

# NAMA VIVIENDA EXISTENTE

Supported NAMA for Sustainable Housing Retrofitin Mexico Mitigation Actions and Financing Packaging











Por encargo de:





# Supported NAMA for Sustainable Housing Retrofit in Mexico Mitigation Actions and Financing Packaging

On behalf of





Mexico City December 18th, 2014

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#### List of acronyms and abbreviations

IDB Inter-American Development Bank

Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (German

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)

BMZ Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (German

Federal Ministry for Economic Cooperation and Development)

CEV Código de Edificación de Vivienda (Residential Building Code)

CFL Lámpara fluorescente compacta (Compact fluorescent Lighting)

CMM Centro Mario Molina (Mario Molina Center)

CONAVI Comisión Nacional de Vivienda (National Housing Commission in Mexico)

CONUEE Comisión Nacional para el Uso Eficiente de la Energía (National Commission for the

Efficient use of Energy in Mexico)

CTF Fondo para la Tecnología Limpia (Clean Technology Fund)

COP Conference of the Parties

DEEVi Diseño Energéticamente Eficiente de la Vivienda (Energy-Efficent Housing Design -

Mexican Green Housing Evaluation System SISEVIVE-ECOCASA calculation tool)

ECO431 Estándar de competencia "Promoción del ahorro en el desempeño integral de los

sistemas energéticos de la vivienda". (Mexican efficiency standard that "Promotes

savings in the whole house energy systems performance")

ENCC Estrategia Nacional de Cambio Climático (Mexico's strategy on Climate Change)

EnerPHit International standard to certify energy retrofits with Passive House Components

FIDE Fideicomiso para el Ahorro de Energía Eléctrica (Mexican Trust Fund for Electricity

Energy)

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

FONHAPO Fideicomiso Fondo Nacional de Habitaciones Populares (Mexican National Trust Fund

for Popular Housing)

FOVISSSTE Fondo de la Vivienda del Instituto de Seguridad y Servicios Sociales de los Trabajadores

del Estado (Housing Fund of the Institute of Social Security and Services for State

Workers)

GHG Greenhouse gas

GIZ Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (German

**Development Cooperation)** 

GOPA GOPA Consultants GmbH

- Mitigation Actions and Financing Packages

IDG Índice de Desempeño Global – Sistema de Evaluación de la Vivienda Verde, SISEVIVE-

ECOCASA (Global performance index of the Mexican Green Housing Evaluation System

SISEVIVE-ECOCASA)

INE Instituto Nacional de Ecología (National Institute of Ecology in Mexico)

INEGI Instituto Nacional de Estadística y Geografía (National Institute of Stadistics and

Geography in Mexico)

Infonavit Infonavit Instituto del Fondo Nacional de la Vivienda para los Trabajadores (Institute of the

National Housing Fund for Workers)

iPHA International Passive House Association

IZN Friedrichsdorfer Institut zur Nachhaltigkeit (Institute for Sustainability in Friedrichsdorf)

KfW Kreditanstalt für Wiederaufbau (Germany's leading development bank)

LAIF Latin America Investment Facility

Low-e Low emissions

CDM Clean Development Mechanism

MEPS Normatividad Mínima de Rendimiento Energético (Minimum Energy Performance

Standards)

MRV Monitoring, reporting, verification

MXN Mexican peso

NAMA Acciones de Mitigación Nacionalmente Apropiadas (Nationally Appropriate Mitigation

Actions)

NAMA VN NAMA de Vivienda Nueva en México (NAMA for new residential buildings)

NAMA VE NAMA de Vivienda Existente en México (NAMA for Sustainable Housing Retrofit)

NOM Normas Oficiales Mexicanas (Mexican Official Standards)

NMX Normas Mexicanas (Mexican Voluntary Standards)

ONNCCE Organismo Nacional de Normalización y Certificación de la Construcción y la Edificación

(National Standardization and Certification Body for Building and Construction in

Mexico)

PDL Préstamo Impulsado por el Rendimiento (Performance-Driven Loan)

PECC Programa Especial de Cambio Climático (Mexico's Special Programme on Climate

Change)

PEMEX Petróleos Mexicanos (Semi-public oil company in Mexico)

- Mitigation Actions and Financing Packages

PHI Passivhaus Institut Dr. Wolfgang Feist

PHPP Passivhaus Planning Package

PNV Programa Nacional de Vivienda (Mexican National Housing Programme)

ProNAMA Mexican-German programme for NAMA

PoA Programme of Activities

SAAVi Simulación del Ahorro del Agua en la Vivienda, parte del SISEVIVE-ECOCASA (Housing

Water Savings Simulation - Mexican Green Housing Evaluation System SISEVIVE-

ECOCASA calculation tool)

SISEVIVE Sistema de Evaluación de la Vivienda Verde (Green Housing Evaluation System -

Classification system for energy and water performance)

RUV Registro Único de Vivienda (Unified Housing Registry)

SEDATU Secretaría de Desarrollo Agrario Territorial y Urbano (Ministry of Agrarian, Territorial

and Urban Development in Mexico)

SEDESOL Secretaría de Desarrollo Social (Ministry of Social Development in Mexico)

SEMARNAT Secretaría de Medio Ambiente y Recursos Naturales (Federal Ministry for the

Environment and Natural Resources in Mexico)

SENER Secretaría de Energía (Ministry of Energy in Mexico)

SHF Sociedad Hipotecaria Federal (Mexican Federal Mortgage Company)

SOFOLES Sociedades Financieras de Objeto Limitado (Limited Purpose Financial Institutions)

USD Dólar Estadounidense (United States dollar)

#### Exchange rates (09/2014)

1 MXN	=	0.06	EUR	=	0.08 USD
1 EUR	=	1.29	USD	=	16.9 MXN
1 USD	=	0.78	EUR	=	13.05 MXN

Source: Finanzas Yahoo (Yahoo Finance) (accessed 08.09.2014)

# **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 way" [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<sup>1</sup>. 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 stakeholders 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.

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<sup>1</sup> www.conavi.gob.mx

In addition, the National Programme for Urban Development 2014-2018<sup>2</sup> 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.

#### 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<sup>3</sup> 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 EnerHPit Standard - hereafter referred to as "Step by step refurbishment to achieve optimal energy and environmental performance" - is not a trademark but a valuable concept that is intended to be applied as a basis for NAMA VE calculations.

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<sup>&</sup>lt;sup>2</sup> 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."

<sup>3</sup> 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.

<sup>&</sup>lt;sup>4</sup> 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.

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 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.

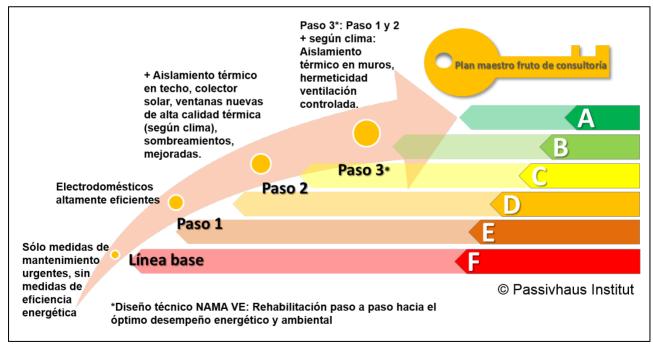


Figure 1: Technical Design for NAMA for Sustainable Housing Retrofit:

Step by step refurbishment to achieve optimal energy and environmental performance, summary of examples calculated (Source: Passivhaus Institut).

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 following table:

Table 1. Annual mitigation emissions in a household by building type and climate zone, tCO2e/a (Source: Passivhaus Institut).

"Aislada" Single-family unit detached house (40 m²)	Monterrey City (Hot dry)	Guadalajara City (Temperate)	Mexico City (Temperate cold)	Merida City (Hot and humid)
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 (Step by step refurbishment to achieve optimal energy and environmental performance)	10.9	4	8.4	14.1
"Vertical" Multi-storey housing u	nits (40 m² per unit	t)		
Step 1	2.2	1.2	1.2	5.1
Step 2	3.1	1.6	1.3	6.7
Step 3 (Step by step refurbishment to achieve optimal energy and environmental performance)	5.2	2.2	4.2	9.4

#### **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.

#### 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).

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

Item	Description
Sector	Building sector
Sub-sector	Housing improvement: primarily for low-income families (social housing) and potentially to middle-income housing
NAMA VE boundary	Entire country
Measures and activities with <u>direct</u> <u>impact</u> 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.
Co-benefits	Economy:
	<ul> <li>Economic savings for households reflected in electricity, fuel and water bills</li> </ul>
	<ul> <li>Reduction of energy subsidy costs to support NAMA VE measures funding</li> </ul>
	Increase in the number of green companies and jobs
	Extended housing quality and lifecycle
	<ul> <li>Workers productivity increase due to improved comfort conditions</li> </ul>
	Environment:
	Air quality
	Water and energy savings
	Social:
	<ul> <li>Leverage effect in comfort increase through the combination of NAMA VE measures with electrical and sanitation equipment refurbishment and/or dwelling expansion</li> </ul>
	<ul> <li>Indoor housing comfort regarding temperature and humidity benchmarks.</li> </ul>
	<ul> <li>Access and promotion of clean energy services</li> </ul>
	Human and institutional capacity building
	Education and awarenes of sustainability for householders
	<ul> <li>Improvements on householders health through comfort and air quality improvements</li> </ul>
NAMA VE timeframe	Preparation (2014)
	First phase (2015 - 2016):
	Structure preparation for large-scale implementation;
	advice from international experts
	Second phase(2016 – 2020):
NIANAA ME wall asstanda adalah	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

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	Energy Advisors through the DEEVi tool v.2. (Updated for existing housing refurbishment).		
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		

# 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 18<sup>th</sup> 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)<sup>5</sup> 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 ecotechnologies 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.

#### **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

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<sup>&</sup>lt;sup>5</sup> 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."

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

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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. 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.

#### Table 3. Prevailing mandatory norms related to housing energy efficiency

#### **ENVOLVENTE DE EDIFICIOS**

#### **BUILDING ENVELOPE**

NOM-020-ENER-2011 Eficiencia energética en edificaciones, Envolvente de edificios para uso habitacional.

NOM-020-ENER-2011 Energy efficiency on buildings, building envelope for housing.

#### **AISLANTES TÉRMICOS**

#### THERMAL INSULATION

NOM-018-ENER-2011 Aislantes térmicos para edificaciones. Características, límites y métodos de prueba.

NOM-018-ENER-2011 Thermal insulation for buildings. Characteristics, standard values and testing methods.

#### **VIDRIO Y SISTEMAS VIDRIADOS**

#### **GLASS AND GLAZING SYSTEMS**

NOM-024-ENER-2012 Características térmicas y ópticas del vidrio y sistemas vidriados para edificaciones. Etiquetado y métodos de prueba.

NOM.024-ENER-2012 Thermal-optical characteristics of glass and glazing systems for buildings. Labeling and testing methods.

#### **EFICIENCIA TÉRMICA**

#### THERMAL EFFICIENCY

NOM-003-ENER-2011 Eficiencia térmica de calentadores de agua para uso doméstico y comercial. Límites, método de prueba y etiquetado.

NOM-003-ENER-2011. Thermal efficiency of water heaters for domestic and commercial use. Standard values, testing methods and labeling.

NOM-025-ENER-2013 Eficiencia térmica de aparatos domésticos para cocción de alimentos que usan gas L.P. o gas natural. Límites, métodos de prueba y etiquetado.

NOM-025-ENER-2013 Thermal efficiency of household appliances for cooking using LP gas or natural gas.

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Standard values, testing methods and labeling.

#### **EFICIENCIA ENERGÉTICA**

#### **ENERGY EFFICIENCY**

NOM-005-ENER-2012 Eficiencia Energética de lavadoras de ropa electrodomésticas. Límites, método de prueba y etiquetado.

NOM-005-ENER-2012. Energy efficiency of household electric washing machines. Standard values, testing methods and labeling.

NOM-015-ENER-2012 Eficiencia energética de refrigeradores y congeladores electrodomésticos. Límites, métodos de prueba y etiquetado.

NOM-015-ENER-2012 Energy efficiency of refrigerators and coolers. Standard values, testing methods and labeling.

NOM-017-ENER/SCFI-2012 Eficiencia energética y requisitos de seguridad de lámparas fluorescentes compactas autobalastradas. Límites y métodos de prueba.

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 Eficiencia energética, requisitos de seguridad al usuario en acondicionadores de aire tipo cuarto. Límites, métodos de prueba y etiquetado.

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 Eficiencia energética en acondicionadores de aire tipo dividido, descarga libre y sin conductos de aire. Límites, método de prueba y etiquetado.

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 Eficiencia energética de lámparas para uso general. Límites y métodos de prueba.

NOM-028-ENER-2010 Energy efficiency of lamps for general use. Standard values and testing methods.

NOM-030-ENER-2012 Eficacia luminosa de lámparas de diodos emisores de luz (LED) integradas para iluminación general. Límites métodos de prueba.

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 Límites máximos de potencia eléctrica para equipos y aparatos que demandan energía en espera. Métodos de prueba y etiquetado.

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)

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.

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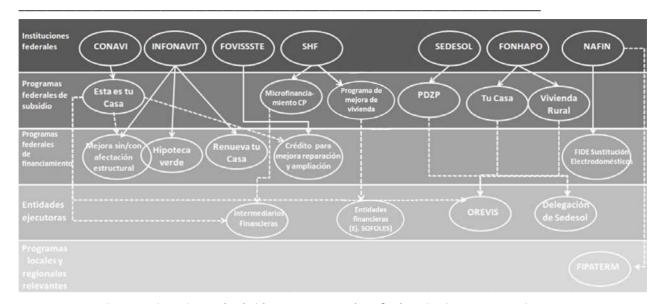


Figura 2. Financing and subsidy programmes chart for housing improvement in 2012 (Source: GIZ/MGM Innova 2012, adaptation by Passivhaus Institut).

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.

# 2.4 Finance for the Mexican existing housing sector

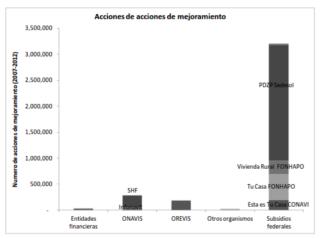
Mexico's financial reforms and capacity building efforts over the past decade have solidified and stabilized the financial sector, as demonstrated during the recent global financial crisis (starting 2008). Strengths of the sector are:

- 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].



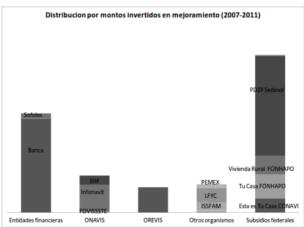


Figure 3. Financing and distribution universe of actions: Invested amounts for housing improvement, period 2007-2011 (Source: GIZ/MGM Innova 2012)

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].

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.

# 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<sup>6</sup>.
- 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.

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<sup>&</sup>lt;sup>6</sup> For more details see www.infonavit.org.mx.

- Mitigation Actions and Financing Packages
- - **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 Mexico, Implementation of NAMA for New Housing (Technical Component: EUR 4 million, 2013-2017; Financial Component: EUR 10 million, 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).

# 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 homeowners 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.

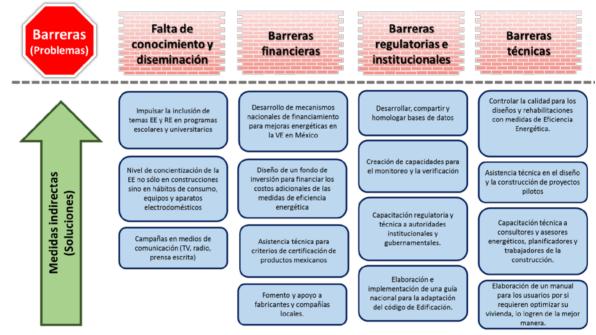
There are also other technical barriers related to the acquisition of technology and solutions that contribute to energy efficiency, as well as a lack of experience and knowledge for proper measures implementation. Due to the lack of knowledge of these measures, builders and local authorities may not

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.

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: Potential, objectives y 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 (homeowners), 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 that 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:

- (1) 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.
- (2) 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 <code>¡Error! No se encuentra el origen de la referencia.)</code>. 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 1 describes NAMA VE design elements:

Table 1: Design elements of the NAMA for Sustainable Housing Retrofit (Source: Point Carbon Thomson Reuters and Perspectives, adaptation by the Passivhaus Institut).

Item	Description
Sector	Building sector
Sub-sector	Housing improvement: primarily for low-income families (social housing) and potentially to middle-income housing
NAMA VE boundary	Entire country
Measures and activities with <u>direct</u> <u>impact</u> 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 <u>indirect</u> <u>impact</u> 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.

# 4.2 Whole house approach

As mentioned in section ¡Error! No se encuentra el origen de la referencia, 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<sup>1</sup> 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

<sup>&</sup>lt;sup>1</sup> 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.

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. 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 consultncy, 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.

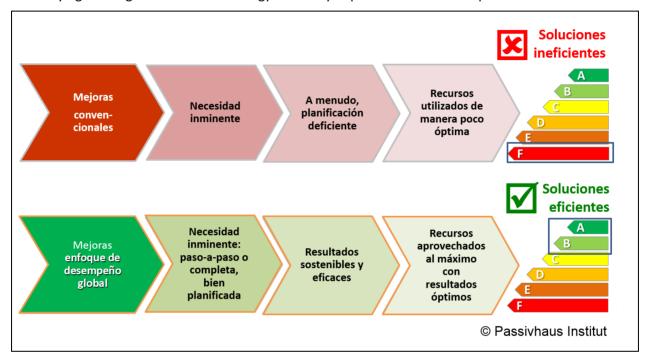


Figure 1: Importance of a well planned refurbishment with a whole house approach (Source: Passivhaus Institut).

For NAMA VE technical design, three unit types typical of the Mexican market of approximately 40m<sup>2</sup> and 50m<sup>2</sup> 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 2: Bioclimatic zones utilized for the NAMA VE<sup>2</sup> 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<sup>3</sup> (see Figure 2) for a reference<sup>4</sup> 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

<sup>&</sup>lt;sup>2</sup> 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.

<sup>&</sup>lt;sup>3</sup> When NAMA is deployed nationally, scope may be extended to other bioclimatic zones.

<sup>&</sup>lt;sup>4</sup> 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/.

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 4.3.3), 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.

- Step 1 considers the replacement of existing low-efficient air conditioning units with high-efficient 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 should be noted that in some cases, Step 1 does not reach the 20% of Co<sub>2</sub> emissions reduction (template cold and template climate zones). In these cases, financing should be directly focused on 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 absortion 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<sup>5</sup> climate zone.
- 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.



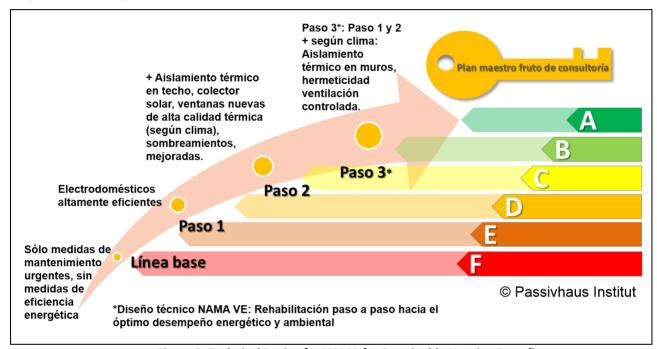


Figure 3: Technical Design for NAMA for Sustainable Housing Retrofit:

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).

As shown in Figure 3, 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

<sup>&</sup>lt;sup>5</sup> 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.

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)<sup>6</sup>. 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 2 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.

Table 2: Example of measures to achieve mitigation goals by climate zone for Adosada building type (Source: Passivhaus Institut).

		Monterrey (Hot Dry)	Guadalajara (Template)	Mexico City (Template Cold)	Merida (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

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<sup>&</sup>lt;sup>6</sup> As a boundary condition, a temperature range of 20°C to 25°C was chosen.

	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
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
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)

The result of implementing these mitigation actions is illustrated in Figure 4, which shows energy savings for Adosada housing units in a hot and humid climate.

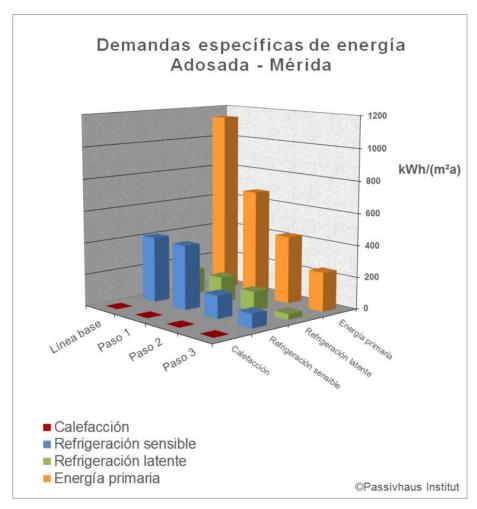


Figure 4: Specific energy demands for Adosada building type in Merida (Source: Passivhaus Institut).

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 5 below).

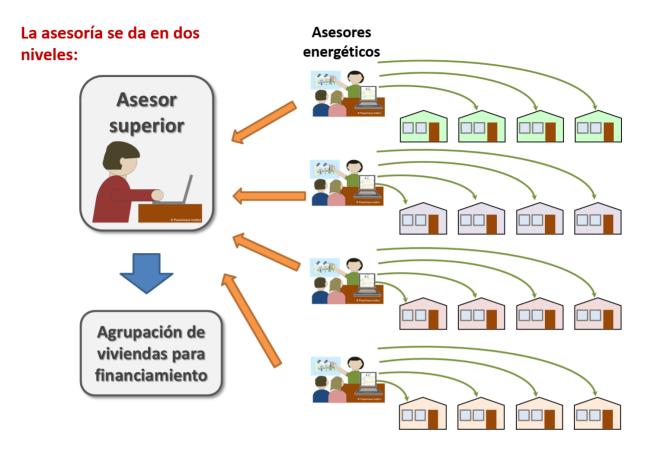


Figure 5: Scheme combining Energy Advisor and Auditor Advisor (Source: Passivhaus Institut).

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 3.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
	<u>Second phase(2016 – 2020):</u>

	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<sup>7</sup>. The SISEVIVE-ECOCASA system uses two independent calculation tools: the DEEVi<sup>8</sup> tool (Energy-Efficient Housing Design tool for energy housing demand simulation considering conditions in Mexico), and the SAAVi<sup>9</sup> (Simulación del Ahorro de Agua en la Vivienda) 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]

<sup>&</sup>lt;sup>7</sup> In cooperation with the Passivhaus Institut and the British Embassy in Mexico co-financing

<sup>&</sup>lt;sup>8</sup> Developed upon request by the Passivhaus Institut in cooperation with the Infonavit, RUV and GIZ/GOPA-INTEGRATION.

<sup>&</sup>lt;sup>9</sup> Developed upon request by the Infonavit, Conagua, Fundación IDEA and GIZ/GOPA-INTEGRATION.

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 (SISEVIVE-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.

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 Mitigtion 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 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.

The next table presents electricity and gas consumption values used for these calculations.

Table 4. Values considered for reduced comfort baseline calculation (Source: Centro Mario Molina 2013, adaptation by Passivhaus Institut).

Tipología	Área m² [CMM 2013]	Aprox SRE m² (85% del área total)	Electricidad (kWh) [CMM 2013]	Elect. kWh/(m²a) SRE	Electricidad kWh/(m²a) para cálculo NAMA*		Gas LP (kg) [CMM 2013]	Gas LP (kWh)	Gas LP kWh/(m²a) SRE	Gas LP kWh/(m²a) para NAMA*
				Guadalajara (te	emplado)					
Adosada	98.17	83.44	1229.43	14.73	15		38.97	494.14	5.92	6
Aislada	104.02	88.42	942.29	10.66	11		60.31	764.73	8.65	9
Vertical	65.36	55.56	984.10	17.71	18		54.66	693.09	12.48	12
				Mérida (cálido	húmedo)					
Aislada	<i>57.7</i> 0	49.05	1578.13	32.18	32		67.13	851.21	17.36	17
Adosada [CFE 2014]		51.50	2384.42	46.30	46		Datos no	disponibles. Se us	an datos de edific	io Aislada
Vertical	I .	Datos no disponib	les. Se usan datos	de edificio Aislado	7		Datos no	disponibles. Se us	an datos de edific	io Aislada
				Monterrey (cá	lido seco)					
Aislada	46.14	39.22	1493.95	38.09	38		183.22	2323.23	59.24	59
Adosada	I	Datos no disponib	les. Se usan datos	de edificio Aislado	7		Datos no	disponibles. Se us	an datos de edific	io Aislada
Vertical	64.92	55.18	1303.86	23.63	24		180.91	2293.94	41.57	42
	Valle de México (semifrio)									
Adosada	60.47	51.40	754.83	14.69	15		331.34	4201.39	81.74	82
Aislada	83.41	70.90	1688.60	23.82	24		222.42	2820.29	39.78	40
Vertical	57.46	48.84	962.28	19.70	20		311.21	3946.14	80.80	81

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.

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

Table 5. Indoor comfort parameters for reduced comfort baseline (Source: Passivhaus Institut).

Parámetros de confort interior: línea base confort						Mei
reducido						
	Valor simulado con P	HPP basado en	Dife	rente	por z	ona.
Temperatura máxima invierno	datos de consumo el	éctrico y de gas				
	de Estudio de Camp	o [CMM 2013]				
Valor simulac		HPP basado en	Dife	rente	por z	ona.
Temperatura máxima verano	datos de consumo el	éctrico y de gas				
	de Estudio de Camp	o [CMM 2013]				
Máxima frecuencia de			Х	Χ	Χ	Χ
sobrecalentamiento aceptada en caso	10 %	[PHI 2013]				
de ausencia de refrigeración activa						
	Valor simulado con P	HPP basado en	Dife	rente	por z	ona.
Humedad absoluta máxima interior	datos de consumo el	éctrico y de gas				
	de Estudio de Camp	o [CMM 2013]				
Fuentes internas de humedad	2 g/(m²h)	[PHPP]	Χ	Х	Х	Χ
Ganancias internas de calor invierno	2.1 W/m²	[PHPP]	Χ	Χ	Х	Χ
Ganancias internas de calor verano	Calculado co	Х	Χ	Х	Х	

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  $T_n$ " 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.

Table 6: Indoor comfort parameters for standard comfort baseline (Source: Passivhaus Institut).

Parámetros de confort interio estándar	or: línea base	e confort	Mty	Gdl	DF	Me r
Temperatura máxima invierno	20 °C	[Fanger 1970] / [PHI 2012]	Х	Х	Χ	Х
Temperatura máxima verano	25 °C	[Fanger 1970] / [PHI 2012]	Х	Χ	Х	Χ
Máxima frecuencia de sobrecalentamiento aceptada	10 %	[PHI 2013]	Х	Х	Х	Х
Humedad absoluta máxima interior	12 g/kg	[Fanger 1970] / [ISO 7730]	Х	Х	Х	Х
Fuentes internas de humedad	2 g/(m²h)	[PHPP]	Χ	Χ	Χ	Χ
Ganancias internas de calor invierno	2.1 W/m²	[PHPP]	Х	Х	Х	Х
Ganancias internas de calor verano	Calculado	con PHPP	Х	Х	Χ	Х

**Figure 6** below presents several energy efficiency scenarios according to standards established for NAMA VE in an Adosada building type in Merida.

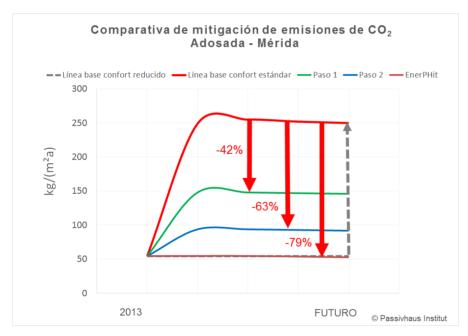


Figure 6: CO2, levels represented under various energy efficiency scenarios in Merida (Source: Passivhaus Institut).

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 CO2e/KWh has been applied. For the emission factor of liquefied petroleum gases, a value of 0.270 Kg CO₂e/KWh has been applied, as agreed in the Mesa Transversal for Sustainable Housing since 2012.

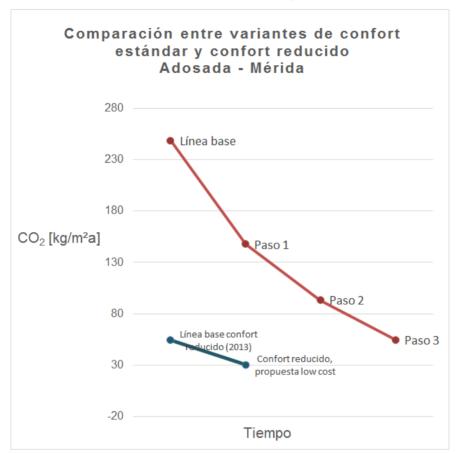


Figure 7: Comparison between standard comfort and reduced comfort variations. Adosada building type in Merida (Source: Passivhaus Institut)

Figure 7 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.

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).

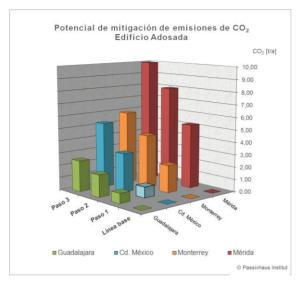


Figure 8: CO<sub>2</sub> emissions mitigation potential for Adosada building type in different climate zones analyzed (Source: Passivhaus Institut).

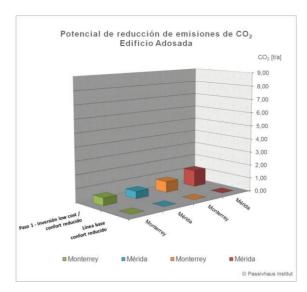


Figure 9: CO<sub>2</sub> emissions reduction potential for Adosada building type in different climate zones analyzed (Source: Passivhaus Institut).

As it can be observed in the figures above, left side (Figure 8) 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 8).

# 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 7: 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
Environment	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 10) represents the proposal of the NAMA VE general operation.

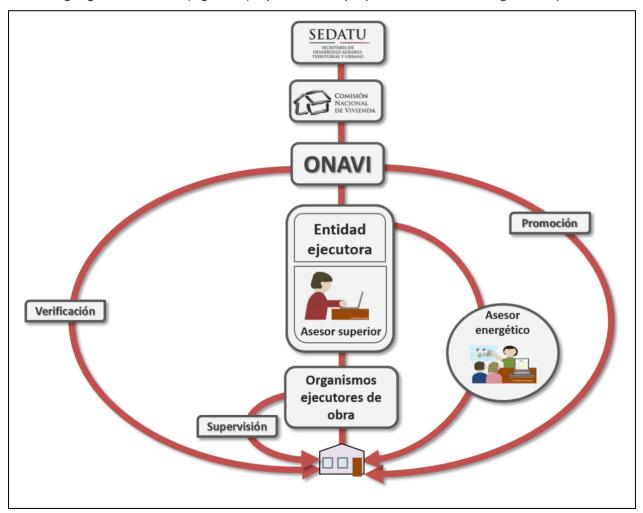


Figure 10: General organization chart proposed to integrate the NAMA for Sustainable Housing Retrofit (Source: GIZ / Passivhaus Institut).

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.

# 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 8: 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 11: Measures for the NAMA for Sustainable Housing Retrofit 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 ¡Error! No se encuentra el origen de la referencia., 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 9: NAMA for Sustainable Housing Retrofit administrative and supportive actions (Source: IzN Friedrichsdorf).

No.	Action
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 y 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 a 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

¡Error! No se encuentra el origen de la referencia.¡Error! No se encuentra el origen de la referencia. below, summarizes the recommended strategy in the original document [GIZ/MGM Innova 2013]:

Supported NAMA for Existing Housing Retrofit in México - Mitigation Actions and Financing Packages

# 5 The MRV system: Monitoring, Reporting y Verification

The primary purpose of an MRV system of any NAMA would be to measure the impact of the measures implemented, with the view to assessing their contribution towards 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, to build an 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 stages 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 and 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 the 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. Such adjustment to the baseline presents the difficulty to access historical data required to project comfort conditions and future housing equipping (especially if in the NAMA VE a 30 year-cycle is considered). 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 a phased MRV system addressed to two different NAMA stages

It is proposed to divide the MRV system in two phases presented below:

- NAMA VE initial phase: MRV system for pilot projects and data collection to calibrate the boundary conditions used in the modeling software for housing performance, as well as initial quality control.
- NAMA VE monitoring phase: MRV system for the NAMA VE in its large-scale implementation stage, 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 below, summarizes the recommended strategy in the original document [GIZ/MGM Innova 2013]:

#### Recommended strategy for the NAMA VE's MRV system

Whole house approach

Consumption adjustment methodology, adapted to a dynamic baseline

# NAMA VE's implmentation process over time

Initial phase	Monitoring phase		
Comprehensive monitoring	Identification data collection	GHG monitoring (simple)	Detailed monitoring
Objectives:  Quality control  Pilot projects impact measuring  Data building for detailed studies and NAMA VE definition  Boundary conditions calibration and modification for the SISEVIVE programme calculation tool	Objectives:  • To obtain data to identify housing and register actions	Objectives: • Emissions reduction measuring	Objectives:  • Quality control  • Calculation system maintenance through continuous calibration of boundary conditions  • Financial data and process monitoring
<ul><li>Tools:</li><li>Calculation tool adapted to existing housing with adjusted boundary conditions</li></ul>		<ul><li>Tools:</li><li>Calculation tool adapted to existing housing with adjusted boundary conditions</li></ul>	

Figure 1: Recommended strategy for MRV system of the NAMA for Sustainable Housing Retrofit. Source [GIZ/MGM Innova 2013], adaptation by Passivhaus Institut

GHG emissions considered by the MRV system of the NAMA for Sustainable Housing Retrofit

# **5.1 GHG Emissions considered by the MRV system of the NAMA for Sustainable Housing Retrofit**

Both for the initial 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 1: 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 <sub>2</sub>	Emissions related to housing electricity consumption. Consider dynamic baseline see [NAMA VE 2014] through applying a correction factor.
визенне	CO <sub>2</sub>	Emissions related to housing gas consumption. Consider dynamic baseline see [NAMA VE 2014] through applying a correction factor.
Drainet	CO <sub>2</sub>	Emissions related to housing electricity consumption.
Project	CO <sub>2</sub>	Emissions related to housing gas consumption.
Leakage (fugas)	CO <sub>2</sub>	Emissions related to the use of replaced equipment but not

	properly destroyed.
HFC	GHG emissions due to equipments wrong used and destroyed.

# 5.2 MRV mitigation emissions baseline

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 in order 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. It is worth mentioning that 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 founded in 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 also beneficial since the need to measure or collect data regarding baseline consumptions is avoided. Only the baseline necessary information for the calculation tool is needed.

# 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 which have influence, as well as emissions from cooling devices for air conditioning and refrigerators.

Building thermal envelope characteristics 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 in the case of being outside. This information may be collected through a survey.

The importance of metrics is highlighted not only from the point of view of the emissions savings monitoring, reporting and verification, but also from the point of view of the boundary conditions calibration for energy balance calculation.

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.

It is worth mentioning that 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 actual 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 the selection process of housing to be improved, definition of improvement packages, IDG criteria definition, improvement actions to 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 given:

- A calculation system with calibrated boundary conditions based on projects measurements is required. Ideally, this system should ease the user calculations configuration according to corresponding measures and data collection. It is recommended to use a calculation tool with high levels of detailed analysis, with which user may have the opportunity to adapt boundary conditions according to measures (for example PHPP tool), especially in higher energy efficiency projects and pilot projects. If required modifications to the NAMA VE Technical Design regarding boundary conditions adaptation are available, DEEVi tool may be used.
- Defined system to register NAMA VE actions
- Energy advisors for existing housing training in the use of a calculation tool (as defined in the NAMA VE's technical design.

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

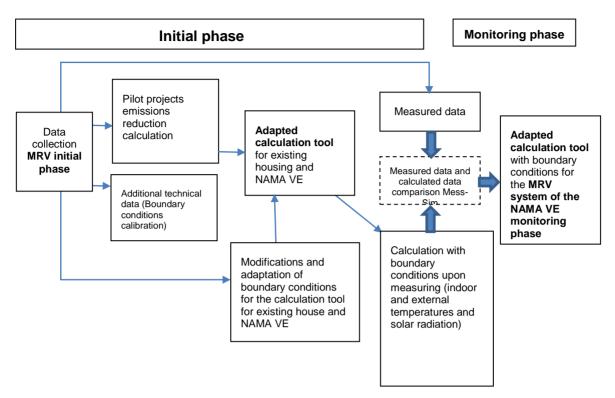


Figure 2: Monitoring system transition process from the initial phase to the monitoring phase (Source: GIZ/MGM Innova, adaptation by Passivhaus Institut).

# 5.5 Monitoring plan

As shown in Figure 15, 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 tramits to obtain credits for improvements, identification data collection shown in the next table is required. This information should be collected in the 100% of the housing where improvements are implemented under the NAMA VE.

Table 2: Data for the registration process (Source: MGM Innova, adaptation by Passivhaus Institut).

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

Simple monitoring is focused on essential data collection for emissions and energy consumption reduction calculations 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 of the NAMA VE in its monitoring phase cannot be defined with previous accuracy to the operation definition and the calculation tool characteristics, it is expected that metrics to be monitored are very similar to those defined for the NAMA VE initial phase.

# 5.6 Definition and selection of the sample size to be monitored

During the implementation of the MRV system in the pilot project phase of the NAMA VE, the monitoring of all pilot housing is proposed. However, if it is a large number within the project, definition of a statistically representative sample is proposed. These criteria would also apply to the monitoring process during the monitoring phase of the NAMA VE. This section describes updated criteria to select the sample to be monitored.

# 5.7 Sample to be monitored at the initial phase

It is important that a sample is statistically representative to draw conclusions with an informative value. Therefore, the proposal is to monitor 15 houses per group and select two building types. The decision of which types are the most representative should be taken considering the current volume of the existing housing stock and the available projects, and define it previous to monitoring. Similarly, the proposal is to monitor only two of the proposed energy efficiency levels so the amount of identical houses to be monitored would be reduced from three to two and the amount of packages, from four to two. It is worth mentioning it is assumed that the baseline would be calculated with a tool such as DEEVi or PHPP, according to the amendment of methodology to use, so that these measures would not be necessary.

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

Proposal for groups regarding pilot projects monitoring

Table 3: Proposal for groups regarding pilot projects monitoring (Source: Passivhaus Institut).

Building type	Bioclimatic zone	Savings percentage levels (Savings min. 20%)	Groups total considered for monitoring	Total of buildings to be monitored (1.85 σ)
Tuno 2	Zone 1 (hot dry) Zone 2 (template)	Step 1 Step 3 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
Type 2	Zone 3 (cold template) Zone 4	Step 1 Step 3 Step 1		

	(hot humid)	Step 3		
Type 3	Zone 1 (hot dry)	Step 1 Step 3	2 building types X	
	Zone 2 (template)	Step 1 Step 3	4 bioclimatic zones X 2 energy efficiency savings levels	
	Zone 3 (cold template)	Step 1 Step 3		
	Zone 4 (hot humid)	Step 1 Step 3	16 groups	

It is worth mentioning that in order monitored results are statistically relevant, 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]:

(Source: MGM Innova)

Table 4: Simple and detailed monitoring elements summary for emissions reduction calculations (Source: GIZ/MGM Innova).

Elements	Simple monitoring	Detailed monitoring
Objective	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 <sup>1</sup>	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 its initial phase	Similar to the one of the MRV system in its initial phase
Data for baseline	Necessary data for ex - ante calculation (once)	Ex - ante energy consumption data through billing (once)

<sup>&</sup>lt;sup>1</sup> 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

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 that the NAMA VE concept is only in its initial phase, it will be counterproductive to define tasks in detail within the MRV of the NAMA VE. This should be done once funding possibilities are clear and which actors will be involved.

In general, 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 implementation of the MRV system tends to be access to data. Lack of necessary institutional frameworks and procedures, trained personnel, and/or resources can provide additional challenges.

The Sustainable Housing NAMA has made great strides towards accessing the data needed to operate the GHG MRV through a series of formal agreements with utility providers such as CFE, CONAGUA, and DTI. The issue becomes more relevant for housing units. The access issue may become more complex in the case of the reference homes where incentives may have to be introduced to gain access to the same amount of data.

Another challenge involves balancing the need for robust and reliable estimates and the need to maintain flexibility, simplicity and cost-effectiveness of the MRV system of the proposed NAMA VE. The MRV system would ideally be as accurate as necessary and as simple as possible. When guidance developed by the UNFCCC, specific requirements for registration under an international regime can be incorporated into the proposed MRV system.

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

In the coming months, as the proposed NAMA VE concept is refined and developed further, additional analyses will be conducted to establish data availability, suitability of the identified approaches, and the possibilities for synergies arising from the need for coordination between the various climate initiatives in the housing sector in Mexico.

NAMA's database currently under development will be a centralized source of information that regulators, researchers, and industry professionals can evaluate and compare performance of sustainable housing developments 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 through a cost estimation of the measures for the three identified steps. A first estimate, 'current costs' reflects the costs incurred if measures described before are executed in 3 phases or steps.

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

Moreover, from an economic point of view, in addition to capital investment costs, energy supply costs and other operating costs should always be factored in when assessing enhanced energy efficiency measures. As shown in the following graphs, reduced energy supply costs (and reduced subsidies) outweigh higher investment costs for the construction of more energy-efficient buildings.

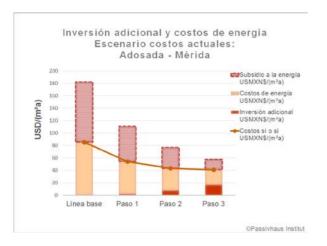
Table 17 shows the basic assumptions for the calculation.

Table 5: Boundary conditions for life-cycle costs calculation. (Source: Passivhaus Institut based on SENER 2014 data)

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.

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 the individual owner are shown in orange, while implied annual subsidies for the energy consumption of the owner are shown in dotted red.

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



Inversión adicional y costos de energía Escenario costos futuros: Adosada - Mérida Subsidio a la energía USMXN\$/(m²a) Costos de energia USMXN\$/(m²a) USD/(m²a) 140 Inversión adicional USMXN\$/(m²a) 120 Costos si o si USMXNS/(m²a) 100 Linea base Paso 1 Paso 2 Paso 3 PPassivhaus Institut

Figure 3: Current costs of the different steps towards the "step by step refurbishment to achieve optimal energy and environmental performance" standard (efficiency improvements) for the Adosada building type (50 m² SRE) in Merida (Source: Passivhaus Institut).

Figure 4: Future costs of the different steps towards the "step by step refurbishment to achieve optimal energy and environmental performance" standard (efficiency improvements) for the Adosada building type (50 m² SRE) in Merida (Source: Passivhaus Institut).

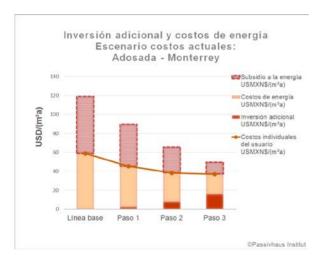




Figure 5: Current costs of the different steps towards the "step by step refurbishment to achieve optimal energy and environmental performance" standard (efficiency improvements) for the Adosada building type (50 m² SRE) in Monterrey (Source: Passivhaus Institut).

Figure 6: Future costs of the different steps towards the "step by step refurbishment to achieve optimal energy and environmental performance" standard (efficiency improvements) for the Adosada building type (50 m² SRE) in Monterrey (Source: Passivhaus Institut).

In both cases, it is clear that since first step it is worth investing on energy efficiency. From a costefficient point of view, 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 has expanded due to housing improvements, the costs of some technologies will be reduced. It is shown that the additional investment decreases and becomes more attractive for the user. It is important to mention that 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 for additional investment costs in energy efficiency measures and water savings, an average amount of 1,447 USD has been calculated. 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 costs of measures in Steps 1 and 2). The complete implementation period is from 2015 to 2019. It should be clear that in this example, average costs shown 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<sup>2</sup> per zone, maximum investments are as follows:

- Step 1: 60 million USD total investment 18 million USD for energy efficiency and water consumption improvements
- Paso 2: 120 million USD total investment 36 million USD for energy efficiency and water consumption improvements
- Paso 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 houses, only in some of them. It is assumed that approximately 50% will participate in Step 1, 40% in Step 2 and the remaining of the 36,000 houses 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.

<sup>&</sup>lt;sup>2</sup>It is estimated that in 2013, there were 27 million houses in Mexico. Assuming that 2% will be refurbished every year, a total of 540,000 units will be refurbished. From this estimation, about 2/3 are social housing units. Therefore, about 360,000 social housing units will be refurbished. These 360,000 units constitute the total market. Thus, 36,000 houses forecast represents 10% of the total market, which seems realistic.

Adding these amounts, a 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 lender contribute with 20% of its own capital (79 million USD), credit requirement would be 317 million USD. Costs of indirect measures should be added, including subsidies on credit subsidies, hard to predict at this time.

It is important to say that 2 kinds of subsidies for home-owners for financial burden relief and to give them an additional incentive: 1) Subsidy to reduce the interest rate (to be determined) and 2) Subsidy to reduce reimbursement installment.

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

## 6.2.2 Indirect mitigation actions (supportive actions)

The cost of supportive actions was estimated for the first phase of the NAMA VE from 2015 to 2019. The estimates were based on assumption of total roll-out 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 of supportive actions is not likely to increase significantly in case of faster roll-out. 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 programs (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 the financing of the NAMA VE are based on the financial requirements that need subsidies to interest rate and possible contributions to reduce lenders (homeowners) reimbursement installment. The financing concept includes international co-financing to initiate with the first implementation activities of the Supported NAMA VE.

## **6.3** Financing scheme for the NAMA for Sustainable Housing Retrofit

A financial vehicle the 'NAMA Fund' will be set up to be the initial recipient of donor funds, whether in the form of soft loans or grants. The initial contribution will be made by the Mexican government. 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 expectations of existing 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 general, 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 be directed also to support the supply of energy refurbishment through building companies (developers),

It is clear that decreasing the overall energy consumption creates savings that have real economic value. However, in order to leverage public and private finance and create a conduit for performance based payments, it is necessary to evaluate where stakeholders can capture value.

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



Figure 7: Added value for different actors of the NAMA (Source: Passivhaus Institut).

## 6.3.1 Financial support for the demand side

The mortgage component is one of the most important parts of the NAMA design because it drives demand for energy efficient homes. Without demand, even the most favorable conditions for developers will not result in a successful program. Furthermore, if a strong market demand can be generated, less assistance 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 ultimately achieves emissions reductions through decreasing consumption of electricity, natural gas and water per unit of housing. Returns on residential energy efficiency investments are driven by the technology performance and resulting costs.

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

Without the NAMA VE, neither of these assumptions is likely to hold. As Figure 17 illustrates, the government, not the homeowner, benefits from the reduction in subsidy payments. In Mexico, on average, 60% of residential energy costs are covered through federal subsidies. This reduces the payback received by the homeowner, and thus the revenue stream that can be used to secure financing for the

equipment. Subsidized mortgage assistance, covering all or some of the incremental cost of the energy efficient features, can overcome this challenge by reducing the investment cost to home owners, and the amount of savings needed each month to make the investment attractive, especially for higher energy efficiency levels as shown in Figure 22.

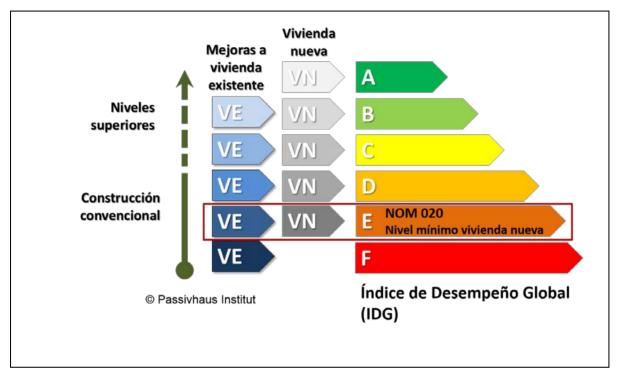


Figure 8: IDG adaptation for the NAMA for Sustainable Housing Retrofit (Source: Passivhaus Institut).

For financing support grants, a financing scheme for sustainable housing 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.

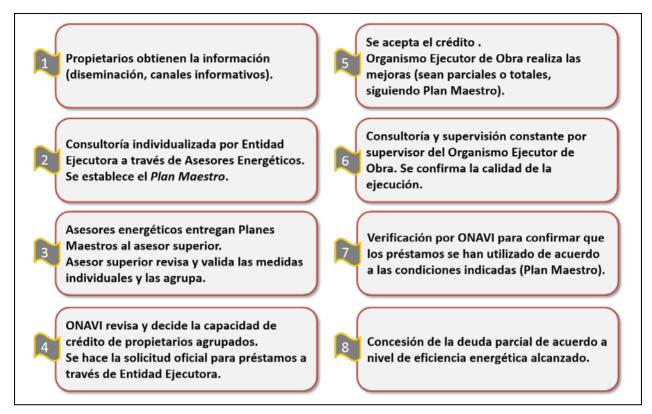


Figure 9: System proposed for credit consent to owners within the NAMA for Sustainable Housing Retrofit framework (Source: KfW, adaptation by the Passivhaus Institut).

## 6.3.2 Financial support for capacity building and MRV

In order to achieve, measure, and report impacts, the NAMA VE will also require funds for administrative capacities and support to develop and apply the MRV system. As there are no revenue generation opportunities under this end use, it is not well suited to attracting private investment; however a robust MRV system is critical to demonstrating emission reductions.

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

- payment in the international NAMA VE Fund and operation by a specific agency (be it national, international or both);
- implementation of new bilateral programmes for technical assistance between a certain host country and Mexico implemented 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 Potencial approaches

## 6.4.1 Corporate Social Responsibility (CSR) Model

The concept behind NAMA VE is that the reductions represent the contributions of the host country towards fighting climate change, thus the emission reductions generated by the project should ultimately count towards Mexico's goals and not be transferred outside of the country for use as offsets. Although the emissions reductions achieved cannot be sold or traded through the carbon market, there are still buyers that perceive value in emissions reductions and in demonstrating their commitment to sustainable development. Examples include large multinationals operating inside Mexico that wishing to demonstrate goodwill, Mexican companies that have nonbinding 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 provide benefits such as NAMA VE employee housing and be rewarded with a "claim" to Mexican emissions reductions. A system could be set up to track the emissions resulting from their investments such that large domestic firms may be able to claim a certain amount of the emissions benefit towards their CSR or 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 claim would be substantiated through MRV systems 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

Analysis of the performance of various types of houses 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 freestanding or detached family homes (Aisladas). Vertical housing units in particular prove not only to be more efficient as to the performance of the building itself, but also allow urban settlements to remain closer to the city centre, thereby avoiding undesirable urban sprawl.

On the basis of the above, five financing packages have been formulated as an example of how international support could advance the NAMA VE, presented in Table 11. Financing needs are split into three categories: subsidies to homeowners, bridge loans to developers in the form of 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 only is shown. See also section 6.2.1.

Table 6: 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
1) Inversión total						
P1:	17,6	35,1	35,1	35,1	35,1	158
P2:	8,3	25	50	58,3	58,3	200
P3:	0	0	4,2	12,7	21,1	38
Suma:	25,9	60,1	89,3	106,1	114,6	396
2) Costos de la inversión						
energética						
P1:	3	6	6	6	6	27
P2:	4	12,1	24,3	28,3	28,3	97
P3:	0	0	2,9	7,9	13,2	24
Suma:	7	18,1	33,2	42,2	47,5	148
3) Necesidades crediticias	20,7	48,1	71,5	84,9	91,6	317
totales (80% de Suma 1)	20,7	40,1	71,3	04,3	31,0	317
4) Necesidades crediticias para						
mejoras en eficiencia energética	5,6	14,5	26,5	33,8	38,0	118,4
y consumo de agua. (80% de	3,0	14,3	20,3	33,0	30,0	110,4
Suma 2)						
5) Necesidad para subsidio de						
reducción de reembolso	0,8	2,2	4,0	5,1	5,7	17,8
(15% de 4) *, **						
6) Necesidad para subsidio para						
asistencia técnica (acc. de apoyo)	17,9	7,2	7,2	7,2	3,6	43
asisterisia teerinea (acc. ac apoyo)						

P1= paso 1, P2= paso 2, P3 = paso 3

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

The total incremental cost of construction indicated in Table 11 (No. 4), is equivalent to the volume of soft loans that the developers would require in the form of bridge financing in order to build the houses to higher energy efficiency standards. The revolving fund to "soften" credits comes from private and official donors, both national and international. It may combine a blend of commercial funds and government grant money, aimed at creating soft conditions for lending. Table 11 shows the accumulated and per year requirements for the revolving fund on assumption of implementation during the period 2015-2019.

Several important considerations apply for the financing packages presented above:

- Flexibility of grant packages: The packages shown below have the character of example packages. Actual packages can be shaped to fit specific requirements of interested donors (e.g. adjustments can be made in terms of financial volume, type of buildings and efficiency standards covered, etc.).
- Combi-packages: The Mexican government, through competent institutions in charge, is willing
  to offer combinations of grant packages for subsidies to home-owners, and/or grant packages
  for supportive actions.

<sup>\*</sup> El subsidio de reducción de reembolso es concedido cuando ciertos objetivos de eficiencia energética se han alcanzado.

<sup>\* \*</sup>El subsidio de la tasa de interés no se puede estimar ya que depende de varios factores que son todavía desconocidos.

• Mexican priorities between soft loan and grant packages: The implementation of the NAMA VE is critically dependent on the support of the international donor community for subsidies to homeowners and supportive actions ensuring the functioning of the NAMA VE. The soft-loan component of the NAMA VE has a complementary character, and represents an important element in the overall finance strategy. The Mexican government has a clear priority to ensure grant financing first, and will try to obtain soft-loan financing in parallel.

## 7 Conclusions y 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, which is an 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 population quality of life conditions, comfort increases through 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 and looking for measures to be implemented for water savings.

This notion of increased comfort over time is also reflected in the MRV concept proposed, where the baseline should be calculated by an adequate tool that enables to take in consideration housing comfort conditions increase to prove the investment on energy efficiency.

A fundamental aspect of the concept presented is the implementation of a mandatory Energy Advisory 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 session is proposed as a mandatory requirement for financing, as well as the supervision and verification on improvements. The accurate application and definition of the NAMA VE operation will have to be carried out by each institution for actions to function optimally.

As first steps, the following actions have been considered: the implementation of the energy advisory scheme together with the establishment of a scheme for projects supervision and verification, adjustments to the SISEVIVE-ECOCASA tool, the development and training of Financial entities and Building companies from the field of housing improvements towards energy efficiency, as well as the dissemination and promotion among home-owners. This last action is identified as a crucial one for the 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, mitigating GHG emissions and improving owners' quality of life.

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Gas (energía final)	kWh/(m²a) kWh/(m²a) kWh/(m²a) kWh/(m²a) kWh/(m²a)	71 242	ADOSADA - Paso 1 - Monterrey 71	ADOSADA - Paso 2 - Monterrey	ADOSADA - Paso 3 (EnerPHit) - Monterrey	ADOSADA - Línea base - Guadalajara	ADOSADA - Paso 1 - Guadalajara	ADOSADA - Paso 2 - Guadalajara	ADOSADA - Paso 3 (EnerPHit) - Guadalajara	ADOSADA - Línea base - Cd.México	ADOSADA - Paso 1 - Cd.México	ADOSADA - Paso 2 - Cd.México	ADOSADA - Paso 3 (EnerPHit) - Cd.México	ADOSADA - Línea base - Mérida	ADOSADA - Paso 1 - Mérida	ADOSADA - Paso 2 - Mérida	ADOSADA - Paso 3 (EnerPHit) - Mérida
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Demanda total específica de refrigeración  Demanda específica de energía primaria  Emisiones totales de CO2 equivalente  COSTOS  Costos de inversión adicional por EE, POR VIVIENDA (actual, USD)  Costos de inversión adicional por EE, POR VIVIENDA (a futuro, USD)		226 38	223 38	84 29	33 27	85 0	81 0	13 0	5	37 0	33 0	5	0	412 160	404 160	138 119	87 36
Demanda específica de energía primaria Emisiones totales de CO2 equivalente COSTOS Costos de inversión adicional por EE, POR VIVIENDA (actual, USD) Costos de inversión adicional por EE, POR VIVIENDA (a futuro, USD)	VAANII (IIII 91	264	261	114	60	85	81	13	U	37	33	U	U	571	564	258	123
COSTOS  Costos de inversión adicional por EE, POR VIVIENDA (actual, USD)  Costos de inversión adicional por EE, POR VIVIENDA (a futuro, USD)	kWh/(m²a)	736	541	352	208	347	279	191	126	596	520	318	126	1138	675	424	244
Costos de inversión adicional por EE, POR VIVIENDA (actual, USD)  Costos de inversión adicional por EE, POR VIVIENDA (a futuro, USD)	kg/(m²a)	162	119	78	47	78	62	43	29	131	114	70	28	249	148	93	55
	USD	\$ -	\$ 2,428	\$ 9,589	\$ 16,017	\$ -	\$ 1,349	\$ 4,233	\$ 6,821	\$ -	\$ 1,349	\$ 5,643	\$ 9,071	\$ -	\$ 2,428	\$ 10,043	\$ 16,883
GRAN TOTAL de costos de inversión POR VIVIENDA (actual, USD)	USD		\$ 2,284	\$ 5,096	\$ 8,664	\$ -	\$ 1,206	\$ 2,549	\$ 4,305	\$ -	\$ 1,206	\$ 2,759	\$ 5,203	\$ -	\$ 2,284	\$ 5,281	\$ 9,054
	USD	\$ 7,934	\$ 11,964 \$ 1,602	\$ 19,125 \$ 1,602		\$ 7,934	\$ 9,965 \$ 682	\$ 12,849 \$ 682	\$ 15,437 \$ 682	\$ 7,934	\$ 10,190 \$ 907	\$ 14,484 \$ 907	\$ 17,912 \$ 907	\$ 7,934	\$ 12,051 \$ 1,688	\$ 19,665 \$ 1,688	\$ 26,505 \$ 1,688
Costos por consultoria general (incl. asesoría energ.)  Variable	Unidad	\$ -	\$ 1,602	\$ 1,602	\$ 1,602	\$ -	\$ 682	\$ 682	\$ 682	\$ -	\$ 907	\$ 907	\$ 907	\$ -	\$ 1,088	\$ 1,088	\$ 1,088
DATOS DE AISLAMIENTO TÉRMICO											,						
Conductividad térmica aislamiento muros y techo	W/mK	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371
Espesor aislamiento muro N, S y O (excepto medianera) ¿Aislamiento interior muro N, S y O (excepto medianera)?	mm Sí/No	n/a No	n/a No	n/a No	100 No	n/a No	n/a No	n/a No	25 No	n/a No	n/a No	n/a No	75 No	n/a No	n/a No	n/a No	150 No
Espesor aislamiento muro E (pasillo)	mm	n/a	n/a	n/a	50	n/a	n/a	n/a	25	n/a	n/a	n/a	50	n/a	n/a	n/a	n/a
¿Aislamiento interior muro E? (pasillo)	Sí/No	Sí	Sí	Sí	Sí	Sí	Sí	Sí	Sí	Sí	Sí	Sí	Sí	Sí	Sí	Sí	Sí
Conductividad térmica aislamiento piso	W/mK	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371
Espesor aislamiento losa de piso	mm	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a 150	n/a 150
Espesor aislamiento techo ¿Aislamiento interior techo?	mm Sí/No	n/a No	n/a No	125 No	125 No	n/a No	n/a No	25 No	25 No	n/a No	n/a No	75 No	75 No	n/a No	n/a No	150 No	150 No
Valor-U puerta exterior (no aplica en adosada)	W/m2K	-	-	-	-	-	0.00	0.00	-	-	-	-	-	-	-	-	-
Coeficiente de absorptividad techo	-	0.50	0.50	0.15	0.15	0.70	0.70	0.40	0.40	0.70	0.70	0.70	0.70	0.50	0.50	0.15	0.15
Coeficiente de absorptividad muros	-	0.60	0.60	0.15	0.15	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.15	0.15
Suplemento PT estándar VENTANAS	W/(mK)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Marco: Valor-Uf	W/m2K	5.50	5.50	1.00	1.00	5.50	5.50	3.00	3.00	5.50	5.50	1.00	1.00	5.50	5.50	0.72	0.72
Acristalamiento: valor g	-	0.87	0.87	0.33	0.33	0.87	0.87	0.60	0.60	0.87	0.87	0.75	0.75	0.87	0.87	0.33	0.33
Acristalamiento: Valor-Ug	W/m2K	5.54	5.54	1.05	1.05	5.54	5.54	2.27	2.27	5.54	5.54	1.06	1.06	5.54	5.54	0.60	0.61
Ψ instalación en muro N, S, O (excepto medianera)	W/mK	0.09	0.09	0.04	0.04	0.09	0.09	0.04	0.04	0.09	0.09	0.04	0.04	0.09	0.09	0.03	0.02
Ψ instalación en muro E VENTILACIÓN	W/mK	0.09	0.09	0.04	0.04	0.09	0.09	0.04	0.04	0.09	0.09	0.04	0.04	0.09	0.09	0.03	0.04
Tasa renovación aire ensayo presión n50	1/h	10.00	10.00	3.00	1.00	10.00	10.00	3.00	1.00	10.00	10.00	3.00	1.00	10.00	10.00	3.00	1.00
Ventilación equilibrada tipo Passivhaus	х	Vent. por	Vent. por	Vent. por	Vent.	Vent. por	Vent. por	Vent. por	Vent. por	Vent. por	Vent. por	Vent. por	Vent. por	Vent. por	Vent. por	Vent. por	Vent.
		ventanas	ventanas	ventanas	Passivhaus	ventanas	ventanas	ventanas	ventanas Aparato	ventanas	ventanas	ventanas	ventanas Aparato	ventanas	ventanas	ventanas	Passivhaus
Sólo aire de extracción	x	n/a	n/a	n/a	n/a	n/a	n/a	n/a	extracción	n/a	n/a	n/a	extracción	n/a	n/a	n/a	n/a
Eficiencia de recuperación de calor efectiva	%	n/a	n/a	n/a	90%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	90%
Eficiencia eléct. Vent. (HRV, extracción o ventanas)	Wh/m³	n/a	n/a	n/a	0.25	n/a	n/a	n/a	0.25	n/a	n/a	n/a	0.25	n/a	n/a	n/a	0.25
Ef. Recuperación energía (humedad)  SOMBRAS	%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	70%
Factor protección solar temporal Z	%	100%	100%	34%	34%	100%	100%	80%	80%	100%	100%	100%	100%	100%	100%	34%	34%
ELECTRICIDAD																	
Porcentaje de lámparas fluorescentes  Demanda lavadora de ropa	% kWhr/Uso	100% 1.12	100% 1.12	100% 0.85	100% 0.85	100% 1.12	100% 1.12	100% 0.85	100% 0.85	100% 1.12	100% 1.12	100% 0.85	100% 0.85	100% 1.12	100% 1.12	100% 0.85	100% 0.85
Demanda refrigerador con congelador	kWhr/d	1.12	0.41	0.83	0.83	1.50	0.41	0.65	0.65	2.68	0.41	0.41	0.85	1.50	0.41	0.83	0.83
Electrónica (TV)	w	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Tipo de estufa	-	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP
Demanda de estufa ELECTRICIDAD-AUX	kWh/uso	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Demanda ventilador de techo	kWhr/a	240	240	240	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	240	240	240	n/a
VENTILACIÓN EN VERANO	· ·	,				, 5	, =	·-, -	, =		·	-y	7-				
Renov. aire sist. ventilación c/aire impulsión	1/h	n/a	n/a	n/a	1.05	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.70
Renovación aire sist. Extracción aire	1/h	n/a 1.05	n/a 1.05	n/a	n/a	n/a	n/a	n/a 1 05	0.50	n/a	n/a 1.05	n/a 1 0E	0.50	n/a	n/a	n/a	n/a
Renovación de aire por ventanas  Renovacon de aire: Ventilación nocturna por ventanas	1/h 1/h	1.05 1.00	1.05 1.00	1.05	0.00 0.10	1.05	1.05 1.00	1.05 1.00	0.00 1.00	1.05 1.00	1.05 1.00	1.05	0.54 1.00	1.05	1.05 1.00	1.05 1.00	0.00
APARATOS REFRIGERACIÓN	±/,·/	1.50	1.50	1.00	5.10	1.00	1.00	1.50	1.00	1.00	1.50	1.00	1.00	1.00	1.50	1.00	5.50
Ref. Circ: Capacidad ref máxima	kW	15.83	15.83	5.28	3.52	5.28	5.28	5.28	3.52	5.28	5.28	5.28	3.52	15.83	15.83	5.28	5.28
Ref. Circ: Volumen de aire en potencia nominal	m³/h	2250	2250	500	500	750	750	750	500	750	750	750	500	2250	2250	500	500
Ref. Circ. SEER  Deshumidificación adicional	-	2.00 Deshum.	3.26 Deshum.	3.26 Deshum.	3.26 Deshum.	2.72 n/a	3.26 n/a	3.26 n/a	3.26 n/a	2.72 n/a	3.26 n/a	3.26 n/a	3.26 n/a	2.00 Deshum.	3.26 Deshum.	3.26 Deshum.	3.26 Deshum.
Deshumidificación: SEER	- X	1.00	1.85	1.85	1.85	n/a n/a	n/a n/a	n/a n/a	n/a n/a	n/a n/a	n/a n/a	n/a n/a	n/a n/a	1.00	1.85	1.85	1.85
DISTRIBUCIÓN ACS																	
	itros/Persona/d	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
COLECTOR SOLAR ACS Tipo de Colector	0	Tub.evac.	Tub.evac.	Tub.evac.	Tub.evac.	Tub.evac.	Tub.evac.	Tub.evac.	Tub.evac.	Tub.evac.	Tub.evac.	Tub.evac.	Tub.evac.	Tub.evac.	Tub.evac.	Tub.evac.	Tub.evac.
Superficie del colector	m²	n/a	1.20	1.20	1.20	n/a	1.20	1.20	1.20	n/a	1.20	1.20	1.20	n/a	1.20	1.20	1.20
CALDERA / BOILER						,								·			
Tipo de generador de calor	Texto		Caldera gas				Caldera gas			Caldera gas							
Rendimiento del calentador con potencia nominal  CALEFACCIÓN	%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%
Directamente eléctrica	%	100%	100%	100%	0%	100%	100%	100%	0%	100%	100%	100%	0%	100%	100%	100%	0%
A través de equipo split	%	0%	0%	0%	100%	0%	0%	0%	100%	0%	0%	0%	100%	0%	0%	0%	100%
OTROS					2.75							2				5 = 5	
	0%	2.70	2.70	2.70	2.70 1.10	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70
Factor de energía primaria Electricidad		1 10	1 10				1 10	1 10	1 10	1 10	1 10	1 10	1 10	1 10	1 10	1 10	1 10
	0% kg	1.10 0.58	1.10 0.58	1.10 0.58	0.58	1.10 0.58	1.10 0.58	1.10 0.58	1.10 0.58	1.10 0.58	1.10 0.58	1.10 0.58	1.10 0.58	1.10 0.58	1.10 0.58	1.10 0.58	1.10 0.58

AISLADA    A
Monters Construction
Demande sepecifica de calefacción   WMh/(m²)   18   118   89   24   67   67   67   60   155   246   246   546   55   0   0   0   0
Demanda especifica de calefacción   WWh/(m²a)   118   M/m   118   90   24   67   67   40   15   244   244   146   53   0   0   0   0   0   0   0   0   0
Electricidad (energia finall)   WW/(m²a)   607   256   174   48   158   155   74   22   311   297   198   23   518   333   190
Demanda specifica de refrigeración servible   MWh/(m²a)   377   383   311   59   165   110   374   10   82   78   14   2   640   622   2040   Demanda specifica de refrigeración latente   MWh/(m²a)   42   447   148   72   140   150   140
Demanda especifica de refrigeración latente   WWH/m²   45   45   56   74   75   75   75   75   75   75   75
Demanda stopal Especifica de energing primaria   WWN/(m²a)   1204   292   530   225   536   250   236   532   532   532   532   532   532   532   533   535   53
Demanda especifica de nergia primaria   WWh/(m*a)   1204   829   530   226   564   530   308   138   232   852   502   168   1517   981   538   1517   150
Costos de Inversión adicional por EE, POR VIVIENDA (actual, USD)  USD 5 - 5 2.267 5 8.300 5 16.586 5 - 5 431 5 2.922 5 5.406 5 - 5 786 5 4.733 5 8.675 5 - 5 2.023 5 12.866 5 Costos de Inversión adicional por EE, POR VIVIENDA (actual, USD)  USD 5 - 5 2.124 5 4.467 5 7.732 5 5 5 227 5 14.51 1 3.266 5 - 5 786 5 4.733 5 8.675 5 - 5 2.033 5 12.866 5 Costos de Inversión adicional por EE, POR VIVIENDA (actual, USD)  USD 5 7.345 5 9.021 2 5 13.695 2 1.2913 5 6.427 5 6.887 8 9.348 6 13.33 5 6.74 5 7.932 5 1.380 5 0.010 5 Costos de Inversión energe.  USD 5 1.493
Costos de inversión adicional por EE, POR VIVIENDA (astural, USD)   USD   S   S   2,247   S   8,300   S   1,586   S   S   431   S   2,922   S   5,000   S   S   7,281   S   8,278   S   1,228   S   S   S   S   S   S   S   S   S
Costo de inversión adicional por EE, POR VIVIENDA (a futuru, USD)   USD   S   S   2.124   S   4.487   S   7.723   S   S   S   287   S   1.451   S   3.266   S   - S   655   S   2.243   S   4.589   S   5   1.879   S   5.010   S   2.0557   S   Costo de inversión POR VIVIENDA (actual, USD)   USD   S   7.455   S   6.817   S   5.612   S   6.427   S   6.437   S   6.438   S   4.888   S   1.832   S   6.744   S   7.525   S   1.448   S   1.829   S   1.5243   S   5.625   S   2.0557   S   2.057   S   2.0557   S   2.0557   S   2.0557   S   2.0557   S   2.05
USD   S   1,459
National Conductividad térmica aislamiento muros y techo   W/mK   0.0371
ACT   Conductividad terrica asialamiento muros y techo   W/mK   0.0371
Espesor aislamiento muro N y S   No
Adistamiento interior muro N y S?
Espesor aislamiento muro E (pasillo), O (limite lote)
Actistamiento interior muro E (pasillo), O (límite lote)?   Si/No   Si   Si   Si   Si   Si   Si   Si   S
Espesor aislamiento losa de piso   mm   n/a
Espesor aislamiento techo
Asislamiento interior techo?   Si/No   No   No   No   No   No   No   No
Valor-U puerta exterior (no aplica en adosada)  W/m2K  2.87
Coeficiente de absorptividad muros  - 0.60 0.60 0.60 0.15 0.15 0.60 0.60 0.60 0.60 0.60 0.60 0.60 0.6
Suplemento PT estándar   W/(mK)   0.10   0
VENTANAS  Marco: Valor-Uf  Marco: Valor-
Marco: Valor-Uf Acristalamiento: valor g - 0.87 0.87 0.33 0.33 0.87 0.87 0.70 0.70 0.87 0.87 0.75 0.75 0.87 0.87 0.87 0.83 Acristalamiento: Valos-Ug W/m2K 5.54 5.54 1.06 1.06 5.54 5.54 2.27 2.27 5.54 5.54 1.06 1.06 5.54 5.54 0.60 W instalación en muro N, S, O W/mK 0.09 0.09 0.04 0.04 0.09 0.09 0.04 0.04
Acristalamiento: Valos-Ug  W/m2K  5.54  5.
Ψ instalación en muro N, S, O
Ψ instalación en muro E
Tasa renovación aire ensayo presión n50 1/h 10.00 10.00 3.00 1.00 10.00 3.00 1.00 1
Ventilación equilibrada tipo Passivhaus x Vent. por Vent
IVentilación equilibrada tipo Passivhaus
ventanas
Sólo aire de extracción x n/a
extraccion extraccion
Eficiencia de recuperación de calor efectiva % n/a
Ef. Recuperación energía (humedad)
SOMBRAS
Factor protección solar temporal Z
Porcentaje de lámparas fluorescentes % 100% 100% 100% 100% 100% 100% 100% 1
Demanda lavadora de ropa kWhr/Uso 1.12 1.12 0.85 0.85 1.12 1.12 0.85 0.85 1.12 1.12 0.85 0.85 1.12 1.12 0.85
Demanda refrigerador con congelador   WWhr/d   2.68   0.41   0.41   0.41   1.50   0.41   0.41   1.50   0.41   0.
150   150
Demanda de estufa
ELECTRICIDAD-AUX
Demanda ventilador de techo   kWhr/a   240   120   240   n/a   240   120   240   VENTILACIÓN EN VERANO
Renov. aire sist. ventilación c/aire impulsión 1/h n/a
Renovación aire sist. Extracción aire 1/h n/a n/a n/a n/a n/a n/a n/a 0.50 n/a n/a 0.50 n/a n/a n/a n/a n/a
Renovación de aire por ventanas 1/h 1.42 1.42 1.42 0.00 1.42 1.42 0.00 1.42 1.42 0.00 1.42 1.42 0.00 1.42 1.42 1.42 0.00 1.42 1.42 1.42 0.00 1.00 1.00 1.00 1.00 1.00 1.00 1.0
Renovación de aire: Ventilación nocturna por Ventanas 1/n 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.0
Ref. Circ: Capacidad ref máxima kW 15.83 15.83 5.28 5.28 8.79 8.79 5.28 4.00 5.28 5.28 4.00 15.83 15.83 8.79
Ref. Circ: Volumen de aire en potencia nominal m³/h 2250 2250 500 1000 1000 1000 1000 750 750 1000 100
Ref. Circ. SEER         -         2.00         3.26         3.26         3.26         2.72         2.72         2.72         3.26         2.72         3.26
Deshumidificación: SEER - 1.00 1.00 1.85 2.20 n/a n/a n/a n/a n/a n/a n/a n/a n/a 1.00 1.00 2.20
DISTRIBUCIÓN ACS
Consumo de ACS por persona y día (60°C)   Litros/Persona/d   25   25   25   25   25   25   25   2
Tipo de Colector 0 Tub.evac.
Superficie del colector m² n/a 2.00 2.00 n/a n/a n/a n/a n/a 1.20 1.20 n/a 1.20 1.20 1.20 1.20
CALDERA / BOILER  Tipo de generador de calor  Texto  Caldera gas   Calde
Tipo de generador de calor  Texto  Caldera gas Caldera
CALEFACCIÓN
Directamente eléctrica         %         100%         100%         0%         100%
A través de equipo split % 0% 0% 0% 100% 0% 0% 0% 0% 0% 0% 0% 0% 0% 0% 0% 0%
Factor de energía primaria Electricidad 0% 2.70 2.70 2.70 2.70 2.70 2.70 2.70 2.70
Factor de energía primaria Gas LP 0% 1.10 1.10 1.10 1.10 1.10 1.10 1.10 1
Factor de CO2 electricidad kg 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58
Factor de CO2 gas LP kg 0.27 0.27 0.27 0.27 0.27 0.27 0.27 0.27

Superficie de referencia energética (por vivienda): 41 m²	]																
VEDTICAL		CAL- ase- arrey	2AL- 11- errey	2 - grrey	CAL- 53 Hit)- errey	CAL- pase - ajara	CAL- 1- ajara	CAL- 2- ajara	CAL- 33 Hit)- ajara	CAL- sase-	CAL- 1- xico	2 - xico	CAL- 0.3 Hit)- ixico	CAL- base-	2AL- 11-	ZAL- 2 -	CAL- 53 Hit)-
VERTICAL		VERTICAL - Línea base - Monterrey	VERTICAL - Paso 1 - Monterrey	VERTICAL - Paso 2 - Monterrey	VERTICAL - Paso 3 (EnerPHit) - Monterrey	VERTICAL - Línea base Guadalajar	VERTICAL - Paso 1 - Guadalajara	VERTICAL - Paso 2 - Guadalajara	VERTICAL - Paso 3 (EnerPHit) - Guadalajara	VERTICAL - Línea base - Cd.México	VERTICAL - Paso 1 - Cd.México	VERTICAL - Paso 2 - Cd.México	VERTICAL - Paso 3 (EnerPHit) - Cd.México	VERTICAL Línea base Mérida	VERTICAL Paso 1 - Mérida	VERTICAL Paso 2 - Mérida	VERTICAL Paso 3 (EnerPHit) Mérida
		7 ] -	Monterrey: Clin		, 01	7 1 6		a: Templado	- 00	/ ] -		: Templado frío	, ,	, ,		lido humedo	
Demanda específica de calefacción	kWh/(m²a)	52	52	59	6	24	24	26	12	105	105	87	17	0	0	0	0
Electricidad (energía final)	kWh/(m²a)	210	150	118	48	91	65	52	29	160	132	110	25	360	204	156	65
Gas (energía final)	kWh/(m²a)	85	60	57	54	88	58	51	52	73	46	46	47	94	66	54	55
Demanda específica de refrigeración sensible	kWh/(m²a)	204	199	88	46	66	61	14	4	24	20	6	0	368	346	150	79
Demanda específica de refrigeración latente	kWh/(m²a)	31	31	20	15	0	0	0	0	0	0	0	0	129	129	126	24
Demanda total específica de refrigeración	kWh/(m²a)	236	231	108	60	66	61	14	440	24	20	240	407	496	474	277	103
Demanda específica de energía primaria	kWh/(m²a)	662	472	381	196	343	241	198	148	513	408	348	137	1075	622	480	236
Emisiones totales de CO2 equivalente	kg/(m²a)	146	104	84	44	77	54	44	34	113	90	77	31	236	137	106	53
COSTOS  Control de inversión edicional year EE DOD VIVIENDA (estual LICD)	LICD	ć	\$ 1,072	\$ 6,080	\$ 15,218	ć	\$ 1,072	\$ 4,055	\$ 6,032	ć	\$ 1,072	\$ 3,251	\$ 9,985	ć	\$ 1,072	\$ 6,405	\$ 16,114
Costos de inversión adicional por EE, POR VIVIENDA (actual, USD)  Costos de inversión adicional por EE, POR VIVIENDA (a futuro, USD)	USD	\$ -	\$ 1,072	\$ 3,090	\$ 7,273	\$ -	\$ 1,072	\$ 4,055	\$ 3,647	\$ -	\$ 1,072	\$ 3,251	\$ 9,985	\$ -	\$ 1,072	\$ 8,405	\$ 7,735
GRAN TOTAL de costos de inversión POR VIVIENDA (artitulo, OSD)	USD	\$ 3,262	\$ 5,856	\$ 10,863	\$ 7,273	\$ 3,262	\$ 4,937	\$ 7,920	\$ 9,897	\$ 3,262	\$ 5,332	\$ 7,512	\$ 14,246	\$ 3,262	-	\$ 11,278	\$ 7,733
Costos por consultoria general (incl. asesoría energ.)	USD	\$ 3,202	\$ 1,522	\$ 1,522	\$ 1,522	\$ 3,202	\$ 603				\$ 998	\$ 998	\$ 998	\$ 3,202	\$ 1,611	\$ 1,611	\$ 1,611
Variable	Unidad	٠ -	\$ 1,322	J 1,J22	3 1,322	,	\$ 003	\$ 003	\$ 003	,	\$ 998	3 336	3 336	7	3 1,011	3 1,011	3 1,011
DATOS DE AISLAMIENTO TÉRMICO	Omada														l		
Conductividad térmica aislamiento muros y techo	W/mK	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371
Espesor aislamiento muro N, S, E y O (excepto N2)	mm	n/a	n/a	n/a	75	n/a	n/a	n/a	75	n/a	n/a	n/a	100	n/a	n/a	n/a	150
¿Aislamiento interior muro?	Sí/No	No	No	No	No	No	No	No	No	No	No	No	No	No	No No	No	No
Espesor aislamiento muro N2 (pasillo)	mm	n/a	n/a	n/a	50	n/a	n/a	n/a	n/a	n/a	n/a	n/a	50	n/a	n/a	n/a	75
¿Aislamiento interior muro N2? (pasillo)	Sí/No	Sí	No	Sí	Sí	Sí	No	Sí	Sí	Sí	No	Sí	Sí	Sí	No	Sí	Sí
Conductividad térmica aislamiento piso	W/mK	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371
Espesor aislamiento losa de piso	mm	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Espesor aislamiento techo	mm	n/a	n/a	100	100	n/a	n/a	75	75	n/a	n/a	50	50	n/a	n/a	200	200
¿Aislamiento interior techo?	Sí/No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Valor-U puerta exterior (no aplica en adosada)	W/m2K	2.87	2.87	2.87	0.90	2.87	2.87	2.87	2.80	2.87	2.87	2.87	0.90	2.87	2.87	2.87	0.75
Coeficiente de absorptividad techo	-	0.50	0.50	0.15	0.15	0.70	0.70	0.40	0.40	0.70	0.70	0.70	0.70	0.70	0.50	0.15	0.15
Coeficiente de absorptividad muros	-	0.60	0.60	0.15	0.15	0.60	0.60	0.50	0.50	0.60	0.60	0.60	0.60	0.60	0.60	0.15	0.15
Suplemento PT estándar	W/(mK)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
VENTANAS																	
Marco: Valor-Uf	W/m2K	5.50	5.50	1.00	1.00	5.50	5.50	3.00	3.00	5.50	5.50	1.50	1.50	5.50	5.50	0.72	0.72
Acristalamiento: valor g	-	0.87	0.87	0.55	0.55	0.87	0.87	0.40	0.40	0.87	0.87	0.75	0.75	0.87	0.87	0.33	0.33
Acristalamiento: Valor-Ug	W/m2K	5.54	5.54	1.06	1.06	5.54	5.54	1.88	1.88	5.54	5.54	1.06	1.06	5.54	5.54	0.60	0.60
Ψ instalación en muro S, E y O	W/mK	0.09	0.09	0.04	0.04	0.09	0.09	0.04	0.04	0.09	0.09	0.03	0.03	0.09	0.09	0.03	0.03
VENTILACIÓN															ı		
Tasa renovación aire ensayo presión n50	1/h	8.00	8.00	3.00	1.00	8.00	8.00	3.00	1.00	8.00	8.00	3.00	1.00	8.00	8.00	3.00	1.00
Ventilación equilibrada tipo Passivhaus	x	Vent. por	Vent. por	Vent. por	Vent.	Vent. por	Vent. por	Vent. por	Vent. por	Vent. por	Vent. por	Vent. por	Vent. por	Vent. por	Vent. por	Vent. por	Vent.
· · ·		ventanas	ventanas	ventanas	Passivhaus	ventanas	ventanas	ventanas	ventanas	ventanas	ventanas	ventanas	ventanas	ventanas	ventanas	ventanas	Passivhaus
Sólo aire de extracción	x	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Aparato	n/a	n/a	n/a	Aparato	n/a	n/a	n/a	n/a
Eficiencia de manuecación de calculafocativa	%	- /-	- 1-		000/				extracción	- 1-	/		extracción			/	90%
Eficiencia de recuperación de calor efectiva  Eficiencia eléct. Vent. (HRV, extracción o ventanas)	Wh/m³	n/a n/a	n/a n/a	n/a n/a	90% 0.27	n/a n/a	n/a n/a	n/a n/a	n/a 0.15	n/a n/a	n/a n/a	n/a n/a	n/a 0.25	n/a n/a	n/a n/a	n/a n/a	0.25
Ef. Recuperación energía (humedad)	wn/m <sup>-</sup> %	n/a n/a	n/a n/a	n/a n/a	0.27 n/a	n/a n/a	n/a n/a	n/a n/a	n/a	n/a n/a	n/a n/a	n/a n/a	0.25 n/a	n/a n/a	n/a n/a	n/a n/a	70%
SOMBRAS	/0	11/4	II/a	II/ a	11/ a	II/a	II/ a	11/ a	II/ a	11/ a	II/a	11/ a	II/ a	II/a	11/4	11/a	70%
Factor protección solar temporal Z	%	100%	100%	34%	34%	100%	100%	34%	34%	100%	100%	100%	100%	100%	100%	34%	34%
ELECTRICIDAD	,,				9.112			2.112								2.77	
Porcentaje de lámparas fluorescentes	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Demanda lavadora de ropa	kWhr/Uso	1.12	1.12	0.85	0.85	1.12	1.12	0.85	1.12	1.12	1.12	1.12	0.85	1.12	1.12	0.85	1.12
Demanda refrigerador con congelador	kWhr/d	1.30	0.41	0.41	0.41	1.50	0.41	0.41	0.91	2.68	0.41	0.41	0.41	1.50	0.41	0.41	0.41
Electrónica (TV)	W	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Tipo de estufa	-	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP	Gas LP
Demanda de estufa	kWh/uso	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
ELECTRICIDAD-AUX																	
Demanda ventilador de techo	kWhr/a	240	120	240	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	240	120	240	n/a
VENTILACIÓN EN VERANO																	
Renov. aire sist. ventilación c/aire impulsión	1/h	n/a	n/a	n/a	0.45	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.45
Renovación aire sist. Extracción aire	1 /1-		n/a	n/a	n/a	n/a	/	n/a	0.45	n/a	n/a	n/a	0.45	n/a	n/a	n/a	n/a
	1/h	n/a					n/a				-				-	-	
Renovación de aire por ventanas	1/h	1.32	1.32	0.72	0.00	1.32	1.32	1.32	0.00	1.32	1.32	1.32	0.00	1.32	1.32	1.32	0.00
Renovacon de aire: Ventilación nocturna por ventanas	-										-				-	-	0.00
Renovacon de aire: Ventilación nocturna por ventanas APARATOS REFRIGERACIÓN	1/h 1/h	1.32 1.00	1.32	0.72 1.00	0.00 0.10	1.32 1.00	1.32 1.00	1.32 1.00	0.00 1.00	1.32 1.00	1.32 1.00	1.32 1.00	0.00 1.00	1.32 1.00	1.32 1.00	1.32 1.00	0.00
Renovacon de aire: Ventilación nocturna por ventanas APARATOS REFRIGERACIÓN Ref. Circ: Capacidad ref máxima	1/h 1/h kW	1.32 1.00 189.90	1.32 1.00	0.72 1.00 126.61	0.00 0.10 42.20	1.32 1.00 63.30	1.32 1.00 189.90	1.32 1.00	0.00 1.00 0.00	1.32 1.00 63.30	1.32 1.00	1.32 1.00	0.00 1.00 0.00	1.32 1.00 189.90	1.32 1.00	1.32 1.00	0.00 42.20
Renovacon de aire: Ventilación nocturna por ventanas APARATOS REFRIGERACIÓN Ref. Circ: Capacidad ref máxima Ref. Circ: Volumen de aire en potencia nominal	1/h 1/h kW m³/h	1.32 1.00 189.90 27000	1.32 1.00 189.90 27000	0.72 1.00 126.61 18000	0.00 0.10 42.20 9000	1.32 1.00 63.30 9000	1.32 1.00 189.90 27000	1.32 1.00 189.90 27000	0.00 1.00 0.00 0	1.32 1.00 63.30 9000	1.32 1.00 189.90 27000	1.32 1.00 189.90 27000	0.00 1.00 0.00 0	1.32 1.00 189.90 27000	1.32 1.00 189.90 27000	1.32 1.00 126.61 18000	0.00 42.20 9000
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER	1/h 1/h kW m³/h	1.32 1.00 189.90 27000 2.00	1.32 1.00 189.90 27000 3.26	0.72 1.00 126.61 18000 3.26	0.00 0.10 42.20 9000 3.26	1.32 1.00 63.30 9000 2.00	1.32 1.00 189.90 27000 3.26	1.32 1.00 189.90 27000 3.26	0.00 1.00 0.00 0 0.00	1.32 1.00 63.30 9000 2.00	1.32 1.00 189.90 27000 3.26	1.32 1.00 189.90 27000 3.26	0.00 1.00 0.00 0	1.32 1.00 189.90 27000 2.00	1.32 1.00 189.90 27000 3.26	1.32 1.00 126.61 18000 3.26	0.00 42.20 9000 3.26
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional	1/h 1/h kW m³/h -	1.32 1.00 189.90 27000 2.00 Deshum.	1.32 1.00 189.90 27000 3.26 Deshum.	0.72 1.00 126.61 18000 3.26 Deshum.	0.00 0.10 42.20 9000 3.26 Deshum.	1.32 1.00 63.30 9000 2.00 n/a	1.32 1.00 189.90 27000 3.26 n/a	1.32 1.00 189.90 27000 3.26 n/a	0.00 1.00 0.00 0 0.00 n/a	1.32 1.00 63.30 9000 2.00 n/a	1.32 1.00 189.90 27000 3.26 n/a	1.32 1.00 189.90 27000 3.26 n/a	0.00 1.00 0.00 0 0.00 n/a	1.32 1.00 189.90 27000 2.00 Deshum.	1.32 1.00 189.90 27000 3.26 Deshum.	1.32 1.00 126.61 18000 3.26 Deshum.	9000 3.26 Deshum.
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER	1/h 1/h kW m³/h	1.32 1.00 189.90 27000 2.00	1.32 1.00 189.90 27000 3.26	0.72 1.00 126.61 18000 3.26	0.00 0.10 42.20 9000 3.26	1.32 1.00 63.30 9000 2.00	1.32 1.00 189.90 27000 3.26	1.32 1.00 189.90 27000 3.26	0.00 1.00 0.00 0 0.00	1.32 1.00 63.30 9000 2.00	1.32 1.00 189.90 27000 3.26	1.32 1.00 189.90 27000 3.26	0.00 1.00 0.00 0	1.32 1.00 189.90 27000 2.00	1.32 1.00 189.90 27000 3.26	1.32 1.00 126.61 18000 3.26	0.00 42.20 9000 3.26
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER  DISTRIBUCIÓN ACS	1/h 1/h  kW m³/h  - x	1.32 1.00 189.90 27000 2.00 Deshum. 1.00	1.32 1.00 189.90 27000 3.26 Deshum. 1.85	0.72 1.00 126.61 18000 3.26 Deshum. 1.85	0.00 0.10 42.20 9000 3.26 Deshum. 1.85	1.32 1.00 63.30 9000 2.00 n/a 1.00	1.32 1.00 189.90 27000 3.26 n/a 1.85	1.32 1.00 189.90 27000 3.26 n/a n/a	0.00 1.00 0.00 0 0.00 n/a n/a	1.32 1.00 63.30 9000 2.00 n/a 1.00	1.32 1.00 189.90 27000 3.26 n/a 1.85	1.32 1.00 189.90 27000 3.26 n/a n/a	0.00 1.00 0.00 0 0.00 n/a n/a	1.32 1.00 189.90 27000 2.00 Deshum. 1.00	1.32 1.00 189.90 27000 3.26 Deshum. 1.85	1.32 1.00 126.61 18000 3.26 Deshum. 1.85	0.00 42.20 9000 3.26 Deshum. 1.85
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER  DISTRIBUCIÓN ACS  Consumo de ACS por persona y día (60°C)	1/h 1/h kW m³/h -	1.32 1.00 189.90 27000 2.00 Deshum.	1.32 1.00 189.90 27000 3.26 Deshum.	0.72 1.00 126.61 18000 3.26 Deshum.	0.00 0.10 42.20 9000 3.26 Deshum.	1.32 1.00 63.30 9000 2.00 n/a	1.32 1.00 189.90 27000 3.26 n/a	1.32 1.00 189.90 27000 3.26 n/a	0.00 1.00 0.00 0 0.00 n/a	1.32 1.00 63.30 9000 2.00 n/a	1.32 1.00 189.90 27000 3.26 n/a	1.32 1.00 189.90 27000 3.26 n/a	0.00 1.00 0.00 0 0.00 n/a	1.32 1.00 189.90 27000 2.00 Deshum.	1.32 1.00 189.90 27000 3.26 Deshum.	1.32 1.00 126.61 18000 3.26 Deshum.	9000 3.26 Deshum.
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER  DISTRIBUCIÓN ACS  Consumo de ACS por persona y día (60°C)  COLECTOR SOLAR ACS	1/h 1/h  kW m³/h - x - Litros/Persona/d	1.32 1.00 189.90 27000 2.00 Deshum. 1.00	1.32 1.00 189.90 27000 3.26 Deshum. 1.85	0.72 1.00 126.61 18000 3.26 Deshum. 1.85	0.00 0.10 42.20 9000 3.26 Deshum. 1.85	1.32 1.00 63.30 9000 2.00 n/a 1.00	1.32 1.00 189.90 27000 3.26 n/a 1.85	1.32 1.00 189.90 27000 3.26 n/a n/a	0.00 1.00 0.00 0 0.00 n/a n/a	1.32 1.00 63.30 9000 2.00 n/a 1.00	1.32 1.00 189.90 27000 3.26 n/a 1.85	1.32 1.00 189.90 27000 3.26 n/a n/a	0.00 1.00 0.00 0 0.00 n/a n/a 25	1.32 1.00 189.90 27000 2.00 Deshum. 1.00	1.32 1.00 189.90 27000 3.26 Deshum. 1.85	1.32 1.00 126.61 18000 3.26 Deshum. 1.85	0.00 42.20 9000 3.26 Deshum. 1.85
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER  DISTRIBUCIÓN ACS  Consumo de ACS por persona y día (60°C)  COLECTOR SOLAR ACS  Tipo de Colector	1/h 1/h  kW m³/h - x - Litros/Persona/d	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25	1.32 1.00 189.90 27000 3.26 Deshum. 1.85	0.72 1.00 126.61 18000 3.26 Deshum. 1.85	0.00 0.10 42.20 9000 3.26 Deshum. 1.85	1.32 1.00 63.30 9000 2.00 n/a 1.00 25	1.32 1.00 189.90 27000 3.26 n/a 1.85	1.32 1.00 189.90 27000 3.26 n/a n/a 25	0.00 1.00 0.00 0 0.00 n/a n/a 25	1.32 1.00 63.30 9000 2.00 n/a 1.00 25	1.32 1.00 189.90 27000 3.26 n/a 1.85	1.32 1.00 189.90 27000 3.26 n/a n/a 25	0.00 1.00 0.00 0 0.00 n/a n/a 25	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25	1.32 1.00 189.90 27000 3.26 Deshum. 1.85	1.32 1.00 126.61 18000 3.26 Deshum. 1.85	0.00 42.20 9000 3.26 Deshum. 1.85
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER  DISTRIBUCIÓN ACS  Consumo de ACS por persona y día (60°C)  COLECTOR SOLAR ACS  Tipo de Colector  Superficie del colector	1/h 1/h  kW m³/h - x - Litros/Persona/d	1.32 1.00 189.90 27000 2.00 Deshum. 1.00	1.32 1.00 189.90 27000 3.26 Deshum. 1.85	0.72 1.00 126.61 18000 3.26 Deshum. 1.85	0.00 0.10 42.20 9000 3.26 Deshum. 1.85	1.32 1.00 63.30 9000 2.00 n/a 1.00	1.32 1.00 189.90 27000 3.26 n/a 1.85	1.32 1.00 189.90 27000 3.26 n/a n/a	0.00 1.00 0.00 0 0.00 n/a n/a	1.32 1.00 63.30 9000 2.00 n/a 1.00	1.32 1.00 189.90 27000 3.26 n/a 1.85	1.32 1.00 189.90 27000 3.26 n/a n/a	0.00 1.00 0.00 0 0.00 n/a n/a 25	1.32 1.00 189.90 27000 2.00 Deshum. 1.00	1.32 1.00 189.90 27000 3.26 Deshum. 1.85	1.32 1.00 126.61 18000 3.26 Deshum. 1.85	0.00 42.20 9000 3.26 Deshum. 1.85
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER  DISTRIBUCIÓN ACS  Consumo de ACS por persona y día (60°C)  COLECTOR SOLAR ACS  Tipo de Colector  Superficie del colector  CALDERA / BOILER	1/h 1/h  kW m³/h - x - Litros/Persona/d  0 m²	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	0.72 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	0.00 0.10 42.20 9000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40	0.00 1.00 0.00 0.00 n/a n/a 25 Tub.evac. 14.40	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40	0.00 1.00 0.00 0 0.00 n/a n/a 25 Tub.evac. 14.40	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	1.32 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	0.00  42.20 9000 3.26 Deshum. 1.85  25  Tub.evac. 14.40
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER  DISTRIBUCIÓN ACS  Consumo de ACS por persona y día (60°C)  COLECTOR SOLAR ACS  Tipo de Colector  Superficie del colector  CALDERA / BOILER  Tipo de generador de calor	1/h 1/h  kW m³/h - x - Litros/Persona/d  0 m² Texto	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	0.72 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	0.00 0.10 42.20 9000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40	0.00 1.00 0.00 0.00 n/a n/a 25 Tub.evac. 14.40 Caldera gas	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40	0.00 1.00 0.00 0.00 n/a n/a 25 Tub.evac. 14.40	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	1.32 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	0.00  42.20 9000 3.26 Deshum. 1.85  25  Tub.evac. 14.40  Caldera gas
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER  DISTRIBUCIÓN ACS  Consumo de ACS por persona y día (60°C)  COLECTOR SOLAR ACS  Tipo de Colector  Superficie del colector  CALDERA / BOILER	1/h 1/h  kW m³/h - x - Litros/Persona/d  0 m²	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	0.72 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	0.00 0.10 42.20 9000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40	0.00 1.00 0.00 0.00 n/a n/a 25 Tub.evac. 14.40	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40	0.00 1.00 0.00 0 0.00 n/a n/a 25 Tub.evac. 14.40	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	1.32 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	0.00  42.20 9000 3.26 Deshum. 1.85  25  Tub.evac. 14.40
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER  DISTRIBUCIÓN ACS  Consumo de ACS por persona y día (60°C)  COLECTOR SOLAR ACS  Tipo de Colector  Superficie del colector  CALDERA / BOILER  Tipo de generador de calor  Rendimiento del calentador con potencia nominal	1/h 1/h  kW m³/h - x - Litros/Persona/d  0 m² Texto	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	0.72 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	0.00 0.10 42.20 9000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40	0.00 1.00 0.00 0.00 n/a n/a 25 Tub.evac. 14.40 Caldera gas	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40	0.00 1.00 0.00 0.00 n/a n/a 25 Tub.evac. 14.40	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	1.32 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	0.00  42.20 9000 3.26 Deshum. 1.85  25  Tub.evac. 14.40  Caldera gas
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER  DISTRIBUCIÓN ACS  Consumo de ACS por persona y día (60°C)  COLECTOR SOLAR ACS  Tipo de Colector  Superficie del colector  CALDERA / BOILER  Tipo de generador de calor  Rendimiento del calentador con potencia nominal  CALEFACCIÓN	1/h 1/h  kW m³/h - x - Litros/Persona/d  0 m²  Texto %	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	0.72 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	0.00 0.10 42.20 9000 3.26 Deshum. 1.85  25  Tub.evac. 14.40  Caldera gas 76%	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40	0.00 1.00 0.00 0.00 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40	0.00 1.00 0.00 0 0.00 n/a n/a 25 Tub.evac. 14.40	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	1.32 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40	0.00  42.20 9000 3.26 Deshum. 1.85  25  Tub.evac. 14.40  Caldera gas 76%
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER  DISTRIBUCIÓN ACS  Consumo de ACS por persona y día (60°C)  COLECTOR SOLAR ACS  Tipo de Colector  Superficie del colector  CALDERA / BOILER  Tipo de generador de calor  Rendimiento del calentador con potencia nominal  CALEFACCIÓN  Directamente eléctrica	1/h 1/h  kW m³/h - x - Litros/Persona/d  0 m²  Texto %	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	0.72 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	0.00 0.10 42.20 9000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76%	0.00 1.00 0.00 0.00 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76%	0.00 1.00 0.00 0 0.00 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	0.00  42.20 9000 3.26 Deshum. 1.85  25  Tub.evac. 14.40  Caldera gas 76%
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER  DISTRIBUCIÓN ACS  Consumo de ACS por persona y día (60°C)  COLECTOR SOLAR ACS  Tipo de Colector  Superficie del colector  CALDERA / BOILER  Tipo de generador de calor  Rendimiento del calentador con potencia nominal  CALEFACCIÓN  Directamente eléctrica  A través de equipo split	1/h 1/h  kW m³/h - x - Litros/Persona/d  0 m²  Texto %	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	0.72 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	0.00 0.10 42.20 9000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76%	0.00 1.00 0.00 0.00 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76%	0.00 1.00 0.00 0 0.00 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	0.00  42.20 9000 3.26 Deshum. 1.85  25  Tub.evac. 14.40  Caldera gas 76%
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER  DISTRIBUCIÓN ACS  Consumo de ACS por persona y día (60°C)  COLECTOR SOLAR ACS  Tipo de Colector  Superficie del colector  CALDERA / BOILER  Tipo de generador de calor  Rendimiento del calentador con potencia nominal  CALEFACCIÓN  Directamente eléctrica  A través de equipo split  OTROS	1/h 1/h  kW m³/h - x - Litros/Persona/d  0 m²  Texto %	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	0.72 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	0.00 0.10  42.20 9000 3.26 Deshum. 1.85  25  Tub.evac. 14.40  Caldera gas 76%  0% 100%	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76%	0.00 1.00 0.00 0.00 n/a n/a 1.40  Caldera gas 76% 0% 100%	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76%	0.00 1.00 0.00 0.00 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76% 0% 100%	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	0.00  42.20 9000 3.26 Deshum. 1.85  25  Tub.evac. 14.40  Caldera gas 76%  0% 100%
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER  DISTRIBUCIÓN ACS  CONSUMO de ACS por persona y día (60°C)  COLECTOR SOLAR ACS  Tipo de Colector  Superficie del colector  CALDERA / BOILER  Tipo de generador de calor  Rendimiento del calentador con potencia nominal  CALEFACCIÓN  Directamente eléctrica  A través de equipo split  OTROS  Factor de energía primaria Electricidad	1/h 1/h  kW m³/h - x - Litros/Persona/d  0 m²  Texto %  % %	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	0.72 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76% 100% 0%	0.00 0.10  42.20 9000 3.26 Deshum. 1.85  25  Tub.evac. 14.40  Caldera gas 76%  0% 100%	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76%	0.00 1.00 0.00 0.00 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76% 0% 100%	1.32 1.00 63.30 9000 2.00 n/a 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76% 100% 0%	0.00 1.00 0.00 0.00 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76% 0% 100%	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a Caldera gas 76%	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	1.32 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76%	0.00  42.20 9000 3.26 Deshum. 1.85  25  Tub.evac. 14.40  Caldera gas 76%  0% 100%
Renovacon de aire: Ventilación nocturna por ventanas  APARATOS REFRIGERACIÓN  Ref. Circ: Capacidad ref máxima  Ref. Circ: Volumen de aire en potencia nominal  Ref. Circ. SEER  Deshumidificación adicional  Deshumidificación: SEER  DISTRIBUCIÓN ACS  Consumo de ACS por persona y día (60°C)  COLECTOR SOLAR ACS  Tipo de Colector  Superficie del colector  CALDERA / BOILER  Tipo de generador de calor  Rendimiento del calentador con potencia nominal  CALEFACCIÓN  Directamente eléctrica  A través de equipo split  OTROS  Factor de energía primaria Electricidad  Factor de energía primaria Gas LP	1/h 1/h  kW m³/h - x - Litros/Persona/d  0 m²  Texto %  % % 0%	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a Caldera gas 76% 100% 0%	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76% 0%	0.72 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76% 0%	0.00 0.10 42.20 9000 3.26 Deshum. 1.85  25  Tub.evac. 14.40  Caldera gas 76% 0% 100%	1.32 1.00 63.30 9000 2.00 n/a 1.00  25 Tub.evac. n/a Caldera gas 76%  100% 0%	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40 Caldera gas 76% 0%	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76% 0%	0.00 1.00 0.00 0.00 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76% 100%	1.32 1.00 63.30 9000 2.00 n/a 1.00  25 Tub.evac. n/a Caldera gas 76%  100% 0%	1.32 1.00 189.90 27000 3.26 n/a 1.85 25 Tub.evac. 14.40 Caldera gas 76% 0%	1.32 1.00 189.90 27000 3.26 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76% 100% 0%	0.00 1.00 0.00 0 0.00 n/a n/a 25 Tub.evac. 14.40 Caldera gas 76% 0% 100%	1.32 1.00 189.90 27000 2.00 Deshum. 1.00 25 Tub.evac. n/a Caldera gas 76% 0%	1.32 1.00 189.90 27000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76% 0%	1.32 1.00 126.61 18000 3.26 Deshum. 1.85 25 Tub.evac. 14.40 Caldera gas 76% 0%	0.00  42.20 9000 3.26 Deshum. 1.85  25  Tub.evac. 14.40  Caldera gas 76%  0% 100%

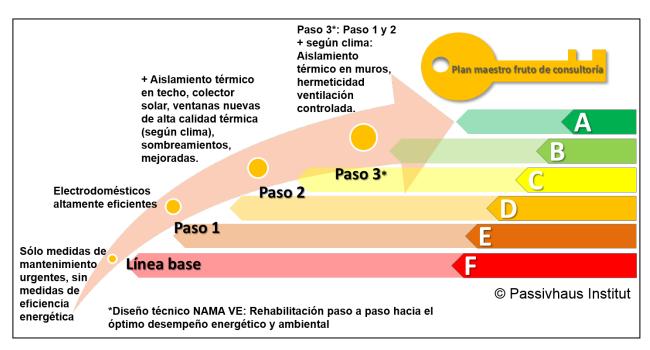


Figure 1: Step by step refurbishment to achieve optimal energy and environmental performance, general summary of examples calculated for NAMA for Sustainable Housing Retrofit

Technical Design (Source: Passivhaus Institut).

[Llave amarilla]

Advisor's Master Plan

[Línea Base]

Baseline home

[Texto en Negrita margen izquierdo] Only urgent maintenance measures without any energy efficiency measures.

[Paso 1]

Step 1

[Texto en Negrita margen izquierdo] Highly efficient domestic appliances

[Paso 2]

Step 2

[Texto en Negrita margen izquierdo] + Insulation of the roof, solar collectors, new insulation and high quality windows, sun protection and improved (depending on the climate)

[Paso 3]

Step 3

[Texto en Negrita margen izquierdo]+ Depending on the climate: Insulation of the walls, air-tightness, controlled ventilation system

[Diseño Técnico: Texto en Negrita borde inferior]

Technical Design NAMA for Sustainable Housing Retrofit:

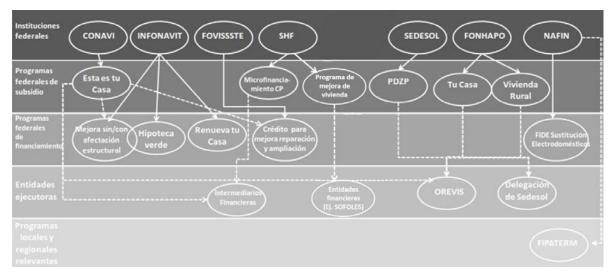


Figura 2. Financing and subsidy programmes chart for 2012 housing renewal (Source: GIZ/MGM Innova 2012, adaptation by Passivhaus Institut).

[Primera línea: sólo se traduce texto al margen izquierdo, las instituciones quedan igual]

**Federal Institutions** 

[Segunda línea: texto al margen izquierdo]

**Federal Subsidy Programmes** 

[Primer óvalo de izquierda a derecha]

This is your house

[Segundo óvalo]

Microfinance CP [Tercer óvalo]

Housing improvement programme

[Sexto óvalo]

Rural housing

[Los demás óvalos quedan igual]

[Tercera línea: texto al margen izquierdo]

**Federal Financing Programmes** 

[Primer óvalo de izquierda a derecha]

Improvement with/without structural modification

[Cuarto óvalo]

Credit for improvement, repair, expansion

[Quinto óvalo]

FIDE replacement of domestic appliances

[Los demás óvalos quedan igual]

[Cuarta línea: texto al margen izquierdo]

**Entities providing Subsidy or Financing services** 

[Traducción de óvalos conforme aparecen de izquierda a derecha]

Financial intermediaries

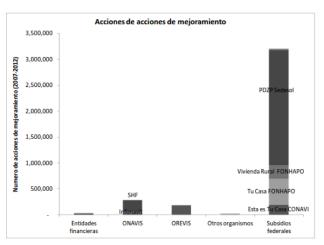
Financing entities (Example: SOFOLES)

**OREVIS** 

**Sedesol Delegation** 

[Quinta línea: sólo se traduce texto al margen izquierdo, el óvalo queda igual]

Relevant local and regional programmes



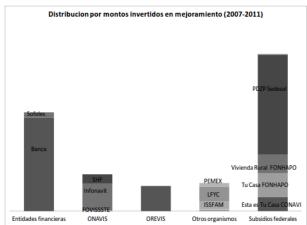


Figure 3. Financing and distribution universe of actions of invested amounts for the improvement of Housing during the period 2007-2011 (Source: GIZ/MGM Innova 2012)

#### FIGURA IZQUIERDA

[Título margen superior] Actions for improvement [Título margen izquierdo] Number of actions for housing improvement (2007-2011)

[Títulos margen inferior de izquierda a derecha] Financial intermediaries **ONAVIS** 

**OREVIS** 

Other organisms

Federal subsidies

#### **FIGURA DERECHA**

[Título margen superior]

Distribution of invested amounts for improvement (2007-2011)

[Títulos margen inferior de izquierda a derecha]

Financial intermediaries

**ONAVIS OREVIS** 

Other organisms

Federal subsidies

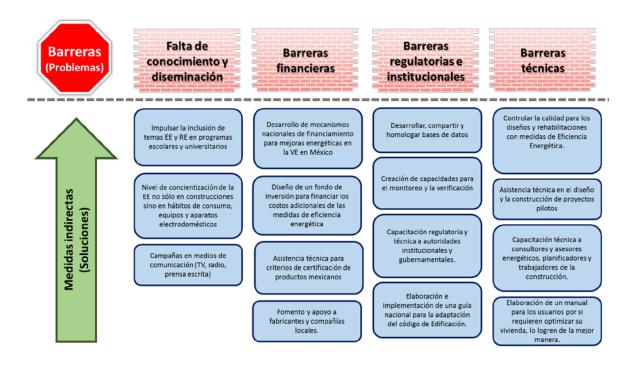


Figure 4. Barriers to low carbon existing housing in Mexico and measures proposed to overcome them. (Source: Passivhaus Institut).

#### [Texto en margen superior, octágono rojo]

Barriers (Problems)

#### [Títulos margen superior sobre línea punteada de izquierda a derecha]

Lack of knowledge and dissemination

Financial barriers

Regulatory and Institutional barriers

**Technical barriers** 

#### [Texto en margen izquierdo, flecha verde]

Indirect measures (Solutions)

#### [Columna 1, texto en rectángulos de arriba hacia abajo]

- 1. Encourage EE and RE matters inclusion in school and university programs.
- Increase awareness on EE, not only in building areas but also consumption behavior as well as equipment and domestic appliances.
- 3. Media advertisement campaign (TV, radio and Newspaper).

#### [Columna 2, texto en rectángulos de arriba hacia abajo]

- 1. Development of national financial mechanisms for energy improvements in Mexican VE housing.
- 2. Design of an investment fund to finance incremental costs of energy efficiency measures.
- 3. Technical assistance for certification criteria of Mexican products.
- 4. Promotion and support to local suppliers and companies.

#### [Columna 3, texto en rectángulos de arriba hacia abajo]

- 1. Data-base development, sharing and homologation.
- 2. Capacity building for monitoring and verification.
- 3. Regulatory and technical training to institutional and governmental authorities.
- 4. Drafting and implementation of a national guideline for Building Code adaptation.

#### [Columna 4, texto en rectángulos de arriba hacia abajo]

- 1. Quality control for owners and refurbishment with energy efficiency measures.
- 2. Technical assistance in pilot projects design and implementation.
- 3. Technical training to consultants and energy advisors, planners and building workers.
- 4. Drafting of a user's manual to support users on housing renewal if required.

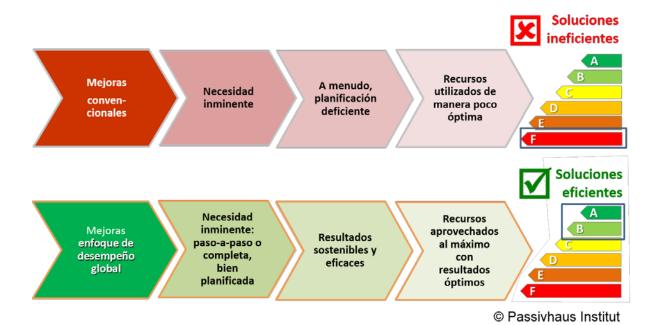


Figura 5: Importance of a well planned refurbishment with a whole house approach (Source: Passivhaus Institut).

[Título superior margen derecho: Soluciones ineficientes]

Inefficient solutions

[Título inferior margen derecho: Soluciones eficientes]

**Efficient solutions** 

[Renglón superior: flechas de izquierda a derecha]

Conventional improvements Imminent requirements Frequent poor planning Resources used in a poor way

[Renglón inferior: flechas de izquierda a derecha]

Improvements with a global performance approach

Imminent requirements: Well planning step by step or overall renewal

Sustainable and effective results

Maximum resources utilization with optimal results



Figura 6: Bioclimatic zones utilized for the NAMA VE<sup>1</sup> for Sustainable Housing Retrofit calculations (Source: Passivhaus Institut).

## [Monterrey]

Monterrey – Hot Dry

#### [Mérida]

Merida – Hot Humid

## [Guadalajara]

Guadalajara – Template

## [Ciudad de México]

Mexico City – Semi dry

## [Zonas bioclimáticas]

Bioclimatic zones [De arriba hacia abajo] Hot Dry Hot Humid

Template

Semi dry

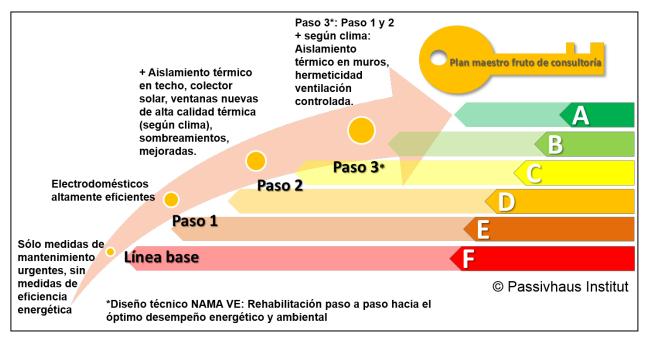


Figure 7: Step by step refurbishment to achieve optimal energy and environmental performance, general summary of examples calculated for the NAMA for Sustainable Housing Retrofit Technical Design from Step 1 to the calculated optimal standard. Classification system bands are only schematic (Source: Passivhaus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

[Llave amarilla]
Advisor's Master Plan

[Línea Base]

Baseline home

[Texto en Negrita margen izquierdo] Only urgent maintenance measures without any energy efficiency measures.

[Paso 1]

Step 1

[Texto en Negrita margen izquierdo] Highly efficient domestic appliances

[Paso 2]

Step 2

[Texto en Negrita margen izquierdo] + Insulation of the roof, solar collectors, new insulation and high quality windows, sun protection and improved (depending on the climate)

[Paso 3]

Step 3

[Texto en Negrita margen izquierdo]+ Depending on the climate: Insulation of the walls, air-tightness, controlled ventilation system

[Diseño Técnico: Texto en Negrita borde inferior]

Technical Design NAMA for Sustainable Housing Retrofit:

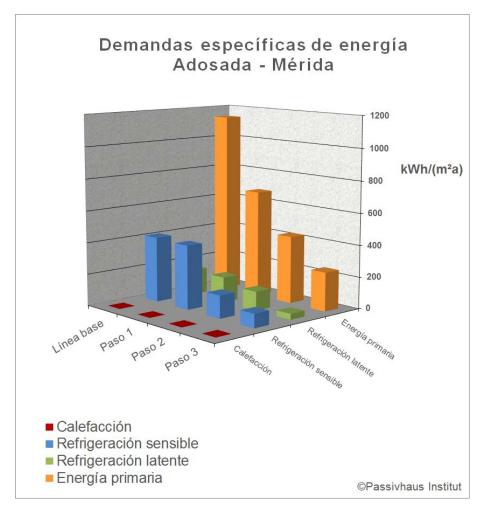


Figure 8: Specific energy demands for Adosada building type in Merida (Source: Passivhaus Institut).

Specific energy demands

Adosada building Merida

#### [Eje izquierdo]

[Línea base] Baseline

[Paso 1] Step 1

[Paso 2] Step 2

[Paso 3] Step 3

#### [Eje derecho, de izquierda a derecha]

[Calefacción] Heating

[Sensible cooling] Sensible cooling

[Latent cooling] Latent cooling

[Energía primaria] Primary energy

#### [Etiquetas de color, margen inferior a la izquierda]

[Calefacción] Heating

[Sensible cooling] Sensible cooling

[Latent cooling] Latent cooling

[Energía primaria] Primary energy

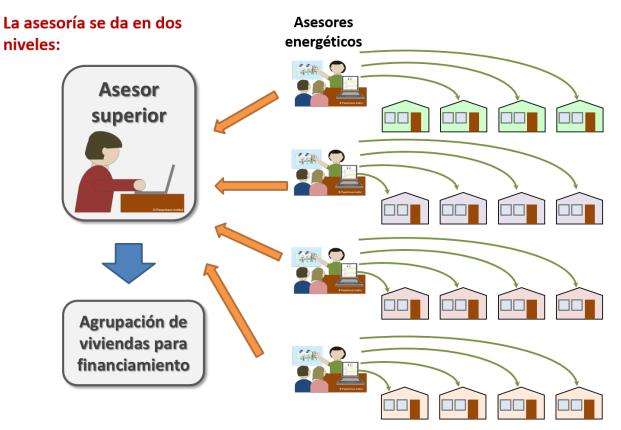


Figure 9: Scheme combining Energy Advisor and Auditor Advisor (Source: Passivhaus Institut).

[Texto: La asesoría se de en dos niveles]
Advisory is provided by two levels
[Texto: Asesores energéticos]

**Energy Advisors** 

[Texto: Auditor Superior]

**Auditor Advisor** 

[Texto: Agrupación de viviendas para financiamiento]

Housing group to be financed

Table 1. Values considered for reduced comfort baseline calculation (Source: Centro Mario Molina 2013, adaptation by Passivhaus Institut).

Tipología	Área m² [CMM 2013]	Aprox SRE m² (85% del área total)	Electricidad (kWh) [CMM 2013]	Elect. kWh/(m²a) SRE	Electricidad kWh/(m²a) para cálculo NAMA*	Gas LP (kg) [CMM 2013]	Gas LP (kWh)	Gas LP kWh/(m²a) SRE	Gas LP kWh/(m²a) para NAMA*		
				Guadalajara (to	emplado)						
Adosada	98.17	83.44	1229.43	14.73	15	38.97	494.14	5.92	6		
Aislada	104.02	88.42	942.29	10.66	11	60.31	764.73	8.65	9		
Vertical	65.36	55.56	984.10	17.71	18	54.66	693.09	12.48	12		
	•			Mérida (cálido	húmedo)			•			
Aislada	57.70	49.05	1578.13	32.18	32	67.13	851.21	17.36	17		
Adosada [CFE 2014]		51.50	2384.42	46.30	46	Datos no disponibles. Se usan datos de edificio Aislada					
Vertical	Datos no disponibles. Se usan datos de edificio Aislada					Datos no	disponibles. Se us	an datos de edific	io Aislada		
				Monterrey (cá	lido seco)						
Aislada	46.14	39.22	1493.95	38.09	38	183.22	2323.23	59.24	59		
Adosada		Datos no disponibi	les. Se usan datos	de edificio Aisladi	7	Datos no	disponibles. Se us	an datos de edific	io Aislada		
Vertical	64.92	55.18	1303.86	23.63	24	180.91	2293.94	41.57	42		
	•			Valle de México	(semifrío)			•			
Adosada	60.47	51.40	754.83	14.69	15	331.34	4201.39	81.74	82		
Aislada	83.41	70.90	1688.60	23.82	24	222.42	2820.29	39.78	40		
Vertical	57.46	48.84	962.28	19.70	20	311.21	3946.14	80.80	81		

[Título de la primera columna: Tipología]

**Building Type** 

[Títulos subsecuentes de la primera columna, quedan igual]

#### [Títulos horizontales, primer renglón, de izquierda a derecha]

Area m<sup>2</sup> CMM 2013]

Aprox SRE m<sup>2</sup> (85% over total area)

Electricity (kWh) [CMM 2013]

Elect. kWh/(m<sup>2</sup>a) SRE

kWh/(m<sup>2</sup>a) for NAMA calculations\*

LP Gas (kg) [CMM 2013]

LP Gas (kWh)

LP Gas kWh/(m<sup>2</sup>a) SRE

LP Gas kWh/(m<sup>2</sup>a) for NAMA\*

#### [Climas y ciudades en renglones horizontales, de arriba hacia abajo]

Guadalajara (template)

Merida (hot-humid)

Monterrey (hot-dry)

Mexico City (semi-cold)

[Texto sombreados en gris, el mismo en todos: Datos no disponibles. Se usan datos del edificio Aislada]

Information not available. Aislada building type data is used

Table 2. Indoor comfort parameters for reduced comfort baseline (Source: Passivhaus Institut).

Parámetros de confort inter reducido	rior: línea base c	onfort	Mty	Gdl	DF	Mer
Temperatura máxima invierno	Valor simulado con P datos de consumo el de Estudio de Campo	Dife	erente	por z	ona.	
Temperatura máxima verano	Valor simulado con P datos de consumo el de Estudio de Campo	Dife	erente	por z	ona.	
Máxima frecuencia de sobrecalentamiento aceptada en caso de ausencia de refrigeración activa	10 %	[PHI 2013]	Х	Х	Х	Х
Humedad absoluta máxima interior	Valor simulado con P datos de consumo ele de Estudio de Campe	Dife	erente	por z	ona.	
Fuentes internas de humedad	2 g/(m²h)	[PHPP]	Χ	Χ	Х	Х
Ganancias internas de calor invierno	2.1 W/m²	[PHPP]	Χ	Χ	Χ	Χ
Ganancias internas de calor verano	Calculado co	n PHPP	Χ	Χ	Х	Χ

#### [Primer renglón, título. (Las abreviaciones Mty, Gdl, DF, Mer, quedan igual)]

Indoor comfort parameters: reduced comfort baseline

#### [Segundo renglón, textos de izquierda a derecha]

- 1. Winter maximum temperature
- 2. Simulated value with PHPP tool, based on electricity and gas consumption data from the Field Study [CMM 2013]
- 3. Different per zone

#### [Tercer renglón, textos de izquierda a derecha]

- 1. Summer maximum temperature
- 2. Simulated value with PHPP tool, based on electricity and gas consumption data from the Field Study [CMM 2013]
- 3. Different per zone

#### [Cuarto renglón, texto margen izquierdo, lo demás queda igual]

Maximum overheating frequency accepted when active cooling is not available

#### [Quinto renglón, textos de izquierda a derecha]

- 1. Indoor maximum absolute humidity
- 2. Simulated value with PHPP tool, based on electricity and gas consumption data from the Field Study [CMM 2013]
- 3. Different per zone

#### [Sexto renglón, texto margen izquierdo, lo demás queda igual]

Humidity from internal sources

#### [Séptimo renglón, texto margen izquierdo, lo demás queda igual]

Heat gains from internal sources in the Winter

#### [Octavo renglón, textos de izquierda a derecha, lo demás queda igual]

- 1. Heat gains from internal sources in the Summer
- 2. Calculated with PHPP tool

Table 3: Indoor comfort parameters for standard comfort baseline (Source: Passivhaus Institut).

Parámetros de confort inter estándar	ior: línea bas	e confort	Mty	Gdl	DF	Me r
Temperatura máxima invierno	20 °C	[Fanger 1970] / [PHI 2012]	Х	Х	Х	Х
Temperatura máxima verano	25 °C	[Fanger 1970] / [PHI 2012]	Х	Х	Х	Χ
Máxima frecuencia de sobrecalentamiento aceptada	10 %	[PHI 2013]	Х	Х	Χ	Χ
Humedad absoluta máxima interior	12 g/kg	[Fanger 1970] / [ISO 7730]	Х	Х	Х	Х
Fuentes internas de humedad	2 g/(m²h)	[PHPP]	Χ	Χ	Х	Χ
Ganancias internas de calor invierno	2.1 W/m²	[PHPP]	Х	Х	Х	Х
Ganancias internas de calor verano	Calculado	Х	Х	Х	Х	

[Primer renglón, título. (Las abreviaciones Mty, Gdl, DF, Mer, quedan igual)]

Indoor comfort parameters: standard comfort baseline

[Segundo renglón, texto margen izquierdo, lo demás queda igual]

Winter maximum temperature

[Tercer renglón, texto margen izquierdo, o demás queda igual]

Summer maximum temperature

[Cuarto renglón, texto margen izquierdo, lo demás queda igual]

Maximum overheating frequency accepted

[Quinto renglón, texto margen izquierdo, lo demás queda igual]

Indoor maximum absolute humidity

[Sexto renglón, texto margen izquierdo, lo demás queda igual]

Humidity from internal sources

[Séptimo renglón, texto margen izquierdo, lo demás queda igual]

Heat gains from internal sources in the Winter

[Octavo renglón, textos de izquierda a derecha, lo demás queda igual]

- 3. Heat gains from internal sources in the Summer
- 4. Calculated with PHPP tool

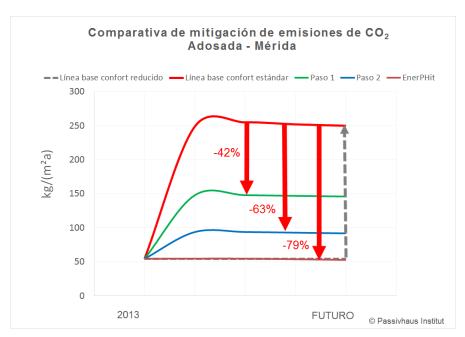


Figure 10: CO<sub>2</sub>, levels represented under various energy efficiency scenarios in Merida (Source: Passivhaus Institut).

CO<sub>2</sub> emissions mitigation comparative Adosada building type – Merida

#### [Etiquetas debajo del título de la gráfica, de izquierda a derecha]

- 1. Reduced comfort baseline
- 2. Standard comfort baseline
- 3. Step 1
- 4. Step 2
- 5. EnerPHit

### [Textos margen inferior]

2013 - 2013

**FUTURO – FUTURE** 

[Texto Passivhaus Institut y todo lo demás en la gráfica queda igual]

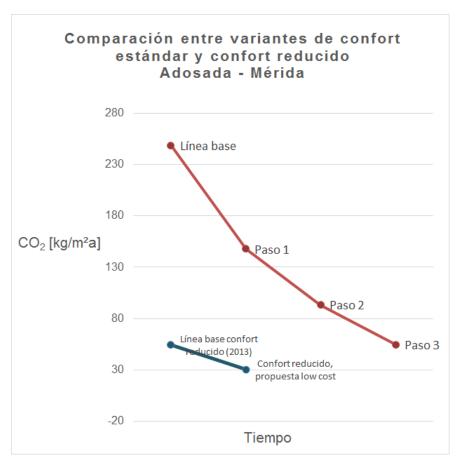


Figure 11: Comparison between standard comfort and reduced comfort variations. Adosada building type in Merida (Source: Passivhaus Institut)

Comparison between standard comfort and reduced comfort variables Adosada building type – Merida

#### [Textos en medio de la gráfica]

[Línea base] Baseline

[Paso 1] Step 1

[Paso 2] Step 2

[Paso 3] Step 3

[Línea base de confort reducido (2013)] Reduced comfort baseline (2013)

[Confort reducido propuesta low cost] Reduced confort low cost proposal

[Texto margen izquierdo, queda igual – Co<sub>2</sub> [kg/m<sup>2</sup>a]]

## [Texto margen inferior - TIEMPO]

TIME

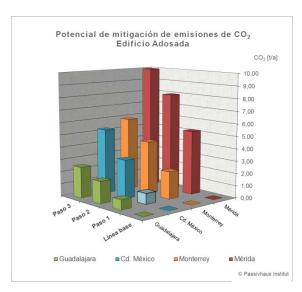


Figure 12: CO<sub>2</sub> emissions mitigation potential for Adosada building type in different climate zones analysed (Source: Passivhaus Institut).

CO2 emissions mitigation potential Adosada building type

#### [Eje izquierdo]

[Línea base] Baseline

[Paso 1] Step 1

[Paso 2] Step 2

[Paso 3] Step 3

## [Eje derecho, de izquierda a derecha]

[Guadalajara] Guadalajara [Ciudad de México] Mexico City [Monterrey] Monterrey [Mérida] Merida

## [Misma traducción para las etiquetas en el margen inferior]

[Guadalajara] Guadalajara [Ciudad de México] Mexico City [Monterrey] Monterrey [Mérida] Merida

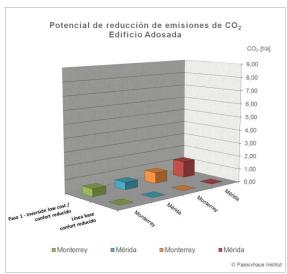


Figura 13: CO2 emissions reduction potential for Adosada building type in different climate zones analysed (Source: Passivhaus Institut).

CO2 emissions reduction potential Adosada building type

## [Eje izquierdo], de arriba hacia abajo]

[Paso 1 – inversión low cost/confort reducido] Step 1 Low cost investment/ reduced comfort [Línea base confort reducido] Reduced comfort baseline

### [Eje derecho, de izquierda a derecha]

[Monterrey] Monterrey [Mérida] Merida [Monterrey] Monterrey [Mérida] Merida

#### [Misma traducción para las etiquetas en el margen inferior]

[Monterrey] Monterrey [Mérida] Merida [Monterrey] Monterrey [Mérida] Merida

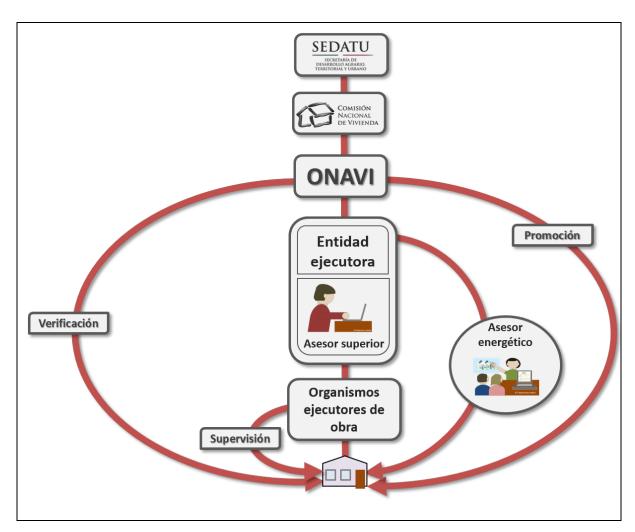


Figure 14: General organization chart proposed to integrate the NAMA for Sustainable Housing Retrofit (Source: GIZ / Passivhaus Institut).

## [Columna central – rectángulos de arriba hacia abajo]

[SEDATU queda igual]

[CONAVI queda igual]

[ONAVI queda igual]

[Entidad ejecutora] Financial entity

[Asesor Superior] Audit Advisor

[Organismos ejecutores de obra] building company

#### [Palabras lado izquierdo de columna central]

[Verificación] Verification

[Supervisión] Supervision

#### [Palabras lado derecho de columna central]

[Promoción] Promotion

[Asesor energético] Energy Advisor



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

#### [Textos margen superior]

[Fase 1] Phase 1

[Fase 2] Phase 2

#### [Texto en flechas de arriba hacia abajo]

- 1. Master Plan to achieve optimal standard (scalable improvements)
- 2. Key players training
- 3. Adaptation of design tools for existing housing (Sisevive-Ecocasa)
- 4. Dissemination and promotion of refurbishment among users
- 5. Financial entities

#### [Texto margen derecho]

[Implementación de la NAMA Vivienda Existente] NAMA Sustainable Housing Retrofit implementation



Figure 16: Current costs of the different steps towards the "step by step refurbishment to achieve optimal energy and environmental performance" standard (efficiency improvements) for the Adosada building type (50 m² SRE) in Merida (Source: Passivhaus Institut).

Additional investment and energy costs Current costs scenario Adosada building type - Merida

#### [Eje vertical, queda igual]

#### [Eje horizontal, títulos de izquierda a derecha]

[Línea base] Baseline

[Paso 1] Step 1

[Paso 2] Step 2

[Paso 3] Step 3

#### [Etiquetas del lado izquierdo, de arriba hacia abajo]

[Subsidio a la energía, renglón de abajo queda igual] Energy Subsidy [Costos de energía, renglón de abajo queda igual] Energy costs [Inversión adcional, renglón de abajo queda igual] Additional investment [Costos sí o sí, renglón de abajo queda igual] Variable costs

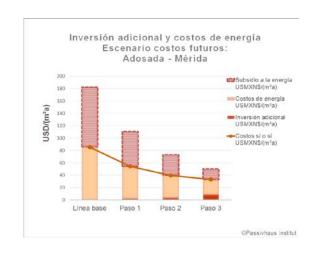


Figure 17: Future costs of the different steps towards the "step by step refurbishment to achieve optimal energy and environmental performance" standard (efficiency improvements) for the Adosada building type (50 m² SRE) in Merida (Source: Passivhaus Institut).

#### [Título de la gráfica]

Additional investment and energy costs Future costs scenario Adosada building type - Merida

#### [Eje vertical, queda igual]

#### [Eje horizontal, títulos de izquierda a derecha]

[Línea base] Baseline

[Paso 1] Step 1

[Paso 2] Step 2

[Paso 3] Step 3

#### [Etiquetas del lado izquierdo, de arriba hacia abajo]

[Subsidio a la energía, renglón de abajo queda igual] Energy Subsidy [Costos de energía, renglón de abajo queda igual] Energy costs [Inversión adcional, renglón de abajo queda igual] Additional investment [Costos sí o sí, renglón de abajo queda igual] Variable costs

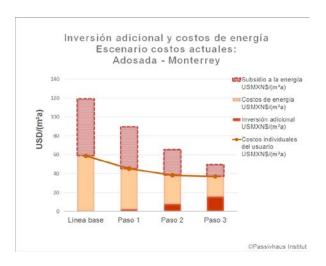


Figure 18: Current costs of the different steps towards the "step by step refurbishment to achieve optimal energy and environmental performance" standard (efficiency improvements) for the Adosada building type (50 m² SRE) in Monterrey (Source: Passivhaus Institut).

#### [Título de la gráfica]

Additional investment and energy costs Current costs scenario Adosada building type - Monterrey

#### [Eje vertical, queda igual]

#### [Eje horizontal, títulos de izquierda a derecha]

[Línea base] Baseline

[Paso 1] Step 1

[Paso 2] Step 2

[Paso 3] Step 3

#### [Etiquetas del lado izquierdo, de arriba hacia abajo]

[Subsidio a la energía, renglón de abajo queda igual] Energy Subsidy

[Costos de energía, renglón de abajo queda igual] Energy costs

[Inversión adcional, renglón de abajo queda igual]

Additional investment

[Costos individuales del usuario, renglón de abajo queda igual] User individual costs

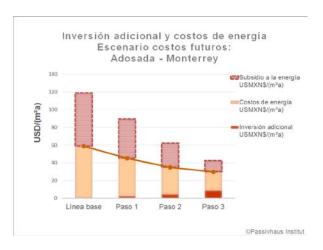


Figure 19: Future costs of the different steps towards the "step by step refurbishment to achieve optimal energy and environmental performance" standard (efficiency improvements) for the Adosada building type (50 m<sup>2</sup> SRE) in Monterrey (Source: Passivhaus Institut).

#### [Título de la gráfica]

Additional investment and energy costs Future costs scenario Adosada building type - Monterrey

#### [Eje vertical, queda igual]

#### [Eje horizontal, títulos de izquierda a derecha]

[Línea base] Baseline

[Paso 1] Step 1

[Paso 2] Step 2

[Paso 3] Step 3

#### [Etiquetas del lado izquierdo, de arriba hacia abajo]

[Subsidio a la energía, renglón de abajo queda igual] **Energy Subsidy** 

[Costos de energía, renglón de abajo queda igual] **Energy costs** 

[Inversión adcional, renglón de abajo queda igual]

Additional investment

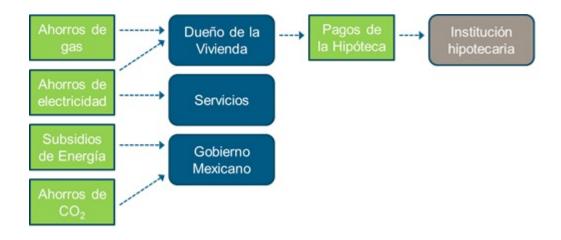


Figure 20: Added value for different actor of the NAMA (Source: Passivhaus Institut).

#### [Textos primera columna, de arriba hacia abajo]

Gas savings Electricity savings Energy subsidies CO2 savings

#### [Textos segunda columna, de arriba hacia abajo]

Home-owners Services Mexican government

#### [Texto tercera columna]

Mortgage payments

#### [Texto cuarta columna]

Mortgage institugion

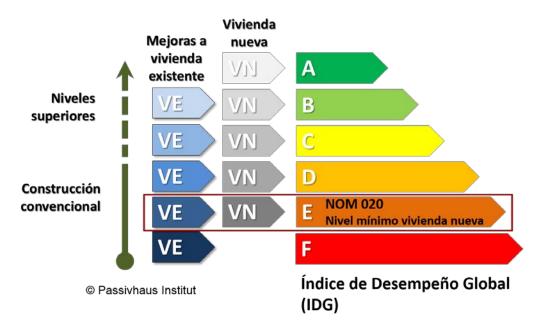


Figure 21: IDG adaptation form the NAMA for Sustainable Housing Retrofit (Source: Passivhaus Institut).

#### [Textos primera columna, de arriba hacia abajo]

[Niveles superiors] Higher levels [Construction convencional] Traditional building

#### [Texto de la segunda columna, todo lo demás queda igual]

Improvements to existing housing

#### [Texto de la tercera columna, todo lo demás queda igual]

New housing

#### [Texto de la cuarta columna, todo lo demás queda igual]

[NOM 020 Nivel mínimo vivienda nueva] NOM 020 Minimum level existing housing [Índice de Desempeño Global (IDG)] Global Performance Index (IDG)

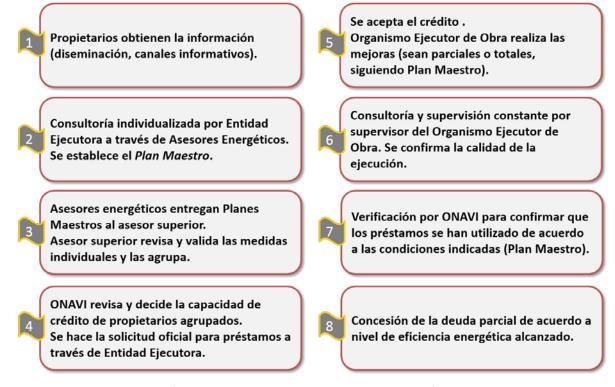


Figure 22: System proposed for credit consent to owners within the NAMA for Sustainable Housing Retrofit framework (Source: KfW, adaptation by the Passivhaus Institut).

#### [Textos primera columna, de arriba hacia abajo]

- 1. Home-owners obtain information (dissemination, information channels.
- 2. Personal advice by financial entity through energy advisors. Master Plan is defined.
- 3. Energy advisors deliver Master Plan to Auditor advisor. Auditor advisor review and validates individual measures and group them.
- 4. ONAVI review and decides credit capacity of grouped owners. Official application for loans through financial entity is delivered.

#### [Textos segunda columna, de arriba hacia abajo]

- 5. Loan is accepted. Building entity implements improvements (partial or total, following the Master Plan)
- 6. Constant advice and supervision by the building entity. Quality of the implementation is confirmed.
- 7. ONAVI verifies that loans have been used according to established conditions (Master Plan).
- 8. Partial debt grant relief, according to energy efficiency level achieved.

Table 4: Examples of financial packages for donor support. Amounts in USD millions reflecting rounding errors (Source: IzN Friedrichsdorf and the Passivhaus Institut).

	2015	2016	2017	2018	2019	Total
1) Inversión total						
P1:	17,6	35,1	35,1	35,1	35,1	158
P2:	8,3	25	50	58,3	58,3	200
P3:	0	0	4,2	12,7	21,1	38
Suma:	25,9	60,1	89,3	106,1	114,6	396
2) Costos de la inversión						
energética						
P1:	3	6	6	6	6	27
P2:	4	12,1	24,3	28,3	28,3	97
P3:	0	0	2,9	7,9	13,2	24
Suma:	7	18,1	33,2	42,2	47,5	148
3) Necesidades crediticias	20,7	48.1	71.5	84.9	91,6	317
totales (80% de Suma 1)		10,1	,-	0.1,0	5 = 7 5	
4) Necesidades crediticias para		5,6 14,5	26,5	33,8	38,0	118,4
mejoras en eficiencia energética	5.6					
y consumo de agua. (80% de						
Suma 2)						
5) Necesidad para subsidio de						
reducción de reembolso	0,8	2,2	4,0	5,1	5,7	17,8
(15% de 4) *, **		6 6 6 24,3 28,3 2 0 2,9 7,9 3 18,1 33,2 42,2 4 48,1 71,5 84,9 9 14,5 26,5 33,8 3				
6) Necesidad para subsidio para	47.0	7.0	7.0		2.6	42
asistencia técnica (acc. de apoyo)	17,9	/,2	7,2	/,2	3,6	43
P1= naso 1 P2= naso 2 P3 = naso 3	P1= paso 1. P2= paso 2. P3 = paso 3					

P1= paso 1, P2= paso 2, P3 = paso 3

<sup>\*</sup> El subsidio de reducción de reembolso es concedido cuando ciertos objetivos de eficiencia energética se han alcanzado.

<sup>\* \*</sup>El subsidio de la tasa de interés no se puede estimar ya que depende de varios factores que son todavía desconocidos.

	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	20,7	48,1	71,5	84,9	91,6	317
Total (80% of Total 1)	20,7	40,1	71,3	64,9	91,0	317
4) Credit req. for energy						
efficiency and water consumption	ا 5,6	14,5	26,5	33,8	38,0	118,4
improvements (80% of	3,0	14,5	20,3	33,8	38,0	110,4
Total 2)						
5) Subsidy requirements						
to reduce reimbursement	0,8	2,2	4,0	5,1	5,7	17,8
Instalments(15% of 4) *, **						
6) Subsidy requirements for	17,9	7,2	7,2	7,2	3,6	43
technical assistance (support ac.)	17,5	7,2	7,2	7,2	3,0	73

S1= Step 1, S2= Step 2, S3 = Step 3

SuEl subsidio de reducción de reembolso es concedido cuando ciertos objetivos de eficiencia energética se han alcanzado.

Table 5: Example of financing packages for donor support. Amounts in USD millions reflecting rounding errors (Source: IzN Friedrichsdorf and the Passivhaus Institut).

#### [Texto en margen inferior]

<sup>\* \*</sup>El subsidio de la tasa de interés no se puede estimar ya que depende de varios factores que son todavía desconocidos.

<sup>\*</sup>Subsidy to reimbursement instalments is granted when certain energy efficiency objectives have been achieved.

<sup>\*</sup>Subsidy to interest rate cannot be estimated as it depends on several factors unknown.

## **ANNEX**

[Textos de la primera COLUMNA margen izquierdo, de arriba hacia abajo. Incluye texto de columna 2 si hay algo que se traduce]

[Superficie de referencia energética 51.35 m<sup>2</sup>] Energy reference surface 51.35 m<sup>2</sup> [ADOSADA] ADOSADA

[Demanda específica de calefacción] Specific heating demand

[Electricidad (energía final)] Electricity (total energy)

[Gas (energía final)] Gas (total energy)

[Demanda específica de refrigeración sensible] Specific sensible cooling demand [Demanda específica de refrigeración latente] Specific Latent cooling demand

[Demanda total específica de refrigeración] Total Specific cooling demand [Demanda específica de energía primaria] Specific primary energy demand

[Emisiones totales de CO<sub>2</sub> equivalente] Total emissions CO<sub>2</sub> equivalent

#### [COSTOS] Costs

[Costo de inversión adicional por EE, POR VIVIENDA (actual, USD)]

Additional investment cost per EB, PER HOUSE (current, USD)

[Costo de inversión adicional por EE, POR VIVIENDA (a futuro, USD)]

Additional investment cost per EB, PER HOUSE (future, USD)

[GRAN TOTAL DE de costos de inversión POR VIVIENDA (actual, USD)]

Investment costs GRAND TOTAL, PER HOUSE (current, USD)

[Costos por consultoría general (incl. Asesoría energ.)]

Costs for general advice (including energy advisory)

[Variable] Variable

[Columna 2, Unidad] Unit

#### [DATOS DE AISLAMIENTO TÉRMICO] THERMAL INSULATION DATA

[Conductividad térmica aislamiento muros y techo] Thermal conductivity walls and roof insulation

[Espesor aislamiento muro N, S y O (excepto medianera)]

Insulation thickness walls N, S and W (except dividing wall)

[¿Aislamiento interior muro N, S y O (excepto medianera)?]

Indoor insulation walls N, S and W (except dividing wall)?

[Espesor aislamiento muro E (pasillo)] Insulation thickness wall E (hallway)

[¿Aislamiento interior muro E (pasillo)?] Indoor insulation wall E (hallway)?

[Columna 2, Sí/No] Yes/No

[Conductividad térmica aislamiento piso] Thermal conductivity floor insulation

[Espesor aislamiento losa de piso] Insulation thickness floor slab

[Espesor aislamiento techo] Insulation thickness roof

[Aislamiento interior techo] Indoor insulation roof?

[Valor-U puerta exterior (no aplica en adosada)]

Exterior door U-value (does not apply in adosada type)

[Coeficiente de absorptividad techo] Roof absorption coefficient

[Coeficiente de absorptividad muros] Walls absorption coefficient

[Suplemento PT estándar] PT standard supplement

#### [VENTANAS] WINDOWS

[Marco: Valor-Uf] Window frame: Uf-value [Acristalamiento: Valor g] Window glazing: g-value [Acristalamiento: Valor-Ug] Window glazing: Ug-value

[Ψ Installation on walls N,S, W (except dividing wall)

[Ψ Instalación en muro E] Ψ Installation on wall E

[Columna 2, Sí/No] Yes/No

[Columna 2, Sí/No] Yes/No

#### [VENTILACIÓN] VENTILATION

[Tasa renovación aire ensayo presión n50] Air recovery rate testing pressure n50

[Ventilación equilibrada tipo Passivhaus] Ventilation type - Balanced PH Ventilation

[Sólo aire de axtracción] Only air extraction

[Eficiencia de recuperación de calor efectiva] Effective heat recovery efficiency

[Eficiencia eléct. Vent. (HRV, extracción o ventanas]

Electric ventilation efficiency (HRV, extraction or Windows)

[Ef. Recuperación energía (humedad)] Effective energy recovery (humidity)

#### [SOMBRAS] SHADING

[Factor protección solar temporal Z] Factor Z for temporary sun protection

#### [ELECTRICIDAD] ELECTRICITY

[Porcentaje de lámparas fluorescentes] Percentage of CFLs

[Demanda lavadora de ropa] Washing machine demand [Columna 2, kWhr/Uso] kWhr/Use [Demanda refrigerador con congelador] [Columna 2, kWhr/día] kWhr/day

Refrigerator with freezer demand [Electrónica (TV)] Electronics (TV) [Tipo de estufa] Type of oven

[Demanda de estufa] Oven demand [Columna 2, kWhr/Uso] kWhr/Use

#### [ELECTRICIDAD AUXILIAR] AUX ELECTRICITY

[Demanda ventilador de techo] Ceiling fan demand

[Columna 2, kWhr/a] kWhr/year

#### [VENTILACIÓN EN VERANO] SUMMER VENTILATION

[Renov. aire sist. ventilación c/aire impulsión] Air renewal through a ventilation system with air impulse

[Renov. aire sist. Extracción de aire] Air renewal through an air extraction system

[Renovación de aire por ventanas] Air renewal through windows

[Renovación de aire: Ventilación nocturna por ventanas] Air renewal: night ventilation through windows

#### [APARATOS REFRIGERACIÓN] COOLING UNITS

[Ref. Circ.: Capacidad ref máxima] Circ. Ref.: Maximum capacity reference

[Ref. Circ.: Volumen de aire en potencia nominal] Circ. Ref.: Air volume rated power

[Ref. Circ.: SEER] Circ. Ref.: SEER

[Deshumidificación adicional] Additional dehumidification

[Deshumidificación SEER] SEER dehumidification

#### [DISTRIBUCIÓN ACS] ACS DISTRIBUTION

[Consumo de ACS por persona y día (60°C)] ACS consumption per person/day (60°C)

[Columna 2, Litros/persona/día]

Liters/person/day

#### [COLECTOR SOLAR ACS] ACS SOLAR COLLECTOR

[Tipo de colector] type of collector [Superficie del colector] collector surface

#### [CALDERA Y BOILER] BOILER

[Tipo de generador de calor] Type of heat generator

[Columna 2, Texto] Text

[Rendimiento del calentador con potencia nominal] Heater performance rated power

#### [CALEFACCION] HEATING

[Directamente eléctrica] Electrical

[A través de equipo split] Through a split system

#### [OTROS] OTHER

[Factor de energía primaria Electricidad] Primary electricity energy factor [Factor de energía primaria Gas LP] Primary LP Gas energy factor [Factor de CO2 Electricidad] Electricity CO2 factor [Factor de CO2 Gas LP] LP Gas CO2 factor

#### [Textos de la primera LÍNEA margen superior, de izquierda a derecha]

[ADOSADA Línea base – Monterrey] ADOSADA baseline - Monterrey [ADOSADA Paso 1 – Monterrey] ADOSADA Step 1 - Monterrey [ADOSADA Paso 2 – Monterrey] ADOSADA Step 2 - Monterrey [ADOSADA Paso 3 (EnerPHit) – Monterrey] ADOSADA Step 3 (EnerPHit) - Monterrey

[ADOSADA Línea base – Guadalajara] ADOSADA baseline - Guadalajara [ADOSADA Paso 1 – Guadalajara] ADOSADA Step 1 - Guadalajara [ADOSADA Paso 2 – Guadalajara] ADOSADA Step 2 - Guadalajara [ADOSADA Paso 3 (EnerPHit) – Guadalajara] ADOSADA Step 3 (EnerPHit) - Guadalajara

[ADOSADA Línea base – Cd. México] ADOSADA baseline – Mexico City
[ADOSADA Paso 1 – Cd. México] ADOSADA Step 1 - Mexico City
[ADOSADA Paso 2 – Cd. México] ADOSADA Step 2 - Mexico City
[ADOSADA Paso 3 (EnerPHit) – Cd. México] ADOSADA Step 3 (EnerPHit) - Mexico City

[ADOSADA Línea base – Mérida] ADOSADA baseline – Merida [ADOSADA Paso 1 – Mérida] ADOSADA Step 1 - Merida [ADOSADA Paso 2 – Mérida] ADOSADA Step 2 - Merida [ADOSADA Paso 3 (EnerPHit) – Mérida] ADOSADA Step 3 (EnerPHit) - Merida

#### [Textos de la segunda LÍNEA margen superior, de izquierda a derecha]

[Monterrey: Clima cálido seco] Monterrey: Hot dry climate

[Guadalajara: Templado] Guadalajara: Template

[Cd. De México: Templado frío] Mexico City: Template cold

[Mérida: Cálido húmedo] Merida: Hot humid

# [Texto de la LÍNEA 22, desde la tercera columna hasta la última, mismo en todas]

[Sí] Yes

#### [Textos de la LÍNEA 39, de izquierda a derecha] Monterrey

[Vent. por ventanas] Window ventilation

[Vent. por ventanas] Window ventilation

[Vent. por ventanas] Window ventilation

[Vent. Passivhaus] Passivhaus ventilation

#### Guadalajara

[Vent. por ventanas] Window ventilation

#### **Mexico City**

[Vent. por ventanas] Window ventilation

[Vent. por ventanas] Window ventilation

[Vent. por ventanas] Window ventilation [Vent. por ventanas] Window ventilation **Merida** 

[Vent. por ventanas] Window ventilation [Vent. por ventanas] Window ventilation [Vent. por ventanas] Window ventilation [Vent. Passivhaus] Passivhaus ventilation

#### [Texto en columnas 10 y 14 de la LÍNEA 40, el mismo en ambas]

[Aparato de extracción] Extraction device

[Texto en todas las columnas de la LÍNEA 51, a partir de la tercera (mismo en todas)] [Gas LP] LP Gas

[Texto en todas columnas 3 a 6 y 15 a 18 de la LÍNEA 64, (mismo en todas)] [Deshum.] Dehumidification

[Texto en todas las columnas de la LÍNEA 69, a partir de la tercera (mismo en todas)] [Tub. Evac.]

[Texto en todas las columnas de la LÍNEA 72, a partir de la tercera (mismo en todas)] [Caldera gas] Gas boiler

# [Textos de la primera COLUMNA margen izquierdo, de arriba hacia abajo. Incluye texto de columna 2 si hay algo que se traduce]

# [Superficie de referencia energética 38.096 m²] Energy reference surface 38.096 m² [AISLADA] AISLADA

[Demanda específica de calefacción] Specific heating demand

[Electricidad (energía final)] Electricity (total energy)

[Gas (energía final)] Gas (total energy)

[Demanda específica de refrigeración sensible] Specific sensible cooling demand

[Demanda específica de refrigeración latente] Specific Latent cooling demand

[Demanda total específica de refrigeración] Total Specific cooling demand

[Demanda específica de energía primaria] Specific primary energy demand

[Emisiones totales de CO<sub>2</sub> equivalente] Total emissions CO<sub>2</sub> equivalent

#### [COSTOS] Costs

[Costo de inversión adicional por EE, POR VIVIENDA (actual, USD)]

Additional investment cost per EB, PER HOUSE (current, USD)

[Costo de inversión adicional por EE, POR VIVIENDA (a futuro, USD)]

Additional investment cost per EB, PER HOUSE (future, USD)

[GRAN TOTAL DE de costos de inversión POR VIVIENDA (actual, USD)]

Investment costs GRAND TOTAL, PER HOUSE (current, USD)

[Costos por consultoría general (incl. Asesoría energ.)]

Costs for general advice (including energy advisory)

#### [Variable] Variable

[Columna 2, Unidad] Unit

#### [DATOS DE AISLAMIENTO TÉRMICO] THERMAL INSULATION DATA

[Conductividad térmica aislamiento muros y techo] Thermal conductivity walls and roof insulation

[Espesor aislamiento muro N y S]

Insulation thickness walls N and S

[¿Aislamiento interior muro N y S?]

[Columna 2, Sí/No] Yes/No

Indoor insulation walls N and S?

[Espesor aislamiento muro E (pasillo), O (límite lote)]

Insulation thickness wall E (hallway), W (land limit)

[¿Aislamiento interior muro E (pasillo), O (límite lote)?]

[Columna 2, Sí/No] Yes/No

Indoor insulation wall E (hallway), W (land limit)?

[Conductividad térmica aislamiento piso] Thermal conductivity floor insulation

[Espesor aislamiento losa de piso] Insulation thickness floor slab

[Espesor aislamiento techo] Insulation thickness roof

[¿Aislamiento interior techo?] Indoor insulation roof?

[Columna 2, Sí/No] Yes/No

[Valor-U puerta exterior (no aplica en adosada)]

Exterior door U-value (does not apply in adosada type)

[Coeficiente de absorptividad techo] Roof absorption coefficient

[Coeficiente de absorptividad muros] Walls absorption coefficient

[Suplemento PT estándar] PT standard supplement

#### [VENTANAS] WINDOWS

[Marco: Valor-Uf] Window frame: Uf-value [Acristalamiento: Valor g] Window glazing: g-value [Acristalamiento: Valor-Ug] Window glazing: Ug-value

[Ψ Instalación en muro N, S, O] Ψ Installation on walls N, S, W

[Ψ Instalación en muro E] Ψ Installation on wall E

#### [VENTILACIÓN] VENTILATION

[Tasa renovación aire ensayo presión n50] Air recovery rate testing pressure n50

[Ventilación equilibrada tipo Passivhaus] Ventilation type - Balanced PH Ventilation

[Sólo aire de axtracción] Only air extraction

[Eficiencia de recuperación de calor efectiva] Effective heat recovery efficiency

[Eficiencia eléct. Vent. (HRV, extracción o ventanas]

Electric ventilation efficiency (HRV, extraction or Windows)

[Ef. Recuperación energía (humedad)] Effective energy recovery (humidity)

#### [SOMBRAS] SHADING

[Factor protección solar temporal Z] Factor Z for temporary sun protection

#### [ELECTRICIDAD] ELECTRICITY

[Porcentaje de lámparas fluorescentes] Percentage of CFLs

[Demanda lavadora de ropa] Washing machine demand [Columna 2, kWhr/Uso] kWhr/Use [Demanda refrigerador con congelador] [Columna 2, kWhr/día] kWhr/day

Refrigerator with freezer demand [Electrónica (TV)] Electronics (TV) [Tipo de estufa] Type of oven

[Demanda de estufa] Oven demand [Columna 2, kWhr/Uso] kWhr/Use

#### [ELECTRICIDAD AUXILIAR] AUX ELECTRICITY

[Demanda ventilador de techo] Ceiling fan demand

[Columna 2, kWhr/a] kWhr/year

#### [VENTILACIÓN EN VERANO] SUMMER VENTILATION

[Renov. aire sist. ventilación c/aire impulsión] Air renewal through a ventilation system with air impulse

[Renov. aire sist. Extracción de aire] Air renewal through an air extraction system

[Renovación de aire por ventanas] Air renewal through windows

[Renovación de aire: Ventilación nocturna por ventanas] Air renewal: night ventilation through windows

#### [APARATOS REFRIGERACIÓN] COOLING UNITS

[Ref. Circ.: Capacidad ref máxima] Circ. Ref.: Maximum capacity reference

[Ref. Circ.: Volumen de aire en potencia nominal] Circ. Ref.: Air volume rated power

[Ref. Circ.: SEER] Circ. Ref.: SEER

[Deshumidificación adicional] Additional dehumidification

[Deshumidificación SEER] SEER dehumidification

#### [DISTRIBUCIÓN ACS] ACS DISTRIBUTION

[Consumo de ACS por persona y día (60°C)] ACS consumption per person/day (60°C)

[Columna 2, Litros/persona/día]

Liters/person/day

#### [COLECTOR SOLAR ACS] ACS SOLAR COLLECTOR

[Tipo de colector] type of collector [Superficie del colector] collector surface

#### [CALDERA Y BOILER] BOILER

[Tipo de generador de calor] Type of heat generator

[Columna 2, Texto] Text

[Rendimiento del calentador con potencia nominal] Heater performance rated power

#### [CALEFACCION] HEATING

[Directamente eléctrica] Electrical

[A través de equipo split] Through a split system

#### [OTROS] OTHER

[Factor de energía primaria Electricidad] Primary electricity energy factor [Factor de energía primaria Gas LP] Primary LP Gas energy factor [Factor de CO2 Electricidad] Electricity CO2 factor [Factor de CO2 Gas LP] LP Gas CO2 factor

#### [Textos de la primera LÍNEA margen superior, de izquierda a derecha]

[AISLADA Línea base – Monterrey] AISLADA baseline - Monterrey [AISLADA Paso 1 – Monterrey] AISLADA Step 1 - Monterrey [AISLADA Paso 2 – Monterrey] AISLADA Step 2 - Monterrey [AISLADA Paso 3 (EnerPHit) – Monterrey] AISLADA Step 3 (EnerPHit) - Monterrey

[AISLADA Línea base – Guadalajara] AISLADA baseline - Guadalajara [AISLADA Paso 1 – Guadalajara] AISLADA Step 1 - Guadalajara [AISLADA Paso 2 – Guadalajara] AISLADA Step 2 - Guadalajara [AISLADA Paso 3 (EnerPHit) – Guadalajara] AISLADA Step 3 (EnerPHit) - Guadalajara

[AISLADA Línea base – Cd. México] AISLADA baseline – Mexico City
[AISLADA Paso 1 – Cd. México] AISLADA Step 1 - Mexico City
[AISLADA Paso 2 – Cd. México] AISLADA Step 2 - Mexico City
[AISLADA Paso 3 (EnerPHit) – Cd. México] AISLADA Step 3 (EnerPHit) - Mexico City

[AISLADA Línea base – Mérida] AISLADA baseline – Merida [AISLADA Paso 1 – Mérida] AISLADA Step 1 - Merida [AISLADA Paso 2 – Mérida] AISLADA Step 2 - Merida [AISLADA Paso 3 (EnerPHit) – Mérida] AISLADA Step 3 (EnerPHit) - Merida

#### [Textos de la segunda LÍNEA margen superior, de izquierda a derecha]

[Monterrey: Clima cálido seco] Monterrey: Hot dry climate

[Guadalajara: Templado] Guadalajara: Template

[Cd. De México: Templado frío] Mexico City: Template cold

[Mérida: Cálido húmedo] Merida: Hot humid

# [Texto de la LÍNEA 22, desde la tercera columna hasta la última, mismo en todas]

[Sí] Yes

#### [Textos de la LÍNEA 39, de izquierda a derecha] Monterrey

[Vent. por ventanas] Window ventilation

[Vent. por ventanas] Window ventilation

[Vent. por ventanas] Window ventilation

[Vent. Passivhaus] Passivhaus ventilation

#### Guadalajara

[Vent. por ventanas] Window ventilation

#### **Mexico City**

[Vent. por ventanas] Window ventilation

#### Merida

[Vent. por ventanas] Window ventilation

[Vent. por ventanas] Window ventilation

[Vent. por ventanas] Window ventilation

[Vent. Passivhaus] Passivhaus ventilation

#### [Texto en columnas 10 y 14 de la LÍNEA 40, el mismo en ambas]

[Aparato de extracción] Extraction device

[Texto en todas las columnas de la LÍNEA 51, a partir de la tercera (mismo en todas)] [Gas LP] LP Gas

[Texto en todas columnas 3 a 6, 10 y 15 a 18 de la LÍNEA 64, (mismo en todas)]

[Deshum.] Dehumidification

[Texto en todas las columnas de la LÍNEA 69, a partir de la tercera (mismo en todas)]

[Tub. Evac.]

[Texto en todas las columnas de la LÍNEA 72, a partir de la tercera (mismo en todas)]

[Caldera gas] Gas boiler

# [Textos de la primera COLUMNA margen izquierdo, de arriba hacia abajo. Incluye texto de columna 2 si hay algo que se traduce]

# [Superficie de referencia energética (por vivienda): 41 m²] Energy reference surface (per unit) 41 m² [VERTICAL] VERTICAL

[Demanda específica de calefacción] Specific heating demand

[Electricidad (energía final)] Electricity (total energy)

[Gas (energía final)] Gas (total energy)

[Demanda específica de refrigeración sensible] Specific sensible cooling demand

[Demanda específica de refrigeración latente] Specific Latent cooling demand

[Demanda total específica de refrigeración] Total Specific cooling demand

[Demanda específica de energía primaria] Specific primary energy demand

[Emisiones totales de CO<sub>2</sub> equivalente] Total emissions CO<sub>2</sub> equivalent

#### [COSTOS] Costs

[Costo de inversión adicional por EE, POR VIVIENDA (actual, USD)]

Additional investment cost per EB, PER HOUSE (current, USD)

[Costo de inversión adicional por EE, POR VIVIENDA (a futuro, USD)]

Additional investment cost per EB, PER HOUSE (future, USD)

[GRAN TOTAL DE de costos de inversión POR VIVIENDA (actual, USD)]

Investment costs GRAND TOTAL, PER HOUSE (current, USD)

[Costos por consultoría general (incl. Asesoría energ.)]

Costs for general advice (including energy advisory)

#### [Variable] Variable

[Columna 2, Unidad] Unit

#### [DATOS DE AISLAMIENTO TÉRMICO] THERMAL INSULATION DATA

[Conductividad térmica aislamiento muros y techo] Thermal conductivity walls and roof insulation

[Espesor aislamiento muro N, S, E y O (excepto N2)]

Insulation thickness walls N, S, E and W (except N2)

[¿Aislamiento interior muro]

[Columna 2, Sí/No] Yes/No

Indoor wall insulation?

[Espesor aislamiento muro N2 (pasillo)]

Insulation thickness wall N2 (hallway))

[¿Aislamiento interior muro N2 (pasillo)?]

[Columna 2, Sí/No] Yes/No

Indoor insulation wall N2 (hallway)?

[Conductividad térmica aislamiento piso] Thermal conductivity floor insulation

[Espesor aislamiento losa de piso] Insulation thickness floor slab

[Espesor aislamiento techo] Insulation thickness roof

[¿Aislamiento interior techo?] Indoor insulation roof?

[Columna 2, Sí/No] Yes/No

[Valor-U puerta exterior (no aplica en adosada)]

Exterior door U-value (does not apply in adosada type)

[Coeficiente de absorptividad techo] Roof absorption coefficient

[Coeficiente de absorptividad muros] Walls absorption coefficient

[Suplemento PT estándar] PT standard supplement

#### [VENTANAS] WINDOWS

[Marco: Valor-Uf] Window frame: Uf-value [Acristalamiento: Valor g] Window glazing: g-value [Acristalamiento: Valor-Ug] Window glazing: Ug-value

[Ψ Instalación en muro S, E y O] Ψ Installation on walls S, E and W

#### [VENTILACIÓN] VENTILATION

[Tasa renovación aire ensayo presión n50] Air recovery rate testing pressure n50

[Ventilación equilibrada tipo Passivhaus] Ventilation type - Balanced PH Ventilation

[Sólo aire de axtracción] Only air extraction

[Eficiencia de recuperación de calor efectiva] Effective heat recovery efficiency

[Eficiencia eléct. Vent. (HRV, extracción o ventanas]

Electric ventilation efficiency (HRV, extraction or Windows)

[Ef. Recuperación energía (humedad)] Effective energy recovery (humidity)

#### [SOMBRAS] SHADING

[Factor protección solar temporal Z] Factor Z for temporary sun protection

#### [ELECTRICIDAD] ELECTRICITY

[Porcentaje de lámparas fluorescentes] Percentage of CFLs

[Demanda lavadora de ropa] Washing machine demand [Columna 2, kWhr/Uso] kWhr/Use [Demanda refrigerador con congelador] [Columna 2, kWhr/día] kWhr/day

Refrigerator with freezer demand [Electrónica (TV)] Electronics (TV) [Tipo de estufa] Type of oven

[Demanda de estufa] Oven demand [Columna 2, kWhr/Uso] kWhr/Use

#### [ELECTRICIDAD AUXILIAR] AUX ELECTRICITY

[Demanda ventilador de techo] Ceiling fan demand

[Columna 2, kWhr/a] kWhr/year

#### [VENTILACIÓN EN VERANO] SUMMER VENTILATION

[Renov. aire sist. ventilación c/aire impulsión] Air renewal through a ventilation system with air impulse

[Renov. aire sist. Extracción de aire] Air renewal through an air extraction system

[Renovación de aire por ventanas] Air renewal through windows

[Renovación de aire: Ventilación nocturna por ventanas] Air renewal: night ventilation through windows

#### [APARATOS REFRIGERACIÓN] COOLING UNITS

[Ref. Circ.: Capacidad ref máxima] Circ. Ref.: Maximum capacity reference

[Ref. Circ.: Volumen de aire en potencia nominal] Circ. Ref.: Air volume rated power

[Ref. Circ.: SEER] Circ. Ref.: SEER

[Deshumidificación adicional] Additional dehumidification

[Deshumidificación SEER] SEER dehumidification

#### [DISTRIBUCIÓN ACS] ACS DISTRIBUTION

[Consumo de ACS por persona y día (60°C)]

ACS consumption per person/day (60°C) Liters/person/day

[COLECTOR SOLAR ACS] ACS SOLAR COLLECTOR

[Tipo de colector] type of collector

[Superficie del colector] collector surface

#### [CALDERA Y BOILER] BOILER

[Tipo de generador de calor] Type of heat generator

[Columna 2, Texto] Text

[Columna 2, Litros/persona/día]

[Rendimiento del calentador con potencia nominal] Heater performance rated power

#### [CALEFACCION] HEATING

[Directamente eléctrica] Electrical

[A través de equipo split] Through a split system

#### [OTROS] OTHER

[Factor de energía primaria Electricidad] Primary electricity energy factor [Factor de energía primaria Gas LP] Primary LP Gas energy factor [Factor de CO2 Electricidad] Electricity CO2 factor [Factor de CO2 Gas LP] LP Gas CO2 factor

#### [Textos de la primera LÍNEA margen superior, de izquierda a derecha]

[VERTICAL Línea base – Monterrey] VERTICAL baseline - Monterrey

[VERTICAL Paso 1 – Monterrey] VERTICAL Step 1 - Monterrey

[VERTICAL Paso 2 – Monterrey] VERTICAL Step 2 - Monterrey

[VERTICAL Paso 3 (EnerPHit) - Monterrey] VERTICAL Step 3 (EnerPHit) - Monterrey

[VERTICAL Línea base – Guadalajara] VERTICAL baseline - Guadalajara

[VERTICAL Paso 1 - Guadalajara] VERTICAL Step 1 - Guadalajara

[VERTICAL Paso 2 – Guadalajara] VERTICAL Step 2 - Guadalajara

[VERTICAL Paso 3 (EnerPHit) - Guadalajara] VERTICAL Step 3 (EnerPHit) - Guadalajara

[VERTICAL Línea base - Cd. México] VERTICAL baseline - Mexico City

[VERTICAL Paso 1 - Cd. México] VERTICAL Step 1 - Mexico City

[VERTICAL Paso 2 - Cd. México] VERTICAL Step 2 - Mexico City

[VERTICAL Paso 3 (EnerPHit) - Cd. México] VERTICAL Step 3 (EnerPHit) - Mexico City

[VERTICAL Línea base – Mérida] VERTICAL baseline – Merida

[VERTICAL Paso 1 - Mérida] VERTICAL Step 1 - Merida

[VERTICAL Paso 2 – Mérida] VERTICAL Step 2 - Merida

[VERTICAL Paso 3 (EnerPHit) - Mérida] VERTICAL Step 3 (EnerPHit) - Merida

#### [Textos de la segunda LÍNEA margen superior, de izquierda a derecha]

[Monterrey: Clima cálido seco] Monterrey: Hot dry climate

[Guadalajara: Templado] Guadalajara: Template

[Cd. De México: Templado frío] Mexico City: Template cold

[Mérida: Cálido húmedo] Merida: Hot humid

#### [Textos de la LÍNEA 22, según lo indicado por cada columna]

[Sí] Yes [No] No

# [Textos de la LÍNEA 38, de izquierda a derecha]

#### Monterrey

[Vent. por ventanas] Window ventilation

[Vent. por ventanas] Window ventilation

[Vent. por ventanas] Window ventilation

[Vent. Passivhaus] Passivhaus ventilation

#### Guadalajara

[Vent. por ventanas] Window ventilation

#### **Mexico City**

[Vent. por ventanas] Window ventilation

#### Merida

[Vent. por ventanas] Window ventilation

[Vent. por ventanas] Window ventilation

[Vent. por ventanas] Window ventilation

[Vent. Passivhaus] Passivhaus ventilation

#### [Texto en columnas 10 y 14 de la LÍNEA 39, el mismo en ambas]

[Aparato de extracción] Extraction device

# [Texto en todas las columnas de la LÍNEA 50, a partir de la tercera (mismo en todas)]

[Gas LP] LP Gas

#### [Texto en todas columnas 3 a 6 y 15 a 18 de la LÍNEA 63, (mismo en todas)]

[Deshum.] Dehumidification

#### [Texto en todas las columnas de la LÍNEA 68, a partir de la tercera (mismo en todas)]

[Tub. Evac.]

### [Texto en todas las columnas de la LÍNEA 71, a partir de la tercera (mismo en todas)]

[Caldera gas] Gas boiler

# NAMA for Sustainable Housing Retrofit Technical Design:

# **Product 3:**

# MRV system design adaptation proposal, including NAMA for Sustainable Housing Retrofit monitoring strategies

Mexico City

Draft date: September 24, 2014







Requested by

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)

Mexico

Technical cooperation between Mexico and Germany

Mexican-German Programme for NAMA



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www.passivehouse.com

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# Main criteria to be considered for the MRV system design of the NAMA for Sustainable Housing Retrofit

**Note.-** This document is based on original documents developed by MGM Innova, requested by GIZ: "Estudio para la identificación de los criterios generales para el sistema MRV de la NAMA de Vivienda Existente" (Study for the identification of general guidelines for the MRV system of the NAMA for Existing Housing Retrofit") [MGM Innova 2013] and its related summary "Principales criterios para considerar en el diseño del sistema MRV de la NAMA de Vivienda Existente" (Main criteria to be considered for the MRV system design of the NAMA for Existing Housing Retrofit) [MGM Innova 2013<sup>a</sup>]. Proposed adaptations to these original documents are presented, based on the development framework of the NAMA for Sustainable Housing Retrofit Technical Design.

#### 1. Introduction

The main objective of a MRV system for any NAMA is to measure the impact of the applied measures and assess their contribution to GHG mitigation objectives (GEI), at national or international level. As previous preparation of the NAMA for Existing Housing Retrofit Technical Design, the consulting company MGM Innova presented the document "Estudio para la identificación de los criterios generales para el sistema MRV de la NAMA de Vivienda Existente" (Study for the identification of general guidelines for the MRV system of the NAMA for Existing Housing Retrofit") and its related summary "Principales criterios para considerar en el diseño del sistema MRV de la NAMA de Vivienda Existente" (Main criteria to be considered for the MRV system design of the NAMA for Existing Housing Retrofit), published in 2014. These documents propose guidelines on which the MRV system of the NAMA VE should be based.

The objective of this report is to review and adapt, if required, the general guidelines for the MRV system of the NAMA for Existing Housing Retrofit (VE), during its Technical Design development. It is mainly based on MGM Innova working documents, complementing the information in some detailed aspects and suggesting alternatives, if necessary. The following specific adaptations to the MRV system will be presented:

- ✓ Review of the existing MRV system design concept and monitoring strategy;
- ✓ Proposals to adapt the preliminary technical design to define parameters and frequency to be monitored;
- ✓ Definition and selection of the sample size to be monitored;
- ✓ Definition of possible responsibilities and tasks within the MRV system;
- ✓ General definition of reporting formats and protocols.

# 2. Review of the existing MRV system design concept and monitoring strategy

The concept for the MRV system of the NAMA VE is based on the following recommendations for a first version of MRV system guidelines: the use a whole house approach, the 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 the development a phased MRV system addressed to two different phases of the NAMA VE. These guidelines are discussed below.

#### 2.1 Whole house approach

This concept 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 assessment and planning of energy efficiency in buildings. The use of the 'whole house approach' in the MRV system is also confirmed by this NAMA VE Technical Design (see [NAMA VE 2014]).

#### 2.2 Consumption adjustment methodology

The consumption adjustment methodology originally proposed by [MGM Innova 2013], is based on *measuring housing performance before project implementation (ex-ante)*. Then, this measured performance should be adapted considering the feasible variables influencing consumption, such as temperature, to adjust the baseline. Considering this, MGM Innova proposed the VM0008 methodology as the appropriate consumption adjustment approach for GHG mitigation analysis (greenhouse gases), within the NAMA VE.

This baseline performance adjustment presents the difficulty to access historical data required and the uncertainty to forecast comfort conditions and future housing equipment (especially if NAMA VE considers a 30 year-cycle). Section 3.3.2 presents an alternative that could solve this problem and would represent an adaptation to the original concept of the consumption adjustment methodology.

#### 2.3 VM0008 methodology adaptation

Although this methodology is still being considered to be used for the MRV system of the NAMA VE, within this document some vital adaptations are proposed to make it work with the NAMA VE concept. However, an alternative is proposed in the conclusions section, in case such methodology is not ultimately considered appropriate.

#### 2.4 Develop a phased MRV system addressed to two different phases of the NAMA VE

The proposal to divide the MRV system in two phases is confirmed. These phases, as originally presented in document [MGM Innova 2013], are presented below:

• **NAMA VE implementation phase:** a MRV system for data collection to calibrate boundary conditions used in the modeling software for housing performance.

- **NAMA VE monitoring phase:** a MRV system for NAMA VE large-scale implementation phase, using a housing performance modeling software.
  - o To include data collection for housing identification and registration of improvement actions, as well as for the credit loan process
  - o In parallel with the NAMA VN, two types of monitoring should be included:
    - Simple monitoring: for emissions and water consumption reductions calculations
    - Detailed monitoring: to collect more information on specific measures and for quality control
  - o To include in the detailed MRV system, a monitoring scheme that enables process and financial data collection

Figure 1 below summarizes the recommended strategy in the original document [GIZ/MGM Innova 2013]:

## Recommended strategy for the NAMA VE's MRV system

Whole house approach

#### Consumption adjustment methodology, adapted to a dynamic baseline

## NAMA VE's implementation process over time

Implementation phase	Monitoring phase			
Comprehensive monitoring	Identification data- collection	Simple monitoring	Detailed monitoring	
Objectives:  • Pilot projects impact measuring	Objectives:  • Data collection to	Objectives:  • Emissions reduction	Objectives:  • Quality control	
Data building for detailed studies and NAMA VE definition	identify housing and register actions	measuring	• Calculation system maintenance <i>through</i>	
Boundary conditions calibration and modification for the SISEVIVE programme calculation tool			continuous calibration of boundary conditions	
			Financial and process data monitoring	
Tools:		Tools:		
Calculation tool adapted to existing housing with adjusted boundary conditions		Calculation tool adapted to existing housing with adjusted boundary conditions		

Figure 1. Recommended strategy for the MRV of the NAMA for Sustainable Housing Retrofit.

Source [GIZ/MGM Innova 2013], adaptation by Passivhaus Institut

Note.- Adaptation for this report is highlighted in bold/italics. Replaced data has been crossed out

# Important

### **Calibration of boundary conditions for calculation**

A simplified calculation software, such as the DEEVi tool (Diseño Energéticamente Eficiente de la Vivienda – Energy Efficient Housing Design Program) to assess energy efficiency of projects within the Sisevive-Ecocasa Programme, requires the generalization of "common" conditions, meaning boundary conditions.

This is considered in order to calculate a large number of projects where uncertainty prevails (such as new housing projects). Since calculations have a whole house approach, not only quality of the thermal envelope (walls, windows, shading, etc.) is required, but also data from other aspects with energy consumption influence, such as domestic appliances, inhabitants, ventilation strategies, etc. Within the frame of the calculation tool extended use, many parameters are generalized, based on available data and recommendations submitted by software developers and counterparts involved in its design.

This parameters or **boundary conditions** may be of great influence to final calculation results. As well, generalization helps the user to enter data easily; results may be comparable between different projects, considering this a benefit for the qualification system purposes. Boundary conditions should be modified with respect to measured data for comparison purposes between monitored projects.

The more information coming from monitored projects measures and other information sources, the more these boundary conditions (basis for accurate energy efficiency calculation) may be refined.

When referring "to calibrate calculation software boundary conditions", it means to specify assumptions for the energy efficiency calculation basis. These assumptions have the following features:

- ✓ Comfort temperatures
- ✓ Climate conditions (radiation, outdoor temperatures, outdoor humidity)
- ✓ Indoor air quality (based on the average air recovery)
- ✓ Air tightness
- ✓ Presence, energy efficiency and patterns of use on air conditioning devices
- ✓ Quantity, quality and energy efficiency on domestic appliances and lighting
- ✓ Number of inhabitants

The following sections present an analysis of main aspects and other specific aspects that would require adaptation to be used within the MRV system for the NAMA VE.

## 3. General monitoring guidelines adaptation proposal

#### 3.1 Gases considered by the MRV of NAMA VE

For both, the implementation and the monitoring phase of the NAMA VE, it is proposed to measure actions impact in order to calibrate calculation boundary conditions. According to the document [MGM Innova 2013] based on the VM0008, GHG emissions considered for NAMA VE's monitoring, are shown in the following table:

Table 1 GHG emissions considered by the MRV system of the NAMA VE (Source: [MGM Innova 2013], adaptation by Passivhaus Institut).

Note.- Adaptation for this report is highlighted in bold/italics. Replaced data has been crossed out

Baseline	CO <sub>2</sub>	Emissions related to household electricity consumption. Consider a dynamic baseline, see [NAMA VE 2014]) through applying a correction factor.
	CO <sub>2</sub>	CO <sub>2</sub> emissions related to household gas consumption.  Consider a dynamic baseline, see [NAMA VE 2014])  through applying a correction factor.
Project	CO <sub>2</sub>	Emissions related to electricity generation corresponding to household electric consumption
,	CO <sub>2</sub>	CO <sub>2</sub> emissions related to housing gas consumption
Lookago	CO <sub>2</sub>	CO <sub>2</sub> emissions related to the persistent use of replaced equipment but not properly destroyed
Leakage	HFC	GHG emissions derived from improper equipment management and destruction

#### 3.2 Baseline

**Baseline** is defined as the household electricity, gas and water consumption used, previous to renewal or project implementation.



#### Baseline, essential basis for real consumption data

For baseline calculation, historical consumption data of monitored housing is required, as defined by the consumption adjustment methodology. Due to its greater influence on the monitoring general concept, the application of a consumption increase forecast owed to housing equipment replacement and comfort conditions is also required.

As mentioned in the NAMA VE Technical Design [NAMA VE 2014], the baseline does not really behave in a static but dynamic way, meaning it increases over time according to family economic conditions and life standard improvement. This is the reason why, in case of deciding to use this methodology with no additional adaptations, consumption data should be adapted through a correction factor calculated in detail, base on real data and considering such increases.

As an alternative, it is proposed that the baseline to be considered for calculations and monitoring measures should be based on a prevention potential, meaning a future forecasted baseline considering improved comfort conditions (see [NAMA VE 2014]). However, this calculation would move away from the VM0008 consumption adjustment methodology. This baseline should be calculated with a simulation tool that enables a detailed entry of building data, for example the already available PHPP tool (Passivhaus Planning Programme), which enables the user to adjust boundary conditions directly, with no additional adjustments. The DEEVi tool could also be used, but it would require modifications not for calculations accuracy (which are based on the PHPP tool), but to enable user to calibrate boundary conditions for calculation. This adaptation would also have operative implications, as a registry and housing large-scale assessment tool. Therefore, it should be thoroughly analyzed to make proper changes (see [NAMA VE 2014]).

Another essential guideline to be considered for the baseline is that same housing comfort levels and equipment should be compared in order to achieve a reasonable analysis. For example, if before the implementation of NAMA VE measures there were no air conditioning system, resulting in very high temperatures for users (such as the reduced comfort scenario presented in the NAMA VE Technical Design), then consumption of those buildings cannot be compared with consumptions of buildings with air conditioning systems that achieve higher comfort levels, even from the baseline. Only buildings with identical quality between them can be compared to achieve a real and useful comparison. This is essential for the MRV system; otherwise, wrong conclusions can be submitted (see section 3.3.1).

#### 3.3 Guidelines and recommendations for the MRV implementation phase (pilot projects)

For NAMA VE implementation phase, as well as for its monitoring phase, a series of parameters based on VM0008 document have been proposed. Some adaptations to the information included in the "Estudio para la identificación de los criterios generales para el sistema MRV de la NAMA de Vivienda Existente" (Study for the identification of general guidelines for the MRV system of the NAMA for Existing Housing Retrofit") [MM Innova 2013] are presented below.

#### 3.3.1 GHG mitigation impact calculation

To calculate the impact of GHG mitigation, an equation for GHG emissions reduction calculation adapted to Mexico and the NAMA VE is recommended. It is similar to the equation presented in the VM0008 methodology "Weatherization for Aislada building type or multi-family building type" of the Voluntary Carbon Standard. Adaptations originally proposed consist of the base-load electricity and air conditioning consumptions definition, simplifying the equation to eliminate the heating degree day (HDD) measure and the general heating consumption.

The equation is as follows:

$$ER_{y} = \sum_{i=1}^{I} \left( \left( ECF * Elec_{bb,i} - Elec_{pb,y,i} \right) + \left( Elec_{ba,i} * ECF * CDDCF_{y} - Elec_{pa,y,i} \right) \right) \times Elec_{CO_{2}} + \sum_{i,j=1}^{I,J} \left( F_{bb,i,j} - F_{pb,y,i,j} \right) * Cal_{j} * F_{CO_{2}j} - L_{y} \quad \text{Eq. (VM8-6corrected-mex)}.$$

ER <sub>y</sub> =	Emissions reduction in year y in metric tons (t CO <sub>2</sub> e/year)
i =	Household
$Elec_{bb,i} =$	Electricity consumption baseline not depending on temperature (base load)
$Elec_{ba,i} =$	Electricity consumption baseline due to air conditioning
$Elec_{pb,y,i} =$	Project electricity consumption in year y not depending on temperature (base load)
$Elec_{pa,y,i} =$	Project electricity consumption in year y due to air conditioning
ECF <sub>y</sub> =	Electricity correction factor for year y to be applied to the baseline
$CDDCF_y =$	Cooling Degree Day correction factor for year y
$F_{bb,i,j} =$	Fuel consumption baseline j not depending on temperature (base load)
$F_{pb,y,i,j} =$	Project fuel consumption <i>j</i> in year <i>y</i> for household <i>i</i> not depending on temperature (base load)
Calj =	Calorific power of fuel type j in GJ/mass or volume
$Elec_{CO_2} =$	Grid electricity emission factor tCO₂e/kWh
$F_{CO_2j} =$	Fuel emission factor by energy unit for fuel <i>j</i> expressed in tCO <sub>2</sub> e / GJ
Ly =	Leakage in year y
<i>I</i> =	Number of households
J =	Number of fuel types
<i>j</i> =	Fuel types
y =	Any consecutive period of 12 months during the project accreditation period. Should be defined
	with an integer, starting with number 1.

#### 3.3.1.1 Implications of using this equation

#### Cooling degree days correction factor y: CDDCF<sub>v</sub>

The cooling degree day correction factor in a year is partially beneficial here. It would be more significant to have a correction factor considering solar radiation, which crucially influences the building cooling requirement. Specific features of the building should be considered, especially windows size, orientation, opaque surfaces and its construction composition.

Correction factor that only considers cooling is counterproductive, as it could drive to wrong conclusions. Therefore, the proposal is the substitution of the CDDCF<sub>y</sub> correction factor with an average electricity consumption derived from air conditioning devices, for a period of 3 years. If this information is not available, CDDCF<sub>y</sub> correction factor should be completely omitted.

#### Electricity correction factor for year y to be applied to baseline ECFy

The proposal in document [MGM Innova 2013], based and adapted from the VM0008 original document, is to apply a standardized factor of 0.98 to the electricity consumption baseline, except in case consumption reduction of the last 10 years is less than 2%. It is assumed that consumption decreases due to household appliances improvements over time. To confirm this assumption, data with 2% decrease on electricity consumption, within the Mexican residential sector, from 2002 to 2012 is presented.

The generalization of electric consumption for the whole Mexican residential sector does not seem to be the most suitable option to justify emissions savings within the NAMA VE, as it does not consider large differences between climate zones and socio-economic situation. Even more, the main difficulty of the formula is that it is assumed that consumption will only be influenced by regular household appliances market improvements, without considering any change in comfort conditions or housing building equipment. For example, it is assumed that a household with actual certain consumption, with no air conditioning or heating and with certain number of household appliances with certain efficiency, will keep exactly the same in the future, except for household appliances improvement. It does not consider the possibility that users may wish to purchase more household appliances (for example, more TVs or an additional refrigerator) and that in a certain moment they may use active measures for housing cooling or heating. In other words, it is assumed that baseline is static or semi -static (see [NAMA VE 2014]).

When observing electricity and gas consumptions data in the Mexican housing sector through the field survey [CMM 2013], it is easy to conclude that housing has very low energy consumption due to low comfort conditions. It can also be concluded that such conditions will change over time, as users report their dissatisfaction.

The concept presented in NAMA VE Technical Design considers a dynamic baseline, meaning that consumption increases over time, reflecting the raise of quality of life and economic capacity levels in the 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 of housing lifespan is being considered (safe period, as housing lasts more than this average).

To summarize, results with the use of this formula as presented, would show that any action to improve housing comfort conditions through the thermal envelope improvement (use of thermal insulation, windows improvement, shadings, etc.) can only prove minor emissions mitigation, or even present emissions increase, as a baseline considering previous year data is a static baseline. Households using minimum energy will hardly achieve lower consumption with energy efficiency improvements besides household appliances improvements, as observed in the following diagram:

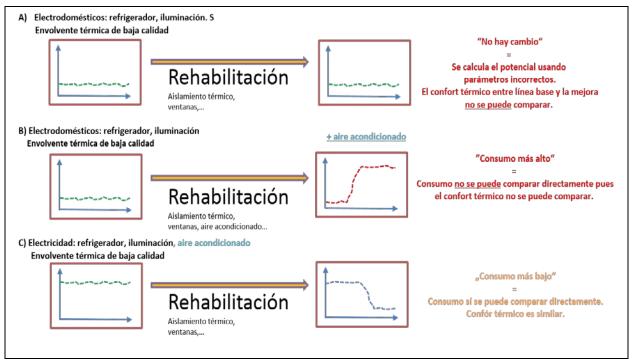


Figure 2. Example of risks when considering a consumption static baseline for the MRV system.

Source: Passivhaus Institut

In case of using this methodology, it is considered essential to review this correction factor, not only based on historical data (preferably local) but also including a forecast of consumption increase on Mexican housing due to comfort conditions improvement and equipment. Otherwise, investment on the NAMA VE will not be confirmed. This is a fact on housing in the center of the country (template and template cold climates), due to lack of air conditioning in general. An alternative for this problem in the proposed methodology would be to calculate the baseline according to energy demand and not consumption demand. This proposal is presented in the following section.

#### 3.3.2 GHG mitigation impact calculation alternative proposal

A way to use the same formula and the methodology presented in [MGM Innova 2013] and considering a static baseline is that, instead of using electricity and fuel consumption data applying the correction factor, indoor housing temperature and outdoor climate conditions data *after improvements* should be used. Once this data is available, boundary conditions of a reliable simulation tool that enables changes by the user may be calibrated (for example, PHPP or DEEVi tools with suitable adaptations). Then, baseline considering the same comfort conditions of the improved housing is calculated.

In this way, the use of the correction factor for electricity demand is no longer necessary, since it is assumed that under the same conditions of improved comfort, the building as it originally was, would behave in an inefficient way. This proves the prevention of GHG emissions increase in the future, in a realistic scenario, considering comfort increase and equipment. The corrected equation proposed is presented again as follows:

$$ER_{y} = \sum_{i=1}^{I} \left( \left( Elec_{bb,i} - Elec_{pb,y,i} \right) + \left( Elec_{ba,i} * CDDCF_{y} - Elec_{pa,y,i} \right) \right) \times Elec_{CO_{2}} + \sum_{i,j=1}^{I,J} \left( F_{bb,i,j} - F_{pb,y,i,j} \right) * Cal_{j} * F_{CO_{2}j} - L_{y}$$
 Eq. (VM8-6corrected-mex-DLB).

For further details see [MGM Innova 2013]

ER <sub>v</sub> =	Emissions reduction in year y in metric tons (t CO₂e/year)
i =	Household
$Elec_{bb,i} =$	Electricity consumption demand baseline not depending on temperature (base load),
	calculated through simulation tool, based on improved household comfort data
$Elec_{ba,i} =$	Electricity demand baseline due to air conditioning
$Elec_{pb,y,i} =$	Project electricity consumption in year y not depending on temperature (base load),
	calculated through simulation tool, based on improved household comfort data
$Elec_{pa,y,i} =$	Project electricity consumption in year y due to air conditioning
CDDCF <sub>y</sub> =	Cooling Degree Day correction factor for year y (could be omitted or substituted, see previous
	section)
$F_{bb,i,j} =$	Fuel consumption baseline j not depending on temperature (base load)
$F_{pb,y,i,j} =$	Project fuel consumption $j$ in year $y$ for household $i$ not depending on temperature (base load)
Cal <i>j</i> =	Calorific power of fuel type <i>j</i> in GJ/mass or volume
$Elec_{CO_2} =$	Grid electricity emission factor tCO₂e/kWh
$F_{CO_2j} =$	Fuel emission factor by energy unit for fuel <i>j</i> expressed in tCO <sub>2</sub> e / GJ
Ly =	Leakage in year y
<i>I</i> =	Number of households
J =	Number of fuel types
j =	Fuel types
y =	Any consecutive period of 12 months during the project accreditation period. Should be
	defined with an integer, starting with number 1.

**Note.**-The option to include building heating again may be considered, if needed, Also comfort conditions improvement for climate zones: template-cold and cold in Mexico may be included.



# Difference between energy "demand" and "consumption"

When referring to monitoring, reporting and verification of energy efficiency optimization projects, it is essential to explain the difference between "energy demand" and "energy consumption" concepts.

**Energy demand** refers to the *forecasted consumption*, with estimations on the use of typical housing under pre-established boundary conditions (e.g. temperature range, predetermined occupancy, etc.).

**Energy consumption** refers to the actual energy used in a particular building. Each family living in a household has different habits. Therefore, consumption is different on each household.

Although building demand may be significantly reduced in calculations through the application of energy efficiency measures, users' influence is still important. However, a building that has been optimized in its safe side will have lower consumption, even with users spending a lot of energy, compared with non-optimized buildings.

Demand is still a theoretical value, while consumption is a real value and they differ from each other in most cases. How deep is this difference, depends on the quality of the calculation or simulation model and the quality of the boundary conditions used to calculate. When comparing field measurement values with energy balance calculations, for example with the help of a software such as PHPP or DEEVi, this difference should always be kept in mind when speaking (differentiate consumption and demand) and when analyzing results.

For example, in order to compare housing cooling or heating energy consumption with cooling or heating demand calculated values or predetermined values, a sample of measured projects big enough to be statistically relevant is required. Final conclusions may be submitted only when the average of measured values on different building consumptions is calculated, as long as they are comparables to each other (see Annex I). Consumption values should follow a normal statistic distribution in general. Only average values provide valid information to draw conclusions on building energy performance.

It is not possible to classify monitoring results statistically, or draw relevant conclusions that apply to all cases, if only one building is monitored; for example, when comparing these measurements with initial energy efficiency calculations. This is why a relevant sample is required. Likewise, in order to compare energy balance calculations with measurements results, it is important to update influence factors in the calculation model, such as indoor and outdoor temperatures, indoor heating sources (electricity consumption), the use of additional shading elements and global solar radiation values (this value may not be obtained from measurements, but through local meteorological stations for the measurement period).

#### 3.3.3 Technical metrics and parameters

As the monitoring system follows the "whole house approach" concept, electricity and gas consumption should be considered. For the electricity consumption, ALL influence parameters should be included, as well as all emissions derived from cooling devices for air conditioning and refrigerators.

Likewise, all thermal envelope features of the building should be considered in detail, due to its great influence on energy consumption. An important aspect that is commonly often forgotten is to determine temporary shading elements (curtains, blinds, etc.), which also have great influence on heat gains through radiation, especially if they are placed in the exterior of the building. This data may be collected through a survey.

The importance of metrics is highlighted not only for emissions saving reporting and verification, but also to calibrate boundary conditions for calculation through a simulation tool.

Essential metrics for emissions reduction calculation and measurement are shown in the following table.

Table 2 Essential technical metrics to be monitored and reported for emissions reduction calculation. (Source: [MGM Innova 2013], adaptation by Passivhaus Institut)

Note.- Adaptation for this report is highlighted in bold/italics. Replaced data has been crossed out

Parameter	Unit	Source	Frequency
Household address		Survey	Once
Bioclimatic zone definition		Definition according to	Once
		address	
$Elec_{b,i} = Electricity consumption$	kWh/year	Electricity bills from 12	Once.
during the previous year to project		months to 6 bimonthly	If simulated baseline is
implementation for household i		periods previous to	chosen, this parameter
(baseline consumption).		refurbishment. <sup>1</sup>	should be eliminated
Important: clearly differentiate			
between households WITH or			
WITHOUT air conditioning			
Elec <sub>p,y,i</sub> = Project electricity	kWh/year	Electricity bills post-	Bimonthly or monthly
consumption in year "y" for		refurbishment	collection, annual
household i (Project consumption)			registration
Important: clearly differentiate			
between households WITH or			
WITHOUT air conditioning			
$F_{b,i,j} = F_{bb,i,j} = Fuel \ consumption \ j \ in$	Monthly	Fuel bills from 12	Once.

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<sup>&</sup>lt;sup>1</sup> Although in many methodologies bills collection from 2 previous years is recommended, in this case only 1 year is recommended, as Energy Advisor may accessed to data on line, which simplifies the process. On the same time, consumption adjustment methodology enables the use of only one previous year.

previous year to project implementation for household i (baseline consumption), including fuel usage type (for example, to cook, for ACS generation, etc.)	mass or volume per household	months previous to refurbishment <sup>2</sup> , as well as users' survey (to define type of use).	If simulated baseline is chosen, this parameter should be eliminated
F <sub>p,y,i,j</sub> = F <sub>pb,y,i,j</sub> = Project fuel consumption j in year "y" for household i (Project consumption), including fuel usage type (for example, to cook, for ACS generation, etc.)	Annual mass or volume per household	Monthly consumption bills post-refurbishment or consumption measuring meter installation, as well as users' survey (to define type of use).	Annual Bimonthly or monthly collection, annual registration
ElecCO <sub>2</sub>	Electricity emission factor	It is recommended to use the published electricity emission factor (consumption not generation)	Annual
ECF <sub>y</sub> = Electricity correction factor for year y to be applied to baseline		Calculation based on national electricity consumption statistics	In case defined threshold is recovered, it applies annually. If simulated baseline is chosen, this parameter should be eliminated. If not, comfort increase and equipment should also be considered (dynamic baseline)
CDDy = Cooling Degree Days in refurbishment year y	Degree Day	Regional statistics <sup>3</sup>	Annual Eliminate or if used: bimonthly or monthly collection, annual registration
CDDb = Cooling Degree Days in previous year to refurbishment	Degree Day	Regional statistics	Annual Eliminate or if used: bimonthly or monthly collection, annual registration
J = Types of fuel	Number	Survey	Biannual
<ul><li>I = Refurbished households from the group</li></ul>	Number	Project data base	Annual

<sup>-</sup>

<sup>&</sup>lt;sup>2</sup> It is recommended to collect bills of the period between the assessment and the implementation, in case they are not available. If gas cylinders are used, one *monthly* surveys should be carried out, with cylinder volume weighing the cylinder with a common scale including a frequency of use survey, to make an estimate.

<sup>&</sup>lt;sup>3</sup> CDDy and CDDb data may be provided by CONAVI based on meteorological data in <a href="http://smn.cna.gob.mx/">http://smn.cna.gob.mx/</a>

a <sub>np,k,y</sub> = Improperly disposed	Number	Registry documents of	Annual
equipment type k in year y		replaced equipment	
		management	
$E_{dem,pre,k}$ = Electricity demand of	kW	Documents of	Once, previous to
equipment type k before		equipment plaque or	replacement
replacement		direct measurement	
It is very inaccurate to calculate			
equipment energy consumption			
based on their power and estimated			
hours of usage only. Although it			
would be more expensive, it would			
be ideal to obtain direct			
measurements from the equipment,			
at least in fewer households.			
$h_k$ = Annual working hours of	Hours	Sampling, surveys,	Once
equipment type k		common practices	
It is very inaccurate to calculate		based on regional or	
equipment energy consumption		national data	
based on their power and estimated			
hours of usage only. Although it			
would be more expensive, it would			
be ideal to obtain direct			
measurements from the equipment,			
at least in fewer households.			
RCC <sub>a</sub> = Cooling gas charge capacity of	Grams	Cooling equipment	Once
replaced cooling equipment, in		specifications	
grams			
Cooling Type R used on equipment		Cooling equipment	Once
		specifications	



# **Table 2.** Presence and usage of air conditioning in monitoring household

Previous table does not include the presence of climate conditioning through air conditioning or heating devices in households, or improvement on comfort conditions, for example, through the use of future climate conditioning devices once inhabitants have the economic resources required.

It is wrong to compare housing with active climate conditioning with housing with no climate conditioning equipment, as it is like comparing "apples and oranges". It is also very important to differentiate the presence of ceiling fans and air conditioning.

Table 3 (below), shows data collection on air conditioning and indoor comfort conditions (indoor temperatures), as well as climate conditions (outdoor temperatures and solar radiation). This data should be included in essential data to be collected. Otherwise, monitoring results may not be

compared between each other, as proposed in the previous section. In addition, it is necessary to show the type of climate conditioning device and its energy efficiency and usage features.

Besides, Table 2 presents, in many cases, to collect data annually. Monthly data collection is recommended, at least during the comprehensive monitoring of the implementation phase and during the detailed monitoring of the monitoring phase. In this way, the use of air conditioning or heating may be differentiated during the months needed.

Table 3 contains metrics and parameters that, although they are not essential for emissions reduction calculation, need to be measured and monitored for quality control, in order to obtain useful information for more detailed subsequent studies and to calibrate simulation models boundary conditions. As mentioned, indoor and outdoor temperatures, as well as solar radiation are essential for the dynamic baseline calculation.

Table 3 Other technical metrics for quality control and simulation model calibration.

Source [MGM Innova 2013]. Adaptation by Passivhaus Institut

Note.- Adaptation for this report is highlighted in bold/italics. Replaced data has been crossed out

Parameter	Unit	Source	Frequency
Household area Energy efficiency surface, based on DEEVi / PHPP methodology. For more information see Annex III	m <sup>2</sup>	Data collection	Once
Household lifetime	Years	Survey	Once
Household type	-	Survey	Once
Building materials type:  - Building system of walls, roof and floor (calculation for U value)  - If there is thermal insulation, description (thickness, location within the thermal envelope, conductivity)  - Colors and/or absorption and reflection coefficient of envelope opaque elements  - Type of windows (type of frame, glass and U values, if possible.  - Detailed description of shading elements: overhang and temporary shading elements (including orientation)		Energy assessment	Once
Household orientation	-	Energy assessment	Once
List of included improvement measures (see Annex II)	-	Project data base	Once

		I	1
List of installed equipments previous	List of	Survey	Once
to project implementation or	equipments		
refurbishment, <i>including electricity</i>	and systems,		
power and usage profile data. In	capacities,		
case of air conditioning devices,	efficiency and		
include data on Seasonal Energy	hours of usage		
Efficiency Ratio (SEER).			
List of new installed equipments due	List of	Survey	Once, thereafter
to replacement, as part of project	equipments		annual
implementation or refurbishment,	and systems,		(It is possible that
including electricity power and	capacities,		after refurbishment,
usage profile data. In case of air	efficiency and		changes on installed
conditioning devices, include data	hours of usage		equipment may
on Seasonal Energy Efficiency Ratio			occur over time.
(SEER).			Therefore, it is important to
			continue making
			surveys annually).
Water consumption previous to	Liters	Water consumption	Once
improvement (ex – ante)	2.00.0	bills of 12 months	01.00
improvement (ex unite)		previous to	
		refurbishment.	
Water consumption after	Liters	Monthly water	Annual
improvement (ex – post)	Liters	consumption after	/ iiiiddi
improvement (ex post)		refurbishment or water	
		meters installation.	
Household occupancy in	Number of	Survey	Annual
refurbishment year "y"	inhabitants	Survey	Ideally, number of
Terurbishinene year y	iiiiabitaiits		inhabitants should
			be registered
			monthly, see Annex
			1
Household occupancy in previous	Number of	Survey	Once.
year to refurbishment <sup>3</sup>	inhabitants		It is essential to
			collect data in the
			same moment of
			the day and the
			year when
			occupancy data was collected to define
			the baseline.
			Correct use of data
			depends on this.
Energy saving measures package		Project data base	,
data		,	
Replaced equipment type k	Number	Project data base	
Destruction certificates of replaced	Number	Project data base	
equipment type <i>k</i>		-,	
Indoor temperature average of	$^{\circ}$	Thermometer (pay	Daily temperature
household habitable rooms		special attention to	registration
			. 59.50. 40.5.

(bedrooms and living/dining rooms). If there are air conditioning devices only in some of the habitable rooms, collect temperature data of rooms with		thermometer location, as they should not receive direct solar radiation or be in direct contact with	
and without air conditioning.		indoor heating sources)	
Outdoor temperatures	℃	Thermometer (pay special attention to thermometer location, as they should not receive direct solar radiation or be in direct contact with indoor heating sources)	Daily temperature registration (one for each housing development, it is not necessary for each household)
Indoor humidity average in household habitable rooms (bedrooms and living/dining rooms).	g/kg	Hygrometer	Daily indoor humidity registration
Outdoor humidity	g/kg	Hygrometer	Daily outdoor humidity registration (one for each housing development, it is not necessary for each household)
Household air tightness	n <sub>50</sub>	Pressurization test	Ideally before and after refurbishment.

Important

## Users influence in monitored consumption

Different types of usage and users behavior have great influence on monitored consumption values. In this case, not only isolated parameters should be compared, for example, cooling energy. This energy could be influenced by other peripheral electricity consumptions, such as inefficient lighting, frequent cooking or type of usage of existing additional shading elements. First, all aspects causing energy consumption should be determined, as well as users' manners and mores to draw conclusions on energy consumptions measured. Calculation considering the whole house approach is based on this principle.

If projects monitored data should be compared with calculation results by using an energy efficiency simulation tool, such as DEEVi or PHPP, it is essential to:

- ✓ Have statistically enough buildings (see section 4)
- ✓ Adapt calculation boundary conditions with actual boundary conditions, considering construction aspects of the building (Such as additional shading elements, indoor heating sources, etc.).

#### 3.4 Guidelines and recommendations for the MRV monitoring phase

As established in document [MGM Innova 2013], 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 (based on the Technical Design, considering the whole house approach), labeling criteria, improvement actions that will be considered, among many other factors. 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 and are presented in the next section.

#### 3.4.1 MRV operation in the monitoring phase

Since the original document [MGM Innova 2013], the recommendation is that MRV system of the NAMA VE should be based on the use of a simulation system, supported by a tool that enables housing Energy Advisors to determine actions to be carried out, to achieve the desired saving percentage and for impact and emissions mitigation calculations. For this reason, conditions proposed on the original document for the MRV monitoring phase of the NAMA VE, are confirmed:

- A calculation system with calibrated boundary conditions based on projects measurements is required. Ideally, this system should facilitate user to configure calculations, according to corresponding measures and data collection (parameters to be modified are presented in Table 1). It is recommended to use a calculation tool with high level of detailed analysis that enables the user to adapt boundary conditions according to measurements, such as the PHPP tool. Especially in higher energy efficiency projects, PHPP software or similar is the most appropriate one. If necessary modifications presented in the Technical Design of NAMA VE to adapt boundary conditions are available, the DEEVi tool could also be used, as it is based on the PHPP tool and has a good accuracy level (see [NAMA VE 2014]). However, DEEVi tool would require adaptations to be used on existing housing.
- Defined system to register NAMA VE actions
- Existing housing Energy Advisors training in the use of the simulation system (as agreed in the NAMA VE's Technical Design).

Next figure shows the updated proposal for the transition process of the monitoring system, from the implementation phase to the monitoring phase:

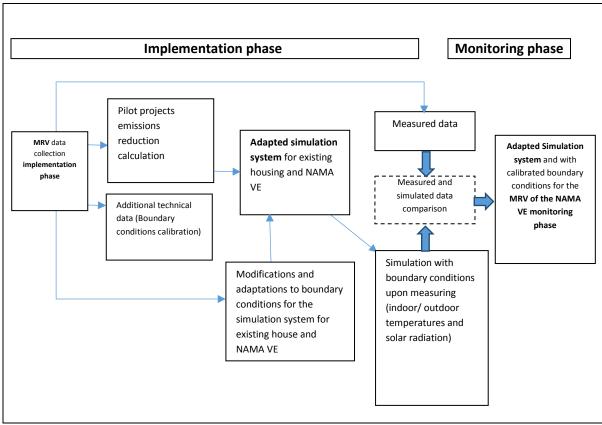


Figure 2. Transition process of the monitoring system, from the implementation phase to the monitoring phase (Source: GIZ/MGM Innova, adaptation by the Passivhaus Institut).

Note.- Adaptation for this report is highlighted in bold/italics. Replaced data has been crossed out

#### 3.5 Monitoring plan

As shown in figure 2, 3 components are proposed in the monitoring phase:

- Identification data collection
- Simple monitoring
- Detailed monitoring

For housing actions registration and with the objective to collect the necessary information for the process to obtain funding for improvement, identification data collection shown in **Table 4** is required. This information should be collected in 100% of the housing considered for improvements implementation under the NAMA VE.

#### Table 4 Data for the registration process (Source: MGM Innova, adaptation by Passivhaus Institut).

Note.- Adaptation for this report is highlighted in bold/italics. Replaced data has been crossed out

Household address
Household area Energy reference surface
Household age
Household type
Building materials type
List of included improvement measures

Simple monitoring is focused on essential data collection for emissions reduction and water consumption reduction calculations due to all installed measures.

On the other hand, detailed monitoring is focused on the frequent calibration of the simulation 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 application and a follow up on other not essential indicators for emissions reduction calculation, such as process and financial metrics.

Although MRV system specific technical metrics and parameters for the NAMA VE monitoring phase cannot be defined with previous accuracy to the definition of the operation and the simulation system features, it is expected that metrics to be monitored are very similar to those presented and updated in this documents, shown in Table 2 and Table 3.

#### 4. Definition and selection of sample size for monitoring

During the implementation of the MRV system in the NAMA VE pilot project phase, it is proposed to monitor all pilot housing, if it is an easy to monitor number. However, if it is a large number within one pilot project, the proposal is to define a statistically representative sample. These criteria also apply to the monitoring process during the NAMA VE monitoring phase. The updated criteria to select the sample for monitoring are described below.

#### 4.1 Implementation phase monitoring: previous proposal

Three housing types presented in the NAMA VN (NAMA for Sustainable New Housing), 4 bioclimatic zones and 4 different saving measures packages are considered. Result would be 48 groups:

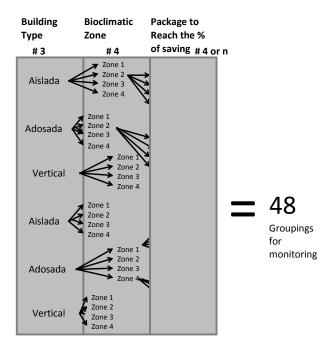


Figure 3. Groups for pilot project monitoring - original proposal.

Source: [MGM Innova 2013]

For the implementation phase of the NAMA for Sustainable Housing Retrofit, in its modality of pilot projects, it is recommended to carry out pilot projects with different combinations, considering bioclimatic zones, housing types and improvement packages to obtain data over the complete universe of possibilities. Since the original document [MGM Innova 2013], it is propose to monitor all pilot project households, as long as it is an easy to monitor number.

In addition, when presenting such grouping, if the number of households in a pilot project is too big, representative samples according to disintegration mentioned before should be defined. This disintegration would represent a great effort, both economical and technical. Therefore, a simplification to define the sample size for the MRV implementation phase is presented below.

#### 4.2 Implementation phase monitoring: updated proposal

It is important that simple is statistically representative to draw conclusions of informative value. Therefore, based on the information in Annex II, the proposal is to monitor 15 households per group.

The proposal of 15 households per group, if applied to 48 different groupings originally proposed (as shown in figure 3), would result in 720 households for the monitoring initial phase. This big number of projects would present implementation and costs difficulties that would be a risk on quality of the information collected. However, if project monitoring sample is reduced to compare the groupings number defined, the risk would be the statistical relevance of results. Therefore, it is better to monitor a smaller number of different groupings, but with the correct identical elements to be compared.

It is proposed to reduce from three building types, to two. 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 achieve saving through refurbishment measures. In this way, the number of identical houses to be monitored could be reduced from three, to two and the number of packages, from four to two. It is assumed that the simulation baseline would be calculated with a tool such as DEEVi or PHPP, according to the amendment of methodology to use. Therefore, baseline measures would not be necessary.

This would result in a total of 480 households to be monitored. The summary of this proposal is presented in the next figure:

Building type Building type	Bioclimatic zone 21: is eliminate	Saving percentage levels (min. 20%) ed to simplify mo	Total of groups considered for monitoring mitoring	Total of buildings to be monitored (1.85 σ)
Typology 2	Zone 1 (hot dry)  Zone 2 (template)  Zone 3 (cold template)  Zone 4 (hot humid)	Baseline Step 1 Step 2 EnerPHit	2 building types  X 4 bioclimatic zones  X 2 energy efficiency savings levels  16 groups	32 groups X 15 buildings to be monitored
Typology 3	Zone 1 (hot dry)  Zone 2 (template)  Zone 3 (cold template)  Zone 4 (hot humid)	Baseline Step 1 Step 2 EnerPHit	2 building types  X 4 bioclimatic zones  X 2 energy efficiency savings levels  16 groups	480 households to be monitored

Figure 4. Groups for pilot project monitoring - new proposal. Source: Passivhaus Institut Note.- Adaptation for this report is highlighted in bold/italics. Replaced data has been crossed out

# Important

## Features of buildings to be monitored

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

- ✓ Architectural design
- ✓ Orientation
- ✓ Location (same building development)

#### 4.3 Monitoring during the NAMA 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 5. Simple and detailed monitoring elements summary for emissions reduction calculations (Source: GIZ/MGM Innova).

Note.- Adaptation for this report is highlighted in bold/italics. Replaced data has been crossed out

Elements	Simple monitoring	Detailed monitoring
Objective	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 households <sup>4</sup>	3% of defined sample for simple monitoring  From 5 to 15 houses by type of energy efficiency benchmark applied (20% minimum of energy saving) See Annex I.
Disaggregation	Similar to the one of the MRV system in the implementation phase	Similar to the one of the MRV system in the implementation phase
Data for baseline	Necessary data for ex - ante calculation (once)	Ex - ante energy consumption data through billing (once)
Data consumption for the project	Energy consumption data ex – post through billing (annually) (monthly, if possible)	Data for Ex – post calculation (annually) (monthly)
Other		Process and financial metrics: data collection for process and financial metrics calculation

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<sup>&</sup>lt;sup>4</sup> This is a temporary or initial proposal as this element cannot be defined a priori, as no variability sources and its degree of variation or dispersion is particularly known

#### 5. Responsibilities within 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 for New Housing (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.

#### 6. Definition of reporting formats and protocols

It is important to previously define the way data should be collected to assure harmony in data comparison and assessment in order to draw right conclusions on energy efficiency measures application.

Table 2 and Table 3 present required metrics to carry out a successful monitoring process, regarding CO<sub>2</sub> emissions mitigation and boundary conditions calibration to adapt the simulation tool for the NAMA VE. Annex II presents reporting formats and protocols proposal of the data collected during monitoring, including the minimum quantity of data required to be collected. This data represent the minimum necessary information to be obtained by a monitoring process to calibrate boundary conditions for energy efficiency calculation.

Since the NAMA VE Technical Design is in its initial phase, it is not possible or beneficial to define yet reporting formats and protocols for the NAMA VE in detail. However, information in Annex II serves as a starting point to give more details on how a successful data collection for the NAMA VE will be accomplished. Once projects to be monitored and the specific monitoring scopes are defined in detail, then recommendations to be applied on projects in particular may be specified. Another recommendation is to read document [AKKP 45, PHI 2012], which contains recommendations for energy-efficient buildings monitoring. Similarly, it is also recommended to consider document [CONAVI SEMARNAT 2013] as an example of the detailed lever required for these protocols, and consider recommendations already applied on the Mexican market, as well as the recommendations included in this document.

#### 7. Conclusions

This document presents the adaptations proposal to the initial MRV concept for the NAMA VE presented in 2013 by MGM Innova, requested by GIZ. These adaptations have been done within the frame of the NAMA VE Technical Design development. Considering the preliminary nature of the NAMA VE until required financing structures are implemented and a formal energy consultancy scheme is developed, the MRV design will require more development, as soon as NAMA scopes are defined in detail.

This proposal intends to simplify, in some way, original formulas and procedures for the MRV, as well as to reduce the monitoring sample to be defined. However, it also has been considered important to present the need of more detailed information, especially if it is intended to calibrate boundary conditions of a simulation tool for the NAMA VE.

It is concluded that the consumption adjustment methodology originally proposed in document [MGM Innova 2013] through the VM0008 approach, presents the following disadvantages:

- ✓ VM0008 seems to be more adequate for middle/high-income housing monitoring than for social hosing, where comfort conditions are lower but more stable.
- ✓ It is not possible to consider a dynamic baseline, which drives to linkage difficulties with the Technical Design presented and difficulties to prove mitigation potential.
- ✓ It is hard to obtain costs and effort reduction to collect detailed data for baseline consumption calculation, which is essential to draw realistic and appropriate conclusions.

Especially regarding baseline calculation to simplify monitoring, it would be better to calculate it through a simulation tool rather than base it on historical consumption data, as proposed in this document. For this comparison, the use of the PHPP tool is recommended. If necessary modifications presented in the Technical Design of NAMA VE to adapt boundary conditions are available, the DEEVi tool could also be used, see [NAMA VE 2014]). However, it would require additional adaptations to the consumption adjustment approach originally proposed through the use of the VM0008 methodology, which has been presented in this document.

As an alternative, the use of a different methodology is proposed, for example, the regression analysis methodology, modeling the baseline by using the simulation system proposed. An example of a possible methodology to be used is document AM0091 "Energy efficiency technologies and fuel switching in new buildings". This decision should be discussed with counterparties involved, in parallel with the NAMA VE definition process.

#### 8. Bibliography

[AKKP 45, PHI 2012] Passivhaus Institut. Protokollband Nr. 45 Arbeitskreis kostengünstige Passivhäuser Phase V "Richtig messen in Energiesparhäusern" (Volumen Nr. 45 Grupo de trabajo para la rentabilidad de las casas pasivas "Monitoreo correcto en edificios de bajo consumo", Darmstadt, Octubre de 2012

[CONAVI, SEMARNAT 2013] CONAVI, SEMARNAT. *Protocolo Mexicano para Planes de Medición y Verificación – PMPMV* Ciudad de México, mayo de 2013

[CMM, 2013] Centro Mario Molina para Estudios Estratégicos sobre Energía y Medio Ambiente A.C. Estudio de campo para analizar casos de referencia del parque de vivienda existente en México 2013. México D.F.

[MGM Innova 2013] Estudio para la identificación de los criterios generales para el sistema MRV de la NAMA de Vivienda Existente GIZ, México, D.F. Noviembre 2013

[MGM Innova 2013a] *Principales criterios a considerar en el diseño del sistema MRV de la NAMA Vivienda Existente* GIZ, México, D.F. Noviembre 2013

[NAMA VE 2014] CONAVI, SEMARNAT. Borrador del Diseño Técnico de la NAMA Vivienda Existente Ciudad de México por Passivhaus Institut, GOPA & IzN, Septiembre 2014

[UNFCCC] AM00091 Energy efficiency technologies and fuel switching in new buildings.

[VCS] Approved VCS Methodology VM0008, Version 1.1.

#### 9. Annexes

#### Annex I. Number of households required for monitoring

Several consumption analysis confirm that users' influence on identical households (households in the same location, measured during the same period) drives to a data spread that typically drives to a standard deviation of  $\sigma$  = +/- 40%.

If the influence of the energy efficiency measures applied may be verified, then the necessary number of identical buildings to monitor "n" is based on the proportion of such energy efficiency measure influence. When energy saving is achieved through measure  $\Delta Q/Q_0$ , then number "n" should be chosen in such a way that savings are bigger than the standard deviation of the average value of all buildings measures (n), based on the next formula:

$$\frac{\Delta Q}{Q_0} \ge \frac{\sigma}{\sqrt{n-1}}$$

Influence percentage of energy efficiency measure on energy consumption.

σ Standard deviation (in %).

**n** Necessary number of buildings for monitoring

Note.- A simple standard deviation of  $1\sigma$  is considered. 68.3% of the cases normally distributed within the interval are included. If a double standard deviation is considered,  $2\sigma$ , then 95.4% of the cases in the interval and the media are being considered. Document VM0008 recommends standard deviation of  $1.85\sigma$ , which would correspond to 90% of the cases.

#### **Example:**

Calculate the influence on the application of high reflective painting for cooling demand on housing to be monitored.

Savings of this energy efficiency measure is estimated in 5% of total energy, compared with the baseline. With this estimated saving as starting point, the necessary number of households to be monitored "n" is calculated as follows:

$$5\% = \frac{40\%}{\sqrt{n-1}}$$
 Therefore, n = 65 households

For other saving levels, it is concluded that:

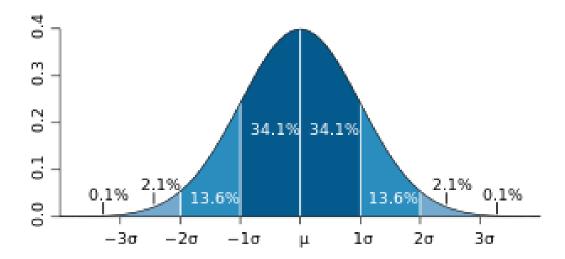
Measure influence (% saving	Influence classification	Minimum number of identical households to be monitored		
compared	Classification	In case of 1 $\sigma$ In case of 1,		

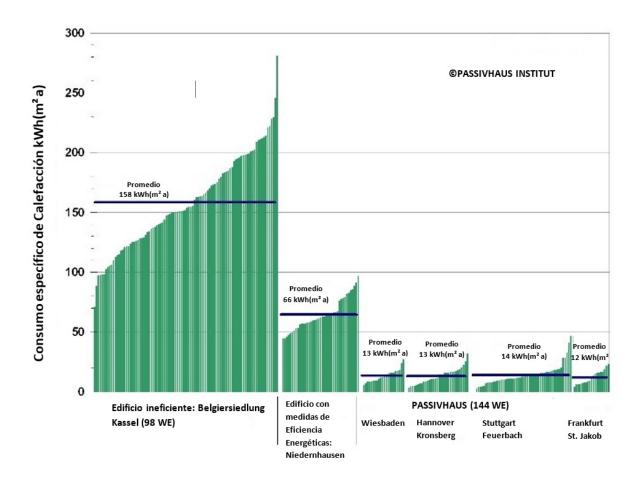
with baseline)			(VM0008 recommendation)
5 %	Very low	65	220
10 %	Low	17	56
15 %	Moderate	8	25
20 %	Considerable	5	15

#### Influence of specifying a maximum number of households to be monitored

According to the previous table classification, only considerable saving influences (in case of 20% minimum influence), should be measured in 5 buildings as minimum (in case of 68% sample normal distribution). At least 15 identical households should be monitored if the goal is 90% of significance (1,85  $\sigma$ ).

As VM0008 guidelines indicate that a maximum of 100 households should be monitored in the initial phase, then only a maximum of 20 measures packages may be monitored, which should have at least a considerable influence, meaning at least 20% of energy savings. Those energy efficiency measures achieving minor savings, will not be considered for monitoring in this phase.





## **Annex II. Reporting formats and protocols**

#### Format sheets for data collection

#### **INSTRUCTIONS**

- Data in these sheets contain essential basic information for a monitoring general assessment.
- Please fill out the requested information on each page with monthly averages of information collected from all households of each climate during the monitoring process.
- Titles at the top of the columns are only for reference. Please adapt according to project.

#### Climate

	Format for	climate data	monitoring	
	Average	Average	Average	Average
	Outdoor air	Global	Diffuse	Land
	temperature	horizontal	horizontal	temperature
Time		radiation	radiation	
	°C	W/m²	W/m²	°C
Jan.15				
Feb 15				
Mar. 15				
Apr. 15				
May. 15				
June 15				
July 15				
Aug. 15				
Sep. 15				
Oct.15				
Nov. 15	_	_		
Dec. 15				
Jan.16				
Feb 16				

### **Indoor temperatures**

#### Format for indoor temperatures data monitoring

Household main room (e. g. living/dining room); with no direct solar radiation on the Measuring meter; should not be installed in kitchen, bedrooms or bathrooms.

	Month	Month	Month	Month	
	average	average	average	average	
	House/dept	House/dept	House/dept	House/deptt	
	rooms	rooms	rooms	rooms	
	temperature	temperature	temperature	temperature	
Time	1	2	3	. 4	
	°C	°C	°C	°C	
Jan.15					
Feb. 15					
Mar. 15					
Apr. 15					
May. 15					
June 15					
July 15					
Aug. 15					
Sep. 15					
Oct.15					
Nov. 15					
Dec. 15					
Jan.16					
Feb. 16					

## Shading

Format for shading data monitoring						
	House/dept	House/dept	House/dept	House/dept		
	shading	shading	shading	shading		
	elements	elements	elements	elements		
	1	2	3	4		
Type of shading element						
Indoor (x / )						
Outdoor (x / )						
Number of windows with shading						
Daly use (x / )				·		
occasional use (x / )						
no use (x / )						

## Electricity

			Format fo	r electricity o	data monitor	ing				
	Month	Month	Month	Month			Month	Month	Month	Month
	Total	Total	Total	Total		1	Total	Total	Total	Total
			electricity	Household electricity			Household electricity	Household electricity	Household electricity	Household electricity
	total		total	consumption <b>total</b> House/Dept			consumption due to AC House/dept	consumption due to AC House/Dept	consumption due to AC House/Dept	due to AC House/Dept
Time	1	2	3	4			1	2	3	4
TITLE	kWh	kWh	kWh	kWh		1	kWh	kWh	kWh	kWh
Jan.15		KVVII	KVVII	KVVII		†	KVVII	KVVII	KVVII	KVVII
Feb. 15						1				
Mar. 15						1				
Apr. 15						+				
May. 15						†				
June 15						†				
July 15						1				
Aug. 15						1				
Sep. 15						ł				
Oct.15						1				
Nov. 15						†				
Dic. 15						t				
Jan.16						t				
Feb. 16						İ			1	1
						t				

### Gas

Format for gas data monitoring						
Gas consumption for cooking (Weigh gas cylinders monthly, if possible)						
	Month	Month	Month	Month		
	Total	Total	Total	Total		
	Final energy	Final energy	Final energy	Final energy		
	consumption	consumption	consumption	consumption		
	for gas	for gas	for gas	for gas		
	House/Dept	House/Dept	House/Dept	House/Dept		
Time	1	2	3	4		
	kg	kg	kg	kg		
Jan.15						
Feb. 15						
Mar. 15						
Apr. 15						
May 15						
June 15						
July 15						
Aug. 15						
Sep. 15						
Oct.15						
Nov. 15						
Dec. 15						
Jan.16						
Feb. 16						

## Heating

Format for heating data monitoring							
Heating, when necesary or available							
	Month	Month	Month	Month			
	Total	Total	Total	Total			
	Final	Final	Final	Final			
	energy	energy	energy	energy			
	consumption	consumption	consumption	consumption			
	for	for	for	for			
	heating	heating	heating	heating			
	House/Dept.	House/Dept.	House/Dept.	House/Dept.			
Time	1	2	3	4			
	kWh	kWh	kWh	kWh			
Jan.15							
Feb. 15							
Mar. 15							
Apr. 15							
May 15							
June 15	•						
July 15							
Aug. 15							
Sep. 15							
Oct.15							
Nov. 15							
Dec. 15							
Jan.16							
Feb. 16							

#### Water

	Farmet for :	veter dete m	- wit o win o	
	Format for v	water data mo	onitoring	
	Month	Month	Month	Month
	Total	Total	Total	Total
	Water	Water	Water	Water
	consumption	consumption	Consumption	Consumption
	House/Dept.	House/Dept.	House/Dept.	House/Dept.
Time	1	2	3	4
	liters	liters	liters	liters
Jan.15				
Feb. 15				
Mar. 15				
Apr. 15				
May 15				
June 15	•			
July 15				
Aug. 15				
Sep. 15				
Oct.15				
Nov. 15				
Dec. 15				
Jan.16				
Feb. 16				

## Occupancy

Format for occupancy data monitoring						
	Month	Month				
	average	average				
No. of persons,	No. of persons	No. of persons				
cero when they						
are away on						
vacations,						
etc.						
	House/Department 1	House/Department 2				
Jan. 15						
Feb. 15						
Mar. 15						
Apr. 15						
May 15						
June 15						
July 15						
Aug. 15						
Sep. 15						
Oct. 15						
Nov. 15						
Dec. 15						
Jan. 16						
Feb. 16						

## **Energy reference surface**

	Energy	Reference Surfac	ce, calculated	as specified i	n annex III	
		DEEVi ma	anual may als	o be consulte	d)	
		ERS	ERS			
		House/Dept.	House/Dept.			
		1	2			
Living room	m²					
Kitchen	m²					
WC	m²					
Larder	m²					
Bathroom	m²					
Hallway	m²					
Bedrooms	m²					
Total	m²	0	0			

## Annex III. Energy Reference Surface (ERS) calculation

## (Extract from the manual DEEVi 2013)

Specifications for residential housing Energy Reference Surface (ERS) calculation

To determine the **Energy Reference Surface (ERS)**, all surfaces **within the thermal envelope** should be counted (see Figure 5), by the percentage that corresponds to each, according to the following classification:

100%	50%	0%
<b>Total</b> surface I considered when including:	Only <b>50%</b> of the surface is considered when including:	Surface is not considered when including:
<ul> <li>Living space</li> <li>Living room</li> <li>Dining room</li> <li>Bedrooms and bedchambers</li> <li>Kitchen</li> <li>Bathroom</li> <li>Closet/dressing room and</li> </ul>	Areas with free height from floor to ceiling of 1.0 a 2.0 m, e.g. Attics (see Figure 6), as well as useful areas under the stairs, e.g. half bathroom under the stairs (see Figure 7)	<ul> <li>Indoor walls</li> <li>Columns and partition walls</li> <li>Doors and windows openings</li> <li>Stairs with more than 3 steps</li> <li>Elevator shaft</li> <li>Service yard and balconies, (as they are located outside the</li> </ul>
<ul><li>built-in closets</li><li>Hall and indoor hallways</li><li>Larder and storage rooms</li></ul>	60%	thermal envelope, see Figure 5) • Installation ducts • Recessed glass doors and only
<ul> <li>Recessed glass doors and only when depth is further than</li> <li>0.13m from the plane of the wall to plane of the glass</li> <li>Business premises</li> </ul>	Only <b>60%</b> of the surface is considered when including:	when depth is less than 0.13m from the plane of the wall to the plane of the glass  • Areas with free height from
	Building adjacent auxiliary rooms or basement, when these represent more than a half of the total surface. (see Figure 8)	floor to ceiling of 1.0 m, e.g. Attics (see examples in Figure 6 and Figure 7)

Note. - Dimensions to housing / building indoor planes and interior floor to finished ceiling heights are considered (see Figure 5)





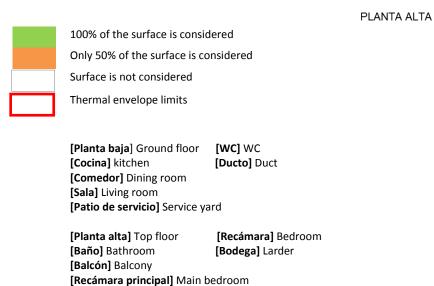


Figure 5: Example of areas to be considered for the ERS calculation in a two-floor building (Source: Passivhaus Institut)

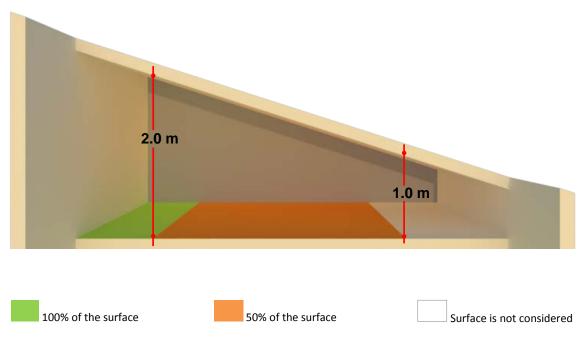


Figure 6. Example of areas to be considered for the ERS calculation in areas under a sloped ceiling (Source: Infonavit/Albarrán)

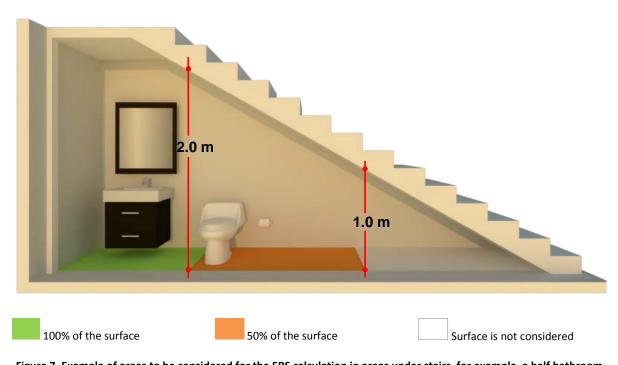


Figure 7. Example of areas to be considered for the ERS calculation in areas under stairs, for example, a half bathroom (Source: Infonavit/Albarrán)

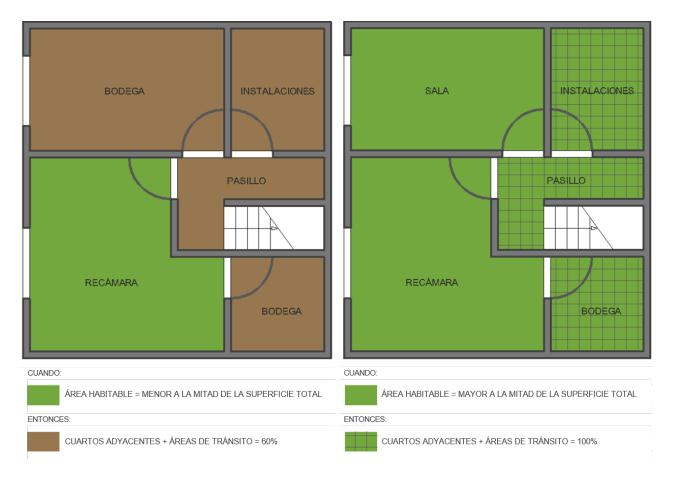


Figure 8: Example for the ERS calculation in households (auxiliary or circulation areas)
(Source: Passivhaus Institut e Infonavit/Albarrán)

[Bodega] Larder [Instalaciones] Installations room [Pasillo] Hallway [Bodega] Larder [Sala] Living room [Recámara] Bedroom [Instalaciones] Installations room [Pasillo] Hallway [Bodega] Larder

When:

Habitable area= less than half of the surface

Then:

Adjacent rooms + Circulation areas= 60%

When:

Habitable area= more than half of the surface

Then:

Adjacent rooms + Circulation areas= 100%

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