# THE CARBON FOOTPRINT OF HOUSING POLICY IN MEXICO FROM 2000 TO 2012.

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ABSTRACT

The data census for Mexico show that between 2000 and 2012, the housing stock grew by 76%, equivalent in absolute this numbers increased 7.610.258 million houses during this period (INEGI, 2012). Therefore, for the massive new residential urban development built during this period causing this increased demand for land, the basic urban services, the transport and the roads. Moreover, in some cases the recharge aquifers areas urbanize, the forests are cut energy costs and greater mobility generated by the distant location, which results in increased production of Greenhouse Gases (GHG). Treat these streams requires the necessity to use of national data to support the development of Inventory Life Cycle (ILC) for the housing sector for a decade. This is achieved through the Input-Output model (IO), which has been used in the development of ILC with good results, allowing to related national data input and output of industrial sectors, from the raw materials used to produce consumption representing transactions and industrial flows.

In this work we present advances of LCI on the Mexico Housing Policy in the period 2000 to 2012, developed from IO model. The results obtained to date suggest that the Housing Policy of Mexico in the period 2000 - 2012 contributed 17% of total emissions of GHG to Mexico within the results demonstrated that during this period the industry cement, lime production and use of limestone and dolomite increased their emissions by 65.2%, 22.5% and 521.7% respectively, as a result of the Housing Policy. Furthermore, it is concluded that the IO approach is a methodology that supports the development of Life Cycle Analysis and allows its use at national level.

*Keywords: Housing, Life Cycle Analysis, Input –Output.*

## 1. INTRODUCTION

At present, there are several complications facing the housing sector in Mexico, related environmental, political, social, economic and cultural. For one population growth makes the housing deficit increases, state policies that favor mass housing construction by private companies, regardless of the actual needs of users leaving aside the necessary infrastructure (health, transportation, education, work) to inhabit a space.

Another no less important point is the consumption of natural resources programs and housing policies have sued, mobility and transport problems, consumption of non-renewable energy, use of raw materials for the production of materials and construction elements among others.

The effects of urbanization and climate change are converging forms dangerous that threatening to the exhaustion of natural resources, and therefore the increase of the environmental impacts that reduces the quality of life of the inhabitants.

This research presents a Life Cycle Analysis (LCA), focused on the impact category Climate Change, in which the emissions of greenhouse gases (GHG) quantified using the Input - Product Tables of the System of Accounts National de Mexico (INEGI, 2010).

LCA is a methodology that assesses the environmental impacts of products or services, considering all stages: extraction of raw materials, production of construction materials, construction of housing, use of housing, demolition and disposal. In this analysis the economic model adopted Input - Output, to identify relationships of materials and energy consumption in housing production in Mexico during the period 2000-2012.

## 1.1. HOUSING POLICY IN MEXICO

Mexico is a nation with an important history in the production of social housing. Since 40 years ago was established, an Institutional Housing System (SIV) based on an interventionist model of State. Since then it has a robust legal and regulatory framework that specifically regulates the production housing.

This SIV was transformed from the 1990's to a facilitator model delegating promoting private sector adopted, while institutions operate as funding of mortgage loans for housing purchasers (PUEC, 2012).

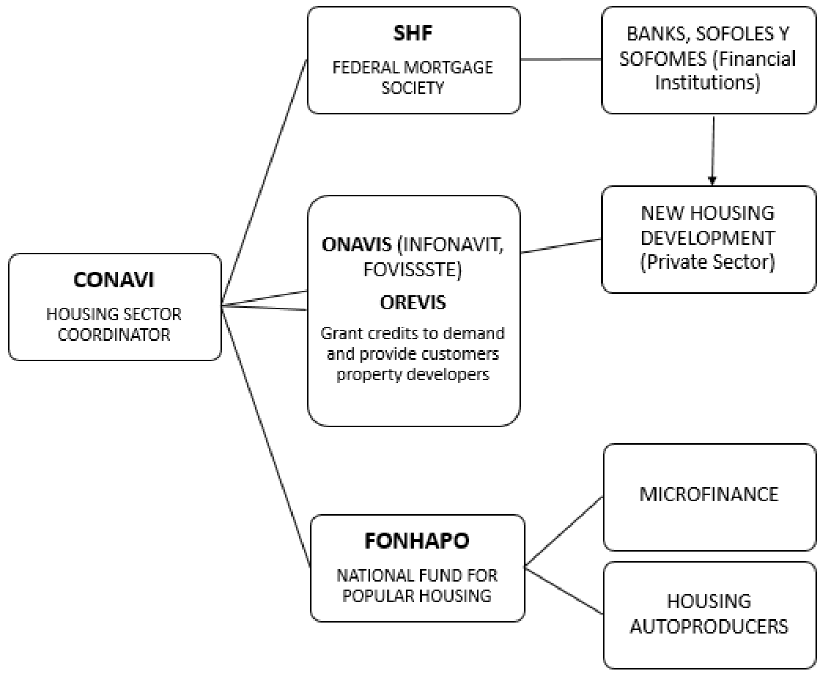



Figure 1. Institutions involved in the IHS. Modification PUEC – UNAM, 2012

## 1.2. ECONOMIC INPUT – OUTPUT MODEL AND THEIR APPLICATIONS

The Economic Input – Output (EIO) model, is an approach that uses the sectorial economic data available nationally therefore manages information of the economy of a country, which is the limit of the analytical system.

The EIO model was developed by Wassily Leontief, this model allows to quantify the proportional relationships between economic sectors of an economy through the worn inputs and industrial production of each sector (Leontief, 1941). Combining national data, sector by sector, economic interaction, considering the dependencies between sectors and showing changes related to economic demand.

The EIO has taken great importance, many countries have information on its industrial sectors, an example of which is the United States the country with more defined industries and a wide range of environmental data available to the public, other countries such as Japan, the Netherlands and China, have complemented the EIO tools methodologies to estimate the environmental aspects and potential impacts associated with industrial processes among the best known and relevant the Life Cycle Analysis (LCA).

The first scientific work that was done by combining data Input-Output Analysis (AIO) was to Bullard in 1978 who focused on the analysis of energy.

At Carnegie Mellon University in the US, has developed a computational tool based on Input - Output Tables and Life Cycle (IO-LCA) (Hendrickson et al 1998, Lave et al 1995) analysis, data IO-LCA include 1997 data Input - Output (IO), (Suh, 2004).

In the US, the Department of Commerce has information on censuses (manufacturing, production and use) in sectors such as electricity, fuel, waste generation and others. The Environmental Protection Agency US has information on climate change, resource consumption data in different industrial processes and emission factors that provide reliable information to develop research projects using the IO-LCA.

In 1990 in Japan the first analysis using the model developed Input - Output, were the first to analyze $CO_2$ emissions life cycle of a car, using both the Input - Output in Japan and process analysis (Suh, 2004).

## 1.3. SYSTEM OF NATIONAL ACCOUNTS OF MEXICO

The System of National Accounts of Mexico (SNCM) is constructed as a sequence of accounts that record economic flows related by different economic activities carried out by agents or sectors in a given period. Each account is related to activities such as production, generation, distribution, redistribution and allocation of income, achieving balance them by introducing a balancing residually defined as the difference between resources and total registered uses on both sides of each account. This balancing item in a specific account, takes as the first item to the following account thereby allowing articulation of all these accounts and the closing balance (INEGI, 2003).

### *Input - Output Tables*

The input-output tables (IOT) is a set of tables that reflect and update the formal relations that perform the various economic sectors and actors involved in all phases of the economic cycle (production, marketing, consumption and accumulation).

The starting element model of Input-Output Economics is the transformation of Tableau Economique of François Quesnay, an instrument of economic analysis and projection, whereby it is possible to make decisions for economic policies (INEGI, 2013).

Considering that each sector produces one product, implies that intersectoral transactions must correspond to a symmetric matrix, so that the model explains this interaction called symmetric Input-Output model. Thus, intersectoral relations transformed into technical relationships and each column of a table of coefficients of input-output represents a production technique (INEGI, 2013).

This model is considered "open" because it relates the total output of a sector, with the final demands of all sectors; that is to say, consider not only the needs of the final production to meet demand, but also the entire chain of reactions that implies in intersectoral transactions. Thus, final demand considered as if it were exogenous.

# 2. METHODOLOGY

In Figure 2 shows the proposed methodology to determine the contribution of National Housing Policy to Climate Change.

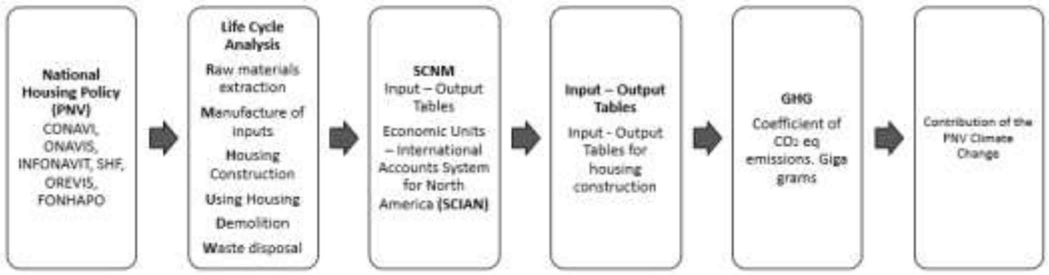



Figure 2. Methodology

## 2.2. Construction of the Economic Table for Housing Construction in Mexico

The construction of the IOT for housing construction in Mexico was performed using data published by the INEGI (2013), in the section on national statistics; for building data subsectors that impact housing construction in Mexico were taken into account.

A detailed survey carried out in the North American Industrial Classification System (SCIAN) to know how they are classified sectors, subsectors and branches of industries in Mexico, as well determining the inputs and outputs involved in the housing in economic aggregates.

### *Construction Emission Coefficient ($CO_2$ eq)*

To determine GHG emissions in units of $CO_2$ equivalent in each of the subsectors involved in the life cycle of the housing of the Input - Output 2003, 2008 and 2012, we start with the information from the National Inventory of Greenhouse Gases from the National Institute of Ecology and Climate Change (INECC, 2013). GHG emissions expressed in Giga grams of carbon dioxide equivalent, obtained by considering the emissions of six greenhouse gases (Gg $CO_2$ eq.): Carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride ($SF_6$).

A review of the categories and subcategories that are in the National Inventory of Greenhouse Gases (2013) performed. In Table 1, the activities involved in the life cycle of housing and $CO_2$ eq emissions presented.

Table 1. Activities and Emissions in the Life Cycle Housing

| CATEGORY OF EMISSION | 2000 – 2012 $CO_2$ eq. |
|---|---|
| 1. ENERGY | - |
| 1A2. Manufacturing and Industry Construction | 1,147,473.43 |
| 1A4b. Residential Sector | 832,282.90 |
| 2. INDUSTRIAL PROCESSES | - |
| 2A. Industry minerals | 875,002.24 |
| 2A1. Cement Production | - |
| 2A2. Lime Production | - |
| 2A3. Limestone and Dolomite Use | - |
| 2A4. Production and use of Sodium Carbonate | - |
| 2A5. Asphalt Roofing | - |
| 2A6. Asphalt paving | - |
| 2A7. Glass | - |
| 2C. Metals Industry | 135,612.04 |
| 2C1. Iron and Steel Production | - |
| 2C2. Ferroalloy Production | - |
| 2C3. Aluminum production | - |
| 2C4. Using sulfur Haxafluoruros smelters Al - Mn | - |
| 2F. Consumption of halocarbons and sulfur hexafluoride | 236,739.78 |
| **TOTAL** | **1,529,698.21** |

The total emissions is 1,529,698.21 Gg $CO_2$ eq., with this value the $CO_2$ eq. emission coefficient is made for each of the subsector IOT involved in the life cycle of housing. Table 2. emission coefficient shown.

Table 2. Emission Coefficients subsectors of the Input – Output Tables

| SUBSECTOR | | UTPI* VALUES IN MILLION PESOS | % SUBSECTOR HOUSING CONSTRUCTION UTPI | COEFFICIENT OF EMISSION $CO_2$ eq. Gg |
|---|---|---|---|---|
| 236 | Edification | 3,393,051.16 | 31.63 | 483,908.61 |
| 237 | Construction of civil engineering works | 1,372,594.22 | 12.80 | 195,756.01 |
| 238 | Specialty Trade Contractors | 396,103.47 | 3.69 | 56,491.30 |
| 321 | Wood industry | 153,147.43 | 1.43 | 21,841.51 |
| 327 | Product Manufacturing Nonmetallic minerals | 639,149.02 | 5.96 | 91,153.86 |
| 331 | Basic metal industries | 1,183,515.45 | 11.03 | 168,790.06 |
| 332 | Manufacture of metal products | 220,398.36 | 2.05 | 31,432.67 |
| 333 | Manufacture of machinery and equipment | 670,022.33 | 6.25 | 95,556.94 |
| 337 | Manufacture of furniture, mattresses and blinds | 872,766.75 | 8.14 | 124,471.85 |
| 484 | Trucking | 1,494,634.72 | 13.93 | 213,161.13 |
| 485 | Land passenger transport, except by rail | 330,494.22 | 3.08 | 47,134.27 |

* Total use of domestic output at basic prices.

# 3. RESULTS

In this analysis 11 subsectors that are associated with the construction of housing sector were identified, these were analyzed under two approaches, the first involved in the life cycle of housing construction, the associated processes from extraction of raw materials, manufacturing inputs, construction, use, demolition and disposal of waste and the second approach, SCIAN 2013, where they are classified economic activities and general considerations of the processes that take into account each subsector.

In Table 2, it can be noted that the Edification subsector (SCIAN 236 identification code), this includes: Economic units devoted mainly to the construction of single family or multifamily; can include new work, additions, renovations, maintenance or repair of buildings. It also includes construction in own grounds before being sold. This subsector represents the first financial flow and consumption of inputs; for the period from 2000 to 2012 with $ 3,393,051.16 in millions of pesos.

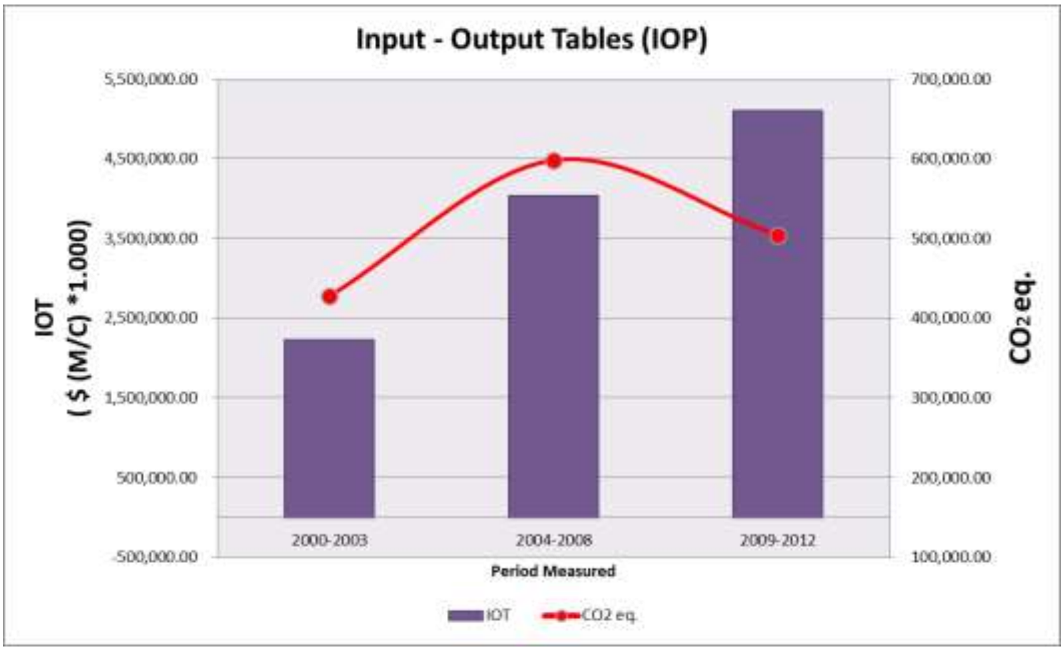
While the Manufacture of wood subsector (SCIAN 331 identification code), comprising: Economic units devoted mainly to the manufacture of various wood products in integrated sawmill; to cut for boards and planks from roundwood; impregnation and wood treatment; in the manufacture of poles and sleepers from lumber; to the manufacture of laminated and bonded wood; manufacturing, from lumber, wood products for construction. It was I represent lower consumption of inputs from 2000 to 2012; their monetary exchanges were at $ 153,147.43 in millions of pesos.

Total emissions of $CO_2$ eq, generated by the subsectors that comprise housing construction (Table 3), distributed according to the interrelationships that generated between them, the subsectors that contribute most to climate change are most establish relationships between inputs and production of goods.

The results obtained so far in this research project suggests that since the life cycle of housing construction approach contributes 17% of total GHG emissions from 2000 to 2012 were of 9,025,262.84 Giga grams $CO_2$ eq., approximately.

In Figure 3, the total GHG emissions from 2000 to 2012 and consumption of inputs and outputs of the subsectors involved in housing construction are related.

Figure 3. Correlation between GHG and housing production from 2000 to 2012




In the analysis it can be seen that the increase in consumption of inputs for housing production became exponentially, along with changes in housing policy in Mexico between 2000 - 2003, 2004 - 2008, of all financing granted by a group of housing agencies predominated full housing refers to housing financing exercised whose execution is done through a continuous and unique process (completed home) under the management of public agents and / or private, accounted for 60% in the first period and 90% in the second.

Following in importance for the physical improvement with a 32.2% share of the total; The initial funding for housing or homeownership with gradual from a basic unit development, had a share of 5%, the financial improvement or financing to facilitate the payment of a mortgage loan for housing in its infancy 1.2% of the total percentage and infrastructure relating to the support for the purchase of lots, supply of construction materials among others, had a share of 0.6% of the total.

From 2000-2012 the institutional changes and the facilities provided by the SIV in Mexico to private sector housing developers moved a constitutional right to a real estate business as it is housing.

The Figure 3, shows an increase of GHG emissions in the first two periods 2000-2003, 2004-2008 30% and then decreased in the last period 2008 to 2012 by 16%, this change in emissions can respond to technological improvement in construction processes, enabling massive developments up to 25,000 homes.

The decrease in GHG emissions in the period 2008 - 2012 can also be attributed to the strategies of mitigation that were implemented in Mexico, such as the Strategic Plan of the Federal Mortgage Society (SHF) 2008 - 2012 environments for promoting sustainable development considering housing infrastructure (health, education, public space, etc.) reducing travel times and energetic costs.

Another important program that was established during this period was the Green Mortgage (HV) program supporting the use of eco-technology to save water, electricity and gas within the housing.

# 4. ACKNOWLEDGMENTS

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# 5. CONCLUSIONS

The Input tables - Product being seen as an instrument of empirical analysis, national and regional planning. In this sense, many countries like US, Japan, Portugal, Sweden, China, Netherlands, Germany, Denmark among others, include analyzes using the Input tables - Product, which support its economic programming and contribute to building sophisticated models forecasting and simulation.

Currently to the already known traditional applications in a matter of economic projection, production requirements, input supply, multiplier effects, you are now added topics such as the relations between environment and productive systems, as well as technological change, mitigation, and in general assessments of government decisions in the areas of taxation and investment.

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