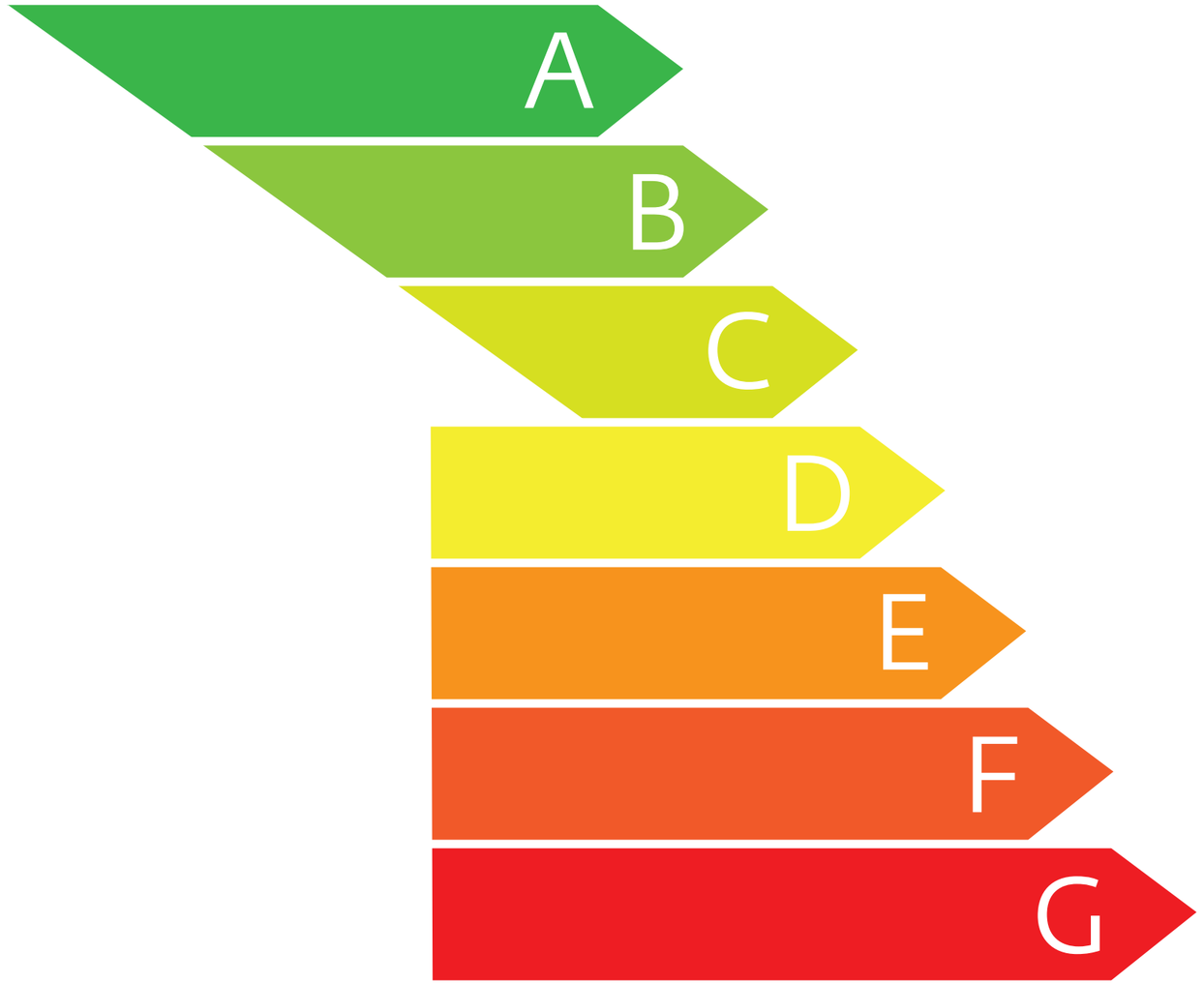
ENERGY AND ENVIRONMENTAL EFFICIENCY IN HOUSING

Survey of national and international practices



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FUNDACIÓN idea
Implementación, Diseño, Evaluación y Análisis de Políticas Públicas

Embajada Británica en México

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CONTENTS

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ACRONYMS

BREEAM	BRE Environmental Assessment Method
CDM	Clean Development Mechanism
COCEF	Border Environmental Cooperation Commission
CO_2	Carbon Dioxide
CONAE	National Commission for Energy Saving
CONAGUA	National Water Commission
CONAVI	National Housing Commission
CONUEE	National Commission for Energy Efficiency
COP16	16th session of the Conference of the Parties (COP 16) to the United Nations Framework Convention on Climate Change
CTE	Technical Building Code (Spain)
DUIS	Comprehensive Urban Developments
EEEES	Energy and Environmental Efficiency Evaluation System
EGC	Enterprise Green Communities
ESP	Energy Sectoral Programme
FIDE	Electric Power Saving Trust Fund
FOVISSTE	ISSSTE Housing Fund
GHG	Greenhouse Gas
gpm	Gallons per minute
IECC	International Energy Conservation Code
INEGI	National Institute of Statistic and Geography
INFONAVIT	National Workers Housing Fund Institute
kWh/m2	Kilowatt hour per square meter
LEED	Leadership in Energy and Environmental Design
LfN	LEED for Neighbourhoods
LFMN	Federal Metric and Standardization Law
L/D/P	Consumption in Litres per day, per person
MEC	Model Energy Code
MINVU	Chilean Ministry of Housing and Urban Development
NAMA	Nationally Appropriate Mitigation Actions for Energy Efficiency in the Housing Sector
NMX	Mexican Standard
NOM	Mexican Official Standard
OECD	Organisation for Economic Co-operation and Development
NDP	National Development Plan
PRONASE	National Program for the Sustainable Usage of Energy
SENER	Mexican Ministry of Energy
USGBC	U.S. Green Building Council

1. Foreword

How is the British Embassy collaborating?

The British Government supports this publication through the Prosperity Fund of the Foreign and Commonwealth Office of the British Government, launched in March 2011, as an instrument of this government to promote sustainable global growth and generate well-being.

Supporting an open global economy, combating the effects of climate change and energy security are the three priorities of this Fund, which operates in 14 countries and gives continuity to achievements through the Strategic Programmes Fund in previous years.

The British Embassy collaborates with Fundación IDEA, GIZ, INFONAVIT, CONUEE, CONAVI and INE in developing a certification system to quantify energy and water use in new and existing dwellings. The object of this new system is bring together the efforts made until now by the different stakeholders involved, and that it may be applied to all types of housing, launching this system nationwide.

Prosperity and Green Growth

The United Kingdom aims to develop the concept of Prosperity as a cornerstone of policy, both in the country and abroad. Prosperity has a broad meaning, encompassing different areas and themes; it is generally understood as developing prosperity by increasing exports and investment, opening markets, guaranteeing access to resources and promoting sustainable global growth.

The idea of prosperity falls within the scope of the environmental development promoted by the British government as a new paradigm for progress in the United Kingdom and around the world. Domestic and foreign policy strategies aimed at promoting this concept, are becoming a new source of national and international competitiveness.

The concept of green growth reflects an appropriate combination of environmental sustainability and economic development, seeking to address both of these two seemingly contradictory issues. By breaking obsolete schemes, it looks into creating new growth engines and jobs through clean technologies and industries that address climate change.

Green growth is not a replacement of sustainable development; rather, it should be considered its complement.

Green growth seeks **to originate the conditions necessary for innovation, investment and competitiveness that can lead to new sources of economic growth consistent with environmental conservation.**

2. Introduction

Currently, there is clear evidence of the effects of global climate change, such as significant rises in temperature, melting glaciers, soil degradation, increased rainfall, and so on. Greatly, these effects are caused by high CO_2 emissions currently produced by the combustion of energy products like coal, gas, oil and wood burning. According to information from the International Energy Agency (Secretaría de Energía, 2009), the energy sector contributes approximately 80% of the world's emissions of GHG Greenhouse Gases. Similarly, the excessive use of electricity and the use of low-efficiency equipment also contribute to global warming.

In Mexico, energy consumption has grown steadily at a rate of 2.6% between 1998 and 2008 (Secretaría de Energía, 2010). According to the National Energy Balance 2009, 17% of national energy consumption corresponds to the residential sector, which corresponds to 5% of GHG emissions in the country.

Along with climate change, another great issue in the global environmental agenda is guaranteeing sustainability of its most precious resource: water. International research suggests that the way to ensure water sustainability is by controlling and reducing demand, accompanied by improvements in water management, since there is little to do on the supply side, without incurring in high economic, social and environmental costs. Within this strategy, reducing domestic consumption is paramount. The Water Agenda 2030 for Mexico suggests a series of measures to close the gap between demand and water offerings estimated for the year. Among the proposed measures, those linked to the housing sector may contribute to a 17% reduction in this gap.

In recognition of the relevant role of the housing sector in the strategies to reduce pollutant emissions, combat climate change and move forward towards the sustainable use of water, the Government of Mexico and the housing industry have undertaken important efforts towards a more sustainable residential sector, through the promotion of energy and environmental efficiency within dwellings.

Unlike developed countries, where household reconversion towards sustainability starts at the top of the pyramid, Mexico has promoted the adoption of "green" features (energy and water saving measures) at the base of the income pyramid, through agencies such as the National Housing Commission (CONAVI), and the National Workers Housing Fund Institute (INFONAVIT). CONAVI's "This is your House" Program, conditions the granting of subsidies to several criteria that guarantees the dwelling's sustainability; until 2011, close to 240,000 credits had been issued for acquiring houses with these characteristics. Also, INFONAVIT has promoted the "Green Mortgage" Program, which gives additional financing for installing eco-technologies in housing, such as solar water heaters, and thermal insulation, among others. INFONAVIT estimates that close to 700,000 homes have been subject to financing under this

scheme. Also, a group of Federal agencies has promoted the construction of Comprehensive Sustainable Urban Developments (DUIS) and Net Zero housing complexes, all guaranteeing a better use of resources and increased environmental and energy efficiency inside dwellings.

With the purpose of providing an even bigger boost to current efforts from the Federal Government and the Mexican Housing Sector, in issues on environmental and energy efficiency, INFONAVIT, with consulting from Fundación IDEA and GIZ, is leading the process of creating an instrument for evaluating energy and environmental efficiency in Mexican homes. This instrument will draw up an Energy and Environmental Efficiency Evaluation System (EEEES) that will promote caring for the surroundings, promoting the sustainable use of resources (energy and water), and communicating the benefits derived from these measures to occupants in terms of economic savings and thermal comfort levels. Apart from creating the HCS, the project includes the promotion, customization and use of this instrument by several housing organizations (CONAVI, for example), and by other institutions in the sector (CONUEE, CONAGUA, etc.) looking to establish a common certification system nationwide.

This publication is part of the research Fundación IDEA has carried out to create the certification system. The first section presents a summary of those energy efficiency policies and programs developed in Mexico, emphasizing those measures and projects directed towards incorporating sustainable criteria in housing. The second presents a worldwide survey on housing and developments certification systems that ensures sustainability of resources and communicate the benefits to occupants in terms of economic savings and comfort levels. From this review, the most relevant elements have been identified, for their integration into the certification system for Mexico. Hence, this publication includes, as recommendations, the main lessons that will be taken into account when creating the evaluation system for Mexico.

The participation of Fundación IDEA in this effort has been generously financed by the British Embassy in Mexico, as part of the project: *Assist in the design, validation and implementation of a multi-agency effort to promote green growth in the Mexican housing market by increasing the energy efficiency of housing units with the use a unified base methodology.*

3

National experiences to mitigate climate change and promote energy efficiency

3. National experiences to mitigate climate change and promote energy efficiency.

Over the last few years, the Federal Government has made important strides in including and highlighting the importance of environmental sustainability in its policies and actions. The National Development Plan (NDP) includes as one of its main axes the issue of environmental sustainability. For the first time in history, objectives and strategies were established to reduce the impact of climate change in our country

In accordance with the NDP, the Ministry of Energy has the responsibility of creating the Energy Sectoral Plan (ESP) and of establishing the commitments from federal agencies and organizations in matters related to energy. This program includes the specific goals for the year 2012 with regards to savings in consumption, decreasing greenhouse gases and defining objectives and actions for energy efficiency.

Apart from ESP, the National Program for the Sustainable Usage of Energy (PRONASE) is focused on implementing strategies for sustainable usage in energy's end uses, such as illumination, transport, household appliances, buildings, etc. These uses or services represent 56% of the national energy consumption (2008) and more than 90% is directed towards the transport, industry, residential and commercial sectors.

Both in issues of energy efficiency and sustainable usage of energy, these programs include several measures and policies that directly impact the housing sector. Specifically, ESP promotes the adoption of energy efficient technologies through policies and financial mechanisms in social housing; mainly, requisites were established for energy efficiency as a condition for financing new housing purchases from [government] agencies such as the National Housing Council (CONAVI) and the National Workers Housing Fund Institute (INFONAVIT) and ISSSTE Housing Fund (FOVISSSTE). On its part, PRONASE promotes measures to increase efficiency of household appliances and lighting inside dwellings, as well as sustainable criteria for the construction process in buildings.

The Ministry of Energy (SENER) leads all political decisions in matters of energy efficiency, while the execution and supervision of all measures, projects and programs falls upon the National Commission for the Efficient Usage of Energy (CONUEE) and the Energy Savings Trust Fund (FIDE). Most of the programs launched by SENER, CONUEE and FIDE are developed in accordance to the Mexican Official Standards.

3.1 Mexican Official Standards

As part of the regulations on energy, it is important to highlight the existence of the Mexican Official Standards (NOM). NOMs are mandatory technical regulations, which contain information, requirements, specifications, procedures and methodologies that enable different government agencies to establish certifiable parameters of safety, health, energy efficiency, and environmental protection, among others.

Specifically, Mexican Official Standards for energy efficiency (NOM-ENER) regulate energy consumption in appliances and installations that, given their energy demands and number of units required, they offer potential saving, where the cost-benefit relationship is satisfactory for the country and the production and consumption sectors. Similarly, there NOMs for elements and components that regulate water consumption inside the home.

Among the Mexican Official Standards for energy efficiency, NOM-020-ENER-2011 is one of the most relevant with regards to energy consumption in buildings. This standard aims to improve the thermal design in buildings and to achieve the comfort of its occupants with minimal energy consumption.

NOM 020 establishes a methodology for calculating heat gains of the envelope, i.e., the material on walls, ceilings, floors, windows, frames, etc. [The envelope's] heat gains are defined as the sum of heat gains by conduction, plus heat gains from solar radiation. The heat gain in the building plans is compared against a reference building with the same characteristics of size and positioning. The heat gain of the abovementioned represents the threshold that must be met by all residential buildings. Thus, NOM-020 limits heat gains in a building by setting minimum conditions for its envelope, therefore contributing to reduce energy demand.

In Mexico, the thermal conditioning of buildings is greatly affected by the electric system's peak demand; with impacts being greater in the northern and coastal areas of the country, where the use of cooling equipment is more common than heating. Here, compliance with this standard partially optimizes the design from the perspective of the envelope's thermal behaviour, resulting in benefits such as saving energy by reducing the use and capacity of cooling equipment, and therefore, reducing GHG emissions.


EFICIENCIA ENERGÉTICA

Ganancia de Calor

Determinada como se establece en la NOM-020-ENER-2011

Ubicación del Edificio para uso Habitacional

Nombre:	Condominios Residenciales
Dirección:	Av. Ahorro de Energía N° 302
Colonia:	Uso Eficiente de la Energía
Ciudad:	México
Delegación y/o Municipio:	Cuauhtémoc
Entidad Federativa:	Distrito Federal
Código Postal:	06500

Ganancia de Calor permitida por esta norma (edificio para uso habitacional de referencia) (watts)	346 392
Ganancia de Calor de este Edificio (edificio para uso habitacional Proyectado) (watts)	287 483

Ahorro de Energía

Ahorro de Energía de este Edificio

17%

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Menor Ahorro Mayor Ahorro

Fecha: 28 de septiembre de 2011

Nombre y Clave de la Unidad de Verificación: Juan Pérez López UV/C-008

Importante

Cuando la ganancia de calor del edificio proyectado sea igual a la del edificio de referencia el ahorro será del 0% y por lo tanto cumple con la norma. La etiqueta no debe retirarse del edificio.

The standard applies to new residential use buildings and extensions of existing buildings; stating that buildings must have

a label that gives users information on the maximum permissible heat gains as allowed by the standard (for the reference building) and heat gains of the constructed building. The label must show graphically the percentage of savings from the planned building, against the reference building.

This regulation comes into full force on December 9, 2011. However, some logistics details, which need to be defined, are required for its implementation. For example: the establishment of verification units; the procedure for municipalities to require a certificate prior to issuing the building permit; updating building regulations, etc.

The following list includes some of the NOMs related to energy and environmental efficiency of buildings, equipment and surroundings. Annex 2 offers a more detailed description of every one.

Table 1. Mexican Official Standards for energy, water and gas efficiency.

Subject	Mexican Official Standard	Description
Energy	NOM-009-ENER-1995	Energy efficiency for thermal insulation in industrial use.
	NOM-006-ENER-1995	Electro mechanic energy efficiency in deep well water pumping systems. Limits and test method.
	NOM-018-ENER-1997	Thermal insulation for buildings. Characteristics, limits, test methods.
	NOM-001-ENER-2000.	Energy efficiency of vertical centrifugal pumps with external vertical electric motor. Limits and test method.
	NOM-008-ENER-2001	Energy efficiency in buildings, envelope of non residential buildings.
	NOM-015-ENER-2002	Energy efficiency of household refrigerators and freezers. Limits, test methods and labelling
	NOM-007-ENER-2004	Energy efficiency for lighting systems in non-residential buildings
	NOM-010-ENER-2004	Energy efficiency of submersible deep well motor pumps. Limits and test methods.
	NOM-013-ENER-2004	Energy efficiency for lighting systems in public ways and outdoor areas
	NOM-014-ENER-2004	Energy efficiency of alternate current (ac), single phase, induction type, squirrel-cage, air-cooled, electric motors, with nominal power of 0.180 to 1.500 kW. Limits, test method and markings.
	NOM-011-ENER-2006	Energy efficiency in central, package and split type air conditioners. Limits test methods and labelling.
	NOM-004-ENER-2008	Energy efficiency of clean water pumps and motor pumps with a power rating of 0.187 Kw to 0.746 Kw, limits, test methods and labelling.
	NOM-019-ENER-2009	Thermal and electric efficiency of mechanized tortilla-making machines. Limits, test method and markings.
	NOM-005-ENER-2010	Energy efficiency of household washing machines. Limits, test methods and labelling.
	NOM-016-ENER-2010	Energy efficiency of three-phase squirrel cage induction ac motors with a rated output of 0.746 kW to 373 kW. Limits, test method and markings.
Energy	NOM-023-ENER-2010	Energy efficiency in split type, free flow, ductless air conditioners. Limits, test methods and labelling
	NOM-028-ENER-2010	Energy efficiency for general use lamps. Limits and test methods.
	NOM-020-ENER-2011	Energy efficiency in buildings. Envelope of residential buildings.
	NOM-003-ENER-2011.	Thermal efficiency of water heaters for residential and commercial use. Limits, test methods and labelling.
	NOM-017-ENER/SCFI-2008	Energy efficiency and safety requirements of compact self-ballasted fluorescent lamps. Limits and test methods.
	NOM-021-ENER/SCFI-2008	Energy efficiency of and user safety requirements for room air-conditioners, limits, test methods and labelling
	NOM-022-ENER/SCFI-2008	Energy efficiency, user safety requirements for commercial self-contained refrigeration appliances. Limits, testing methods and labelling
	NOM-003-SCFI-2000	Electrical products. Safety specifications.

Subject	Mexican Official Standard	Description
Water	NOM-008-CNA-1998	Showerheads used in personal hygiene. Specifications and testing methods.
	NOM-009-CNA-2001	Toilets for sanitary use – specifications and testing methods.
	NMX C415 ONNCE 1999*	Construction. Valves for household water use. Specifications and test methods.
	NOM-244-SSA1-2008	Equipment and germicides for domestic water treatment. Health requirements.
	NOM-127-SSA1-1994	Environmental health. Water for human use and consumption. Permissible quality standards and required purification processes.
	NOM-230-SSA1-2002	Environmental health. Water for human use and consumption. Sanitary requirements, for compliance by public and private supply systems during handling of water. Sanitary sampling procedures.
	NOM-201-SSA1-2002	Products and services. Water and ice for human consumption, bottled and bulk. Health specifications.
	NOM-010-CONAGUA-2000	Specification and testing methods of Admission Valves and Flush Valves for Toilet Tanks.
	NOM-013-CONAGUA-2000	Specifications for air-tightness and testing methods for drinking water distribution networks.
	NOM-007-CONAGUA-1997	Security requirements for the construction and operation of water tanks.
	NOM-127-SSA1-1994	Environmental Health. Water for human use and consumption. Permissible limits of quality and treatments.
	NMX-AA-149/1-SCFI-2008¡	Methodology to evaluate the efficiency of drinking water, sewarage and sanitation services. Guidelines for the evaluation and improvement of services to users.
	NMX-AA-149/2-SCFI-2008*	Methodology to evaluate the efficiency of drinking water, sewarage and sanitation services. Guidelines for the provision and evaluation of waste water services.
	NMX-AA-148-SCFI-2008*	Methodology to evaluate the efficiency of drinking water, sewarage and sanitation services. Guidelines for the provision and evaluation of drinking water services.
	NOM-011-CONAGUA-2000	Conservation of water resources. Specifications and method to determine the mean annual availability of the nation's waters.
Gas	NOM-007-SECRE-2010	Natural Gas transport, technical specifications and minimum security requirements for compliance by systems of natural gas transport through pipelines.
	NOM-002-SECRE-2010	Natural gas installations

* Mexican Standards (NMX) are not mandatory, and are created by a national organisation for standardization, or a Ministry, since their common use is expected, and repeated in regulations, specifications, and attributes, etc.

Implementation and supervision of these regulations is responsibility of the main agencies in matters of energy efficiency in the country. Hereafter, the functions of those agencies and the programs they implement specifically for sustainable elements and components in the housing sector.

3.2 National Commission for Energy Efficiency (CONUEE)

The National Commission for Energy Efficiency (CONUEE) replaces, since 2008, the National Commission for Energy Saving (CONAE), and it aims to promote energy efficiency and establish itself as a technical body, in matters related to sustainable usage of energy.

Among its powers are actions related to regulation, public policy for the sustainable use of energy, promotion, publicity, information and evaluation on energy.

CONUEE is responsible for implementing and monitoring programs, advisory and financing in the government sector, federal, state and municipal governments, the private sector - distinguished by large corporations, small and medium enterprises, the transport sector, and actions of cogeneration. It is also responsible for standardization, certification and verification of the Mexican Official Standards on energy.

Regarding energy efficiency in dwellings, emphasis must be made on the role of CONUEE as the responsible agent for the enactment of [Mexican Official] Standard 020 and, therefore, of certifying those houses compliant with the stipulations set forth in this regulation. Also, as it is detailed as follows, the Commission is responsible for designing and implementing a certificate regarding energy efficiency of new homes

3.2.1 Program to Promote Certification of Products, Processes and Services

The Law for Sustainable Energy stipulates in Article 26 that individuals voluntarily may, through the certification for processes, products and services, carry out a methodological examination of its operations, regarding the level of incorporation in energy efficiency; and the degree of compliance with standards in the sector. It also establishes CONUEE as the responsible agent for developing a program that allows certification. This program should consider:

I. Methodologies for certification.
II. Approval and accreditation system for experts and auditors.
III. Training programs on surveys and audits.
IV. Recognition system for those who obtain certification.

Article 32 of the Law confirms the responsibility of CONUEE for granting certificates. Pursuant to these provisions, in September 2010, CONUEE published the Program to Promote Certification of Products, Processes and Services. This program aims to recognize the efforts in energy issues made by companies, individuals and government entities, and thus, promote market adoption of certified products, processes and services.

Within PRONASE's action lines is specified the need to establish a certification for energy efficient practices, products and services. Since 2012, CONUEE has among its responsibilities, the implementation of a voluntary certification program for compliance with Mexican Official Standards (NOM), measuring efficiency in products, new residential buildings, non-residential buildings and new industrial plants.

This program contemplates four types of certification:

Table 2. Certification Types of the Program to Promote Certification of Products, Processes and Services.

Type	Description
Product Badges	The product badge is an energy efficiency symbol due to its low energy consumption. It offers information to consumers on [the product's] potential economic savings, and the level of environmental protection, in terms of greenhouse gas emissions.
Recognition for buildings	The certification recognizes those commercial and public administration buildings that meet energy efficiency standards (NOM), while also making use of efficient technologies. (NOM-007-ENER-2004, NOM-008-ENER-2001, NOM-018-ENER-1997)
Recognition for industrial plants.	For certification of plants showing an energy consumption index below the averages reported for the industry.
Recognition for new dwellings.	For certification of those dwellings that comply with energy efficiency standards (NOM), while also making use of efficient technologies. The architectural project of the dwelling must comply with NOM-020-ENER-2011

3.2.2 Electrical Energy Savings Trust (FIDE)

The Electrical Energy Savings Trust (FIDE) promotes savings and the efficient use of electrical energy through programs and projects, aiming for new technologies being adopted by markets. Some of its main programs are:

1. FIDE Seal.
2. Sectoral Technology Financing.
3. Energy Efficient Appliance Replacement Program.
4. "Sustainable Light" Program.

3.2.2.1 "Sello FIDE" Seal

The Electrical Energy Savings Trust (FIDE) issues the "Sello Fide" seal to those products that guarantee energy savings as expressed in NOM regulations. This distinction gives consumers information about appliances available for purchase with regards to economic savings on energy consumption. For businesses, this represents recognition to their environmental conservation efforts, and allows for product differentiation against competitors. The "Sello FIDE" seal of approval is voluntary, thus, interested companies must pay [the certification process] to receive it. Some of the products that may receive the "Sello FIDE" seal include:

- Air-conditioning and commercial refrigeration
- Air compressors,
- Appliances,
- Lighting ballasts, lamps, luminaries and control systems,
- Tortilla-making machines,
- Motors,
- Photovoltaic panels,
- Products for buildings: concrete, foams, fibres, sealants, films, polystyrene, doors, coverings, tiles, windows and glass,
- Variable speed drives.

3.2.2.2 Sectoral Technology Financing:

The FIDE has several financing programs for the acquisition of energy efficient technologies, according to the needs each sector: the households, businesses, industry, municipalities; it also offers businesses technical support. For the housing sector, direct support and funding are given for the replacement of refrigerators and air conditioning equipment with new, more efficient appliances. Also relevant to the purpose of this study is the financial support to municipalities, for projects that represent 35 to 50% savings for the population through the adoption of technologies.

3.2.2.3 Energy Efficient Appliance Replacement Program. "Trade your old one for a new one"

In order to reduce household spending on electricity and promoting energy saving in dwellings; the Ministry of Energy launched, in 2009, the "Trade your old one for a new one" Program. Through the FIDE, the program provides aid and facilitates replacing energy-intensive appliances, namely refrigerators and air conditioning, for more efficient appliances.

Appliance replacement can be done through two kinds of aid: direct or financing. Direct aid is a free voucher that covers the cost of new appliances, and transportation and installation costs. Financing consists of a four-year preferential rate loan that is charged to the electricity bill. The issuing and the amount of the aid depend on consumption levels of the old appliances; therefore, the beneficiary may receive direct aid and financing; or simply financing. Appliances available for purchase must comply with applicable Mexican Official Standards.

Until September 2011, the program had replaced 1.3 million inefficient appliances.

3.2.2.4 "Sustainable Light" Program

According to PRONASE, energy consumption from lighting in Mexico represents approximately 18% of the total energy consumption. Each year, it is estimated that 270 million light bulbs are sold in Mexico, of which, only 40 to 50 million are compact fluorescent lamps, commonly known as saving lamps.

To familiarize consumers with new technologies while promoting the use of saving bulbs in the household, the Ministry of Energy launched, through FIDE, the "Sustainable Light" Program. The program strives to promote the replacement of bulbs, by offering an exchange of up to four incandescent light bulbs for the same amount of saving lamps, in authorized exchange centres. The only requirement is to provide an official ID and the latest paid electricity bill.

4

Sustainable Measures and Criteria of the Mexican Housing Sector

4. Sustainable Measures and Criteria of the Mexican Housing Sector.

In recent years, several instruments promoted by the Federal Government have been implemented for achieving sustainability in housing. Unlike developed countries, where the adoption of sustainable measures in the household usually starts at the top of the socioeconomic pyramid, in our country, efforts have been implemented primarily to promote the adoption of sustainable measures in social housing, which are the most economically benefited from the savings associated to "green" dwellings: lower energy, gas and water consumption.

Within the federal housing institutions, INFONAVIT's Green Mortgage Program and the subsidy allocation "This is your House" program of the National Housing Commission are worth highlighting, and are described as follows.

4.1 Green Mortgage Program2. National Workers Housing Fund Institute (INFONAVIT)

Since 2007, the National Workers Housing Fund Institute (INFONAVIT) implemented the Green Mortgage Program with the goal of providing measures to promote sustainability within the dwelling through the inclusion of eco-technologies. Besides the reduction in energy consumption and greenhouse gas emissions, adopting these technologies also mean savings for beneficiaries from reducing the consumption of electricity, water[1] and gas. These savings translate into more disposable income which is intended to cover the loans with the Institute.

The Green Mortgage Program is a credit scheme which provides an additional amount to beneficiaries financing the purchase of eco-technologies for their homes. From 2011, all housing loans granted by INFONAVIT, regardless of the credit product chosen, must include an additional amount for the adoption of eco-technologies in the home. That is, the Green Mortgage program is mandatory for all beneficiaries eligible to acquire a loan with INFONAVIT. The amount of additional credit is subject to the worker's monthly income. An additional feature included in the program starting this year is to give credit holders flexibility in choosing the eco-technologies they consider appropriate.

The combination of these eco-technologies must ensure minimum savings in the household, subject to the beneficiaries' income:

Table 3. Minimum savings, in pesos, with the adoption of eco-technologies, according to the beneficiary's monthly income levels.

Income (monthly integrated wages)		Minimum monthly savings required (in pesos)
From $1,818.53	$12,729.69	$215.00
From $12,729.70	a $20, 003.80	$290.00
From $20,003.81	and above	$400.00

Source: www.infonavit.org.mx

1 "Green Mortgage also includes a savings component related to purchasing bottled drinking water, by financing the acquisition and installation of water purifying filters. This is one of the biggest sources for savings in families.

Once the minimum monthly savings are established, the beneficiary may choose among eco-technology packages that provide that level of savings, which vary accordingly to the bioclimate where the dwelling is located. The packages include combinations of the following eco-technologies:

- Energy saving lights (compact fluorescent lamps);
- High efficiency or low consumption air conditioning units;
- Thermal insulation in roofing and walls;
- Reflective coverings in walls and roofing.
- Solar water heater;
- Gas water heaters;
- Eco-friendly toilets;
- Water saving shower head;
- Water saving faucets and valves;
- Water purifying filters.

Suppliers of these eco-technologies are previously authorized by INFONAVIT and abide by corresponding energy efficiency regulations.

To date, more than 500,000 green credits have been granted, which translate into monthly savings of $217 pesos per household and a reduction of 0.6 tons of CO_2 per household.

4.2 "Esta es tu Casa" Program. National Housing Commission (CONAVI)

The National Housing Commission is the federal body in charge of coordinating housing promotion activities, and of applying and ensuring that the objectives and goals of the federal government with regards to housing are met in agreement with the National Housing Program 2007-2012: Towards sustainable housing development. The law gives CONAVI the mandate of verifying that all housing activities are carried out while properly caring for urban development, land-use planning and sustainable development.

Two main goals of CONAVI in the short run are: 1) satisfying the demand of new housing, while reducing the ongoing deficit in coverage. 2) establishing the basis for sustainable development, in order to prevent housing growth from harming the natural patrimony of future generations.

In this sense, CONAVI develops and promotes mechanisms and programs for financing, subsidizing and savings in housing purchases, focusing on lower income families. Since 2007, it has been in charge of operating the "Esta es tu casa (This is your house)" Program, which allows the lower income segment of the population to access housing solutions through a subsidy (up-front grant) in several categories: purchase of new or used dwelling, purchase of land plot with services for self-building and improving or rehabilitation of dwelling. The amount of the grant varies according to the category and the value of the dwelling or project.

Starting in 2009, the handling of "This is your house" subsidies for new dwellings is subject to meeting the guidelines, criteria and sustainability parameters as defined by CONAVI in relation to the type of housing (single-family or semidetached) and its bioclimatic location. These guidelines strive to promote sustainability in the housing sector and are classified as follows:

1. Site Analysis:
- Legal issues.
- Out of risk areas.
- Available infrastructure: water and sewage, drainage, electricity and public lighting.
- Road influence areas.
- Paved roads and streets.
- Land use.

2. Efficient energy usage:
- Electricity.
  - Energy efficient residential lamps.
- Hybrid (solar-gas) water heating system –in semi-cold and temperate bioclimates.
- Gas: tank less (or instantaneous) water heater.
- Thermal envelope:
  - Thermal insulation materials for roofs, such as plates, caissons, foams, fibres and coverings –in semi-cold and warm bioclimates.
  - Insulation materials in walls on higher sun exposure –in warm bioclimates.
  - Reflective materials in flat or inclined slabs –in warm bioclimates.
  - Use of shingle, dry palm, grass and similar materials –in warm bioclimates.

3. Efficient water usage:
- Toilet:
  - Installed toilet with a maximum consumption of 6L per flush.
  - Installed toilet meeting CONAGUA and ecological guidelines (housing registered since 2010).
- Shower:
  - Low-flow showerhead.
  - Low-flow showerhead meeting CONAGUA and ecological guidelines (housing registered since 2010).
- Valves:
  - Valves certified for domestic use.
  - Sectioning valves for washbasins, toilets, sinks, water heater, water tanks and cisterns.

- Hydrostatic testing of in-house installation (0,75kP pressure).
- Water flow meter meeting guidelines.
- Water main connection meeting CONAGUA guidelines.

4. Proper handling of solid waste:
- Housing complex level: solid waste separation, ventilated areas with easy access for pick up –applicable in municipalities with mandatory waste separation.
- Handling of residues during construction –in municipalities with this requisite.
- Housing: specific spaces and equipment for separating residues.

5. Maintenance:
- Providing the buyer with a maintenance manual for equipment and facilities.

Fulfilment of said criteria and guidelines is ensured by a certified inspector that evaluates the dwelling and, should it satisfy all characteristics required in the Basic Package for the Subsidies Program, a certificate is issued by an approved Certification Organization, in the terms of the Federal Metric and Standardization Law (LFMN). Until 2010, more than 156,000 subsidies have been granted in the category of Acquisition of New Sustainable Housing.

Along these federal programs promoting the adoption of sustainable measures within dwellings, the following projects were developed looking to reduce the environmental impact at a housing complex and urban surrounding levels.

4.3 DUIS: Desarrollos Urbanos Integrales Sustentables (Comprehensive Sustainable Urban Developments)

DUIS are comprehensive urban development projects that include the integration of housing, industry, infrastructure, equipment, amenities and other inputs or services, to create new communities with a sustainable vision. They are the result of a transversal strategy that gathers five secretaries of state from the Federal government, seven public sector institutions related to housing and urban development and private actors. The objective is to achieve a comprehensive sustainability (social, environmental, economic) in the housing sector in Mexico.

Under an adequate urban planning scheme, DUIS try to generate community coexistence and integration spaces, in a way that long and costly transfers to and from schools, workplaces, or routine family activities may be avoided. The objective of these developments is for dwellings to be near all basic services needed for everyday life, and to labour centres. This manages to reduce people transfers and the large amounts of energy consumed as a result. The abovementioned translates into lesser CO_2 emissions, family savings, and improved quality of life. It also looks for better uses of the land and its re-densification, a strategy that also carries

important economic and environmental benefits.

Given their features, two types of DUIS were defined: 1. Intra-urban developments, that promote *intelligent re-densification* by taking advantage of land available within cities; and 2. Peri-urban complexes, citifying macro-lots with mixed land use (housing, equipment, services, industry, etc.), where new communities may be developed. These complexes should preferably be located in areas close to the city.

Until 2010, four DUIS have been certified, amounting to 223,000 homes located in various complexes in [the states of] Baja California, Guanajuato, Sonora and Tabasco. Likewise, similar efforts are being developed in Yucatan and Jalisco. It is worth noting that DUIS are the result of joint and inter-agency efforts by federal, state and municipal governments, in partnership with the private sector.

The DUIS project has a technical evaluation methodology applied to all projects. It includes 83 criteria and parameters divided in 11 determinants, 23 pre-requisites and 48 indicators.

4.4 Net Zero: Zero Energy Dwellings

In the Net Zero program, housing developers have promoted pilot projects for residential developments and dwellings that self-produce energy at a level equivalent to its consumption, achieving a significant reduction in CO_2 emissions.

Within the housing complex, the amounts of renewable energy generated match the total energy demand. This is, the energy provided by dwellings inside the complex, is the same amount they require, therefore, real consumption is zero. To achieve this null consumption, Zero Energy housing complexes include several elements, such as thermal efficiency in the design and construction of houses, and telemetric and photovoltaic systems.

Some examples of Net Zero projects are:

Real Ibiza, Playa del Carmen Quintana Roo, Grupo Vinte:

- Low income houses of 56 m2 with passive design.
- Double airtight glass panes, thermal insulation, fluorescent lamps, photovoltaic system. It also includes urban equipment inside the housing complex, like shops, schools and parks.
- Bi-directional meters, allowing feedback into CFE's distribution network.
- The price of the house increases 18%.

Jardines del Sur, Cancun Quintana Roo, Sadasi:

- Middle-income housing, 92m2.
- Insulation panels in walls and slabs, double pane windows and parasols, low-energy luminaries, air conditioning, water saving devices, efficient appliances, minisplit and photovoltaic panels.
- This dwelling requires 40.4% less energy that traditional houses.

Coatzacoalcos, Veracruz y Acapulco, Guerrero, GEO:

- 3-level vertical housing, social interest: natural ventilation, solar control, volume adjustment, fluorescent lighting, thermal insulation efficient air conditioning, photovoltaic system.
- Duplex, middle-income housing: natural ventilation, solar control, volume adjustment, local vegetation, fluorescent lamps, thermal insulation, efficient air conditioning, photovoltaic system.
- GEO sets 10 criteria being: community life, urban design, housing, basic services, urban mobility, green areas and open spaces, supplies and goods, health, employment and education.

Cancun, Quintana Roo, y Mexicali, Baja California, Urbi:

- Vertical, three levels, social interest: tubular dome, underground ventilation, eaves, vegetation, LED lamps, thermal insulation and photovoltaic system.
- Single Family, middle-income housing: beam and vault slab, insulation in walls, double glazed windows, solar control eaves, vegetation and photovoltaic system.

Vista Real, Cancún Quintana Roo, Ara**:**

- Energy efficient water and gas systems in place,
- *Net Zero:* housing has photovoltaic panels and doesn't require supply from the electricity grid.
- *Vent:* housing offering ventilation and thermal comfort without the need for electricity. Dwellings have photovoltaic panels that feed the ventilation system and fans working with solar energy.

4.5 Clean Development Mechanism (CDM)

Defined under the Kyoto Protocol, seeking to decrease of greenhouse gas emissions around the world, the Clean Development Mechanism allows for the promotion of internationally funded projects, to reduce greenhouse gas emissions in developing countries, which certify generated emission reductions for obtaining resources through carbon credits.

Taking this mechanism into account, and under the coordination of CONAVI, the **Specific Program for Sustainable Housing Development against Climate Change** was created. Currently, the program is under review at the United Nations, pending authorization to participate in carbon credits trading.

4.6 Nationally Appropriate Mitigation Actions for Energy Efficiency in the Housing Sector (NAMA)

NAMA seeks to establish a legal framework that promotes policies to mitigate greenhouse gas emissions in the housing sector. It is a financing option for projects not qualifying as CDM.

With the NAMA program, Mexico obtains funds for boosting dwelling sustainability. Energy-efficiency Resource Standards in the Residential Building Sector (EERS), in the medium term, strive for actions directed to sustainability in the housing sector, including aspects such as urban planning (development design) and sustainable construction methods.

The objective of NAMA is to obtain additional international resources, strengthen and expand efforts in environmental and energy-efficient housing already undertaken in the country; expanding to all dwellings built in the country, and enabling the incorporation of technology which costs are beyond the reach of homeowners. Specifically the objectives are:

- Include more dwellings.
- Adopt more and better technologies.
- Establish more strict building standards.
- Obtain technical support, training and technology transfers.

5

Evaluation systems and tools for energy and environmental efficiency in Mexico and the world

5. Evaluation systems and tools for energy and environmental efficiency in Mexico and the world.[1]

Over time and with the challenge to quantify environmental damage, its mitigation and generation of "green" or sustainable constructions, several certification or evaluation systems for construction have appeared. The Organisation for Economic Co-operation and Development defines "green" or sustainable buildings those which have a minimal environmental impact. (OECD, 2003). The Green Building Council of Australia (GBCAus) defines it as one that incorporates design, construction and operational practices that significantly reduce or eliminate the negative impact on the environment and its occupants with strategies for addressing: (Hes, 2007)

- Energy efficiency;
- Greenhouse gas emission abatement;
- Water conservation;
- Waste avoidance, reuse and recycling;
- Pollution prevention - noise, water, air, soil & light;
- Enhanced biodiversity;
- Reduced natural resource consumption; and
- Flexible and adaptable spaces.

Most of the systems are focused or prioritize housing energy efficiency measurements. These systems strive to meet the following objectives:

1. Provide market recognition to buildings with low environmental impact.
2. Guarantee the inclusion of sustainable best practices in the design, construction and operation of buildings.
3. Promote energy efficiency by delivering objective information on the energy characteristics of a building.
4. In some cases, guarantee that buildings comply with specific levels of energy and environmental efficiency and to remain under a determined amount of greenhouse gas emissions.

Early certification systems were designed to evaluate the energy performance of commercial buildings. Lately, the sector has started to adopt this type of evaluation to promote energy efficiency within the dwelling. The energy efficiency of a dwelling is understood as the minimum amount of energy needed to satisfy the needs associated to the regular uses of a dwelling, either retaining or improving its level of comfort. Generally, a building or dwelling's energy

1 The document Diagnóstico y análisis de sistemas internacionales de certificación energética en viviendas (Sielfeld, 2010) was an important element in reviewing the evaluation systems in this document.

needs are heating, cooling, lighting, hot water, hygiene and food preparation. As a dwelling requires less amounts of energy to satisfy these needs, the more energy efficient it becomes.

This document identified 13 certification systems, 12 international and one national; mainly focused on measuring energy efficiency. This review of international and national experiences shows that certification systems vary according to the type of construction evaluated, the elements for evaluation, their baseline, their efficiency rating, and the information generated for users, among others. Essentially, they score accordingly to the energy and environmental performance –whether potential or real- of the dwelling (ranging from high to low efficiency), which is compared to a reference dwelling, and is based on the parameters established in each country's standards or to desirable or optimal performance levels.

The following certification systems were identified and reviewed; and are later described:

1. Energy Performance Certificate Part L1A Conservation of Fuel and Power (United Kingdom)
2. BREEAM (United Kingdom)
3. Green Star (Australia)
4. Green Rating for Integrated Habitat Assessment GRIHA (India)
5. EnerGuide (Canada)
6. Dwelling Energy Performance Certificate (Certificado de desempeño energético de la vivienda) (Chile)
7. Minimal regulations of energy efficiency: Model Energy Code (MEC), International Energy Conservation Code (IECC) (United States)
8. LEED for Homes (United States)
9. Energy Star (United States)
10. Energiepass (Alemania)
11. Passivhaus Institute (Alemania)
12. Technical Building Code (Código Técnico de Edificación) (CTE) (Spain)
13. Indicator System for Sustainable Housing Developments. Border Environmental Cooperation Commission (Mexico- United States)

These certification systems may be classified in two larger groups according to their methodology for measuring. In some cases, the certification systems provide a rank with different levels of energy efficiency whose sections are defined in relation to the level of energy consumption. Others, especially those that incorporate additional dimensions to energy efficiency, provide a score based on the sustainable elements held in the dwelling or its surroundings (checklist).

1. Efficiency scale:

These systems define a baseline from energy demand estimates of the dwelling in terms of lighting and water heating. In most cases, it also considers the energy demand for cooling

or heating according to the climate zone the dwelling is located. The construction of the energy efficiency scale considers approximations and calculations of minimum, maximum and optimal consumption for several types of dwellings and bioclimatic regions. Generally, these estimates are measured in Kilowatts/hour per square meter (kWh/m2).

2. Score calculation:

These systems are not defined by a scale of energy and water consumption levels, but on the presence of sustainable elements, assigning points to each one. Generally, these elements are subject to basic regulations for sustainability and energy efficiency in buildings. These systems normally add other elements related to dwelling sustainability such as transport, surrounding services, sustainable aspects of the housing complex, and others.

5.1 Analysis and description of energy and environmental certification systems.

Mostly, energy efficiency certification systems tend to adopt an integral approach that considers the dwelling as a whole. Under this approach considerations must be made: initially, to the energy demand estimated in relation to its design and materials; and secondly, to the many ways the demand will be covered (primary consumption). In this sense, certification systems see the dwelling as a unit, evaluating the dwelling's construction features and other factors affecting its energy performance, among them:

- Envelope components in the building: materials in walls, roof, flooring, thermal insulation, etc.
- Other building features, such as windows, doors, thermal bridges, etc.
- Positioning, shading and natural ventilation of the dwelling.
- Household appliance energy yield which carry larger energy consumption, like the refrigerator and air conditioner.
- "Active" heating and cooling systems.
- Water heating systems for personal hygiene (hot water return) or heating.
- Types of combustible used and usage or renewable resources (if applicable).

Elements in certification systems

To gather a more deep and systematic understanding of the many certification systems for energy and environmental efficiency from around the world, the following characteristics were identified:

Eligible type of construction:

- New dwellings: evaluate the energy and environmental efficiency of a new building from the features defined during its design and planning stages. Compliance is verified during construction and on the finished dwelling.
- Existing or remodelled dwellings: evaluation of features in existing or remodelled dwellings, with improvement recommendations made for implementation in the short, medium and long run.

Performance:

- Potential performance: estimating the energy performance of a dwelling or building based on its design elements and taking into account several accepted facts on consumption (mostly about new dwellings). Estimates may differ from reality in relation to the consumption levels of the occupants and the equipment and fuels used.
- Real performance: calculates the energy performance of a dwelling once it's occupied and routinely used. It greatly depends on the occupants' habits.

Enforcement:

- Mandatory: In some countries, building laws and codes set forth an energy efficiency certificate as a requirement for builders and sellers, setting minimum levels for compliance by all dwellings. Generally, this focuses on the yield/efficiency of one issue –energy or water- and in some cases is implemented by government institutions with the purpose of establishing and complying with consumption-related standards or regulations.
- Voluntary: It is those measuring or certification systems, whether public or private, that builders, developers or owners of dwellings may voluntarily earn. They determine environmental efficiency and reward the presence of sustainable elements in dwellings that protect the environment, mitigate the environmental impact of the dwelling and improve the quality of life of its occupants.

Elements evaluated: description of elements rated by the system, grouped in categories.

Methodology: details of the evaluation method such as baseline definition, assigned scores, etc.

Rating: definition of the energy and environmental Rating of the system.

Process: especifies the steps to earn the score/certification.

Measuring/certification instrument: includes software, inspection visits, among others.

Implementation:

- Internal: the same institution responsible of designing and creating of the tool certifying the building.
- External: the responsibility is assigned to external supervisors, accredited by the same institution responsible of designing the tool, ensuring the validity of the certificate.

Information: Details the information or results generated by the certification system and, should it be the case, contains the energy efficiency certificate or label, once the process is concluded.

Source: Compiled by the authors.

The identified certification systems are described as follows. It is important to mention that even though many of these systems originate in a specific country (in parenthesis), independent systems, such as BREEAM, Passivhaus or LEED, are usually applicable in many countries.

5.1.1 Energy efficiency certificate Part L1A Conservation of Fuel and Power (United Kingdom)

PartL1A regulations are the building codes for new dwellings and set the criteria, calculation methods and minimum requirements for compliance on dwelling's energy efficiency. To guarantee its enforcement, this power efficiency certificate must be presented along with all documentation necessary for the sale of any house.

The characteristics of the system follow:

PartL1A regulations are the building codes for new dwellings and set the criteria, calculation methods and minimum requirements for compliance on dwelling's energy efficiency. To guarantee its enforcement, this power efficiency certificate must be presented along with all documentation necessary for the sale of any house.

The characteristics of the system follow:

Eligible type of construction: New and existing dwellings.

Performance: Potential.

Enforcement: Mandatory for new housing. (Seller in charge of registration).

Evaluated elements: Estimates on emissions from heating, hot water returns, ventilation and interior lighting.

- Thermal insulation of the envelope.
- Ventilation and ventilation equipment.
- Heating efficiency and system control.
- Inner gains.
- Type of fuel.
- Passive solar design: window size and positioning, solar protection, ventilation, water pumps.

Methodology: From design, estimations of emissions are made (Dwelling Emission Rate-DER), which must not surpass the emissions of the reference dwelling (Target Emission Rate-TER). The reference dwelling has the same shape, size and positioning. The estimation of demand adjusts to the type of technology and fuels used inside the dwelling.

Rating: 100 point scale divided in 6 categories.

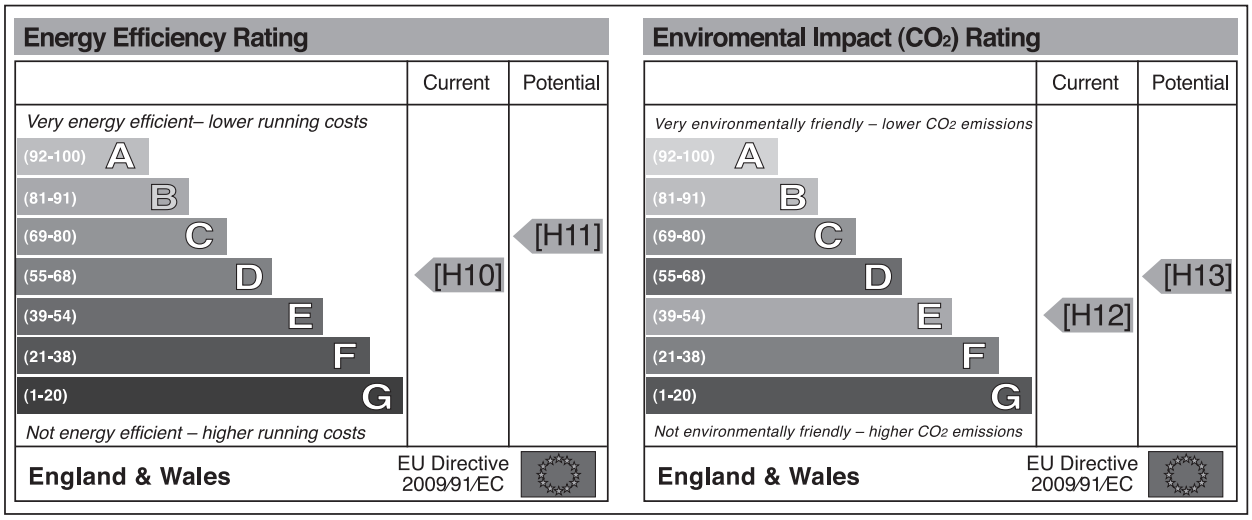
Process: Estimation on emissions based on the design is made by an energy assessor as a building requirement. Periodical inspections are made, and a second estimation is prepared in the post-construction stage. The built dwelling must be consistent with the architectural project (DER).

Measuring/certification instrument: Software and inspection visits.

Implementation: internal.

Information:

- Cost of energy index.
- Environmental impact index.
- CO_2 emissions index.
- Efficiency potential and savings upon implementation of low-cost measures.
- Fuel energy costs.
- Recommendations for improving low and high-cost efficiency and savings potential of each measure.



Source: (The Buildings Regulation 2000, 2006)

5.1.2 Building Research Establishment's Environmental Assessment Method – BREEAM, (United Kingdom)

The Building Research Establishment's Environmental Assessment Method was established in 1990 in the United Kingdom, and to date is used in several countries (Netherlands, Norway, Sweden, Spain, etc.). It is a method to evaluate the environmental efficiency of buildings (dwellings, governmental, commercial, etc.), and considers a wide spectrum of features to evaluate: energy, water, transport, pollution, materials, residues, etc. It foresees the entire life cycle of the building, its design, construction and operation.

The purpose of this methodology is to alleviate the environmental impact of buildings in the short and medium run; establish a standard of better practices for sustainable buildings; recognize the efforts of builders for developing sustainable buildings, issuing a trustworthy environmental performance label. Finally, is stimulates the demand for sustainable builders, informing owners, occupants, designers and evaluators all the benefits of an environmentally sustainable building.

This methodology consists of a point-accumulation system which is given to the building, taking special consideration to the building's surroundings. Among its many products, BREEAM has an "EcoHomes" methodology, an estimation tool measuring the environmental behaviour of housing developments.

The characteristics of the system follow:

Eligible type of construction: New and existing dwellings.

Performance: Potential and real (for the latter there is a tool called EcoHomes XB).

Enforcement: Voluntary.

Evaluated elements: The EcoHomes score system measures the following:

- Energy: emissions, envelope heat losses, dwelling lighting, appliance efficiency, etc.

- Transport,
- Pollution,
- Materials,
- Water,
- Land use and ecology,
- Health and environment.
- Development management.

Methodology: It's a point-accumulation system. Each category has a relative weight. The energy section considers the dwelling's CO2 emissions (Dwelling Emission Rate), and is supported by SAP software.

Rating: A scale of 107 points that rates dwellings in 5 categories: not approved, good, very good, excellent.

Process: Ideally, housing or building projects must be registered with a BREEAM advisor since the concept-design stage in order for convenient modifications to be included. Certification is issued based on the behaviour verified by the BREEAM advisor in the occupied dwelling.

Measuring/certification instrument: Ecohomes and Ecohomes XB Software, and inspection visits by certified advisors.

Implementation: It requires the support and approval of a BREEAM certified advisor.

Information: The dwelling's total rating, with scoring for each of the considered sections.

Source: (BREEAM, 2006)

5.1.3 Green Star (Australia)

Green Star is the environmental certification system that reviews green design and construction processes of dwellings and buildings in Australia. The system was created by the Green Building Council Australia, and has different certifications for offices, schools, hospitals, industrial facilities and dwellings. Unlike other systems, The Green Star rating includes components related to the urban surroundings and the protection of the environment. This document presents the certification system for housing developments.

The characteristics of the system follow:

Eligible type of construction: New dwellings.

Performance: Potential.

Enforcement: Voluntary.

Evaluated elements:

- Management.
- Interior environmental quality.
- Energy
- Transport.

- Water.
- Materials.
- Land use and ecology
- Emissions.
- Innovation.

Methodology: Each category presents compliance measures which are given a score. Every category represents a percentage of the maximum available score. The category's score is weighted by Green Star, to later calculate the final score, adding up all categories. These weighted amounts vary between states and territories to adapt them to local environment and climate conditions. Lastly, additional points are given for innovations.

Rating: Certification is issued starting at 45 points:

- 4 stars (45-59)
- 5 stars (60-74)
- 6 stars (75 points and up)

Process: Green Star provides guides and spreadsheets as preparation for the interested project's registry. Upon finishing said documentation, it must be reviewed by the evaluating committee in order to receive certification. In the event of certification not being granted, recommendations are made to apply in a second round.

Measuring/certification instrument: Inspection visits and calculations (spreadsheet)

Implementation: Documents review by evaluating committee, including consultants approved by the Green Building Council Australia.

Information: The certificate does not provide details

Source: (Green Star Building Australia)

5.1.4 Green Rating for Integrated Habitat Assessment GRIHA (India)

GRIHA is the certification system that measures dwelling energy performance in India, through the Ministry of New & Renewable Energy. The system evaluates elements in the design stage, once the building is occupied, and its maintenance stage. This system, unlike others included in this document, is not limited to exclusively rate dwellings, and may be used for evaluating any type of building.

The characteristics of the system follow:

Eligible type of construction: Any type of new building.

Performance: Potential.

Enforcement: Voluntary.

Evaluated elements: Evaluates 34 areas under the following categories:

- Land location and planning:
  - Conservation and efficient usage of natural resources.

    - Health and safety measures for workers during construction.
  - Construction process:
    - Water and energy consumption efficiency.
    - Waste management.
    - Interior quality of life.
  - Building maintenance.
  - Innovation.

From a total of 34 sections, 8 are mandatory requirements, the rest are optional.

Methodology: Each category includes measures with an assigned score.

Rating:

- 1 star	50-60 points
- 2 stars	61-70 points
- 3 stars	71-80 points
- 4 stars	81-90 points
- 5 stars	91-100 points

Process: Construction must be registered online by the interested party, providing all relevant information to find out its rating. Once the information is registered, it's reviewed by a specialist committee to determine the accuracy of the rating, issuing the certificate.

Measuring/certification instrument: Online forms and software.

Implementation: each category requires each section to be evaluated by a different specialist (landscape architect, energy specialist, public health official, etc.)

Fuente: www.grihaindia.org

5.1.5 EnerGuide (Canada)

With the purpose of controlling greenhouse gas emissions in the country, the Canadian Office of Energy Efficiency designed the EnerGuide program to qualify and certify the energy efficiency of products such as appliances, vehicles, commercial buildings and new or existing dwellings.

The characteristics of the system follow:

Eligible type of construction: New or existing dwellings

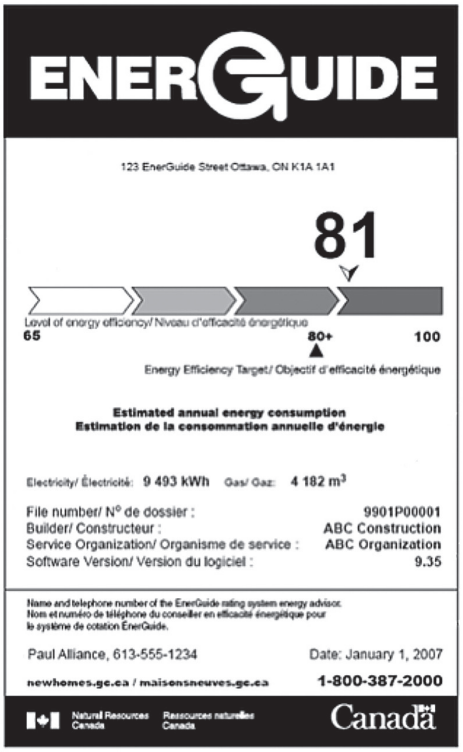
Performance: Potential

Enforcement: Voluntary

Evaluated elements:

Envelope's features:

  - Construction materials.



- Household appliance efficiency.

Methodology: Upon registration of the dwelling's specifications, calculations are made of the energy demand of the project to be certified. From those calculations, the developer is presented with a plan to incorporate features to improve the dwelling's energy efficiency, including its cost analysis.

Rating: 0 to 100, where zero represents a dwelling with air leaks, no isolation and high energy consumption. The 100 score represents an isolated dwelling, with ventilation and no need for annual energy purchases. According to their features, certified houses fall in the following ratings:

Used house	(0-50)
Remodelled used house	(51-65)
New regulation compliant house or energy efficient used house	(65-72)
New house with some energy efficiency measures	(73-79)
New energy efficient house	(80-90)
House that requires no energy purchases	(91-100)

Process:

1. Blueprint and document registration of the project.
2. Estimations of potential energy demands.
3. Delivery of measures for improving energy efficiency.
4. Final inspection upon construction completion.

Measuring/certification instrument: Software and inspection visits.

Implementation: External, EnerGuide approved.

Information:

- Score, compared to the reference house.
- Calculation of energy consumption in the home for heating, lighting and appliances.
- Estimated consumption of electricity and gas.
- Recommendations for improving energy efficiency.

Source: www.oee.nrcan.gc.ca

5.1.6 Dwelling Energy Performance Certificate (Chile)

The Chilean Ministry of Housing and Urban Development (MINVU) manages the system for energy certification of dwellings, regulates its operations, monitors the accuracy of calculations and the certificates it issues. The system started in 2011, becoming the first Latin American country that certifies new homes regarding their energy performance. The characteristics of the system follow:

Eligible type of construction: New dwellings (eventually to include existing ones).

Performance: Potential.

Enforcement: Voluntary (there are minimal mandatory compliance regulations).

Evaluated elements:

- Material nature of the exterior walls, roof, windows orientation and other architectural features that affect its energy performance,
- Efficiency of household appliances,
- Types of fuel used in housing,
- Overheating,
- Contribution of renewable energy.
- CO_2 emissions.

Methodology:

- A baseline is set estimating the energy demand for heating, lighting and hot water by type of dwelling and bioclimatic zone.
- An energy efficiency scale is created from maximum, optimum and minimum consumption levels recommended for each bioclimatic zone.
- Every evaluated home is compared against a reference home that meets the same characteristics.

Rating: 6 categories (A-G) where A is the maximum efficiency possible and F is for homes meeting the minimum standards required.

Process:

- May be carried out in two stages:
  1. The pre-certification of plans and specifications: sets a provisional estimate for the proposed architectural project and is valid for 2 years.
  2. Certification of completed works, inspections visits and verification of the finished home are carried out.

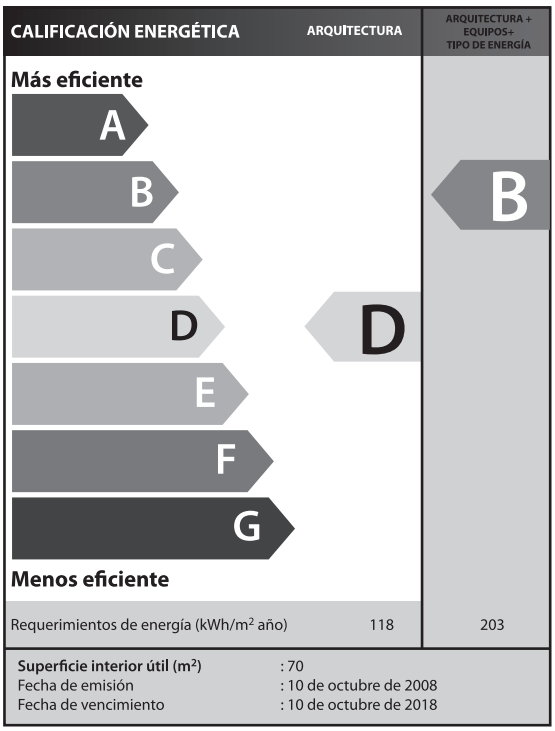
Measuring/certification instrument: Software applications estimating primary energy demand and consumption in terms of housing features. During construction, visits are made to verify compliance with the characteristics specified in the design.

Implementation: Energy certifier, project manager authorized by MINVU

Information: two scores provided; one solely considers efficiency from the dwelling's architecture (envelope). The other is more complete and reports on the dwelling's energy efficiency as a whole: the architecture, appliance efficiency and types of energy used in heating, lighting and hot water. Gives information on the overheating rate for summer and contributions of renewable energy produced in-situ.

Source: (Sielfeld, 2010)

5.1.7 Minimum Energy Efficiency Regulations: Model Energy Code (MEC), International Energy Conservation Code (IECC). (United States)



Since 1998, the Model Energy Code system was replaced by the International Energy Conservation Code System (IECC). The system establishes energy efficiency standards for new buildings for commercial and residential use, as well as extensions in existing buildings; and is administered by the International Code Council (ICC). Each American state determines its own energy requirements.

The characteristics of the system follow:

Eligible type of construction: New and existing dwellings.

Performance: Potential.

Enforcement: Mandatory.

Evaluated elements:

- Envelope: roofing material, walls, floors and windows.
- Foundation.
- Hot water systems and equipment, air conditioning and lighting.
- Solar gains quotients.

Methodology: The regulation and methodology depends on each state in the country. In California, it established a total maximum energy demand for each bioclimatic zone (16 in the state).

Process: In California, the project manager must assess and ensure compliance with the provisions of the code. With the submission of the project a building permit is issued. The local authority monitors compliance. It performs verification visits on the finished project.

Implementation: external evaluators, accredited by authorized institutions

Measuring/certification instrument: Software and inspection visits.

Source: (US Department of Energy , 1999) (Sielfeld, 2010)

5.1.8 LEED for Homes (United States)

In the year 2000, the U.S. Green Building Council (USGBC) developed the "Leadership in Energy and Environmental Design" system (LEED) in order to provide developers and home buyers a framework for identifying and implementing sustainable practices in design, construction, operation and maintenance on any type of construction.

There are different LEED rating systems according to the type of construction: residential, neighbourhood development, commercial, schools, hospitals and department stores, among

others. There is even an initiative to create a LEED rating system for low-income housing. This section refers to the LEED for Homes system which assesses energy efficiency in housing and its surroundings.

LEED stands out when compared to other environmental survey and evaluation systems, because it recognizes that environmental efficiency of a building or housing goes beyond energy efficiency and is related to consumption and water savings, and the dwelling's surroundings. Also worth mentioning is LEED's recognition of innovative technologies and designs that reduce environmental impact.

The characteristics of the system follow:

Eligible type of construction: New dwellings

Performance: Potential.

Enforcement: Voluntary.

Evaluated elements: Evaluates 35 measures in the following categories:

- Location,
- Land Sustainability
- Water and energy consumption,
- Building materials,
- Level of comfort
- Awareness and environmental education,
- Innovation in design.

Methodology: Each category includes architectural, design or technology measures where compliance is assigned a certain score (check list). These steps include:

- Requirements (0 points).
- Good practices (1 point).
- Best practices (2 points).

Rating: Top score: 136 points

1. Certificate (45-59)
2. Silver (60-74)
3. Gold (75-89)
4. Platinum (90-136)

Process: Before construction begins, the project must be registered with LEED-approved supplier to follow up on the entire construction process. Once the construction is complete, a field inspection is made. The evaluator must complete the forms and questionnaires as required

by LEED to determine the final score. Upon submission of documentation, the LEED Council reviews the project, and issues certification.

Measuring/certification instrument: Forms for registration, estimation and inspection visits. Score system.

Implementation: External, LEED approved evaluators.

Information: Total score, category ratings and type of certification (silver, gold, platinum)

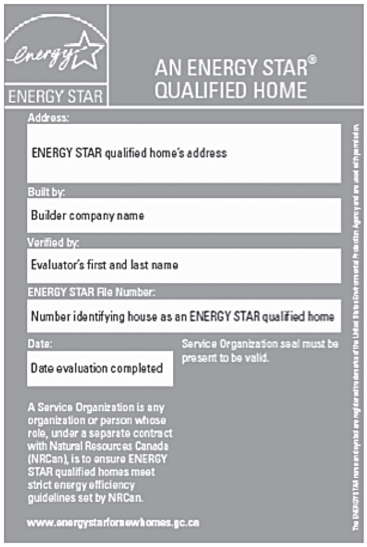
Source: (US Green Building Council , 2011)

5.1.9 Energy Star (United States)

Energy Star is a program developed by the United States Environmental Protection Agency and the U.S. Department of Energy to promote energy efficiency through certification and labelling of products and practices.

For the residential sector, Energy Star certifies energy efficient products and appliances and has also developed a rating system for certifying new homes and commercial buildings.

In 2009, a tax incentive program was approved to encourage the adoption of Energy Star-certified appliances and certain green materials (windows or doors). Specifically, it provides a tax credit equivalent to 30% of product's cost.



The characteristics of the system follow:

Eligible type of construction: New and existing dwellings.

Performance: Real.

Enforcement: Voluntary.

Evaluated elements:

- Elements of the envelope,
- High efficiency windows,
- Insulating materials,
- Efficiency in A/C equipment, lighting and appliances.

Methodology: Statistical comparison of energy consumption in existing buildings with the same features of the project to be evaluated.

Rating: Top score: 100 points. Certification is granted at 75 points and up.

Process: Requires a database with historical data on energy consumption figures for the project to be evaluated. An efficiency index is created based on this information and is corroborated by field visits.

Measuring/certification instrument: Software and inspection visits.

Implementation: External evaluators.

Information: Notifications about the developer, the supervisor, the Energy Star dwelling registration number and the date of certification.

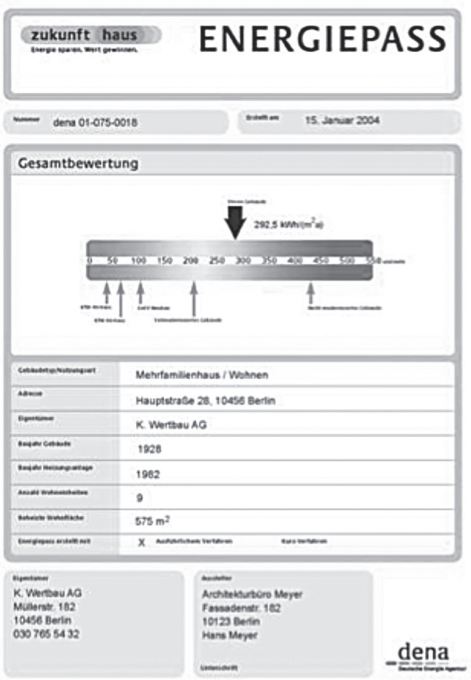
Source: (Sielfeld, 2010)

5.1.10 Energiepass (Germany)

Since 1995, Germany enacted regulations related to the presence of thermal insulation in new constructions. From this regulation, each region enacted its own set of guidelines until 2007, when their criteria were unified under Energiepass. This system evaluates the energy efficiency of a construction regarding its total annual primary energy consumption in kWh/m2. Today, it is mandatory for all new constructions and has a validity of 10 years

Las características de este sistema son:

The characteristics of this system are:



Eligible type of construction:

Energy labelling has two options:

- Certificate of Demand: new and existing buildings.
- Certificate of Consumption: Existing buildings.

Performance: Potential.

Enforcement: Mandatory.

Evaluated elements: Includes: "theoretical primary energy annual demand"= demand of heating, thermal appliance efficiency, type of energy.

- Type of fuel.
- Efficiency of employed technologies.
- Envelope heat losses.
- Heat losses due to ventilation.
- Solar and inner charge gains.
- Thermal bridges.
- Renewable energy sources.

Methodology:

- Estimations of the dwelling's demand are calculated from its requirements for heating and hot water, taking into account performance factors of the equipment used.
- Comparisons of estimated demand in the design, setting limit values for a building of the same characteristics.
- Considerations made for the type of building, construction system, the number of floors and the useful area.
- To receive consumption certification for existing dwellings, a field visit is made to record the dwelling's real consumption to determine its efficiency.

Rating: Semaphore with ranges from 0 to 400kWh/ (m2 year), with 7 reference levels.

Process: Estimations are made based on the design, as a building requirement. A comparison is later made to verify that the building's features match the design.

Measuring/certification instrument: Software and inspection visits.

Implementation: Architect or external energy advisor.
Information: showcases the final values for each element evaluation:

- Final energy demand and primary energy demand.
- Estimated CO2 emissions.
- Itemized demands for heating, hot water, auxiliary equipment.
- Comparison with other types of housing, new and existing.

Source: (Sielfeld, 2010)

5.1.11 Passivhaus Certification (Germany)

The Passivhaus certification is subject to a new or existing building meets the Passivhaus (passive house) standard, which is defined as the scenario where the heating or cooling energy demands in a dwelling are reduced to a minimum as a result of "passive" actions, meaning its design, positioning, and mostly, to its envelope's features, guaranteeing maximum comfort levels. Consequently, the use of "active" sources of thermal comfort –heating or cooling- is null or very low. This standard may be applied to dwellings, and commercial, industrial or public buildings.

The Passivhaus Institute is located in Germany and has a program for approving evaluators around the world.

The characteristics of the system follow:
Eligible type of construction: New dwellings and commercial, industrial or public buildings.
Performance: Potential.
Enforcement: Voluntary.
Evaluated elements: Energy demands, specific demand of primary energy and hermetic level from the following characteristics:

- Dimensions of constructed areas.
- Positioning, ventilation and shading.
- Envelope materials.
- Type of windows and doors.
- Distribution systems, domestic water heating and ventilation.
- Efficiency of lighting systems and appliances.
- Minimum solar contribution to hot water.
- Thermal building behaviour in summer.

Methodology: Self-referencing method, certification is obtained by comparing the building's theoretical energy performance against compliance parameters of the Passivhaus standard.

- Specific heating demand: <=15kWh/m2 annually
- Primary energy demand: <=120kWh/m2 annually
- Hermetic level: <=0.6 ach @50 Pascal

Rating: Scale not applicable. Building must meet Passivhaus standard to receive certification.
Process: Blueprints and relevant technical information must be presented before the evaluator. The information is entered into PHPP software to verify compliance with the Passivhaus standard. Field visits are made to test the dwelling's hermetic level.
Measuring/certification instrument: Calculations with PHPP software and inspection visits.
Implementation: Internal.
Information: Upon certification, building is validated in reaching the Passivhaus standard. The final results of the tool provide information about: specific heat demand, the demand for primary energy, requirements for heating and cooling, the dwelling's overheating rate, and the amount of energy conserved by the use of solar energy.

Source: www.passivhaus.org.uk, www.passiv.de

5.1.12 Código Técnico de Edificación (CTE) (España)

The Technical Building Code (CTE) is the regulatory framework that establishes the requirements for compliance by buildings with regards to safety (structural, fire) and liveability (safety, sound insulation, energy saving) in Spain. The Spanish Ministry of Housing is the agency responsible for its development and maintenance.

With regards to energy efficiency, the code includes five technical requirements (HE) which upon compliance would correspond to an independent energy certificate or label.

The characteristics of the system follow:
Eligible type of construction: New and existing dwellings.
Performance: Potential.
Enforcement: Mandatory (the code established minimum mandatory requirements for compliance)
Evaluated elements: The following elements are evaluated in estimating energy demands:

- Envelope (according to bioclimatic zone).
- Efficiency of thermal installations.
- Efficiency of lighting installations.
- Minimum solar contribution to hot water.
- Minimum photovoltaic contributions to electricity.

Methodology: Self-referencing method, the score is obtained by comparing the theoretical energy consumption of the building to be certified against a reference building meeting the minimum standard required in the above mentioned five areas.

There are two rating systems:

- Simplified option: mandatory and involves a simplified estimation of energy demand, only considering the envelope.
- General option: optional computer-verified calculations, which includes energy, hot water heating and lighting.

Rating: Establishes seven different levels of energy efficiency from A to G, from highest to lowest efficiency

Process: The project evaluates and certifies that the design meets the requirements. A project is drafted including energy details. The building department inspects during construction. A third party performs an inspection visit to the finished works. Effective for 10 years.

Measuring / certification instrument: Simplified indirect calculations or software-based estimations and inspections.

Implementation: Internal and external, computer calculations must be validated by a certified advisory committee.

Information:

- Rating (scale A-G).
- Climatic zone.
- Estimated annual energy consumption.
- CO_2 emissions.
- Description of the energy characteristics of the property (thermal envelope, facilities, details of occupation, etc.).

Source: (Sielfeld, 2010) , www.codigotecnico.org

5.1.13 Indicator System for Sustainable Housing Developments. Border Environmental Cooperation Commission (Mexico- United States)

The Border Environmental Cooperation Commission (BECC) was created as a result of the signature of the North American Free Trade Agreement with the United States, with the objective of improving environmental conditions of the Mexico-United States border region. Together with the North American Development Bank, the focus on applying policies and programs that foster sustainable development in environmental infrastructure of the border.

BECC developed an indicator system to determine the sustainability level of housing developments.

The characteristics of the system follow:

Eligible type of construction: New and existing dwellings.

Performance: Potential.

Enforcement: Voluntary.

Evaluated elements:

- Urban, environmental and public safety aspects.
- Urban design: architecture and application of eco-friendly technologies.
- Efficient usage of energy.
- Efficient usage of water.
- Proper handling of solid waste.

• Community building and sense of belonging factors.

Methodology: It establishes 71 indicators separated into 6 categories, with assigned scoring adding up to 100 points.

Rating: Upon reaching 75 points, the complex is considered a Sustainable Housing Development. If score is less than 75 points, the project is deemed as simply compliant with current legal norms.

Note: This evaluation system is yet to be implemented.

Source: (Comisión de Cooperación Ecológica Fronteriza (COCEF), 2010)

5.2 Evaluating water consumption in dwellings.

Most rating systems described above focus on estimating the energy efficiency of dwellings. However, to build an evaluation system for estimating efficiency or environmental impact is necessary to integrate other aspects in addition to measuring energy consumption. Key aspects to consider include water consumption, domestic waste treatment and the environmental impacts resulting from the dwelling's location and its urban environment.

Among the above mentioned items, water is a priority both for the essential role this resource plays for human life, as by the growing problems the world faces in terms of availability. In Mexico, for example, water availability per person has declined dramatically in recent years, from 18,000 m3 per capita per year in 1950 to only 4,422 m3 in 2010. According to international standards, this is considered as low availability (see Table 4).

Table 4. Water availability in the world.

Category	Availability (m3 per capita/annually)	World countries
Very low	Less than 1,000	16%
Low	1,000 – 5,000	35%
Medium	5,000 – 10,000	14%
High	More than 10,000	35%

Source: (Comisión Nacional de Fomento a la Vivienda, 2005)

It is worth noting that the resource is unevenly distributed at the national level. For instance, considering the thirteen hydrologic regions in which the country is divided, the southern border region had 23,835 m3/per capita/year while the Valle de Mexico only had 164 m3/capita/year available (CONAGUA, 2011).

Prospectively, it is estimated that in the year 2030, demand will increase to 91.2 billion cubic meters, while supply will only increase by 1.3 billion cubic meters to reach a total of 68.2 billion cubic meters. That is, the estimated gap between supply and demand by 2030 will be 23 billion cubic meters (CONAGUA, 2011).

International studies suggest that the way to ensure water sustainability is to control and reduce demand as well as improving water management, since there is little that can be done supply-side without incurring high economic, social and environmental costs (Domene Gómez, 2004; Foro Mundial del Agua, 2006). In this strategy the reduction of domestic consumption plays a key role

The Water Agenda 2030 for Mexico suggests a series of measures to close the hydric gap by the year 2030. The proposed solutions consider measures both technically feasible and profitable given their cost, such as leakage reduction, efficiency improvements in all water uses and the construction of new water infrastructure (CONAGUA, 2011).

Amongst the proposed measures, those linked to the housing sector could reduce 17% of the above mentioned gap. These measures include:

- Repair leaks inside and outside of homes.
- Re-use of public parkland irrigation.
- Replacement of showers.
- Introduction of waterless urinals.
- Replacement of household toilets.
- Re-use of treated water.
- Groundwater recharge.

Therefore, ensuring efficiency in household water consumption is considered an important aspect of a rating system that tries to estimate the environmental impact (not just energy) of the dwellings. While most international experiences described above focus on energy demand and consumption, the research found that some of them also estimated and evaluated projected levels of water consumption. Additionally, other tools and studies were identified to help highlight the key elements to achieve greater efficiency in domestic water use and to estimate the expected savings. Here are some examples:

5.2.1 Green Star (Australia)

The Green Star building environmental rating system also considers, besides energy efficiency, water use, indoor environmental quality and conservation of environmental resources. The sections related to water consumption provide only 12 of 167 possible points. The aspects assessed are:

- Designs that reduce consumption of water potable: points are awarded when consumption estimates for domestic use fall below the best practices identified elsewhere.

  There is a calculation system that considers:

  - Two out of five points when using efficient use systems.
  - Three or more points when water re-usage systems are available in laundry and bathrooms.

- Heat rejection system (cooling).

  - One point when water usage is reduced by 50%.
  - Two points when the system's water consumption is reduced by 90%, or when there is no system.
- Reducing the consumption of potable water in of the building's fire protection system.
- Efficient water storage systems within the home.
- Water efficient appliances:
  - Dishwashers.
  - Washing machine.
- Pool:
  - Existence of a cover that prevents evaporation.
  - Potable water usage is reduced by 70% if:
- An efficient filtration system is in place.
- Water that is discarded is collected and treated for re-use.
- The pool water is not drinkable.

Source: (Green Star Building Australia)

5.2.2 BREEAM-EcoHomes (United Kingdom)

With regards to water, BREEAM's Eco-Homes tool provides 6 out of 107 possible points (for example, the dwelling's emissions as defined by energy efficiency receive 15 points) (BREEAM, 2006). The tool considers two levels of water consumption:

a. Internal drinking water consumption (5 points): evaluated according to the following characteristics:

- Type of toilet,
- Types of faucets,
- Showerheads,
- Dimensions of the tub,
- Using sink for washing dishes versus use of a dishwasher, and
- Characteristics of the washing machine.

The calculation of water consumption in each dwelling multiplies:

Estimated consumption in litres for each one of the above mentioned elements, by the amount of times each element is used annually, times the number of occurrences per space (bed_space).The final tally is the number of cubic meters/per space-bed/annually

For example:

5L Toilet * 365 days/year * 6 uses per space_bed = Number of litres per year / 1000 = m3/space_bed/year

Should it apply, deductions to this result may be made for water amounts from recycling

or rainfall destined for domestic use (toilets, washing machine, etc.). Deductions may not exceed those estimated consumptions for using toilets and clothes or dish washing machines.

Table 5. Credits assigned according to water consumption.

Number of credits	Estimated water consumption (m3/space_bed/year)
1	<52
2	≤ 47
3	≤ 42
4	≤ 37
5	≤32

b. External consumption of drinking water (1 point): it seeks to promote using rainfall or recycled water for irrigation. Credits are granted when homes have a water collection system for these sources intended for irrigation or cleaning of outdoor spaces (patios). A minimum storage capacity is required of the system according to the dwelling's features:

- 100 litres for houses with terraces or patios.
- 150 litres minimum for households with one or two bedrooms and private garden.
- 200 litres minimum for dwellings with 3 or more rooms and private garden.
- 1 litre per square meter of green area shared.

Source: (BREEAM, 2006)

5.2.3 LEED for Homes (United States)

LEED for homes methodology includes, within the multidimensional calculation of sustainability building conditions, a component related to water consumption and use. The variables for water add up to 15 of 136 possible points in the scoring system (up to 38 points for energy efficiency, for example). Aspects considered by LEED are:

- Water re-uses 5 potential points: use of recycled water by the municipality or the existence of an internal capture and controlled reuse of rainwater or waste water. Water may be used for irrigation or inside the house.
- High efficiency irrigation system, 4 potential points: points are awarded to households which have designed or installed high efficiency irrigation systems (garden design); or that reduced weekly irrigation by 60% or more, (4 potential points) to garden designs that use plants with lower water demands.
- Water use within the household, 6 potential points: efficiency in water consumption using water-saving devices.

Table 6. Points assigned according to device and water consumption.

Device	1 point per device	2 points per device
Showerheads	≤ 2 gallons per minute	≤ 1.75 gallons per minute
Faucets	≤ 2 gpm	≤ 1.5 gpm
Toilets	(≤1.3 gpm or double flushing buttons	≤ 1.1 gpm

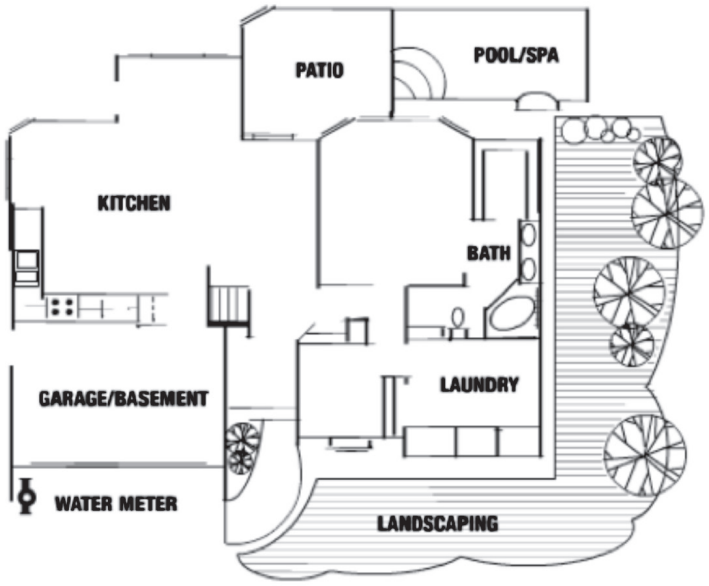
Source: (US Green Building Council , 2008)

5.2.4 H2ouse (United States)

H2ouse is a website (http://www.h2ouse.org) created by the California Urban Water Conservation Council in cooperation with the U.S. Environmental Protection Agency. The purpose of this tool is creating awareness about water consumption and prove that, by taking simple steps, it is possible to conserve this resource while generating significant savings in household expenditures for both water and energy consumption.

The site features a virtual blueprint of an average house, where users can navigate between rooms to see different spots where conservation measures can be effectively implemented. Each sub-section is divided into a series of facts and recommendations on the use and consumption of various products. Elements considered as sources for savings are:

Figure 1. Average house distribution plan.



i. Bathroom

- **Showerhead:**

Low flow: 9.4635 Litres per minute (LPM) or less

High flow: 18.927 LPM

- **Faucets:**

Low flow faucet aerators: less than 3.7854 LPM.

Table 7. Water consumption in faucets: Water saving vs. non-saving households.

	Typical flow rate (LPM)	Average tap water consumption L/P/D	Average faucet usage, minutes/Person/day
Non-saving household	4.5425	34.826	8.4
Saving household	3.7854	30.283	8.9

It is estimated that a non-saving household with four people consumes 50,846 litres annually, while a saving household will consume an average of 44,214 litres per year. To sum up, low flow aerators faucets generate savings of approximately 6,435.2 litres per year, of which 4,921 are would be consumed as hot water. (This information refers to usage in every faucet in the house: bathroom, kitchen, laundry room, etc.).

- **Toilet:** Toilets represent a large percentage of water consumption in the home, which could be reduced by installing efficient toilets, which generate a lower consumption of water per flush.

Table 8. Water consumption in toilets: Water saving vs. non-saving households.

	Flush volume	Number of daily flushes per capita	Daily per capita consumption in litres
Non-saving household average	13.66 L per flush	5.17 flushes	71.166 L
Saving household average	5.829 L per flush	5.46 flushes	34.447 L
Difference	**- 7.8358 L**	**0.29 flushes**	**- 36.718 L**

- **Bathtub:** An element of high consumption of water. H2ouse gives some suggestions for improving efficiency, such as filling the tub with only the amount of water needed, and ensuring that caps are tightly closed.

Bath volume	90.85L
Daily per capita usage	4.5425L
Daily baths per capita	0.1 day

ii. Kitchen:

- **Taps:** Same information applied to bathroom faucets.
- **Dishwasher:** Use high efficiency dishwasher. The standard model uses 35.24L per charge, while the efficient model uses between 24.498L and 18.927L per charge.
- **Treatment of water for household usage**: Gives a series of recommendations on water purification systems as reverse osmosis and some water softeners. Recommends installing filters on water taps, since they avoid wastefulness and represent savings when compared to buying bottled water.
- **Systems for on-demand hot water consumption**. There are several systems, such as recirculation, thermosiphon systems, and point-of-use water heaters. These systems may or may not save water at home, depending on the situation and type of system to install.

iii. Laundry room:

- **Faucets:** Same information applied to bathroom faucets.

• **Washing machines:** Using high-efficiency washers represents significant savings when compared to standard washers, reducing total water consumption by an average

Table 9. Water consumption in washing machines: Water saving vs. non-saving households.

	Average charge volume (L)	Average hot water volume per charge (L)	Daily charge average, per capita	Daily average litres, per person
Non-saving household	154.821	34.154	0.36	56.024
Saving household	91.986	15.899	0.38	34.826

• **Usage of waste waters/dual plumbing system for saving water:** Makes simple recommendations ranging from using a bucket in the shower or sink, for reusing water, to complex recommendations, such as installing a specialized plumbing system, which could represent daily savings of 132.49 litres per capita.

iv. Other elements considered include:

• Water treatment systems.
• Standard hot water system.
• Water meters.
• Exterior cleanliness.
• Garden: Recommendations on irrigation, maintenance and soil improvements. Region-appropriate flora, which in warm climates require little water.
• Pool: Recommendations on covering pools, to prevent water losses due to evaporation, immediate reparation of leaks, among others.
• Coolers (by water evaporation): evaporation coolers use large amounts of water, approximately 249.84 L per day. Water consumption may vary for several reasons depending on the cooler, but generally there is a higher level of consumption on coolers without purging valves.

Table 10. Water consumption in valves: Water saving vs. non-saving households.

	Average water consumption (L/hour)	Average usage time (hr/year)	Annual water consumption (L/year)
Without purge valve Non-saving household	39.747	2,100	83,468
With purge valve Saving household	13.25	2,100	27,823

5.2.5 Housing types and water consumption in Barcelona (Domene Gómez, 2004)

The study by Domene and colleagues for the city of Barcelona, Spain (2004) analyzes the factors that influence of households water consumption and suggests strategies to reduce it. It is suggested that consumption levels are determined by the following factors:

• Climate variables such as temperature and rainfall,

- Economic variables such as household income,
- Political variables such as water pricing, subsidies and supply costs,
- Demographic variables such as family and dwelling size, and type of dwellings,
- Types of dwellings, from high to lower levels of consumption:
  - Single family.
  - Multi-family, semi-intensive.
  - Multi-family, intensive.
- Population density of the dwelling: higher density means lower levels of per capita consumption.
- Internal consumption: technological variables, such as the type of facilities.
  - Total consumption points.
  - % consumption points from eco-technologies.
  - The biggest water expenditures belong to the shower and the toilet.
- External consumption: gardens and swimming pools use great amounts of water, especially when gardens have vegetation that requires large amounts of water, as it is the case with grass.

Asimismo, el estudio destaca las siguientes estrategias de ahorro en el consumo:

- Type A savings:
  - Indoors: Installation of all water saving devices: mixer taps with flow limiter, showers with adjustable temperature and flow, toilet tanks with dual flush devices.
  - Outdoors: i) Lawn replacement with plants suited to the weather, ii) Decrease lawn area up to a maximum 30% of the garden; iii) Maintenance according to the garden, but with efficient irrigation systems.
- Type B savings:
  - Reuse of treated water from sink and shower, in toilets. Toilet water consumption achieved may be zero.

Source: www.h2ouse.org

5.3 Water Consumption Levels

A key element for the creation of a water consumption efficiency evaluation system is having references on the standard consumption level in homes, and those which are considered optimal or efficient.

With regards to consumption, Mexican statistics indicate marked differences according to the region; family income level and access to the public supply system (see Table 11). For example, while the average middle class person consumes 230 litres a day in warm climates, in the cold climate consumption averages 195 L/ person / day. Considering the same bioclimate, consumption in the "residential" area more than doubles its "popular" area counterpart.

Finally, low-income populations without piped-in water services, given their living conditions in the outskirts of cities, or because they live in small villages without access to clean water, consume on average 5 to 7 m3 per month per family (33 to 46 litres per capita). In contrast, people who have water and sewer services at home, average consumption levels in the 200 litres per capita range.

Table 11. Levels of water consumption in Mexico, by region and y socioeconomic status (Litres/per capita/Day)

Climate	Consumption by socioeconomic status		
	Residential	Middle	Low income
Warm (22°C and up)	400	230	185
Semi-warm (18 to 22° C)	300	205	130
Temperate (12 to 17,9° C	250	195	100
Cold (less than 12° C)	250	195	100

Source: (Comisión Nacional de Fomento a la Vivienda, 2005)

In other surveyed countries the reported levels of average consumption per person per day are lower. In Barcelona, for example, a survey conducted in 2004 found that usage levels vary significantly according to the dwelling: lower consumptions were registered in the intensive multi-family type (120.1 ± 47.8 litres / person / day, lpd), followed by the semi-intensive multi-family type (147.7 ± 61.9 lpd) and, finally, the single-family type (203.2 ± 116.4 lpd). On average, therefore, families living in single family houses consumed 1.69 times more water than those living in the intensive multi-family type (Domene Gómez, 2004).

Using the study of Domene Gomez and colleagues (2004), the Environmental Sustainability Indicator System of the City of Seville, Spain (ECO-URBANO, Gobierno de España, 2011) sets a target for an optimal intake between 82 and 160 litres/person/day, depending on the type of housing, where less than 70 litres/day should be of drinking water, leaving the remaining water to be re-used or treated (see Table 12).

Table 12. Optimal water consumption averages by water qualities

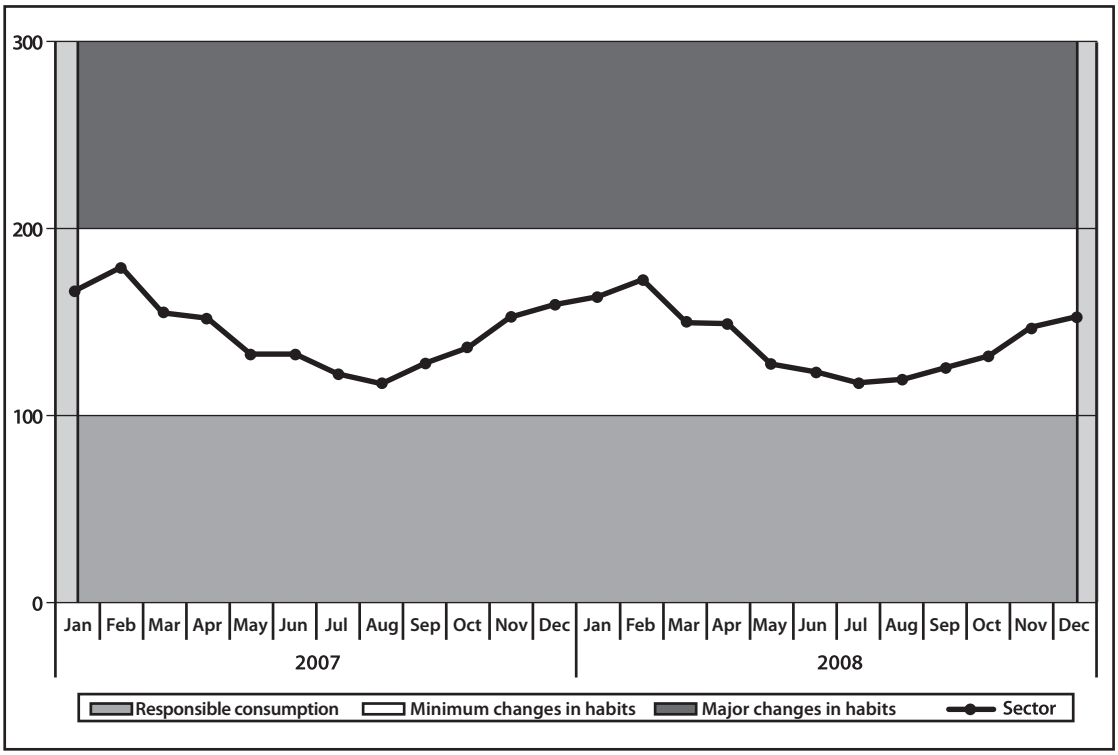
	Multi-family housing unit *			Residential development			Single family detached house		
Water uses	Drinkable water	Non drinkable water	Total	Drinkable water	Non drinkable water	Total	Drinkable water	Non drinkable water	Total
Residential	64	18	82	68	28	96	70	90	160
Public		14	14		14	14		14	14
Commercial	4	4	8	4	4	8	4	4	8
Total	**68**	**36**	**104**	**72**	**46**	**118**	**74**	**108**	**182**

*Multi-family housing unit: apartment building; Residential development: multiple housing units in one lot.
Residential: Consumption linked to residential use. Public: Cleaning of urban areas, park and garden irrigation, etc. Commercial: Economic activity in urban areas.
Consumptions levels in this table respond to conditioning factors considered to build this indicator.

Source: (ECO-URBANO, Gobierno de España, 2011)

For the Chilean experience, the document "Drinking water consumption 2007-2009" commissioned by the Superintendence of Sanitary Services (SISS) of the Chilean government, established, based on the behaviour of 4 million users, that normal average consumption fluctuates between 100 and 200 litres/person/day, depending on the time of the year; peaking at 170 litres per day in during the summer period (February). The document establishes the threshold for responsible consumption in 100 litres/person/day. It also suggests that consumption between 100 and 200 litres may transform into responsible consumption stemming from minor changes in people, whereas when consumption levels surpass 200 litres, major changes in people´s habits and infrastructure are required.

Figure 2. Daily per capita consumption. Health Sector



Source: (SISS, Gobierno de Chile, 2009)

5.3.1 Types of water consumption inside the household

A second aspect to consider in the rating system regarding water is to understand how water is consumed inside the household, in order to see the potential savings of different devices. In the Mexican case, data shows that most of the household's consumption goes to personal hygiene (showers, washbasins and toilets). Between 25 and 30% of water is consumed in the shower and sink, and another 30 and 40% is used in the toilets.

Table 13. Household distribution of water consumption (litres per capita/day

City	Hermosillo (Sonora)	Querétaro (Querétaro)	Tijuana (Baja California)	Sonora (COAPAES)
Litres per capita/day	300L	166L	200L	300L
Shower and washbasin	35%	25%	30%	70%
Toilet	30%	40%	40%	
Kitchen, food preparation	20%	10%	11%	13%
Lavatory	11%	15%	15%	15%
Irrigation	-	10%	-	-
Drinking	1%	-	-	2%
Other	3%	-	-	-

Source: Compiled by the authors with information from (Comisión Nacional de Fomento a la Vivienda , 2005)

5.4 Components of the urban surroundings within certification systems

Most of the systems in this sector focus on knowing the energy efficiency of the dwelling, to optimize energy and water consumption and reducing greenhouse effect gases. However, a sustainable housing complex must go further than consumption and house inner-characteristics, which is why there is an increasing number of evaluation systems that consider elements in housing complexes and their urban surroundings.

The logic behind this statement is that the environmental impact of dwellings involves both consumption activities that take place indoors, and actions and consumption resulting from the location of the houses: characteristics of the housing complexes to which they belong, and the urban environment where homes and their complexes are located. This is particularly relevant in Mexico, where the growth of the housing sector, especially for lower income families, has been primarily under the figure of housing developments of considerable size, located outside cities, in many cases, quite far from urban centres that concentrate the supply of jobs and services.

Incorporating the dimension of the complex and its urban surroundings is also relevant because it allows for sustainable solutions beyond the scope of the household. In this sense, there are systems that evaluate all elements related to housing complexes and their urban environment, such as reducing waste, the availability of sustainable transport nearby, the environmental impact on the grounds, the incorporation of technologies for the self-generation of energy, water collection, treatment and reuse, common area maintenance, etc.

Below are some systems that evaluate different characteristics of housing complexes and the urban environment:

5.3.1 BREEAM (United Kingdom)

The BREEAM rating system focuses on the assessment of new buildings in the commercial sector (offices, retail stores, industrial plants), in the public sector (schools, hospitals, prisons) and others such as hotels, museums, libraries, etc. The criteria for this rating system does not provide for the evaluation of dwellings or housing developments. However, it includes several

elements of the urban environment to be considered in the analysis. The methodology suggested by BREEAM considers the entire building cycle: planning, design, construction, and operation. It is a flexible approach that allows incorporating different technologies, leaving an open space for innovation. The elements are grouped into the following categories:

1. Transport:
   - Access to public transport.
   - Closeness to services.
   - Cycling facilities.
   - Limits on car park capacity.
   - Transportation network.
2. Residues
   - Handling of resides during construction.
   - Deposits for separation of residues.
3. Land use and the environment
   - Location.
   - Respect of protected environmental areas or areas close to them.
   - Mitigation of environmental impact.
   - Actions and measures to maintain the ecological value of the land.
   - Impact on biodiversity.
4. Pollution
   - Reduction of flood risk.
   - Optimization of lighting at night.
   - Noise Reduction.

Source: (Bre Global Ltd, 2011)

5.4.2 LEED for Neighbourhoods (LfN)

In 2009, the LEED rating system created an exclusive protocol for certifying planning and neighbourhood development. LEED for Neighbourhoods (LfN) aims to promote sustainable practices in the design and construction of housing developments, through "intelligent" growth measures and urbanism. According to LfN, the planning and design of a neighbourhood should align those building blocks and infrastructure with the local and regional surroundings. A district must have a good location and infrastructure that offers services and amenities to its residents, it should also take into account the availability of transport systems that allow for easy and sustainable movements and finally, it must consider the energy efficiency of other buildings within the neighbourhood and its common areas[2].

The system evaluates several components in the following categories:

2 The system is designed in accordance to environmental and land use policies of the United States.

- Location: Location: including proximity to work centres, availability of bike paths and bicycle spaces, protection of agricultural land or wetlands, conservation of species, etc.
- Neighbourhood Design: preference for pedestrians, public transportation facilities, access to public spaces and recreational facilities, availability of schools, local food production, etc.
- Sustainable Infrastructure and Building: Energy efficiency in buildings (other than housing), waste management, renewable energy, efficient irrigation areas, and so on.
- Innovation Processes: integration of highly innovative elements according to LEED criteria.
- Credits for compliance with local or regional policies according to standards of the United States.

From the scores in each category, certifications are issued accordingly to the scale described below:

1. Certificate (40-49 points)
2. Silver (50-59 points)
3. Gold (60-79 points)
4. Platinum (80 points and up)

The system is voluntary and certifies neighbourhoods in both, the design and construction process, as well as existing neighbourhoods, which is especially useful for redeveloping urban areas or areas classified as historical

Source: (US Green Building Council , 2011)

5.4.3 Enterprise Green Communities (EGC)

EGC aims to promote the environmental and economic benefits of sustainable buildings within the housing sector in the United States. To encourage these practices in the sector, EGC developed its own rating system, tailored to its needs. The system gives significant weight to characteristics of the urban environment, and may be grouped into the following categories:

- Integral design: promotes the formation of interdisciplinary teams during the project design to ensure compliance with each requirement of the grading system
- Location: rewards the location of projects with nearby services, respecting environmental and protected areas, while providing access to pedestrian paths.
- Ground improvements: includes measures to reduce the environmental impact of the project in the ground (erosion and sedimentation control, identification of hazardous materials, efficient irrigation of common areas, landscaping with native species, low irrigation, etc.).
- Water Conservation: promoting water efficiency measures inside the dwelling and the common areas in the complex.
- Energy Efficiency: focuses on achieving the development's optimum energy performance.

- Green Materials: rewards the use of environmentally harmless materials and promotes waste reduction practices during the construction process.
- Healthy environment: includes measures of environmental quality within the dwelling to ensure adequate ventilation and prevent the presence of moisture.
- Operation and maintenance: provides education to the residents and managers of the development regarding efficient operation once construction is completed.

To receive certification, the developments must comply with mandatory measures in each category, while achieving a minimum score on the remaining optional measures, according to its nature (new dwelling or remodel).

Source: (Enterprise Communities Partners, Inc , 2011).

6
Conclusions

6. Conclusions

The analysis of the many evaluation systems around the world makes it possible to identify commons threads that become the basis when designing an energy and environmental efficiency evaluation system (EEEES) in Mexico.

The following table resumes the main characteristics shared by the many evaluation systems.

Table 14. Summary of the features of evaluation systems under analysis.

Type of Construction:	Generally, evaluation systems give priority to new dwellings. In some cases, like Germany's Energiepass, existing houses and remodels are also evaluated.
Performance:	Most of the reviewed systems calculate estimates for energy demand and potential primary consumption in housing, in relation to the design, the envelope's materials, and electric equipment, among others.
Enforcement:	There is no common pattern; certification may be required to obtain a construction license (especially in Europe), or voluntary. Voluntary evaluation systems usually have a wider array of factors for consideration.
Evaluated Elements (input):	Generally, many factors are considered. First, the energy demand is estimated from the envelope's characteristics; second, the energy consumption is estimated from lighting, heating, cooling, hot water, and proper use of household appliances and electronics. Estimations are adjusted to the source of energy used (gas, electric, solar, etc.). For water related issues, the elements taken into account are: the existence of [water] saving devices in showerheads, toilets, faucets; water saving household appliances like a washing machine and dishwasher. Outside the home, the elements considered include water meters, water re-use irrigation system for gardens. On another level, possible savings may come from reutilizing residual water and rainfall inside and out of dwellings.
Methodology:	Spreadsheets or specialized software is used in estimating the demand and energy consumption with regards to the characteristics specified in the dwelling's design. Some systems generate a score by granting additional points with regards to the dwelling's features (check list), while others generate an estimate of energy demands or CO_2 emissions.
Scale:	Most of the systems reviewed generate a scale (letters, stars, categories, etc.) that easily communicate the level of the house's energy efficiency. The base line of these scales is usually defined by the minimal conditions as indicated by current regulations.
Process:	The many systems carry out a pre-estimate or pre-evaluation of the dwelling's energy efficiency from the design. During the building process, verification is carried out to ensure compliance with the project's specifications. A definite grade or certification is given when the project is completed.
Measuring System	Spreadsheet or other specialized software.
Execution:	Generally, estimates of energy demand are made by an energy advisor certified by the government or an independent organization. Builders/developers are responsible of the information recorded for receiving certification.
Information (output):	Some results generated by the systems are: estimated energy demand, primary energy consumption, CO_2 emissions, usage of renewable energy, and potential demand by making modifications to design or adopting more efficient technologies.

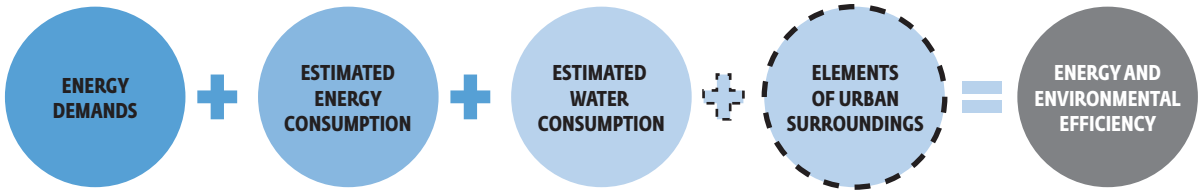
7

Recommendations for creating the Energy and Environmental Efficiency Evaluation System in Mexico

7. Recommendations for creating the Energy and Environmental Efficiency Evaluation System in Mexico.

This literature review provides important lessons that may be considered in the creation of the evaluation system. In accordance to international experience, and in harmony with the results of the "Green Mortgage Workshop for Housing Energy and Environmental Evaluation System" (GIZ-INFONAVIT, 2011) the following diagram is offered to summarily explain the main components an evaluation system should rely upon for its energy and environmental criteria.

Figure 3. Key Components of an energy and environmental certification system.



Source: Compiled by the authors.

7.1 Elements to include in the EEEES

The energy demand refers to a dwelling's needs in terms of cooling or heating with relation to its envelope's features (materials in roofs, walls, windows, etc.) Through thermal design, it is possible to guarantee an acceptable level of comfort for the dwelling's interior, therefore reducing costs associated to cooling and heating to a minimum. The characteristics of the materials in the envelope are of paramount importance in a dwelling's energy efficiency, making it a key element when designing a HCS.

With regards to the energy consumption estimate, certification systems consider an efficient set of household appliances and water heating systems. Currently, in Mexico there is an offer of efficient household appliances available to consumers. However, it is necessary to take into account the income restrictions on a large segment of the population when acquiring this type of appliances. The situation has a direct impact as increased energy consumption among families with lower incomes. Facing this scenario, the HCS should consider those appliances available in Mexican households, regardless of efficiency, and the real (or approximate) energy consumption practices gathered at The National Institute of Statistic and Geography (INEGI) and other sources.

The estimated water consumption is greatly determined by the occupants of the household. Certification systems take notice of the measures introduced to curb the resource's consumption inside the household through water-saving devices (faucets, valves, showerheads, toilets, etc.) and outside of it (irrigation system, swimming pool, water treatment system, recovery and re-usage on the housing complex). As with the approximations to energy consumption, the HCS should

determine the optimal water usage levels according to the patterns of consumption registered in the many Mexican bioclimates with information provided by CONAGUA and other sources.

In a second phase, the HCS should add to its evaluation elements sustainable components for housing complexes and urban surroundings, such as water treatment, recovery and reuse systems, availability of public transport, and distance to services (schools, shops, hospitals, etc.); "green" transport, and handling of solid waste, among others. The integration of these elements is complex but fundamental for developing a system that aids in decreasing the environmental impact of housing while promoting sustainable housing complexes in environmental, social and economic terms.

7.2 Labelling of the EEEES

This analysis also identified the relevant information elements that should be included in the labelling of the HCS, making it the most important information for the market, whether it is the developer, the authorities or the buyer. The relevant information to be included in the labelling should showcase the following:

- Levels of energy demand and consumption measured in kWh/m2*a.
- Water consumption levels.
- Estimated CO2 emissions.
- Percentage of energy provided from renewable sources.
- Percentage of water provided from re-usage of residual water or rainfall.
- Days of the year the dwelling will face interior overheating.
- Estimated economic savings.
- Potential levels of demand and consumption for energy and water, with additional` efficiency measures (energy and water).
- Other.

7.3 Creation of the ranking system for the EEEES

Another lesson from reviewing international cases is the importance of having, with regards to communication with the developer and buyers, a ranking that allows for easy identification of energy and environmental efficiency in dwellings. The definition of the scale for the Mexican scenario should consider the following:

- Adapting to the diverse bioclimates, which have an impact in energy demands for cooling and heating, and therefore, the conditions for the envelope's compliance.
- Consider the differences between housing types: single-family, semi-detached, vertical.
- Recognize the current state of Mexican housing, in terms of energy and environmental efficiency to create a baseline from its diagnosis.
- Adjust to requirements established in existing regulations.

7.4 Implementation and process of the EEEES

Apart from the analyzed features, the experience in implementation and process of the certification systems provides important lesions to be duplicated or adapted to the Mexican scenario, with the intervention of the proper institutions. Generally, we observe that the certification procedure must begin at the design phase of the dwelling or housing complex, to provide an opportunity to builders to optimize the estimated energy demand during design. Also needed is the existence of a strict process of verification during construction and when works are finished to verify compliance with the conditions set forth in the design. In most of the analyzed cases this process is achieved with the support of external advisors in matters of energy and environmental efficiency in dwellings.

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Annex 1. Summary of Energy and Environmental Efficiency Certification Systems

Name of Certification	Country	Enforcement	Elements Evaluated	Methodology	Ranking	Instruments	Process	Information	Responsible	Dwellings Considered
Dwelling Energy Performance Certificate	Chile	Voluntary, there are minimal mandatory regulations for the envelope's compliance.	Estimates energy demands for heating, cooling and lighting: Material nature of the exterior walls, roof, windows orientation and other architectural features that affect its energy performance, Efficiency of household appliances, Types of fuel used in housing, Overheating, Renewable energy Contributions. CO_2 emissions.	In a comparison against a reference dwelling: Baseline is set estimating energy demand by type of dwelling and bioclimatic zone. A scale is created from maximum, optimum and minimum consumption levels recommended for each bioclimatic zone.	6 categories (A-G) where A is maximum efficiency possible and F is for homes meeting the minimum standards required.	Software, inspection visits.	Pre-certification of plans and specifications, valid for 2 years. Certification after inspection & verification visits of the finished home.	Separately informs in the envelope's energy efficiency + appliances + type of energy. Itemized efficiency reports.	Energy certifier, project manager.	New dwellings, eventually to include existing ones
Minimal regulations of energy efficiency: Model Energy Code (MEC), International Energy Conservation Code (IECC), International Residential Code (IRC)	United States	Mandatory	Envelope design: roofing, walls, floors, windows, foundation, heating and A/C equipment, and lighting. Solar gains quotients.	The regulation and methodology depends on each state in the country. In California, it established a total maximum energy demand for each bioclimatic zone (16 in the state).		Software	In California, the project manager must assess and ensure compliance with the provisions of the code. With the submission of the project a building permit is issued. The local authority monitors compliance. It performs verification visits on the finished project.		Certifier approved by authorized institutions.	New and existing
LEED for Homes	United States	Voluntary	Evaluates 35 measures in the following categories: Location, Land Sustainability Water and energy consumption, Building materials, Level of comfort Awareness and environmental education, Innovation in design.	Each category measures with assigned scores. They include: Requirements (0 points). Good practices (1 point). Best practices (2 points).	Top score: 136 points for levels: 1. Certificate 2. Silver 3. Gold 4. Platinum	Inspection visits	The project is inspected during and after the construction. Paperwork is filed with the project's features and other compliance measures to determine the final score.	Provides information on the project's design and makes recommendations to improve its efficiency.	LEED approved certifier	New
Energy Star	United States	Voluntary	Effective insulation, High efficiency windows, Insulating materials, Efficiency in A/C equipment and lighting.	Statistical comparison of energy consumption in existing buildings with the same features of the project to be evaluated.	Top score: 100 points. Certification is granted at 75 points and up.	Software and inspection visits.	Requires a database with historical data on energy consumption figures for the project to be evaluated. An efficiency index is created based on this information and is corroborated by field visits.	Reports on the type of building, year of construction, square footage, number of workers, weekly operation hours, summary of energy consumption.	Evaluators	Existing and operating

Name of Certification	Country	Enforcement	Elements Evaluated	Methodology	Ranking	Instruments	Process	Information	Responsible	Dwellings Considered
Energiepass: Certificate of Demand: Design and construction	Germany	Mandatory: Required for construction EnEv Regulations.	Includes: "theoretical primary energy annual demand" = demand of heating, thermal appliance efficiency, type of energy. Type of fuel. Efficiency of employed technologies. Envelope heat losses. Heat losses due to ventilation. Solar and inner charge gains. Thermal bridges. Renewable energy sources.	Comparisons between estimated demand in design and defined limit values, for a building of the same class. Demand should fall below said values. Demand is calculated from requirements for heating and hot water, taking into account performance factors of the equipment used. Considerations made for the type of building, construction system, the number of floors and the useful area.	Semaphore, range: 0- 400 KWh/(m2-a) With 7 levels of reference.	Software	Estimations are made based on the design, as a building requirement. A comparison is later made to verify that the building's features match the design.	Indicators:: Final energy demand and primary energy demand. Estimated CO_2 emissions. Itemized demands for heating, hot water, auxiliary equipment. Comparison with other types of housing, new and existing.	Architect or energy advisor.	New and existing
Certificate of Consumption	Germany			Field visits to record the dwelling's energy consumption.		Field Visits				Existing
The Technical Building Code (CTE), with five technical requirements.	Spain	Mandatory (the code establishes minimum mandatory requirements for compliance)	Energy demands:: Envelope (according to bioclimatic zone). Efficiency of thermal installations. Efficiency of lighting installations. Minimum solar contribution to hot water. Minimum photovoltaic contributions to electricity (tertiary sector buildings only).	Self-referencing method, the score is obtained by comparing the theoretical energy consumption of the building to be certified against a reference building meeting the minimum standard required in five areas. Two rating systems: -Simplified option: mandatory and involves a simplified estimation of energy demand, only considering the envelope. - General option: optional computer-verified calculations, which includes energy, hot water heating and lighting.	Seven different levels: from A, the highest, to G, the lowest efficiency. Simplified option only issues D and E values. Computer option covers the entire range.	Simplified indirect calculations or software-based estimations.	The project's draughtsman evaluates and certifies that the design meets requirements. A project is drafted including energy details. The building department inspects during construction. A third party performs an inspection visit to the finished works. Effective for 10 years.	Energy Efficiency Certificate: Rating. Climatic zone. Estimated annual energy consumption. CO_2 emissions. Description of property's energy features.	Internal and external, computer calculations must be validated by a certified advisory committee.	New and existing.
Certificate of Energy Efficiency Part L1A, Conservation of Fuel and Power.	United Kingdom (England & Wales)	Mandatory for new housing. (Seller in charge of registration).	Estimates on emissions from heating, A/C, ventilation and interior lighting. Thermal insulation of the envelope. Ventilation & equipment. Heating efficiency and system control. Inner gains. Includes improvement factor: % savings from efficient technologies Type of fuel. Passive solar design: window size and positioning, solar protection, ventilation, water pumps.	From the design, estimations of emissions are made (Dwelling Emission Rate- DER), which must not surpass the emissions of the reference dwelling (Target Emission Rate- TER). The reference dwelling has the same shape, size and positioning. The estimation of demand adjusts to the type of technology and fuels used inside the dwelling.	100 point scale divided in 6 categories.	Software	Estimation on emissions based on the design is made by an energy assessor as a building requirement. Periodical inspections are made, and a second estimation is prepared in the post-construction stage. The built dwelling must be consistent with the architectural project (DER).	Cost of energy index. Environmental impact index. CO_2 emissions index. Efficiency potential and savings upon implementation of low-cost measures. Fuel energy costs. Recommendations for improving low and high-cost efficiency and savings potential of each measure.		Energy assessor or Home Inspector

Name of Certification	Country	Enforcement	Elements Evaluated	Methodology	Ranking	Instruments	Process	Information	Responsible	Dwellings Considered
Green Star	Australia	Voluntary	Management. Interior environmental quality. Energy Transport. Water. Materials. Land use and ecology Emissions. Innovation.	Each category presents compliance measures which are given a score. Every category represents a percentage of the maximum available score. The category's score is weighted by Green Star, to later calculate the final score, adding up all categories. These weighted amounts vary between states and territories to adapt them to local environment and climate conditions. Lastly, additional points are given for innovations.	Certification is issued starting at 45 points: 4 stars (45-59) 5 stars (60-74) 6 stars (75 points and up)	Inspection visits and calculations (spreadsheet)	Green Star provides guides and spreadsheets as preparation for the interested project's registry. Upon finishing said documentation, it must be reviewed by the evaluating committee in order to receive certification. In the event of certification not being granted, recommendations are made to apply in a second round.		Documents review by evaluating committee, including consultants approved by the Green Building Council Australia.	New, in building process
Green Rating for Integrated Habitat Assessment	India	Voluntary	Evaluates 34 areas under the following categories Land location and planning: Conservation and efficient use of natural resources. Health and safety measures for workers during construction. Construction process: Water and energy consumption efficiency. Waste management. Interior quality of life. Building maintenance. Innovation. From a total of 34 sections, 8 are mandatory requirements, the rest are optional.	Each category includes measures with an assigned score.	-1 star 50-60 points -2 stars 61-70 points -3 stars 71-80 points -4 stars 81-90 points -5 stars 91-100 points	Online forms and software.	Construction must be registered online by the interested party, providing all relevant information to find out its rating. Once the information is registered, it's reviewed by a specialist committee to determine the accuracy of the rating, issuing the certificate.		Each category requires each section to be evaluated by a different specialist (landscape architect, energy specialist, public health official, etc.)	Any type of new building.
EnerGuide	Canada	Voluntary	Envelope's features. Construction materials. Household appliance efficiency.	Upon registration of the dwelling's specifications, calculations are made of the energy demand of the project to be certified. From those calculations, the developer is presented with a plan to incorporate features to improve the dwelling's energy efficiency, including its cost analysis.	Scale of 0-100 points.	Software and inspection visits.	Blueprint and document registration of the project. Estimations of potential energy demands. Delivery of measures for improving energy efficiency. Final inspection upon construction completion.	Score, compared to the reference house. Calculation of energy consumption in the home for heating, lighting and appliances. Estimated consumption of electricity and gas. Recommendations for improving energy efficiency.	External, EnerGuide Certified.	New and existing.

Source: Compiled by the authors with information from (Sielfeld, 2010), (US Green Building Council , 2011), www.grihaindia.org, www.oee.nrcan.gc.ca.

Annex 2. Catalogue of Mexican Official Standards related to energy efficiency and water consumption

The Mexican Official Standards (NOM) are mandatory technical regulations that include the information, requirements, specifications, procedures and methodology that allow the many government agencies to set certifiable parameters in issues such as safety, health, energy efficiency, environmental protection, among others.

These Standards are created with the collaboration and agreement of technical committees for particular areas, and include government officials, researchers, academics and industry organizations. Before the enactment of a NOM, it must be approved by the National Consulting Committee.

Specifically, Mexican Official Standards in energy efficiency (NOM-ENER) regulate the energy consumption of appliances that, given their energy demands and the number of units needed in the country, offer savings potential whose cost-benefit relationship proves satisfactory for the country, productive sectors and consumers.

Energy:

NOM-008-ENER-2001 Energy efficiency in buildings, envelope of non residential buildings. This standard represents an effort geared towards improving the thermal design of buildings, looking to achieve comfort for its occupants with minimal energy consumption. In Mexico, the largest use of energy in buildings comes from air conditioning, during warm seasons, mainly in the northern and coastal areas of the country. The solar radiation gains are the most important source to control, which is achieved with an adequate envelope design.

This standard optimizes the design from the stand point of the thermal behaviour of the envelope, managing benefits such as energy savings by a reduction of cooling equipment capacities and increased comfort in occupants.

The units used in this standard belong to the General System of Measurement Units, the only legal and mandatory in Mexico (with some exceptions allowed in NOM-008-SCFI)

NOM-009-ENER-1995 Energy efficiency in industrial thermal insulation.
This standard has the purpose of regulating energy losses, by dissipation into the environment in systems operating at high temperatures, as well as heat gains in low temperature systems through the use of thermal insulation, in industrial facilities. As a complement, it also provides the general guidelines for the selection, design, specification, installation and inspection of thermo-insulation systems.

NOM-001-ENER-2000. Energy efficiency of vertical centrifugal pumps with external vertical electric motor. Limits and test method.

The purpose of this standard is setting the minimum energy efficiency of vertical centrifugal pumps with external vertical electric motors being commercialized in Mexico, and to establish the test method to verify such compliance; this, in order to save energy and contribute to the conservation of the nation's energy resources and ecology, and to protect consumers from lesser quality products and excessive energy consumption.

NOM-020-ENER-2011 Energy efficiency in buildings: Envelope of residential buildings. This Mexican Official Standard limits heat gains in residential buildings through its envelope, with the goal of rationing energy usage in cooling systems.

It represents an effort geared towards improving thermal design in buildings and achieving the comfort of the occupants at minimum energy consumption. In Mexico, the thermal retrofitting of these buildings has a significant impact in the peak demands of the electricity network, with the biggest impact happening in the northern and coastal areas of the country, where air conditioning is more common than heating.

In this sense, this standard optimizes the design from the standpoint of the building's thermal behaviour, generating benefits such as energy savings by decreasing the capacity of air conditioning equipment.

The units used in this standard belong to the General System of Measurement Units, the only legal and mandatory in Mexico, with some exceptions allowed in standard NOM-008-SCFI-2002.

NOM-003-ENER-2011. Thermal efficiency of water heaters for residential and commercial use. Limits, test methods and labelling.

It establishes the minimal levels of thermal efficiency for residential and commercial water heaters, and the testing method to be applied for verification, it sets the minimal requirements of information for the general public on the thermal efficiency values for said devices, in order to increase energy savings and conservation of energy resources; apart from protecting the consumer from lesser quality appliances that may enter the national market.

This Mexican Official Standard is applied to residential and commercial water heaters commercialized in Mexico, which use liquefied petroleum gas (LPG) or natural gas as combustible and solely delivering hot liquid water.

NOM-004-ENER-2008. Energy Efficiency of Clean Water Pumps and Motor Pumps with a Power Rating of 0.187 kW to 0.746 kW, Limits, test methods and labelling.

This standard functions in defining the way energy efficiency is determined and expressed, easing the user's decision making, and avoiding the commercialization of inefficient pumps and motor pumps for residential water pumping with a power rating of 0.187 kW to 0.746 kW,

promoting a rational use of the nation's non-renewable energy resources.

It sets out the minimum levels of energy efficiency that must be met by residential water pumps, and the maximum levels of energy consumption in motor pumps, using single-phase squirrel-cage induction motors; it also establishes the test methods to verify such compliance, as well as public information requirements to be included in labels.

NOM-005-ENER-2010 Energy efficiency of household washing machines. Limits, test methods and labelling.

The purpose of this Mexican Official Standard is to establish the energy factor level (EF) that household washing machines shall meet. It also establishes the test methods to verify such compliance, and labelling [requirements]. It looks to represent the new technological reality of these appliances and therefore aid in the conservation of the country's natural resources.

* Energy Factor: is the measure of the total amount of energy consumed by a washing machine; expressed as: the relation of the volume of the clothes drum, divided by the sum of the total energy consumption, the external energy used in producing hot water and the energy used in humidity extraction.

NOM-006-ENER-1995 Electro mechanic energy efficiency in deep well water pumping systems. Limits and test method.

It establishes the energy efficiency values for deep well water pumping systems operating in site, and the test method to verify such compliance.

This applies to vertical centrifugal pump and electric motor (external or submersible) used in deep well water pumping, with power output from 5.5 to 261 kW (7.5 to 350 HP).

NOM-007-ENER-2004 Energy efficiency for lighting systems in non residential buildings

This standard looks to establish energy efficiency levels in terms of Densities of Electric Power for Lighting for the compliance of lighting systems in new non-residential buildings, expansions and modifications of existing ones with the purpose of building towards an efficient use of energy with the optimization of design and the usage of equipment and technology that increase energy efficiency while respecting required illumination levels. Within the standard, there is a method for calculating DEPL.

The standard applies to indoor and outdoor lighting systems for new non-residential buildings with a total load for lighting of >= 3 kW; which may be included in the following categories:

a) Offices, b) Schools, c) Commercial establishments, d) Hospitals, e) Hotels, f) Restaurants, g) Warehouses, h) Recreation and Culture, i) Service workshops, j) Passenger terminals.

NOM-010-ENER-2004 Energy Efficiency of Submersible Deep Well Motor Pumps. Limits and test methods.

It sets the minimum values of energy efficiency to be met by Submersible Deep Well Motor Pumps and establishes the test method to verify such compliance in laboratories. It only applies to submersible deep well type water motor pumps operated by a submersible three-phase electric motor sold in Mexico; the standard does not apply to sewage and mud pumps.

NOM-011-ENER-2006 Energy Efficiency in Central, Package and Split Type Air Conditioners: Limits Test Methods and labelling.

The standard establishes the minimum level of the Seasonal Energy Efficiency Ratio (SEER) for the compliance of central type air conditioners; it also specifies the test methods to be used in verifying such compliance and defines the requirements to include in the public information label.

It answers to the need of increasing energy savings and the conservation of energy resources; it also protects the consumer from lesser quality and higher energy consumption products that may enter the national markets.

NOM-013-ENER-2004. Energy efficiency for lighting systems in public ways and outdoor areas.

It sets out energy efficiency levels in terms of the highest values for Densities of Electric Power for Lighting for the compliance of new public lighting and public outdoor areas in the different applications indicated by the standard, for them to be designed and constructed under energy efficiency criteria, and by optimizing the design and the usage of technologies and equipment that increase efficiency while complying with legal requirements. It covers all new lighting systems for roadways, open and closed public car parks, and open air public areas.

NOM-015-ENER-2002 Energy Efficiency of Household Refrigerators and Freezers. Limits, Test Methods and Labelling

It updates the maximum energy consumption limits for household refrigerators, refrigerators-freezers and freezers as a result of technological advances and conditions of both national and international markets. The standard also allows, apart from promoting energy savings, to contribute to the conservation of the nation's non-renewable natural resources.

The present Mexican Official Standard sets the maximum energy consumption limits for household refrigerators, refrigerator-freezers and freezers using hermetic motor-driven compressors; establishes the testing methods to determine energy consumption and calculations of total refrigerated volume, and defines the mandatory energy label and its contents.

It applies to household refrigerators, refrigerator-freezers up to 1,104 dm3 (39 cu ft) and freezers up to 850 dm3 (30 cu ft) using hermetic motor-driven compressors sold in Mexico.

NOM-016-ENER-2010 Energy efficiency of three-phase squirrel cage induction AC motors with a rated output of 0.746 kW to 373 kW. Limits, test method and markings.

This standard establishes the values for nominal efficiency and its minimum associated, the testing method, the acceptance criteria and minimum information specifications in the markings of three-phase squirrel cage induction AC motors with a rated output of 0.746 kW to 373 kW, open or closed, with a rated voltage up to 600 V being sold in Mexico. This is the result of technological advances and conditions of both national and international markets. The standard also allows, apart from promoting energy savings, to contribute to the conservation of the nation's non-renewable natural resources.

This Mexican Official Standard applies to three-phase squirrel cage induction AC motors with a rated output of 0.746 kW to 373 kW, open or closed, with a rated voltage up to 600 V, with single rotation frequency, in horizontal or vertical position.

NOM-017-ENER/SCFI-2008 Energy efficiency and safety requirements of compact self-ballasted fluorescent lamps. Limits and test methods.

This Mexican Official Standard establishes the minimum efficiency limits for all self-ballasted compact fluorescent lamps, the user safety specifications and the test methods applicable to verify compliance. It also lists the type of information included in these products as they are sold within the Mexican territory, while also catering to the need of said products to promote efficient usage and energy savings.

NOM-018-ENER-1997 Thermal insulation for buildings. Characteristics, limits, test methods.

This official standard establishes the characteristics and test methods for compliance of all materials, products, components and thermo-insulating elements, for roofs, ceilings and walls in buildings.

NOM-019-ENER-2009 Thermal and electric efficiency of Mechanized tortilla-making machines. Limits, test method and markings.

It establishes the maximum amounts of electricity and liquefied petroleum gas (LPG) or natural gas, and the test method to use in verifying its compliance; as well as the cooking times, the kilograms of tortillas per hour and the requisites for markings in Mechanized tortilla-making machines used in manufacturing corn and wheat flour tortillas; excluding manual and domestic tortilla-making machines that do not require electrical motors to operate.

NOM-021-ENER/SCFI-2008 Energy Efficiency of and User Safety Requirements for Room Air-conditioners, Limits, Test Methods and Labelling

The standard establishes the update of the testing method and the values of the Energy Ef-

ficiency Ratio (EER) for room air-conditioners, as a result of the technological advances and the current conditions of both the national and international markets.

This Mexican Official Standard also incorporates user safety requirements; which added to energy efficiency, allows for the protection and promotion of environmental improvements, and the conservation of natural resources.

The standard establishes the specifications and testing methods of the Energy Efficiency Ratio (EER) for room air-conditioners, the user safety requirements and the testing methods to verify such compliance. It also sets out the information to be included in the Energy Efficiency label that accompanies markings in all appliances subject to the standard and that are sold in Mexican territory.

NOM-023-ENER-2010 Energy efficiency in split type, free flow, ductless air conditioners: Limits, test methods and labelling.

The standard sets out the minimum Energy Efficiency Ratio (EER) for compliance of to split type air conditioners, free discharge and without air ducts (known as minisplit and multisplit) simple cycle (cold) or reverse cycle (heat pump) with air-cooled condensers.

It also establishes the test method that must be applied to verify compliance and defines the public information requirements for labelling.

NOM-028-ENER-2010 Energy efficiency for general use lamps. Limits and test methods.

The standard establishes minimum limits of efficacy for all purpose lamps destined for lighting residential, commercial, services, industrial sectors and public lighting, as well as their test methods.

Water:

NOM-009-CNA-2001. Toilets for sanitary use – Specifications and testing methods

The standard sets out the specifications and test methods toilets must meet, with the goal of saving water during usage and hydraulic operation.

Currently, the growing demand of hydraulic resources has provoked the deterioration of supply sources, impacting water availability and made worse by leaks, operation and maintenance deficiencies; and due to the indiscriminate use of the resources in homes, offices, commercial spaces and industry.

Research shows that squandering in toilets and restrooms is significant, with the largest portion going to household toilets. Therefore, since 1986, and with the agreement of the Federal Government and the toilet industry, the Mexican Official Standard has been applied as 6 litres of water used per flush, becoming one of the most adequate tools in guaranteeing the rational use of the resource, decreasing waste.

NOM-008-CNA-1998 Showerheads used in personal hygiene: Specifications and testing methods.

This Mexican Official Standard establishes the specifications and test methods to be fulfilled by showerheads employed in personal hygiene, to ensure water conservation. To preserve the country's water resources, is necessary to continue the efforts to foster the efficient use of drinking water for human consumption, which will maintain and increase the supply of this vital resource to the nation's population.

To achieve the rational use of water, it becomes necessary and indispensable to regulate domestic consumption with water saving devices, also known as low consumption devices. The national market has different types of showerheads for personal use of local and foreign manufacturing, which require large amounts of water for its proper operation, making it necessary to regulate its output, avoiding unnecessary water waste, without impacting user comfort.

NMX C415 ONNCE 1999 Construction: Valves for household water use; specifications and test methods.

Domestic valves that allow water flows. The standard is applicable to valves in hydraulic installations used in washbasins, sinks and laundries for embedding, pass and retention; manufactured nationally or imported and commercialized in the country.

NOM-230-SSA1-2002 Environmental health. Water for human use and consumption: Sanitary requirements, which must be met by public and private supply systems during handling of water; sanitary sampling procedures.

This Mexican Official Standard establishes sanitary requirements for compliance by public and private supply systems during handling of water, to preserve water quality for human use and consumption; as well as sanitation procedures for sampling. It is mandatory throughout the country and is applicable to all operating organizations of public and private water systems, or any person or business handling water for human use and consumption.

Monitoring the quality of water is paramount to reducing the risks of transmission of diseases to the population due to its consumption, such as gastrointestinal diseases and those arising from toxic contaminants. Monitoring is carried out through enforcing permissible limits for water quality and also, by inspecting that characteristics of all constructions, installations and equipment used in hydraulic works of collection, chlorination, purification, storage or regulation tanks, distribution lines and networks, tanks in vehicles for transport in distribution, and water intakes, protect water from contamination. The results of the inspection of the abovementioned elements are compared against the conditions in supply systems, also with minimal sanitary requirements for preserving water quality. For new works, choosing

the location and its protection are of vital importance for the supply of safe water. Protecting water from contamination will always be preferable to treating it once it's contaminated.