

REGIONAL LEVEL MARKET ANALYSIS OF THE CONSTRUCTION SECTOR AND PILOT PROJECT BASED ON A PUBLIC POLICY PORTFOLIO IN ORDER TO REDUCE SLCP OF TRADITIONAL BRICKYARDS IN MEXICO

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Introduction

The supply of baked clay bricks made by hand in Mexico is generated by an estimated 17,000 of units distributed throughout the country. Due to the rudimentary technology, the conditions under which the bricks are made is less than ideal, product offering differ regionally in terms of dimensions and characteristics of appearance and probably on their mechanical properties

The majority of bricks baked use inefficient kilns that do not allow the control of emissions. Whereas, the minorities of bricks are baked using kilns that use, easily accessed and lower cost, various biomass fuels.

As a result, the artisanal brick making craft is a source that negatively affects air quality by producing harmful emissions of greenhouse gases, including short-lived climate pollutants (SSLP). In turn, the repeated harmful emissions expelled from brick baking negatively impacts the health of those who live in the surrounding area(s).

The Instituto Nacional de Ecología y Cambio Climático (INECC, 2013) and The Directorio Estadístico Nacional de Unidades Económicas (INEGI, 2015) provided sector studies of brick makers within the country. However, due to the informality of the trade, there is a lack of official data, which has proven to be a major obstacle in planning new strategies.

Unlike artisanal brickwork, the industrial sector has a standardized selection of mixing of clays and quality standards in place that were determined from observing supply and demand trends of products: such as, extruded hollow bricks, concrete blocks¹ and bricks. In addition to the quality standards in place, these products are created by using much more sophisticated machinery that uses natural and/or petroleum gases, making the process much safer for the environment and persons living in the vicinity.

What is the future of the artisanal clay brick making craft in Mexico? What are the alternative products competing in the market? What is the best strategy to modernize of the sector? With focus on market study, this report seeks to provide responses to the previous questions. In this regard, the August 1st. of 2015, was signed the Contract INECC/RPA1-001/2015 between Instituto Nacional de Ecología and Cambio Climático y el Centro de Innovación Avanzada en Tecnologías Competitivas (CIATEC), with the purpose of creating and delivering the **“Regional Level Market Analysis of the Construction Sector and Pilot Project based on a Public Policy Portfolio in order to reduce SLCP of Traditional Brickyards in México”**.

¹ In compliance with the definitions established in Mexican Standard NMX-C-404-ONNCCE-2012 Structural Use Parts (ONNCCE, 2012), this report uses the following denominations according to the glossary of this document: Solid product of clay baked handmade is identified with the name artisanal brick. The term industrial brick is reserved for solid or hollow products, made of clay, but of industrial manufacture. Under the name of "mud" are considered materials referred to as clays in the literature, once the material is wetted. Concrete block and "tabicón" are terms that are reserved for parts manufactured by compaction of mixtures of aggregates of different nature added with lime and / or cement, without baking processes.

Background

The search for solutions to the problem of pollution caused by the artisanal brick industry dates back to the last century: which was documented in 1994, when the Secretariat of Social Development conducted a study of the financial engineering in the technological reconversion or relocation of the kilns within the northern border of Mexico. This study concluded that organizational, financial, environmental, commercial and technical assistance was required to achieve the level of success within the sector (Dirección General de Financiamiento al Desarrollo Urbano, 1994)

In 2000, Resources for the Future published a study that focused on the costs incurred and benefits of pollution control within the artisanal brick making. The study started in the city of Ciudad Juárez, where it was pointed out that, as far as they know, it is the first case in which this type analysis is done for the informal sector (Blackman, Newbold, Shih, & Cook, 2000). The objective of the study was to contribute to the decision-making effort by supplying information on the impacts of the activity based on four scenarios: change to MK2 kilns, use of natural gas, relocation and limitation of burning days and costs included the assessment of health risks.

Recently, results of studies and research have been published stating that the focus of solution is to achieve better environmental efficiency of brick kilns; this is based on regulatory and technology approaches and not taking into consider the market aspects (IIDFC, 2009).

In contrast, in the same year, the World Bank published the political economy analysis of the Bangladeshi brick-and-mortar sector that focused on three issues: systematic problems hampering efforts to improve brickyard practices, that underlie problems and how associations and communications can help address these issues (World Bank, 2009).

This analysis highlights the fact that the market forces may act as a pressure for the change in brickwork industry. For example, as soon as the growth of cities and price of properties increase, it is profitable for the owners to sell to urban developers.

In an evaluation report on the brick industry in South Asia, the “war room” (Lopez, Loyda, Segal, & Tsai, 2012) includes market analysis, as one of the aspects, identifying that the industry in Asia is especially resistant to change despite the size of the sector in this region's economy. This is primarily due to the labor patterns, quality of brick, Government regulations and legal property/land rights. The report identifies opportunities for investment in appropriate technologies with acceptable rates of return on investment. However, it is necessary to overcome barriers of information, innovative financing solutions and a broad involvement of all stakeholders related to the brick market. In particular, the authors of the report refer to the lack of Government regulations surrounding the pollution created by the brick and mortar sector must be strengthened as an accompaniment of financial and technological measures.

With the support of the 2012 Eficiencia Energética de Ladrilleras Artesanales (EELA) project, a diagnosis of brick-makers situation on a national level in Mexico was published. The study was based on a market study (Ortiz Herrera, 2012) that characterizes the artisan brick-making sector, describes the marketing mechanisms,

and identifies government regulations. However, the issue of product demand does not address the substitutability of alternative products or market trends.

The 2012 EELA project also financed another artisanal brick making market study in the Department of Cochabamba in Bolivia, whose main contribution is that it was based on the so-called M4P (Making Markets Work for the Poor) approach that focuses on "the underlying constraints Which impede the development of market systems " (Benavides Salmón & Heredia Quispe, 2012). The scope of the study included characterizing the value chain through its different links and the identification of various scenarios that started from the understanding of bottlenecks within the chain.

The study concluded that in Cochabamba, the demand for artisanal brick has increased in recent years and therefore, predicts a favorable trend in future growth although the response generated by internal competition among producers is not precisely elucidated. Furthermore, the authors conclude that industrial products are not the direct competition of the artisanal product.

Other characteristics of the sector determined in the Cochabamba study were low diversification, rudimentary kiln technology with empirical innovations and low access to credit due to the lack of accounting records of its activities. On the other hand, the role of local governments is strongly regulatory not only for the activity itself but also for the exploitation of raw materials used in production.

The Climate and Clean Air Coalition (CCAC) launched the *Mitigación de Carbono Negro y otros Contaminantes de la Producción de Ladrillos* (CCAC, 2016) initiative in September 2012, with the aim of boosting the political interest in Latin America, Asia, Africa and the Caribbean and identify emission mitigation measures in artisanal brick making from an intersectorial perspective through information and knowledge sharing. As part of the actions, it gave impetus to the Red de Políticas Públicas para la Producción Limpia de Ladrillos (PAN LAC). In May 2016, "Más allá de los ladrillos" document was published as an attempt to change the way governments understand and design their public policies and to prevent the social and environmental effects of artisanal brick production (CEDHA/CHRE, 2016).

The approach adopted by INECC seeks to overcome the vision of focusing on technological or environmental aspects and expand it to that of market analysis to support transformational projects in the brick-making sector in Mexico.

Objectives

This study aims to raise the level of knowledge and awareness of the construction sector within Mexico, through market analysis that is specifically oriented to the constructive elements, such as block, extruded brick and the brick making craft. As well as, provide a portfolio of public policy instruments to meet the needs of each type of producer, particularly the artisanal brick maker and design a focused pilot project.

Specifically, will include in-depth knowledge of the following:

Offer: type and characterize the producers from small brick-makers to industrial companies. Describing the various trends within the sector; including those related to self-construction.

Demand: identify innovations, new construction materials, and new types of commercial and residential buildings, construction regulations and in general the key factors affecting demand.

Economic Aspects of the Market: document a prospective look at trends in the use of bricks as building materials, compared to other alternate materials.

Public Policy Measures: identify the public policies portfolios that serve the sector in an integral way; with the aim of modernizing it and transforming the conditions of production.

Pilot Project Design Elements: select the municipality with the best possibilities of implementing the pilot project. As well as, articulate the public policies and the action plans aimed at the modernization of the sector.

This study has a national scope in the supply and demand aspects of industrialized bricks. For artisanal brick, the project scope includes the states of the Megalopolis², in Guanajuato and in Jalisco.

Figure 1. Typical Mexican brickyard with fix kilns and drying area



Source: INECC.

² Megalópolis in conformed by: Mexico City and the states of Hidalgo, Tlaxcala, Puebla, Morelos and Estado de México.

Methodology

4.1 Offer analysis

This study used three different methodological instruments in analyzing artisanal brick, industrial brick and concrete blocks offer: artisanal brick-makers producer survey, in-depth interviews to industrial producers and focus groups, all of them documented by means of photography, audio registers and attendance records.

4.1.1 Survey methodology

The representative samples were collected from various brick making factories within states of megalopolis (Hidalgo, Tlaxcala, Puebla, Morelos, Mexico) and Jalisco and Guanajuato, which are home to 58.64% of the 17,054 factories craft country (INECC, 2013), distributed as shown in the following table:

Table 1. Number of Artisan Brick Factories Registered by State

State	Registered brick units	Planned surveys	Performed surveys
Hidalgo	285	28	35
Tlaxcala	29	3	3
Puebla	4,500	440	461
Morelos	24	2	4
Ciudad de México	0	0	0
Estado de México	803	78	89
Jalisco	1994	195	202
Guanajuato	2,366	231	249
Total	10,001	977	1043

Source: (INECC, 2013).

To obtain samples, we used the equation for finite populations to calculate the sizes from predetermined populations (Stevenson, 1981) with a confidence level of 95%, which gave as result $n = 977$ brick-makers distributed in a proportional way by state and municipality in accordance to the numbers established by INECC in 2013 :

$$n = N * z^2 * \rho(1 - \rho) / (e^2 * (N - 1) + z^2 * \rho(1 - \rho))$$

Where:

$N = 10,001$ Brick making units (population size).

$z = 1.645$ (Z value for standard normal distribution with 95% confidence).

$e = 2.5\%$ (Allowed standard error).

$p = 0.5$ (Proportion of the population of interest).

$n =$ Sample size.

The survey was designed (Annex 1) using the following characteristics:

- a) Identification data of the person applying the survey.
- b) Details of the brick-maker's location and socio-economic profile.
- c) Characteristics of the kiln and auxiliary equipment.
- d) Number of staff and family members that participate in the production.
- e) Days and periods of work.
- f) Products made fuels /raw materials used and waste generated.
- g) Problems encountered during production.
- h) Alternate products that compete with the handmade brick.
- i) Changes in product and production.
- j) Barriers to change.
- k) Sales and marketing.
- l) Permits and authorizations.
- m) Training and funding received.
- n) Safety, hygiene and health.

4.1.2 Artisanal brick and clay Samples

Ninety samples were collected from bricks from various municipalities within seven states. The samples were then wrapped with a plastic film, labeled, and measured (length ± 0.5 mm) and (weight ± 12.5 g). The data was entered into a data base for determine descriptive statistics by state.

Following the methods described in the M-MMP-1-02/03 manual (SCT, 2016) "Methods of sampling and test of materials" from the Secretaría de Comunicaciones y Transportes, 47 clay samples from various municipalities within seven states were collected and processed. The classification textural Triangle was based on the same system used by the United States Department of Agriculture (USDA, 2016) according to the size of the particles of sand, silt and clay (granulometry).

4.1.3 Industrial Brick Producer Interviews

In order to obtain information from alternative brick and block producers, in-depth industrial brick producer interviews were performed on a sample determined on the base of 2014 Directorio Estadístico Nacional de Unidades Económicas published by Instituto Nacional de Estadística Geografía e Informática (INEGI, 2015)³.

In the case of companies that manufacture concrete blocks, the sample size of 101 production units was calculated with the equation for finite populations with the following parameters:

$N = 369$ Economic units (population size).

$z = 1.645$ (Z value in normal standard distribution with 95% confidence).

$e = 0.07$ (Allowed standard error).

$p = 0.5$ (proportion of the population of interest).

$n =$ Sample size.

In the case of industrial manufactured clay bricks, we identified only six companies in DENUE directory (Table 2):

Table 2. Producers who manufacture extruded bricks

Companies	Occupied personal	State	Municipality
BINSA Internacional S.A. de C.V.	101 to 250	Coahuila de Zaragoza	Piedras Negras
Laminados de Barro S.A. de C.V.	101 to 250	Coahuila de Zaragoza	Piedras Negras
Ladrillera Mecanizada S.A. de C.V.	51 to 100	Nuevo León	San Pedro Garza García
Ladrillera Santa Clara S.A. de C.V.	101 to 250	Nuevo León	Pesquería
Tabiques y Ladrillos Modernos S.A. de C.V.	51 to 100	Puebla	Puebla
Novaceramic S.A. de C.V.	101 to 250	Tlaxcala	Tetla de Solidaridad

Source: INEGI, 2015.

The main objective of in-depth interview was to characterize national level the production of blocks, concrete “tabicones” and industrial extruded clay bricks (only structural materials). The questions of production (Annex 2) are displayed in the following:

- A) General information: before the interview, we meet with the interviewee at their site to consult about the interview that will take place. After which, the person is interviewed and results are obtained.
 - a. Location (City, site address, phone, email, web page, type of venue, geographical coordinates or geo-statistics basic area (GSBA) in which it is located).
 - b. Type of organization (company name, member of an association, specialization of any person(s), marketer, etc.).

³ It includes codes 327330 for manufacturing of cement and concrete products, 327391 (concrete presforzed products), 327399 (other concrete products), 327420 (cast products), 327991 (quarry products), 327999 (other non-mineral products) and 327121 (non-refractory clay construction products).

- c. How long the business has been in business.
- d. Company size (number of full-time employees, temporary workers, laborers, administrative, male and female employees).

B) Production Aspects

- a. Number, production type and production cost of units produced per month.
- b. Installed capacity vs. used capacity.
- c. Technology and machining aspects used for brick; including of clay fired, type of kiln, type of fuel and overall consumption. Machinery used for brick and concrete block.
- d. Raw materials and inputs: type, origin and quantity of raw materials used.
- e. Description of the process and its characteristics (manual, mechanical or mixed).
- f. Final disposal of scrap and waste.
- g. Quality Certifications.
- h. Three main product physical characteristics and dimensions.
- i. Plans for change, incorporating and innovating new products and processes. Main motivation for a change of products and/or processes. Improvements established.
- j. Prospects for growth

C) Market aspects

- a. Installed capacity vs. used capacity.
- b. What market trade is addressed: export, national, regional, local?
- c. Existence of barriers to market access.
- d. Whom does he sell his product to: housing developers, government, intermediaries, and self-construction.
- e. Who are his competitors and for what products: brick and concrete block, clay brick and extruded bricks.
- f. Market Trends: new materials and/or products potentially competitors.

4.1.4 Focus groups (offer)

As a complement to the surveys and interviews, two focus groups meetings were held for homogeneous groups of artisanal brick makers: on September 8th the first one in León, Guanajuato and the second in Cholula, Puebla on October 22th, the goal of both focus groups was to verify survey design. On October 30th a third focus group was held in Valle de Guadalupe, with the participation of producers, authorities and professionals of the construction (Annex 3). The objective was to analyze market and business drivers through the next questions:

- a. Prevalence of regulations within the brick market.
- b. Factors of professional/industrial activity that affect the brick market.
- c. Trends in the use of building materials.
- d. Trends in technological innovation.
- e. Aspects that determine the decisions of purchase and use of bricks and/or alternate materials.
- f. Influence of the environmental aspects of artisanal brick making in the purchase decision.

4.2 Demand analysis

For demand analysis this study used consumer interviews, focus group in six municipalities in different states and a visual analysis of material preference in self-construction within the so called priority attention zones (PAZ) as determined by Consejo Nacional de Evaluación de la Política Pública de Desarrollo Social (CONEVAL, 2016).

4.2.1 In-depth interviews to demand stakeholders

In 2016, 118 in-depth interviews were made to construction professionals and construction firms located throughout the country of Mexico. The sample size was calculated by using the equation for a finite population of 2,024 consumers detected in the DENUE (INEGI, 2015). The parameters for the calculation of the sample are as follows:

$N = 2,024$ Consumers (population size).

$z = 1.645$ (Z value for standard normal distribution (95% confidence)).

$e = 0.074$ (Allowed standard error)

$p = 0.5$ (Proportion of the population of interest).

The number of interviews corresponding to each state was distributed on the basis based on its participation by economic region within the construction industry. The output generated by the construction companies and the data obtained was from the Banco de Información Económica (BIE), in the month of December in the year 2015 (INEGI, 2016a). The following issues were addressed in the interviews (Annex 4):

- a. Interview data: including but not limited to the interview date and the name of the company.
- b. Characteristics of the company: kind of activity, location, seniority, number of employees.
- c. Structural products used in making products: brick, block, extruded bricks.
- d. Quantity and price of the most widely used product(s).
- e. Maximum price to be paid in scarcity conditions.
- f. Opinion about the future of the traditional brick making and market trends.
- g. Problems encountered in the execution.

4.2.2 Analysis of the demand and offer workshops

From April to May of 2016, six regional workshops were conducted in association with the Cámara Mexicana de la Industria de la Construcción (CMIC) (Table 3) with the objective of improve the understanding of demand on artisanal and industrial bricks and concrete blocks. Environmental authorities, artisanal producers, industrial producers, construction companies, architects and civil engineers attended the meetings (Annex 5).

Table 3. Demand analysis workshops

City	Place	Date	Number of participants
León, Guanajuato	CMIC Delegación Guanajuato	April 27 th , 2016	18
Guadalajara, Jalisco	MIND Build, Guadalajara Jalisco	May 18 th , 2016	31
Cuernavaca, Morelos	CMIC Delegación Morelos	May 24 th , 2016	9
Toluca, Estado de México	CMIC Delegación Edo. de México	May 25 th , 2016	17

Pachuca, Hidalgo	CMIC Delegación Hidalgo	May 26 th , 2016	15
Puebla, Puebla	CMIC Delegación Puebla	May 31 th , 2016	16

Source: INECC.

The mechanics of the workshops was based on the following ten questions:

1. Are artisan brick used in its construction activity?
2. What qualities do you look for in handmade brick(s)?
3. What supply problems have you discovered/encountered in the acquisition of handmade brick?
4. What is the minimum and maximum price that has been paid in the last five years for handmade brick? How has the price of the brick changed during that time?
5. If the artisanal brick craft meets your requirements, how much are you willing to pay for the product?
6. In the case that business was steady or decreasing; would you also steady or decrease the price of the product: would the consumption increase?
7. What if shortage is increasing? Do pay more? How much?
8. What role does the intermediary play? How does he acquire the handmade brick: because he does not acquire it straight with the producer?
9. What are the environmental and health consequences of handmade brick production?
10. What is the future of the brickmaking craft against other options (industrial)? What is the trend in the use of building materials?

4.2.3 Evaluation of material preference in self-construction

To evaluate the demand of handmade brick in self-construction areas of priority (PAZ), a visual recognition method of the preference of artisanal bricks on concrete “tabicón” (Annex 6) was applied on 108 urban images of the PAZ in 72 cities of the 32 states of the Mexican Republic. Table 4 shows scale used.

Table 4. Scale of visual valuation of urban images

Level	%	Description
Total	100%	Almost all construction uses artisanal (red) bricks.
High	80%	Most of constructions made with artisanal bricks compared to concrete block and “tabicón”.
Medium	60%	Small dominance of artisanal bricks use in construction over concrete blocks and “tabicón”.
Low	40%	Number or artisanal bricks made constructions slightly less than those with concrete blocks and “tabicón”.
Very low	20%	Most of construction made with concrete blocks and “tabicón”.
Null	0%	Constructions made with artisanal bricks are very uncommon.

Source: INECC.

4.3 Economic analysis for offer and demand of artisanal bricks

The economic analysis included study of production factors using Cobb-Douglas model (Cortázar Martínez & Montaña Raygoza, 2011); offer and demand approach analysis with logit models and elasticity analysis for price-offer, price-demand and cross demand.

The study was made using survey and interviews data, segmented and coded for each questions group by means of numbers for discrete variables and original values for continuous variables. Data analysis was made through clustering techniques for discrete variables and statistical methods for continuous variables (Annex 7).

4.3.1 Analysis for artisanal bricks production factors

The supply study was carried out by applying the Cobb Douglas Model to analyze the production through the function described by:

$$Q = AT^\alpha K^\beta$$

Where:

Q = Monthly production value of artisanal bricks by i-producer, (pesos/month)

A = Total productivity factor (estimated as the residual value of the other variables)

T = Monthly labor work force utilized by i-producer (production value in pesos/month of i-employee)

K = Capital utilized by i-producer as kilns, mixers, fans, turbines, trucks, etc. (pesos/month)

α = Output Elasticity – Monthly labor work force influence in production; response in production given a change in labor force.

β = Output Elasticity – Monthly capital influence in production; response in production given a change in capital.

Q = Value of monthly production of artisanal bricks by i-producer (pesos/month)

Once estimated the capital and labor force values, approximation of the elasticity of the work output and capital output values was made applying regressions of the variables of capital and labor on the basis of the income earned by the producing unit per previous month, transformed into natural logarithm and obtained the value of the coefficients α , β and A .

4.3.2 Logit models for offer and demand

Logit model (Moscote Flórez & Arley Rincón, 2012) was applied to offer and demand of artisanal brick by means of the next equation:

$$P(Y = 1) = \frac{1}{1 + e^{(-\alpha - \beta_1 X_1 - \beta_2 X_2 - \beta_3 X_3 - \beta_4 X_4 \dots - \beta_K X_K)}}$$

Where:

$P(Y=1)$ = Probability value of dependent variable

α = Constant

β_1 = Parameter of variable X_1

β_2 = Parameter of variable X_2

β_3 = Parameter of variable X_3

β_4 = Parameter of variable X_4

Table 5 shows identification and categorization of quantitative and qualitative variables for both models (offer and demand):

Table 5. Logit model identification and categorization of variables

Definition and categorization of variables in logit models				
Variables	Offer		Demand	
	Definition	Categorization	Definition	Categorization
P (Y-1)	Probability of production for brick units with capacity equal or bigger than 20,000 bricks/month.	0 for units producing less than 20,000 bricks/month. 1 for units producing 20,000 bricks/month or more.	Probability for artisanal brick consumption.	0 for people not demanding artisanal bricks. 1 for people demanding artisanal bricks.
X ₁	Labor work force	Discrete values from 1 to k number of workers.	Tradition	0 for consumers that think artisanal bricks will be in the market for different reasons to tradition. 1 for consumers thinking that tradition is the main reason for permanence of artisanal bricks.
X ₂	Technology in combustion equipment	0 for brick-makers that feed fire in a manual way 1 for brick-makers using one or more of the next: fuel dispenser, burner, fan or other similar.	Concrete blocks choice	0 if concrete blocks are not chosen. 1 if consumer includes concrete blocks in her choices.
X ₃	Location of kilns in brick-maker house proximity	0 for producers whose kiln is far away from their house. 1 for producers whose kiln is in the proximity of their house.	Quality	0 if quality is not one of consumer choice criteria. 1 if quality is a consumer choice criterion.
X ₄	Used tools for clay mixing and shaping of raw artisanal bricks.	0 for producers without one of the next: cube, agitator, shovel, gloves, hoe or wheelbarrow. 1 for producers with all the tools mentioned.	Efficiency	0 for consumers not considering construction efficiency as critical choice criteria. 1 for those consumers considering construction efficiency as one criteria.

Source: INECC.

Use of variables in table 5 allowed estimate the probability for artisanal brick offer and consumption given a combination of offer and demand factors

4.3.3 Market elasticity analysis for artisanal bricks

The study of economic variables in terms of quantities and prices of different goods are supported by economic theory through the analysis of elasticity, which determines the ability of one variable to respond to the other; in the present study, we applied the analysis of price-supply, price-demand and demand elasticity.

The study of the price-offer elasticity (POE) of the artisanal brick was carried out by analyzing the variation observed in the quantity and price of the good offered in the rainy season (June to August) compared to the dry season (September to May). The economic approximation was made by the equation:

$$EPO = \alpha * \frac{q_i}{p_i}$$

Where:

α = Regression coefficient of q_i and p_i .

q_i = Quantity offered by i-producer in a given season.

p_i = Price of offered brick by i-producer in a given season.

The calculation made to obtain the value of the price demand elasticity (PDE) was based on the data of quantity and price demanded in the interviews in depth to experts and was described by the equation:

$$EPD = \frac{\Delta\%q_i}{\Delta\%p_i}$$

Where:

$\Delta\%q_i$ = Percentage of variation of quantity of artisanal bricks demanded

$\Delta\%p_i$ = Percentage of variation in price of artisanal bricks.

The analysis of substitutability and complementarity between products was made through the application of cross-demand elasticity (CDE) analysis. For this purpose, data on quantities demanded of brick and price of blocks that were obtained in the in-depth interviews applied to demand actors segmented in the four regions of the country already mentioned were used: north, central-north, center and south of Mexico, 2016).

Cross-demand elasticity is defined as:

$$ECD = \frac{\Delta QX_i}{\Delta QY_i}$$

Where:

ΔQX_i = Variation in quantity demand for artisanal bricks in the i-zone.

ΔQY_i = Variation in concrete block Price (12x20x40) in the i-zone.

4.4 Public policy design

A national meeting of strategies for the modernization of artisanal brick production for the reduction of short-lived climate pollutants (Annex 8) was held in Mexico City, with a large group of producers, municipal, state and federal authorities, builders, Academics, architects and independent engineers.

The objective was to know the visions of the participants regarding the strategy of attention to the sector, through the identification and weighting of the aspects in environmental, economic and social spheres. Aspects were selected under the consideration of its relevance in the build-up of public policies focused on to address the problem of the pollution produced by artisanal brick making and its effect on health.

Based on the diagnosis of the problems associated with the manufacture of handicraft bricks, the plans and programs of the federal public administration, the applicable environmental regulations and the available market instruments were revised, in order to identify the aspects of the problem Addressed in the implicit or explicit public policies in plans and programs.

4.5 Pilot Project configuration

The four municipalities with the greatest potential to develop a pilot project for the modernization of brick production were selected based on a matrix of 17 factors grouped in six environments described in Table 6. The weighting of both the environments as well as the 17 factors were made in consensus with the staff of the National Institute of Ecology and Climate Change and is included in Annex 9.

Table 6. Defined “environments” and weighting for comparing municipalities

“Environment”	Definition	Weighting
Socio-demographic	Grouping of related factors the number of people in each municipality could be affected by the emissions of the brick activity depending on the location of the same with respect to human settlements. It also includes two additional aspects: the opportunity for municipal action based on the year in which the municipal administration is located in 2016 and the social perception of the activity of production of handmade brick. In general, it is considered that, to a larger population impacted by emissions from brick production, greater relevance of a pilot project.	25%
Economic Offer/Demand	Set of factors related to the supply and demand of the artisanal product. In this environment, a pilot project is given more value to the municipalities whose artisanal production is "exported" to other municipalities or even other federative entities. The level of use of artisanal brick in areas of priority attention is used as an indicator of the demand for the product. It includes both direct participation in the commercialization and the interest of the groups of constructors, as important elements to take the decision of location of a pilot project.	15%

Geographic	It includes factors that make it possible to judge the relevance of each municipality for a pilot project based on the geographical location of the bricklayers in relation to human settlements, their location in concentrations of producers or dispersed and their location "downwind" or "wind up" to the population.	20%
Productive	It includes factors that allow judging the importance of the productive activity in each municipality, starting from the premise that a pilot project should be executed where it has the best opportunity to provoke the effect of "seeing to believe". In this sense, the factors measure the magnitude of the production activity and include additionally an assessment of the fuels used.	20%
Technological	The factor used for this environment evaluate past experiences of artisanal producers in using auxiliary equipment or new types of kilns. It gives a higher weight to those municipalities in which the mentioned changes have occurred.	10%
Organizational	In this environment, the factor used is related to the existence of formal associations of producers under the consideration that for a pilot project it is highly probable that an organization of the producers is required.	10%
SUMA		100%

Source: INECC.

Four regional workshops for the analysis of strategies and components for the modernization of artisanal brick production (Annex 9) were carried out in the selected municipalities, with the objective of identifying proposals for strategies and components of a project to modernize artisanal production of brick according to their particularities and specific needs. The participants were municipal, state and federal authorities from the environmental, economic and social areas, as well as artisan producers and consumers in the area of construction. The results were analyzed using interrelated maps of the identified components.

Results

5.1 Characterization of the supply of artisan brick in the Megalopolis, Jalisco and Guanajuato

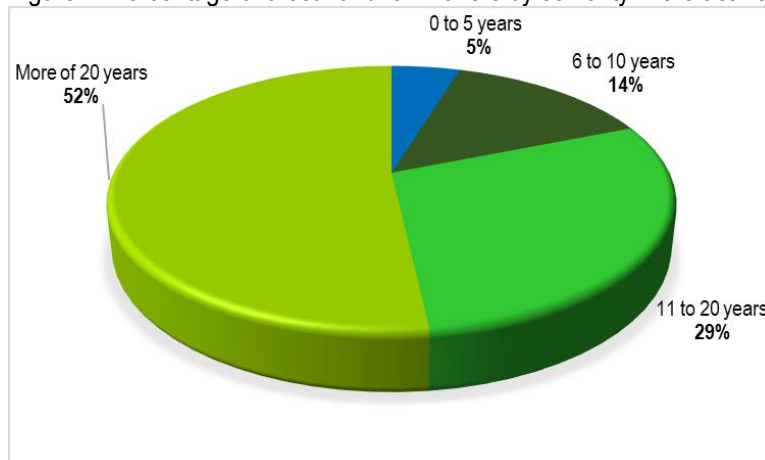
In this section, the results of the characterization of the artisan brick production appear in the following order: profile of the producers, characteristics of the problematic production and of the production.

5.1.1 Producers profile

Towards 2015, 92% of the artisanal brick-makers of the Megalopolis, Jalisco and Guanajuato are dedicated permanently and in exclusive form to the activity, although during periods of economic difficulties people without experience usually get involved into the activity. Based on the carried out analysis, it is estimated that 52% of them have more than 20 years developing the activity, 29% have between 10 and 20 years, and only 19% are 10 years old, or less, producing bricks (Figure 2), which aims at a low incorporation of new permanent producers. On the other hand, only 8% have a complementary activity that can be agriculture, construction or commercial activities. A minimum fraction of the (0.02%) migrates seasonally⁴.

⁴ The seasonal migration is generated, mainly, towards the United States of America; this migration is considered temporal.

Figure 2. Percentage of artisanal brick-makers by seniority in the activity

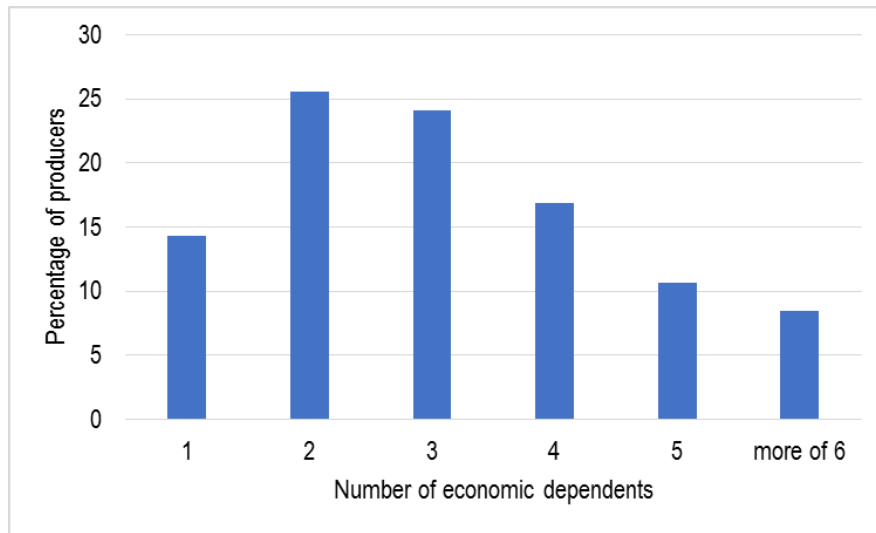


Source: INECC.

The artisan brick activity is made predominantly by relatives (an employee by each two occupied relatives), and executed by men (a woman for each 6 or 7 men); among the women who participate, 85% come from the familiar nucleus. The participation of the direct relatives is not remunerated and, in the culture of the brick-maker, it is considered an obligation.

In the case of number of economic dependents, the greater percentage correspond to the brick-makers that have between 2 and 3 with a value of 50%, whereas the percentage of brick-makers that have from 4 to 10, or more, surpasses 30% (Figure 3), which agrees with the data of the size of the registered home in the country during 2010 year (INEGI, 2016b).

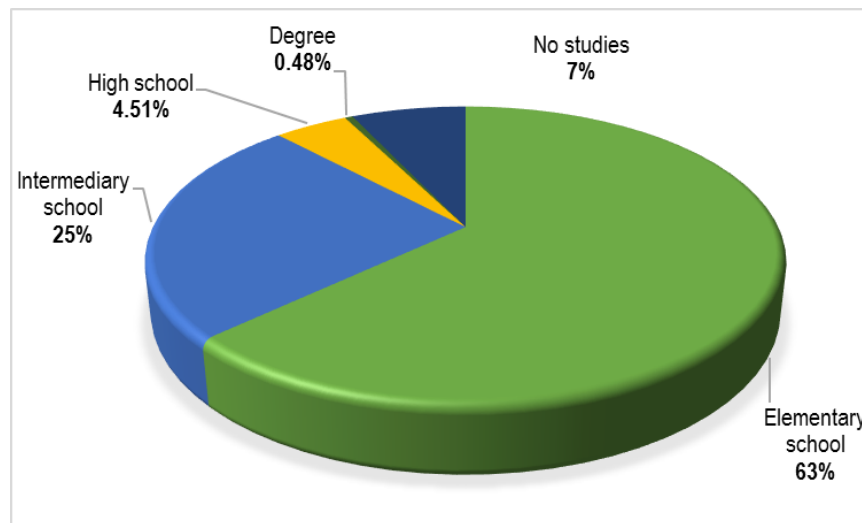
Figure 3. Percentage of artisanal brick-makers by number of economic dependents



Source: INECC.

The economic backwardness of the sector, the relative character of the activity and the incorporation at an early age into the activity, are factors that do not encourage an adequate access to educational services. This is reflected in the indicators of educational levels: 7.6% did not received education or only had a pre-school education, 4.5% of the people involved in brick production did not completed elementary education, 28.0% did finished elementary education, 25.3% have basic secondary education (secondary), 4.5% have upper senior education (high school diploma) and only 0.5% have higher education (Figure 4).

Figure 4. Maximum level of schooling (finished or unfinished) of artisanal brick-makers

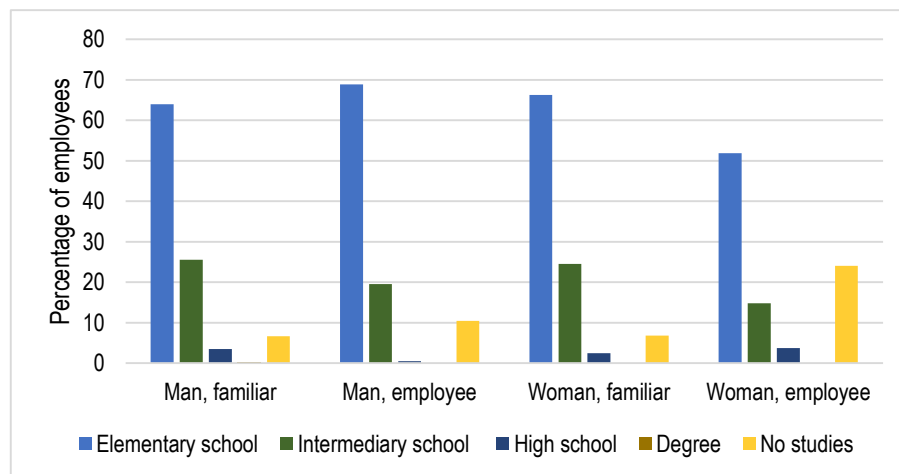


Source: INECC.

By performing the same analysis for the workforce, the percentage represented by those who do not have any educational degree or just the preschool level increases slightly for those with primary education and the percentages of the remaining categories decreases. The gender analysis indicates that women have a lower educational level, and a higher percentage of them do not have education (Figure 5).

The low educational profile of people engaged in the production of brickwork represents a barrier to a better insertion of people in the labor market of greater specialization, as well as a challenge for the execution of modernization projects in the sector.

Figure 5. Maximum level of schooling (finished or unfinished) by gender and familiar category or employees



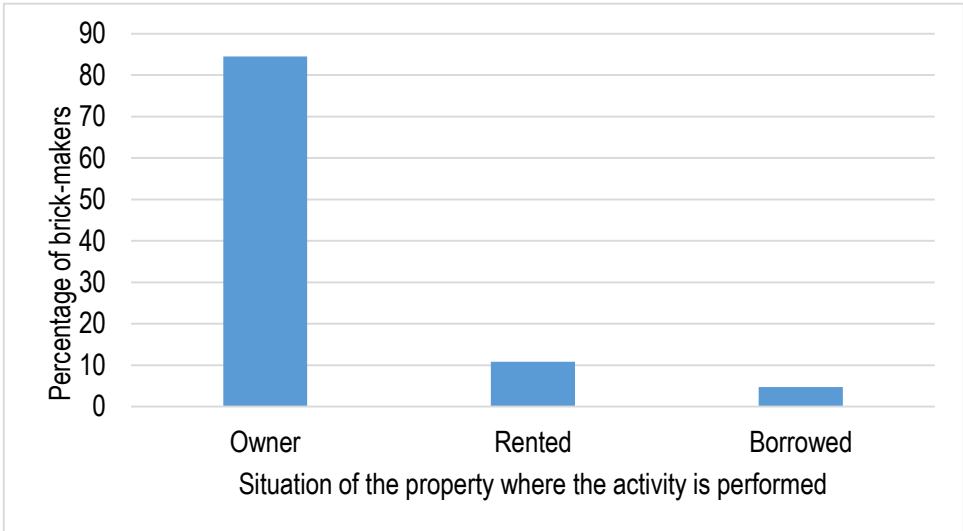
Source: INECC.

In association to the described social conditions, there exist structural weaknesses of the artisan brick-makers, where the most important is the irregularity in land tenure; 18% of them rent or have in quality of loan the estate in which they make their activity (Figure 6), while 82% of the brick-makers own the property where they carry

out their activity. On the other hand, 48% have their kiln in the same place where they inhabit, which turns positive for the family's link but increases the exposure to the pollutants produced in the production process.

Based on the testimonies obtained in the workshops, evidence was gathered that property or rent of the property does not generate an explicit cost, so the brick-maker does not account it in the cost function of the production unit. A foreseeable consequence of this is that it favors the brick-maker's perception of apparent higher economic benefits than the real ones.

Figure 6. Percentage of artisanal brick-makers by property or possession of the land



Source: INECC

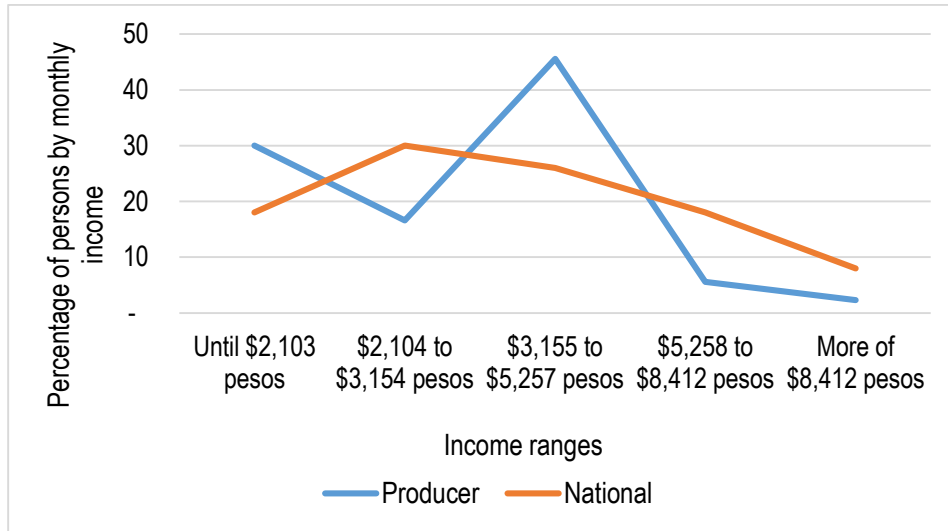
Another structural weakness of supply is the informality of brick production, which causes deficiencies in official statistical information, hinders a better understanding of the market by lacking records of transactions and reduces the competitiveness of brick-makers due to their inability to dispatch invoices (only 20% of them have Federal Taxpayers Registry).

Informality also affects the ability of artisanal brick-makers to obtain financing or support with public resources, and practically cancels the possibility of regularization of the activity in accordance with applicable local regulations (63% of brick-makers do not have municipal permit of land use).

The irregularity in the ownership of the properties used, and the informality of the activity itself, are associated with the low income obtained by the brick-makers: 92% receive less than \$ 6,240 pesos per month (equivalent to 4 or less minimum salaries) and 30 % receives less than \$ 1,500 pesos per month (equivalent to a minimum salary).

Comparatively, the percentage of artisanal brick-makers, with incomes of 4 or more monthly minimum salaries, lower than the percentage observed at national level (Figure 7); this means, that brick-makers are in a condition of income below the national average.

Figure 7. Percentage of artisanal brick-makers by range of monthly incomes in 2015, compared to national data



Source: artisanal brick-makers data obtain by CIATEC and national data by INEGI (INEGI, 2016a).

The analysis of the previous variables for each of the states (Table 7), reveals that in the State of Mexico, Jalisco and Guanajuato brick-makers have more economic dependents and that the bigger the proportion of brick-makers with secondary level studies are in the states of Hidalgo and Morelos (while the state of Jalisco has the lowest proportion). It is also possible to find that the states of Tlaxcala and Mexico have the highest proportion of brick-makers who own the land where they have the production kiln in contrast to the case of Guanajuato.

The poverty conditions of artisanal brick brick-makers require careful evaluation as potential causes of deterioration of the social environment, such as domestic violence and addictions. The sources of information for this evaluation cannot come from the brick-makers themselves, since 95% of them do not declare to recognize such situations, so it should be done from a diagnosis that determines the specific attention and monitoring programs.

Table 7. Between states differences in artisanal brick-maker profile

Characteristics	States
-----------------	--------

Identifier	Measurement unit	Hidalgo	Tlaxcala	Puebla	Morelos	Estado de México	Jalisco	Guanajuato
Economic dependents	Number: $\bar{X} \pm S$	3.0 +/- 1.4	3.0 +/- 1.0	2.9 +/- 1.5	3.0 +/- 2.0	3.5 +/- 1.4	3.3 +/- 2.7	3.7 +/- 2.3
Maximum education level	Primary school	48%	67%	65%	50%	67%	78%	68%
	Secondary school	42%	33%	29%	50%	29%	19%	28%
	High school	10%	0%	6%	0%	4%	2%	4%
Brick-makers that own the land	% Of land owners	60%	100%	84%	0%	85%	48%	66%
Monthly income	Pesos/month: $\bar{X} \pm S$	2,974 +/- 1,800	3,900 +/- 2,310	2,601 +/- 1,710	2,917 +/- 1,440	2,319 +/- 1,995	2,650 +/- 2,385	4,282 +/- 2,415

Source: INECC.

5.1.2 Characteristics of the brick production process

Artisanal brick production in Mexico is carried out using rudimentary technology compared to the process used in other Latin American countries, such as Brazil and Colombia (Schilli, 2012). The kilns used in Mexico are called "traditional" (Figure 8) and are of the fixed type (75%) with partial walls that delimit the space of accommodation of the crude brick to be cooked, or of the campaign (22%) when the tower of crude bricks gives shape and breaks down when the cooked brick is discharged. Other types of kilns (less than 0.5%) are MK2 type in the states of San Luis Potosí, Querétaro, Durango, Puebla, Chihuahua and Jalisco (SERPRO, 2012) and the horizontal multi-chamber type (Table 8).

Figure 8. Campaign kiln (left), fix type (center) and MK2 (right)



Source: INECC.

Table 8. Comparison of characteristics of commonest kilns

Type of kiln

Characteristic	Traditional: fix type	Traditional: campaign type	MK2	Multi-camera horizontal kiln
Foundation at	Ground level.	Ground level or in an excavation.	In an excavation.	Ground level.
Permanent walls	No	Yes	Yes	Yes
roofing	No	Optional.	Yes	Yes
Geometry of the base	Square or rectangular.	Square or rectangular.	Circular.	Rectangular.
Combustion camera ("Hogar" or "cocina"):	Made every time with raw bricks.	Made with raw bricks or pre-fabricated with baked bricks.	Made with raw bricks or pre-fabricated with baked bricks.	Pre-fabricated with baked bricks.
Kiln capacity in equivalent artisanal bricks (7x14x28 cm)	5,000 to 20,000	5,000 to 60,000	5,000 to 10,000	Variable per camera, but usually 10,000 (several cameras)
Fuels	Biomass, other solids or liquids	Biomass, other solids or liquids	Biomass, other solids or liquids	Biomass, other solids or liquids
Qualitative comparison of carbon emission (organic, total and elemental)*:	Big	Big	Less than others**	Without data

* Based on published data by Luisa Molina (2014). In her study does not explain if traditional kilns were fix or campaign types. Source of other data: CIATEC

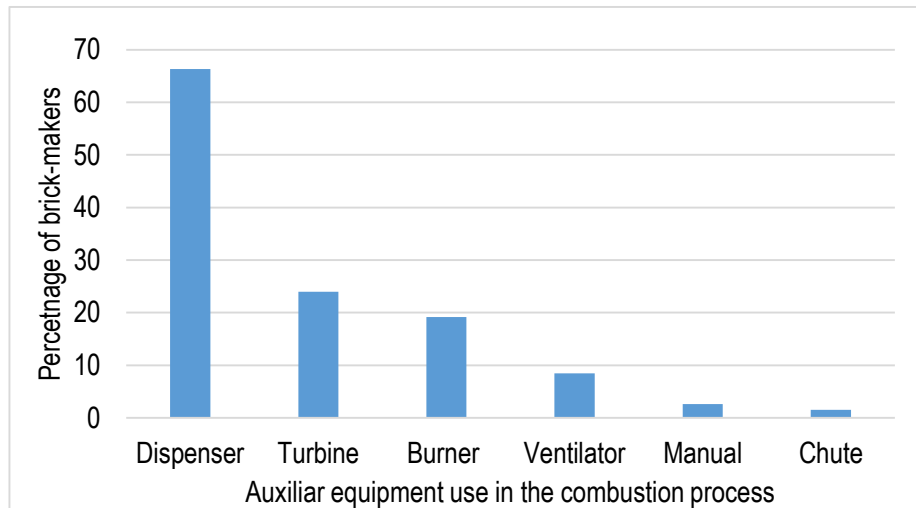
** Coincident with Co and CO2 reductions in coupled kilns as published by (Chávez, 2008)

As for auxiliary equipment for furnace operation, more than 65% of producers use dosers, 22% use turbines, 19% have burners and 8% fans (Figure 9). Those who perform the activity manually use basic tools such as hoes, buckets, shovels, wheelbarrows, sugar mills (molds) and gloves; Only 32% of them have their own cargo vehicles used to transport their product.

10% of the producers have tried other ways of producing: 7% by means of the use of mixers for the preparation of the land or by means of the substitution of fuel, 2% of the producers have tried to produce different parts to the ones that it accustoms, such As tiles, petatillo, or, to change the dimensions of the brick and less than 1.0% has made changes in the furnaces. Of these, 38% said they had faced barriers due to cost, lack of financing or difficulties in using the new form.

Among those who tried to change their way of production, 61% gave up mainly because the changes did not work, either because they did not like the operation of the change or because it was costly, although 4% said they had faced economic barriers.

Figure 9. Percentage of brick-makers that use different auxiliary equipment in the combustion

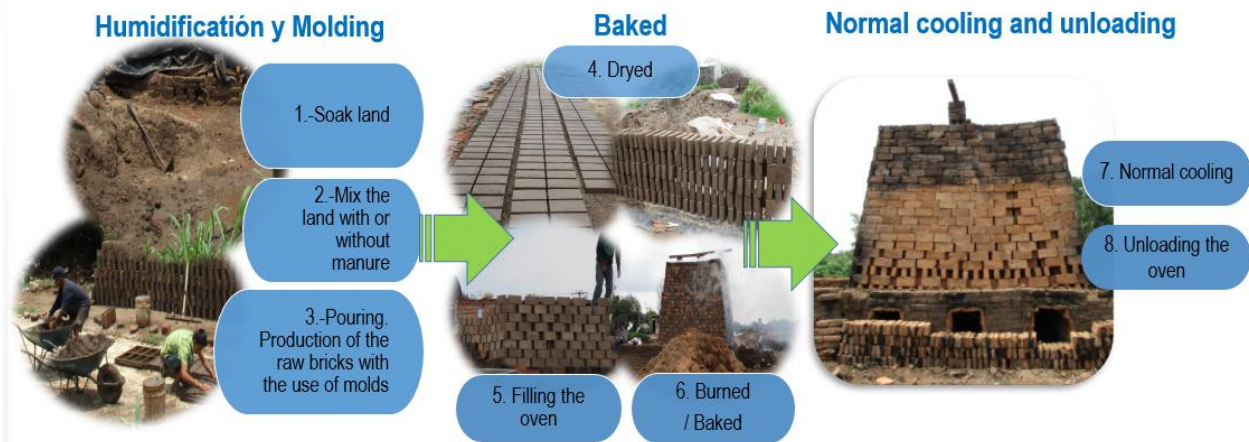


Source: INECC.

The process of baked clay brick production comprises the activities of humidification and molding, baking of the pieces, cooling and unloading of the kiln, as well as listing of the product for commercialization. Each activity is subdivided into several stages, as illustrated in Figure 10.

The soaking, mixing and kneading of different types of land is done by manual methods and can consist of a mixture with organic materials, mainly manure: the brick-maker empirically decides the proportion of the different types of land and additional materials. The mass thus prepared is molded into frames made of wood, aluminum or metal coated wood, and the raw bricks produced are stacked in a vertical "wall" of no more than one meter and a half in height, forming a latticework which allows ventilation and accelerates drying.

Figure 10. Process of artisanal brick making process



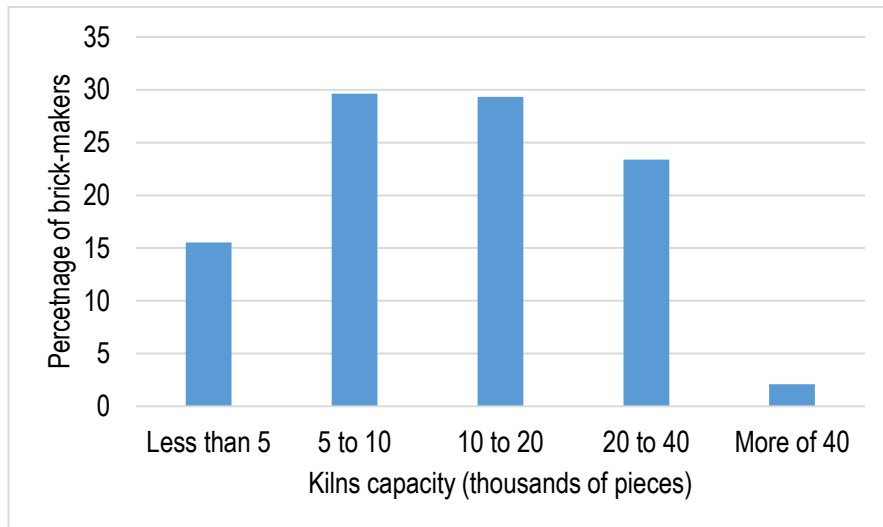
Source: INECC.

When the product reaches sufficient dehydration, the kiln is filled (when it is a fixed type kiln) or the tower is built with the same raw brick (when it is a campaign kiln) and is sealed on the outside. In both cases, the next step is to prepare the lower combustion camera or "kitchen" to proceed to the baking of the raw brick. The baking process is controlled by the supply of fuels in the order and quantity that the experience of each brick-maker indicates and can last from less than ten hours to more than two days depending on variables such as land type, fuel type, the number of pieces and the prevailing climate (rainy climates demand more cooking time).

Finally, once the brick-maker determines that his product is sufficiently cooked, he suspends the combustion and initiates the period of cooling to the point so that the temperature of the product and the radiation of the own kiln allows its discharge, and delivery the bricks to the person that will take charge of the marketing, without generating finished product storage.

Artisanal brick making occurs at low productive scales; the main element of production is the low capacity kiln, its production capacity expressed in quantity of pieces of brick per burn depends on its design as well as local tradition and goes from 5,000 pieces/burn up to 40,000 or more pieces/burn although 60% of them have capacities ranging from 5,000 to 20,000 pieces (Figure 11).

Figure 11. Percentage distribution of brick-makers by production capacity



Source: INECC.

From this "design" capacity, each brick-maker determines how many burns he makes per month based on product demand, but also on his physical and financial capacity to produce raw brick. Some limiting production factors are: the space available for raw brick laying, the ability to pay employees' wages, the availability of employees and the time required for the use of the kiln in the loading, burning and cooling operations. And discharge, which in aggregate sum at least a week and a half. Another limiting factor of production is the seasonal change from dry season to rainy season, because it limits the laying of raw brick, whose purpose is precisely to dehydrate them when done in the air, lengthening the duration of the process and decreasing the monthly frequency of the operation. Those brick-makers who have a "tejabán" (rustic roof), can carry out the process with greater independence from the rain season (Figure 12).

Figure 12. Brickyard for drying process protected by a "tejabán" (light roof)



Source: INECC.

Under these conditions, approximately 50% of the monthly production in the dry season ranges from 5,000 pieces/month to 20,000 pieces/month and, in contrast, less than 15% produce more than 35,000 pieces/month (Figure 13).

Figure 13. Percentage of artisanal brick-makers by monthly production (dry season)

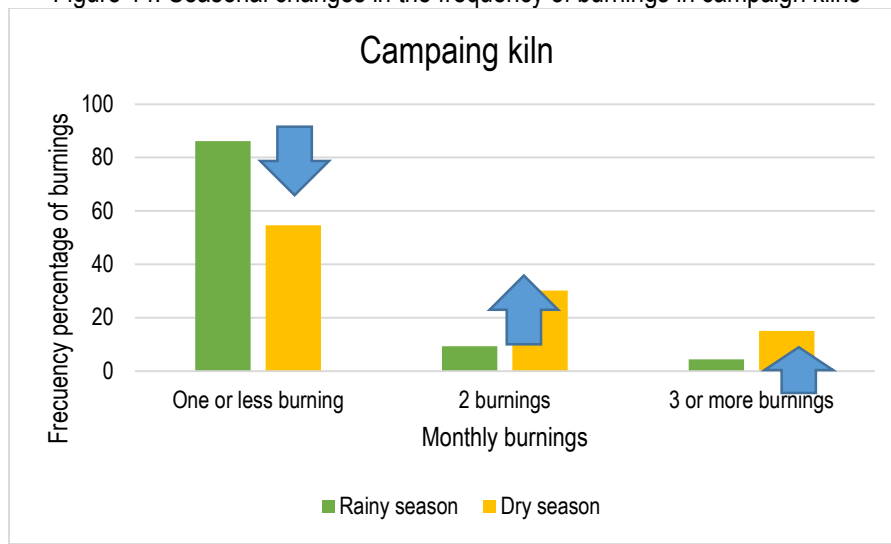


Source: INECC.

To get an idea of the level of production that this means we can mention that the productive capacity in industrial plants of extruded brick reaches from 50,000 to one million pieces per day, which clearly illustrates the low production volumes of this artisanal activity and with minimal technology. It should be noted that for the construction of individual housing the purchases of brick are measured precisely by thousands or sometimes by a few tens of thousands.

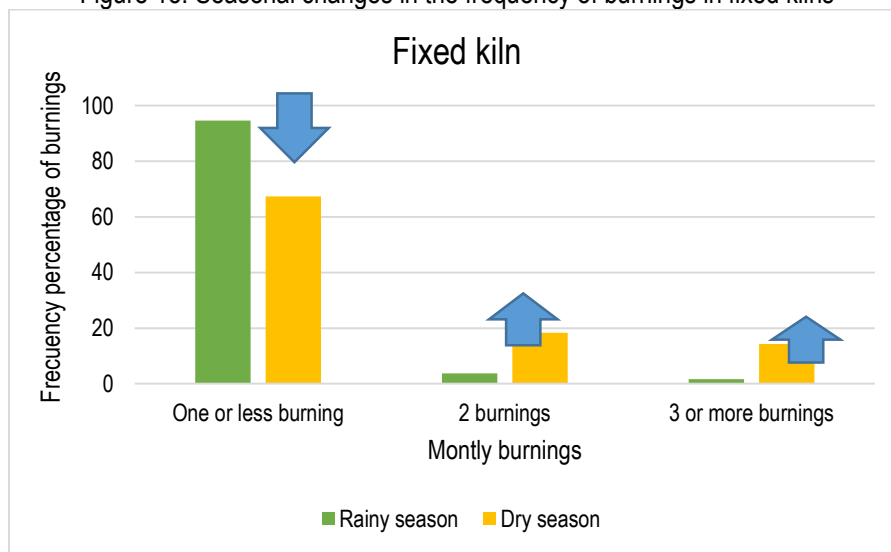
Rainy season also affect the firing of the brick by causing a decrease in the number of burns per month, although as can be seen in Figures 14 and 15, the impact is slightly higher in the kilns of the campaign compared to the fixed kilns, because it counts with fixed walls that allows the protection, through its walls, the combustion process maintaining the temperature.

Figure 14. Seasonal changes in the frequency of burnings in campaign kilns



Source: INECC.

Figure 15. Seasonal changes in the frequency of burnings in fixed kilns

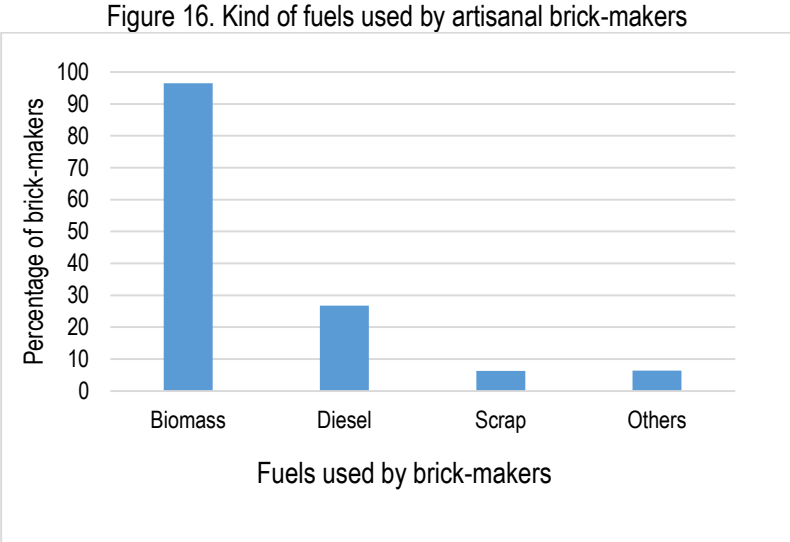


Source: INECC.

In terms of air pollution, the emissions generated by burning in the kilns cause an impact on the environmental quality and health risks, which is due, on the one hand, to the lack of combustion control and emissions control technology and on the other hand, the fuels used which generally are those of free access or smaller cost in each region, because of the precarious economic situation of the brick-maker and the informality of the artisan process.

Although the fuels used in the production of bricks are diverse, the use of biomass (firewood, used wood, agricultural vegetable residues, livestock residues and pruning waste) predominates among other types of fuels. The combustion is carried out with different combinations of fuels, usually differentiated in an initial or starting

stage of the same (in which liquid fuels are usually preferred) and another main stage of longer duration. In addition to the use of biomass as fuel, the use of hazardous and highly polluting materials such as wasted oils, textiles, tires and plastics persists in some areas: 33% of brick-makers in Tlaxcala, 15% in Guanajuato and the State of Mexico, 6% in Jalisco and 5% in Puebla.



Source: INECC.

Regarding the purchase of firewood, 28% of the brick-makers do not verify that they have permission to operate, 38% said that the supplier has it and 34% do not know the legality of the source. Although information on input prices was not obtained in the fieldwork, there is information indicating that the price of illegal firewood is up to 40% lower compared to firewood marketed in the formal market (SERPRO, 2012). The materials used as fuels are acquired mainly through purchase since, for example, the collection of waste by means of collection occurs in less than 2% of the brick-makers.

The use of gas as a fuel is very scarce and there are reports that mention what happens under government initiatives that have not prospered, due to the increase of its price, as happened in Ciudad Juárez, Chihuahua where the local government financed and introduced equipment for the use of Petroleum Liquid gas, which was discarded later by the brick-makers (Romo-Aguilar, 2004).

The diversity of types of handicraft products (Table 9) is limited and the vast majority of brick-makers produce only bricks, although there are alternative products as shown in Figures 17 and 18. However, brick remains the main product as well as reported for El Refugio location (located in Leon, Guanajuato), where 97% of the brick-makers make exclusively brick, while 2% produces brick and “zotehueta”, and the remaining 1% is dedicated to brick and small pieces called “cuñas” (SERPRO , 2012).

Table 9. Types of artisanal clay products

	Guanajuato	Jalisco	Morelos	Tlaxcala	Estado de México	Hidalgo	Puebla
Artisanal bricks (7x14x28 cm)	●	●	●	●	●	●	●
“Adobón” or “listón” (8x14x38 cm)		●					
“Cuña” (4.5x 9x22 cm)	●	●	●	●			●
“Zotehuela” (2 x10x20 cm)	●	●					
Petatillo” (2x12x24 cm)		●		●			
“Loseta” (2x30x30 cm)	●		●	●	●	●	●
Tiles		●			●	●	●
“Pecho de Paloma” (roof corners)	●						●
“Cintilla” (decorative apparent bricks)							●

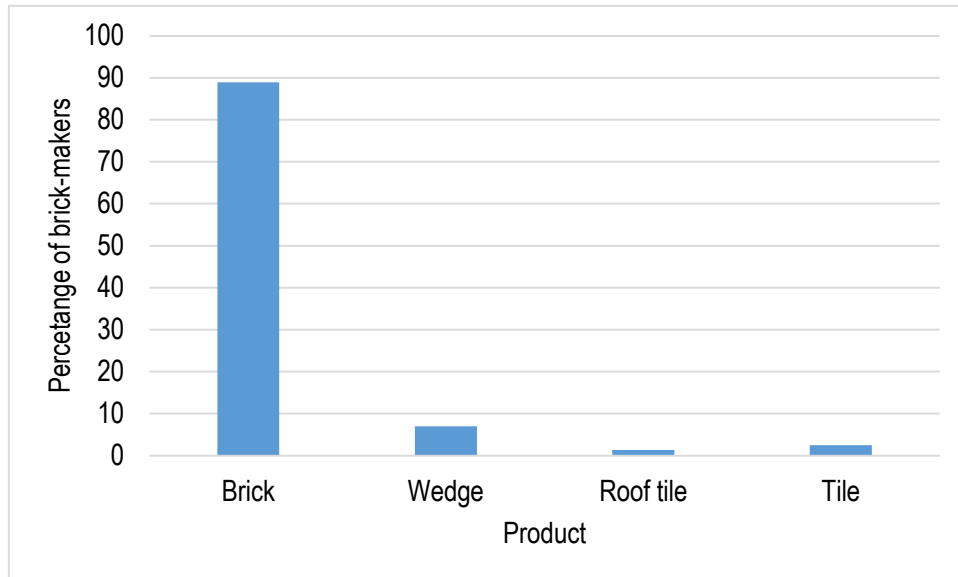
Source: INECC.

Figure 17. Examples of complementary artisanal products: “loseta” in Tlaxcala (left), ornate bricks from Metepec in Estado de México (center) and “petatillo” and roof tiles from El Arenal in Jalisco (right).



Source: INECC.

Figure 18. Percentage of brick-makers by type of product



Source: INECC.

Unlike industrial products, handcrafted bricks are produced without standardization of size despite the tendency to approach the size 7x14x28 cm. The dimensions vary from one brick-maker to another, even in the same state (Figure 19).

Figure 19. Examples of diversity in artisanal bricks sizes



Source: INECC.

Table 10 shows the results of the measurement of 90 pieces collected in the period from September to December of 2015. The samples from Jalisco showed the greatest variability and, at the other extreme, those of Puebla are the least variable; in terms of dimensions, those corresponding to Guanajuato have the highest average volume followed by those of Jalisco, one sample from Tlaxcala and one from Morelos. The samples from Puebla

and State of Mexico are the ones of smaller average volume. A similar pattern follows the average weights of the pieces, with the notable exception of the Hidalgo samples, which are very heavy in relation to their comparatively smaller size. Inside table 8, it can be observed that in general there is no direct relationship between price and volume and weight of bricks, but it is confirmed that the bricks of the State of Mexico and Puebla are the smallest and the smallest price.

Table 10. Artisanal brick dimensions from a CIATEC sample.

State	Number of bricks	Average dimensions						Area variance (cm ²)
		Length (cm)	Width (cm)	Height (cm)	Volume (cm ³)	Weight (Kg)	Unit price (pesos)	
Guanajuato	17	25.9	12.8	6.8	2254	3.2	\$ 1.55	498.1
Hidalgo	5	26.4	13.2	5.3	1846	3.2	\$ 1.59	931.5
Tlaxcala	1	25.5	13.5	6	2066	3.1	\$ 2.00	NA
Jalisco	10	29	12.7	5.8	2136	3	\$ 1.27	4,516.5
Morelos	1	27	13.5	5.2	1895	2.8	\$ 1.63	NA
Puebla	49	22.9	11.8	5.3	1432	2.3	\$ 0.94	180.7
Estado de México	7	24	12	4.7	1354	2	\$ 1.20	1328.7

Total: 90

NA = Not apply
Source: INECC.

The percentage of defects due to major critical defects such as broken bricks (78% of brick-makers), cast bricks (64% of brick-makers) or crude bricks (49% of brick-makers) are shown in Table 11, where it can be seen that 4% of the baked pieces per month in Morelos, to 10% in Tlaxcala, Puebla or Hidalgo.

Evaluating against the NMX-Z-12-2-1987 (SECOFI, 1987), it resulted that brick-makers in the state of Morelos have an acceptable reject ratio by critical defects (cast, broken or crude bricks), while 12% of brick makers in Estado de México, 13% in Guanajuato and 14% in Jalisco has no-acceptable reject ratio. 19 to 20% of brick-makers has an unacceptable reject ratio and brick-makers of Tlaxcala have the highest percentages of unacceptable losses: 33 %.

Table 11. Acceptability of percentage of artisanal brick shrinks by state

State	Average batch number of bricks per backing	Percentage of shrinks per batch	Acceptable shrink percentage from critical defects NMX-Z-12-2-1987	Percentage of brick-makers with no acceptable level of shrinks
Morelos	26,250	4%	7%	None
Estado de México	12,040	6%	11%	12%
Guanajuato	12,810	6%	11%	13%
Jalisco	12,595	7%	11%	14%
Puebla	20,327	10%	11%	19%
Hidalgo	7,398	10%	11%	20%
Tlaxcala	10,667	10%	11%	33%

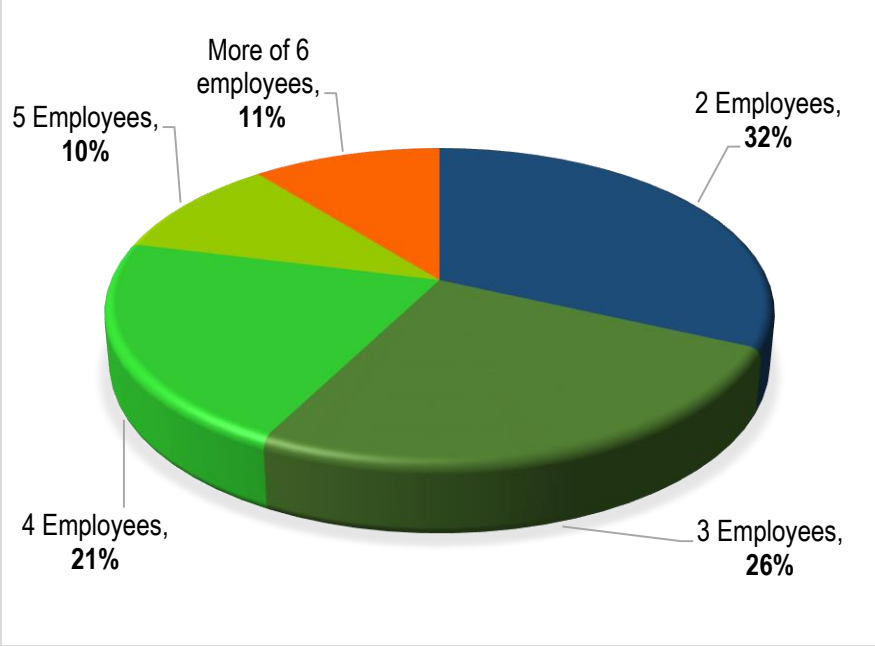
Source: INECC.

On the other hand, 45% of the brick-makers that generate broken bricks reuse them as coverage of new fires. The rest of the brick-makers discard them and give them some unknown final disposal or as fillings of roads, floors and agricultural land. Sixty nine per cent of the brick-makers who produce cast bricks put them up for sale as a product that the architects use in finishing⁵, while 32% of the brick-makers that produce raw bricks, they cook them again. Other residues are the ashes they use for their crude brick layings and the nails from the pallets, which they sell as metal.

As far as the knowledge of the brick-makers with respect to other forms of production, only 14% of them know devices like turbines, blowers, dispensers, mixers and mills. Very few (less than 3%) know of other types of kilns and this experience is mainly due to the direct observation of other brick-makers. It points out that less than 2% knew or used other forms of production promoted by both government interventions and other initiatives such as the Swiss Contact ELLA Project.

The production artisanal character and the low volumes of pieces produced are reflected in the size of the productive units measured by the number of employees. Under this criterion, the units are classified as "micro-enterprises", with a stagnation in the accumulation of capital associated with the lack of financial education or profitability, as well as the difficulties to obtain work force, as expressed by brick-makers in the workshop In the State of Mexico. The number of employees involved in production varies between two and ten, with two to four people more often, 79% of all cases, as shown in figure 20.

Figure 20. Percentage of artisanal brick making units by numbers of employees
Source: INECC.



The activities carried out within the production of bricks are several, and it is very common (up to 47% of cases) that a person performs more than one activity; women perform a smaller variety of tasks compared to men, such

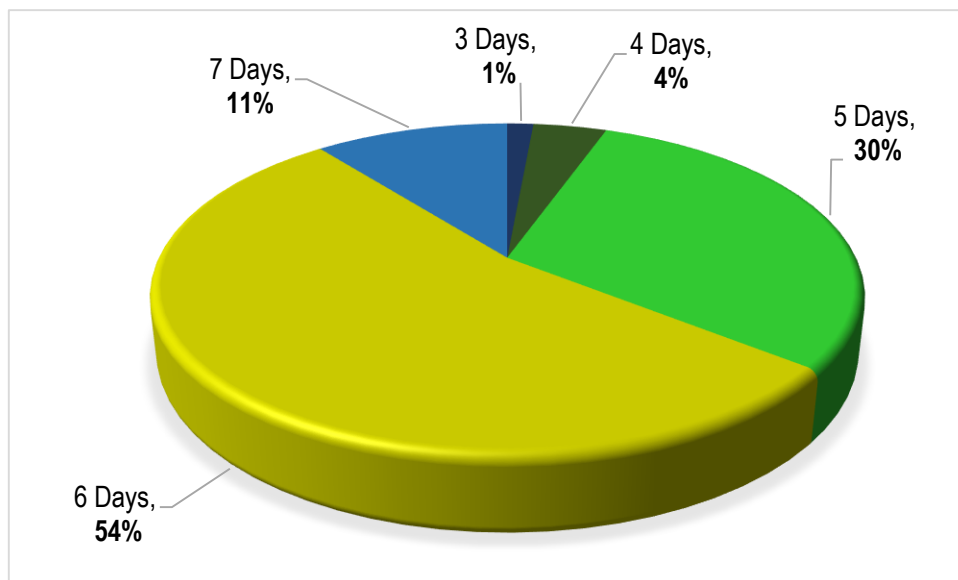
⁵ Data confirmed in the workshops.

as cleaning and molding or cutting of raw brick. Their participation in the accommodation and burning is reduced. The activities in general are:

1. Carry and load materials for the mixing of clays.
2. Mix or knead materials used in the formation of clays.
3. Molding or cutting raw craft bricks.
4. Laying of raw handmade brick.
5. Braid (accommodate inside the kiln) or accommodate raw craft bricks.
6. Burning raw handmade bricks in the kiln.
7. Cleaning of handmade bricks.

The informality of the activity and the low financial capacity lead to a work rate, which is flexible according to the demand and the rate of the burns carried out, since they mark the periods with longer days (up to 46 hours) for those who attend them. Eighty four percent of brick-makers work from 5 to 6 days a week without fixed schedules (Figure 21).

Figure 21. Percentage of artisanal brick-makers by number of workings days per



Source: INECC.

It is evident that the conditions under which production is carried out determine the presence of health risks, both for the performance of the work in the open with exposure to moist and cold mud mixtures, and the heat and suspended particles irradiated from the kilns. It has been detected that the main health problems of the people who participate in the activity are diabetes 8%, arthritis 8%, hypertension 3%, rheumatism 3%, asthma 2%, visual deficiencies 2% and hearing impairments 1%. Despite of this, the profile of the activity does not

include the culture of personal protection, 76% of the producers use, as protective equipment, hat or cap, 67% use gloves of various types and not necessarily appropriate for the activity, 21% wear rubber boots to protect against moisture, only 9% occupy safety glasses as eye protection and less than 1% use some type of hearing protection.

The analysis of the main variables by state is shown in Table 12; the most important differences are: producers in the states of Jalisco, Tlaxcala and Guanajuato have the lowest percentages of owners whose kiln is in the same place in which they live; the kilns of the producers of Puebla and Morelos are those of greater capacity; in Puebla it highlights the use of diesel while Tlaxcala and to a lesser extent Guanajuato and State of Mexico unleash the use of waste.

Table 12. Between states differences on production variables

Characteristics		States						
Identifier	Unit of measurement	Hidalgo	Tlaxcala	Puebla	Morelos	Estado de México	Jalisco	Guanajuato
Artisanal brick-maker whose kiln is close to his own house	% Of brick-makers	49%	33%	59%	100%	53%	32%	39%
Production per backing	Pieces /backing batch: $\bar{X} \pm S$	7,398 +/- 4,961	10,667 +/- 9,866	20,327 +/- 11,533	26,260 +/- 4,145	12,040 +/- 12,105	12,595 +/- 9,968	12,714 +/- 8,067
Monthly production	Pieces /month: $\bar{X} \pm S$	21,420 +/- 24,869	12,000 +/- 8,178	22,879 +/- 12,790	33,750 +/- 17,970	15,916 +/- 19,063	19,203 +/- 19,915	23,134 +/- 18,255
Percentage of brick-makers that uses as fuel:	Biomass	97%	0%	92%	75%	89%	92%	75%
	Diesel	3%	0%	7%	0%	0%	1%	1%
	Wastes	0%	100%	1%	0%	11%	0%	20%
	Others	0%	67%	4%	0%	0%	11%	5%
Percentage of artisanal brick-makers that produces:	Bricks	100%	100%	99%	100%	100%	86%	100%
	“Cuña”	17%	0%	2%	0%	9%	24%	4%
	Tiles	9%	0%	2%	0%	4%	2%	0%
	“Loseta”	11%	67%	2%	25%	2%	1%	1%
Employees working in the artisanal brick making unit	Employees: $\bar{X} \pm S$	2 +/- 3.1	1.3 +/- 2.3	0.2 +/- 0.8	2.5 +/- 2.4	2.7 +/-2.6	1.9 +/- 2.3	1.7 +/- 2.4
Working days per week	Days /week: $\bar{X} \pm S$	5.8 +/- 1	5.6 +/- 0.5	5.7 +/- 0.7	5.25 +/- 0.9	5.3 +/- 0.7	5.5 +/- 0.8	5.7 +/- 1.1

Source: INECC.

5.1.3 Cases of private and governmental intervention.

In San Diego Cuachayotla, Puebla, was inaugurated in 2007 a tunnel-type brick kiln based on 90 infrared lamps (temperatures of 800 degrees Celsius and one hour of cooking) (Herrera, 2010), which was disused by The high consumption of electrical energy. As described in the second report, another kiln was built in San Pedro Cholula with financing from the Government of the State of Puebla, which ceased to be used due to an un-transparent management that did not generate trust among the producers.

In El Refugio location in Leon, Guanajuato, the State Ecology Institute and the Mexican Chamber of Construction Industry, Guanajuato delegation, in 2010 they financed an MK2 demonstration kiln that continues to function even though the producers are waiting for the corresponding official validation of emission compliance. In that same locality the University of Guanajuato constructed another kiln with an experimental technology that consisted of a gas burner in a chamber lined of ceramic fiber and chimney for 25,000 bricks (at the moment exists a prototype in the University of Guanajuato with a capacity of 50 bricks), but that it did not come into operation because in the preliminary tests it did not obtain the suitable baking of the bricks and it has been gradually dismantled.

The National Institute of Nuclear Research (ININ) carried out a two-kiln coupling project under the same operating principle of the MK in Metepec, State of Mexico, adapting a temperature control module. The project concluded in February 2013, with the analysis of the emissions in the chimney of the coupled kilns by means of gas-mass chromatography, a kiln with chimney and the traditional ones for comparison in CO₂, CO, CH₄ and SO₂. Tests of compression of the bricks to different temperatures and times of cooking under the Mexican Norm: NMX-C-441-ONNCCCE-2005, tests of a control system for the operation of the gates according to the dosage of the fuel and temperature of the Kiln and gases generated from the combustion and chimney draft studies for a natural convection of the combustion gases towards the coupled kiln. There is interest of several municipalities of the country but the installation of the same has not yet materialized (Chávez-Towers, 2016).

Since 2012, CIATEC has developed a project for the geometric redesign and numerical validation of the optimization of heat transfer in field kilns, with the support of the Ministry of Energy, with financing from the Council of Science and Technology of the State of Guanajuato. MK2 in the state of Guanajuato. The objective is to contribute to the productivity, efficiency and reduction of the environmental impact of the brick industry in the state of Guanajuato (Alonso, 2016).

In the municipality of Loreto, the government of the state of Zacatecas promoted and supported 10 artisanal producers to form the "Ladrilleros Ecologistas de Loreto, Zacatecas" cooperative since 2013, which already has more than 60 regional clients and is probably the only case of Government intervention that continued to operate at the commercial level (Zac.net Directorates, 2016). The municipality gave them a land of 4 hectares to install their industrial warehouse, where they built a traditional kiln with conducted emissions and burn system modified to use treated oils, with capacity to produce between 40,000 and 50,000 pieces, endowed with band and Extruder. The technology allowed a reduction of the burning time from 3 days to only 18-20 hours and a significant reduction of its emissions.

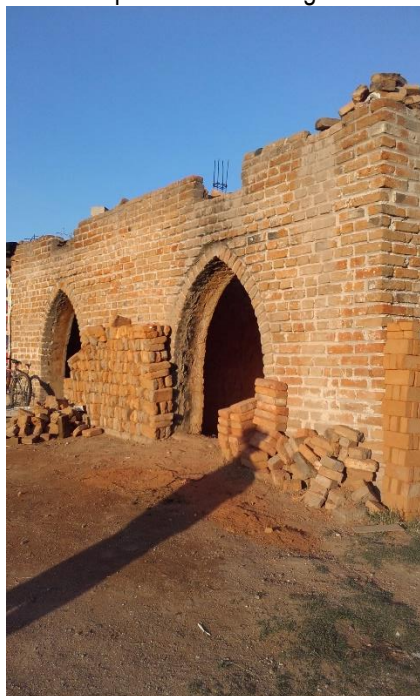
This enterprise produces bricks with holes and pieces customized to the customer's needs, although the price of the brick produced was higher in comparison to the prices that each piece of traditional producers reach. The project is currently seeking municipal funding to strengthen the marketing of products and Dr. Hernández, the initiative's promoter, is trying to replicate it in Jerez, a municipality in the state of Zacatecas (Hernández-León, 2016).

3.2 In Durango, Durango, the municipality of Durango announced the creation of a brick park with MK2 kilns and electric compressors to improve the burning process, which aim to reduce the emissions caused by burning up to 50% (INECC , 2015).

Based on the knowledge shared with Colombian producers at the meeting held in Guanajuato in September 2012, the Union of “Ladrilleros y Conexos de Irapuato A.C.” constructed with the support of the University of Guanajuato a bi-chamber kiln with fixed arches, with 15,000 pieces of capacity and with a potential of 50,000 pieces per month, with a burn time of 17 hours (Figure 22). In an interview, the lead producer of the initiative indicated that fuel savings and low emissions are achieved and are projected to build another one with four cameras (Santoyo-Reyes, 2015).

Regarding the development of productive and entrepreneurial capacities, 96.5% of artisanal producers have not benefited from training programs and only 3.5% have benefited from any program; In terms of credit support only 1.2% have had access to credit support while 98.8% have not been able to access it, so they maintain their activity according to the empirical experience accumulated and transmitted between them. The topics in which it has received training are costs and administration, technological improvements, marketing and environmental issues. This situation does not derive from the lack of interest of the producers, because 67% of them are clear about the need for training in the aforementioned issues and on legal issues regarding property ownership.

Figure 22. Two-camera kiln with permanent burning structure. Irapuato, Guanajuato.



Source: INECC.

5.1.4 Examples of international efforts

Colombia is a leading country in intervention actions on the brick industry in South America, through the Corporate Environmental Corporation under the Bogota Chamber of Commerce and with international support, has had a trajectory ranging from the adoption in 1997 of a policy Of emissions standards for fixed sources, to the implementation of a program of energy efficiency opportunities in the brick industry in 2008.

Since 2010, the intervention of the Swiss Agency for Development and Cooperation (SDC) and EELA for the modernization of brickworks is part of the Colombian Low Carbon Development Strategy. The projects in 2015 address the issue of energy efficiency of bricklayers, implementation of adequate air-fuel systems, inventory and characterization of the sector. The fundamental objective has been the reduction of greenhouse gas emissions through the massification of technological changes and good practices.

The Colombian model is sectorial and encompasses studies and research, strengthening of entrepreneurial skills, transfer of technology and institutional articulation. As a result, more than 200 bricklayers serviced with a cumulative reduction of more than 52,000 tons of CO_{2eq} and income improvements for \$ 1,439,215 dollars were reported in 2015. (Herrera-Cuéllar, 2015)

In Brazil, a package of public policies aimed at promoting innovation and competitiveness in the manufacture of septum was launched (Lima, 2012). These policies are represented in specific programs such as:

- "Streets of the Town" that paved streets with ceramic blocks, which has the advantage of generating less heat and gave sources of employment.
- Green energy efficiency due to the use of biomass available between agro-business waste and the furniture industry, in connection with the commercialization of carbon credits (56 certified brick blocks).
- Comparative analysis of the life cycle, which showed that the impact on climate change by clay tiles is 69% less than with concrete tiles and in the case of blocks for walls, clay tiles generate 50% less impact.
- Sectorial Quality Program, which seeks technical standardization and the fight against non-conformity of products.
- Construction of ceramic block houses to demonstrate their goodness.
- Innovation in designs and colors.
- Energy efficiency labeling of dwellings.

In Bangladesh, the World Bank supported in 2009 the monitoring of the operation of a hybrid Hoffman kiln, which demonstrated the reduction of coal usage from 24-26 tons per 100,000 pieces to 14 tons, in addition to meeting the Indian standard of 1000 mg / m³ Of particles emitted into the atmosphere (in Mexico the standard ranges from 350 to 450 mg / m³). This intervention also evaluated the positive effects on occupational hygiene and safety, both in the construction phase of the kiln and in the operation phase. There are no reports of the impact of this intervention on the transformation of brick production (IIDFC, 2009).

The World Bank has had a vigorous intervention in the South Asian region, oriented to the clean production of bricks. The actions of this intervention are sector review; south-south knowledge sharing, carbon market planning and carbon finance projects (Li, 2012).

The Asian Bank provided an additional \$ 50 million loan to support the energy-efficient brick production in Bangladesh in May 2012. The main lessons learned were.

- Initial investment in new technologies is very high
- Unfair competition from traditional technologies
- Resistance to change
- Difficulty meeting environmental standards
- Collecting data to access carbon markets is challenging because of its technical complexity

5.1.5 Forms of organization between brick-makers.

As described above, the production is organized into family units that use the work of piecework employees under an individual production scheme even when the brick-makers form part of an association; in some cases, the associations are formalized before the Ministry of Finance, as in "Juanita Construction Materials" in Actopan, Hidalgo and two other associations in the State of Guanajuato.

The tendency to associate has arisen in different places where they carry out their activities, with the intention of establishing a dialogue with the authorities in search of support, in addition to the extension of their commercialization channels. Through the surveys, interviews and data obtained in the workshops, 33 associations of brick brick-makers were detected, of which half are in Guanajuato, another 25% in Hidalgo and the remaining 25% in Puebla, Tlaxcala, Morelos, Mexico and Jalisco (Table 13). The existence of these associations does not necessarily imply an improvement in the performance and achievements of those who integrate them: in the workshop held on October 22, 2015 in Jalisco and in different interviews, problems were detected between the associated brick-makers and resistance to associate in which are not.

Table 13. Formal artisanal brick-makers associations detected by surveys or in workshops

State	Municipality	Association name	Source
Hidalgo	El Arenal	Asociación Unión de Ladrilleros El Arenal	Survey
Hidalgo	El Arenal	Ladrilleros y asociados	Survey

Hidalgo	Santiago Tulantepec	Asociación de Ladrilleros	Survey
Hidalgo	Tulancingo de Bravo	Productores de Tabique El Paraíso	Survey
Hidalgo	Tulancingo de Bravo	Sindicato de Horneros	Survey
Hidalgo	Tulancingo de Bravo	Tabiqueros Tulancingo	Survey
Hidalgo	Actopan	Sociedad Cooperativa Los Arcos	Survey
Hidalgo	Actopan	Materiales para la Construcción Juanita	Taller
Puebla	San Pedro Cholula	No indicó el nombre	Survey
Puebla	Chignahuapan	No indicó el nombre	Survey
Estado de México	Chalco	No indicó el nombre	Survey
Estado de México	Chicoloapan	No indicó el nombre	Survey
Jalisco	Acatic	Acatitejas	Survey
Jalisco		Emiliano Zapata	Taller
Jalisco	Zapopan	Unión de Ladrilleros	Survey
Jalisco	Acatic	Asociación de Ladrilleros Acatic	Taller
Jalisco		Unión Ladrillera de la Caberiana	Taller
Guanajuato	Acámbaro	Unión de Productores ladrilleros de Acámbaro	Survey
Guanajuato	Apaseo el Alto	Apaseo el Grande	Survey
Guanajuato	Celaya	Ladrilleros de San Miguel	Survey
Guanajuato	Cuerámbaro	Comité de ejidatarios	Survey
Guanajuato	León	Ladrilleros Unidos	Survey
Guanajuato	León	Unión de ladrilleros del Refugio A.C	Survey
Guanajuato	León	Unión 15 de Mayo	Interview
Guanajuato	Irapuato	Unión de Ladrilleros y Conexos de Irapuato A.C.	Interview
Guanajuato	Romita	No se indicó el nombre	Interview
Guanajuato	León	Productores de Barro y Arcilla del Refugio, A.C.	Survey
Guanajuato	San Felipe Torres Mochas	Productores de Barro y Arcilla	Survey
Guanajuato	San Luis de la Paz	Unión de ladrilleros de San Luis	Survey
Guanajuato	San Luis de la Paz	Unión de productores A. C.	Survey
Guanajuato	Silao	Ladrilleros Unidos de Silao	Survey
Guanajuato	Valle de Santiago	7 luminarias	Survey
Edo. De México	Chalco	Unión de Productores de los Volcanes	Workshop

Source: INECC.

Another form of non-formalized functional organization is the "maquila" (production) scheme in which kiln owners rent it from brick-makers to burn their raw brick: 6% of the brick-makers use this option and it is reported in the literature that in the El Refugio locality in Leon, Guanajuato, some brick-makers use this mechanism (SERPRO, 2012). Of course, there are isolated cases of kiln owners who use labor intensively from employees thanks to the acquisition of technology and thus achieve the accumulation of capital, through strategies such as promotion and direct marketing (SERPRO, 2012).

5.1.6 Agents of the value chain of artisanal brick production.

Various actors, such as suppliers, brick-makers, marketers, consumers or final claimants and actors linked to government support or technical support are involved in the value chain. The production financing activity rests with the marketers themselves (Figure 23).

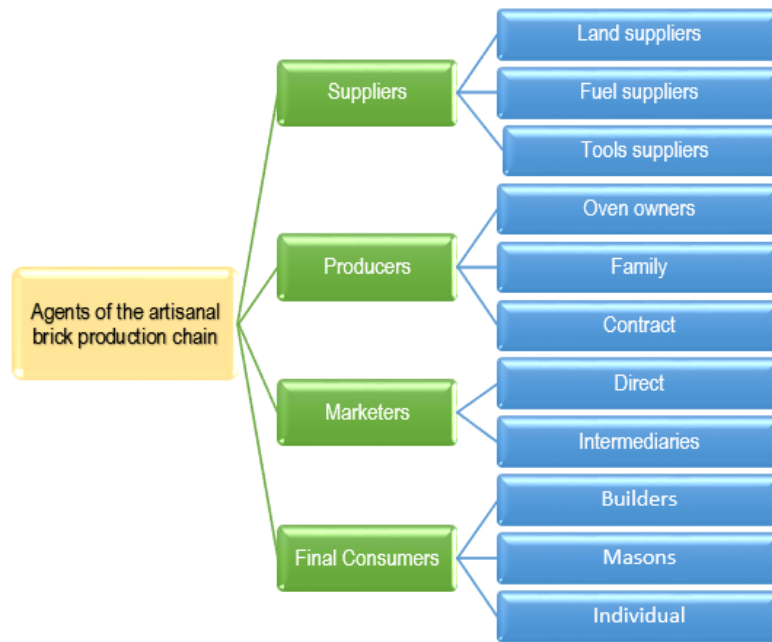
Mainly suppliers carry inputs, such as land of different types, manure, fuel materials and eventually water, which are required for production, and probably 32% of brick-makers with their own truck perform this function. The earth material is supplied from material banks, but also as material of prey disassociation or part of the subdivisions in construction. A practice detected throughout the Bajío is that the owners of agricultural parcels "rent" their property so that the brick-makers exploit the superficial layer of material (1 or 2 meters), leaving with it a sinuous topography and diverse damages to the environment. These lands can return to agricultural production over time, because the layer of arable land is not exhausted (Source: INECC.).

The own brick-maker is in charge of the commercialization if it owns own truck (32% of them), avoiding in this way the intermediary and offering its product to the final consumer; however, the most common marketing scheme is the sale at the foot of the kiln, to where buyers usually are intermediaries, who have contact with both brick-makers and final consumers, a fact that was reiterated by engineers and architects consulted in the 6 workshops on demand analysis.

In León, Guanajuato, three marketing mechanisms have been identified for the artisanal brick-maker: sale to intermediaries only (48.4%), sale to the direct consumer only (10.3%) and flexibility of sale of one form or another (41.3%) (SERPRO, 2012). Construction materials marketers sell alternative products such as concrete blocks or even extruded bricks, but usually do not sell artisanal brick.

Throughout the workshops, participants indicated that the financial capacity of the intermediary allows him to offer liquidity to the artisan brick-maker by paying cash the product, or even, to finance the production by paying in advance, albeit at a lower price. The market analysis of the artisan brick-making sector in El Refugio of León, Guanajuato, published in 2012, describes that the price for prepayment may be 17% lower than the price at the kiln (SERPRO, 2012). In this way, the intermediary plays a double role: on the one hand, it connects production with the consumer market and, on the other hand, provides a "financial" service to brick-makers, thereby avoiding waiting for payment terms.

Figure 23. Agents in value chain of artisanal bricks



Source: INECC.

Intermediaries are not necessarily formalized nor taxed before the treasury, which prevents them from delivering invoices to their customers (SERPRO, 2012) even though they take the product directly to the site of the work or are stationed on land and public fixed places that allow the potential buyer to locate them easily. This scheme can be observed in different places of the cities or in their accesses as the case of Morelos, where the constructors buy brick of Cholula, Puebla; in very few cases, engineers and/or architects buy their product with suppliers of handmade brick at the foot of the region.

Three classes of final consumers were identified for the artisanal brick. The first is the professionals⁶ who are engaged in construction, either on their own or as small or medium-sized construction companies. It is made up of engineers and architects and its main market is the constructions by client's order and eventually by public works. The second group consists of companies that build housing in series, mainly economic or social interest and the third group, which emerged as a result of the analysis of the comments of the six workshops, is that of self-construction, constituted by people who, without Being professionals in the field, build on their own account or with the help of other people their own home. It was clear that this segment of self-construction is the one that predominates in the ZAP (Zone of Priority Attention).

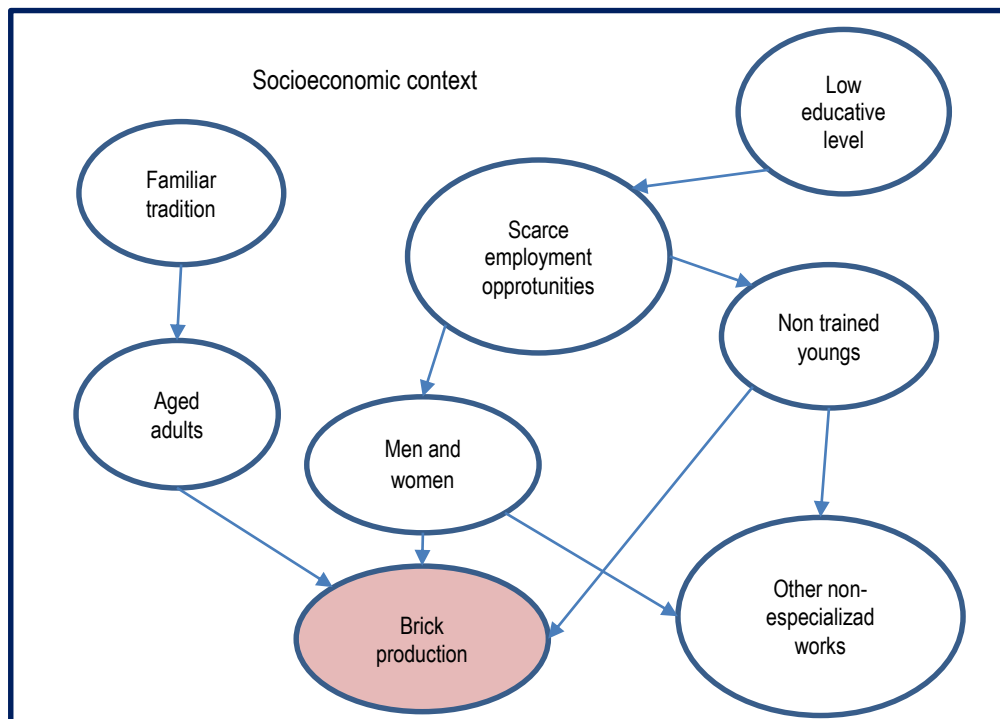
5.1.7 Socioeconomic and environmental constraints on the production of artisanal brick.

In the social profile of brick brick-makers, the low educational level, which limits access to specialized work opportunities, stands out. Given the need to generate economic income, the option that is mainly left to women

⁶ Construction professionals are those who are dedicated to providing their services to third parties based on civil engineering training, architecture or similar.

and young people without training, are non-specialized jobs such as fieldwork, domestic work and construction work. The production of bricks represents an option for contracting piecework (although the work of family members is usually not considered as employment, but as an unpaid contribution). Brick-makers usually come from families who have dedicated themselves to the activity in the absence of better opportunities, because the brick production does not imply greater specialization in the work, although it requires sufficient empirical knowledge. For the elderly, it may be the main or only work option (Figure 24).

Figure 24. Socioeconomic context of artisanal brick making



Source: INECC.

On the other hand, a number of material conditions are required for the activity to be feasible and production is carried out. The availability of land at the local level can determine the success of production, as well as the location of the activity, inside, either on the periphery or near the urban areas that constitute its market. The same happens with the need for access roads that allow the transfer of the raw material and the finished product, whose value is associated with the least possible loss of the raw material.

The proximity of the production areas to the urban areas plays a double role, on the one hand, as a competitive advantage the production is carried out as close to the consumption sites as possible, but on the other hand, this proximity increases the annoyance and the complaints of the neighbors against the activity and the reactive response of the municipal environmental authorities. Finally, the rainy weather is one of the limiting aspects of the activity, reason why non-humid climates are ideal for the production of brick.

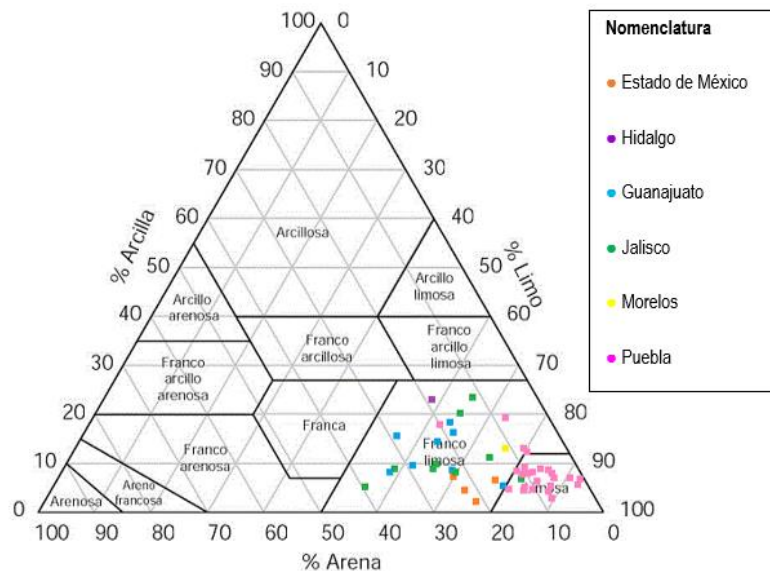
The main problems in the acquisition of fuels are economic reasons, 54% of the brick-makers are concerned about the price, 32% for their availability and 15% for the transportation problems of the same. By contrast, legal

concerns are minor, only 15% of them consider permits to be a problem, and 11% consider environmental monitoring a problem to be faced.

The availability of soil to form bricks is a condition that limits or favors their production. In order to better understand the influence they have, we analyzed 47 samples obtained directly from the different types of land used by brick makers from the Megalopolis and the states of Jalisco and Guanajuato, located within the limits of the Neo-volcanic Axis, whose Lithological nature is dominated by extrusive and intrusive igneous rocks, as well as sedimentary rocks and alluvial materials in the lower parts topographically (Cruz-Ortiz, NL et al, 2016). The region where the brick-makers are located has repercussions on the access to the clays, due to the relative ease (or difficulty) of obtaining the inputs, which results in stability and productive competitiveness.

According to the classification of the textural triangle (Figure 25), the soils used in the production of artisanal brick are organic and inorganic silts and not clays, as is alluded to when speaking of bricks, which in different proportions together with a portion of Sand and other clays make up the material used by the brick-makers. The texture is loamy-loamy but in Puebla it is definitely loamy, which explains why sites were found where the earth is used directly without mixing with other materials to form the bricks and also the remarkable production of pieces in that region.

Figure 25. Classification of clay samples used by artisanal brick-makers



Source: modified by CIATEC from texture triangle from USDA ((USDA, 2016)

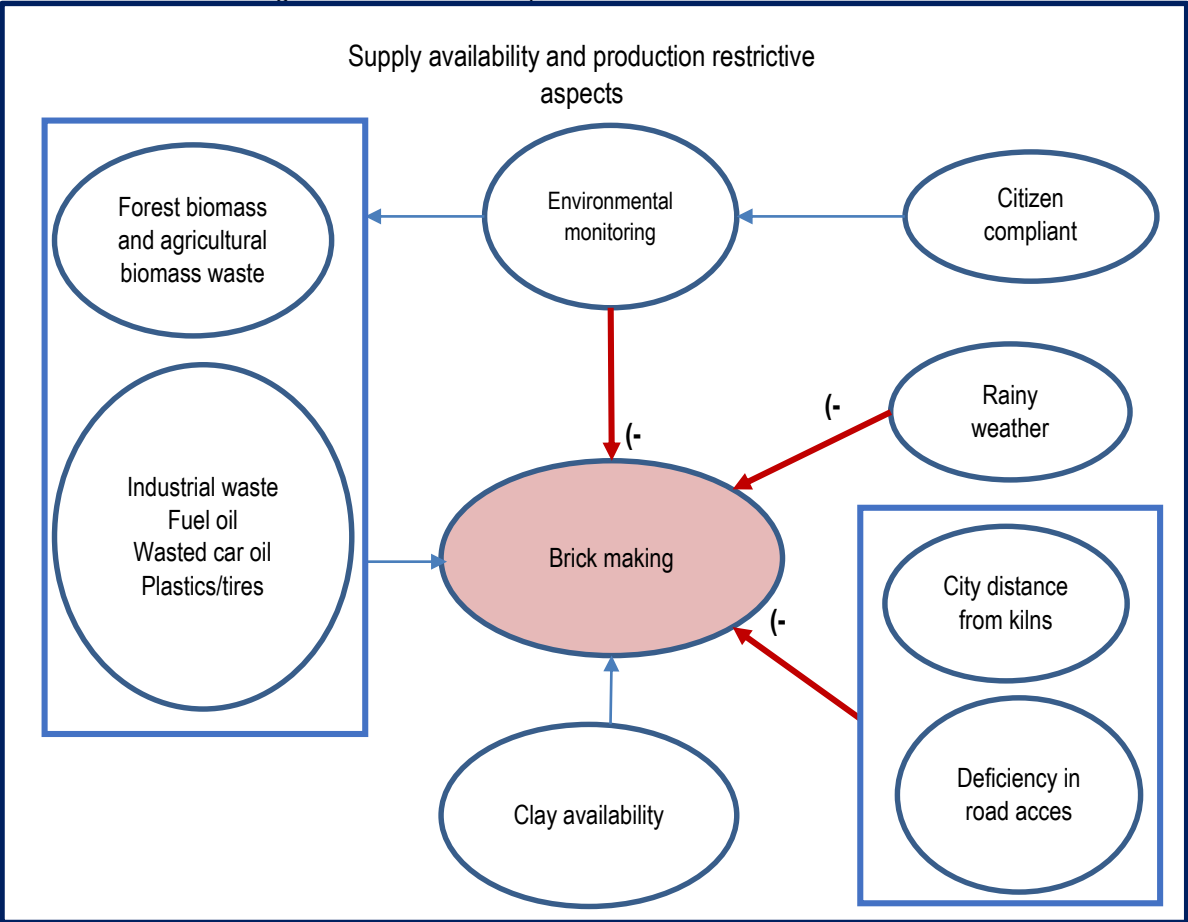
In terms of how to produce, it is notable that brick-makers do not focus on technological and process improvements, access to other types of infrastructure or cost reduction. In the view of 56% of brick-makers, the improvements to be made in the processes focus on having control of direct sales, less than 1% of brick-makers expressed the need for a truck, despite the fact that would allow selling directly its product avoiding the intermediary and increasing its participation in the value chain.

In terms of atmospheric pollution, 53% of the kilns are located in urban areas or in suburban areas, with significant interaction depending on the distance that pollutant emissions can reach due to the use of various

fuels in kilns Of low thermal efficiency and depending on the direction of the wind that prevails in that moment, which increases the risk of conflicts by the emissions and complaints against the activity (SERPRO, 2012).

In the workshop held in Puebla, a participant from the state delegation of the Ministry of the Environment and Natural Resources (SEMARNAT) stressed the impact of the activity on the use of fertile soil. The intensive use of biomass also causes pressure on the forest resources of each region, and ecosystem services that emerge from them, in cases where wood is used, since, as indicated above, there is no certainty that the Make with unauthorized suppliers for the exploitation and / or transportation of firewood. Figure 26 summarizes the most important constraints for artisanal brick production.

Figure 26. Artisanal brick production conditions and restrictions



Source: INECC.

5.2 Characterization of the supply of substitute products.

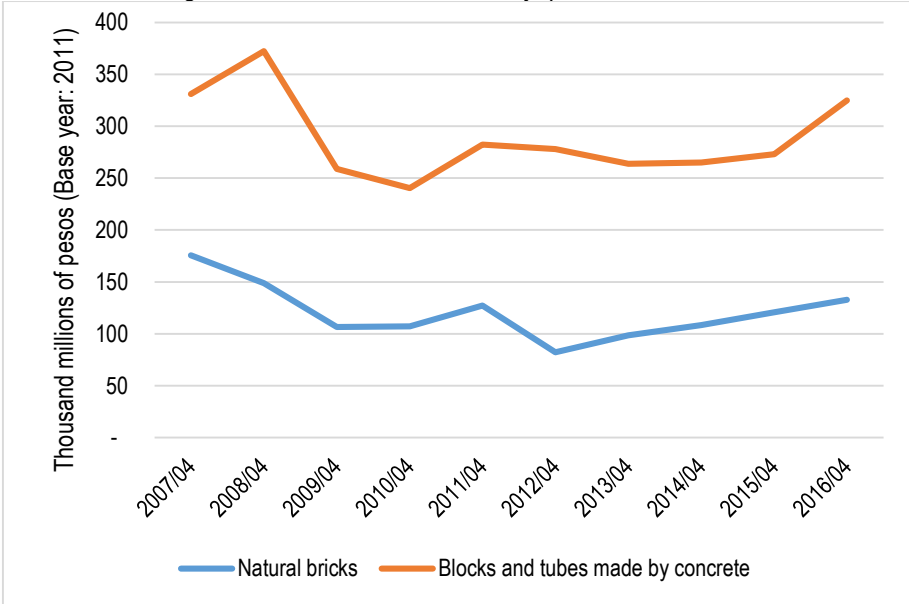
In the opinion of 78% of the artisanal brick-makers, concrete blocks are the main substitute product of the brick, while for 22% are the “tabicones” and none of them identifies the compacted earth blocks (CEB) or the extruded block as competitors. This last one, according to the information gathered in the workshops, competes mainly

with concrete products, since it is used in markets other than housing construction (the main market to which the brick is directed). The CEBs have a very small market and practically do not appear in the surveys to artisan brick-makers or in the 104 interviews to industrial producers.

5.2.1 Concrete blocks and “tabicones”.

According to the data of the Monthly Survey of Manufacturing Industry (MSMI) published by INEGI, the value of the production of tubes and concrete blocks showed an increase in the first quarter of 2015 (Figure 27), although it should be clarified that the figures do not disaggregate the value of concrete blocks so it is assumed that the increase in production occurred both in these and in pipes in terms of the production of artisanal brick has not increased considerably over the last eight years. In the figure described, the May data is illustrated as the month of greatest production value throughout the year, which is related to the end of the dry season.

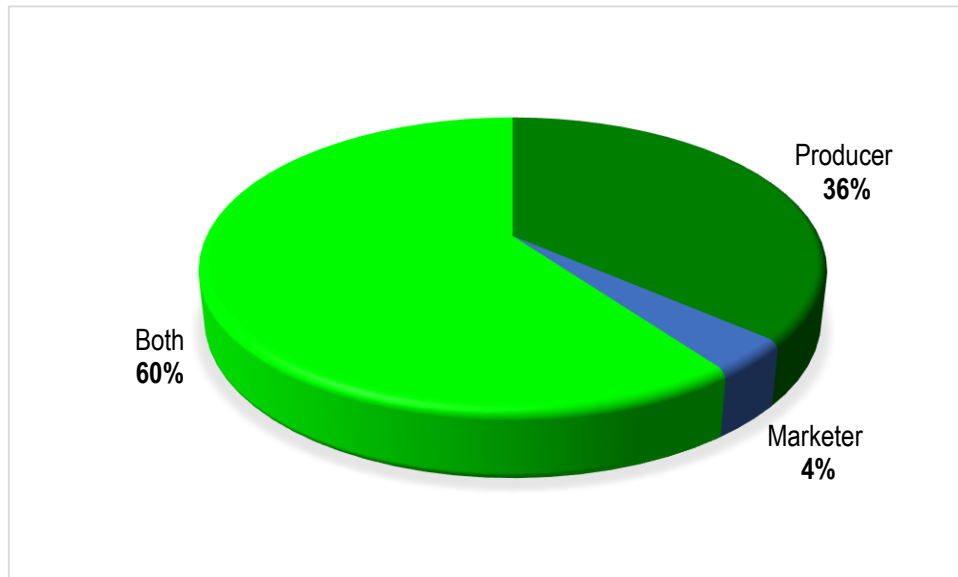
Figure 27. Production value in May, period 2007 - 2016



Source: INEGI. 2016, Encuesta Mensual de la Industria Manufacturera.

Based on the results of interviews with construction materials applicants, it is concluded that those who produce concrete block, usually market it directly or even that companies that started with the commercialization, expanded their activity by entering into block production of concrete (Figure 28).

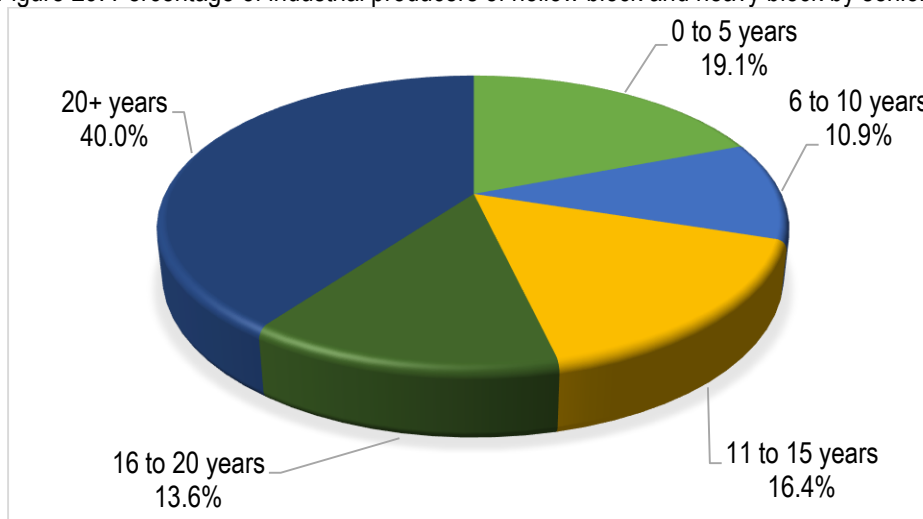
Figure 28. Percentage of brick-makers by activity



Source: INECC.

The explanation for this is that with a low capital investment, without the need for specialized workers and without sufficient surface demand, marketers can easily dedicate themselves to the manufacture of “tabicones” and blocks. In this sense, it is difficult for a marketer to acquire sufficient expertise to install a kiln and master the process of making baked brick. In support of the above idea, the age of more than 80% of the companies, dedicated to the production of “tabicones” and blocks, does not exceed 30 years and one fifth has a seniority of 5 or less years (Figure 29). On the other hand, among those who market, 66% do it directly to the consumer and 34% use other marketers. In contrast, artisanal bricklayers do not have sufficient bargaining power to influence prices paid by intermediaries, nor do they have access to an increase in profit margin for direct marketing.

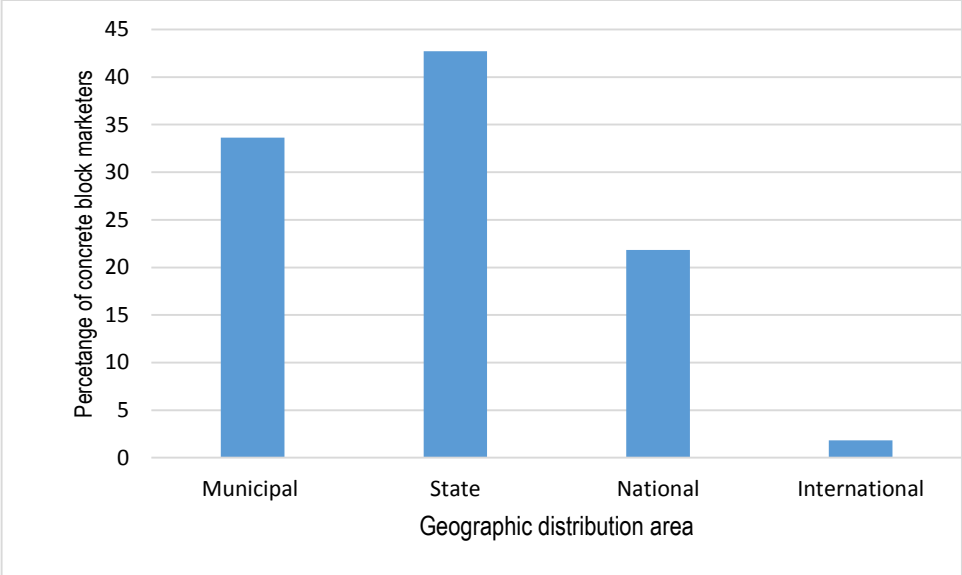
Figure 29. Percentage of industrial producers of hollow block and heavy block by seniority



Source: INECC.

The combination of manufacturing and commercialization of “tabicones” and concrete blocks at the same site allows the use of cargo transportation to cover larger distribution areas of the product. In this way, it is common that the scope of these products is state in greater proportion or even national (Figure 30). In the workshop held in the city of Pachuca, Hidalgo, the participants described the commercial movement of the block and the brick of local manufacture by the one produced in the city of Perote, Veracruz, because it is a cheaper product, although of lower quality. The reason for its low price is that, for its transport, it takes advantage of the return of the transport of cargo that travels towards the ports of the Gulf.

Figure 30. Percentage of concrete blocks marketers by geographic distribution area

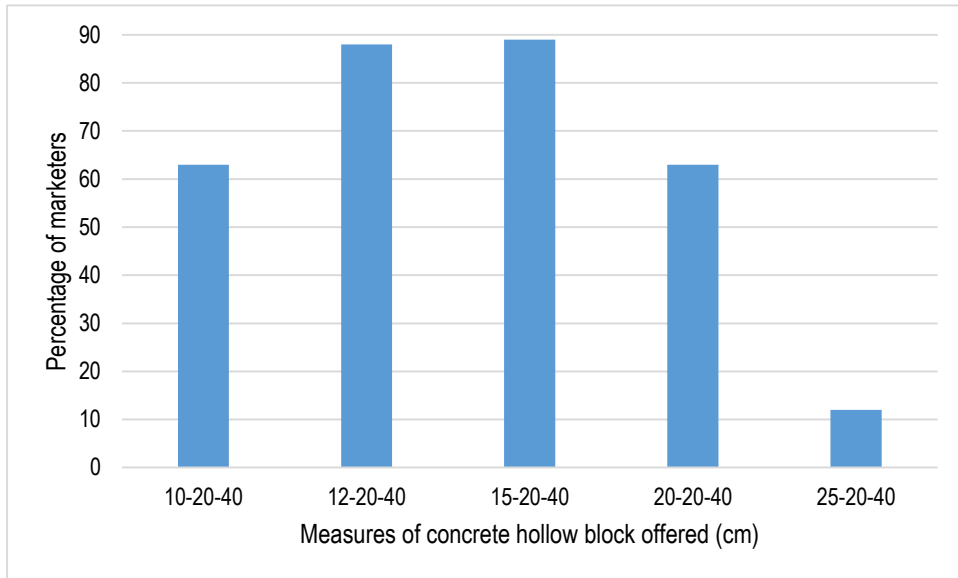


Source: INECC.

One of the important characteristics of the manufacture of concrete products is that they do not require cooking. Eighty four per cent of the producers do not consume fuel or electric energy, and 8% only use the last one. This is a difference with artisanal brick-makers who depend 100% on the use of energy in the form of fuels. The commercialization of concrete blocks and “tabicones” is carried out in part by the suppliers of construction materials (60%).

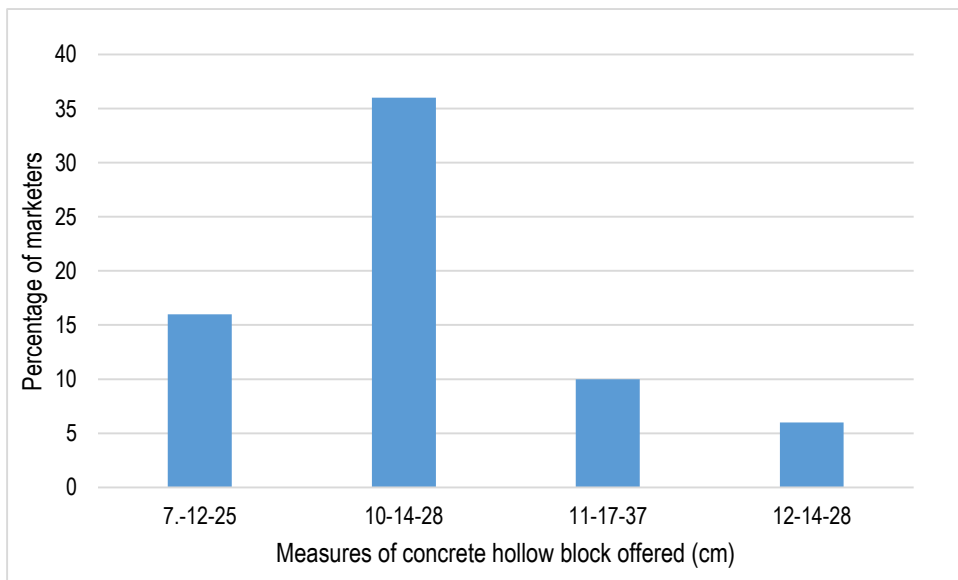
Another important feature is the standardization of dimensions, in contrast to the situation that prevails in the production of handmade brick. At the country level, blocks and “tabicones” of the same size can be acquired within a limited set of options as shown in Figures 31 and 32. The block offer is concentrated in four basic sizes and the one in two sizes. On the one hand the diversification of the size of the products creates the opportunity to expand the consumption basket, which generates a competition not only for standardization, but also for differentiated products according to the needs of each type of consumer; On the other, in terms of size the dimensions of the product are well specified regardless of the producer.

Figure 31. Percentage of marketers by concrete hollow block sizes



Source: INECC.

Figure 32. Percentage of marketers by concrete solid block sizes

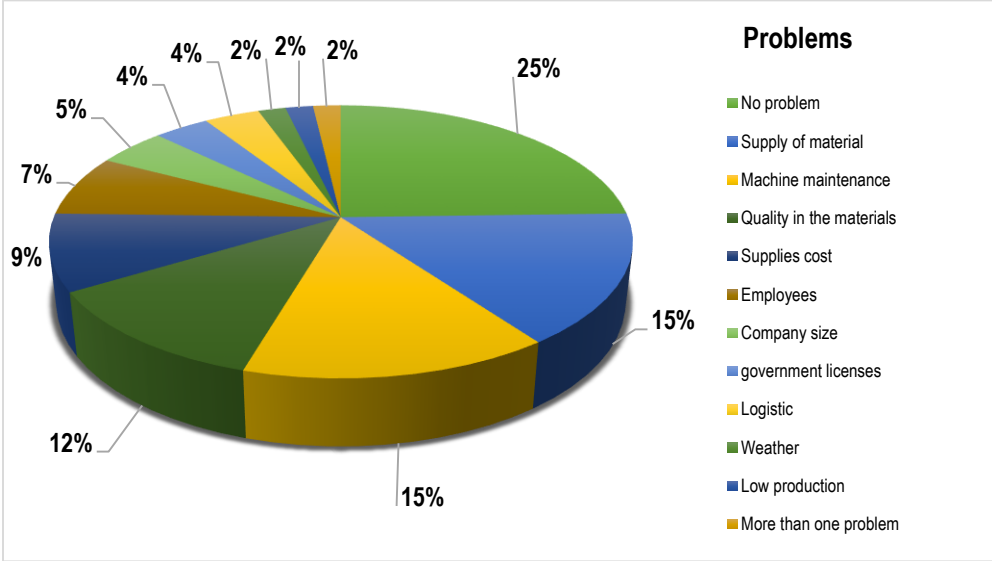


Source: INECC.

The problems encountered by 51% of the producers of concrete blocks and breeze block are the supply of raw materials, the maintenance of the machinery used in their production, the quality of the inputs and the costs of the same; it should be noted that 25% do not report problems in production (Figure 33). Other problems that are

less frequent in the production of concrete blocks are of labor type, by permissions required for the activity and logistics among others.

Figure 33. Main problems in concrete block value chain



Source: INECC.

5.2.2 Extruded bricks.

The largest industrial producer of extruded septum in the country is the company NOVACERAMIC S.A. Of C.V., located for 23 years in the municipality of Tetla de Solidaridad in Tlaxcala. Its installed capacity is equivalent to 1,000,000 of daily pieces of perforated septum of size 10x20x24 cm (3 kg of weight). The production of NOVACERAMIC is in tunnel-type kilns based on natural gas.

Its effective commercial distribution radius is 800 km and 70% of its sales are located in Mexico City, Veracruz, Puebla and Querétaro through a team of distributed vendors, as well as direct sales to social housing construction companies whether vertical or individual. Beyond the 800 km, they cannot compete with the small producers of block that operate with simple machinery and a minimum investment.

According to NOVACERAMIC staff, the share of the extruded breeze block in the construction market against bricks and concrete blocks is only 10% nationally, despite its advantages such as half the weight per square meter built, saving tipping and finishing material, better insulation capacity and low water consumption.

5.3 Characterization of the demand for structural materials for construction.

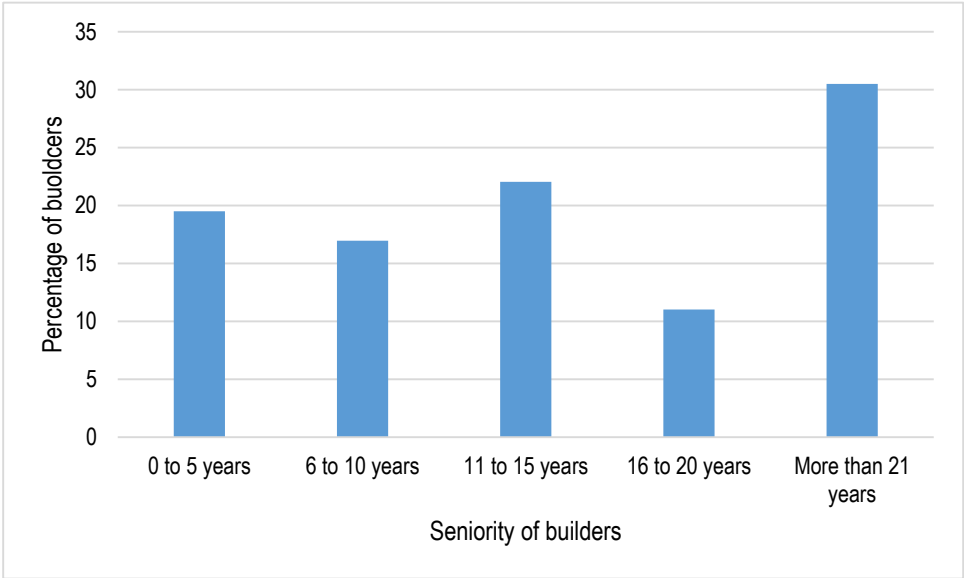
It is recognized that the demand for brick is linked to the growth of the Gross Domestic Product (GDP) and construction, mainly driven by self-construction coupled with the constant growth of the national population in not only this sector but also the different types of consumers. Although there are no more precise data, there is

some published data that support this hypothesis, a study in Ciudad Juárez showed the boom and fall of brick activity as a result of the crisis of 1995, which caused that they passed from 450 kilns to only 290 in the year 2002 (Romo-Aguilar, 2004).

5.3.1 Demand of products by construction professionals.

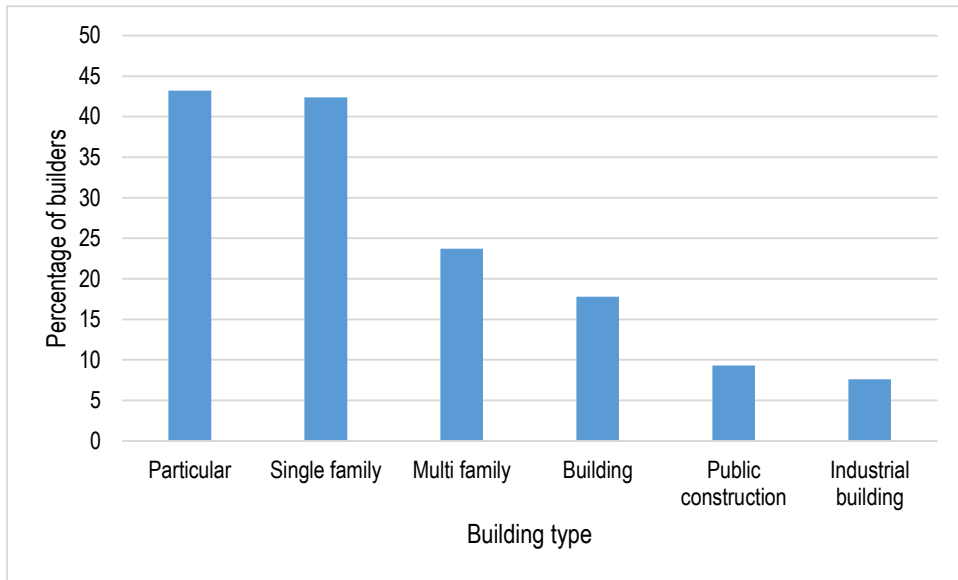
The age of individuals and/or construction companies' ranges from 19% who are under 5 years old to 31% who are 21 years of age or older (Figure 34): although they are engaged in different types of construction, 43% build particular houses, 42% single family dwelling, and 23% to multi-family housing (Figure 35). The percentage of builders who develop other types of works such as buildings, ships and public works is less than 10% and especially in the latter category do not include construction companies less than five years old.

Figure 34. Seniority of builders



Source: INECC.

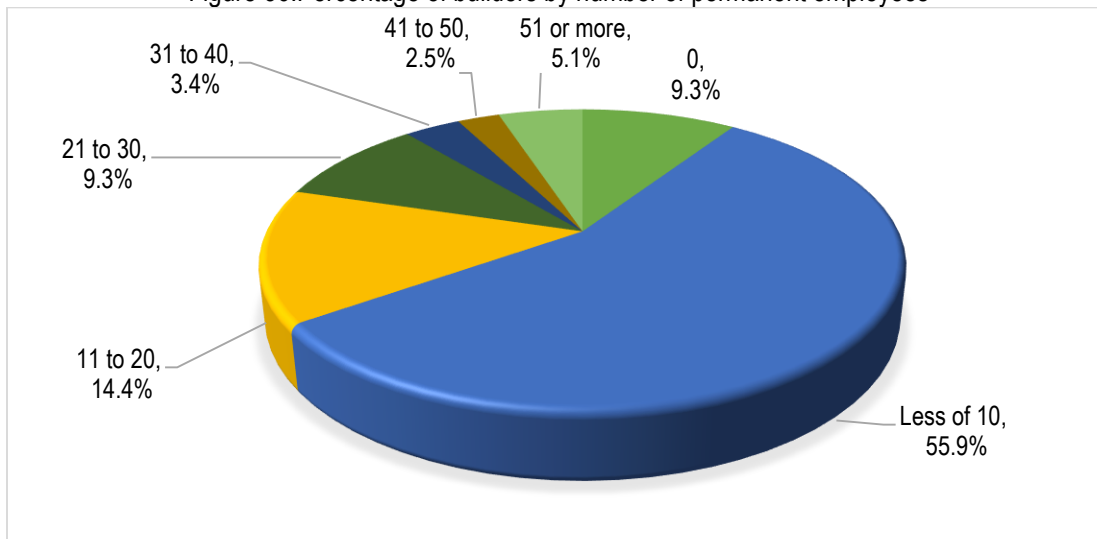
Figure 35. Percentage of builders by building type



Source: INECC.

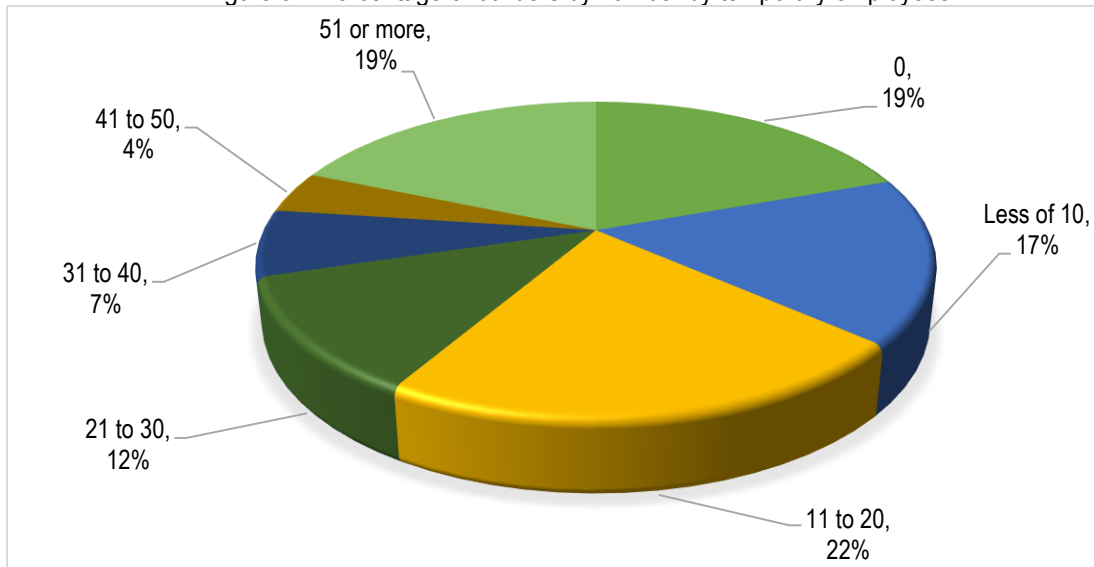
Construction companies tend to be small, since 80% of them have 40 or fewer employees, predominantly companies with less than 10 permanent employees (56%), 14% have 11 to 20 employees and 9% have between 21 and 30 employees. This means that the demand for construction products is made up of a large number of small companies. The nature of its activity implies that, depending on current projects, the number of temporary employees ranges from ten or less to more than 51 persons, although about 40% of these companies have on average between 10 and 20 temporary employees (Figures 36 and 37).

Figure 36. Percentage of builders by number of permanent employees



Source: INECC.

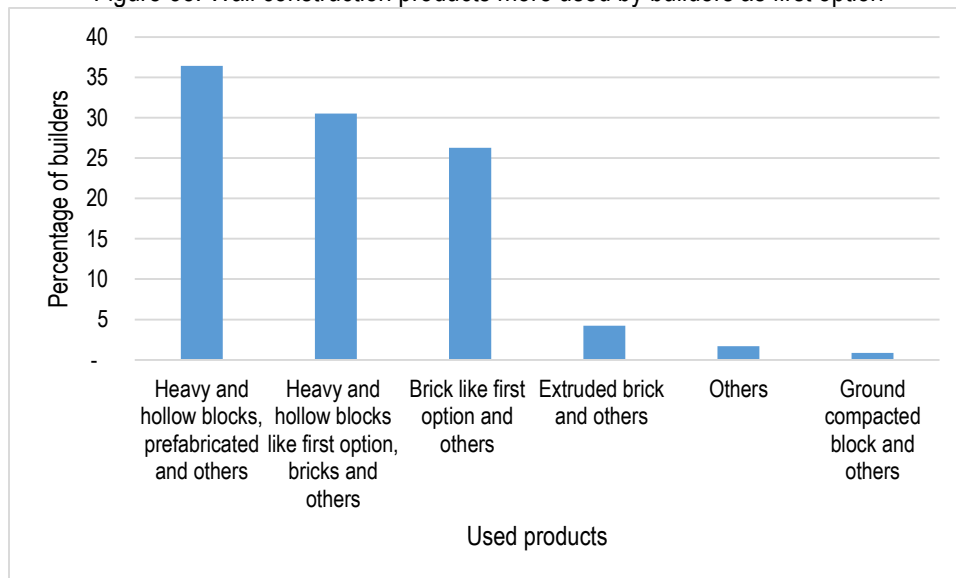
Figure 37. Percentage of builders by number by temporary employees



Source: INECC.

The preference of the constructors for the consumption of concrete block and “tabicones” as the first choice of materials to construct walls, represents about 65% of the same, compared to the 26% that prefers to the brick as first choice. Less than 5% of builders prefer the extruded brick as the first option and less than 1% the compacted soil block (Figure 38).

Figure 38. Wall construction products more used by builders as first option

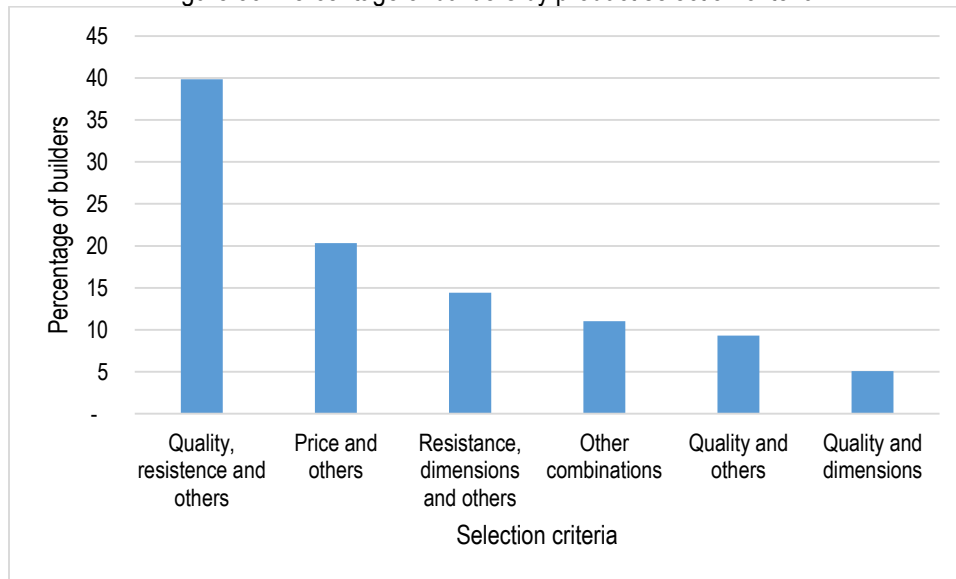


Source: INECC.

In this context, 40% of the manufacturers choose the consumer basket based on the physical properties of the material mainly for quality and resistance (Figure 39), 20% of consumers tend to choose products given the

price at which it is offered; this pattern of selection of the belonging shows that the producer tends to increase the budget constraint if he decides consumption according to the physical characteristics or adjusts his budget constraint if the purchase choice is subject to the price of the belonging.

Figure 39. Percentage of builders by product selection criteria



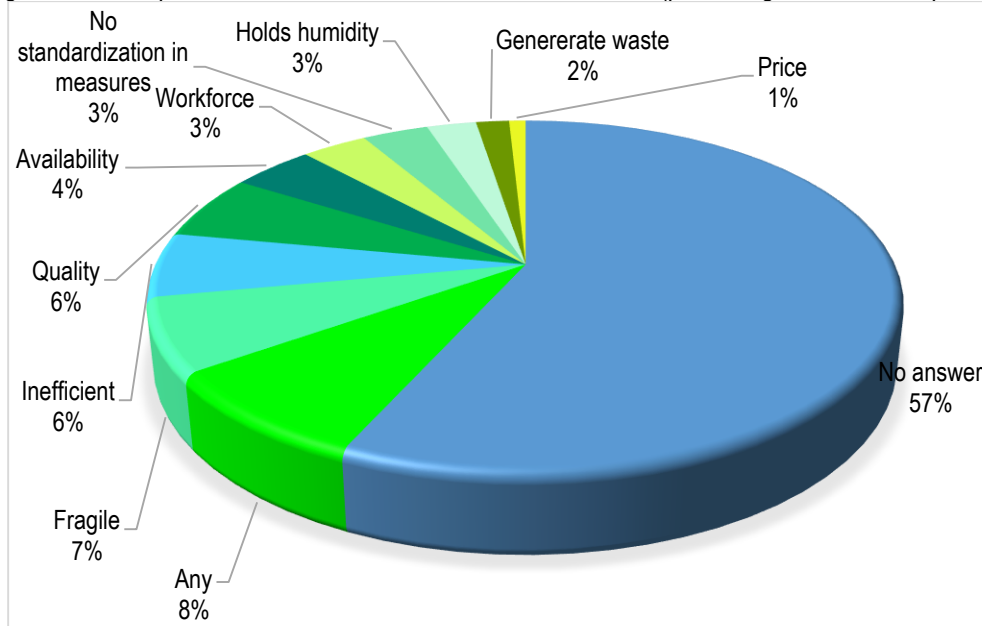
Source: INECC.

In the six workshops focused on the demand for construction materials, the participants explained that brick is used by specifications established by the client rather than by the selection of the designer, so the configuration of a portfolio of public policies must take into account to the final customer. This was mentioned, for example, in the case of school buildings in accordance with the guidelines of the National Institute of Physical Educational Infrastructure (INIFED) and the average housing.

An illustrative data of the purchase decision based on a client's budget requirement is the following: The Institute of Physical Educational Infrastructure of Guanajuato specifies the use of brick as a red brick wall and in its list of unit prices determined for August 2014 (INIFEG, 2016), that the construction of walls of 28 cm of thickness constructed with brick 7x14x28 cm or with breeze block of concrete of 10x14x28 cm, have the same price: \$ 410.77 per square meter. If it is made of brick, it requires approximately 78 pieces, while if it is made of breeze block it will require only 60 pieces; this establishes that once added the highest consumption of labor and mortar required to build a square meter with brick, there is a maximum price limit of these to remain competitive with its immediate replacement of concrete when the decision of the buyer is just for price. At current prices, the average price of brick is \$ 1.81/piece and the breeze block is \$ 2.64/piece.

Sixty five percent of the builders did not identify any problem for the brick to be selected as the first option and among those who mentioned a problem; they mentioned the fragility, low efficiency in progress during construction and quality. Only 3.4% of the participants commented on the lack of standardization and size (Figure 40). According to CANADEVI, the demand for brick by the government does not exceed 4% (SERPRO, 2012). In addition, some participants in all the workshops expressed that a disadvantage of the bricks is the uncertainty in the availability of product and the lack of invoice in the sale.

Figure 40. Main problems identified in the use of artisanal brick (percentage of builder's opinions)



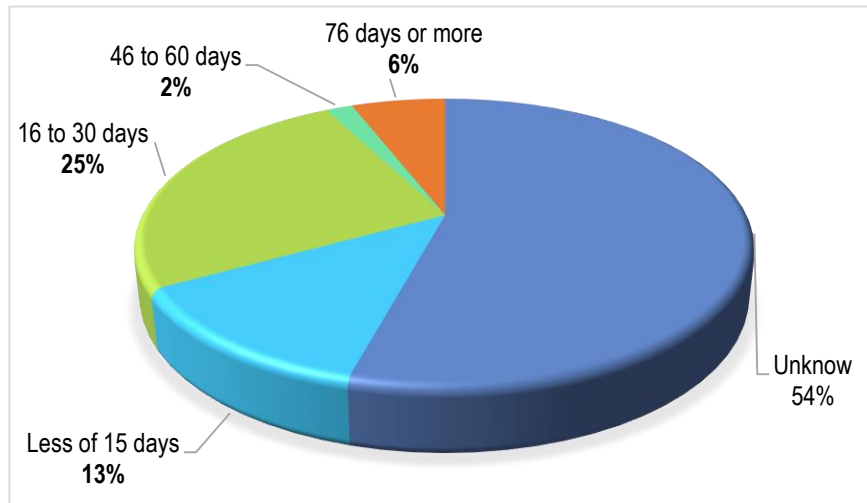
Source: INECC.

Regarding the forms of acquisition of the artisanal brick, 66% of the builders buy directly from the producer, 24% with intermediaries and the rest with either or unknown the answer. 75.3% buy with local suppliers and 21.9% buy from domestic suppliers. The discount and credit mechanisms are common: 70% of the builders have access to discounts ranging from 5% to more than 21%. They also get payment deadlines ranging from 15 to more than 76 days. This set of conditions of purchase, leaves out of the possibilities of direct commercialization to the small artisan producer without the necessary financial capacity (Figure 41).

When it comes to product standards, 55% of the builders did not give data or are unaware of them, while only 17% referred to official Mexican standards or Mexican standards. Only one participant in the workshop in Morelos referred to the complementary technical standards. Fourteen per cent of builders know the product resistance standards. During the workshops, the participants considered that the lack of resistance of the product is remedied by the calculation of the load structures, so that the requirements marked by the NMX-404⁷ are unnecessary.

⁷ Compressive strength, dimensions, initial absorption, total water and shrinkage by drying.

Figure 41. Timeframe of credit for purchases



Source: INECC.

5.3.2 Demand for materials for self-construction

Poor planning of city growth, poor access to housing options for the majority of the population, urban poverty and the low credit market for low-income families, among other factors, causes that many of them are established irregularly on marginal urban areas also called zones of priority attention (ZPA), so that in this study it was hypothesized that those concentrate a significant fraction of self-construction and, hence, brick demand.

In that respect, the report prepared for the Swiss Agency for Development and Cooperation (SDC) in 2012 provides relevant information, by noting that self-construction in Latin America "covers approximately 60% of housing construction" (Schilli, 2012), a fact that should be taken as a conservative reference as long as there is no more specific information for Mexico.

The National Household Survey (NHS) of 2015, carried out by INEGI, indicates that 2% of the households surveyed do not have adequate materials for decent housing, while 98% have been built with resistant materials (Table 14); Although it does not disaggregate the data by type of material or type of dwelling, nor does it allow to know the percentage of use of these materials in the self-construction (INEGI, 2016 a).

Table 14. Characteristics of housing construction in México

Characteristics of housing in México	Total
Total of housing	31,849,822
Walls	
Fragile	496,379
Resistant	31,353,443
Floor	
Earth	880,825
Other	30,968,828
No specified	169
Roofs	
Fragile	523,190
Resistant	31,326,632

Source: Encuesta Nacional de Hogares. INEGI, 2016.

Based on the hypothesis of the importance of the brick demand in the self-construction and since the NHS does not show specific statistical information for the types of resistant materials⁸ in the homes, the visual preference of the brick on gray brick was realized (see Example in Figure 42).

Figure 42. Ecatepec (Estado de México) urban image for visual analysis of preference



Source: Google Earth, 2016.

The results obtained are shown in figure 43. In the northern region, the preference for brick in the ZPA is "low" and even "null", except for the state of Sonora where brick and gray "tabicones" are preferred along. For the north - central region, the preference for brick in the ZPA varies from "low", in the states of Nayarit and Querétaro, although Aguascalientes, Jalisco, Michoacán, Sinaloa and Zacatecas with "high" preference", to "total" in Guanajuato.

For the central region, it was corroborated by the method of visual survey that the preference for brick in ZPA is "very low" in the states of Hidalgo and Mexico and "average" in the states of Morelos and Puebla; although the last one has the largest number of artisan producers at national level. Finally, for the southern region, the zones of self-construction generally present a preference from "null" to "very low", only the states of Chiapas and

⁸ The fragile materials on walls referred to in the ENH are: cardboard sheet, asbestos or metal sheet, reed, bamboo or palm and others. The resistant materials in walls are: wood, adobe, septum, brick, block, stone, quarry, cement and concrete.

Guerrero stand out for a preference "low" for the brick. Figure 43 shows these results by state and their resulting distribution shows that the use of brick and block has displaced brick as a traditional material in some regions of the country.

Figure 43. Artisanal brick preference in priority attention zones by Mexican state



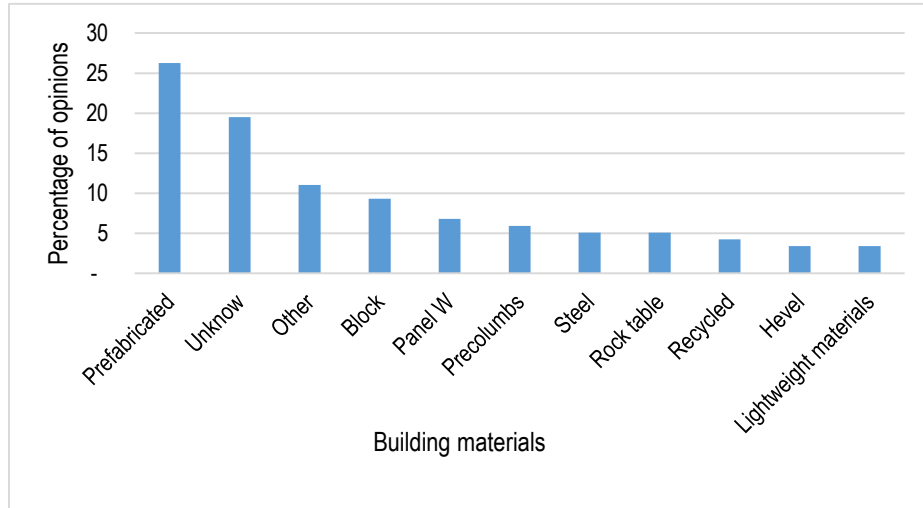
Source: INECC.

5.3.3 Trends in the use of construction materials.

In the construction segment carried out by construction professionals, 35% think that in five years a decrease in the share of artisanal brick in the market could occur, while 68% of the producers of concrete block and “tabicones” believes that these products can replace the red brick. In the workshops, the participants reiterated that, for example, the construction of a series of dwellings opts for the use of concrete “tabicones” and blocks, or of extruded bricks, while for constructions of more than three levels of height, the extruded products are most used (Figure 44).

In other types of constructions, especially in department stores and hotels or high-rise buildings, the trend is to use new products such as “W” panel, flat panel and heavel, which guarantee sufficient and timely supply, lightness of materials, as well as the quality and speed of construction. Actually, there is a diversity of materials used in the construction that have replaced or eliminated the use of the handmade brick, but also to the “tabicones” and blocks, especially in the mentioned constructions.

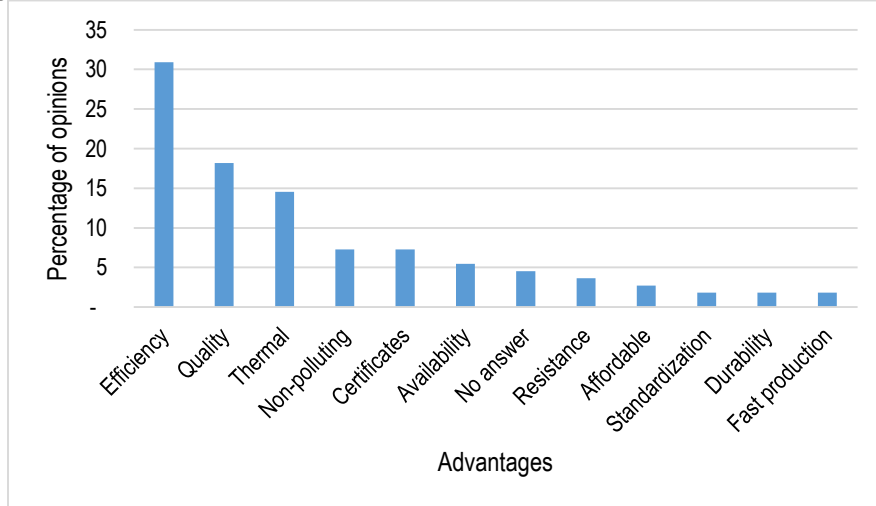
Figure 44. New trends for the use of building materials



Source: INECC.

Among the reasons that the brick has lagged are the greater contamination associated with the kilns used during its elaboration, the less efficiency in the construction of each square meter due to the smaller dimensions of each piece and the heterogeneous quality (Figure 45). On the other hand, “tabicones” and blocks have begun to experience innovations that seek to improve their properties, and there are even bigger companies that manufacture quality export products. An example of this is the development of blocks with improved thermal properties that respond to extreme climates, especially when walls do not adjoin another building. This need does not seem relevant to hot-humid climates.

Figure 45. Percentage of opinions on advantages of concrete blocks over artisanal bricks



Source: INECC.

Extruded bricks are also subject to the tendency to innovate. A company, located in Monterrey, develops several improved products, including an extruded brick with holes that competes with the concrete block 15x20x40 cm, with the following advantages: 57% less weight, good thermal insulation, greater mechanical resistance and shorter construction time (Ladrillera Santa Clara, 2016). In an interview with company personnel (Andrade, 2015) it was indicated that they offer, in Monterrey and surrounding areas, light extruded bricks in measures 10, 15 and 20x30x20 cm.

One of the global trends is to return to land-based construction without going through polluting cooking processes. BTCs are one of the industrial options and there are already companies dedicated to producing them. The Autonomous University of San Luis Potosí in its Laboratory of Earth Architecture in the Faculty of Habitat investigates, through the architect Gerardo Arista, the formulation of clays and additives to develop BTC of 15x30x10 cm with resistances similar to those required by INFONAVIT and FOVISSSTE To the blocks used in the houses and their thermal properties are superior to those of the bricks and blocks. According to the architect, the use of this material has better possibilities in periurban and rural areas as it has happened in houses in the southeast of the country, where it can even be adapted for self-construction. The company ITAL MEXICANA already offers all the machinery to produce these BTCs, although the key is still in the formulation of clay mixtures (Arista-González, 2015).

Other innovative construction products that could compete with craft brick in the future in addition to compacted earth blocks are: adobe, blocks of compacted and stabilized earth and blocks of synthetic sand. Houses with blocks of compacted soil have been built in Abasolo, Chiapas and San Miguel de Allende, Guanajuato, with eco-bricks (without explanation) in Tlajomulco de Zúñiga, Jalisco and with fiber cement in Nogales, Sonora (Erbe, 2011).

Andreas Froese promotes construction using earth, lime earth, soil with cement and PET bottles ("biomimetics"). His experience in Salinas, was in the construction of classrooms and storage tanks of rainwater (Froese, 2016).

POLEC Industrias, a Mexican company, created polybrick, a construction unit manufactured with almost any type of soil combined with a polymer capable of creating a brick under a concept of "synthetic cement" that does not require machinery or cooking. Its original target market was the artisan producer to replace the traditional brick with a product of better ecological performance and with ample possibilities in the rural self-construction. The company's evolution of 2012 to date has led to strategic alliances with US institutions and with a view to serving international markets. The formats of your product are varied: 20x30x20 cm, 60x30x18 cm, 40x40x20 cm and others more (POLEC INDUSTRIES, 2016)

Another case of innovation detected is that of INAMBTEC in Toluca, State of Mexico, which currently develops technology to produce blocks made from compacted waste with the addition of binding agent. The trash is all the material that remains of the normal process of recovery of recyclables. The project continues with the configuration of the production plant and the tests of safety and mechanical resistance of the blocks produced, so the product is not yet available in the market (Simran-Palacios, 2015).

In an interview, information was collected about entrepreneurs from Morelia who developed expanded concrete blocks with "bubbles" from another material. This material is lighter, can be produced in larger pieces and offer greater thermal insulation (Salgado-Rebollar, 2015).

In the workshop held in Morelos, the representative of the Construction Company of Morelos S.A. Of CV, described its innovative product called MUROMOL, which consists of pre-fabricated modular prefabricated

inputs that offer simplicity in construction procedures, combining ability with other construction systems, improved sound insulation and competitive parameters of bulk density, water vapor permeability And moisture adsorption. The formulation of its prefabricated remains an industrial secret.

In Silao, Guanajuato, the architect Alina Irazu Sandoval, has been working since 2009 on the development of Inter Eco-Tabique made from recycled paper with flame retardant coatings. The development is still in experimental phase of new production technologies, the use of ecological additives and the updating of its business plan. The goal is to offer a product with dimensions compatible with mass production, with superior thermal properties, customized in colors and its target market is self-construction and probably for interior design. The estimated price to go to the market will be around \$ 1.90 pesos each piece (Sandoval, 2015).

In the workshop in Puebla, the participants reported that there is a hollow and high temperature baked stove (TSA) with uniform dimensions of 12x12x24cm, produced by extrusion, whose characteristics are to be hollow, extruded, cooked with gas and at high temperatures. Among its peculiarities are the lightness (only 3.1 kg / piece), strength and performance (30 pieces / m²). This replacement product is already being used in rural housing built with federal subsidies in Chiapas, Tabasco, Puebla, Tlaxcala and Oaxaca at a price of \$ 3,900.00 per thousand.

In the Technological Institute of Celaya developed a geo polymer that works as a refractory mortar, allows to increase its useful life when applied to the interior of the brick kilns. This development addresses the fracture problem of ovens derived from the use of these ovens and has consequences for reducing the efficiency of burn-out by heat losses (Instituto Tecnológico de Celaya, 2014). There is no knowledge of the transfer of this technology.

In the workshop in Puebla, the participants reported that there is a hollow and high temperature cooked artisanal substitute brick (ASB) with uniform dimensions of 12x12x24cm, produced by extrusion whose characteristics are hollow, extruded, cooked with gas and on high temperatures. Among its peculiarities are the lightness (only 3.1 kg/piece), strength and performance (30 pieces/m²). This replacement product is already being used in rural housing built with federal subsidies in Chiapas, Tabasco, Puebla, Tlaxcala and Oaxaca and the price is \$ 3,900.00 a thousand.

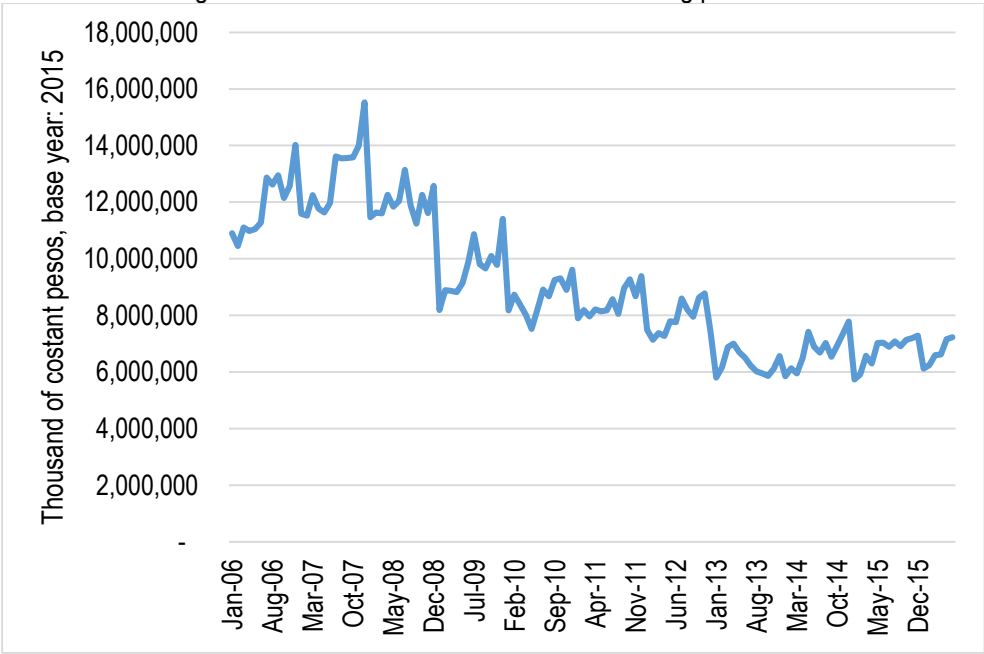
5.4 Economic analysis of brick production

3.3 In the national diagnosis of the craft brick industry published in 2012, it is mentioned that the National Chamber of Housing Development and Promotion (CANADEVI) envisaged in that year a better performance of the construction sector in the period 2012 to 2018, based In the federal proposal to invest amounts for housing development similar to those given in 2007, so that in 2018 an approximate goal of twice the financing granted in the period 2001-2006 will be achieved.

3.4 The evolution of investment in housing development, shown in figure 46 (INEGI, 2016), indicates a downward trend from 2007 to the first quarter of 2016. In that last quarter, the construction sector showed a slight improvement due to the dynamism in the central regions of Mexico, as much by public work as by private construction.

3.5 At the regional level, the construction sector in the northern center of the country resumed its positive trend during the aforementioned quarter, influenced by some federal housing programs, while the southern region slowed its downward trajectory since 2014. For the northern region, the sector showed a deceleration in its growth trend, since the year began with an increase of 2% and ended the quarter without change in its respective rate. In the central region the construction of the elevated viaduct of Puebla and the repair of the Cutzamala System were factors that strengthened the sector, in the indicated period. In the first quarter of 2016 private works were reactivated in all regions except in the south due to the unfavorable performance of the oil sector (BANXICO, 2016).

Figure 46. Time evolution in the value of housing production



Source: Encuesta Nacional de Empresas constructoras, INEGI, 2016.

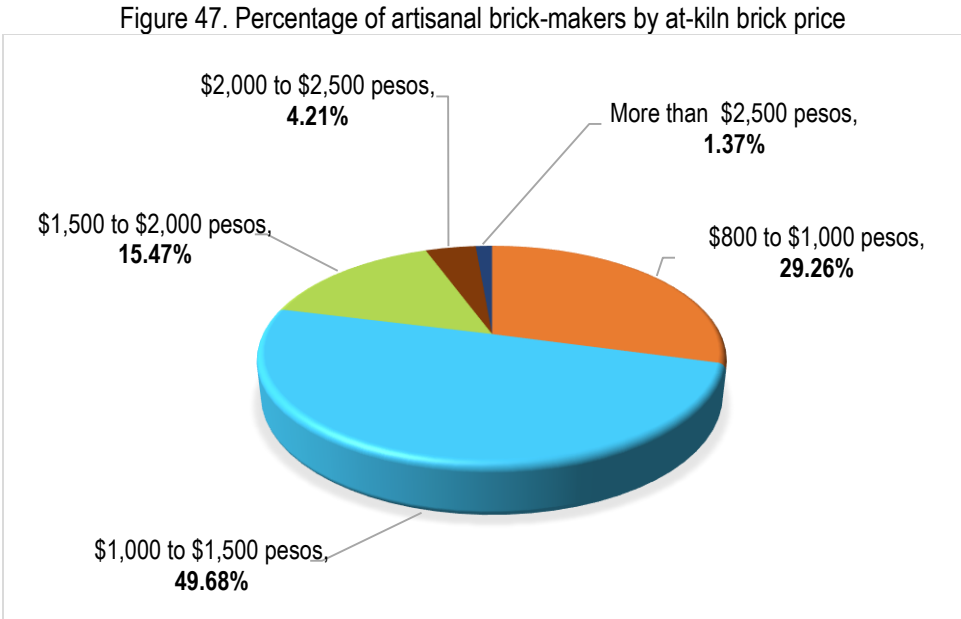
3.6 The Housing Mortgage Department of the Sociedad Hipotecaria Federal (SHF) forecasts in its housing demand report that in 2016, 39,700 loans will be granted for housing acquisition, which means a decrease of 6.5% compared to 2015, due to the The country's macroeconomic situation coupled with monetary policy decision-making aimed at controlling inflation by raising the benchmark interest rate, which means limiting consumption through credit, including the acquisition of debt in the sector Real estate In contrast, credits for self-construction will show an increase of 15.2%, due to new programs to support the popular sector, with which the public policy of housing support acquires a social orientation (SHF, 2016).

3.7 According to the aforementioned report, in 2016, 1,166,872 loans are expected to be granted, of which private banks are contemplating 105,000 for acquisition, 10,000 for improvement and 3,500 for self-construction. No information is available to confirm which of the credit solutions are most closely linked to the demand for

brick, but according to the opinions received in the workshops carried out in six states of the Republic⁹ could be those related to middle class housing and Self-construction.

5.4.1 Price of product

3.8 The price of artisanal brick ranges from \$ 800.00 pesos to more than \$ 2,500.00 pesos per thousand (Figure 47) and this is due to the supply and demand levels that characterize each region, such as the states of Guanajuato and Puebla, in the Which there is a greater supply, which generates a surplus in the market, to that circumstance are obtained prices lower than those that the good is offered; In contrast in the states of Morelos and Tlaxcala, there is a shortage of the product which generates a higher price due to the lower supply of the good.



3.9 To know the relationship between the price and the weight of the brick, the analysis of multiple correlation was carried out by means of which the correlation coefficient was obtained, with a value of 0.4; Which shows that the level of linear interrelation between the quantity produced by each producer and the weight of the product has a weak correlation with the price of the good; Therefore the weight of the brick does not determine the price of the good.

3.10The testimonies obtained in the workshops reveal that a factor of stationary character that affects the price is the rainy season, because it limits the supply of the brick that, when becoming a scarce commodity, increases its value. To verify the above, the bricklayers of the town of El Refugio in León were consulted during August of 2016 (rainy season), who agreed that the price of the brick was between \$ 1,500.00 and \$ 1,600.00 pesos per

⁹ Hidalgo, Puebla, Morelos, Estado de México, Jalisco and Guanajuato states.

thousand, while in the dry season The price drops to approximately \$ 1,400.00 and \$ 1,500.00 pesos per thousand.

5.4.2 Analysis of production function

3.11 The microeconomic analysis, for the case study of the artisan brick producers in terms of the production function, is based on marginalist theoretical assumptions¹⁰; The market structure faced by the brick producer resembles a competitive market, this characteristic is considered to be due to the existence of exogenous variables in the interaction of the market that limit the strict scope of competitive market analysis Characterized by: 1) the existence of a large number of producers, consumers and intermediaries, who make their decisions independently; 2) goods produced and marketed are homogeneous for the purpose of use, which implies that they are perfect substitutes and that there is no differentiation between them, as long as they are from similar geographical regions; 3) each producer has a reduced market power to fix the price, because if they tried to raise it, consumers would go to another bidder for the same good and otherwise, other producers would lower it to obtain zero profits.

3.12 In a competitive market it is important to make factor adjustments within the production function; In the case of increased capital or labor, if the demand increases, the "company" or production unit chooses the optimum amount of production that can satisfy the market and obtain the optimum benefits; Otherwise, it reduces the factors of production in the face of a contraction of demand; In the previous short-term assumption, the company chooses to decrease the amount of workforce, adjusts production, and chooses the amount that reports higher profits.

3.13 The production function of Cobb-Douglas (Bellod-Redondo, 2011) is composed of the labor force and capital, the set of factors determines the amount of production and the factor of productivity, which in turn shows the potential growth Of production, given the respective increases in the factors of production¹¹.

3.14 Through the surveys of the artisanal brick producers, the results shown in table 15 for the calculation of A (productivity factor), α and β , were obtained, in which it can be seen that the combination of the factors of the force Labor and capital at the national level classifies the states of Hidalgo and Jalisco with a productivity parameter lower than the national average, this disadvantage is due to the high participation of the labor force in the production process; The states of Guanajuato, the State of Mexico and Puebla have a more adequate combination of factors, allowing a better productivity parameter compared to the national average.

¹⁰ The marginalist theory analyzes the benefits obtained by the producer, the costs of production as well as the utility that the consumer acquires starting from the principle of the analysis of the change in the unit, in the producing units we study the marginal changes in the production, the costs per The production of one more unit, as well as the revenue generated by the sale of one more unit (Pindyck & Rubinfeld, 2009).

¹¹ In a similar case (Cortázar-Martínez & Montaña-Raygoza, 2011) the Cobb-Douglas production function was applied to the production of cotton in the Juárez Valley in the state of Chihuahua in Mexico, whose purpose is the efficient use The factors of production for future projects, which allowed them to draw conclusions about the specific participation of the labor force and the working capital in the production, with that to make decisions on future investments channeled towards the factor that is vulnerable given the situation of the market.

3.15 In the case of Guanajuato, it can be seen that the combination of factors of production allows it to have the highest productivity indices at the national level, since in a scenario of 10% increase in capital, production could increase by an average of 7.1%, almost Triple that if it intervened in an increase of the labor force.

3.16 The state with greater elasticity of the labor force is Puebla; under a scenario of 10% increase in the factor of the same and maintaining the constant capital factor, there would be an average growth of 3.3% of the brick production. On the other hand a 10% increase in the capital factor keeping the labor force constant, would obtain an average increase of 6.7% in production. These scenarios of increase to some factor of the production allows to analyze the participation of the labor force or the capital, as well as allows to approximate the benefits that would be obtained by the positive modification of some factor of the production.

Table 15. Parameter analysis of productivity, labor mass and capital factors

State	Parameters		
	A	α	β
Estado de México	2.13	0.29	0.69
Jalisco	1.92	0.31	0.69
Guanajuato	2.2	0.27	0.71
Puebla	1.98	0.33	0.67
Hidalgo	1.6	0.31	0.71
National	1.97	0.31	0.69

Source: INECC.

3.17 An optimal productive combination between capital and labor force would be one in which the costs could be reduced in the short term, ie, from the adoption of technology without neglecting the proportional increase of the specialized labor force, in order to obtain Increasing marginal yields with reduction of the total cost of production.

5.4.3 Price-offer elasticity by weather seasonal changes

3.18 For the calculation of the price-supply elasticity (EPO) we analyzed the price movements that occur at the change of the rainy season and the dry season; When the dry season begins during the months of January to May and September to December, the conditions to maintain a high production capacity due to the facilities for both the acquisition of raw material and for the production of brick are improved, They decide to produce the maximum capacity given the combination of capital and labor factors and the demand for brick in the season.

3.19 The second moment is the arrival of the rainy season in the period June - August, when the producer is unable to produce with the maximum capacity, reason why he chooses to reduce the amount of production, given the high costs for the process of Combustion and difficulties in the production of crude brick.

3.20 The price elasticity of supply is defined by the percentage variation of the quantity supplied divided by the variation in the price; A competitive market shows elasticity in its behavior, because the producer is encouraged to perform the ith quantity given the increase in the price of the good (Pindyck & Rubinfeld, 2009).

3.21 The result of the analysis described in the methodology determined the existence of price-supply inelasticity associated with variations in the climatic season, since the producers do not respond with an increase in their production due to the increase in price, due to two main reasons: first, The lack of capacity to respond to the market with an increase in production in the dry season, due to lack of capital or labor force; Second, the rainy season limits the production capacity because the processing is done in an area without roofing for both the furnace and the area where the clays are mixed, for this eventuality the producers work when the odds of rainfall are low during the day; Table 16 shows the elasticities of the producers corresponding to each analyzed state.

Table 16. Price offer elasticity per state in dry and rainy seasons

State	POE in dry season	POE in rainy season
Puebla	0.11	0.03
Guanajuato	0.21	0.08
Estado de México	0.27	0.10
Jalisco	0.46	0.07
Morelos	0.12	0.03
Hidalgo	0.17	0.09
National	0.22	0.06

Source: INECC.

3.22 The insensitivity of producer response given an increase in price is not an isolated case of a state but is contemplated at the national level starting from this observation that characterizes the states shows a slight difference in the responsiveness of the supply of the good. In the state of Puebla since it has a higher elasticity among the states analyzed, which can be associated with the best combination of labor force, which allows the market to satisfy price variations and / or because it is the main brick producing state.

3.23 The artisanal brick producing states studied are characterized by responding to the market with a low elasticity both in the dry and rainy seasons, this is due to the low participation of the factors of production; For example, in terms of the low labor force participation is Guanajuato; Puebla is characterized by a low share of capital; Hidalgo shows low factor productivity. The previous factor constraints in isolation as well as in the aggregate, respond to the low sensitivity of reaction of the quantity offered by the producers in relation to the positive variation of the price.

3.24 Therefore, the greater elasticity found in Puebla means that the success of a modernization pilot project in the state would be conditioned to maintain the sale price, or to obtain a government subsidy or guarantee price, to cover the price differential. Real production (short-term) against the market price.

5.4.4 Logistic model of artisanal brick offer function

3.25 Based on the analysis carried out, a producer with possibilities to remain in the market is considered to offer more than 20 thousand brick per month, using as reference that 54% of the producers make burns above the amount mentioned, With this it can be inferred that this production is considered as dominant in the market

because it has greater capital capacity as labor force, together with the fact that with these characteristics producers can resist unfavorable scenarios generated by the market.

3.26 The coefficients obtained in Table 17 are derived from the analysis of the capital used (technology used in the mixing and combustion process) in the production process; The labor force was determined by the number of family members or employees involved in the production unit; The location of the furnace is considered in relation to the proximity to the place of residence of the producer since it reduces indirect costs.

Table 17. Coefficients of probabilistic offer model

Coefficients	Values
α	-1.52
β_1	0.17
β_2	0.33
β_3	0.51
β_4	0.97

Source: INECC.

3.27 From the results, it can be indicated that the intervention of the labor force in the production process is vital in the artisan production, but the increase in the same does not contribute to an improvement in the competitiveness of the production unit of artisanal brick, if not is complemented by an increase in conjunction with capital, mainly described under this analysis by the tool used in the mixing, production near or at home and the intervention of technology in the combustion process.

3.28 The marginal contribution obtained for the capital factors analyzed on the production dependent variable is described by 23% for the tool used in the process of clay mixing and shaping of raw brick, 12% for the location of the Oven, 4% in the workforce, 8% in the technology used in the combustion process; According to the iteration of the factors of production has a greater representativeness the participation of the capital than the labor force, which contributes to a greater possibility of the producer by offering a competitive quantity in the market; The producer with the largest share of capital in its production function is more likely to remain in the market.

3.29 The analysis of the production function is complemented by the present prediction model, since it shows the probability that for a producer, given a change in the production factors mentioned, mainly capital, used in the process of mixing and burning together with The location of the furnace, can remain in the market by offering more than twenty thousand bricks.

5.4.5 Price-demand elasticity of artisanal brick, extruded bricks and concrete blocks

3.30 Price elasticity of demand (EPD) is the proportional change in quantity demanded divided by the proportional change in the price of the good; This elasticity shows the answer of the demand of the good that is intended to acquire before the change in the price of the same. The materials that compose the walls were analyzed as

block, handmade brick, extruded bricks and wall. The calculated elasticity is the national average, according to each type of material demanded, the cases studied show a perfectly inelastic elasticity (Table 18). The observed inelasticity shows that construction materials will continue to be demanded even though there are price increases in the short and medium term.

3.31 The main causes of inelasticity observed in the demand are: the consumer's need to continue construction, the continuous supply of the same material with which construction was started, the specification terms in the construction contract, the construction season, among others.

Table 18. Price demand elasticity of materials for construction al national level

Material	National PDE
Artisanal brick	0.01
Concrete block 15 x 20 x 40	0.00
Concrete block 12 x 20 x 40	0.00
Concrete block 10 x 20 x 40	0.00
Extruded bricks	0.00
Concrete "Tabicón"	0.00

Source: INECC.

3.32 The inelasticity observed in the brick with a value of 0.01 is not considered an isolated case over the others, the particularity of having a higher value of elasticity, is considered because the producers are price-acceptors, which allows the demand to exercise some control about the price.

3.33 The artisan brick producer is in a market of perfect competition characterized by being price-accepting that has limitations of capital to be able to realize the sale to the final consumer considered like constructor, same that proved to characterize itself by having an inelastic demand; The intermediary obtains the economic benefit in the purchase and sale of the good, on the one hand benefits from the competitive market for the possibility of obtaining the lowest price and on the other hand benefits from the inelasticity of the final consumer.

5.4.6 Logistic model of artisanal brick demand

3.34 An approximation for the acquisition of artisanal brick, based on consumer theory¹², is an indifference curve of perfect substitutes, which can be represented in two moments: the first when the producer chooses to use a specific type of material between a Basket of consumer goods that will be used during construction and secondly, given the shortage of the good consumed with which the work began, so the builder has a second opportunity

¹² Consumer theory is centered on analyzing consumer behavior and its different choices between the goods and services market (Varian, 2010): given the breadth of goods offered in the capitalist system, the consumer chooses a basket that represents greater utility. The utility principle refers in a broad sense to the welfare generated by the consumer when acquiring the optimal basket, given their preferences to satisfy their purchase needs. In the theoretical model of ordinal utility, a specific value is not assigned to the chosen basket, therefore a comparison is made between different basket choices.

to choose another type of product among the basket of goods for the construction; This consideration is based on the fact that the construction materials market offers a wide range of consumer options, which makes the brick a substitutable good, so that the consumer is free to acquire the basket that generates greater utility.

3.35 With the coefficients obtained that are shown in table 19 the participation of the decision-making of the consumers to the consumption of artisanal brick was analyzed; The opinion on traditional brick consumption given the tradition represents a marginal value of 39%, which represents a strength in the purchase decision influenced by the culture; on the other hand the brick is faced with the challenge of being able to stay in the market given the existence of substitute materials that have acquired greater force in consumption, as is the block itself that has a negative marginal participation of 29% depending on the decision Of the purchase of handmade brick; The variables of quality and efficiency are presented as a challenge in the improvement of the artisanal brick, since the consumers tend to decrease in marginal values of 21% in quality and 36% of efficiency in the decision to buy artisanal brick In comparison with the substitute goods.

3.36 By using the described variables, a probabilistic approach was obtained, which predicts 71.2% of the cases that are to be analyzed. This allows to know the influence on the selected variables and to know the behavior of the consumer of materials The construction.

Table 19. Coefficients for probabilistic demand model

Coefficients	Values
α	2.27
β_1	2.31
β_2	-1.54
β_3	-0.93
β_4	-1.54

Source: INECC.

5.4.7 Cross demand elasticity

3.37 The basket of goods demanded by the construction sector is chosen given its budget constraint and the choice of goods that represent greater utility; the demand by the consumer also part of their tastes and preferences depending on the place where the work is located. Faced with this situation, craft brick tends to be a substitute or complementary good for other goods against which it is compared.

3.38 It is for this reason that an analysis of complementarity and substitutability of the brick in comparison with the block with measures 12x20x40 cm is carried out, this analysis has its economic foundation by the calculation of the cross elasticity of the demand that measures the response of the demand of the given brick A change in the price of the selected block. To achieve the national approach, the Mexican states are divided into four economic zones: North, Center North, Center and South.

3.39 By calculating the cross elasticity, they define whether the goods are complementary or substitute; The complementary goods are identified by having a value of elasticity less than 0, while the substitute goods have a value of elasticity greater than 0 (Gould & Lazear, 1994).

3.40 In the North, North and South Center, the cross-elasticity of demand determines the brickwork as a complementary good (Table 20), ie its consumption is accompanied by the block 12x20x40 cm, so if the price of the block goes up, it falls The demand for brick. In the central region, the cross-elasticity of demand determines the handicraft brick as a substitute, due to an increase in the price of the block, increasing the demand for handmade brick. This approach is based on the indifference curves that each producer experiences between which they are substitutes, which allows the consumer to choose between the brick and the block, which generates the same utility at the moment of deciding, given the situation of the increase in the price.

Table 20. Cross elasticity demand per region

Region	Cross demand elasticity	Kind of good
Norte	-0.14	Complementary
Centro	1.08	Sustitute
Centro Norte	-0.44	Complementary
Sur	-0.02	Complementary

Source: INECC.

3.41 Figure 48 shows the case of complementarity of the northern region, where the joint use of the block and the artisanal brick is identified; The basket chosen in this region joined to the north center (Figure 49) and south (Figure 50); It is clear that the artisanal brick does not act as a primary decision by the consumer, but uses the block to perform the work.

Figura 48. North región: complementarity of artisanal brick with concrete 12x20x40 cm block

CENTRO NORTE Region

State	Sonora	PAZ No.	2603000016639
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Municipality	Hermosillo	Adress	Manlio Fabio Beltrones/Laura A. Frías
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Source: INECC.

Figure 49. North central región: complementarity of artisanal brick with concrete 12x20x40 cm block

5. CENTRO NORTE Region

6. State	7. Aguascalientes	8. PAZ No.	9. 0100100014113
10. Municipality	11. Aguascalientes	12. Adress	13. Calle Pie De La Cuesta (Vista Inferior)

14.



Source: INECC.

Figure 50. Soutg region: complementarity of artisanal brick with concrete 12x20x40 cm block

SUR Region

State	Chiapas	PAZ No.	0710100012552
Municipality	Tuxtla Gutiérrez	Adress	Calle Pompochuti Oriente/ Calle Pompochuti Poniente



Source: INECC.

3.42 In the case of substitutability, the center zone (Figure 51) is identified, where the block or the brick is chosen for the construction of the work; In view of this situation, the consumer determines the consumption of the brickwork based on the variation of the price of the block, given that variation the consumer chooses to carry out the work with brickwork if the price of the block increases and decides to acquire it if the price of the same decreases.

Figure 51. North region: sustitution case of artisanal brick for concrete 12x20x40 cm block

1. CENTRO Region

2. State	3. México	4. PAZ No.	5. 1503300014053
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6. Municipality	7. Ecatepec de Morelos	8. Adress	9. Calle Acolman/Calle Villa Guerrero
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10.



Source: INECC.

5.5 Regulatory frame and government programs

Mexican environmental legislation does not specifically indicate which of the three levels of government are responsible for artisanal manufacturing activities, so it is necessary to make an interpretation of the Ley General del Equilibrio Ecológico y la Protección al Ambiente. In this sense it is necessary to define the process of production of red brick, as a transformation process that change the raw material into a product or as the productive process in which the creative manual technique, individually produces goods or services (Instituto de Ecología del Estado de Guanajuato, 2012).

From the above it is assumed that given that brick production is an industrial process, in the understanding that a commercial and service establishment will be one in which only products and / or services are rendered without processing.

Based on the distribution of competences (H. Congreso de la Unión, 2016); in accordance with Sections III and IX of Article 7 of Chapter II based on the distribution of competences of the Ley General de Equilibrio Ecológico y la Protección al Ambiente (LGEEPA), states are responsible for the prevention and control of air pollution generated by fixed emission sources that function as industrial establishments, as well as the formulation, dispatch and execution of programs of ecological management of the territory referred to in Article 20 BIS 2 of the aforementioned Law, with the participation of the respective municipalities. Article 8 establishes as competence of the municipality "The application of legal provisions on the prevention and control of air pollution generated by fixed emission sources that function as commercial establishments or services".

Therefore, in the matter of prevention and control of air pollution generated by fixed emission sources, the State is responsible for its regulation. Likewise, the LGEEPA regulations on the Prevention and Control of Air Pollution in Chapter V, Article 50, of control and security measures and sanctions, stipulates that infractions in matters of competence of the Federal and State Entities Municipalities, will be sanctioned administratively by the state, municipal authorities within their respective territorial districts, according to the provisions of applicable local laws.

On the other hand, in relation to the Ecological Ordinance of the Territory according to what is established in the LGEEPA, the competences of the state and municipalities are defined in articles 20 BIS 2 AND 20 BIS 4 respectively, which establishes that states Formulation, issuance and execution of the ecological planning programs of the territory referred to in Article 20 BIS 2 of the said Law, with the participation of the respective

municipalities and it is the responsibility of the municipalities to formulate and issue the programs of local ecological management Of the territory referred to in Article 20 BIS 4 of the said Law, in the terms provided for therein, as well as the control and monitoring of the use and change of land use.

The review of the legal instruments available for consultation, in environmental matters including programs for the improvement of air quality in the states of the Megalopolis and in addition Jalisco and Guanajuato were carried out. The instruments of public works and construction were also consulted for the states of the Republic available for consultation.

5.5.1 Environmental and building regulations involving brick products or brick making

Three technical environmental standards were detected regarding the brickworks, a state regulation with a specific chapter and four municipal regulations:

1. Hidalgo, NTEE.COEDE-002/2000, which establishes the requirements, specifications and procedures to be met in the State territory of the kilns for the production of parts made of clays, including installation, operation, relocation and extraction of their raw material (Gobierno del Estado de Hidalgo, 2010).
2. Guanajuato, NTE-IEG-001/2010, which establishes the conditions for the location and operation of fixed emission sources with artisan activity for the production of pieces made with clay, which abrogated to NTE-IEG-001/1998 (Instituto de Ecología del Estado de Guanajuato, 2012). This rule was very restrictive because it marks that the fuel should be gas when the brickworks are located less than three kilometers from the urban area. There is no evidence that this standard is being met.
3. Michoacán, Regulation of the Law of Ecological Balance and Protection to the Environment of the State of Michoacán de Ocampo, in which a specific section is established for bricklayers (Gobierno del Estado de Michoacán de Ocampo, 2005).

The three instruments mentioned focus on the regulation of location, types of fuels and raw materials. The following normative instruments were also found at the municipal level:

1. Tlajomulco de Zúñiga, Jalisco. Regulation that establishes the conditions that must meet the sites destined to the installation and relocation of brick, as well as the conditions for the operation of the same in the municipality of Tlajomulco de Zúñiga, Jalisco (H. Ayuntamiento de Tlajomulco de Zúñiga, 2016).
2. Tonalá, Jalisco. Regulation of ecology for the municipality of Tonalá, which establishes the necessary measures regarding environmental protection, ecological balance, municipal solid waste, material banks, brick kilns, use and management of municipal vegetation, water and The protection of animals, in order to increase the quality of life of the population of Tonalá (H. Ayuntamiento de Tonalá, 2016 a).
3. Aguascalientes, Aguascalientes. Municipal Code of Aguascalientes, in which it is specified in its Article 507, that it must have the operating permit for bricklayers or pottery issued by the Ministry of Environment and Sustainable Development (SEMADESU), for the installation and operation thereof (H. Ayuntamiento de Aguascalientes, 2016).
4. San Pedro Tlaquepaque, Jalisco. Approved on November 9, 2016 its Regulation of Ladrilleras in the Municipality of San Pedro Tlaquepaque, which regulates the installation and operation of bricklayers, prioritizing the protection of the environment and sustainable management of natural resources that

guarantee better conditions of quality of life And public health for the inhabitants (H. Ayuntamiento de San Pedro Tlaquepaque, 2016).

The Instituto de Ecología del Estado de Guanajuato published in 2010 the document "Actions for the strengthening of the brick industry in Guanajuato", which from an intersectoral point of view focuses on the brickwork, covering aspects of economic development, social development, environmental, health and educational aspects (Instituto de Ecología del Estado de Guanajuato, 2016).

Management programs to improve air quality (PROAIRE) for the states of Puebla and Jalisco, as well as those of the metropolitan areas of León-Purísima del Rincón, -San Francisco del Rincón and Salamanca-Celaya-Irapuato in Guanajuato , In addition to the ProAire of the Valley of Toluca and the Valley of Mexico in the State of Mexico, establish specific measures focused on strengthening the brick industry related to the improvement of technology, use of cleaner fuels, relocation and promotion of normative instruments for its regulation in How much to the burned and the location mainly (Table 21). The majority of PROAIRE agree on the need to make inventories of emissions from brick-kilns and on awareness of their environmental impact and on measures of command and control.

Table 21. Programs for air quality improvement in cities (PROAIRE)

PROAIRE	Actions on brick making sector
Programa de Gestión de la Calidad del Aire del Estado de Puebla 2012-2020	Program measure 14 proposes to regulate brickmaking activities with the aim of reducing emissions. Its activities include: signing a collaboration agreement to improve the manufacturing process, promote technologies that improve combustion and publish a state environmental technical standard.
Programa para Mejorar la Calidad del Aire. Valle de Toluca, 2012-2017	Measure 16 establishes technological alternatives for the treatment and control of atmospheric pollutants in brick kilns and pottery workshops. It

	includes financing activities, research for the technological reconversion and the elaboration of an environmental technical norm.
Programa para Mejorar la Calidad del Aire. Jalisco 2011-2020	It indicates a number of brick masks that exceeds 2000 for the whole state. Measure 21 proposes to regulate the activities of artisanal brick making and to create a program for producers to apply the best practices to bricklayers. Activities include the development of an environmental technical standard, implementation of technologies to improve combustion, a cost-benefit study to build a brick park, relocate the brick and promote the manufacture of organic bricks.
Programa de Gestión para Mejorar la Calidad del Aire de la Zona Metropolitana de León, Purísima del Rincón, San Francisco del Rincón y Silao, 2013-2022	In strategy 2 of reduction and control of emissions in specific sources, the program includes measure 6 applicable to the artisanal brick sector, focusing on the regulation of land use and the elaboration of a diagnosis to specify the detailed actions to be carried out.
Programa de Gestión para Mejorar la Calidad del aire de Salamanca, Celaya e Irapuato, 2013-2022	This program does not have a measure dedicated to the brick industry, so the relevant activities are included in measure 11, regulation, monitoring and inspection of fixed emission sources and measure 14 reduction of volatile organic compounds in fixed and area emission sources.

Source: INECC.

5.5.2 Building regulations involving artisanal bricks.

Other state and municipal legal instruments related to construction, which mention brick or brick, are shown in Table 22 to Table 25. Particularly noteworthy are the municipalities of Zapotlán el Grande and Ameca in Jalisco, which specify the Size of the brick, as well as the municipality of Puerto Vallarta that specifies the use for constructive elements that affect the urban image. Also in three regulations of the municipalities of Salvatierra, Silao and Tarimoro, regulations are bound for bricklayers.

Table 22. Building regulations referring artisanal bricks

Legal instrument	Considered aspect			
	Product specifications	Definitions applied to bricks	Use bricks specificatios	Regulations to production brick area
Hidalgo State				

"Reglamento de Construcciones del Municipio de Pachuca de Soto, Estado de Hidalgo"	No	No	Masonry wall	No
Puebla State				
"Reglamento de Construcciones para el Estado de Puebla"	No	No	Brick walls 14 cm and 28 cm in dividing walls	No
"Reglamento de Construcciones para el Municipio de Tehuacán" (Puebla)	No	No	Walls 28 cm thick in deposits of explosive and flammable substances and materials	No
Morelos State				
"Reglamento de Construcciones para el Municipio de Cuautla, Morelos"	Specifies seismic coefficients for confined hollow bricks	No	No	No
Reglamento de Construcción del Municipio de Cuernavaca, Morelos	No	Non-combustible material	No	No

Source: INECC.

Table 22. Construction regulations referring to brick or area of production of bricks (continuation)

Legal instrument	Considered aspect			
	Product specifications	Definitions applied to bricks	Use bricks specificatios	Regulations to production brick area
Jalisco State				

"Reglamento de Construcción y Desarrollo Urbano del Municipio de Zapopan" (Jalisco)	No	Structural component of masonry	Maximum permissible set-up for load-bearing walls constructed from them	No
"Reglamento de Construcciones de Puerto Vallarta, Jal."	No	No	Use of brick for apparent building elements such as benches, flower beds and garrison	No
"Reglamento de Construcción del Municipio de Tonalá, Jalisco"	No	No	28 cm thick walls for storage of explosive materials	No
"Reglamento de Construcción de Ciudad Guzmán, Municipio de Zapotlán el Grande, Jalisco"	Specifies the following dimensions: Thin brick: 5x11x23 cm Thick brick: 7x14x28 cm. It indicates the sound to be hit, the rejection of those that served to cover the kiln and a minimum resistance of 25 kilograms per square centimeter. For extrusion bricks, it specifies the same compressive strength.	Traditional building material systems, non-combustible.	No	No
"Reglamento de Construcción para el Municipio de Ameca, Jalisco"	Specifies the following dimensions: Thin brick: 5x11x23 cm Thick Brick: 7x14x28 cm As characteristics of the brick, it indicates the sound when struck; That the cooking is complete and a minimum resistance of 25 kilograms per square centimeter, with a maximum tolerance of 10%. For extrusion bricks, it specifies the same compressive strength.	No	No	No

Source: INECC.

Table 22. Construction regulations referring to brick or area of production of bricks (Continuation)

Legal instrument	Considered aspect			
	Product specifications	Definitions applied to bricks	Use bricks specificatiois	Regulations to production brick area

Guanajuato State				
"Reglamento de Construcciones para la Ciudad de León, Guanajuato"		Defined brick as non-combustible material		
"Reglamento de Construcciones y preservación del Centro Histórico del Municipio de Dolores Hidalgo, Guanajuato"		Defined brick as non-combustible material	Specifies its use in walls of 28 cm of thickness in deposits of explosive materials	
"Reglamento de Construcciones y Entorno Urbano para el Municipio de Salvatierra, Guanajuato"		Defined brick as non-combustible material		The brick production area should comply with the provisions laid down by the competent authorities
"Reglamento de Construcciones para el Municipio de Silao, Gto."		Defined brick as non-combustible material		Classifies the brick production as a risk activity, group 3.
"Reglamento de Construcciones y Entorno Urbano para el Municipio de Tarimoro, Guanajuato"		Defined brick as non-combustible material		The brick production area should comply with the provisions laid down by the competent authorities
"Reglamento de Construcción y Conservación de la Fisonomía para la Capital del Estado de Guanajuato y su Municipio"		Defined brick as non-combustible material		

Source: INECC.

Table 22. Building regulations referring artisanal bricks (continue)

Instrumento jurídico	Aspecto considerado			
	Especificaciones de producto	Definiciones aplicadas a ladrillos	Especificaciones en uso del ladrillo	Regulación a ladrilleras
Otros estados				
"Normas Técnicas Complementarias del Reglamento de Construcciones para el Municipio de Campeche"			Especifican el uso de ladrillos para fachadas, dinteles, remates y cornisas	
"Reglamento de Construcción y Normas Técnicas para el Municipio de Chihuahua"		Define al ladrillo como material incombustible		
"Reglamento de Construcciones para el Estado de Coahuila de Zaragoza"		Define al ladrillo como material incombustible		
"Reglamento de Construcción para el Municipio de Colima"		Define al ladrillo como material incombustible. Define al ladrillo como material de tradicional de construcción		

Source: INECC.

3.43 In the revision of the construction regulations of the states of Tlaxcala and Mexico no references were found to bricks or brick¹³.

3.44 The complementary technical norms in force in Mexico City recognize as masonry pieces the annealed clay bricks, the mud bricks with holes (extruded), the heavy concrete blocks and the "tabicón"s. For all of them, volumetric weights, diagonal compression strength, shear modulus, modulus of elasticity and penetration of mortar in "tabicón"s drilled during construction are specified (Gobierno del Distrito Federal, 2016). They regulate the use of bricks for the construction of sight wells, floor glue, valve operating boxes and trenches.

3.45 The Cámara Mexicana de la Industria de la Construcción promoted the creation of NMX-AA-164-SCFI-2013, "Sustainable Building - Criteria and Minimum Environmental Requirements. Technical specifications for materials. It indicates the thermal properties of materials", but it does not refer to the use of the brick. The NMX-R-021-SCFI-2013, "Quality of Physical Educational Infrastructure - Requirements", nor does it establish specifications in this regard (Secretaría de Economía, 2016).

¹³ It does not include also those states in whose regulations consulted no references were found to the topic

3.46 The revision of the public works regulations of the states of the Megalopolis, Jalisco and Guanajuato did not detect the existence of a systematic regulation for the production of the bricks. In order to identify areas of opportunity for the promotion of public policies, an interview was conducted with the Director General de Proyectos y Costos and with the Coordinador de Proyectos of Secretaría de Obra Pública from Estado de Guanajuato, who agreed to mention that within the procedure for the execution of works, the executive projects specify the use of the brick or, in its case, of other materials according to the type of work. Therefore, the specification of the use of brick depends on who requests the work, and not on the criteria established by the Secretaría.

As for works in hospitals, health centers, universities and schools, it is explicit the request for the use of brick and is considered such product in the catalog of concepts that is issued for the calculation of costs by the contractor. However, it was not possible to obtain evidence of specifications or executive projects in which the indication of the use of brick could be verified.

5.6 Federal government programs and market mechanisms

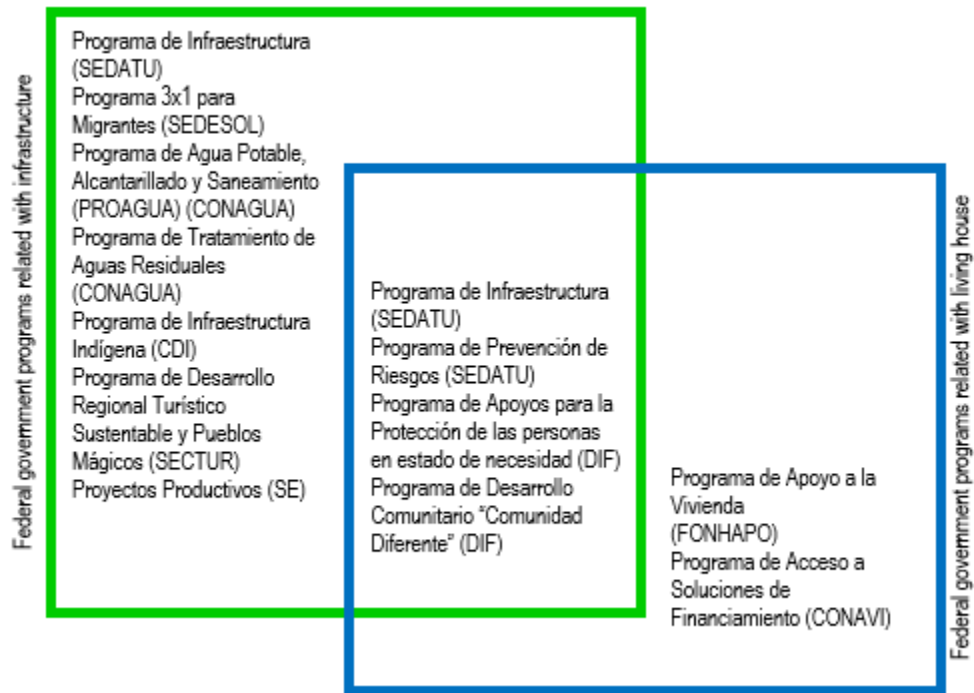
A total of 13 programs were identified from 11 federal agencies that affect construction, although none of them specifically mention the use of artisanal brick or other alternative materials. All of them allocate federal resources under schemes of concurrence with local governments and even with the final beneficiaries; These resources are destined to the construction, reconstruction, rehabilitation or improvement of constructions: 7 they focus on infrastructure works, 2 specifically in housing and 4 in both areas.

The two housing programs correspond to the National Housing Commission (CONAVI) and the National Housing Fund (FONAHPO), target low-income segments of the population, low-income housing, housing in priority areas or housing for People with limitations. This orientation is relevant to the results obtained by the linkage that was found between areas of priority attention, self-construction and use of artisanal brick.

The opportunity that is observed in these programs is that in their operation it could include specifications of use of artisanal brick under a public policy that seeks to promote the use of artisanal bricks produced under sustainable environmental and economic schemes.

These programs are mentioned in Figure 52 and include five other programs aimed at improving productivity and access to financing for legally constituted micro and small enterprises, which imposes restrictions on the access of artisanal production units that are generally they work in situations of informality. Annex 10 lists each of the programs mentioned.

Figure 52. Federal government programs supporting building projects and competitive improvement for small and medium companies



SEDATU. Secretaría de Desarrollo Agrario, Territorial y Urbano.
 SEDESOL. Secretaría de Desarrollo Social.
 CONAGUA. Comisión Nacional del Agua.
 CDI. Comisión Nacional para el Desarrollo de los Pueblos Indígenas.
 SECTUR. Secretaría de Turismo.
 SE. Secretaría de Economía.
 DIF. Sistema Nacional para el Desarrollo Integral de la Familia.
 FONHAPO. Fideicomiso Fondo Nacional de Habitaciones Populares.
 CONAVI. Comisión Nacional de Vivienda.
 STPSS. Secretaría del Trabajo y Prevención Social.

1.7 Public policy portfolio

The configuration of a pilot project requires the support of public policies designed to solve the problems of the artisanal brick production activity described in sections 5.1 to 5.4, underpinning the premise that the efforts deployed so far have been ineffective in carrying to the activity to better levels of competitiveness and environmental performance. It was also clear that for probably cultural reasons, the production activity of small-scale brick in the short or medium term will not disappear and, on the contrary, this sector of the economy has the opportunity to change in order to respond better to the market.

3.47 In general terms the activity in Mexico is informal and atomized in most of the territory although with areas of greater demand and its technological level is extremely rudimentary. The assistance and auxiliary equipment endowments have not been shown to have the necessary scope or desired depth.

3.48 First of all, it is clear that it is necessary to integrate a series of public policies to address the complexity of the Mexican situation under five initial considerations of public policy:

1. The impulse to regulation from the federal level recognizing that an initiative is needed that supports but also binds to the local governments: ***it is not possible the solution without the commitment of the governments of states and municipalities, but a national guiding vision is required That guides the efforts.***
2. ***The cross-cutting approach to address the issue of artisanal production from multidisciplinary approaches, allowing connectivity between economic, social and environmental visions,*** recognizing that although concern for the environment and health is a priority, the problem will not be solved without approaches Systems.
3. ***The firm perspective that the population dedicated to the activity deserves the same opportunities to integrate with the national development with respect to the rest of the population in conditions of equality and equity,*** including gender perspectives and to return to the young the opportunities of education And development that the current poverty conditions cancel them.
4. ***The impulse to the activity as an area of economic potential capable of being included in the growth of the country*** under other conditions of competitiveness in the activity, as much in the technological as in the formalization and professionalization of the activity.
5. The activity is intimately linked to the accelerated urban growth, so ***it is urgent to find other forms of exercise of productive activity that produce less damage to the exposed population.*** The attention to this assumption must consider the dynamic processes of metropolitanization of urban areas, with their associated opportunities and challenges.

3.49 Based on those five pillars of public policies that must permeate the coordinated effort of all sectors of government and society itself, the following portfolio of public policies is proposed.

3.50

3.51 *Social policies (extension): access to the right to social development to improve the quality of life*

- Social assistance to the needs of artisanal producers and communities where their activity is inserted, in the areas of health, gender equity education and the offer of urban alternatives to combat family disintegration and non-harmonious coexistence. Public policies in this area already exist but artisanal producers' groups have been marginalized as a result of the situation of the particular informal conditions in which their activity occurs.
 - Comprehensive health care for producers, their families and employees associated with the activity in order to raise awareness of the damages caused by the activity at the levels of technology that prevail and that the quality of life is closely related to it. As a result of this policy, health care programs should be aligned from outpatient clinics to access to clinic health services and even hospitals

- Education up to high school guaranteed for the young population; Literacy education for the elderly to eradicate illiteracy and provide opportunities for the regularization of primary education for all adults.
- Strengthening the identity of producers based on the revaluation of the artisanal identity of their activity as a starting point for the modernization of the same.

3.52

3.53 Normative policies (strengthening): recognition of artisanal activity and its reality in the environmental, territorial and construction regulatory framework

- Since the current regulatory framework has shortcomings in explicitly recognizing the artisanal brick production activity and makes it difficult to regulate, it is necessary to adopt a policy of strengthening environmental and territorial regulations that provides legal certainty to state, municipal and society authorities With respect to the decisions made about it. It requires a technical regulation from the federation that guides and guides the efforts of local governments to adapt their regulatory framework.
 - Conformation from the federal level, specific environmental technical standards that establish the necessary bases to create or adapt those that exist at the local level.
 - Adequacy of federal territorial legislation that explicitly and unambiguously identifies the classification corresponding to the activity of brick production both in its current craft form and in the forms of progressive mechanization and industrialization that are sought in a modernization project , So that it becomes an instrument of environmental policy for an integral planning of the use of the territory that adequately foresees the protection of the environment.
 - Promotion from the federal level of the creation and / or adaptation of local regulations in the areas of territorial and ecological management as environmental, in a way that allows efficient management of land use and protection of the environment, preventing growth Of the city provokes in the future new conflicts between the brick activity and the other uses of the territory.
 - Integration of the three orders of government in the training and discussion of the issues that must be adapted at the level of the local (state and municipal) legal framework, under the principle of subsidiarity that strengthens its intervention.
 - Strengthening of the metropolitan vision of the municipal governments involved territorially in the metropolitan zones already created, in order to look for local decisions that contribute to the adoption of solutions with a metropolitan impact. Current metropolitan areas have not necessarily succeeded in impressing this vision (Meza, Pacheco-Vega, Purón, Rodríguez, & Sáinz, 2016).

3.54

3.55 Technological development policy (guidance): growth of technological capabilities transferred to the sector

- The national policy is already aimed at linking technological development capacities with the needs of the productive sectors, with emphasis on the transfer of technology and knowledge in general. An orientation of this policy is required towards the search for the areas of opportunity represented by the modernization of an activity based on rudimentary technology. The success of this policy in the context of a pilot project will also enable technological ventures capable of satisfying future demands derived from the modernization effort.

- Through the concurrent mixed funds between federation and states, it is possible to promote the development, assimilation and effective transfer of technology to the artisan producers under a patrimonial scheme socially subsidized by the State.
- Promotion of the entrepreneurship to create the base of companies with technological content able to offer solutions and to support a possible takeoff of the production of brick with mechanization and increasing technology.
- Creation of regional centers for training in the use of new technologies under the principle of "seeing to believe", in which the trainers are producers who have assimilated the changes of equipment, furnaces and good practices that they want to demonstrate.

3.56

3.57 Economic policies (extension): full insertion of artisanal activity in the construction sector

- As in social policies, there are already economic policies that are applicable but are not implemented with this sector derived from its own informal character. Therefore it is necessary to extend those that exist to attend with specificity to the sector of artisan producers of brick. For example, the federal government has made a considerable effort to include a series of economic actors in the formality and this initiative should be extended to brick producers in articulation with the implementation of other policies and especially the ultimate goal of improving environmental performance as a necessary condition to improve the quality of life of producers.
- Given the monopolistic nature of the marketing of artisanal products in the hands of intermediaries, which imposes high internal competition, a policy of price regulation is required. Without it, it will not be possible to break the vicious circle of poverty by the inadequate distribution of wealth that has hampered the sustained economic growth of activity.
- On an external level, control of brick demand for self-construction in those areas of the country where the preference for such a product prevails requires that social policy provide for access to adequate housing for the poor. The reality clearly indicates that self-construction continues despite the massive construction of social housing, possibly because it is not available to the entire population and it can then be concluded that in areas where it is preferred, it will maintain the consumption of brick in as much as improve the economic conditions of the population.
- The next element of these economic policies is to print the vision of artisanal production as an integrated business to the value chain with quality and prepared for the diversification of products and markets.
 - Training for the formalization of activity and associationism as an effective way to achieve the desired competitiveness objectives, under the goals of expeditiously identifying the cases of greater probability of success in the formal formation of professional groups of artisan producers.
 - Job training and certification processes to ensure available labor with adequate salary conditions that do not jeopardize the profitability of the activity.
 - Facilitation of adequate leverage schemes and mechanisms for access to both refractory credit (financing to meet the need for fixed assets) and maintenance of cash flow for the operation and under schemes that consider grace periods that support the learning curve and consolidation of the enterprises of organized artisan producers.

- Subsidy to the development of market studies and business plans that contemplate the identification of the target market that is wanted and can be attended with vision of products and quality production.
- Creation of certification schemes for products and processes, aligned to the integral efforts of attention to the sector and under economic rules that identify and value the advances of environmental compliance and improvement of the competitiveness of the producers.
- Promote the principles of social responsibility of construction companies within the value chain to support the comprehensive modernization strategy through market differentiation that supports the efforts of producers committed to the modernization of the sector.
- Impulse to local demand for quality bricks through the implementation within the government of purchases of environmentally appropriate products linked to product certification schemes.
- Creation and application of emission reduction certification schemes within a clean development mechanism, based on payment for environmental services or local carbon market sales markets.
- Creation of market incentives such as reduction of tax burdens on the payroll tax, companies that consume products for the construction offered under the pilot project or modernization that are promoted. This initiative can be associated with the concept of creation of parks of sale of bricks with "green" label offered by the pilot project or projects that are put in place.
- Impulse to financial support to fund lost for companies that innovate with the use of materials produced under "green" labeling as a privileged criterion in the allocation of the Fund for the Innovation Stimulus Program.
- Incorporation of the use of brick with "green" label in the scoring criteria to qualify the subsidy to the construction of ecological housing of social interest.
- Creation of specific schemes of accelerated fiscal depreciation of investment in technological innovation for the production of "green" labeled brick.
- Differentiation of economic support for modernization aimed at local producers that are consistent with the efforts made by previous policies.

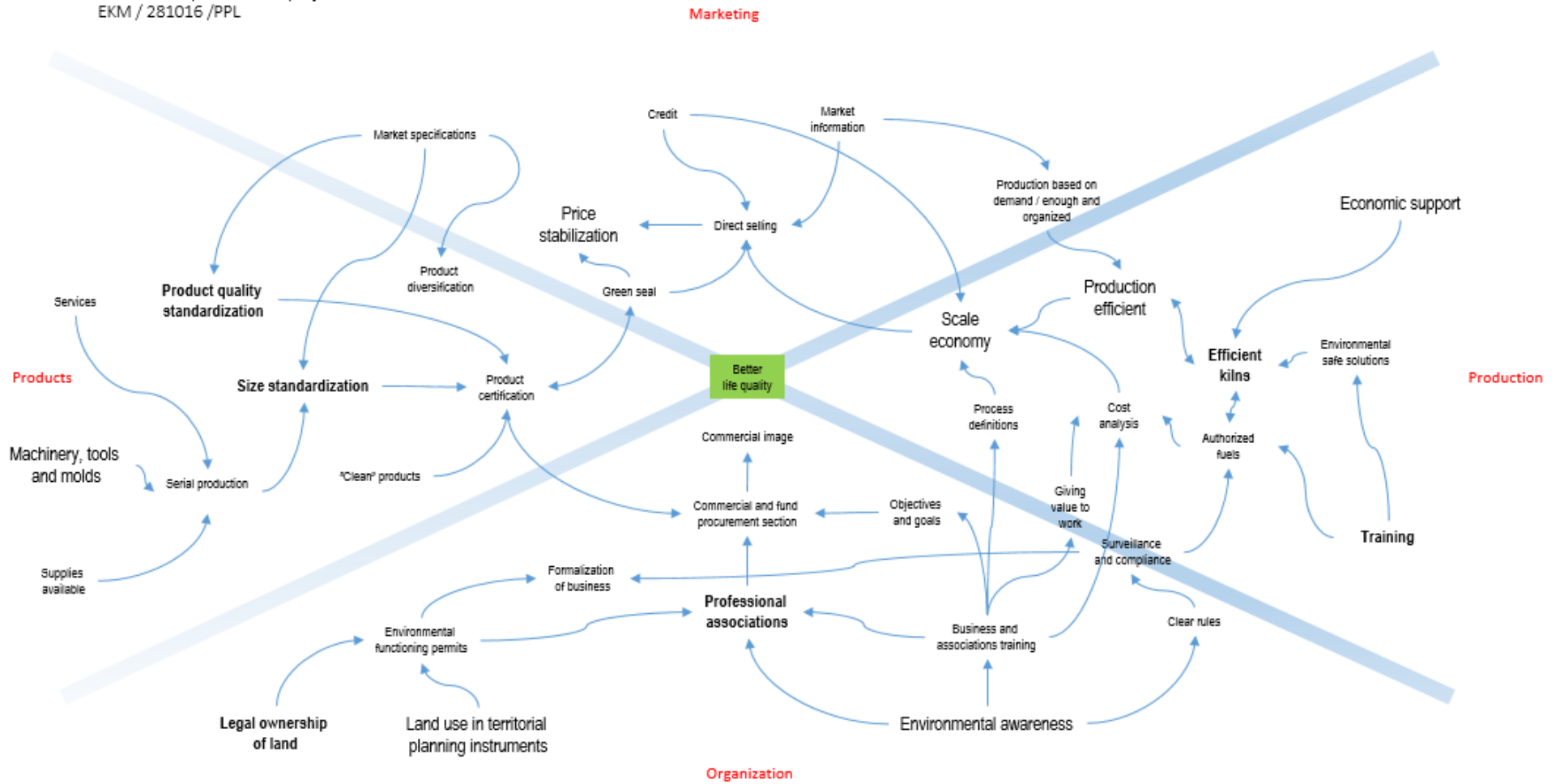
1.8 Components of a pilot project

By applying the qualification criteria elicited from 20 municipalities, contained in the selection matrix included in Annex 9, it was decided that workshops would be held in the municipalities of León in Guanajuato, Zapopan in Jalisco, Chalco in the State of Mexico and Cholula in Puebla. The objective of the workshops was to identify the components necessary to implement the modernization of artisanal production pilot project. Unfortunately the participation in Cholula was scarce and the dialogue only included the most relevant points. Figures 53, 54 and 55 depict the conceptual mapping of workshops held in the León, Zapopan and Chalco and table 26 summarizes the demographic and composition with the common components identified in three municipalities.

Figure 53. Results of components of a project (Workshop León Gto.)

Workshop León, Guanajuato / October 18th, 2016

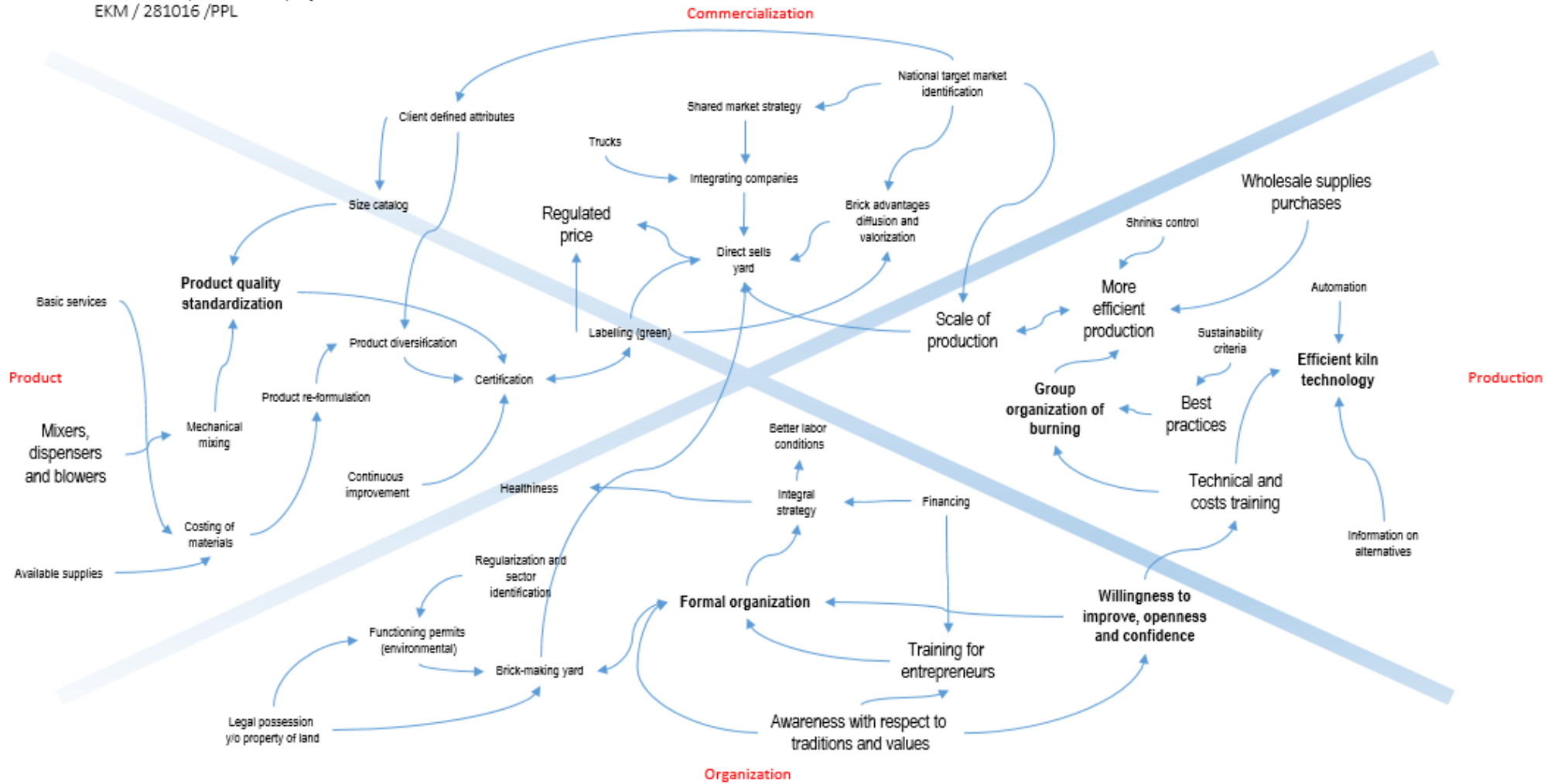
Results: components of a project
EKM / 281016 / PPL



Source: INECC.

Figure 54. Results of components of a project (Workshop Zapopan, Jal.)

Workshop Zapopan, Jalisco / October 18th, 2016
 Results: components of a project
 EKM / 281016 / PPL

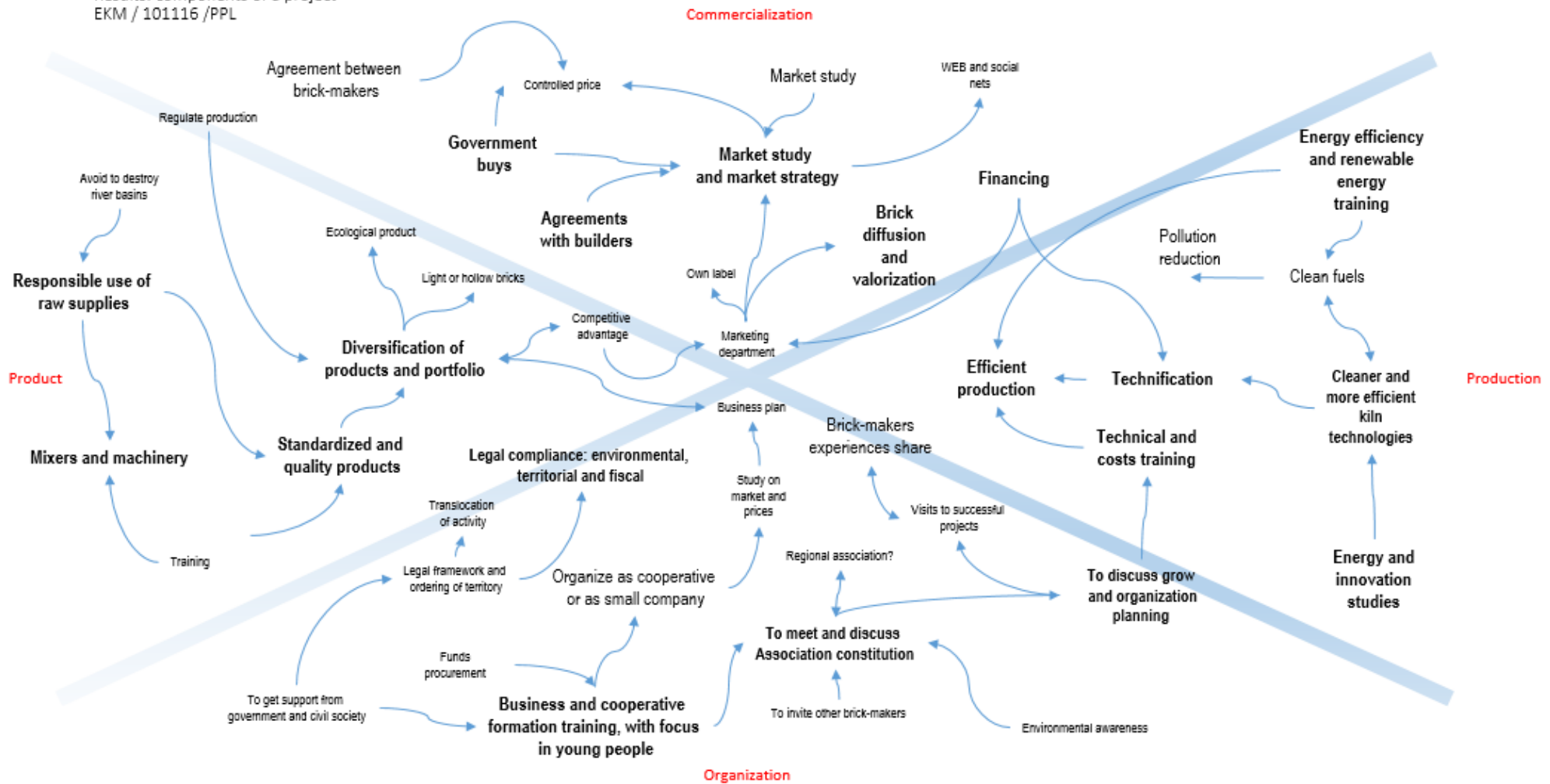


Source: INECC.

Figure 55. Results of components of a project (Workshop Chalco, Edo. de México)

Workshop Chalco, Estado de México/ October 31th, 2016

Results: components of a project
EKM / 101116 / PPL



Source: INECC.

Table 23. Specific Components Captured from León, Zapopan and Chalco Workshops

Municipality:	León	Zapopan	Chalco
	October 18, 2016	October 20, 2016	October 31, 2016
Participants			
SEMARNAT	-	1	-
INECC	1	1	1
State Government	8	5	9
Municipal Government	3	4	4
Private Sector	1	1	1
Academia	-	5	-
Artisanal Producers	7	5	7
Total Participants	20	22	22
Common components:	<ol style="list-style-type: none"> 1. Formalization of clusters 2. Raising awareness for collective work 3. Business and cost training 4. Land use for the ecological and territorial municipal plan 5. Machinery, tools and molds 6. Standardization of product and quality 7. Standardization of sizes 8. More efficient kilns 9. Training for technology (good practices and technology management) 10. Target market information (regional and/or national) 11. Stabilization and price regulation 12. Financing 13. Seal or product brand 		
Specific components	<p>Economies of scale.</p> <p>Product specifications by market.</p> <p>Production efficiency.</p> <p>Direct selling product.</p> <p>Legal ownership of property.</p>	<p>Production of scale.</p> <p>Quality attributes requested by the customer.</p> <p>Direct sale yard.</p> <p>Integrative companies.</p> <p>Professional brick-makers organization for purchase of inputs and product baking.</p>	<p>Exchange of experiences between producers.</p> <p>Efficient production and energy efficiency training. Adoption of better technology.</p> <p>Agreements with construction companies and local governments.</p> <p>Market strategy (marketing department).</p>

Source: INECC.

In the workshops held in Leon (Guanajuato), Zapopan (Jalisco) and Chalco (State of Mexico), there was a consensus made on the need to create or strengthen producer groups and bring them to formalization through raising awareness and training and support on business skills. In addition, the legal use of land for the brick activity was an aspect present in all three workshops. However, in Zapopan it was seen as an obstacle and not as an issue that must be resolved.

The standardization of product qualities in response to market requirements was also a shared concern, along with the use of more efficient furnaces and auxiliary equipment and the corresponding technical training for its handling. Marketing was a common aspect in the workshops but with a difference in the way of approaching it. Leon and Zapopan opted for locations for direct sale of the product, while Leon and Chalco agreed on the need to have a marketing department. In conclusion, the formal group of producers agreed on the need for funding to carry out the actions proposed.

Finally, in the three municipalities a product labeling was proposed: in Zapopan and León more along the lines of a product certification mark and in Chalco as a trademark. The price of the product was a common theme in each workshop with the focus on price regulation.

Only in Leon was the urgent need to solve the legal tenure of the property problem. While Zapopan highlighted that the organization needs to be effective to make purchases by volume and to coordinate the burning of the brick. On the contrary. In Chalco the creation of a very clear and aggressive commercial strategy that includes agreements with governments and the construction sector and a mechanism to share experiences between producers.

In the municipality of Chalco, the workshop was characterized by the lack of state authorities, lack of assistance, lack of raising awareness of grouping producers into organizations and the relatively isolation from municipal environmental dependence. The participation of the producers revealed a resistance to work together for the modernization of the sector. It should be added the complex mechanism of governance by Stewardship that exists in that municipality by cultural tradition, which coexist and interact with the municipal government administration structure. This distinctive and unique quality of Cholula in comparison with the remaining three municipalities, is an aspect that well managed, can strongly support a modernization project.

With the above inputs, the components of a project to modernize artisanal brick production that maintains a national vision with the following five axes of the project: 1) collaborative entrepreneurial culture, 2) regulatory framework, 3) technology access, 4) product quality and diversification, 5) market mechanisms. With each of the five explained in greater detail below.

Collaborative Entrepreneurial Culture

3.58 The premise of this axis is that it is not a country wide solution to provide all producers with the financial and material means for modernization. This is due to the limited resources and the great diversity of individual visions among producers. Individually treated it is possible that in some cases, access to government support for the acquisition of auxiliary equipment or even new furnaces; however, would be isolated cases that would not correspond to the expected efficiency of a national public policy. This axis is the strengthening of the entrepreneurial culture of a collaborative nature through:

- work with formal or de-facto groups that already exist to create a work case that is an example of "seeing is believing". It is clear that this action is feasible in the states of Mexico, Guanajuato and Jalisco: with smaller possibilities in Hidalgo, Tlaxcala and Puebla,
- link the selection of the producer group to the viability of the land tenure and the availability of raw materials: either in its current location or in a proposed brick park,
- create a social training program that addresses the basic needs of gender equity, community vision and social valuation of the artisanal activity,
- promote an extensive entrepreneurial training program based on gender and age, including raising awareness of the need for change and aiming at a better quality of life. Sharing experiences through visits to organizations already established and with some level of success. The identification of environmental and health aspects and the fundamentals of business management of the activity including the valuation of human capital. Emphasis is placed on incorporating young people into this action,
- formulate a business plan based on a local and regional reach,
- design a coordinated government strategy that guarantees access and advice for the formalization of associations or cooperatives that are formed.

Strengthening of the Regulatory Framework

Public policies of command and control are not sufficient but are necessary to create a reference baseline for producers. This implies the clarification of responsibility of the local authorities in the regulation, surveillance and control of the activity. Although the brick factories do not provide the greatest amount of pollutants to the atmosphere compared to other fixed and mobile emission sources, they are a focus of health effects and the emission of short-lived climatic pollutants. Monitoring attention from local broadcasting sources can give better results by focusing on informal sectors compared to the performance observed in formal economic sectors.

Other relevant regulatory areas refer to land use for the legal location of the activity and the legal solution of the mechanisms for granting the necessary environmental permits under the appropriate environmental performance rules. The required actions are as follows:

- design and implement sound environmental and social regulations (human rights, child labor and intra-family violence among others) and business (formalization, land tenure and use),
- create specific environmental and / or regulatory technical standards for brick-kilns with approaches that go beyond mere territorial and environmental visions and establish a cross-cutting link with the mechanisms of public economic and social policy,
- review and adapt municipal land and ecological planning plans in a way that recognizes the brick activity and assigns the territorial criteria and restrictions that must be respected, in order to give certainty to the economic activity that they generate,
- analyze the mechanisms that make it possible to link the normative framework of public works, building regulations and urban development to the creation of a regulatory framework that recognizes the use of brick as an element,
- create an inventory system that can be upgraded to trace the conditions and extent to which it occurs in the municipality in question: without this information, it is not possible to address the following three axes.

Technological Access

3.59 Linked to the two previous axes, it is necessary to change the access conditions that currently have the producers to access new technologies more suitable for the purposes of improving the quality of the product but also the environmental performance of the process involved. This is perhaps one of the key factors in the local adaptation of a modernization project, since it must take into account numerous factors such as the current technological level, the location in relation to the urban spot, the conditions under which it is carried out Activity and availability of territory to carry out collaborative projects of magnitude greater than that represented by individual and atomized production activity.

3.60 This axis is key to implementing a modernization project, since it must take into account the gradual access, given the current low technological level of the producers, the effective control of the polluting emissions, and the organizational changes and infrastructure requirements demanded by technologies of Greater productive capacity. Technological change in Mexico should be closely associated with the management of dry biomass from different sources, taking care of forest sustainability, and the use of liquid fuels that have been technically validated by environmental authorities.

- establish a network to exchange knowledge and positive and negative experiences among producers. Taking into account the challenge of doing this with producers given their educational level and access to information technologies,
- create a catalog of technological solutions that incorporate its advantages and disadvantages: especially in environmental aspects. Guaranteed under protocols established by federal environmental authorities and binding for universities and public centers interested in technological innovation,
- identify, and where appropriate, create rules for the operation of funding sources compatible with funding for the acquisition of technology. It is important that this action are not independent from other actions in all the axes because by itself the acquisition of technology will not solve the problem,
- **create projects of assimilation and development of new technologies under strictly collaborative schemes with producers,**
- identify where new technologies have been tested and to finance their operation as training centers in the assimilation of new technologies by the producers. There is a training school in MK2 kilns in Tequisquiapan, Querétaro and it is possible to take advantage of experimentation with multi-chamber kilns by Irapuato producers in Guanajuato and the experimentation of ININ in kilns docked in Metepec, State of Mexico.

Product Quality and Diversification

This axis responds to the identification of quality as one of the issues that lags behind the artisan production. In all the workshops it was identified as a problem that needs to be addressed. The improvement in the quality of the base product that is the brick is a priority; while the product diversification is considered in a medium term horizon. The necessary actions are as follows:

- create a technical manual for formulating soil mixtures to improve product quality,
- based on the manual, identify the machinery and auxiliary equipment that is required to improve the quality of the product. Attention should be focused on the acquisition of equipment for the formulation of mixtures and shaping of raw brick. In addition, the combustion devices as burners, fuel dispensers and turbines as a function of the fuel suitable for a given pilot project,
- provide training in the handling of the burn process using approved fuels,
- start a program of sample verification for the conformity of mechanical qualities of the brick,
- train producers on high quality customer service,
- socialize best practices knowledge of the burning of brick. Paying special attention to the educational limitations and access to information and technologies that afflict some producers,
- linking to market studies that identify alternative products in order to diversify product offerings to the consumer.

Market Mechanisms

This axis and the previous one allow to "close the clamp" in a pilot project. This is thanks to the direct link of the production with the demand. Throughout this study, we have documented the structural marketing weaknesses of producers: it would not be successful to organize them, adapt the framework that regulates them, give them access to technology and quality standards, if the project does not Is able to improve the margins of profit of the producers themselves and to expand the market served. Therefore, this axis requires the following:

- create a label of bricks and producers that allows for a differentiation in the consumers decision. This seal is linked to the collaborative strategy of all axis's It also requires the creation of the mechanisms of certification and diffusion in order to provide commercial value to the seal,
- link the purchases of bricks made by the government for its public work and infrastructure of social programs,
- create microfinance and / or production mechanisms to maintain the flow of capital,
- agree with construction sector on specific mechanisms to support the pilot project initiatives: especially regarding the selective purchase of certified products,
- create incentives to reduce local tax burdens (municipalities and states) in order to that make it more attractive to differentiate consumption towards certified products,
- regulate open brick outlets to link them to pilot project strategies.

3.61 The execution of a pilot project demands the establishment of a permanent dialogue and work table in which the three levels of government of the economic, social and environmental sectors, the organized sector of the construction, the agents involved in the processes of adaptation Normative and producers, and even the academy. The ideal scenario is one in which the organized producers are managed through associations that allow them to have a common and integrating voice. The main task of this working group will be to continue and follow up the cycle of planning, execution and evaluation of the actions undertaken within the framework of the project and it is fundamental that it is a local authority that coordinates the work to be carried out.

3.62 A pilot project should be based on the careful design of the public policy portfolio that integrates the actions of authorities, builders, intermediaries and marketers around producers. Technical support in this project is essential, and it is critical that it be based on a correct social approach that overcomes the natural resistance of producers and generates a motivation for change and continuous improvement. Another factor that emerges clearly and conclusively from this study is the need for affordable financing mechanisms for production, an aspect that, in the absence of applicable institutional support, is today covered by intermediaries with a high cost of producer profit.

3.63 In view of the above, the main recommendation of this study is to develop a National Program for the improvement of the artisanal brick industry, which feels the basis of the process governance with scope throughout the territory, but taking into account the regional strengths and weaknesses, the which ideally should integrate elements:

- regulations (regulation of emissions, product quality, land use, protocols for validation of technologies and fuels authorized and regulation of exploitation of clay materials),
- social awareness (environmental, valuation of artisanal activity, gender equity and quality of life),
- training (in productive and business aspects, including marketing, certification of labor competencies, technology transfer in training centers based on "seeing to believe"),
- organizational (economies of scale, formation of cooperatives, platforms for information exchange and sharing of experiences),
- innovation (promotion of technology-based companies and financing for the assimilation of successful technology),

- Promotion and incentives (incentives, direct support and boosting the product among buyers, such as the big developers of housing, labeling "green" product with its respective "marketing").

3.64 Based on the success stories identified in other countries, and particularly in Colombia, the gradual nature of policies to promote the required changes in environmental, territorial and product standards, production processes and marketing is an important factor for the success of a program like the one proposed.

3.65 The implementation of the policies and pilot cases derived from the National Improvement Program must address regional differences based on a range of solutions that allow the execution, from simple measures of equipment and access to technologies of better environmental performance, to organizational processes of the producers linked to economies of scale favored by furnaces of more efficient technology.

3.66 The variety of possible solutions generated by the National Program should be framed in a comprehensive management of social, economic, environmental and innovation policies, but always at a speed controlled by two fundamental factors: the social appropriation of the changes by the producers And the success of the process of assimilation of technology (sound operating practices in production, equipment and furnaces).

Conclusions

3.67 The artisanal brick production sector in Mexico is characterized by being predominantly a family and informal activity, without culture or entrepreneurial skills, which is carried out under conditions of scarce economic resources and with a technological backwardness that is reflected in the lack of quality and Standardization of its products. All this in turn links and explains the polluting and generating character of greenhouse gases that turns producers into victims of social rejection and pressures from local governments, in a vicious circle from which they can not escape to access better forms of Production without external help.

3.68 The problem is not the existence of better technologies for better environmental performance and, above all, greater competitiveness, but the limitations imposed by poverty both in the growth of its activity and in the social development of family members, Which condemns them to low educational levels and access to unskilled jobs.

3.69 The interventions to address the problem range from the application of command and control policies, to relocations of the activity that seek to solve the problem by moving away from those who complain about it, but without contemplating technological change, so that the condition of Poverty continues and exacerbates over time. Other interventions registered in Mexico fall into the provision of auxiliary equipment such as burners and fans or fuel dispensers, or furnaces of disruptive technologies for the culture of the artisan producer.

3.70 Attempts based on energy endowment have generally not thrived because of a lack of participatory approaches that work with the social structure of producer groups addressing their needs and capabilities, as well as involving them in building solutions, With which they are alienated from them and the cultural assimilation of changes fails. The provision of numerous MK2 kilns in different parts of the country, or the impetus given by the EELA project to the auxiliary equipment, have also not shown effectiveness, nor have they yielded the

expected results and do not represent a transformational change in the way the brick is produced today, These efforts obviously require follow-up to create the necessary learning as public policy.

3.71 In this panorama of failed efforts carried out for decades, which may be due, among other many causes, precisely to the fact that the atomization of the sector hinders the provision of support, highlight two initiatives that may prosper in the future, one of them is the The formation of a cooperative of ecological bricklayers in Loreto Zacatecas that began in 2012 and prevails, although with the need of government support to strengthen its penetration in the market. The second initiative is the formation of an association between a small group of Irapuato producers on their own initiative, based on a common project to build and operate a multi-chamber oven whose manufacturing was inspired by successful experiences in South America

3.72 Attempts to find solutions from governments also encounter the restrictions of environmental regulations that only exist in a few municipalities and states with different orientations, although they coincide in the command and control based on the type of fuels and the location with respect to human settlements . In territorial planning municipalities face the absence of explicit definitions and this makes it difficult to locate the activity in the allocation of territorial vocations.

3.73 In terms of product characteristics there is also a standard that establishes qualities of mechanical resistance that, in practice, do not seem to be decisive in the purchase decision of the plaintiff. Although there are some local regulations that directly involve the brick of artisan production in the specifications of works, the weakness in this subject is notorious; Even the approach of the Mexican standard in sustainable building does not provide elements to create a product requirement to guide the modernization of production. A consequence of the above is the high variability of sizes, weights and resistances in the same product in different regions or even between that of different producers.

3.74 One of the most important characteristics of this sector is its atomization, that is to say, the existence of a large number of brick manufacturers producing and selling their products independently in clusters in which they create a competition to place their products, causing a generalized tendency to Reduce sales prices. An important structural problem is that producers are price-takers in a system of high internal competition to oligopolistic groups of intermediaries who control the link between information between demand and supply, who also set the price paid for the product taking advantage of the weakness Of the bricklayers. The lack of access of the bricklayers to the financing is satisfied by the intermediaries, which further distances them from the possibility of control of the prices of the product.

3.75 This contributes to maintaining the contaminating effects of the artisanal activity by the combustion of biomass and waste materials in furnaces of rudimentary technology, without conduction of emissions and of course, without technology of environmental control, therefore also represent a danger to the Health.

3.76 The low levels of education of the members of these communities impose a special challenge on the training that producers require not only in matters of business management, but in the experience of seeing and testing the functionality of new technologies that truly transform their possibilities and break The vicious circle generated by the generational transmission of their work with a totally empirical basis.

3.77 The common need has led to the emergence of producer associations that do not focus on defined modernization projects and often represent the response that producers give to the pressure of the authorities or to access resources. There is, however, in all states, a sufficient critical mass of organized groups, to make a selection of cases that are viable candidates for a future pilot project.

3.78 The analysis shows that the production of brickwork has not grown at the rate of the economy and that substitutes partly satisfy the demand for construction materials, although in a different way, in the central and central areas of the country. The brick preference remains high.

3.79 It is also concluded that the construction of average housing and self-construction are the main niches for bricks under the current conditions of price and supply and that demand is due to factors such as price and traditional preference for brick, although the product does not have quality control and lacks standardization.

3.80 The main competitors of the brick are the brick, the concrete blocks and "tabicones", these substitute products are characteristic in the constructive methods of massive housing, industrial buildings and buildings. Other new materials such as compacted earth or waste materials are at a medium stage of their technological development without having penetrated massively in the market. Innovations in building materials occur in large buildings or in massive housing construction, niches in which brick does not compete favorably. However, a wide cultural interest was detected by the products of cooked clay, frequently associated to characteristics like the color, the appearance. If we add factors such as the price of the product, it is possible to understand that the production of brick will not disappear at least in the medium term in high preference areas such as Guanajuato, Jalisco and Puebla, despite social pressure and Environmental control that are exerted against the activity by its polluting effects.

3.81 Some related aspects that emerge as determinants to boost production to another level and achieve a concentration of capital are the ability to offer in time demanded volumes of product, standardization of dimensions and formalization to invoice the product. Quality in terms of mechanical strength is heterogeneous and should be taken care of, but it does not seem to be a first-order limitation for product acceptance.

3.82 Air quality programs and municipal and state environmental regulations specifically mentioning brickworks are neither abundant nor approved in their approaches, often using command and control schemes, for example in the creation of environmental technical standards State. There are no comprehensive care approaches to the sector with a focus on the market as intended in this study.

3.83 A pilot project should be based on the careful design of the public policy portfolio that integrates the actions of authorities, builders, intermediaries and marketers around producers. The technical support in this project is indispensable and it is critical that it be based on a correct social approach that overcomes the natural resistances of the producers and creates the self-motivation for the change. Another factor that emerges clearly and forcefully is the need for affordable financing mechanisms for production, an aspect that, in the absence of applicable institutional support, is now covered by intermediaries with a high cost in the utility of the producer.

3.84 In view of the above, the main recommendation of this study is to develop a National Improvement Program for the handicraft brickwork sector that feels the basis of the governance of the process with scope throughout the territory, but taking into account regional strengths and weaknesses, which, It should ideally integrate normative elements (regulation of emissions, product quality, land use, protocols for validation of technologies and fuels authorized and regulation of the exploitation of clay materials), social awareness (environmental, valorization of artisanal activity, Gender equity and quality of life), training (in productive and entrepreneurial aspects, including commercialization, certification of labor competencies, technology transfer in training centers based on "seeing to believe"), organizational (economies of scale, Cooperatives, platforms for information exchange and sharing of experiences), innovation (promotion of technology-based companies and financing for the assimilation of successful technology) and promotion (such as incentives, direct support and boosting the

product among buyers, such as Like the big developers of housing, labeled "green" product with its respective "marketing").

3.85Based on the success stories identified in other countries, and particularly in Colombia, the gradual nature of policies to bring about the changes required in their production and marketing processes is an important factor for the success of a program such as the one proposed , Especially given the complexity of the social fabric of brickwork craftsmen and, in particular, the design and application of environmental, territorial and product standards.

3.86The implementation of the policies and pilot cases derived from the National Improvement Program must address regional differences based on a range of solutions that allow the execution, from simple measures of equipment and access to technologies of better environmental performance, to organizational processes of The producers linked to economies of scale favored by furnaces of more efficient technology.

3.87The variety of possible solutions offered by the National Program should be framed in a comprehensive management of social, economic, environmental and innovation policies, but always at a speed controlled by two fundamental factors, the social appropriation of the changes by the Producers and the success of the process of assimilation of the management of sound operative practices in the production and of equipment and improved furnaces. In this sense, unlike the Colombian experience, technological change in Mexico is closely associated with the management of dry biomass from different sources, taking care of forest sustainability and the use of liquid fuels technically validated by the competent environmental authorities.

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Abbreviations

BANXICO	Banco de México
BCE	Block of compacted earth
BIE	Banco de Información Económica
CANADEVI	Cámara Nacional de la Industria de Desarrollo y Promoción de Vivienda
CDE	Cross-demand elasticity
CDI	Comisión Nacional para el Desarrollo de los Pueblos Indígenas
CONAGUA	Comisión Nacional del Agua
CONAVI	Comisión Nacional de Vivienda
CONEVAL	Consejo Nacional de Evaluación de la Política Pública de Desarrollo Social
COSUDE	Agencia Suiza Para el Desarrollo y la Cooperación (Swiss Agency for Development and Cooperation)
DENUE	Directorio Estadístico Nacional de Unidades Económicas
DIF	Desarrollo Integral de la Familia
EELA	Proyecto Eficiencia Energética en Ladrilleras Artesanales
EMIM	Encuesta Mensual de la Industria Manufacturera
ENH	Encuesta Nacional de los Hogares
FONAHPO	Fondo Nacional de Habitaciones Populares
FONHAPO	Fideicomiso Fondo Nacional de Habitaciones Populares
GSBA	Geo-Statistic Basic Area
INEGI	Instituto Nacional de Estadística Geografía e Informática
INIFED	Instituto Nacional de Infraestructura Física Educativa
ININ	Instituto Nacional de Investigaciones Nucleares
LGEEPA	Ley General de Equilibrio Ecológico y la Protección al Ambiente
PAZ	Priority attention zones
PDE	Price-demand elasticity
POE	Price-offer elasticity
PIB	Gross Domestic Product
PROAIRE	Programas de Gestión para Mejorar la Calidad del Aire
SCT	Secretaría de Comunicaciones y Transportes
SE	Secretaría de Economía
SECTUR	Secretaría de Turismo
SEDATU	Secretaría de Desarrollo Agrario, Territorial y Urbano
SEDATU	Secretaría de Desarrollo Agrario, Territorial y Urbano
SEDESOL	Secretaría de Desarrollo Social
SEMADESU	Secretaría de Medio Ambiente y Desarrollo Sustentable
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales
SHF	Sociedad Hipotecaria Federal
SLCP	Short-lived climate pollutants
STPSS	Secretaría de del Trabajo y Prevención Social
TSA	Brick artisanal substitute
USDA	United States Department of Agriculture

Glossary

Alluvial materials

The alluvium is detrital material transported and deposited temporarily or permanently by a stream of water, which may be sudden and cause flooding, the term alluvial refers to non-consolidated material. It can be composed of sand, gravel, clay or silt. It accumulates in alluvial fans, channels of river currents, flood plains and deltas. Some authors also include under this term the materials that sediment in lakes or estuaries.

Artisanal brick

Piece of masonry with dimensions smaller than those of a block, made by hand with mud (mixtures with clays) baked.

At-kiln sell

It refers to the sale of baked brick that the producer makes directly in the place where the kiln is located. Usually the discharge of the brick occurs once the product has cooled in the kiln and is loaded directly to the buyer's truck.

Biomass

Term under which are considered firewood from forest exploitation or urban pruning of different species of trees, collected litter, wooden platforms, residues such as sawdust, manure or agricultural wastes of various crops.

Block

Masonry piece whose nominal length is 400 mm or greater in modules of 100 mm and whose nominal height is 200 mm (including the masonry joint). It is usually made of concrete and can be solid, multi-perforated and hollow.

Block with hollows

Rectangular prismatic element manufactured by the molding with or without vibro-compaction of a mixture of stone aggregates, hydraulic cement and other cementants (concrete piece). The blocks must have a net area, calculated on the face of lesser wall thickness, greater than or equal to 50% and less than 75% of the gross area, for bricks the exterior walls must have a thickness of not less than 15mm and the interior walls Must have a thickness of not less than 13mm.

Compacted earth blocks

A masonry part generally having a rectangular parallelepiped shape, obtained by static or dynamic compression of wet earth, followed by immediate demolding, and which may contain stabilizers or additives to achieve or develop the particular characteristics of the products. UNE 41410-2008

Compression resistance

The opposition of a specimen or mortar or concrete element under an axial load expressed as the force per unit area generally given in (kg / cm²). NMX-C-251-1997-ONNCCE

“Despalme”

It is the removal of surface material from the ground, according to the project or approved by the secretariat, in order to avoid mixing the material of the earthworks with organic material or with deposits of non-usable material.
N•CTR•CAR•1•01•002/11

Extrusive igneous rocks

Typical volcanic rocks formed by the fast cooling of lava and pyroclastic fragments. This process occurs when the magma is expelled by the volcanoes; Already in the surface and the contact with the ambient temperature, is cooled quickly developing small crystals that form fine grained rocks (not visible to the naked eye) and pyroclastic rocks, they are product of the explosive volcanic eruptions and they contain fragments of rock of different origins .

Edafology

Science that studies the soils and the processes that give rise to it from a rock of specific geological nature.

Geology

Science that studies the materials that make up the earth and how they are structured by virtue of their origin and evolution.

Igneous rocks

The igneous rocks (from the Latin ignis, fire) also named magmatic, are all those that have been formed by solidification of a material, hot and mobile called magma; This process, called crystallization, results from the cooling of the minerals and the entanglement of their particles. These types of rocks also formed by the accumulation and consolidation of lava, a word that is used for a magma that cools on the surface when it is expelled by the volcanoes.

Intemperism

It is the decomposition, wear, disintegration and destruction of rocks, in response to their exposure to agents to weathering agents (eg water, air, temperature variations, action of organisms). It is classified into two types: physical or mechanical and chemical. Physical or mechanical weathering produced by one or a combination of the following causes and processes: Presence of zones (planes) of weakness, Expansion provoked by decompression, Ice fragmentation or gelifraction, Thermal expansion / contraction, Mineral growth fragmentation And Biological activity. The main chemical processes are dissolution, oxidation and hydrolysis.

Intrusive igneous rocks

They are rocks formed in the interior of the terrestrial crust. When a magma cools beneath the surface, it does so more slowly, allowing a better development of the crystals, which because of that reach sizes that can be observed with the naked eye, usually cover large areas of land and reach the Earth's surface by deformations of The Earth or processes of erosion.

Masonry piece

It is a rectangular prismatic element, which can be made of compressed or extruded "clay" clay subjected to a firing process or by the molding with or without vibro-compaction of a mixture of stone aggregates, hydraulic cement and other cementants (concrete part) or Well made with other materials with different processes.

Roof

Housing component of a building for residential use that has an exterior surface whose normal has an angle with respect to the vertical greater or equal to 0 ° and up to 45 °. NOM-020-ENER-2011

Sedimentary rocks

Sedimentary rocks (from the Latin sedimentum, settlement) are formed by the precipitation and accumulation of mineral matter of a solution or by the compaction of vegetable and / or animal remains that are consolidated in hard rocks. The sediments are deposited, one layer on the other, on the surface of the lithosphere at relatively low temperatures and pressures and may be composed of fragments of other rocks of different sizes, minerals, organism residues and products of chemical reactions or evaporation.

Because sedimentary rocks are formed near or at the surface of the earth their study informs us about the environment in which they were deposited, the type of transport agent and, sometimes, the origin from which the sediments were derived. Sedimentary rocks are generally classified, according to the way they occur, in detrital or clastic, and chemical or nonclassic.

Short-lived climate pollutants

Also known as short-lived climate forcers, they include: methane, black carbon, tropospheric ozone and some hydrofluorocarbons. These pollutants have important effects on the climate and a lifetime in the atmosphere shorter than CO₂ (National Strategy for Climate Change).

Solid block or "tabicón"

Rectangular prismatic element manufactured by the molding with or without vibrocompaction of a mixture of stone aggregates, hydraulic cement and other cementants (concrete piece).

"Tejabán"

Light roofing is set in a patio to protect the product from the weather and particularly from rain.

Wall

Component of the envelope of a building for residential use whose normal has an angle greater than 45° and up to 35°. NOM-020-ENER-2011

Annexes

1. Surveys to artisanal producers
2. In-depth interviews to industrial producers
3. Focus groups (offer)
4. In-depth interviews to demand agents
5. Offer and demand analysis workshops
6. Visual evaluation method for material preference in self-construction
7. Offer and demand data-base analysis
8. National workshop
9. Regional workshops