction products evaluation
BOUSTEAD MODEL® 5.0	Analyzes the energy sources and raw materials
CMLCA® 4.2	Helps on the execution of processes in different industries
DUBO-CAL®	Makes inventories of construction materials
ECOINVENT™ 1.2	Evaluates environmental impacts and the footprint in different materials and industries
ECO-QUANTUM™	Evaluates the quality and quantity of the information about construction of 1000 products
EDIP PC-TOOL®	Reviews information of processes and materials about the life cycle of different products
EIOLCA.NET®	It´s a web page that allows users to estimate the impacts of products and materials
ENVIRONMENTAL IMPACT INDICATOR™	This software was prepared by architects, engineers and researches to get information about LCA of products and materials for construction
GABI® 4	It´s that evaluates the LCA, environmental impacts, costs of life cycle and aspects of social responsibility of the products, processes and technologies
GEMIS®	Evaluates the life cycleof the energy, materials and transport systems. Offers information about renewable and fossil energies and its intervention in transport systems
GREET® 1.7	Focuses basically on the evaluation for the life cycleof fuels destined to the production and use of energy
KCL-ECO®4.0	Evaluates the Life Cycle (LC) of complex systems that includes characterization, normalization and application, and provides graphics.
LCAIT™ 4.1	Includes information in its data base for the evaluation of environmental impacts including characterization and application factors.
LCAPIX™ 1.1	It´s a program that is use to evaluate the availability of environmental products, processes and services, based on the analysis of cost and environmental impact of each product.
MIET® 3.0	It´s used to generate inventories on excel related with the LCA and environmental impacts.
SIMAPRO™ 6.0	It´s a software tool that evaluates environmental impacts through different methods and different inventories of data base.
UMBERTO™	It´s used to evaluate the environmental impacts mainly the raw material and energy used by the products.

Source: Hernández, 2012

Theoretical and Empirical Researches in Urban Management
Volume 11 Issue 2 / May 2016

3. REGULATORY FRAMEWORK ABOUT CLIMATE CHANGE IN MEXICO

The regulatory framework for environmental impact in Mexico starts with the General Law of Ecological Balance and Environmental Protection (Ley General del Equilibrio Ecologico y Proteccion al Ambiente, LGEEPA) emitted by the Secretariat of Environment and Natural Resources (Secretaría del Medio Ambiente y Recursos Naturales, SEMARNAT); in its section of environmental impact article 28, said that all the work and activities that change the environment must be evaluated in order to be authorized, for the studies of environmental impact. This is very important because organizes the territory plans in the cities and stablishes the mechanism for its regulation. The evaluation of the environmental impact, is the process in which the SEMARNAT stablishes the conditions to regulate the processes and activities that could change the ecological balance and overpass the limits and conditions establishedunder the regulations to protect the environment and preserve the ecosystems, in order to prevent or reduce to the minimum the negative effects to the environment (Cámara de Diputados del H. Congreso de la Unión, 2012). The rules of the LGEEPA will determine the construction and activities that refer to its article 28 according to location, dimensions and characteristics that might produce significant environmental impacts In order to prevent ecological damage, making sure that none of this activities overpass the regulatory dispositions or will be subject to a process of evaluation of environmental impact according to the law (Cámara de Diputados del H. Congreso de la Unión, 2012). The article 29 of the LGEEPA mentions the negative effects to the environment, natural resources, wild flora and fauna and other resources that refers this law, could be subject to the official Mexican dispositions and regulations about environment and the legislation through permits, licenses and concessions regulated by the framework (Cámara de Diputados del H. Congreso de la Unión, 2012), this means that every activity that might change the environment in the cities would be regulated and control by the regulatory framework.

The same way we highlight the agreement that refer to the National Strategy on Climate Change (Estrategia Nacional de Cambio Climatico) (3-junio-2013) emitted also by SEMARNAT as the instrument to regulate the national policies in the mid and long terms to face the effects of climate change and to move into a competitive economy, sustainable and with low carbon emissions elaborated by SEMARNAT and with the participation of the National Institute of Ecology (Instituto Nacional de Ecologia) and the opinion of the Council of Climate Change (Consejo de Cambio Climatico); approved by the Inter-secretariat Commission on Climate Change (Comision Intersecretarial de Cambio Climatico) and published in the Official Journal of the Federation (Diario Oficial de la Federacion) (Diario Oficial de la Federacion, 2013). This agreement was made in order to follow the National Plan of Development (Plan Nacional de Desarrollo) that is taken like the main direction for sustainability, and

applies in all the national territory to prevent and reduce the quantities of gas emissions in the greenhouse effect.

The objectives in this agreement are as follow:

1. The strategy looks for a long period (the route for 10, 20 and 40 years).
2. Promotes the sustainable handle of the natural resources (forests, water, soil, air) in the three orders of government.
3. Promotes the use of clean and renewable energies that allows the development of lower gas emissions that are part of the greenhouse effect. Authorities have a responsibility in the field of renewable energy, therefore, their role in managing the energy sector being more diverse and profound (Zamfir, 2014).
4. For Mexico, to become prosper and competitive country that has a social global responsibility that generates enough and well paid jobs for its population.
5. Propose a nation that is socially equitable, with a green economy, with ecosystems and populations resilience to the climate change and with sustainable cities.
6. To count with coordinated and articulated politics to develop the economic and financial instruments to promote the investigation to reach a climate culture in society in order to measure, monitor and report about the climate change to strengthen the international cooperation.
7. To complied with the objectives of reducing 20% of the emissions by the year 2020 and 50% by the year 2050 comparing by the emission of the year 2000. This requires structural transformations in the developing model of the country.

“Mexico will transform this great challenge into the opportunity to conserve and use are natural resources in a sustainable way using wisely our enormous potential to develop clean energies, correcting inefficiencies in the use of the energy, generating jobs in a green economy, promoting the sustainable territorial development, increasing competitively and improving the public health and the quality of life of its population”(Diario Oficial de la Federacion, 2013).

a) Transition to cleaner sources of energy.

b) Making the consumption of energy more efficient.

Theoretical and Empirical Researches in Urban Management
Volume 11 Issue 2 / May 2016

c) To move into sustainable city models with integral systems of mobility and waste management with lower carbon footprint.

d) To improve the agricultural practices to preserve and increment the natural reduction of carbon.

e) To conserve the biodiversity of the ecosystems.

Part 7 of the agreement about climate change focuses in the development of low emissions, and it´s resume in the following.

Short term:

- The use of alternative energies for example: biogas, wind and solar energy.
- To increase the number of national hybrid vehicles and control the foreign vehicles.
- The reduction of wood burning and make more efficient lighting and refrigeration.
- Creating programs to improve the quality of the air in the cities.
- Replacing 30-50% to clean energies.
- Reforesting to absorb more carbon.

Long term:

- To use 100% of vehicles with clean energy.
- Change to a 100% of clean energies in all areas.
- To use the hydrogen as a main source of energy.

In the other hand, it´s important to mention that in 1990 and 2010 the gas emissions of the greenhouse effect in Mexico increase in 33% (Instituto Nacional de Ecología, 2010) and because of this nowadays this high tendency it´s been under observation, there´s a little improve however. After the agreement of the Estrategia Nacional para el Cambio Climatico, there is no clear evidence or improvements that can be measured due to the lack of will from recent governments. One of the objectives of the Estrategia Nacional para el Cambio Climático is to reduce the carbon emissions in 30% by the year 2020, objective that looks unreachable at this moment. The fact is that all this agreements and laws look to be well written and with the best intentions but for the moment the governments that are responsible to make this happen find many obstacles like the lack of public planning and concrete programs, specifically in the development of science and technology in Mexico. The same problem is found with

the extraction, production and distribution of oil that instead of generating our own techniques and technologies for extraction, we open the doors for foreign companies to come and do what we suppose to. Because of this there are risks for the Instituto Nacional de Ecología to stay behind its problems like the Oil Institute (Instituto del Petróleo) regarding hydrocarbons.

Talking about the environmental impacts caused in the cities, it is important to mention two of the sectors that present more emissions are the residential sector with 19 % of the total and the transport sector with 10% which affects directly in the urban areas and cities (Instituto Nacional de Ecología, 2013). To be responsible architects, constructors and developers should adopt and adapt environmental models and methodologies in their process of design, plan and construction, in order to be part of the solution and not the problem. The following information approaches solutions in the form of strategies, actions and recommendations to adapt cities to the climate change.

To talk about the reference and reduction of the carbon footprint in buildings there is an international norm ISO/TS 14067:2013 (Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification and communication) that is designed to describe a method to calculate the carbon emissions in materials. This rule could be very helpful for architects, engineers, builders and producers of construction materials to develop studies that allow taking decisions during the election of materials construction systems and the way to design spaces, installations and services.

4. STRATEGIES AND ACTIONS TO IMPLEMENT REDUCTION AND ADAPTION OF CLIMATE CHANGE IN MEXICAN CITIES. URBAN-ARCHITECTURAL APPROACH

The LGEEPA says that the construction and activities that modified the environment should be evaluated with studies of environmental impact in order to be authorized. Technically these studies are regulated under a technical rule and should cover the following points to be presented to the SEMARNAT. To elaborate an environmental impact study, different stages and tasks are required and are mention as followed (SEMARNAT, 2015):

1. 1.Description of the project or activity to be done: in this stage the project or activity is described and analyzed, highlighting the environmental approach with its most evident strengths and weaknesses.
2. Divided the project or activity in its main elements: this task should be performed in a uniform and systematic way for each of the four phases accepted: site preparation, construction, operation and project ending. Every activity related to the project should be checked in order to identify the environmental impacts.

Theoretical and Empirical Researches in Urban Management
Volume 11 Issue 2 / May 2016

3. Description of the environmental state previously stablish in the project: description of the physical environment and its elements biotic and abiotic in a clear way and backup with reported evidence and direct observations in the field. This stage includes the study of the social and economic environment in the zone where the project is going to be developed.

4. The most significant elements of the environment: this part resumes the information that allows determining the meaning that the most relevant elements of the environment have, previously analyzed for their conservation. The criteria according to the magnitude of importance in the environment will have to be defined, such as diversity, altered singularity, and devalue of each topic should have an integral approach.

5. Application scope of the environmental impact study: the application scope of the study will defined the coverage that this one will have, for each of the elements previously described its presence or not on each of the natural protected areas or with partial developing urban plans or the territory, as well as the following of the official Mexican rules to the date.

6. Impact identification: with this stage, the study reaches one of its most important faces, the idea is to define the aftermath that the project will have or the activity to be done about the described environment and all its significant elements will have. Each impact should be valued on a logical base, which can be measured and easily identified. Later the analysis should reach a point that will allow identifying, value and measuring cumulative effect of the total impacts identified.

7. Alternatives: if there were two or more alternatives for the project or activity, these will be analyzed and measured according to the base of its environmental significance and selected by its capability to better adjust to the needs and maintenance of the environmental balance, like the objectives, characteristics and necessities of the project.

8. Identification of the mitigation measurements: the importance of this stage should be evident in the final report with the proposal of the logical measurement and viable in its application.

9. Valuation of the residuals impacts: this concept is applied to the identification of those situations, negative for the environment that can be generated for the lack of prevision or the men interference after the project started its operation.

10. Monitoring and control plan: in this stage the study should defined the impacts that would be considered In the monitor and control planning; to determine the evaluation parameters the

efficiency indicators of the plan, the activity frequency, and the areas and characteristics of the sample.

The manifest of the environmental impact assures, in most cases that the changes in the environment will not cause irreversible damaged of negative environmental impacts of significance in the site of the project. The environmental impact studies helps in the national territorial system and the urban development plans of the different locations and regions where they are located. It is also a legal document for the development projects that put in risk the environment and its resources: biotic, abiotic, scenery social-cultural environment and everything within. The cities are an environment built in the middle of a natural environment and because of this will require good environmental and urbanistic planning.

On the other hand based on the Ley de Cambio Climatico and the agreement for the Estrategia de Cambio Climatico, (both mention in the previous point) the following actions and strategies are proposed to help specifically in the reduction of gas emissions in the greenhouse effect in the cities of Mexico. In the form of Decalogue and with urban-architectural approach:

1. Conservation of the biodiversity of the place, including the conservation of resources not only biotic (flora and fauna) but also abiotic (weather, topography, soil, water reserves, atmosphere, etc.) and the scenery.
2. Respect and improvement of the use of land and the regional and local urban plans. The idea is to integrate plans and strategies based on the local urban plans to help in the reduction of negative environmental impacts, specifically the carbon emission to the atmosphere. It is being confirm that the change in the use of land (generally from forestall to housing or commercial) it´s very harmful to the environment. This added to the use of fossil fuels, is causing a severed increment on the global warming (Cheung y Jor, 2013) and destroys the natural climate cycle and the natural water reserves, causing always erosion and damage to the ecosystems.
3. Using sustainable urban planning and architectural design that should include: sustainable manage of the area, sustainable manage of water resources, sustainable manage of energy (passive and active), sustainable manage of constructions materials and waste and comfort in and out of the buildings (Hernandez, 2010).
4. Sustainable manage of parks and gardens in the cities, including reforestation and carbon capture. We all know that the green areas capture carbon and it´s very important that the cities

Theoretical and Empirical Researches in Urban Management
Volume 11 Issue 2 / May 2016

count with green areas not only to capture carbon but also to improve the thermic comfort in the environment and to recharge the water supplied available (Wilcox, 2012).

5. Sustainable manage of the transport and mobility in the cities. Refers to the sustainable planning and management of the transport infrastructures in the cities. Mainly providing choices for alternative transport, like bicycle, motorcycle and public transport that includes: buses, trains and other vehicles that use clean energies free of carbon; reducing the use of private vehicles and increasing pedestrians in the cities (Thomas et Al., 2014). In the Mexican cities like in many other countries the increment of the quantity of modern vehicles is generating over population in the cities, this is why is difficult for cities to provide coverage for this infrastructure. For this reason programs like "hoy no circula1" are implemented to try to reduce that problems. The programs that should be implemented in Mexico are mainly: a) to create the use of vehicles with low emissions based on clean fuels and cleaner engines; b) the used of ecological fuels, mainly electricity for trains and buses (produce by hydro-electric plants); c) improvement of the public transportation; d) pedestrians and bicycles; e) improvement of the urban infrastructure to promote the use of public transport, motorcycles, bicycles and pedestrians (Hickman et Al., 2010); f) reduction in the cost of transport, mainly the gasoline and diesel.

6. Sustainable infrastructure and equipment through the urban design and planning. About the improvement of the infrastructure and equipment in the cities through the design and planning specifically in the population and sizes of the cities that would help in the efficiency of the infrastructure and installations by cubic meters required (Welzig and Steixner, 2012), and its sustainable design (Hernandez, 2010).

7. Integral management of residues including those of the construction industry. It´s very important that all the municipalities together with the people in charge of the construction be responsible for 100% of the waste generated by constructions in the cities. The government will have the obligation not only to administrate the municipal waste, but also to stablish the programs for the recycling of the construction residues. For example a study developed in Japan shows that one of the forms to better reduce the carbon emission in the construction industry is to reduce the quantity of construction materials, specifically the reduction of steel,

[1]This can be understood as "A day with no car" (literally, Today your car does not circulate). A governmental program that prevents certain vehicles from being used one day of the working week and on Saturdays. Set late in 1989 in Mexico City, this scheme was devised to lower carbon emissions from automotive vehicles, and so improve the quality of air.

aluminum and cement in the buildings. Some of these elements could be replaced by the waste of ash coming from high volume ovens to elaborate concrete to be used for constructions that require high mechanical resistance (Dong et Al., 2014).

8. Planning of the durability and service life of components in the cities. It is very important to make inventories for the life cycle of the products, studies of durability and service life of materials, to make a quantities estimate of the environmental impacts. Very specific Life Cycle Evaluation (LCE) of the construction products that are generating a quantity of carbon to the atmosphere and other environmental impacts. Also important is to design the durability of the construction components to make sure that they complied with the service life expectancy and above all to reduce the cost of maintenance and replacements (Hernandez, 2015a).
9. Conservation of soil, air and water. All this actions are taken in order to guarantee the protection of soil, air and water wherever they could be affected (Cámara de Diputados del H. Congreso de la Unión, 2012).
10. Prevention and reduction of risks in the cities. This point is the vital importance to stablish mechanisms that could protect the human beings from possible floods, earthquakes, hurricanes, etc., cause mainly by the effects of global warming (Harlan and Ruddell, 2011; Li et Al., 2011).

In order to reduce the carbon footprint there are in the world different models of environmental design for buildings and cities, such as the American model Leadership in Energy and Environmental Design (LEED®) (United States Green Building Council, 2014) which is very useful for the certification of environmental building in the United States, but here in Mexico not all its aspects can be applied because, in Mexico we use different materials and systems for construction and urban planning. In particular designing and planning of the infrastructure and equipment sometimes doesn't adjust to the foreign models; this is why the task of the Mexican architects is to adopt and adapt these models and methods to the Mexican context (With some modification are very useful), which is the case of the present Decalogue. There are some other models like the European BREEAM® (Building Research Establishment, 2015), there are also some Arab and Japanese models based on the same areas of environmental design similar to the LEED® and BREEAM® (site, water, energy, materials, waste, transport, air quality and technological innovation).

The government of Mexico City through the Secretaría del Medio Ambiente emitted in 2008 through the Gaceta del Distrito Federal a program for certification of sustainable buildings, which is based in the same models mentioned on the previous paragraph and which objective is to promote the reduction of

Theoretical and Empirical Researches in Urban Management
Volume 11 Issue 2 / May 2016

contaminant emissions and the use of enough natural resources in the design and operation of buildings in Mexico city; as an instrument of environmental planning, designed to transform and adapt the buildings today and tomorrow under the same criteria of environmental efficiency and sustainability.

5. CONCLUSIONS

We can conclude the following:

- The climate change is imminent and it´s necessary to implement actions, strategies and programs that can reduce and prevent the increment of the global warming in the atmosphere because this brings many negative consequences to the planet and the human beings in the form of natural disasters that we have to be prepared to face like hurricanes, floods, tidal waves, etc.
- From the urban-architectural approach is necessary to implement and carry out methods of design and planning for cities that allow reducing the effects of CO2 in the areas of: energy, water, transport, materials and waste in cities and buildings.
- It´s important to mention that nowadays there are “good” intentions from the three levels of Mexican government, but in reality the sexennial goals haven’t been reached. In the paper the written laws and regulations show and strategic plan but in the practice is not happening, which is a national problem and something that has to be taking in consideration in order to find a quick solution.
- Dealing with culture and education it´s very important if you want to modify the uses and customs about the use and consumption of human and material natural resources, this is why in the urban-architectural approach, methods and models that allow reducing the environmental impacts during the service life of the infrastructure and equipment should be implemented.

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