SUPPORTED NAMA FOR SUSTAINABLE HOUSING RETROFIT IN MEXICO

EXISTING HOUSING

NAMA

MITIGATION ACTIONS AND FINANCING PACKAGING

NAMA
de vivienda
existente

SEDATU
SECRETARÍA DE DESARROLLO AGRARIO, TERRITORIAL Y URBANO

ESTADOS UNIDOS MEXICANOS

CONAVI
COMISIÓN NACIONAL DE VIVIENDA

cooperación alemana
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On behalf of:

Department of Energy & Climate Change

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ÍNDICE

Supported NAMA for sustainable housing retrofit in Mexico – Mitigation actions and financing packages–

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EXECUTIVE SUMMARY

In accordance to Mexico's Special Programme on Climate Change 2009-2012 (PECC), Mexico has established as a voluntary goal to achieve Greenhouse gas (GHG) emissions reductions of 30% for 2020 and 50% for 2050 with respect to year 2000. This goal has been included in the General Law on Climate Change (LGCC) of June 2012 and confirmed by the new government in Mexico´s strategy on Climate Change (ENCC) of June 2013. One way to meet this goal is through Nationally Appropriate Mitigation Actions or NAMAs implementation.

Nationally Appropriate Mitigation Actions (NAMA) are emerging market mechanisms used for greenhouse gas (GHG) emissions reduction. They are implemented by developing countries under the "context of sustainable development supported and enabled by technology, financing and capacity building in a measurable, reportable and verifiable manners" [TdR 2013].

After the successful implementation of the NAMA programme for sustainable new Housing (NAMA VN, see [CONAVI 2011] and [CONAVI 2013]), NAMA for Sustainable Housing Retrofit (NAMA VE) has been developed. Its objective is to mitigate GHG emissions in the sector of existing homes by providing supplemental finance to improve energy efficiency through deployment of eco-technologies, proliferation of design improvements and the use of efficient building materials.
In the last years Mexico has taken important steps on sustainable development progress in the housing sector through technical capacity building, development of pilot projects in different energy efficiency levels, coordinating the key stakeholders in the Multilateral Committee on Sustainable Housing in Mexico (Mesa Transversal) and with the development of a tool adapted to the Mexican market to asses whole house approach.

This reflects that Mexico promotes sustainable housing[1]. NAMA VE described in this document along with previous NAMA VN, are essential elements for the environmental strategy of Mexico´s government to homologate and align the different programmes, activities and efforts of main stake-holders to contribute to mitigation and transform housing sector towards an improved sustainability.

All of these activities have the major objective to accomplish established goals in the National Development Plan 2013-2018:

- **"Mexico as a Prosperous country" to generate an environment that encourages country productivity growth and economic confidence.**
- **"Mexico as a country with Global Responsibility" to promote Mexican culture internationally, expand its commerce and defend its interests.**

In addition, the National Programme for Urban Development 2014-2018[2] and the National Housing Programme lines of work look for actions to ensure decent housing for all Mexicans among a sustainable urban environment. This includes promoting Nationally Appropriate Mitigation Actions (NAMAs) regarding urban development and housing.

[1] www.conavi.gob.mx

[2] Within the National Programme for Urban Development (PNDU) 2014-2018, NAMA implementation is pointed out as a strategy. Strategy 2.5, Line of Action 3: "To promote Nationally Appropriate Country Mitigation Actions (NAMAs) accordingly regarding urban development and housing."

What is Mexican NAMA for Sustainable Housing Retrofit?

Mexico has already taken unilateral action in the existing housing sector through programmes such as 'Ampliación y/o Mejoramiento de vivienda' ('Housing expansion and/or improvement') (CONAVI) and 'Mejoravit' (INFONAVIT). Both programmes provide supplemental finance or subsidies to cover the incremental cost for different improvement measures to the existing housing. However, housing improvement programmes are currently directed to solve urgent housing problems rather than focusing on environmental sustainability as well as a more dissemination among home-owners.

NAMA VE is aimed to extend and expand the scope of these programmes, increasing the overall number of existing energy efficient homes, thus contributing to GHG emission reduction while increasing their comfort. With this purpose, Mexico along with international and domestic cooperation stakeholders[3] has developed the process to follow on energy efficiency in the existing social housing type in Mexico and for which home-owners may receive support. This process intends to achieve optimal energy efficiency levels through a flexible range of interventions through a "step by step" refurbishment plan to achieve the energy and environmental performance standard desired, with high quality energy efficiency components defined by the EnerPHit for most common climates in Mexico, as this standard criteria establishes.

This standard was developed by Passivhaus Institut under an international application scheme for energy efficiency refurbishments. It is based on improvement actions that should be implemented on housing over their lifecycle and should be carried out on any construction for maintenance purposes (for example, exterior painting, window changing, etc.). The idea is to take advantage of this situation by optimizing these inevitable actions with energy efficiency measures, ensuring comfort and excellent indoor air quality while avoiding structural damage to the construction. The EnerPHit Standard[4] – hereafter referred to as "Step by step refurbishment to achieve optimal energy and environmental

[3] The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (German Development Cooperation) has supported the development of this NAMA VE on behalf of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). BID, CTF, KfW, Environment Canada, United Kingdom, and numerous development banks have also provided technical and financial support.

[4] The EnerPHit standard calculated in Step 3 of every example establishes target values for building heating, cooling and primary energy according to its climate zone. If heating and/or cooling target value may not be reached due to difficulties concerning refurbishment, characteristic values are determined for building components based on quality needed to achieve Passivhaus standard in each climate, considering profitability aspects as well. For more information see [PHI 2014]. EnerPHit refurbishment may be carried out all at once or step by step.

performance" – is not a trademark but a valuable concept that is intended to be applied as a basis for NAMA VE calculations.

Considering that not all building elements need improvements or replacements at the same time, it is essential to consider all steps in the refurbishment process to ensure the optimal building improvement. This improvement may be either complete (all at once) or step by step (partial improvements, as required and according to construction components lifecycle). NAMA VE refurbishment process starts with the current existing building assessment, detailing one or two intermediate steps according to climate zone (Step 1 and Step 2), until complete refurbishment achieves the energy efficiency level previously defined.

NAMA VE efficiency levels are translated to the Mexican Green Housing Evaluation System for Energy and Water Performance SISEVIVE-ECOCASA, based on the levels defined by the Global Performance Index (IDG). The development of the SISEVIVE-ECOCASA system, including the adaptation of its tools to assess existing housing in Mexico, will enable to inform home-owners and householders about expected efficiency regarding energy and water use in a clear way.

Refurbishment measures to be carried out over time, should be captured in a "Master Plan" drafted by an Energy Advisor. This "Master Plan" contains the energy refurbishment actions to be followed along the useful life of the building, to achieve planned objectives on a timely and profitable basis.

At the same time, Energy Advisors should be coordinated by an Auditor Advisor who plans the application of certain general measures in packages for housing groups with similar features to facilitate financing. This energy advisor scheme should be a mandatory condition for financing to

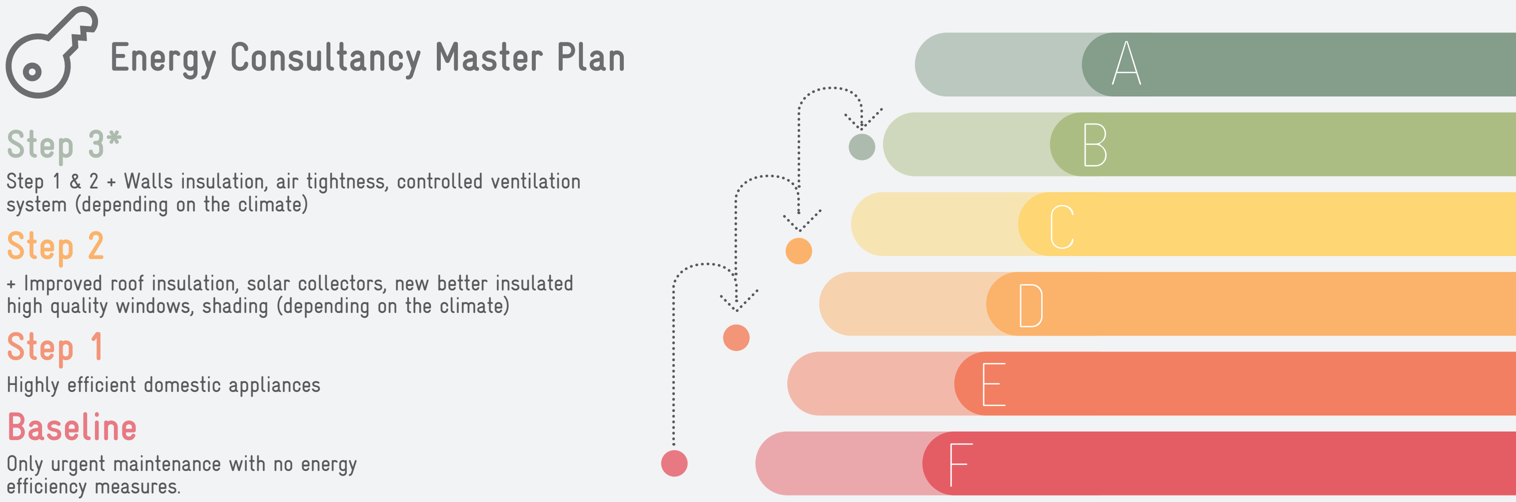


Figure 1: Technical Design for NAMA for Sustainable Housing Retrofit: Step by step refurbishment to achieve optimal energy and environmental performance, summary of examples calculated (Source: Passivhaus Institut).

* Technical Design for NAMA for Sustainable Housing Retrofit: Step by step refurbishment to achieve optimal energy and environmental performance

guarantee that measures proposed will generate expected savings and to ensure the home-owner will take appropriate decisions, supported by a team of experts. This also ensures that investment resources on energy efficiency will be applied for adequate and necessary measures. The verification through a neutral institution is proposed to confirm the overall process quality, from the energy consultancy to the application of the measures.

Unlike the previous Mexican programmes, which have focused on promoting and measuring the impact of specific eco-technologies, the NAMA VE, as the NAMA VN, address building efficiency from a 'whole house approach' concept, which considers all factors that affect energy demand of a building and their interaction during its lifecycle. From this perspective, minimal efficiency benchmarks to be reached are set, translated into GHG emissions reduction. These values are based on building type and climate zone. Building developers and home-owners are then able to employ any combination of interventions that achieve the targeted efficiency level, always following their household "Master Plan".

By developing the Master Plan with such a housing approach, numerous benefits are obtained. It enables a simple and cost-efficient MRV system that captures the net efficiency improvements of a broad range of eco-technologies, building design, and building materials. It also enables stakeholders to find the most cost-efficient combination of these features and obtain implementation support. Furthermore, the tiered benchmark approach, meaning the "step by step" model as shown in Figure 1, provides flexibility for regulators to increase the stringency of the programme over time and enables donors to target specific activities aligned with their development priorities. It is important to mention that all these steps for any building type at any climate zone represent a significant improvement on GHG mitigation of at least 20% or more, compared to the baseline (when referring to Step 1), or compared to its previous corresponding steps (when referring to Step 2 and 3), with the same comfort level. These are target values established to receive subsidies for financial burdens relief.

NAMA VE MITIGATION POTENTIAL

Taking into account demographic growth rates, Mexico is expected to have an estimated 150 million inhabitants by 2050 [CONAPO 2014]. Due to long life-cycle of buildings and in order to achieve significant GHG emissions reductions to meet the ambitious goals set, it is necessary to focus not only in new residential buildings, but also to improve construction and energy quality of the existing housing. This turns really important when considering that by 2030 a third of the existing buildings in Mexico will require partial or total refurbishment [CONAVI, 2010]. Therefore, investments made now in sustainable development will pay dividends for decades to come, from an economic, environmental and social perspective.

SIZE OF THE OPPORTUNITY

Housing sector in Mexico represents a great opportunity for energy savings and GHG mitigation actions as it represents 32% of emissions associated to energy consumption in the country [INE, 2006] and 16.2% of final energy consumption [SENER, 2012], as well as 26% of final electricity consumption [SENER, 2012]. This sector is represented by approximately 28 million of inhabited dwellings and additionally 4.6 million of empty dwellings [INEGI 2010]. It is expected that by 2030, 11 million of new dwellings will be built and 9 million will require partial or total refurbishment [SEMARNAT/GIZ, 2011]. In other words, by 2030 there will be 39% more dwellings and 32% of the existing dwellings will already be refurbished or renewed in some way.

NAMA VE PROGRAMME MITIGATION POTENTIAL

In NAMA VE, the difference between "reduction potential" and "mitigation potential" regarding GHG emissions is that the first concept refers to the current conditions of existing social housing in Mexico, where low comfort conditions result in low energy consumption (see [CMM 2013]). Mitigation potential, where NAMA VE is focused on, is based on comfort increase over time, assuming that if energy efficiency measures are not established, Mexican families will gradually increase their comfort by an inefficient use of energy, therefore increasing GHG emissions.

Energy balance calculations for the "whole house approach" were estimated considering standard comfort conditions according to the International Standard [ISO 7730], with the help of the Passive House Planning Package (PHPP) and the DEEVi (Energy Efficient housing design) tools. Three representative examples of existing social housing most common building types in Mexico were analyzed Aislada (single isolated house unit), Adosada (row housing unit) and Vertical (multi-storey housing unit) based on different bioclimatic regions in Mexico. Likewise, various efficiency scenarios for each type of building and climatic region were developed, demonstrating emissions mitigation as shown in the table 1.

EXPECTED RESULTS AND NEXT STEPS

Current refurbishment housing programmes in Mexico support only a limited segment of the existing housing market, mostly not addressed to environmental sustainability improvements or the application of the whole house approach. The NAMA VE is a key instrument developed to scale up and expand existing initiatives.

In order to achieve the desired level of penetration and up-scaling, additional funds are needed beyond what the Mexican government can unilaterally provide. Carbon finance and international donors have a key role to play, and their involvement in the NAMA VE can be used to leverage Mexican public and private investment. Different options have been studied in how donors and interested investors can participate in this NAMA.

The value and potential of the NAMA VE concept can be demonstrated through the pilot projects. These projects offer the opportunity to governments and international donors to recognize the potential that the programme offers on GHG emissions reduction. They are considered data sources for politics and financing decision making. These pilots will also enable to collect empirical performance data that will be used to define benchmarks for calculation tools.

	Monterrey (Hot Dry)	Guadalajara (Temperate)	Ciudad de México (Temperate cold)	Mérida (Hot and humid)
"Aislada" Single-family unit detached house (40 m²)				
Step 1	4.2	0.4	0.8	6
Step 2	7.5	2.7	4.7	10.9
Step 3 (EnerPHit)	10.9	4	8.4	14.1
"Adosada" Single-family unit row housing unit (51,4 m²)				
Step 1	4.2	0.4	0.8	6
Step 2	7.5	2.7	4.7	10.9
Step 3*	10.9	4	8.4	14.1
"Vertical" Multi-storey housing units (40 m² per unit)				
Step 1	2.2	1.2	1.2	5.1
Step 2	3.1	1.6	1.3	6.7
Step 3*	5.2	2.2	4.2	9.4

* Step by step refurbishment to achieve optimal energy and environmental performance

Table 1. Annual mitigation emissions in a household by building type and climate zone, tCO_2e/a (Source: Passivhaus Institut).

FINANCING THE NAMA

For interested donors and investors in providing direct support for improvements focused on energy efficiency and sustainability on existing housing, a 'NAMA Fund' should be set up as the recipient of donor funds, whether as soft loans or as grants. Considering the first case, a financial entity with legal capacity should be involved. While this fund is implemented, donors can partner directly with CONAVI or any other financial entity in Mexico, such as Infonavit, SHF, among others. At the same time, these entities will decide the optimal resource allocation. Funding provided for the NAMA VE will be channeled primarily to the demand side (home-owners) and potentially to the supply side (building companies) of the housing market through financial entities. Beneficiaries will receive funding (either loans, subsidies or other financial instruments) in order to support them in any refurbishment or renewable phase.

Donors wishing to provide support to the NAMA can provide financing support, crucial for the Mexican government to finance investment measures, carry out administrative and supportive actions or promote bilateral cooperation initiatives. These actions include capacity building at a federal and local level, providing professional training services to Energy Advisors, Auditor Advisors, supervisors and verifiers and the establishment and maintenance of monitoring and reporting frameworks. As the examples of financing packages illustrate, donors will have significant flexibility to adjust the scale coverage (number of units) and the efficiency level (Step 1, Step 2 or Step 3).

Item	Description
Sector	Building sector
Subsector	Housing improvement: primarily for low-income families (social housing) and potentially to middle-income housing
NAMA VE boundary	Entire country
Measures and activities with direct impact on GHG emission reduction	Introduction of ambitious energy efficiency benchmarks to minimize primary energy consumption. Housing improvement according to the standard level is incentivized by a scaled-up financial promotion system (step by step) and is optimized by the introduction of a mandatory comprehensive energy consultancy to define the "Master Plan" since the beginning

Item	Description
Measures and activities with indirect impact on GHG emission reduction	Supportive actions for NAMA VE implementation, operation and support for a wider transformation process within the housing sector: introduction of energy performance requirements according to the legal system and license granting process, training and energy consultancy program establishment, development of pilot project models for each efficiency level proposed and the adaptation of calculation tools for energy consultancy and projects assessment
Co-benefits	**Economy** • Economic savings for households reflected in electricity, fuel and water bills • Reduction of energy subsidy costs to support NAMA VE measures funding • Increase in the number of green companies and jobs • Extended housing quality and lifecycle • Workers productivity increase due to improved comfort conditions **Enviroment** • Air quality • Water and energy savings **Social** • Leverage effect in comfort increase through the combination of NAMA VE measures with electrical and sanitation equipment refurbishment and/or dwelling expansion • Indoor housing comfort regarding temperature and humidity benchmarks. • Access and promotion of clean energy services • Human and institutional capacity building

Item	Description
Co-benefits	• Education and awarenes of sustainability for householders • Improvements on householders health through comfort and air quality improvements
NAMA VE timeframe	**Preparation (2014)** **First phase (2015 - 2016):** Structure preparation for large-scale implementation; advice from international experts **Second phase(2016 – 2020):** Large-scale implementation
NAMA VE roll-out schedules	**First phase (2015 - 2016):** Projects identification and advice from international experts in suitable areas of action. Prepare Master Plan and energy balance using PHPP international tool v.9. Structures preparation for large-scale implementation: Players development and training (including Energy Advisors), establishment of financial structures, DEEVi tool adaptation for existing housing refurbishment, refurbishment dissemination and promotion among users, development of financial entities. **Second phase (2016 – 2019):** Suitable energy efficiency improvements Implementation funded by international donors and Mexican government following the “Master Plan” according to characteristics and identified requirements by Energy Advisors through the DEEVi tool v.2. (Updated for existing housing refurbishment).

Item	Description
NAMA VE investment costs	400 Mio. USD.
NAMA VE operation costs (supportive measures and technical assistance)	12 Mio. USD.
NAMA VE type	NAMA VE framework consisting of unilateral and supported components
Type of support required under the NAMA VE	Financial, technical and capacity building

Table 2. Main elements of NAMA VE Sustainable Housing Retrofit Design (Source: Passivhaus Institut).

1 Introduction

Nationally Appropriate Mitigation Actions (NAMAs) are emerging market mechanisms that enable developing economies to align their sustainable development with their national economic and strategic priorities.

Mexico took the first steps towards a sustainable housing sector through programmes such as 'Hipoteca Verde' ('Green Mortgage') and 'Ésta es tu casa' ('this is your house'). Both programmes provide finance to cover the incremental cost of energy-efficient measures for new homes. Also loans and subsidy programmes have been developed for existing housing improvement, for example "Mejora tu Casa" and most recently "Mejoravit". However, these programmes do not have a strong direction towards environmental sustainability. Neither they have planning or follow up mechanisms to control the use of resources by home-owners or householders, especially regarding GHG emissions reduction. Besides, most programmes in the market provide funding for urgent improvements and not for energy efficiency measures.

An action presented as part of Mexico´s Special Programme for Climate Change (PECC) is precisely to reduce GHG emissions within the housing sector through NAMAs application, considering benefit-cost relationship of the measures during the lifecycle of a building. A first great achievement is the NAMA for New Residential Buildings (NAMA VN, see [CONAVI/GIZ 2011 AND 2013] presented in 2011 and currently in its implementation phase. NAMA VN has already achieved important steps as the development of pilot projects, technical capacity building and key stakeholders coordination. The result is a strong progress towards the NAMA for Existing House Retrofit (NAMA VE) implementation, as presented in the 18th United Nations Climate Change Conference (COP 18) in Doha, Qatar.

This document describes the proposal of a Supported NAMA for Existing Housing Retrofit in Mexico. The objective is to mitigate GHG emissions in the residential sector by providing supplemental finance to improve efficiency on electrical, water and gas consumption in existing housing. These improvements are achieved through the deployment of eco-technologies, household thermal envelope quality improvement, and the use of energy efficient building materials and equipment. Either "All at once" or "step by step" concepts may be selected for improvement actions, according to building requirements and available resources. To determine improvements, a whole house approach through a personalized energy consultancy is proposed.

The difference between "reduction potential" and "mitigation potential" regarding GHG emissions is that the first one refers to current conditions on existing social housing building type in Mexico, where low comfort conditions may cause also very low energy consumption (see [GIZ/CMM 2013]. On the other hand, "mitigation potential", where NAMA VE is focused on, is based on comfort increase over time, assuming that if energy efficiency measures are not established, Mexican families will gradually increase their comfort by an inefficient use of energy, therefore increasing GHG emissions. The NAMA is not only looking for current emissions reduction but also intends to avoid possible GHG emissions increase in the future.

In the following sections a description of the NAMA VE will be provided, including an overview of the Mexican existing housing sector and barriers to its implementation along with direct measures and recommendations to achieve it. At the same time, an analysis of the impact of such measures in the country emissions profile is presented, as well as a description of the MRV system and possible financing options to fund the proposed measures.

2 Overview of the Mexican existing housing sector

The action field of the NAMA VE is the existing housing sector in Mexico. To better understand the current situation of the sector, this section presents an overview and the relevance of its contribution to GHG emissions mitigation, including current public policy actions, main players, current financing schemes and prevailing international cooperation actions.

2.1 RELEVANCE OF THE SECTOR

Taking into account demographic growth rates, Mexico will have an estimated 150 million inhabitants by 2050 [CONAPO 2014]. At the same time, the country lives a continuous urban sprawl, so it is expected that cities populations grow from 71.6% in 2010 to 83.2% in 2030 [National Programme for Urban Development 2014-2018]. This growth anticipates a big challenge for both urbanization matters and housing provision.

Due to this increasing need of housing in urban areas, it is estimated that in average 600,000 houses will be constructed per year until 2020. It is expected that this housing will be for low-income families mostly. For the third decade of this century, Mexico will have nearly 40 million households [CONAVI 2013]. Additionally, the construction of all this households also represents a challenge from the point of view of energy efficiency and sustainability, as during the last decades mostly existing housing in the country has been built without considering these matters [see GIZ/CMM 2013] y [GIZ/Cruz Jiménez 2012]).

For this reason and within the context of controlling emissions growth and achieving country economic targets, the housing sector has been identified by the Mexican government as a key opportunity to address national growth and development needs in a sustainable and responsible manner, in order to meet the objectives of 30% GHG emissions reduction by 2020 and 50% by 2050 [LGCC, 2012]. The housing sector represents 32% of emissions associated to energy consumption in the country [INE, 2006] and 16.2% of final energy consumption, as well as 26% of final electricity consumption [SENER, 2012].

The extended housing lifecycle represents a high potential for GHG emissions mitigation within the sector. This emphasizes the importance to concentrate not only in households building, but also in existing housing improvements as a great potential to mitigate current and future emissions. In 2010 the housing stock in Mexico included almost 36 million dwellings. Approximately 28 million (80%) are inhabited while 6% are for temporal use and 14% represent empty dwellings [GIZ/Cruz Jiménez 2012, based on INEGI 2010]. It is expected that by 2030, one third of these units will require partial or total refurbishment [SEMARNAT/GIZ, 2011].

From this estimation, 90% are single units ("Aislada" or "Adosada") and the remaining 10% are dwellings within multi-storey housing units ("Vertical") [Cruz Jiménez 2012]. This is particularly real at the north side of the country and reflects a cultural preference in Mexico for single units. This also represents a great opportunity regarding GHG emissions mitigation, as this type of building is less efficient regarding energy consumption than multi-storey housing units.

2.2 MEXICAN HOUSING POLICY IN THE CONTEXT OF CURRENT CLIMATE CONDITIONS

The Mexican government has proposed the following action lines within its 2013-2018 National Development Plan:

- "Mexico as a Prosperous country" to generate an environment that encourages country productivity growth and economic confidence.
- "Mexico as a country with Global Responsibility" to foster Mexican culture internationally, expand its commerce and defend its interests

In 2013 the Mexican government established the SEDATU (Secretaría de Desarrollo Agrario, Territorial y Urbano – new Ministry of Agrarian, Territorial and Urban Development) in charge of agrarian and urban development affairs, as well as housing. The objective of this entity is to promote development and welfare for all Mexicans both in rural and urban areas, seeking for an "urban comprehensive and sustainable development model" [DOF 2013]. Considering the importance of the National Development Plan 2013-2018 action lines previously mentioned, as well as the 2014-2018 National Urban Development Programme (PNDU 2014-2018)[5] and the National Housing Programme 2014-2018 (PNV2014-2018), the basis for a sustainable housing consolidation in Mexico has been set up. Through the coordination between institutions, both the PNDU 2014-2018 and the PNV 2014-2018 will be implemented by the SEDATU through actions to provide Mexicans with decent housing in a sustainable urban environment, improving social conditions and focusing not only in housing aspects but also cities consolidation and the urban environment, intra-urban housing, transportation, redensification and verticality, as well as new measures including social benefits [SEDATU 2013].

Sustainability within the housing sector considering social, economical and environmental aspects is a clear priority for the Mexican government. The PNV 2014-2018 promotes the dissemination of eco-technologies besides the development and implementation of rules and regulations for criteria standardization in order to move forward to sustainable and high quality housing. It also promotes subsidies and green mortgages. However, the implementation of such sustainable measures should be focused on existing housing. The CONAVI (Comisión Nacional de Vivienda – National Housing Comission in Mexico) has started several pilot training programs designed to raise awareness regarding sustainable housing benefits and keeps implementing the housing policy under the SEDATU political terms.

[5] Within the National Programme for Urban Development (PNDU) 2014-2018, NAMA implementation is pointed out as a strategy. Strategy 2.5, Line of Action 3: "To promote Nationally Appropriate Country Mitigation Actions (NAMAs) accordingly regarding urban development and housing."

CLIMATE CHANGE POLICIES

As mentioned, Mexico has already taken actions to reduce greenhouse gas (GHG) emissions and to deal issues originated by climate change.

In 2010, Mexico presented a voluntary goal to reduce GHG emissions up to 30% by 2020 with respect to a common scenario and the commitment to complete the implementation of Mexico's Special Programme on Climate Change (PECC) adopted in 2009, which includes more than 100 activities nationwide to reduce GHG emissions. In addition, the recent approval of the General Law on Climate Change together with the National Strategy on Climate Change (ENCC) supports this engagement and promotes, among other activities the formulation, regulation, direction and instrumentation of guidelines for mitigation actions. The accomplishment of these actions will depend on financial and technological support that can be received from developed countries. This ambitious agenda will be achieved through improvements on energy efficiency, land use and renewable energy implementation within different economic sectors.

In Addition, the General Law on Climate Change established a legal framework for the transition to a competitive and sustainable economy with low carbon emissions, in order to generate environmental, social and economic benefits. The Law compels to establish a National Mitigation Policy on Climate Change to promote population health and safety by controlling and reducing emissions. It identifies reduction on energy demand, meaning energy efficiency, as a priority action line. It also foresees actions for settlements and urban areas, as well as the adaptation to the national environmental planning.

This Law establishes the creation of a Fund for Climate Change to collect and channel public and private resources with the purpose to support the implementation of actions to face the climate change. The Fund can receive contributions from national and international sources and can be capitalized by federal and public funds, foreign government contributions, donations, international ONGs as well as the value of emissions reduction generated within Mexico [LGCC 2014].

In addition, ENCC action lines demand to reconsider the current structure for electricity and water subsidies in all sectors. The idea is to incentivize energy efficiency and water consumption and to gradually adjust residential electricity and water tariffs, which currently have very high subsidies (see section 3). The objective is that tariffs reflect real market prices, even though compensatory measurements for more vulnerable groups should be considered. Another important action line is to promote new economic mechanisms to incentivize mitigation actions, such as NAMAs [SEMARNAT 2013].

This NAMA VE is presented in order to complement and align the PECC programme with the General Law on Climate Change. The Fund for Climate Change described within the General Law could be used to finance technology deployment and capacity building. Moreover, this NAMA VE implementation promotes key goals stipulated within the General Law, including:

- Promotion of consumption and sustainable production patterns through the economy.
- Promotion of energy efficiency practices, especially in real estates and entities operated by federal, state and local governments as well as agencies assets.
- Drafting, executing and observance of urban development plans that include energy efficiency criteria to mitigate GHG direct and indirect emissions.
- Issuing regulations to standardize housing energy refurbishment, including the use of low carbon footprint building materials.

ENERGY EFFICIENCY IN THE BUILDING CODE

CONAVI has developed a comprehensive voluntary building code: CEV (Código de la Edificación de la Vivienda) which includes energy efficiency and sustainability regulation and standards, as well as sustainability guidelines for housing. However, CONAVI is a federal agency and building codes and standards are established and enforced at municipal and state levels. Therefore, the agency cannot compel either the adoption or the implementation of its recommendations.

Currently, CEV serves only as a model code. To support its adoption, the CONAVI, Infonavit (Instituto del Fondo Nacional de la Vivienda para los Trabajadores – Institute of the National Housing Fund for Workers) and SHF (Sociedad Hipotecaria Federal – Mexican Federal Mortgage Company) created the "Fondo de Competitividad", a fund allocated to promote sustainable codes and urban development programmes. CEV operates under the prevailing Mexican regulations for relevant fields on housing, such as the NOMs related to energy efficiency, among others. Table 3 presents the prevailing mandatory norms related to housing energy efficiency.

The current Minimum Energy Performance Standards (MEPS) in Mexico correspond to the Normas Oficiales Mexicanas (NOM), which are mandatory, and the Normas Mexicanas (NMX) which are voluntary. Mexican Energy Efficiency Agency (CONUEE) main purpose is to promote energy efficiency and become the technical entity in charge of sustainable energy use affairs. The CONUEE issues NOMs that promote efficiency within the energy sector and supports its implementation.

There are no norms related to existing housing refurbishment within the current Mexican regulation scenario.

Table 3. Prevailing mandatory norms related to housing energy efficiency

BUILDING ENVELOPE
NOM-020-ENER-2011 Energy efficiency on buildings, building envelope for housing.
THERMAL INSULATION
NOM-018-ENER-2011 Thermal insulation for buildings. Characteristics, standard values and testing methods.
GLASS AND GLAZING SYSTEMS
NOM.024-ENER-2012 Thermal-optical characteristics of glass and glazing systems for buildings. Labeling and testing methods.
THERMAL EFFICIENCY
NOM-003-ENER-2011. Thermal efficiency of water heaters for domestic and commercial use. Standard values, testing methods and labeling. NOM-025-ENER-2013 Thermal efficiency of household appliances for cooking using LP gas or natural gas. Standard values, testing methods and labeling.
ENERGY EFFICIENCY
NOM-005-ENER-2012. Energy efficiency of household electric washing machines. Standard values, testing methods and labeling. NOM-015-ENER-2012 Energy efficiency of refrigerators and coolers. Standard values, testing methods and labeling. NOM-017-ENER/SCFI-2012 Energy efficiency and safety requirements of auto-ballasted compact fluorescent lamps. Standard values and testing methods. NOM-021-ENER/SCFI-2008 Energy efficiency, safety requirements for users in air conditioners room type. Standard values, testing methods and labeling. NOM-023-ENER-2010 Energy efficiency on air conditioners split type, free downloading without air ducts. Standard values, testing methods and labeling. NOM-028-ENER-2010 Energy efficiency of lamps for general use. Standard values and testing methods. NOM-020-ENER-2012 Luminous efficiency of light-emitting diode lamps (LED) implemented for general lighting. Standard values and testing methods. NOM-032-ENER-2013 Maximum electrical power Standard values for electrical equipment and appliances that require standby power. Testing methods and labeling.
(Translation for information purposes only. There is still no Mexican NOMs official translation in English)

However, 'NOM-020-ENER-2011, Eficiencia energética en edificaciones – Envolvente de edificios para uso habitacional' includes building expansion for residential use, described in point 2 of this standard.

Despite these initiatives, there is a low rate on MEPS adoption within the building codes at state and municipal levels. Even with their inclusion, monitoring and enforcement of efficiency standards are insufficient. Therefore, there is a need to broaden the coverage of energy efficiency within the building codes and to widen its oversight and application. This is one of the NAMA objectives.

2.3 HOUSING MARKET PLAYERS IN THE EXISTING HOUSING SECTOR

The Mexican housing sector includes a range of key players, including public and private financial institutions, housing developers and consumers. There are also two distinct market segments: the mortgage market, which provides funding for individual home-owners; and the developers market, which provides funding for building developers and construction firms for large-scale new housing building.

CONAVI is the Mexican federal agency in charge to coordinate housing promotion and to implement and to confirm the accomplishment of the federal government objectives and goals regarding housing. The SEDATU was created in 2013 to work as CONAVI´s technical branch for housing affairs. It is in charge of drafting the Mexican housing programme and controlling all the subsidy operation. CONAVI has worked to institutionalize responsibilities and efforts in order to implement sustainable housing as a policy. This work has been organized through the "Mesa Transversal", a Multilateral Committee on sustainable housing in México introduced and lead by CONAVI in 2012 and since 2013, politically coordinated by SEDATU. The "Mesa Transversal" is a group of experts from domestic and international institutions, including the cooperation of several multilateral organizations and international agencies with technical and financing capacities, civil associations, specialized investigation and academic centers, all interested in sustainable housing development which participate in regular coordination meetings. This committee not only shares resources, but coordinates actions to avoid potential problems, incompatible designs, and overlaps.

The mortgage market is dominated by two large public housing funds, both over 40 years old, which provide long-term saving schemes based on mandatory contributions. The Institute of the National Housing Fund for Workers (Instituto del Fondo Nacional de la Vivienda para los Trabajadores, Infonavit) provide services to employees in the private sector, and the Housing Fund of the Institute of Social Security and Services for State Workers (Fondo de la Vivienda del Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado, FOVISSSTE) that provide services to public sector employees. Both collect 5% of employees' salaries, withheld by the employer, through individual savings accounts. The Federal Mortgage Society (Sociedad Hipotecaria Federal, SHF) is a government-owned mortgage development state bank and acts as a secondary mortgage market facility. These institutions dominate 76% of the market. In addition to supplying home mortgages, federal institutions also provide public subsidies directly to low income home buyers through the National Housing Commission (CONAVI) and National Trust Fund for Popular Housing (Fondo Nacional de Habitaciones Populares, FONHAPO).

Even these institutions are focused on the new housing market, especially regarding mortgage loans; they also participate in the renewal and expansion of the existing housing market. CONAVI estimates that between 2007 and 2011, 7.1 million financing or subsidy actions for existing housing were taken [GIZ/MGM Innova 2012]. Figure 2 presents a summary of the main federal institutions that have subsidy or financing programs to support existing housing improvements.

Unlike the new housing sector, existing programmes for housing improvements support is particularly focused on federal subsidies. FONHAPO and the Secretaría de Desarrollo Social- Ministry of Social Development (SEDESOL) register 80% of the total support provided for housing improvement actions carried out, 41% of the total resources invested during the period 2007 – 2011. Subsidies programmes are implemented through local financial entities that identify user requirements for housing improvement. However, these entities are still not enough for a big-scale implementation (see section 3.3).

ONAVIS (Housing organisms) like Infonavit and FOVISSSTE, are in second place. These organisms have a small participation on the existing housing improvements sector, as they are focused on housing acquisition programmes. Another programme is "The home appliance replacement programme" implemented by the Fideicomiso para el Ahorro de Energía Eléctrica -Mexican Trust Fund for Electricity Energy (FIDE), which supported an important number of actions for appliance replacements, such as air conditioning and refrigerators with more than 10 years of use in existing housing between 2009 and 2012.

FIDE provided approximately 1.8 million in credits. The Fideicomiso para el Aislamiento Térmico - Mexican Trust Fund for Thermal Isolation (FIPATERM), which main objective is electric power consumption reduction, is another programme that financed about 805 actions, mainly to install household thermal insulation and the replacement of cooling appliances, air conditioning and obsolete lighting in houses.

The Fideicomiso para el Aislamiento Térmico
Mexican Trust Fund for Thermal Isolation (FIPATERM)

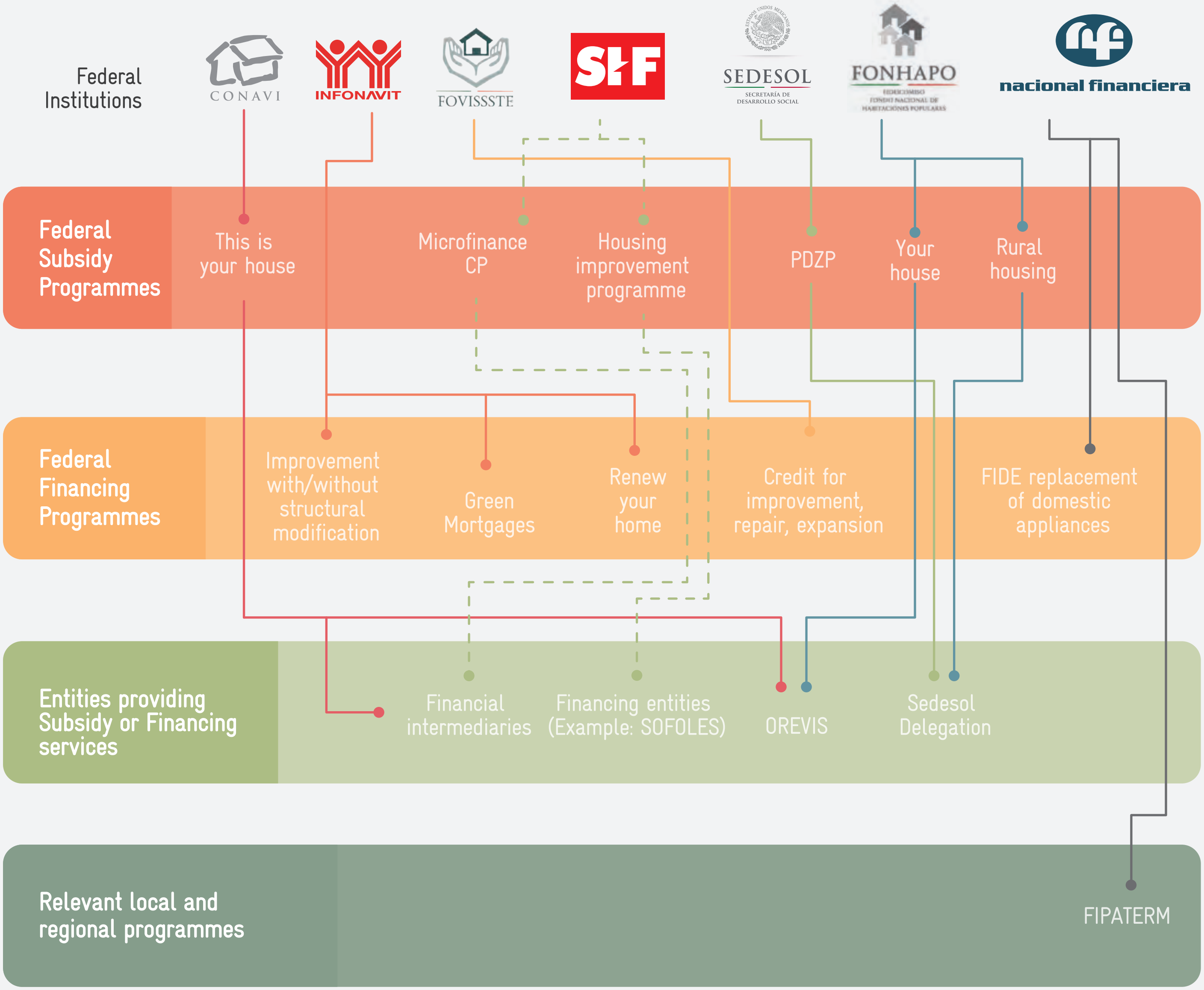


Figure 2. Financing and subsidy programmes chart for housing improvement in 2012
(Source: GIZ/MGM Innova 2012, adaptation by Passivhaus Institut).

2.4 FINANCE FOR THE MEXICAN EXISTING HOUSING SECTOR

Mexico's financial reforms and capacity building efforts over the past decade have solidified and stabilized the financial sector, as demonstrated during the recent global financial crisis (starting 2008). Strengths of the sector are:

- High solvency ratio (15,2% in February 2014), exceeding "Basel III" demands (7%),
- Good profitability (14% return on investment capital),
- Low delinquency rate on loan portfolio (3,7% over total portfolio) despite some problems with borrowers (of consumer and construction)
- Good reserves level to balance risks,
- Limited exposure to foreign currency
- Relatively low reliance on wholesale funding and strong liquidity.

These factors leave Mexican commercial banks (80% foreign property) in a comfortable position. As a caution measure, Mexican authorities have tightened the regulations and bank supervision, including mandatory "stress tests" implementation. In 2013 the government took actions to raise competence between banks in order to increase credit loans for Pymes sector mostly. Even these reforms do not have any direct impact on the housing sector most of them encourage financing and ease access to credits.

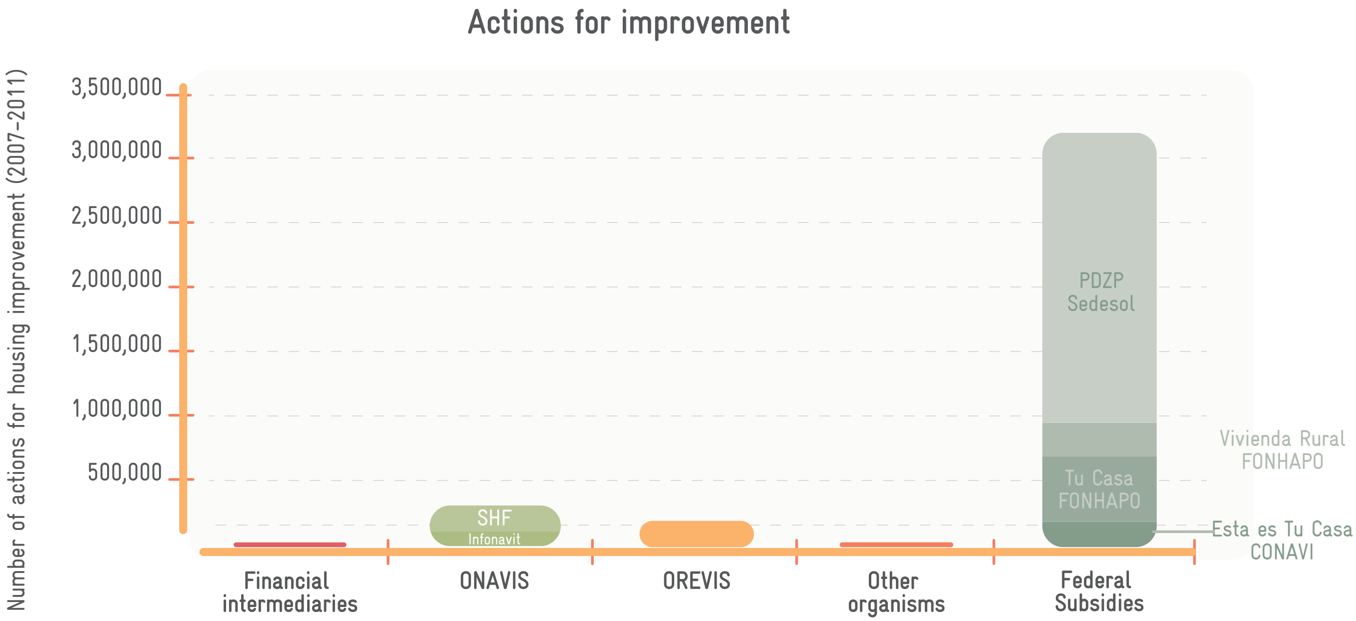
The mortgage sector of the state institutes, cover approximately 75% of the new housing market (loans granted, accumulated figures of period 1973-2012). The sector is segmented considering whether the individual is a public or private worker, also by the overall value of the mortgage. INFONAVIT and FOVISSSTE channel mandatory contributions into direct residential mortgage loans to their members. INFONAVIT is responsible for providing mortgages to private-sector employees, and FOVISSSTE provides service to employees in the public sector (see also section 2.2).

In the case of existing housing, most programmes focused on housing improvements support, currently provide it through federal subsidies. These subsidies are distributed through welfare programmes that intend to support the population sector with fewer resources [GIZ/MGM Innova 2012].

As shown in Figure 3, FONAPO and SEDESOL programmes register 80% of the total support provided for housing refurbishment actions, 41% of the total resources invested for housing improvement. On average, subsidy per improvement action is approximately $ 7,500 MXN (575 USD). In addition, the sum of mortgage loans used for housing improvements through Infonavit and FOVISSSTE is fewer than the subsidies total, but with larger individual amounts, an average of $ 230,000 MXN (18,000 USD) per action.

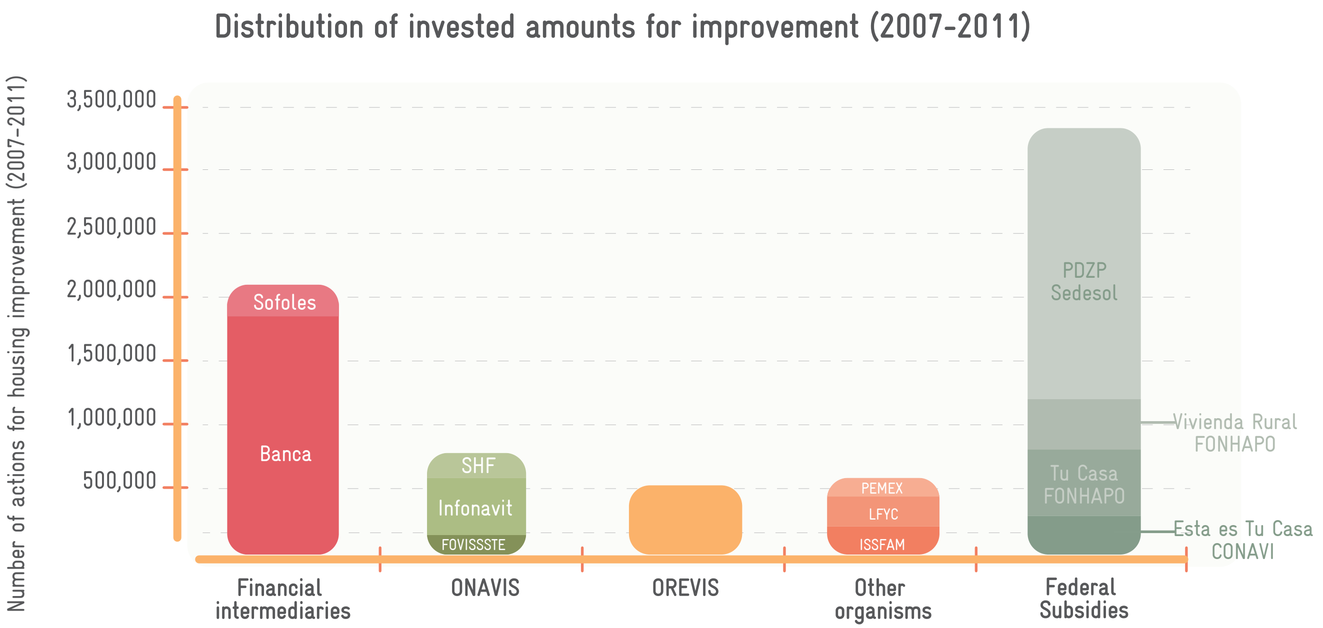
On the other hand, SHF offers a short-term line of credit for housing improvements with an average of $7,000 MXN (536 USD) per action, but also with a large number of actions as shown in the previous figure. An investment between finance and subsidies of 1.2 billion MXN (92 million USD) overall was registered. In this case, ONAVIS provided most of the investment, with approximately 58%, followed by financial entities, such as SOFOLES [MGM Innova 2012].

Figure 3. Financing and distribution universe of actions: Invested amounts for housing improvement, period 2007-2011 (Source: GIZ/MGM Innova 2012)



Generally speaking, there is a big opportunity for current programmes to grow, especially if they are focused on environmental sustainability and its magnitude. NAMA VE represents an excellent opportunity for Mexican institutions to strengthen the programmes for housing improvements by addressing their financial strategies to an environmental sustainability approach. Additionally, this growth has to be carried out together with the development of specialized companies on sustainable housing improvements and the integration of actions carried out by large new housing developers.

Figure 3: Financing and distribution universe of actions: Invested amounts for housing improvement, period 2007-2011 (Source: GIZ/MGM Innova 2012)



2.5 INTERNATIONAL COOPERATION WITH THE MEXICAN HOUSING SECTOR

Mexico has engaged more and more international support for sustainability programmes within the housing and building sector. Some of the efforts are related to technical and co-financing support and can be seen as an example, as they promoted the NAMA VN and could be a basis to support the NAMA VE:

Sustainable Energy Programme for Mexico
(EUR 7 million, 2009-2013 and EUR 6 million, 2013-2017; technical support)

This programme was financed by the German Federal Ministry for Economic Cooperation and Development (BMZ) and implemented by the Mexican government consultant GIZ (German International Cooperation Agency), to improve conditions to increase energy efficiency and the use of renewable energies. The Building component of the programme carried out by GOPA-INTEGRATION, provides technical assistance to SENER, CONUEE, CONAVI and Infonavit sustainable energy focused in the building and housing sectors.

25 Thousand Solar Roofs Project for Mexico

(EUR 2 million, 2009-2014; financial and technical support)

The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has provided funds for subsidies awarded to cover a part of the investment cost for up to 25,000 solar water heaters – combined with technical support for proper installing and verification training. These incentives were offered through the Green Mortgage programme and demonstrate how international donors and investors can induce the scale up and penetration of energy-efficient technology through the support of existing initiatives.[6]

Mexican-German Programme for NAMA

(EUR 7 million, 2011-2015; technical support)

The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has commissioned GIZ to support the development of Mexico's NAMA for building sector (new and existing), small and medium enterprises (PyME), road freight and the development of a NAMA office in SEMARAT.

ECOCASA Programme

(aprox. EUR 168 million, 2012-2019; financial and technical support)

This is one of the major efforts the Mexican government has made to develop a sustainable building sector. The Programme combines funding from BMZ, KfW, the CTF, the IDB, and the Latin American Investment Facility (LAIF) of the European Commission.

NAMA Facility México

Implementation of NAMA for New Housing (Technical Component: 4 millones EUR, 2013-2017; Financial Component: 10 millones EUR, 2013-2020)

This project combines the technical assistance to CONAVI (technical component implemented by GIZ) and financial incentives with the cooperation of Sociedad Hipotecaria Federal - Federal Mortgage Society (SHF), (financial component implemented by KfW) to channel the NAMA initial development towards the implementation of sustainable housing into a wide sector.

The World Bank is not directly financing green housing. Instead, the group has contributed with 1 billion USD through SHF, which capitalizes other financial entities for housing, and is considering an additional 1 billion USD. It has supported the implementation of renewable energy (such as wind energy) and promoting the installation of energy efficient lighting, efficient home appliances and other electric equipment, through a financing fund of 250m USD from the Clean Technology Fund (CTF). The Bank also supports regulatory reforms under the Mexican Special Programme on Climate Change (PECC),initiated by the Mexican government, through a USD 401m Low Carbon Performance-Driven Loan (PDL).

6 For more details see www.infonavit.org.mx.

3 Barriers to a low carbon existing housing sector in Mexico

Even though great achievements have been reached on the implementation of sustainability aspects in Mexico´s housing sector, especially for new housing, there are still barriers that avoid moving forward faster. Particularly for the large-scale implementation of improvements on energy efficiency and other aspects of sustainability on existing housing, there are more barriers to overcome, such as financial, knowledge and dissemination, regulatory and institutional, as well as technical. A brief description of these barriers is provided below.

3.1 FINANCIAL BARRIERS

Home-owners and developers focus on up-front refurbishment costs and not on life-cycle economy, even economic benefits based on energy efficiency are medium to long-term cumulative. Life-cycle economy is negatively affected by the policy of subsidies to electricity cost. Even though the Mexican government is foreseeing changes on this policy, as described in the ENCC (see section 2.2), current energy subsidy is a deeply rooted social and political practice and it seems it will not change soon. Due to the unreal prices, savings on energy efficiency are not worthwhile to users.

Additionally, as described in section 2.4, current financing programmes of Mexican institutions are focused on new housing, with a lag on finance credits for existing housing improvements. Besides the few offer options, there are even less opportunities for them to be focused on sustainability improvements.

Another important barrier is that nowadays, in order to receive a second credit, e.g. through Infonavit, is subject to complete payment of the first credit and currently it is not mandatory to use the second credit for sustainability and energy efficiency. Therefore, it is more likely that improvement or expansion requirements on housing will appear before first mortgage payment is completed and beneficiaries are not capable to extend the credit amount for these measures.

Finally, multi-family buildings for social housing are under a scheme of individual owners. In this type of building, it is hard to find centralized equipment systems as each dwelling is an independent unit from an administrative point of view. This is a problem for the whole house approach concept (see section 4.2), as this methodology is centered in considering the building as a whole unit. The split of the building among individual owners becomes an administrative challenge that should be overcome, especially for improvements on thermal envelope (for example, installation of thermal insulation) or renewable energy-efficient equipments integration (for example, solar heaters). Likewise, it will be a challenge to find buildings where all owners agree to make improvements and they are all able to obtain a credit. This is an even major problem, considering that although multi-family buildings represent a minority in the existing social housing stock, are the optimal solution for urban energy efficiency and sustainability.

3.2 BARRIERS ON KNOWLEDGE AND DISSEMINATION

Several barriers on knowledge and dissemination regarding energy efficiency for existing housing can be defined. There is few or no information for home-owners, developers, planners and local administration regarding energy-efficient improvements implementation and the application of other sustainability aspects on housing. This goes from the assessment methodology to the implementation of such measures.

Furthermore, building professions in Mexico know relatively little about energy efficiency of buildings, especially regarding improvements on existing housing. Besides, nowadays home-buyers and builders have no national models to emulate and promote energy-efficient construction.

Other crucial aspect is that, due to the individual nature of refurbishments, it is necessary that home-owners are aware of available programmes and find motivation to request credits for house improvements. Consciousness on the necessity and on the advantages of energy efficiency improvements is fundamental. Lack of programmes dissemination and home-owners consciousness also represent important barriers for NAMA VE implementation that must be overcome.

3.3 REGULATORY AND INSTITUTIONAL BARRIERS

As already mentioned, yet the Mexican regulatory framework considers a reduction on subsidies, the real situation is that energy power and water consumption are still highly subsided in the country, especially for the social housing sector. Therefore, home-owners have fewer incentives to look for efficient solutions on energy and water use. There are no comprehensive regulations for energy efficiency and housing refurbishment either.

Similarly, credit and subsidies provided by federal institutions are based on previously established operational rules. Considering energy efficiency or sustainability measures implementation as part of the subsidy for enlargement or refurbishment is not clear and mandatory within the 2014 regulation, they can be considered an institutional barrier for the NAMA VE development if they remain valid until 2018.

In addition, even certain energy standards established by the Mexican government do exist and are being implemented for new housing projects, such as NOMs, NMXs and energy performance minimal standards (see section 2.2), these requirements does not apply to existing housing refurbishment. The only exception is NOM-020-ENER-2011 referring to existing building expansion for housing, which establishes a minimum performance level of the thermal envelope for new housing and expansions. Unfortunately, even it is an official standard, generalized implementation throughout the country has not been done and the mechanism to make it become mandatory is still being defined by institutions. Besides, these standards are not included in local regulations and no verification systems of implementation are available.

Finally, contrary to the new housing sector where a large number of consolidated and active housing developers across the country are available, there are not enough project building companies for improvements on the existing housing sector for large-scale implementation nationwide, besides the lack of knowledge and experience on energy efficiency and sustainability implementation in this sector.

3.4 TECHNICAL BARRIERS

Improvements on existing housing are defined together with home-owners. Once a house is purchased by a family, changes can turn it in a unique and individual project suitable for each owner. This is a problem for massive measures implementation, especially regarding financial matters and energy consultancy.

Likewise, from the point of view of energy efficiency, design and improvements implementation face a challenge on fixed parameters that cannot be modified, such as unfavorable compactness, thermal bridges, low airtightness, unfavorable windows orientation and lack of space for additional insulation implementation.

There are also other technical barriers related to the acquisition of technology and solutions that contribute to energy efficiency, as well as a lack of experience and knowledge for proper measures implementation. Due to the lack of knowledge of these measures, builders and local authorities may not realize the impact that these technologies and solutions may produce in the existing housing. Therefore, they are not able to select suitable alternatives. The lack of regulations and supervision in the sector has an impact on the quality of building materials too. Although a lot has been achieved during the last years regarding energy efficiency, there is still a lag in technologies and equipment which makes high costs of necessary technologies unreachable, as such technologies should be imported or limited-produced. Due to the lack of qualified personnel, there is also a lack of building entities and enough companies offering specialized services for existing housing improvements, as well as proper equipment installation to reach energy efficiency.

3.5 BARRIERS SUMMARY

Figure 4 shows all the above mentioned barriers. They justify the selected indirect and support measures, as described in section 4.

	Lack of knowledge and dissemination	Financial barriers	Regulatory and Institutional barriers	Technical barriers
Barriers (problems)				
Indirect measures (solutions)	Encourage EE and RE matters inclusion in school and university programs.	Development of national financial mechanisms for energy improvements on Mexican VE housing.	Data-base development, sharing and homologation.	Quality control for owners and refurbishment with energy efficiency measures.
	Increase awareness on EE, not only in building areas but also consumption behavior as well as equipment and domestic appliances.	Design of an investment fund to finance incremental costs of energy efficiency measures.	Capacity building for monitoring and verification.	Technical assistance in pilot projects design and implementation.
	Media advertisement campaign (TV, radio and Newspaper).	Technical assistance for Mexican products certification criteria.	Regulatory and technical training to institutional and governmental authorities.	Technical training to consultants and energy advisors, planners and building workers.
		Promotion and support to local suppliers and companies.	Drafting and implementation of a national guideline for Building Code adaptation.	Drafting of a user´s manual to support users on housing refurbishment, if required.

Figure 4. Barriers to low carbon existing housing in Mexico and measures proposed to overcome them. (Source: Passivhaus Institut).

4 Mexican NAMA for sustainable Housing Retrofit: Potencial objectives & actions

NAMA VE´s objective is to implement housing improvements in Mexico channeled to increase sustainability and GHG emissions mitigation. This section describes the NAMA VE technical design, including objectives, scope, mitigation potential as well as programme co-benefits within the housing sector in Mexico.

4.1 NAMA FOR SUSTAINABLE HOUSING RETROFIT

The basis of the proposed NAMA VE concept is the enhancement of mechanisms for the financial system to promote existing housing refurbishment with a high level of energy performance within the national mortgage market. The financial incentives will be linked directly to the housing global performance index (IDG) defined by the SISEVIVE-ECOCASA system, through which primary energy demand and water savings target values are set to define its performance from a sustainability point of view.

The NAMA has been designed as a framework consisting of unilateral and supported components. Unilateral components are those implemented and financed by the Mexican government and constitute Mexico's contribution to international climate change goals. On the other hand, supported components are those for which international donors and Mexican government funding are needed: incremental costs to strengthen penetration of Mexico's actions, or to achieve more ambitious performance standards. International support may also be received as technical assistance and capacity building, especially to strengthen energy consultancy, which is considered a basis for the NAMA VE performance.

As NAMA VN, NAMA VE differs from the CDM/PoA by adopting a "whole-house approach" (see section 4.2). From this perspective, efficiency benchmarks are set for total primary energy demand based on building type and climate. This enables building developers and home-owners to employ any combination of interventions to achieve the targeted efficiency level. This combination is defined on a comprehensive planning basis through an individualized and comprehensive energy consultancy scheme, included in the NAMA VE approach. In the medium to long-term, it is foreseen that the NAMA VE will expand its scope, leading to further decreasing emissions with other mechanisms that might be implemented in the future. Furthermore, the NAMA is not only limited to the demand side (home-owners), it could influence the supply side too with housing improvements leaded to higher energy efficiency (for example, through financial entities).

The following steps define the incremental improvement through the NAMA VE described in this report:

- Increased penetration (more houses covered during the same time) and/or
- Technology innovations and process up-scaling (more ambitious efficiency standards and/or inclusion of technologies currently not covered by the programmes).

4.1.1 OBJECTIVE OF THE NAMA FOR SUSTAINABLE HOUSING RETROFIT

The NAMA VE intends to complement on-going initiatives in the sector, leaded to the optimization of housing resources consumption, based on the programmes tthat promote improvements on existing housing sustainability in Mexico. These initiatives are defined within the framework of the Mexican policy for urban, sustainable and intelligent development and in the commitments on climate change. Therefore, NAMA VE´s main objectives are:

- Penetration and expansion of basic energy efficiency improvements for the existing housing sector. Specific targets including the Infonavit and the FOVISSSTE market, as well as the SHF-refinanced segment and to implement a comprehensive energy consultancy scheme.
- Technology up-scaling achievement or stepwise adjustment of the first steps to meet the most ambitious efficiency energy standards described in this report, in all market segments.

The challenge of the NAMA VE design is to adequate Mexican development priorities, while also attracting support from other countries. In this regard, the NAMA VE needs to provide financial incentives for existing housing refurbishment with an energy performance level above the standards achieved with the current Mexican programmes. Through the technical design calculations, it is being confirmed that the implementation of high energy efficiency measures on the most popular social housing building type in Mexico, achieves an important GHG mitigation. Therefore, it also becomes an economically viable option by establishing goals for the housing primary energy demand. Financial incentives proposed will be linked to minimum primary energy target values for the different housing types.

Housing to be improved under the NAMA VE will promote the dissemination of new technologies and approaches in the existing housing refurbishment sector. In the long term, this-will have positive spill- effects on the Mexican building sector.

4.1.2 SCOPE OF THE NAMA FOR SUSTAINABLE HOUSING RETROFIT

NAMA VE is aimed to influence the overall existing housing sector in Mexico, specially the social building type sector. This includes the Mexican mortgage market, federal subsidies as well as private sector banks.

The NAMA VE will be open to the participation of Infonavit, FOVISSSTE, SHF and other financial institutions. Initially, the NAMA will target existing housing and will work with public credit institutions. This includes SHF credits to private financial intermediaries (SOFOLES, SOFOMES) to finance mortgage credits.

As mentioned before, there is a Norma Oficial Mexicana (NOM) that establishes the minimum performance level for thermal envelope in new housing and expansions. This norm intends to restrict heat gain in order to optimize energy consumption on cooling systems, NOM-020-ENER-2011. It is valid since 2011 and became mandatory for all new residential buildings and expansions in the existing residential housing.

Before 2011, there was no regulation for energy efficiency regarding the building envelope. Therefore, it is assumed that the housing where this norm was not implemented has an improvement potential in the thermal envelope that would justify the implementation of the NAMA VE financed measures, except for those households that participated in specific programmes that included thermal envelope improvement, such as FIPATERM (see section 2.4). Similarly, it is probable that recent housing include household appliances with some kind of efficiency, as norms and minimal standards on energy efficiency for domestic appliances have applied for several years. These appliances should be considered in the energy consultancy of each project. The Mexican government, together with the SEDATU and the CONAVI through a dialog with the OREVIs, should define the NAMA VE action field by establishing implementation strategies for a short, medium and long-term.

It is foreseen that this approach to efficient housing could, in the future, be included in a more holistic approach to urban sustainability. This goal is already being pursued through the Urban NAMA proposal to the Partnership for Market Readiness promoted by the SEDATU.

The NAMA VE provides financial incentives to two distinct groups: existing housing house-buyers/owners (demand) and construction companies (supply). The financial incentive framework under the NAMA VE will ensure that:

- The greater the level of energy efficiency achieved, the more favorable the financial support conditions;
- House-buyers/owners will receive a subsidy to the loan granted by a financial institution (i.e.. reduced interest or lower reimbursement installments, or subsidies), as long as housing improvements follow the Master Plan established during an energy consultancy. This Master Plan has the objective to achieve energy efficiency standards established by the NAMA VE. Therefore, financing to cover a part of the incremental investment costs may be granted;
- A scheme of professional energy consultancy will be established to ensure the high quality and proper implementation of energy efficiency measures, including improvement's supply side through construction companies. Even though the improvement is partial and not total, the Master Plan drives to whole-house energy efficiency improvement, establishing steps to follow over its lifecycle.

Table 4 describes NAMA VE design elements:

Item	Description
Sector	Building sector
Subsector	Housing improvement: primarily for low-income families (social housing) and potentially to middle-income housing
NAMA VE boundary	Entire country
Measures and activities with direct impact on GHG emission reduction	Introduction of ambitious energy efficiency benchmarks to minimize primary energy consumption. Housing improvement according to the standard level is incentivized by a scaled-up financial promotion system (step by step) and is optimized by the introduction of a mandatory comprehensive energy consultancy to define the "Master Plan" since the beginning.
Measures and activities with indirect impact on GHG emission reduction	Supportive actions for NAMA VE implementation, operation and support for a wider transformation process within the housing sector: introduction of energy performance requirements according to the legal system and license granting process, training and energy consultancy program establishment, development of pilot project models for each efficiency level proposed and the adaptation of calculation tools for energy consultancy and projects assessment.

Table 4: Design elements of the NAMA for Sustainable Housing Retrofit (Source: Point Carbon Thomson Reuters and Perspectives, adaptation by the Passivhaus Institut).

4.2 WHOLE HOUSE APPROACH

As mentioned in section 2, most of the existing initiatives in the financial sector for housing improvements, lack of an environmental sustainability approach. On the other hand, existing initiatives considering sustainability improvements are focused on the implementation of specific technologies or Interventions, except the NAMA VE for sustainable housing retrofit that introduces the 'whole house approach' for energy efficient improvements in buildings since its implementation in 2012.

The "whole house approach" concept provides optimal solutions for projects energy efficiency, comfort, financial aspects and profitability. It is proposed to define and monitor the values of the whole primary energy demand on each household, instead on focusing in particular performance solutions or technologies. This proposal has great advantages that can be summarized as follows:

- Target values represent an incentive to reduce total energy consumption, since they take into account the interaction between different measures.
- As long as a technical measure achieves the target value for the whole house, the house-builder and/or home-owner is free to choose such measure.
- Target values promote further technical development and flexible cost effective solutions.
- Target values can be tightened, step by step, in line with environmental policies and technical development.
- Target values allow the establishment of different support levels in parallel.

4.3 TECHNICAL DESIGN OF THE NAMA FOR SUSTAINABLE HOUSING RETROFIT

Based on the foreseen objectives and scopes of the NAMA VE, and in order to demonstrate the mitigation potential of the existing social housing sector in Mexico, the International Standard EnerPHit[7] methodology and concept established by the Passivhaus Institut [PHI 2014] has been applied. It contemplates a complete housing improvement or partial improvement scenarios if required, as steps to be followed to achieve a more ambitious mitigation goal. It establishes an energy consultancy scheme through a comprehensive planning to complement and validate energy efficiency measures, considering individual measures per each household. Basic concepts of the NAMA VE technical design are described below.

4.3.1 HOUSING ENERGY EFFICIENCY STANDARDS UNDER THE NAMA FOR SUSTAINABLE HOUSING RETROFIT

Energy efficiency improvement planning within the NAMA VE concept has the objective to achieve a standard, such as the International Standard EnerPHit – from now on "Step by step refurbishment to achieve an optimal energy and environmental performance" – since the starting point of the planning. The energy efficiency and sustainability levels proposed, follow the same conceptual principles of the NAMA VN, but focused on existing housing and considering its own refurbishment challenges, including cost-effective aspects and different requirements depending on climates.

[7] The EnerPHit standard calculated in Step 3 of every example establishes target values for building heating, cooling and primary energy according to its climate zone. If heating and/or cooling target value may not be reached due to difficulties concerning refurbishment, characteristic values are determined for building components based on quality needed to achieve Passivhaus standard in each climate, considering profitability aspects as well. For more information see [PHI 2014]. EnerPHit refurbishment may be carried out all at once or step by step.

Basic principles of both concepts are very clear and are based on the implementation of energy efficiency measures differentiated by the climate, such as: continuous thermal insulation overall the thermal envelope, high thermal quality of frames and window glasses, study and minimization of thermal bridges in detail, envelope air tight to avoid non-desired air infiltration, optimal natural and/or energy recovery ventilation through a controlled ventilation system with heat and/or humidity recovery or, if climate allows, through an extraction system.

In this same way, standard values for building envelope quality are set in accordance to global climate zones, optimizing the housing heating and humidity loads both external due to climate conditions, and internal due to building use, people and heating sources. Once this is done, low demands of heating, cooling and/or dehumidification are covered with the implementation of energy-efficient technology, as required. At the same time, project cost-effectiveness should always be kept in mind due to difficulties on building improvements, especially from an energy efficiency point of view.

This standard is based on actions to be taken over the housing lifecycle, for example replacement of windows or exterior walls painting. These measures apply on any building for maintenance purposes. Likewise, this circumstance should be embraced to optimize necessary measures with energy efficiency measures. For example, when replacing windows, frames and glasses to improve building thermal quality until optimal cost-effective level is reached are better. Future savings when installing this kind of efficient components throughout the useful lifetime of the building should be considered.

As not all building elements require improvements or replacements at the same time, it is especially essential to consider every step during the refurbishment process to ensure an optimal improvement of the building. For both, a complete (all at once) or step by step (partial improvements as required according to construction components lifecycle) refurbishment, the final objective of the Master Plan should always be considered. Instead of a complete refurbishment with a low efficiency standard, highly-efficient components are refurbished with the option to complement it with other components that allow optimal performance to be reached in a medium or long-term, until the “refurbishment to achieve optimal energy and environmental performance” is completed. This Master Plan should be established at the beginning of the process and can only be defined as a result of an individualized energy consultancy. The timeframe and the strategic planning process are elements that make the difference between both approaches. Possible linkage effects as well as cost-effective issues may occur between the implementation of measures..

Such an approach has numerous benefits. It enables a simple and cost-efficient MRV system that captures the net efficiency improvements of a broad range of eco-technologies, building design, building materials and measures to be implemented. It also enables stakeholders to find the most cost-efficient combination of these features and receive support for implementation. Furthermore, the tiered benchmark approach provides flexibility for regulators to increase the stringency of the programme over time and enables donors to target specific activities that align with their development priorities. It is important to mention that calculated steps represent a significant improvement on GHG mitigation of at least 20% or more, compared to the baseline (when referring to Step 1), or compared to its previous corresponding steps (when referring to Step 2 and 3), of a same comfort level in the most extreme calculated climates (hot/humid and hot/dry). In other analyzed climates (template and semi-cold) depending on building type, it is possible that Step 1 cannot achieve such mitigation level (for more details see Annex at the end of this document). In this case, by joining Step 1 with Step 2, it is intended to achieve this 20%. This standard is considered as the target value to receive subsidies to lower the financial burden.

Due to its importance and possible complexity, the Master Plan should be defined in a proper energy consultancy, as described in section 0. The advantage of this process is that intermediate steps are scalable, meaning that each one may reach a maximum category. At the same time, quality controls are established since the early improvement stages to ensure steps followed are the appropriate ones. It also ensures that only housing with improvement potential is included in the NAMA VE programme by identifying housing not suitable for energy efficiency improvements owed to poor conditions.

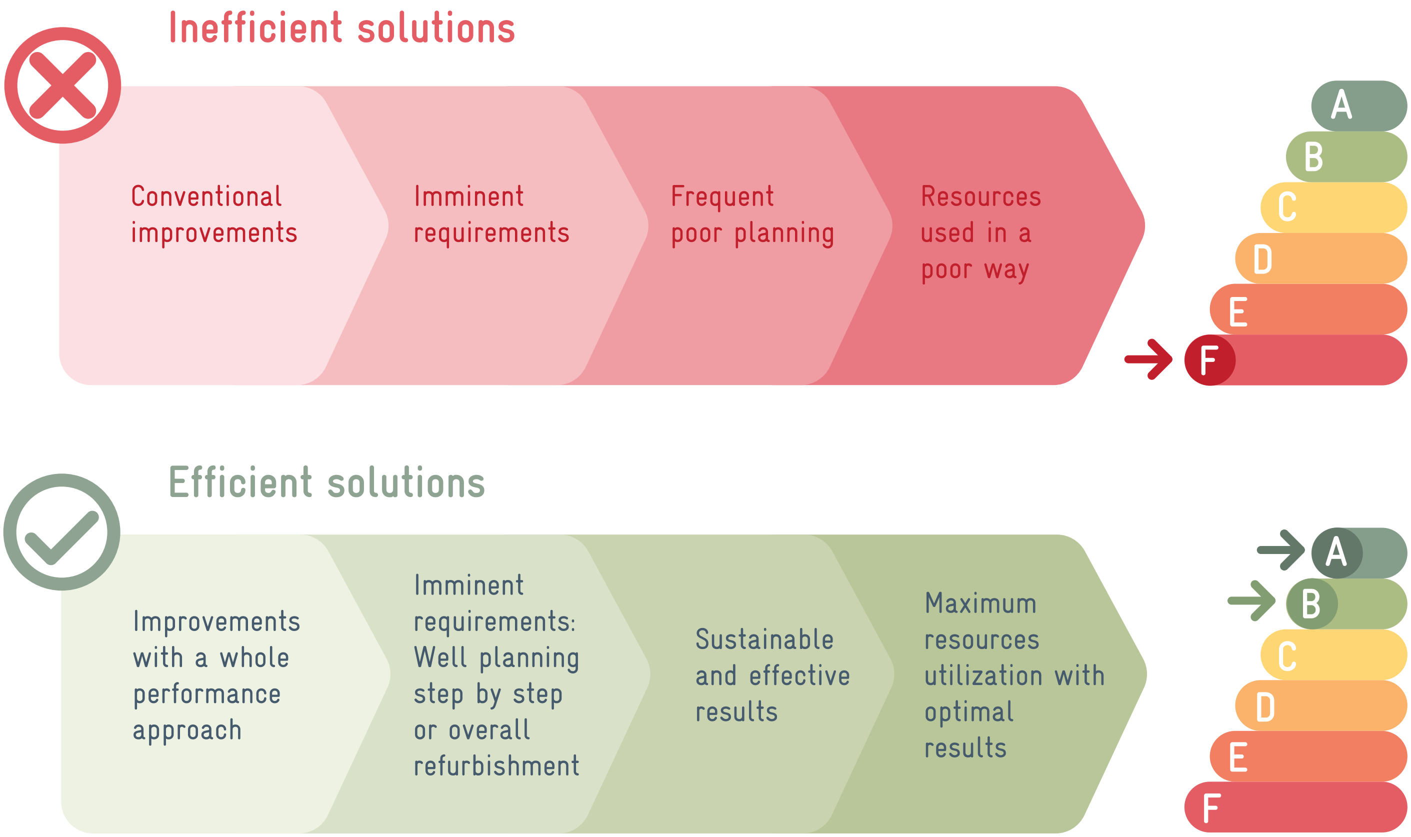


Figure 5: Importance of a well planned refurbishment with a whole house approach (Source: Passivhaus Institut)

For NAMA VE technical design, three unit types typical of the Mexican market of approximately 40m² and 50m² in floor area have been analyzed:

AISLADA

A single unit detached house.

ADOSADA

a rowing housing unit sharing one or two middle walls.

VERTICAL

Multi-storey housing units, consisting of two or more floors with an average of two apartments each.

Besides these three types, there is another very common Mexican housing type called 'Duplex', consisting of four 'Adosada' type apartments in two floors, two apartments in the first floor and two in the top floor. This type of housing is similar in geometry, size and disposition for construction to the 'Adosada' type. Therefore, results of this last type may apply to the 'Duplex' type.

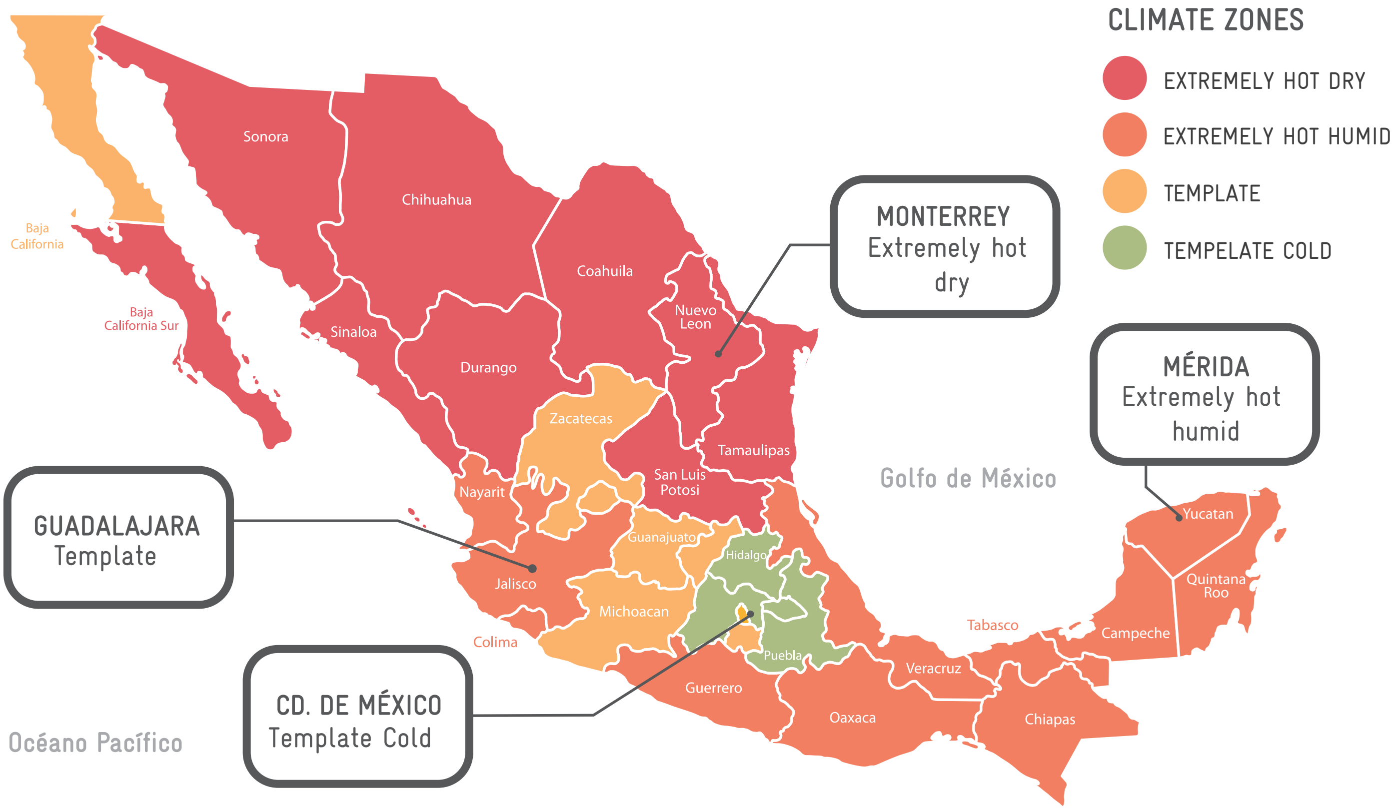


Figure 6: Bioclimatic zones utilized for the NAMA VE[8] for Sustainable Housing Retrofit calculations (Source: Passivhaus Institut)

To develop the energy efficiency scenarios, preliminary designs of the buildings including construction systems, occupation and equipment were examined. They were differentiated by type of housing and bioclimatic zone according to the Field Study on Existing Housing [GIZ/CMM 2013]. With this information, an energy balance of the three building types in four basic climate zones in México[9] (see Figure 2) for a reference[10] household with a baseline that represents housing current conditions was determined. Energy balance was calculated with the help of the Passive House Planning Package (PHPP), always considering the whole house approach concept.

Then, the possibilities of optimizing buildings in energy efficiency without significant changes to the building design were analyzed (very difficult for existing housing). First, the maximum energy efficiency was sought (IDG high level, meaning reaching the "Step by step refurbishment to achieve an optimal energy and environmental performance"). Measures to achieve energy efficiency intermediate levels are described as follows. These intermediate levels represent steps to achieve better improvements, considered as partial housing improvements. This is important when following the step by step refurbishment concept.

These same scenarios were simulated with the DEEVi tool (Energy-efficient Housing Design); a tool specially designed for simplified energy assessment calculations on new housing (see section 4.3.4), easy to apply for social housing registration. It is based on the PHPP and plays a crucial role in the energy efficiency development of this sector in Mexico. PHPP calculation results were assessed and compared to DEEVi results, concluding that this tool needs to be adapted to be applied to the existing housing. Additionally, a cost-efficient analysis was carried out considering lifecycle costs of a whole building.

On the basis of this analysis, the highest energy efficiency standard by each housing type in different climates was defined. For extreme climates (hot dry and hot humid), two intermediate steps for partial improvements (Step 1 and Step 2) were established, while for moderate climates (Mexico City), only one intermediate step was established. The last step drives towards the highest efficiency level for existing housing. In the following example, possible linkage effects between measures have been considered. For example, air tightness is not considered completely improved until energy recovery ventilation is implemented (Step 3) to avoid humidity problems inside the building that may cause structural damage. This kind of effects should be considered in the individualized consultancy included in the NAMA VE for each project.

The different steps of the technical design calculated examples are described below. It is important to mention that the technical options outlined above, are for descriptive purposes only; home-owners do not need to install all of the above mentioned technologies. To be eligible for NAMA VE funding, stakeholders must reach the previously established level of energy efficiency by using the most convenient combination of technologies, according to climate and building type by following the Master Plan defined in the energy consultancy to achieve the optimal standard when this NAMA VE ends. In other words, eligibility is determined by the overall energy performance of the household, not the specific technologies used. At the same time, cost-efficient of these measures should always be considered.

[8] Initial design work was performed using four basic climate zones but cities were selected according to the municipal climate classification. The national-scale NAMA will use seven.

[9] When NAMA is deployed nationally, scope may be extended to other bioclimatic zones

[10] The Passive House Planning Package (PHPP) is software developed by the Passive House Institute to support the design of energy efficiency housing. More p information about the tool is available at: http://www.passivehouse.com/.

STEP 1

Step 1 considers the replacement of existing low-efficient air conditioning units with high-efficient A/C systems both for climate and dehumidification, depending on climate requirements. Another measure is to incorporate a solar water heater for hot gray water. The replacement of the refrigerator for a more efficient one to achieve energy consumption reduction is also considered. It shoud be noted that in some cases, Step 1 does not reach the 20% of CO_2 emissions reduction (template cold and template climate zones). In these cases, financing should be directly focused on Step 2.

STEP 2

Step 2 includes Step 1 measures and forsees the optimization of passive measures, such as insulation in the roof, special painting on the walls to reduce heat absorption in hot climates, high quality frames and window glasses suitable for each climate and raising housing air tightness always ensuring enough natural ventilation, specially in a hot humid[11] climate zone.

STEP 3*

Step 3 represents the highest energy efficiency level, the most ambisious goal and the sustainable level all households should achieve, each one on its own time. It is achieved by installing solutions described in Steps 1 and 2. Besides, it considers other additional measures such as thermal insulation in exterior walls, work more in housing air thightness by installing mechanical controlled ventilation with heat and humidity recovery, or hybrid ventilation systems with extraction devices, depending on climate.

Figure 7 shows a general summary of calculated measures within the development of this document.

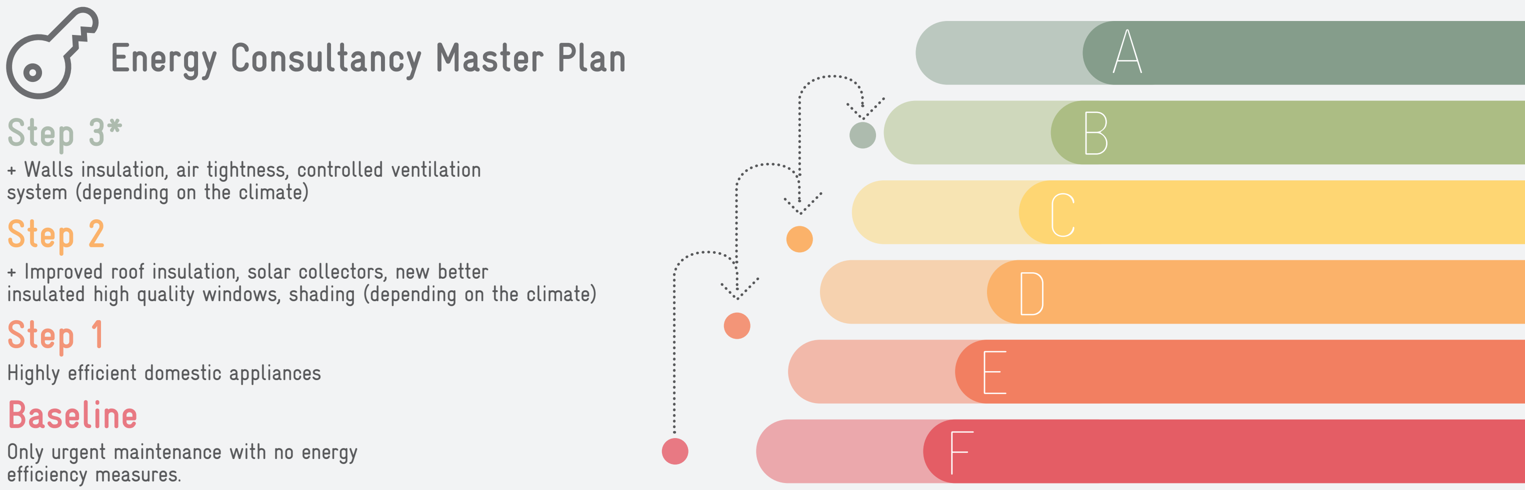


Figure 7: Technical Design for NAMA for Sustainable Housing Retrofit: Step by step refurbishment to achieve optimal energy and environmental performance, summary of examples calculated from Step 1 to the calculated optimal standard. Classification system bands are only schematic (Source: Passivhaus Institut).

* Technical Design for NAMA for Sustainable Housing Retrofit: Step by step refurbishment to achieve optimal energy and environmental performance

As shown in Figure 7, the different steps and their equivalent efficiency levels correspond to different classification bands when using a system easy to understand and approved by the NAMA VN and the Green Housing Evaluation System – SISEVIVE-ECOCASA. An important aspect to motivate existing housing home-owners to make energy efficiency improvements and to prevent a bouncing effect is to increase comfort since the first step. This improves quality of life and costs on inefficient applications are prevented.

4.3.2 MITIGATION OPTIONS UNDER THE NAMA ENERGY EFFICIENCY STANDARDS FOR SUSTAINABLE HOUSING RETROFIT

The following section provides a brief overview of the results of the energy balance modeling, considering the measures to be undertaken for the buildings analyzed (Vertical, Aislada and Adosada) in four locations (Monterrey, Guadalajara, Mexico City and Mérida)[12]. Specific energy demand was tracked across four uses: space heating, space cooling, dehumidification, and all other primary energy demand – which includes water heating, cooking, and appliances. The results are illustrated and exemplified by the Adosada building type but similar results, with more or less demanding values, were achieved for the other house types, Aislada and Vertical. At the end of this document, in the Annex, general results and calculation parameters of the three building types in the four climate zones are provided.

Demand for heating, cooling, and dehumidification, vary significantly between the different climate zones. Specific primary energy demand is generally much higher in hot climates than in the template regions. Because of these regional differences, the types of mitigation options employed are specific to each of the climates found in Mexico. As Table 5 shows, this can mean using entirely different types of technologies, or scale interventions to the demands of the region, for example, insulation and glazed low-e windows.

The following example is based on adopted measures for a single-family Adosada building type in Merida climate (hot-humid). Solutions have been optimized according to each housing type in the four most representative climate zones in Mexico. Therefore, these solutions may vary depending on the analyzed building types and climate zones. At the end of this document, in the Annex, general results and calculation parameters of the three building types in the three climate zones are provided.

[11] For the hot tropical climate zone where environmental humidity is high, while there is no energy recovery ventilation installed, it is recommended to ensure enough natural cross ventilation to eliminate humidity excess in the house. This aspect should be cared especially after installing energy-efficient and air tight windows by removing the air tight package until energy recovery ventilation is installed or have ventilation grids. These options should be analyzed on detail in the professional energy consultancy.

[12] As a boundary condition, a temperature range of 20°C to 25°C was chosen.

		Monterrey (Hot dry)	Guadalajara (Template)	Ciudad de México (Template cold)	Mérida (Hot Humid)
Exterior Walls	Step 1	No insulation	No insulation	No insulation	No insulation
	Step 2	No insulation	No insulation	No insulation	No insulation
	Step 3	Insulation: 100 mm and 50 mm (depending on orientation). Reflective paint	Insulation: 25mm	Insulation: 75 mm and 50 mm (depending on orientation).	Insulation: 150mm Reflective paint
Roof	Step 1	No insulation	No insulation	No insulation	No insulation
	Step 2	Insulation: 125 mm Reflective paint	Insulation: 25 mm Reflective paint	Insulation: 75 mm	Insulation: 150 mm Reflective paint
	Step 3	Insulation: 125 mm Reflective paint	Insulation: 25 mm Reflective paint	Insulation: 75 mm	Insulation: 150 mm Reflective paint
Windows	Step 1	Simple glazing	Simple glazing	Simple glazing	Simple glazing
	Step 2	Double glazing with sun protection	Simple glazing	Simple glazing	Triple low-e glazing
	Step 3	Double glazing with sun protection	Double glazing	Double low-e glazing	Triple glazing with sun protection

Table 5: Example of measures to achieve mitigation goals by climate zone for Adosada building type (Source: Passivhaus Institut).

		Monterrey (Hot dry)	Guadalajara (Template)	Ciudad de México (Template cold)	Mérida (Hot Humid)
Heating, ventilation, and air conditioning	Step 1	Heating and cooling by split system. Natural ventilation.	Heating and cooling by split system (when existing). Natural ventilation.	Heating and cooling by split system (when existing). Natural ventilation.	Cooling by split system. Natural ventilation.
	Step 2	Heating and cooling by split system. Natural ventilation.	Heating and cooling by split system (when existing). Natural ventilation.	Heating and cooling by split system (when existing). Natural ventilation.	Cooling by split system. Natural ventilation.
	Step 3	Heating and cooling by split system. Natural ventilation.	Heating and cooling by split system (when existing). Natural ventilation.	Heating and cooling by split system (when existing). Natural ventilation.	Cooling by split system. Natural ventilation.
Hot gray water production	Step 1	Through solar thermal collector in cover	Through solar thermal collector in cover	Through solar thermal collector in cover	Through solar thermal collector in cover
	Step 2	Through solar thermal collector in cover	Through solar thermal collector in cover	Through solar thermal collector in cover	Through solar thermal collector in cover
	Step 3	Through solar thermal collector in cover	Through solar thermal collector in cover	Through solar thermal collector in cover	Through solar thermal collector in cover

Table 5: Example of measures to achieve mitigation goals by climate zone for Adosada building type (Source: Passivhaus Institut).

		Monterrey (Hot dry)	Guadalajara (Template)	Ciudad de México (Template cold)	Mérida (Hot Humid)
Efficient appliances	Step 1	CFL lamps Efficient household appliances	Efficient tankless LP gas water heater CFL lamps Efficient household appliances	CFL lamps Efficient household appliances	CFL lamps Efficient household appliances
	Step 2	CFL lamps Efficient household appliances	Efficient tankless LP gas water heater CFL lamps Efficient household appliances	Efficient tankless LP gas water heater CFL lamps Efficient household appliances	CFL lamps Efficient household appliances
	Step 3	Efficient tankless LP gas water heater CFL lamps Efficient household appliances	Efficient tankless LP gas water heater CFL lamps Efficient household appliances	Efficient tankless LP gas water heater CFL lamps Efficient household appliances	CFL lamps Efficient household appliances
Baseline emissions		138 kg/(m²a)	59 kg/(m²a)	112 kg/(m²a)	205 kg/(m²a)
Min. Achievable emission level	Step 1	99 kg/(m²a)	47 kg/(m²a)	108 kg/(m²a)	118 kg/(m²a)
	Step 2	60 kg/(m²a)	28 kg/(m²a)	64 kg/(m²a)	63 kg/(m²a)
	Step 3	27 kg/(m²a)	13 kg/(m²a)	14 kg/(m²a)	34 kg/(m²a)

Table 5: Example of measures to achieve mitigation goals by climate zone for Adosada building type (Source: Passivhaus Institut).

The result of implementing these mitigation actions is illustrated in Figure 8, which shows energy savings for Adosada housing units in a hot and humid climate.

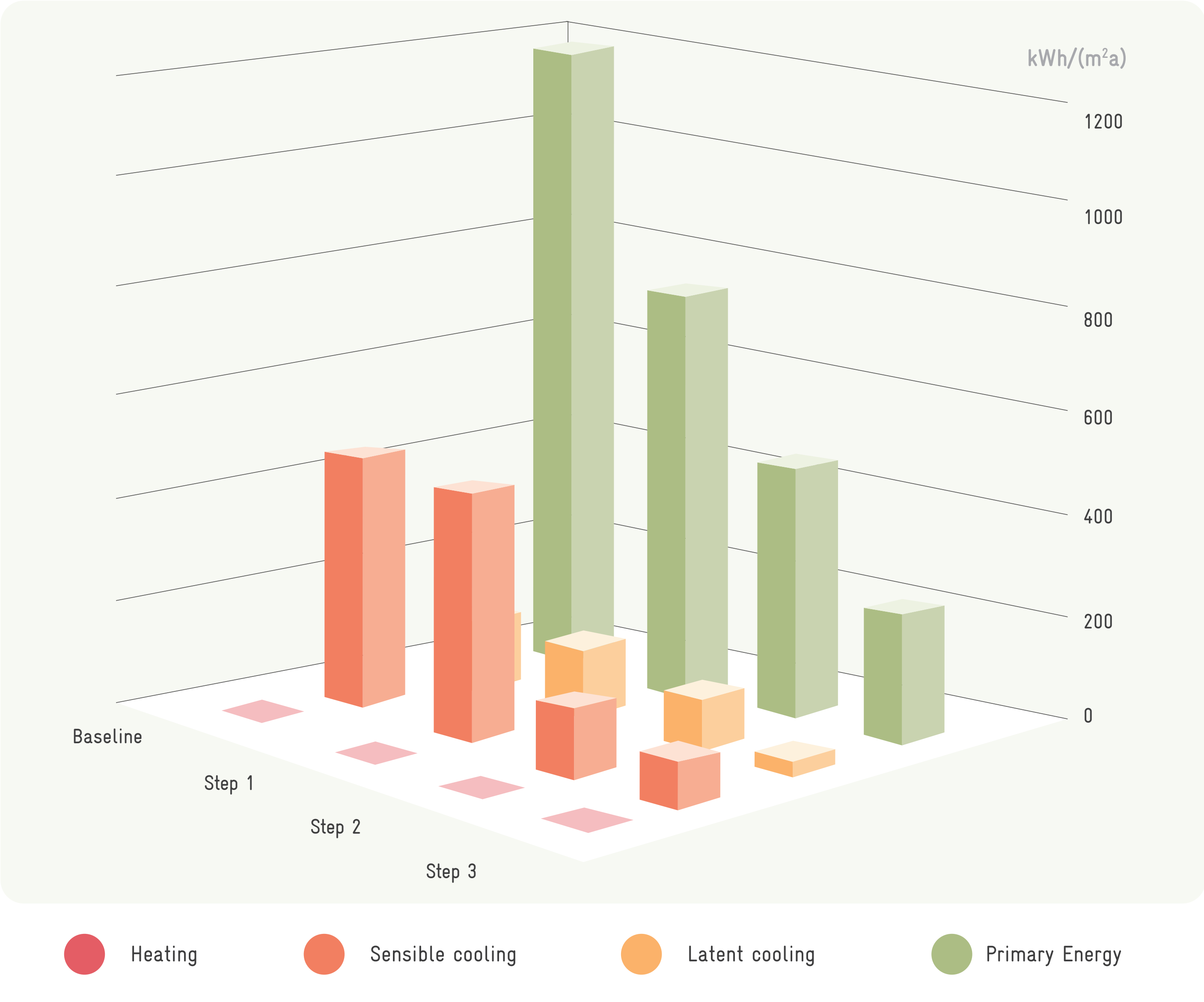


Figure 8: Specific energy demands for Adosada building type in Merida (Source: Passivhaus Institut).

Figure above shows an example of specific energy demands for an Adosada building type in Merida. Lack of heating demand is the result of climate characteristics. On the other hand, cooling demand to achieve previously established baseline comfort standards is very high. It also shows that since Step 1, energy demand reduction is achieved. Step 3 represents the maximum potential achieved by the calculated example, with a diminution of the different demands. The energy consultancy should be the starting point for actions.

In general, building improvements are carried out according to economic capacity or when it is absolutely necessary due to esthetic, comfort, expansion or even structural reasons. As improvements become an imminent necessity, an appropriate planning to use available resources in a maximum optimal way is not commonly considered. An organized and well coordinated process with a main objective and with a whole house approach, will allow viable actions to be carried out taking into account ecological, economical and social aspects. Improvements on existing housing are defined together with users. Once a household is purchased by a family, changes can turn it in a unique and individual project suitable for each owner. In this way, the whole house approach is closely linked to the technical advisory. This is the reason why the NAMA VE needs an energy consultancy scheme that will be linked to a financial credit for improvements.

In Mexico, energy competence standard EC0431 ´Promotion of savings in whole house energy performance’ has been developed. This standard defines an entity called “Energy Advisor” for new and existing housing. Based on the EC0431 standard, this person is proposed to be in contact with building owners and specific users to identify current conditions and the requirements of each family. Experience shows that direct contact with the owner to get to know his necessities and wishes, is the path towards a greater success in housing improvements application.

Once the high qualified and comprehensive energy consultancy ends, and the appropriate required measures for each unit have been identified by the Energy Advisors, large-scale solutions are applied. It is essential that these measures reflect and follow the previous defined Master Plan for each unit – containing the accurate solutions to be implemented for energy standard values achievement – ensuring maximum GHG emissions reduction. This is why it is essential for the NAMA VE to group measures in packages according to housing developments (for example, change the windows of a household development with several years of lifetime, to group the related finance credit). This represents an advantage for finance aspects too, as it anticipates a simplification of the funding administration.

To apply energy efficiency measures in packages as mentioned, a person highly trained in energy efficiency, building, financing and other related matters is required. A person combining the energy consultancy scheme with skills on general orientation, supervision and specific instructions follow up is proposed by the entity of “Auditor Advisor”, with at least bachelor degree in areas related to building and energy efficiency subjects (according to level three of the Mexican Competence System programme, included in the EC0431 standard), that should be trained within the NAMA VE framework (see Figure 9 below).

Advisory is provided in two levels:

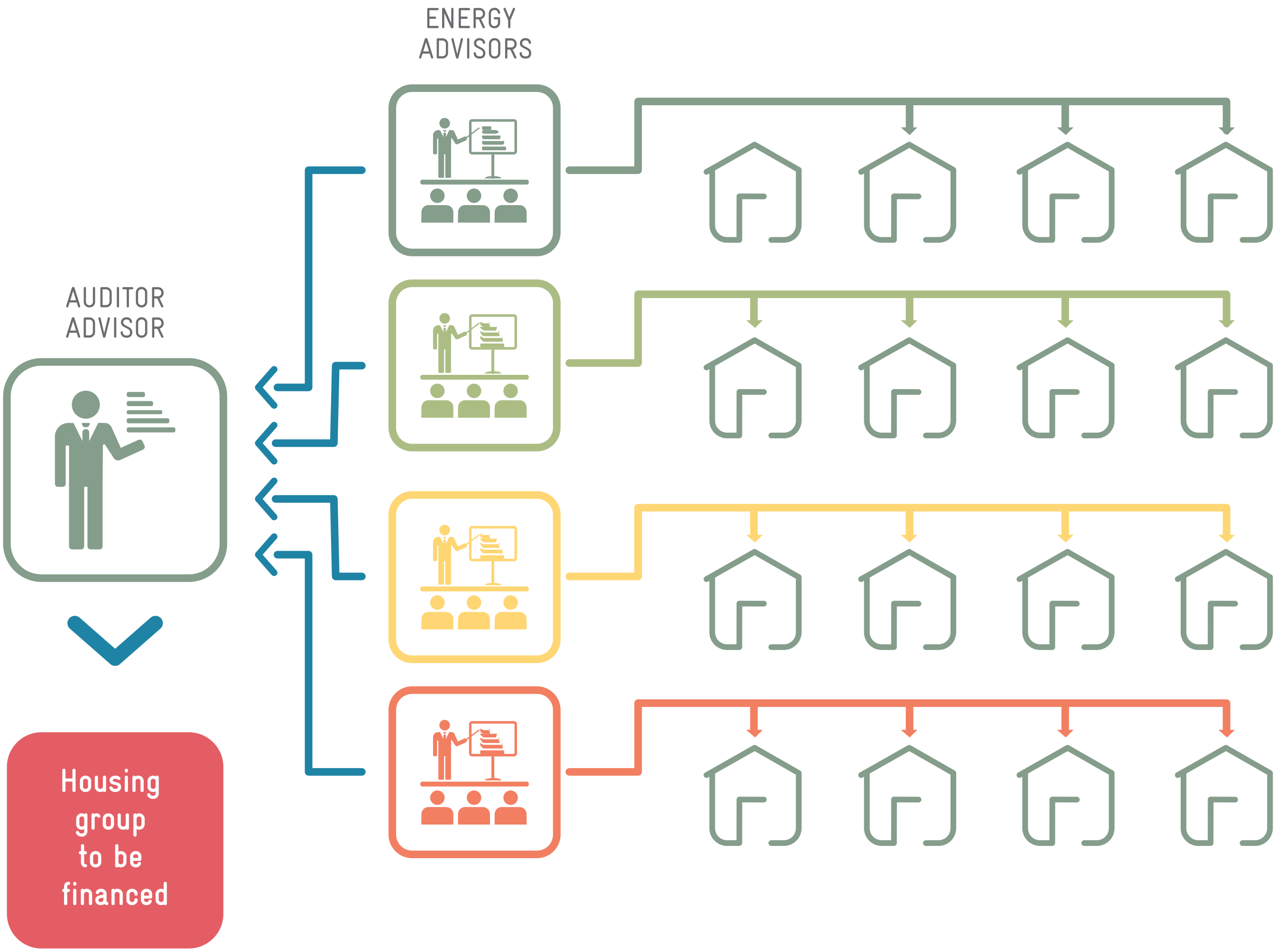


Figure 9: Scheme combining Energy Advisor and Auditor Advisor (Source: Passivhaus Institut).

The comprehensive energy advisory should also consider that units or even whole housing developments may be in such bad conditions, that refurbishment is not suitable. In this case, densification solutions may apply (new housing building, especially for whole household developments). However, this possibility is out of the NAMA VE scope.

Advisory process ends with a verification process by a third party, an institution not related to the Auditor Advisor or the Energy Advisor. This is to confirm the quality of the overall process, beginning with the energy consultancy and ending with the application of measures, to make sure financial resources were actually used for measures defined in the Master Plan.

Ultimately, confirmation of measures required for each unit or group will guarantee GHG emissions mitigation of at least 20% when adopted solutions include all measures in “Step 1”; in “Step 2”, 40% and in “Step 3”, 60%. All these emissions mitigation percentages are compared to the existing housing baseline and are standard values to receive subsidies for financial burden relief.

Table 6: Timeframe and chronology of NAMA for Sustainable Housing Retrofit implementation (Source: Passivhaus Institut)

NAMA VE timeframe	**Preparation (2014)** **First phase (2015 - 2016)**: Structure preparation for large-scale implementation; advice from international experts **Second phase(2016 – 2020)**: Large-scale implementation
NAMA VE roll-out schedules	**First phase (2015 - 2016)**: Projects identification and advice from international experts in suitable areas of action. Prepare Master Plan and energy balance using PHPP international tool v.9. Structures preparation for large-scale implementation: Players development and training (including Energy Advisors), establishment of financial structures, DEEVi tool adaptation for existing housing refurbishment, refurbishment dissemination and promotion among users, development of financial entities. **Second phase (2016 – 2019)**: Suitable energy efficiency improvements Implementation funded by international donors and Mexican government following the “Master Plan” according to characteristics and identified requirements by Energy Advisors through the DEEVi tool v.2. (Updated for existing housing refurbishment).

4.3.3 CALCULATION TOOL

To apply the 'whole house approach' following the previously established Master Plan developed during the energy consultancy, a reliable and adequate planning tool that allows detailed analysis of all energy efficiency parameters is needed.

The Infonavit has developed the Green Housing Evaluation System – SISEVIVE-ECOCASA – within Mexico´s Sustainable Energy Programme framework, implemented by GIZ[13]. The SISEVIVE-ECOCASA system uses two independent calculation tools: the DEEVi[14] tool (Energy-Efficient Housing Design tool for energy housing demand simulation considering conditions in Mexico), and the SAAVi[15] (Water housing saving simulation) which estimates projected water consumption through household devices that use water. By using these tools together, housing energy and environmental impact may be calculated.

Through the Mesa Transversal for Sustainable Housing, the CONAVI intends to apply the SISEVIVE-ECOCASA classification system for NAMA VN large-scale implementation and adapt it to be used in the existing housing sector. Because of its increasingly expanded use, once it is adapted to the existing housing, it would be of great advantage to use it for the NAMA VE energy consultancy scheme.

4.3.4 WATER SAVING

When referring to improvements on existing housing, it is essential to consider water consumption reduction, as these are "nationally appropriate" measures. Besides its mitigation potential, Mexico should pay special attention to water consumption reduction due to its generally low availability, which tends to decrease even more over time, especially in the north regions and the center of the country [CONAGUA 2013]. Because of the relevance of water care in Mexico, and aligned with the LGCC goals and the ENCC action lines, water consumption reduction should be part of NAMA VE´s objectives.

The SISEVIVE-ECOCASA qualification system through its SAAVi tool, estimates projected household water consumption per unit and inhabitant (liters/inhabitant/day), based on projected consumptions per device that use water. This Projected Water Consumption (CPA) is one of the three indicators that form the IDG and its value is weighted in the assessment, depending on the hydril pressure and its capacity installed for sewage treatment in the place of the unit to be assessed (SISVIVE -ECOCASA model). As the SAAVi tool was also designed for new housing calculations, the minimum level of water saving meets the prevailing norms. Because the level of water saving for older equipments might be lower, its use on existing housing calculations may require adaptations.

Moreover, it is estimated that the energy used in a water system to produce and distribute water among the population, as well as its treatment after use and final disposal, is 0.95 kWh/m3 [GIZ 2010]. Even this value may vary depending on the region, general average indicates that there is a GHG mitigation potential in housing water saving. Whether defined by a federal entity, by the local government, or depending on the locality size, this Specific Energetic Consumption Index value expressed in (kWh/m3), enables to quantify the energy related to water consumption and therefore, the GHG emissions on water consumption. Currently, this energy equivalent of water saving is not included in the SISEVIVE-ECOCASA tools. However, it would be highly recommended to include it in the tools for calculation.

[13] In cooperation with the Passivhaus Institut and the British Embassy in Mexico co-financing

[14] Developed upon request by the Passivhaus Institut in cooperation with the Infonavit, RUV and GIZ/GOPA-INTEGRATION.

[15] Developed upon request by the Infonavit, Conagua, Fundación IDEA and GIZ/GOPA-INTEGRATION

Although improvement measures on water saving are considered only in a standardized manner in the example calculated in the technical design, the NAMA VE energy consultancy should also analyze the potential of these savings by assessing and incorporating the quantification of the projected water consumption in GHG emissions.

4.4 MITIGATION POTENTIAL

In practice, the actual emissions reductions achievable by the NAMA will be highly dependent to the financing attraction. Instead of forecasting new expectations for the programme, this section provides general scenarios that illustrate the overall potential of the NAMA to affect the long-term emissions profile on the housing sector.

The calculation of the mitigation potential will follow three NAMA scenarios representing a 100% penetration of the efficiency standards, Step 1, Step 2 and Step 3 across all bioclimatic zones and building types.

The difference between "reduction potential" and "mitigation potential" regarding GHG emissions is that the first one is calculated through a standard comfort scenario, considering that the baseline is dynamic and the comfort and quality of life in Mexico will increase over time. The second one is calculated through a reduced comfort scenario, based on current existing conditions in Mexico. These two scenarios have been considered as the basis for the calculations provided below, in order to clearly illustrate both potentials.

There are several ways to move from the current situation to the achievement of GHG reduction objectives. Housing considered by this NAMA VE has no passive measures. Indoor comfort is low, as surveys show regarding users´ dissatisfaction of indoor climate conditions both in winter and summer (see [CMM 2013]). It was concluded that in general, there is no comfortable temperature inside the household. Therefore, the common solution to obtain comfort in this kind of climates, when resources are available, is to use cooling or heating active measures. The user may feel the comfort (although the risk of too much dry or cold air exists), but environmental consequences would be that the high production of energy when using air conditioning would generate GHG emissions.

Considering this, it may be argued that a way to reduce these GHG emissions would be the energy production through renewable sources. However, social housing considered by this NAMA VE is so inefficient, that to cover all the renewable energy demand, a high capacity to generate it would be required. Besides, wether this energy comes from renewable sources or not, there is obviously an impact to users economy when having to pay large electric power consumption bills to feel comfortable indoor.

Furthermore, if energy-efficient solutions are seeked, the indoor climate comfort will be reached. After their implementation, efficient housing is achieved, the demand to obtain comfort is reduced and energy and money expenses are lower. This is a safe way, not only for the user but also for the Mexican government, which benefits from savings on energy cost subsidies and from demand reduction, peak of the national electric system.

To provide a frame of reference, two baseline scenarios were calculated:

First scenario is calculated with a reduced comfort baseline, where temperature range is established, according to electricity and gas consumption values provided by GIZ through documents [GIZ/CMM 2013] and [CFE 2014].

For calculation purposes, efficiency values suggested in both documents, as well as the information of the NAMA VN Technical Design baseline, are considered. The assumption to define reduced comfort temperatures is that electricity and gas consumption values are considered a guide to establish the housing comfort level average, depending on each city climate. Electricity consumption values can provide information of possible presence of air conditioner in households. This is confirmed by the electricity consumption highest values reflected in Hot-dry climates: Monterrey and hot-humid climates: Merida. Following this assumption, after considering common domestic appliances that can be found in social housing, it is assumed that the difference in electricity consumption in these climates is owed to cooling systems during the summer. At the same time, energy efficiency values of air conditioning equipments removed

Building Type	Area m^2 [CMM2013]	Aprox SRE m^2 (85% over total area)	Electricity (kWh) [CMM 2013]	Electr. kWh/(m^{2}a) SRE	Electricity kWh/(m^{2}a) for NAMA calculations*
Guadalajara (Template)					
Adosada	98.17	83.44	1229.43	14.73	15
Aislada	104.02	88.42	942.29	10.66	11
Vertical	65.36	55.56	984.10	17.71	18
Mérida (Hot Humid)					
Aislada	57.70	49.05	1578.13	32.18	32
Adosada [CFE 2014]		51.50	2384.42	46.30	46
Vertical	Information not available				
Monterrey (Hot Dry)					
Aislada	46.14	39.22	1493.95	38.09	38
Adosada	Information not available				
Vertical	64.92	55.18	1303.86	23.63	24
Valle de México (semi - cold)					
Adosada	60.47	51.40	754.83	14.69	15
Aislada	83.41	70.90	1688.60	23.82	24
Vertical	57.46	48.84	962.28	19.70	20

Table 7. Values considered for reduced comfort baseline calculation
(Source: Centro Mario Molina 2013, adaptation by Passivhaus Institut).

LP Gas (kg) [CMM 2013]	LP Gas (kWh)	LP Gas kWh/(m²a) SRE	LP Gas kWh/(m²a) for NAMA*
Guadalajara (Template)			
38.97	494.14	5.92	6
60.31	764.73	8.65	9
54.66	693.09	12.48	12
Mérida (Hot Humid)			
67.13	851.21	17.36	17
Information not available. Aislada building type data is used			
Information not available. Aislada building type data is used			
Monterrey (Hot Dry)			
183.22	2323.23	59.24	59
Information not available. Aislada building type data is used			
180.91	2293.94	41.57	42
Valle de México (semi - cold)			
331.34	4201.39	81.74	82
222.42	2820.29	39.78	40
311.21	3946.14	80.80	81

during the ASI programme are used to determine the difference of kWh used for weatherization. In the way, the highest temperature allowed for summer is calculated. For climates in Guadalajara and Mexico City, no climate control device is considered, as concluded from the [GIZ/CMM 2013] information.

Table 7 presents electricity and gas consumption values used for these calculations.

Gas consumption data represent estimated values only, due to the difficulty of verifying cylindered LP gas consumption through the household survey [CMM 2013]. Therefore, results are used only as reference. This represents a challenge for the MRV system too, as data should be obtained in the most accurate possible way in housing with improvements.

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The following table show the parameters used to define baseline boundary conditions for the different climates.

Indoor comfort parameters: reduced comfort baseline			Mty	Gdl	DF	Mer
Maximum temperature for Winter	Simulated value with PHPP tool, based on electricity and gas consumption data from the Field Study [CMM 2013]		Different per zone			
Maximum temperature for Summer	Simulated value with PHPP tool, based on electricity and gas consumption data from the Field Study [CMM 2013]		Different per zone			
Maximum overheating frequency accepted when active cooling is not available	10 %	[PHI 2013]	X	X	X	X
Indoor maximum absolute humidity	Simulated value with PHPP tool, based on electricity and gas consumption data from the Field Study [CMM 2013]		Different per zone			
Humidity from internal sources	2 g/(m²h)	[PHPP]	X	X	X	X
Heat gains from internal sources in Winter	2.1 W/m²	[PHPP]	X	X	X	X
Heat gains from internal sources in Summer	Calculated with PHPP tool		X	X	X	X

Table 8. Indoor comfort parameters for reduced comfort baseline (Source: Passivhaus Institut).

The second scenario is calculated with a standard comfort baseline, where a comfort temperature range between 20°C (minimum for winter moths) and 25°C (maximum for summer months) was set based on [Fanger 1970] and International Standard [ISO 7730].

Maximum comfort limit, especially relevant for Mexico where hot climates dominate, is confirmed in the study [Gómez-Azpeitia 2007]. In this document, the temperature called "neutral temperature Tn" is determined for all regions, 26°C in general. In order to achieve the energy optimization required to ensure emissions reduction and prevention through a climate control system, the use of a 25°C temperature as the maximum comfort level is considered appropriate (allowing to surpass this temperature 10% over at all time), even in climates such as Monterrey and Merida. This also considers the assumption that, when possible, people used to environments with no air conditioning will prefer the same comfort levels that people used to environments with air conditioning (as established in [Fanger & Toftum 2002]).

This range avoids falling in the so called "bouncing effect" in which as soon as the occupants are able to raise the indoor comfort through the use of active cooling and/or heating, they do, thereby increasing their CO_2 emissions. Therefore, this range is proposed as the adequate for energy efficiency calculations and first projections on mitigation potential.

Indoor comfort parameters: standard comfort baseline			Mty	Gdl	DF	Mer
Maximum temperature for Winter	20 °C	[Fanger 1970] /[PHI 2012]	X	X	X	X
Maximum temperature for Summer	25 °C	[Fanger 1970] /[PHI 2012]	X	X	X	X
Maximum overheating frequency accepted	10 %	[PHI 2013]	X	X	X	X
Indoor maximum absolute humidity	12 g/kg	[Fanger 1970] /[PHI 7730]	X	X	X	X
Humidity from internal sources	2 g/(m²h)	[PHPP]	X	X	X	X
Heat gains from internal sources in Winter	2.1 W/m²	[PHPP]	X	X	X	X
Heat gains from internal sources in Summer	Calculated with PHPP tool		X	X	X	X

Table 9: Indoor comfort parameters for standard comfort baseline (Source: Passivhaus Institut).

Figure 10 below presents several energy efficiency scenarios according to standards established for NAMA VE in an Adosada building type in Merida.

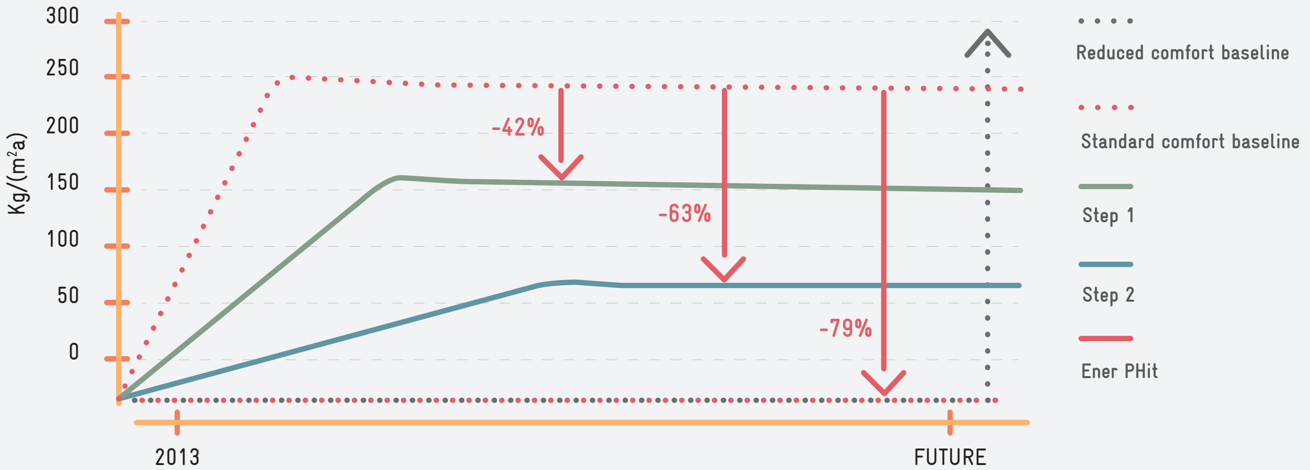


Figure 10: CO_2, levels represented under various energy efficiency scenarios in Merida (Source: Passivhaus Institut).

The different energy efficiency scenarios previously summarized, support housing energy refurbishment in a medium and long-term. Gray line represents the static baseline, while the red line represents the dynamic baseline and the maximum mitigation potential of NAMA VE actions. The other lines represent steps to follow to achieve the housing optimal performance, represented by the maroon line. The only standard that represents part of the saving compared with the baseline, is this last line. This shows how little is the potential if the baseline is considered static.

For the emission factor of the effective grid, a value of 0.584 Kg CO_2e/KWh has been applied. For the emission factor of liquefied petroleum gases, a value of 0.270 Kg CO_2e/KWh has been applied, as agreed in the Mesa Transversal for Sustainable Housing since 2012.

Figure 11 shows the optimization potential expressed in CO_2 emissions kg /m²a. In the case of reduced comfort (blue line), consumption is very low and improvement potential is limited. Line red represents the standard comfort case. While housing is refurbished and until comfort conditions are maintained for a whole year, the improvement potential is very significant. Step 1 for both scenarios is the same. The problem is that when comfort increases, even optimizations present higher consumption than the reduced comfort baseline.

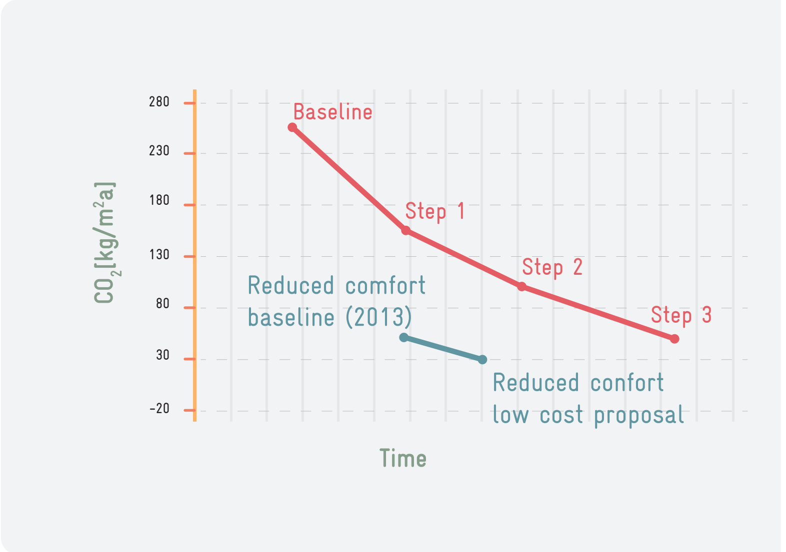
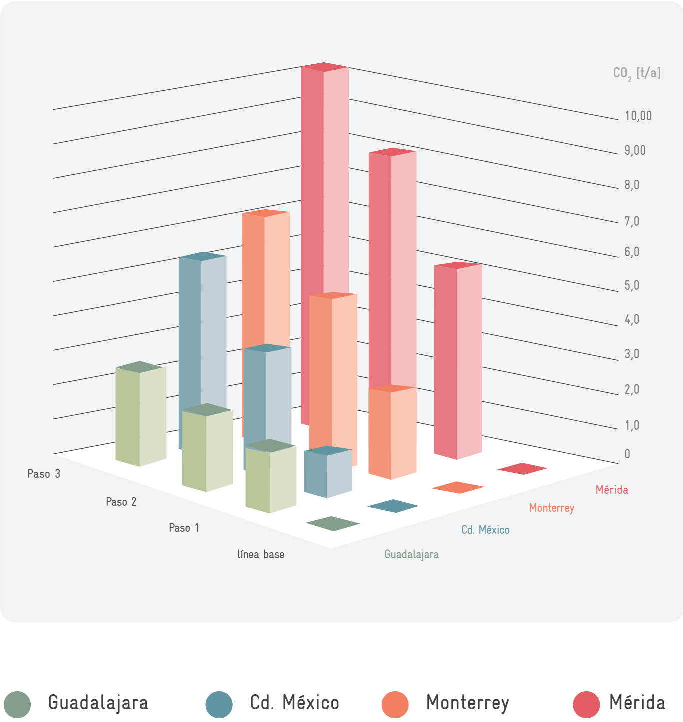


Figure 11: Comparison between standard comfort and reduced comfort variations. Adosada building type in Merida (Source: Passivhaus Institut)

The following figures illustrate the summary of mitigation potential and emissions reduction through the standard comfort calculation (left side) and the reduced comfort calculation (right side).



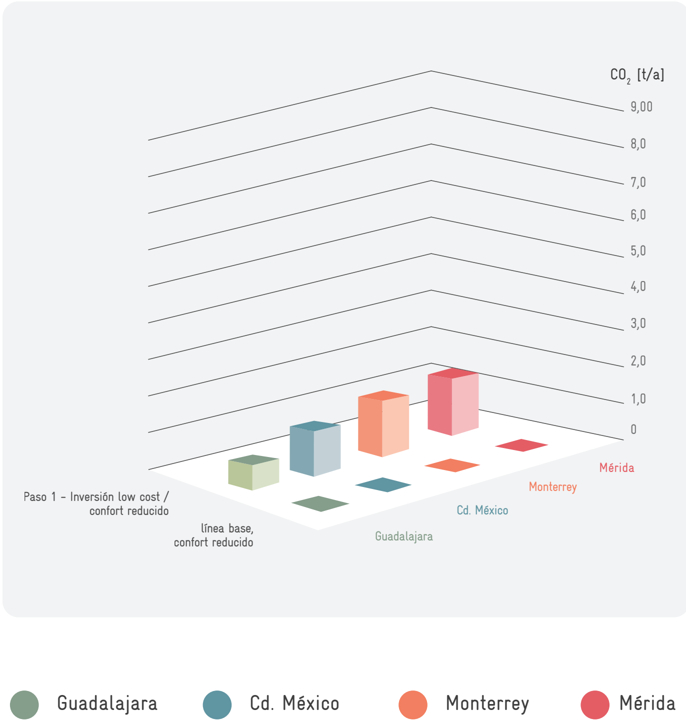


Figure 12: CO_2 emissions mitigation potential for Adosada building type in different climate zones analyzed (Source: Passivhaus Institut).

Figure 13: CO_2 emissions reduction potential for Adosada building ttype in different climate zones analyzed (Source: Passivhaus Institut).

As it can be observed in the figures above, left side (Figure 12) represents the mitigation potential and the right side (Figure 13) represents the reduction potential for the calculated example (Adosada building type), in the four climate zones indicated. It is clear the low potential it would represent to apply housing improvements in current conditions, due to the lack of comfort. A big difference between the potentials is observed, especially in the case of Step 1, even for both scenarios same measures apply (domestic appliances replacement and solar heater). In the case of Mexico City, and for some building types in Guadalajara, mitigation potential for Step 1 is less than 20%. Therefore, this first step does not achieve the mitigation optimal level. Therefore, for the NAMA VE implementation, this example would be cancelled (light blue in Figure 13).

4.5 NON-GHG CO-BENEFITS (BENEFITS NOT RELATED TO GHG EMISSIONS BENEFITS)

NAMA VE should result in benefits other than GHG emissions reductions for the country. The NAMA concept looks for a demonstrable effect on sustainability which is included in the MRV system. In general terms, both the integrated actions approach of NAMAs and the expansion of the sector become additional contributions that can lead the transformation of the sector towards sustainable development.

Some co-benefits have been preliminarily studied and precise monitoring procedures are being designed. These co-benefits will most likely contribute to following scopes:

Table 10: Selected co-benefits of the NAMA for Sustainable Housing Retrofit
(Source: Mesa Transversal for Sustainable Housing, adaptation by the Passivhaus Institut).

Economy	• Economic savings for households reflected in electricity, fuel and water bills • Reduction of energy subsidy costs to support NAMA VE measures funding • Increase in the number of green companies and jobs • Extended housing quality and lifecycle • Workers productivity increase due to improved comfort conditions
Enviroment	• Air quality • Water and energy savings
Social	• Leverage effect in comfort increase through the combination of NAMA VE measures with electrical and sanitation equipment refurbishment and/or dwelling expansion • Indoor housing comfort regarding temperature and humidity benchmarks • Access and promotion of clean energy services • Human and institutional capacity building • Education and awareness of sustainability for householders • Improvements on householders health through comfort and air quality improvements

4.6 NAMA FOR EXISTING HOUSING RETROFIT IMPLEMENTATION

The implementation of the NAMA VE should be integrated to the institutional structures in Mexico. The following organization chart (Figure 14) represents the proposal of the NAMA VE general operation.

In general, it is proposed that the NAMA VE operates through the ONAVIs. In case of international financing, funds should be sent directly to the corresponding ONAVI. It is also proposed that the financial entity should be the body responsible to manage financing and the energy consultancy through the Auditor Advisor and Energy Advisors. Promotion prior to actions is essential, and it is proposed to be carried out through the ONAVI. The building companies should implement, supervise and execute the proposed measures of projects, essential for its application success. Similarly, at the end of these actions, a neutral verification process (ideally by the ONAVI) should be carried out to guarantee that funds have been used based on the Master Plan. Each institution should work to integrate the suggested functions in their respective structures or, as appropriate, adapt them for optimal performance.

NAMA
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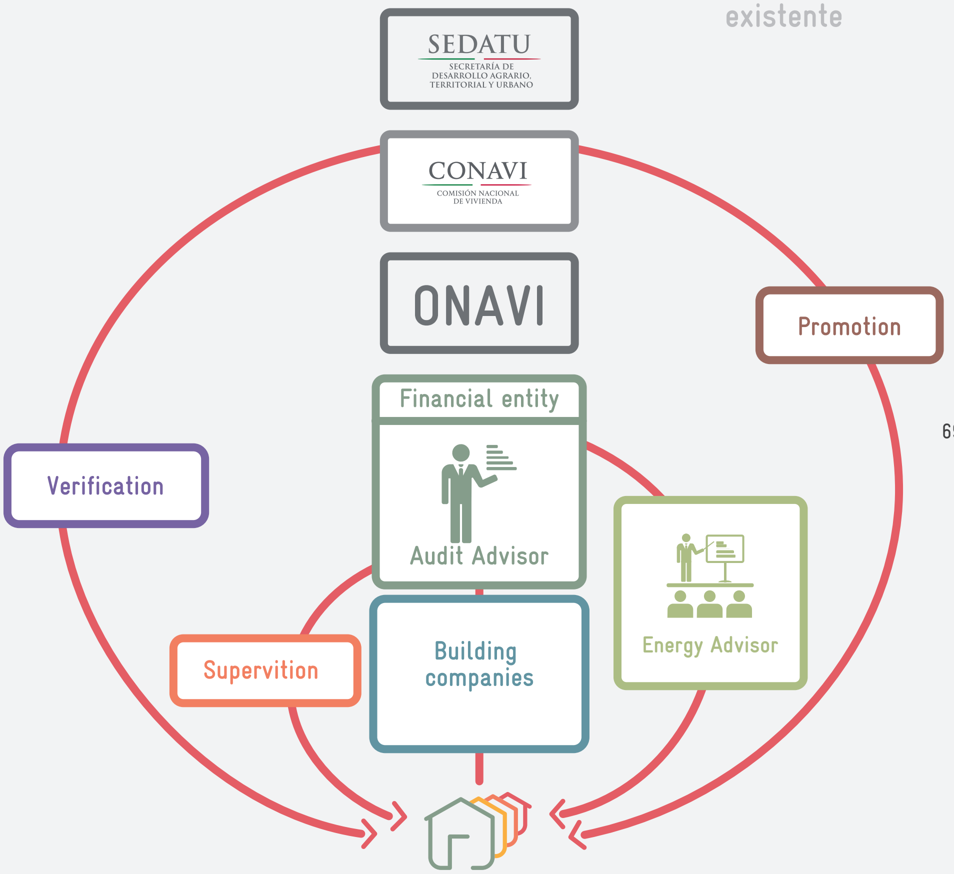

Figure 14: General organization chart proposed to integrate the NAMA for Sustainable Housing Retrofit (Source: GIZ / Passivhaus Institut).

4.7 MEASURES FOR THE INITIAL IMPLEMENTATION PHASE

For NAMA VE implementation phase, certain essential actions should be performed to start working. These measures are described below:

- Development of the methodology and teaching material to train Energy Advisors, Audit Advisors, supervisors and verifiers in energy assessment and existing housing refurbishment, including knowledge on the NAMA VE administrative processes
- Training and certification of Energy Advisors, Audit Advisors, supervisors and verifiers
- Adaptation of calculation tools for existing housing assessment (i.e. SISEVIVE-ECOCASA) including adapting the IDG to integrate existing housing in the calculation
- Energy consultancy for projects in NAMA VE implementation phase

Table 11: Measures for implementation phase including estimated costs (Source: Passivhaus Institut, GOPA)

Concept	Estimated cost
Development of methodology and teaching material to train Energy Advisors, Audit Advisors, supervisors and verifiers in energy assessment and existing housing refurbishment, including knowledge on the NAMA VE administrative processes (includes teaching material for instructors, training material for Energy Advisor course and "train-the-trainer" course)	300,000 USD
Training material for the additional module to train Auditor Advisors (Two courses including training material for Auditor Advisors, certification and travel expenses for international experts)	175,000 USD
Training courses for other key players	Auto-financed
Adaptation of SISEVIVE-ECOCASA calculation tools (DEEVi, SAAVi and IDG), including training materials and corresponding manuals	Between 110,000 USD and 175,000 USD

The following figure shows the actions that should be carried out in parallel to prepare the existing housing sector for NAMA VE large-scale implementation:

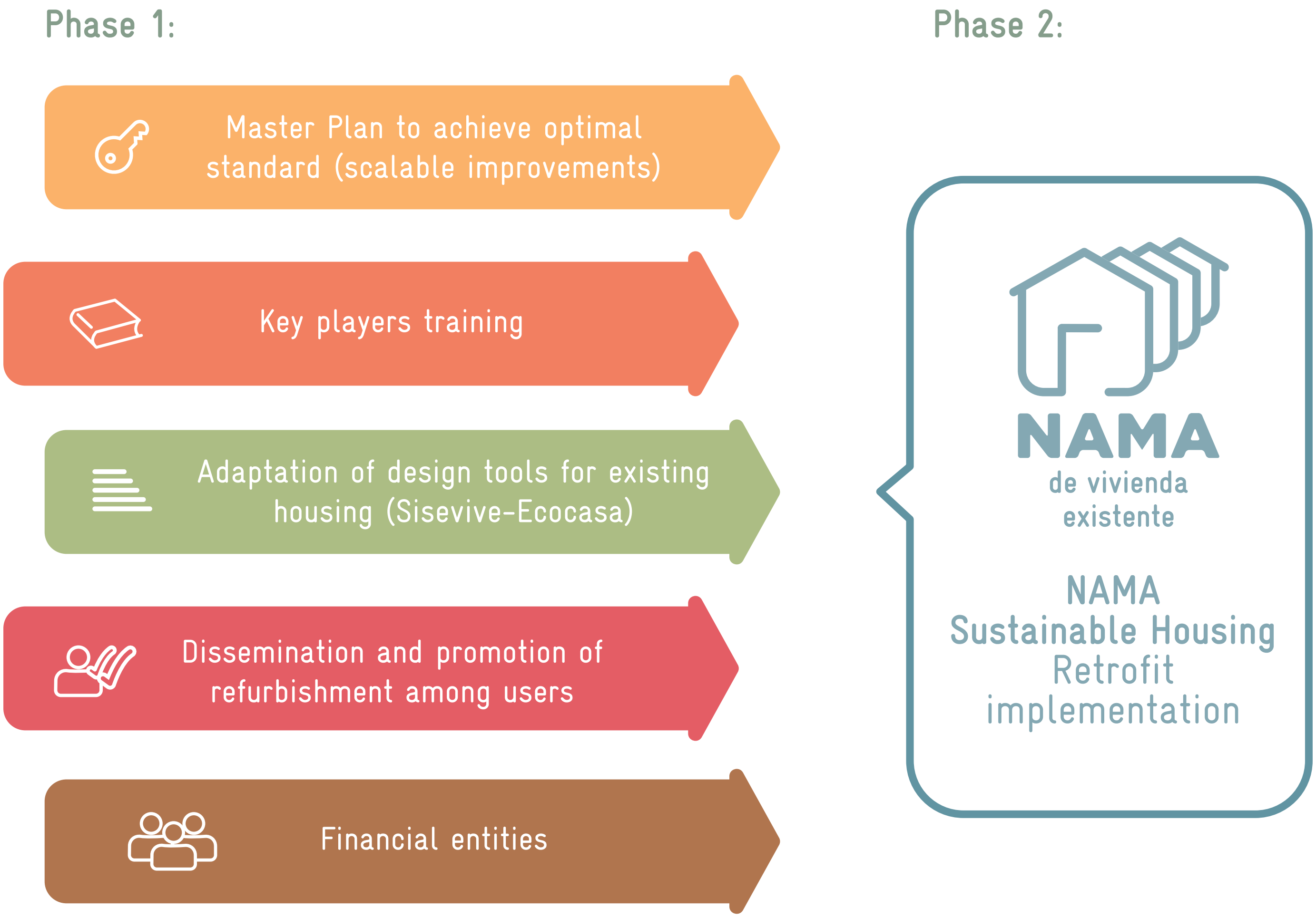

Figure 15: Measures for the NAMA for Sustainable Housing Retrofit initial implementation phase (Source: Passivhaus Institut).

4.8 INDIRECT MEASURES OF THE NAMA FOR SUSTAINABLE HOUSING RETROFIT

Besides housing improvement actions, which have a direct impact in GHG mitigation emissions, there are other essential measures that will indirectly support the achievement of the ambitious goals.

Promotional System

A promotional system through the NAMA VE will have positive effects on the overall energy efficiency system in the building sector in Mexico:

• It will demonstrate that it is possible to introduce primary energy demand target values into the Mexican building sector, promoting the further development of building regulations.

• It will create a demand for Energy Advisors, Energy Auditors and qualified architects capable of applying specific calculation and design tools. Thus, it will lead to additional jobs and strengthen the capacities while building process continues using existing platforms and personnel, such as RUV and housing verifiers.

• It will also create demand for more energy-efficient buildings, building equipment and further appropriate construction materials. Energy-efficient equipment and construction material which have to be imported nowadays, could then be produced in Mexico and be offered at more attractive prices on the local market, thus making energy-efficient houses more competitive.

• The implementation of pilot projects with partial improvement, as well as the application of the energy efficiency highest standard for refurbishments (based on the methodology of Step by Step Refurbishment to achieve the optimal energy and environmental performance), will demonstrate the feasibility to implement energy efficiency in residential buildings for low-income families through very high standards, contrasted internationally.

The following aspects are also crucial for the NAMA VE indirect measures:

Development of mandatory building codes and licensing procedures

As discussed in section 2, the building codes applied in the Mexican housing sector, do not cover the full spectrum of potential energy efficiency measures. Moreover, weak enforcement of building codes contributes to low levels of energy efficiency in standard newly built houses. The NAMA VN and NAMA VE will introduce clear efficiency standards contrasted internationally.

Because local governments have the authority regarding enforcement of the building codes, an additional coverage should be defined to ensure that NAMA VE standards are compatible with local mandates.

Capacity building

One of the key prerequisites to achieve the objectives is the transfer of knowledge and experience related to energy efficiency in buildings. This can be done through wider educational experiences and specific training with a wider scope.

The 'Mesa Transversal' was promoted by the CONAVI to share and increase knowledge about energy efficiency and sustainability among building developers, international cooperation agencies, the academia, and the public and private sectors. CONAVE has involved these entities in the NAMA VN development process and could similarly support the NAMA VE.

In order to promote the 'whole house approach' in buildings and environmental friendly development, there is also a need for capacity building at municipal and state levels regarding the Public Sustainable Housing Policy.

Within the context of the NAMA VE, the supply-chain in the building sector should be considered. These stakeholders need reliable information, individual support (consultancy), and clear criteria in order to develop solutions and orient their business activities towards sustainable investments. Additionally, the increase of local production and the installation of energy-efficient building materials and equipment can be supported by training and informing the business sector, construction and housing technicians (non-academic background): plumbers, masons, electricians, building service installers, among others.

Promotion, awareness and information given to home-owners who in the end decide whether or not implement refurbishment, should also be integrated in the NAMA VE, seeking to increase Mexican families motivation to household refurbishment, considering improving energy efficiency.

In summary, for the Sustainable Housing NAMA to succeed, it is critical that stakeholders such as citizens, housing developers and regional governments understand the value and benefits that can be generated through pro-active efforts to improve housing sustainability

Pilot Projects: Demonstrating the NAMA for Sustainable Housing Retrofit

To demonstrate quality and energy efficiency, several pilot projects have been implemented by CONAVI and Infonavit, with support from GIZ and domestic housing consultants. These projects will not only provide an excellent training opportunity, but also valuable data for the development of the planning tool and an opportunity to calibrate the MRV system as well as data collection of the first experiences, in order to identify opportunities to upgrade the NAMA VE implementation.

It is also expected to implement in these projects, the highest energy efficiency defined by the NAMA VE (Step 3) to demonstrate the quality and energy efficiency that can be achieved in existing housing in Mexico. They will not only demonstrate emissions mitigation through the MRV system, but may also serve as an opportunity for builders who are dedicated to house improvements to be trained and learn. For the development of these first pilot projects, the support of experts in the application of energy efficiency refurbishment will be required, especially in the most extreme climate zones in Mexico. Experts working together local builders will also be very positive for NAMA VE large-scale implementation.

Raising public awareness

The Mexican government is developing an 'internal' marketing strategy in Mexico, using several communication channels to raise general awareness and achieve broaden participation. This could be done through mass media campaigns on TV, radio and newspapers as well as the distribution of information brochures and marketing material. In addition, the creation of a website to explain and promote the benefits of the NAMA VE is suggested. Pilot projects are also an excellent mean to promote the concept: a refurbished household example is a better proof than any brochure, publication, or discussion. In order to overcome the barriers outlined in section 3, these developments will need to be supported by information campaigns, training and advisory services during the implementation of the NAMA VE.

Table 12, shows the supportive and administrative actions that will be required during the implementation phase of the NAMA VE (2015–2019):

Table 12: NAMA for Sustainable Housing Retrofit administrative and supportive actions (Source: IzN Friedrichsdorf).

1.	**Institutional set-up and NAMA administration**
1.1	Designing a fund for financial resources, including legal agreements
1.2	Integrate the development of the NAMA VE in the Mesa Transversal and consolidate it through a Technical Working Group
1.3	Designing, establishment and operation of the "NAMA Programme Office Unit"
1.4	Baseline, MRV and framework addition
1.4.1	Development of data-collection systems to accurately measure, report and verify emissions: Integration of a comprehensive data base (baseline and MRV) of houses and energy consumption and demand to the CONAVI data base for NAMA VN
1.4.2	Capacity building and capacity build-up for monitoring and auditing. Establishment of a professional and specialized inspection and supervision system
1.4.3	Comprehensive household monitoring and auditing surveys (i.e. simulation using data base and detailed surveys)
1.5	Development of national financing mechanisms for energy improvements in existing housing
1.6	Development and implementation of the energy consultancy programme for existing housing and the creation of the energy advisor charge to supervise all actions
1.7	Adaptation of the Sisevive calculation tool and the qualification system to include the existing housing
1.8	Technical Assistance to CONAVI, RUV, Infonavit, FOVISSSTE and SHF in the establishment of their institutional set-up for the implementation of the NAMA VE

2. Building Codes and permitting procedures

2.1	Technical Assistance to local governments and organizations at state and municipal levels for introduction of a minimum energy performance standard, the whole building approach and target values for primary energy consumption as well as sustainability criteria Elaboration of a national guideline for Building Code adaptation

3. Capacity building

3.1	Training for consultants (supervisors) energy advisors, planners and construction workers on energy efficiency building through simulation tools
3.1.1	Scaling up of university/commercial school curricula on EE buildings and RE in buildings
3.1.2	Translation and adaptation of European/PHI training material to Mexican climate and building traditions; check after experience
3.1.3	Training through a 'Train the trainer approach' with local partners. The local partners consecutively, provide training and design of energy-efficient buildings for developers and planners throughout Mexico and special training for construction workers
3.1.4	Training for construction workers on proper installation of proposed measures, especially those that are more innovative
3.1.5	Training for products and components suppliers on energy efficiency
3.2	Training to local authorities and stakeholders

3.2.1	CONAVI will also perform capacity building for local, state and federal authorities by attendance courses, virtual learning and the construction of an inter-institutional platform. Objective: local authorities and stakeholders are able to introduce and implement sustainability criteria in their daily processes and decisions involved in urban housing master plans and house construction efficiency levels
3.3	Training to house-owners/users
3.3.1	Production of a manual for house-owners/users in order to understand and optimize the use of energy efficient Houses
3.3.2	Campaigns to increase awareness of energy efficiency not only for buildings but also with design, equipments and appliances
3.4	Encouragement and support of regional manufacturers and companies to increase the availability of suitable products
3.4.1	Guideline and support for manufacturers through local partner and international advisory
3.4.2	Adaptation of certification criteria for local Mexican products

4. Pilot Projects and software adaptation	
4.1	Quality assurance of all designs and refurbishment applying standard Step by step refurbishment to achieve optimal energy and environmental performance. Develop and adaptation of DEEVi calculation tool for existing housing refurbishment
4.2	Technical assistance in design and construction of Pilot Projects in different locations in Mexico
4.3	Monitoring of Pilot Projects and transfer of results and lessons learned into capacity building, demonstration projects and dissemination

5. Marketing and advertising	
5.1.	Website (development & maintenance)
5.2.	Mass media campaign (TV, radio, newspaper)
5.3.	Promotion for participation (brochures and marketing material)
5.4.	Demonstration and dissemination: make success visible

5 The MRV system: Monitoring, Reporting & Verification

The primary purpose of a MRV system of any NAMA would be to measure the impact of the measures implemented to assess their contribution to the national and international energy and climate policy objectives. The general consensus appears to be that the MRV should allow more flexibility and simplicity than the current approaches under the CDM, and that MRV procedures should be practical, rather than a burden or a barrier to the implementation of the NAMA, but at the same time ensuring the quality and accuracy of the collected data.

The concept for the MRV system of the NAMA VE is based on the following recommendations: use a whole house approach, use a consumption adjustment methodology, build a MRV system based on the adaptation of the VM0008 methodology "Weatherization for Aislada building type or multi-family building type" of the Voluntary Carbon Standard and develop a phased MRV system addressed to two different phases of the NAMA VE. These guidelines are discussed below.

WHOLE HOUSE APPROACH

The "whole house approach" concept (see section 4.2) is the core of the NAMA VE concept, as it was for the NAMA VN concept. It is considered the most appropriate approach for the evaluation and planning of energy efficiency in buildings.

CONSUMPTION ADJUSTMENT METHODOLOGY

The consumption adjustment methodology is based on measuring housing performance before project implementation (ex-ante). This measured performance should be then adapted considering the feasible variables that influence consumption, such as temperature, to adjust the baseline. This adjustment presents the difficulty to access historical data required and the uncertainty to forecast comfort conditions and future housing equipping (especially if NAMA VE considers a 30 year-cycle). The proposal is to combine this methodology with the calculation of a baseline through a calculation tool (for example, the Sivive-Ecocasa tool). This enables to consider a dynamic baseline, which is the basis for the emissions mitigation calculation of the technical design.

DEVELOPMENT OF AN MRV PHASE-BASED SYSTEM, ADDRESSED TO TWO DIFFERENT NAMA PHASES

The proposal is to divide the MRV system in two phases presented below:

- NAMA VE implementation phase: a MRV system for pilot projects and data collection to calibrate boundary conditions used in the modeling software for housing performance, as well as initial quality control
- NAMA VE monitoring phase: a MRV system for NAMA VE large-scale implementation phase, using modeling software for housing performance

In parallel with the NAMA VN, include two types of monitoring:

- Simple monitoring: for emissions reductions calculations and water consumption reduction
- Detailed monitoring: to collect more information on specific measures and for quality control

Figure 15, summarizes the recommended strategy in the original document [GIZ/MGM Innova 2013]:

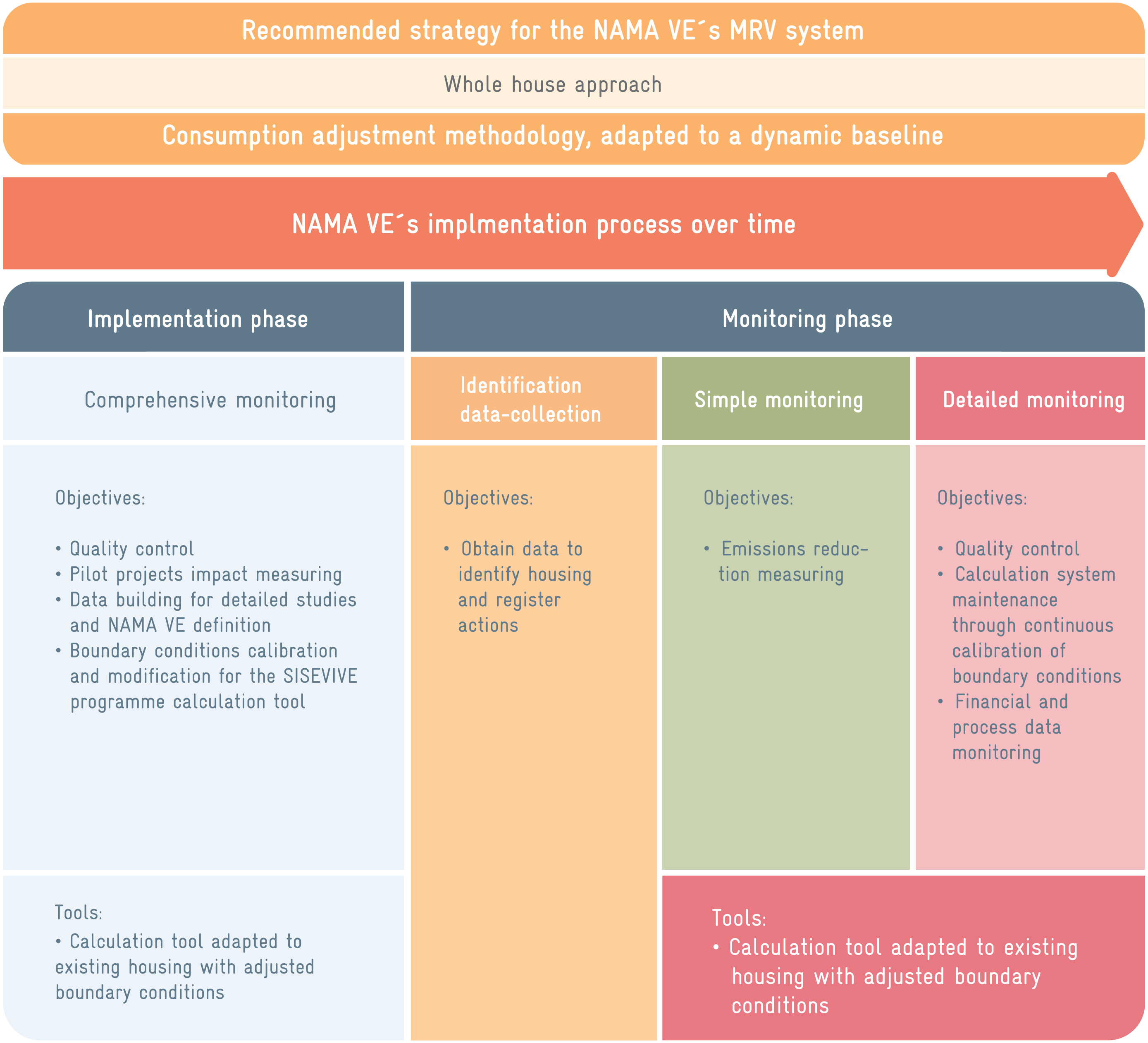

Figure 16: Recommended strategy for MRV of the NAMA for Sustainable Housing Retrofit. Source [GIZ/MGM Innova 2013], adaptation by Passivhaus Institut

5.1 GHG EMISSIONS CONSIDERED BY THE MRV SYSTEM OF THE NAMA FOR SUSTAINABLE HOUSING RETROFIT

Both for the implementation and the monitoring phase, the NAMA VE intends to measure actions impact in order to calibrate calculation boundary conditions. GHG emissions considered for NAMA VE´s monitoring are shown in the following table:

Table 13: GHG emissions considered by the MRV system of the NAMA for Sustainable Housing Retrofit (Source: MGM Innova 2013 based in VM0008, adaptation by Passivhaus Institut).

Baseline	CO_2	Emissions related to housing electricity consumption. Consider dynamic baseline (see [NAMA VE 2014]) through applying a correction factor.
	CO_2	Emissions related to housing gas consumption. Consider dynamic baseline (see [NAMA VE 2014]) through applying a correction factor.
Project	CO_2	Emissions related to housing electricity consumption.
	CO_2	Emissions related to housing gas consumption.
Leakage (fugas)	CO_2	Emissions related to the use of replaced equipment but not properly destroyed.
	HFC	GHG emissions due to wrong use of equipments and destruction.

5.2 MRV MITIGATION EMISSIONS BASELINE

The baseline is established by the household electricity, gas and water consumption previous to renewal or project implementation, based on calculations made by a pre-defined tool to compare identical comfort and equipment levels.
For the NAMA VE concept, a dynamic baseline is set up. This means that consumption increases over time, reflecting the raise of quality of life and economic capacity levels of a country, including the social housing type. This assumption has not only been observed in Mexico, but in many other countries where economic conditions have improved and, along with them, inhabitant comfort and energy consumption. A period of 30 years is being considered as the housing lifespan (safe period, as housing lasts more than this average).

To define this dynamic baseline, housing indoor temperature and external climate conditions after improvements should be collected. Once this data is registered, boundary conditions from a reliable calculation tool may be calibrated. The user will be enabled to change boundary conditions (for example, PHPP or DEEVi tools, with proper adaptations), to calculate a baseline based on the same comfort conditions of improved housing.

Thus, it is no longer necessary to use correction factors, e.g. for electricity demand, as it is assumed that under the same conditions of improved comfort, the original building behaves inefficiently. In this way, prevention of GHG emissions increase in the future within a realistic scenario of increased comfort and equipment, is proved. This is a benefit too, since the need to measure or collect data regarding baseline consumptions is avoided. Only the necessary information of the baseline for the calculation tool is needed.

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5.3 METRICS AND TECHNICAL PARAMETERS

As the monitoring system has a whole house approach, electricity and gas consumptions should be considered. For electricity consumption, it is important to consider all parameters having direct influence, as well as energy emissions from cooling devices for air conditioning and refrigerators.

Building thermal envelope features should be considered in detail due to its great influence in energy consumption. An important commonly forgotten aspect is to determine temporary shading elements (curtains, blinds, etc.) with great influence in building radiation heat gains too, especially if they are outside. This information may be collected through a survey.

The importance of metrics is highlighted not only because of emissions savings monitoring, reporting and verification, but also for boundary conditions calibration to calculate energy balance.

The different uses and users' behavior have a crucial influence in monitored consumption values. In this case, not only isolated parameters should be compared, for example energy for cooling. This energy could be influenced by other peripheral electric consumptions, such as inefficient lighting, frequent cooking or the use of additional existing shading elements. First, all energy consumption aspects should be determined, as well as users' customs and traditions to draw conclusions on measured energy consumptions. The whole house approach calculation is based in this principle.

When comparing data from monitored projects with the results of an energy efficiency calculation tool such as DEEVi or PHPP, it is essential:

- To have statistically enough buildings
- To adapt the calculation model boundary conditions to real conditions, including all construction aspects of the building (and aspects such as additional shading elements, internal heating sources, etc.).

5.4 CRITERIA AND RECOMMENDATIONS FOR THE MRV SYSTEM AT ITS MONITORING PHASE

MRV system detailed design in NAMA VE´s monitoring phase will depend on specific structuring matters, such as the selection process of housing to be improved, definition of improvement packages, IDG criteria definition, improvement actions that will be considered, among others. However, despite strategies to follow for the NAMA VE monitoring phase can only be discussed, some aspects to apply in the monitoring phase may already be recommended:

- A calculation system with calibrated boundary conditions based on projects measurements is required. Ideally, this system should ease user to configure calculations, according to corresponding measures and data collection. It is recommended to use a calculation tool with high levels of detailed analysis that enables the user to adapt boundary conditions according to measures (for example PHPP tool), especially in higher energy efficiency projects and pilot projects. The DEEVi tool could also be used in case modifications to the NAMA VE Technical Design regarding boundary conditions adaptation are available.

- Defined system to register NAMA VE actions

- Energy advisors training on the use of a calculation tool for existing housing (as agreed in the NAMA VE's technical design).

The following figure presents an updated proposal for the transition process of the monitoring system from the implementation phase to the monitoring phase:

The following figure presents the updated proposal for the transition process of the monitoring system from the initial phase to the monitoring phase:

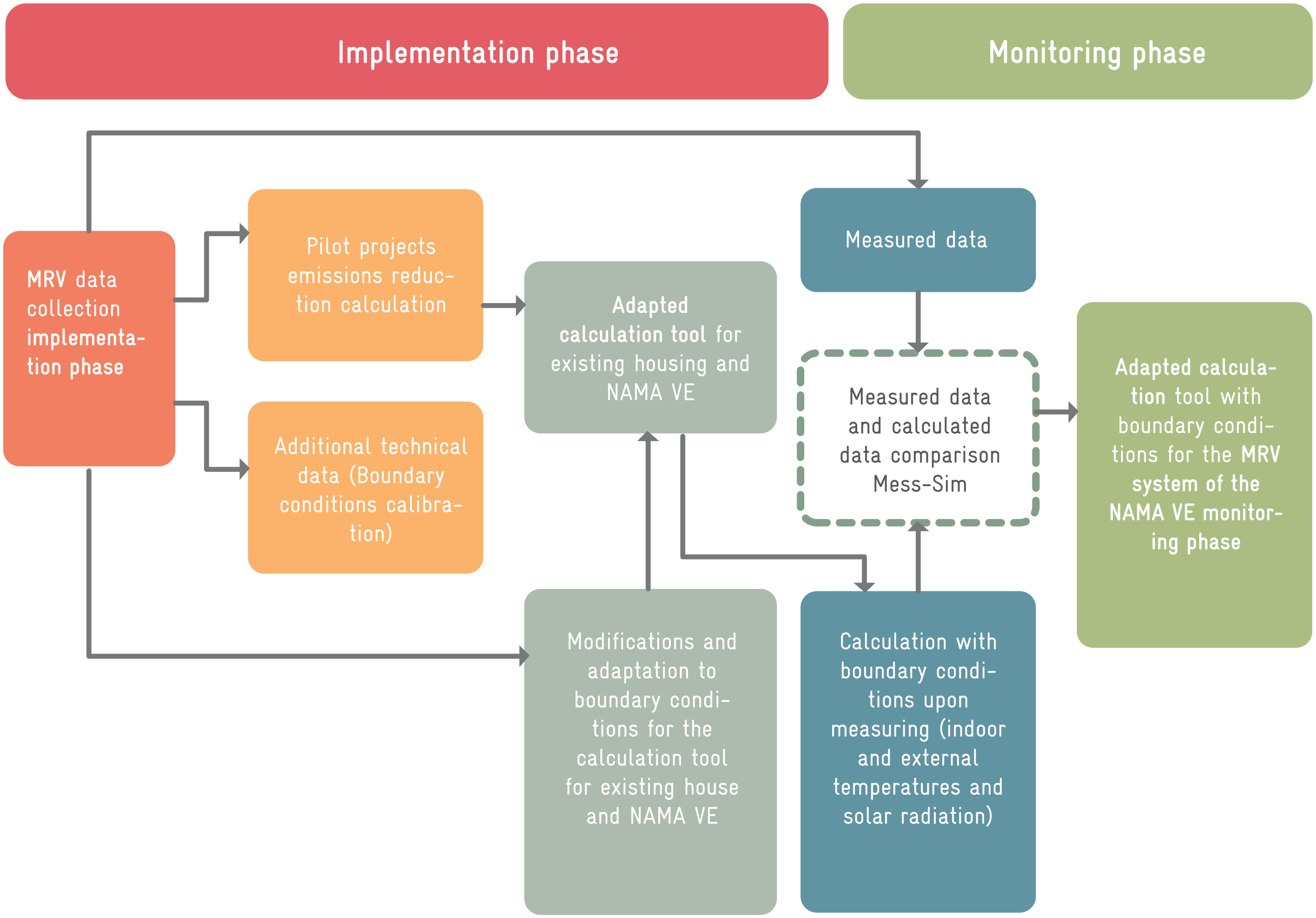

Figure 17: Transition process of the monitoring system, from the implementation phase to the monitoring phase (Source: GIZ/MGM Innova, adaptation by the Passivhaus Institut).

5.5 MONITORING PLAN

As shown in Figure 16, in the monitoring phase, 3 components are proposed:

- Identification data collection
- Simple monitoring
- Detailed monitoring

For the registration of housing actions and with the objective to collect the necessary information for the process to obtain funding for improvements, identification data collection shown in the next table is required. This information should be collected in the 100% of the housing considered for improvements implementation under the NAMA VE.

Building address
Energy reference surface
Building lifecycle
Building type
Type of building materials
List of improvement measures

Table 14: Data for the registration process (Source: MGM Innova, adaptation by Passivhaus Institut).

Simple monitoring is focused on essential data collection for emissions to calculate energy consumption reduction of all installed measures.

On the other hand, detailed monitoring is focused on the frequent calibration of the calculation tool boundary conditions. This should enable to obtain an energy saving and water consumption breakdown of specific measures, with the purpose to assess their effectiveness, execute quality control on measures installation and a follow up on other not essential indicators for emissions reduction calculation, such as process and financial metrics.

Although MRV system metrics and specific technical parameters for the NAMA VE monitoring phase cannot be defined with previous accuracy to the definition of the operation and the calculation tool features, it is expected that metrics to be monitored are very similar to those defined for the NAMA VE implementation phase.

5.6 DEFINITION AND SELECTION OF THE SAMPLE SIZE TO BE MONITORED

For the implementation of the MRV system during the NAMA VE pilot project phase, it is proposed to monitor all pilot housing. However, if this is a large number within one project, a statistically representative sample should be defined. These criteria also apply to the monitoring process during the NAMA VE monitoring phase. The updated criteria to select the sample to be monitored are described as follows

5.7 SAMPLE TO BE MONITORED AT THE MONITORING PHASE

It is important that a sample is statistically representative to draw conclusions of informative value. Therefore, the proposal is to monitor 15 houses per group and select two building types. To decide which types are the most representative previous to monitoring, the current volume of the existing housing stock and the available projects should be considered. Similarly, the proposal is to monitor only two of the energy efficiency levels proposed in order to reduce the amount of identical houses to be monitored from three to two and the amount of packages, from four to two. The baseline would be calculated with a tool such as DEEVi or PHPP, according to the amendment of methodology to use.

The result would be 480 houses to be monitored. The summary of this proposal is presented in the following table:

Table 15: Proposal for pilot projects monitoring groups (Source: Passivhaus Institut).

Building type	Bioclimatic zone	Savings percentage levels (Savings mín. 20%)	Total of groups considered for monitoring	Total of buildings to be monitored (1.85 σ)
Type 2	Zone 1 (hot dry)	Step 1 Step 3	2 building types x 4 bioclimatic zones x 2 energy efficiency savings levels ---------------- 16 groups	32 groups x 15 buildings to be monitored ------------ 480 houses to be monitored
	Zone 2 (template)	Step 1 Step 3		
	Zona 3 (cold template)	Step 1 Step 3		
	Zona 4 (hot humid)	Step 1 Step 3		
Type 3	Zone 1 (hot dry)	Step 1 Step 3	2 building types X 4 bioclimatic zones X 2 energy efficiency savings levels ---------------- 16 groups	
	Zone 2 (template)	Step 1 Step 3		
	Zone 3 (cold template)	Step 1 Step 3		
	Zone 4 (hot humid)	Step 1 Step 3		

To have statistically relevant monitoring results, monitored buildings should be identical to each other in terms of the following characteristics:

Architectural design | Orientation | Location (same building development)

5.8 MONITORING DURING THE NAMA FOR SUSTAINABLE HOUSING RETROFIT MONITORING PHASE

The following table shows the summary of elements for simple monitoring and detailed monitoring that enables emissions reduction calculation, based on [GIZ/MGM Innova 2013]:

Table 16: Simple and detailed monitoring elements summary for emissions reduction calculations (Source: GIZ/MGM Innova).

Elements	Simple monitoring	Detailed monitoring
Objetivo	Emissions and water consumption reduction calculation	Boundary conditions calibration for the calculation tool, quality control, process and financial metrics
Sample size	The square root of the total number of houses[16]	From 5 to 15 houses by type of energy efficiency benchmark applied (20% minimum of energy saving).
Disaggregation	Similar to the one of the MRV system in the initial phase	Similar to the one of the MRV system in the initial phase

[16] This is a temporary or initial proposal as this element cannot be defined a priori, as no variability sources and its digree of variation or dispersion is particularly known

Elements	Simple Monitoring	Detailed Monitoring
Data for baseline	Necessary data for ex – ante calculation (once)	Ex – ante energy consumption data through billing (once)
Data consumption for the project	Ex – ante energy consumption data through billing (monthly, if possible)	Data for Ex – post calculation (Monthly)
Other		Process and financial metrics: data collection for process and financial metrics calculation

5.9 RESPONSIBILITIES IN THE MRV SYSTEM

Because the responsibility of the MRV system is held by each investor to verify expected performance and given the NAMA VE concept is only in its implementation phase, it will be counterproductive to define tasks in detail within the MRV of the NAMA VE. This should be done when funding possibilities are clear and which actors will be involved.

For the definition of responsibilities, the CONAVI and the Infonavit are identified as possible NAMA VE's MRV coordinators. Because of its previous experience with the NAMA VN and considering the data base that is being developed to register NAMA VN monitoring results, the CONAVI would be a cornerstone to manage the MRV of the NAMA VE too. In addition, the Mesa Transversal may be the framework that enables collaboration and a harmonic development of the MRV among all stakeholders involved, finding synergies and assuring a profitable learning during the process for all players. Also, the RUV (Registro Único de Vivienda), as an administrator of the social housing registry in Mexico, would play a leading roll regarding housing data and its availability.

5.10 BARRIERS AND CHALLENGES

The major barrier to implement the MRV system is data access. Additional challenges are lack of necessary institutional frameworks and procedures, trained personnel, and/or resources.

The Sustainable Housing NAMA has made important progress on data access needed to operate the MRV through a series of formal agreements with public service providers such as CFE, CONAGUA, and DTI. The issue becomes more relevant for housing units. Access may become more complex in the case of reference homes, where initiatives would be implemented to access to the same data.

Another challenge is to balance the need for robust and reliable estimates and the need to maintain MRV system flexibility, simplicity and cost-effectiveness for the proposed NAMA VE. Ideally, MRV can be as accurate as necessary and as simple as possible. Once the guide is developed by the UNFCCC, specific requirements for registration under an international regime can be incorporated to the proposed MRV system.

This challenge have methodological issues, such as the selection of the baseline approach, the selection of monitoring data-collection methods, selection of monitoring metrics and monitoring frequency.

In the coming months, as the proposed NAMA VE concept is refined and developed, further analysis will be carried out to establish data availability, identified approaches suitability, and the possibilities to develop synergies to coordinate the climate initiatives in the housing sector in Mexico.

NAMA´s database is currently under development and will become a centralized source of information for regulators, researchers, and industry professionals to assess and compare sustainable housing developments performance, both for NAMA VN and NAMA VE.

6 Financing the NAMA for Sustainable Housing Retrofit: Required resources and institutional set-up

6.1 INCREMENTAL INVESTMENT COSTS AND ENERGY SAVINGS

The investment costs were calculated based on the estimation of the measures costs for the three identified steps. A first estimate, 'current costs', reflects the costs incurred if measures described are applied in 3 phases or steps.

A second scenario is based on the (more realistic) assumption that once the energy-efficient building becomes common in Mexico through the NAMA VE, the costs of some components will reduce significantly due to local production of building components and a competitive market situation. This scenario is called 'future (investment) costs'.

From an economic point of view, besides capital investment costs, energy supply costs and other operating costs should always be factored when assessing enhanced energy efficiency measures. As shown in the following graphs, reduced energy supply costs (and reduced subsidies) overtake the highest investment costs for energy-efficient housing refurbishment.
Table 17 shows the basic assumptions for calculation.

Indicator	Value	Unit
Real interest rate	3.00%	p.a.
Life cycle	30	Years
Gas price	1.1	MXN/kWh
Gas price increase	6.8%	p.a.
Electiricity price	1.2	MXN/kWh
Electiricity price increase	4.5%	p.a.
Electiricity price subsidy	1.7	MXN/kWh
Subsidy increase	4.5%	p.a.

**Table 17: Boundary conditions for life-cycle costs calculation.
(Source: Passivhaus Institut based on SENER 2014 data)**

The following graphs demonstrate the incremental life cycle costs of "Adosada" buildings in four climate zones. Compared to the base case, annual incremental capital costs (annuities) are shown in red, average energy costs for each owner are shown in orange, while implied annual subsidies energy consumption of the owner are shown in dotted red.

Introducing energy efficiency measures produce significant energy savings. The savings achieved affect also the total life-cycle cost of the household; however, part of these savings is a saved subsidy which does not reach the home-owner directly, but the Mexican government.

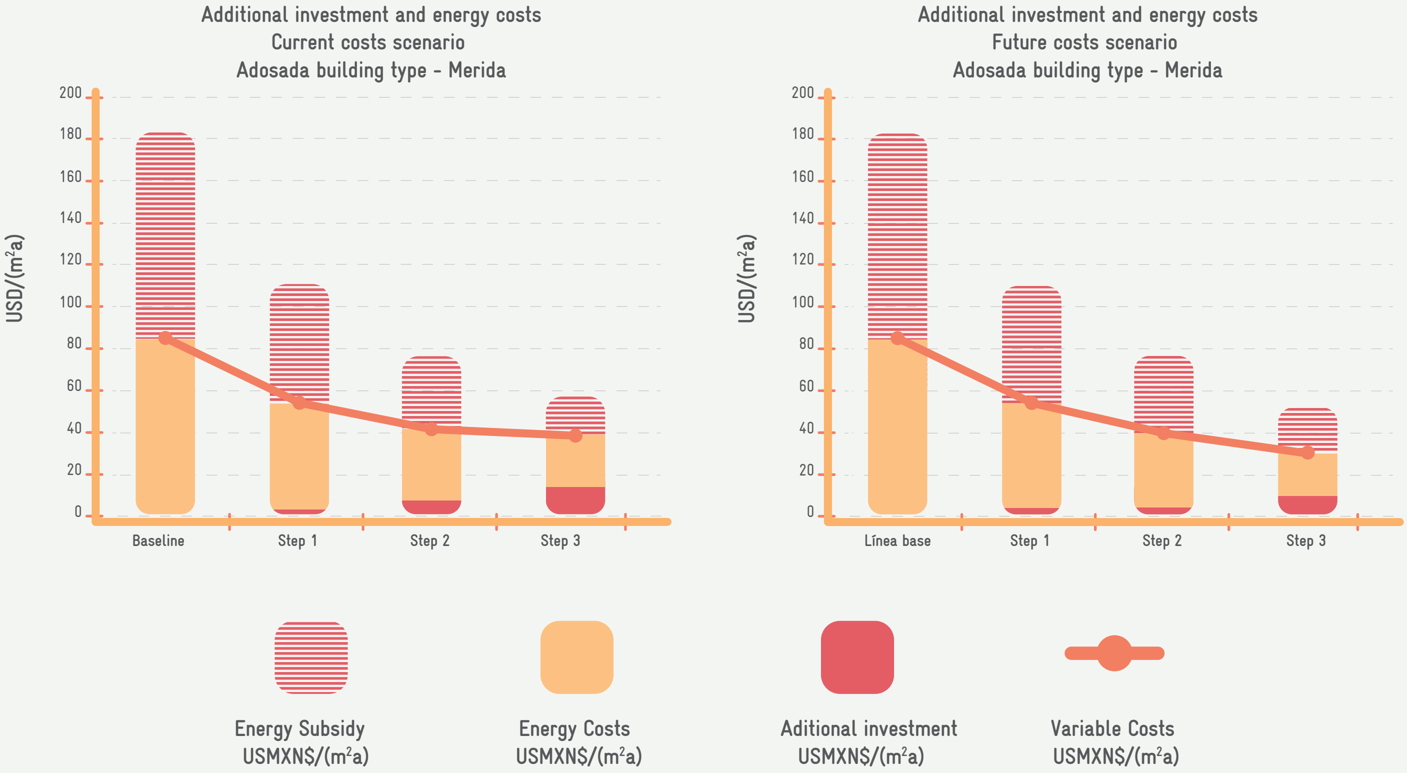

Figure 18: Current costs of the different steps towards the "step by step refurbishment to achieve optimal energy and environmental performance" standard (efficiency improvements) for Adosada building type (50 m² SRE) in Merida (Source: Passivhaus Institut).

Figure 19: Future costs of the different steps towards the "step by step refurbishment to achieve optimal energy and environmental performance" standard (efficiency improvements) for Adosada building type (50 m² SRE) in Merida (Source: Passivhaus Institut).

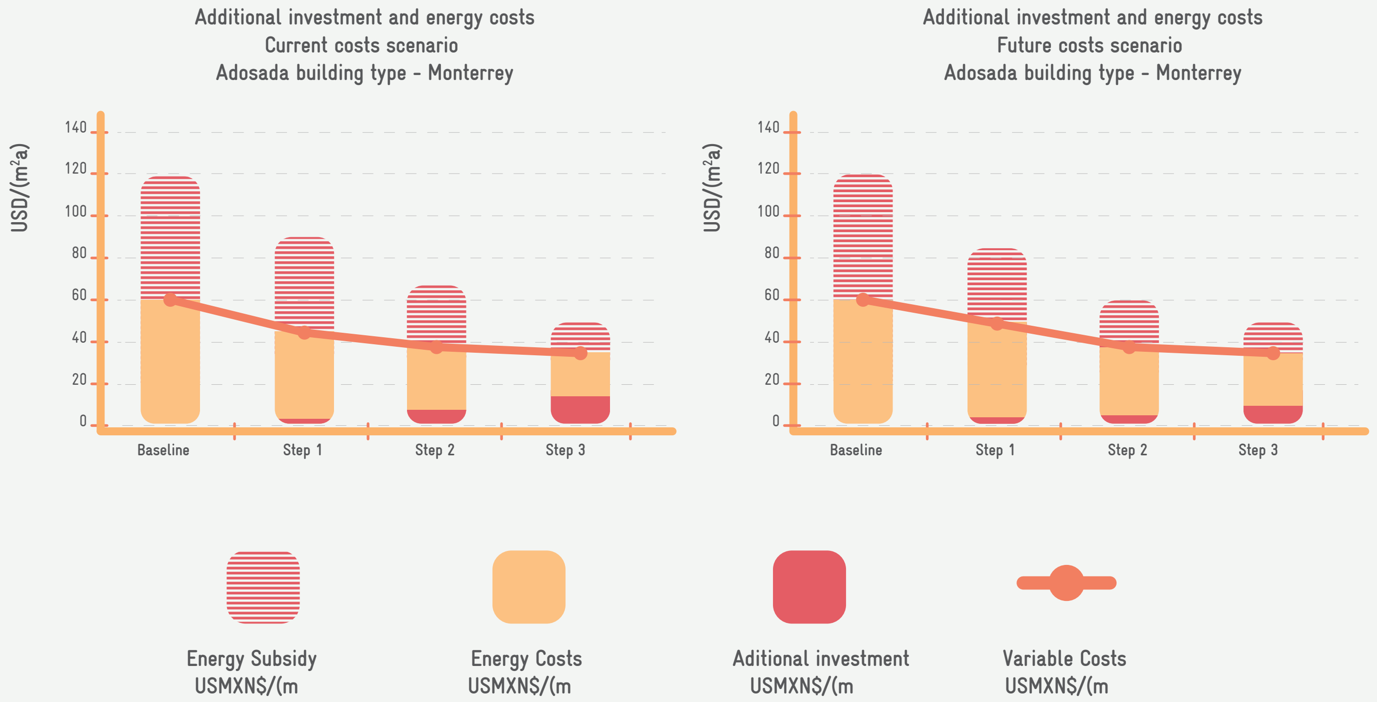

Figure 20: Current costs of the different steps towards the “step by step refurbishment to achieve optimal energy and environmental performance” standard (efficiency improvements) for Adosada building type (50 m² SRE) in Monterrey (Source: Passivhaus Institut).

Figure 21: Future costs of the different steps towards the “step by step refurbishment to achieve optimal energy and environmental performance” standard (efficiency improvements) for Adosada building type (50 m² SRE) in Monterrey (Source: Passivhaus Institut).

It is clear that in both cases, it is worth investing on energy efficiency since first step. Regarding cost-efficiency, step 3 is the optimal level. Both Figure 19 and Figure 21 show a ‘future costs’ scenario based on estimates, assuming that when energy efficiency on housing improvements has expanded, the costs of some technologies will be reduced. It shows that the additional investment cost decreases and becomes more attractive for the user. These processes require support and technology transfer to achieve market set up and transformation.

6.2 REQUIRED RESOURCES FOR THE NAMA FOR SUSTAINABLE HOUSING RETROFIT IMPLEMENTATION

6.2.1 DIRECT MITIGATION ACTIONS

The following is an explanation of a simple example regarding financial needs, based on costs estimations of the examples calculated in the technical design:

Based on the assumption that the implementation of Steps 1 and 2 may begin in a relatively short-term (2015-2016) followed by Step 3, an estimated average amount of 6,882 USD for inevitable improvements in overall housing has been calculated. To achieve Step 1 from the baseline, an average amount of 1,447 USD has been calculated for additional investment costs in energy efficiency measures and water savings. To reach Step 2 from the baseline, an additional amount of 6,474 USD has been estimated. Finally, to reach Step 3 from the baseline, an additional amount of 11,903 USD will be required (this cost includes measures costs in Steps 1 and 2). The complete implementation period is from 2015 to 2019. In this example, average costs to get from one step to the next are included. Therefore, for estimated costs in Step 2, actions on Step 1 are included. Similarly, for estimated costs in Step 3, actions in Steps 1 and 2 are included.

Based on four bioclimatic zones and 9,000 houses to be refurbished per zone, maximum investments are as follows:

- Step 1: 60 million USD total investment – 18 million USD for energy efficiency and water consumption improvements
- Step 2: 120 million USD total investment – 36 million USD for energy efficiency and water consumption improvements
- Step 3: 300 million USD total investment – 90 million USD for energy efficiency and water consumption improvements

Not all 3 Steps will be implemented in all households, only in some of them. It is assumed that approximately 50% will participate in Step 1, 40% in Step 2 and the remaining households of the 36,000 in Step 3. Thus, the 36,000 will participate in one of the Steps.

For 19,000 houses in Step 1, a total investment of 158 million USD and 27 million USD for energy efficiency and water consumption improvements has been calculated. For 15,000 houses in Step 2, a total investment of 200 million USD and 97 million USD for energy efficiency and water consumption improvements has been calculated. For 2,000 houses in Step 3, a total investment of 37 million USD and 23 million USD for energy efficiency and water consumption improvements has been calculated.

Adding these amounts, the total amount of 48 million USD (energy efficiency and water consumption improvements) and 396 million USD of total investment has been calculated.
If it is assumed that a home-owner and borrower contribute with 20% of its own capital (79 million USD), credit requirement would be 317 million USD. The costs for indirect measures should be added, including credit subsidies, hard to predict at this time.

Two kinds of subsidies have been foreseen to home-owners for financial burden relief and to as an additional incentive:
1) Subsidy to reduce the interest rate (to be determined), and
2) Subsidy to low reimbursement instalments.

This last subsidy will be granted when certain energy efficiency objectives have been reached through individual steps or complete refurbishment. The energy advisor has to approve that an intermediate level of efficiency has been achieved and should be proved by the Sisevive-Ecocasa tool with specific calculations on that household.

6.2.2 INDIRECT MITIGATION ACTIONS (SUPPORTIVE ACTIONS)

The cost for supportive actions for the first phase of the NAMA VE from 2015 to 2019 was estimated. The estimates were based on the assumption of the start-up of approximately 36,000 houses (4 x 9,000 per climate zone) over five years under various standards. Because of the nature of the NAMA VE, the cost for supportive actions is not likely to increase significantly in case of a faster start-up. At levels of up to 100,000 houses, the costs are likely to remain stable. Due to its fixed costs nature, costs will neither decrease in case fewer houses are financed. It is estimated that these supportive actions will have a value of 11,65 million USD

6.2.3 MEXICAN CONTRIBUTIONS AND INTERNATIONAL DONORS

México already uses CONAVI's subsidy programmes (Financing Schemes Programme and Federal Subsidy Programme for Housing) to promote energy efficiency. For example, the "Adquisición de Vivivenda Nueva" programme is linked directly to the "Hipoteca Verde" programme and to minimum characteristics of sustainability (Step 1), as well as the "Ampliación y/o Mejoramiento de Vivienda" programme and the "Mejora de Vivienda" SHF programme for existing housing. This demonstrates that Mexico is able and willing to offer substantial co-financing.

Estimates of additional donor support for NAMA VE financing are based on financial entities need of subsidies for interest rates and possible contributions to reduce home-owners reimbursement instalments. The financing concept includes international co-financing to initiate with the first implementation activities of the Supported NAMA VE.

6.3 FINANCING SCHEME FOR NAMA FOR SUSTAINABLE HOUSING RETROFIT

It is proposed to set up the 'NAMA Fund' as a financial vehicle to be the initial recipient of donor funds, whether in the form of soft loans or grants. The Mexican government will make the first contribution. However, additional funds are needed beyond what the Mexican government can provide to achieve a high level of penetration and up-scaling.

Carbon finance, international donors, and private investment will all be potential sources of funding for the NAMA VE for Sustainable Housing Retrofit. It is also convenient to leverage private investment ("ethical funds", possibly), although doubtfully investors will provide this kind of financing in a significant volume due to the poor existing expectations of commercial profitability. While the NAMA fund is being established, donors can partner directly with CONAVI, which will provide coordinated assistance with the different stakeholders.

In a fist phase, funding for NAMA VE projects can be directed towards two end-uses: supporting demand for housing improvements (mortgages subsidies) and provide MRV & capacity building services that enable NAMA VE operation. In a second phase, funding can also be directed to support the energy refurbishment supply side through building companies (developers),

It is clear that by decreasing the overall energy consumption, savings with real economic value are achieved. However, in order to promote public and private finance and create a channel for payments based on performance, it is necessary to identify where added value for stakeholders can be found.

This analysis will report structures needed to channel added value to support sustainable NAMA VE activities.

Ultimately this analysis will inform structures needed to channel created value to support sustainable NAMA VE activities.

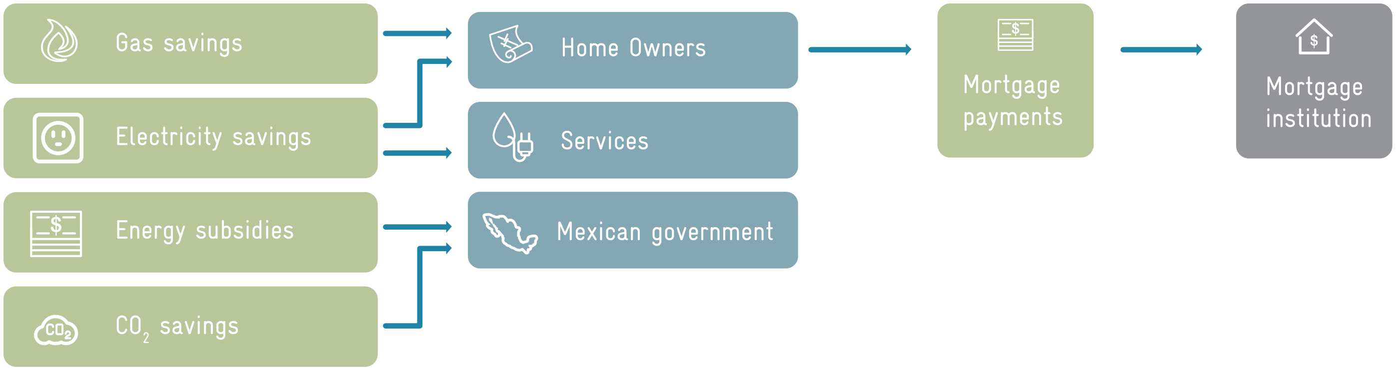

Figure 22: Added value for the different actors of the NAMA (Source: Passivhaus Institut).

6.3.1 FINANCIAL SUPPORT FOR THE DEMAND SIDE

The mortgage is one of the most important components of the NAMA design because it drives demand for energy efficient equipment and building materials. Without demand, even the most favorable conditions for developers will not result in successful programs. Furthermore, if a strong market demand can be generated, fewer subsidies will be required in a medium and long-term, e.g., the price of different products and services to support energy-efficient increase will be reduced due to the increasing demand. The NAMA VE achieves emissions reductions by minimizing electricity, natural gas and water consumption per housing unit. Returns on residential energy efficiency investments are driven by the technology performance and savings on resulting costs.

Under a 'traditional' energy efficiency financing model, the amount saved on these recurring costs is enough to compensate the financial cost of installed equipment. This model is based on two assumptions (1) that the home owner is able and willing to reserve the capital to purchase the equipment and materials, and; (2) that the value of avoided costs to the home owner is enough to pay (and ideally exceeds) the monthly payments on the improvements.

Without the NAMA VE, neither of these assumptions would count. As Figure 23 illustrates, not the home owner but the government, benefits from the reduction in subsidy payments. On average, 60% of residential energy consumption costs are covered through federal subsidies in Mexico. This reduces the payback to the home owner, and thus the income flow to ensure equipment financing. Subsidized mortgage assistance, covering all or some of the incremental cost of the energy efficient features, can overcome this challenge by reducing home owners investment cost and the monthly savings amount to make the investment attractive, especially for higher energy efficiency levels shown in Figure 22.

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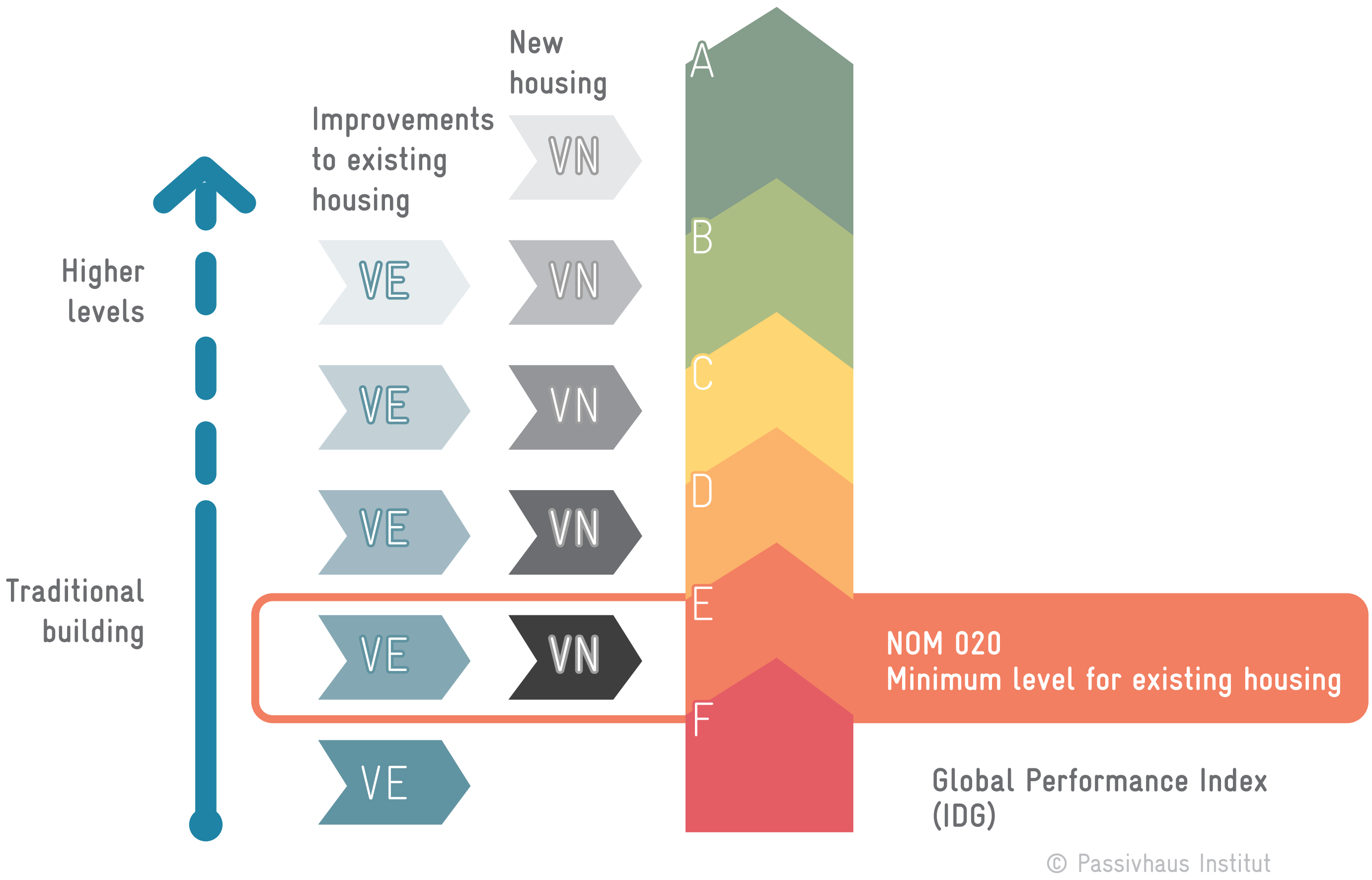

Figure 23: IDG adaptiation for the NAMA for Sustainable Housing Retrofit (Source: Passivhaus Institut).

A financing scheme for sustainable housing support is proposed, as described in Figure 24. However, this is just a suggestion of how the system may work. Each institution should adequate the steps according to their internal processes and structures.

Figure 24: System proposed for credit consent to owners within the NAMA for Sustainable Housing Retrofit framework (Source: KfW, adaptation by the Passivhaus Institut).

6.3.2 FINANCIAL SUPPORT FOR CAPACITY BUILDING AND MRV

To achieve, measure and report impacts, the NAMA VE will also requires funds for administrative actions and support to develop and apply the MRV system. As there are no opportunities for income generation for this use, it is not attractive for private investment; however, a robust MRV system is critical to demonstrate emission reductions.

Technical assistance for supportive and administrative actions can be channeled in two ways:

- Contribution to the International NAMA VE Fund to be operated by a specific agency (national, international or both).

- Implementation of new bilateral programmes for technical assistance between a certain host country and Mexico, according to standard procedures used by the different donor countries. Development of financing schemes within the Mexican government taking advantage of the international advisory.

6.4 POTENTIAL APPROACHES

6.4.1 CORPORATE SOCIAL RESPONSIBILITY (CSR) MODEL

The concept behind the NAMA VE is that reductions represent host country contributions towards fighting climate change. Thus, emissions reduction generated by the project should be considered within Mexico's goals and should not be transferred outside the country to be used as tradeoff. Although emissions reduction achieved cannot be sold or traded through the carbon market, there are still buyers that perceive some value in emission reductions. Therefore, they show commitment to sustainable development. Examples include large multinationals operating inside Mexico wishing to demonstrate good practices and sustainable policies and Mexican companies that have unenforced mandates to reduce emissions in Mexico, or investors with a mandate to invest in green funds.

Under the CSR model, companies can provide soft loans or benefits such as NAMA VE housing for employees, to be rewarded with benefits for their participation in Mexico's emissions reduction. To track emissions resulting from their investments, a system could be set up so large domestic firms are able to claim for certain emissions reduction benefits for their CSR or towards their emissions reduction goals (e.g. "PEMEX's investment in the NAMA fund contributed 3 million tons to the government's emissions goals and provided a return"). This benefit would be processed by the MRV system and could serve as an important motivator to attract financial support.

6.5 NAMA FOR SUSTAINABLE HOUSING RETROFIT FINANCING PACKAGING OFFERED TO THE INTERNATIONAL DONOR COMMUNITY

The analysis of various types of household performances, shows that the specific savings (reductions of primary energy demand per square meter of living surface) are much more favorable with terraced houses (Adosadas), multi-storey buildings (Verticals), compared to the traditional single independent or detached family homes (Aisladas). Vertical housing units in particular, prove not only to be more efficient regarding the performance of the building itself, but also allows urban settlements to remain closer to the city centre, thereby avoiding undesirable urban sprawl.

On this basis, five financing packages were formulated and are presented in Table 18 as an example of how international support could make the NAMA VE move forward. Financing needs are split into three categories: subsidies to home owners, bridge loans for developers as soft loans and technical support (support actions: 317 million USD; see section 6.2.1).

The financing needs indicated in the table cover total investment costs for housing improvement. However, cost for energy efficiency improvement measures is only shown. See also section 6.2.1.

	2015	2016	2017	2018	2019	Total
1) Total Investment						
S1:	17,6	35,1	35,1	35,1	35,1	158
S2:	8,3	25	50	58,3	58,3	200
S3:	0	0	4,2	12,7	21,1	38
TOTAL:	**25,9**	**60,1**	**89,3**	**106,1**	**114,6**	**396**
2) Energy Investment costs						
S1:	3	6	6	6	6	27
S2:	4	12,1	24,3	28,3	28,3	97
S3:	0	0	2,9	7,9	13,2	24
TOTAL:	**7**	**18,1**	**33,2**	**42,2**	**47,5**	**148**
3) Credit requirements (80% of total 1)	20,7	48,1	71,5	84,9	91,6	317

Table 18: Example of financing packages for donor support. Amounts in USD millions reflecting rounding errors (Source: IzN Friedrichsdorf and the Passivhaus Institut).

	2015	2016	2017	2018	2019	Total
4) Credit requirement for energy efficiency and water consumption improvements (80% of total 2)	5,6	14,5	26,5	33,8	38,0	118,4
5) Subsidy requirements to reduce imbursement instalements (15% of 4) *,**	0,8	2,2	4,0	5,1	5,7	17,8
6) Subsidy requirements for technical assistance (support actions)	17,9	7,2	7,2	7,2	3,6	43
S1 = step 1, S2 = step 2, S3 = step 3						

* Subsidy to reimbursement instalments is granted when certain energy efficiency objectives have been achieved.

** Subsidy to interest rate cannot be estimated as it depends on several factors unknown.

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Table 18: Example of financing packages for donor support. Amounts in USD millions reflecting rounding errors (Source: IzN Friedrichsdorf and the Passivhaus Institut).

Donors support will be necessary to particularly finance lines 3 (80%), 5 and 6.

The total incremental cost of construction indicated in Table 18 (No. 4), is equivalent to the volume of soft loans developers would require in the form of bridge financing, to drive their investments on households refurbishment with higher energy efficiency standards. Revolving funds to "soften" credits come from private and official donors, both national and international. This fund may combine a mix of commercial and funds capital for government contributions to provide credit soft conditions. Table 18 shows accumulated and per year requirements for the revolving fund, assuming implementation would be carried out during the period 2015-2019.

For the financing packages, several important considerations apply and are presented below:

- Flexibility on donation packages: Packages shown are examples. Actual packages can be adapted to fit interested donors specific requirements (e.g. adjustments can be made in terms of financial volume, type of buildings and efficiency standards covered, etc.).
- Combi-packages: Through competent institutions in charge, the Mexican government is willing to offer combinations of packages for subsidies to home-owners, and/or packages for supportive actions.
- Mexican priorities on soft loan and donors packages: NAMA VE's implementation and operation strongly depend on the support of the international donor community for subsidies to home-owners and supportive actions. The soft-loan is a supplementary component of the NAMA VE and represents an important element in the overall finance strategy.

The Mexican government has a clear priority to ensure donors financing first and try to obtain soft-loan financing in parallel.

7 CONCLUSIONS AND RECOMMENDATIONS

As part of its commitment to mitigate GHG emissions and achieve a sustainable development, the Mexican government seeks to promote the application of energy efficiency and water saving measures in the existing social housing through the NAMA VE.

This document has proved that through the application of ambitious energy efficiency standards, high GHG emissions savings are achieved, contributing in this way to the fulfillment of the national goals. This mitigation potential is calculated considering standard comfort conditions, estimate that considers the increase of comfort in Mexican housing over time. Thus, although currently social housing reflects low energy consumption individually, it is expected that by improving quality of life conditions, comfort increases by an inefficient use of energy in case no mitigation measure is applied. The proposed measures based on a whole house approach, show that since the first optimization, 20% of GHG emissions mitigation is achieved, improving also housing indoor comfort conditions. This approach also considers measures to be implemented for water savings.

This idea of "increased comfort over time" is also considered in the proposed MRV concept, where the baseline should be calculated by an adequate tool that enables to include housing comfort conditions increase in order to prove the investment on energy efficiency.

An essential aspect of the concept is the implementation of a mandatory energy consultancy scheme before the application of energy efficiency measures. In this way, a proper planning and application of measures is guaranteed, achieving the optimal use of available resources. This advisory and the supervision and verification process on improvements are proposed as mandatory requirements for financing. The accurate application and definition of the NAMA VE operation will have to be carried out by each institution, to ensure actions run optimally.

As first steps, the following actions have been considered: the implementation of the energy consultancy scheme together with the supervision and verification scheme for projects; adjustments to the SISEVIVE-ECOCASA tool; the development and training of financial entities and building companies from the field of housing improvement towards energy efficiency, as well as the dissemination and promotion among home-owners. This last action is identified as a crucial one for NAMA VE success.

Thus, a system that can be integrated to the Mexican housing organisms is proposed, seeking to strengthen the objective to improve existing housing in Mexico, GHG emissions mitigation and owners' quality of life improvement.

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On behalf of:
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of the UK Government