TOWARD A HOUSING NAMA[1]:

ROADMAPPING A NATIONAL LOW-CARBON HOUSING MARKET TRANSFORMATION STRATEGY

Jeffrey D.A. Ranson

Submitted to OCAD University in partial fulfillment of the requirements for the degree of

Master of Design (MDes) in Strategic Foresight & Innovation

Toronto, Ontario, Canada, April 2014

[1] Nationally Appropriate Mitigation Actions

AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this MRP. This is a true copy of the MRP, including any required final revisions, as accepted by my examiners.

I authorize OCAD University to lend this MRP to other institutions or individuals for the purpose of scholarly research.

I understand that my MRP may be made electronically available to the public.

I further authorize OCAD University to reproduce this MRP by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

Signature _____

ABSTRACT

Nationally Appropriate Mitigation Actions (NAMAs) offer developing countries an important means to work toward their sustainable development and emissions reduction goals through the structure of an international climate change mechanism. The implementation of NAMAs in the housing sector opens the door to support a wide variety of national-scale sectoral mitigation activities which includes policy, capacity building, technology transfer, and research and development. Countries looking to establish a housing NAMA are required to go through an extensive and thus far unguided planning phase to identify, evaluate and prioritize mitigation actions that will support sustained market transformation of the housing sector. This paper looks at the experiences of three countries, Costa Rica, Mexico and Peru, through the creation of a low-carbon housing roadmap – a guiding document for the establishment of a housing NAMA. By examining their process, a common pattern of questions and processes was identified and systematized into a framework that is useable for other countries to develop these roadmaps in a more structured and comprehensive fashion.

ACKNOWLEDGEMENTS

I would like to thank the following people for their support throughout this process:

The Low-Carbon Housing Roadmap teams, especially Team Canada: Garrick Ng, Jean-Francois Obregon, Anthony Watanabe, Amanda Kramer & Jeff Culp, and honourary Canadians Ken Mentzer and Craig Silvertooth; Odón de Buen, Rebeca de Buen, Arturo Echeverria, and Tomasz Kotecki in Mexico; Jaime Cabrera Valencia and Claudia Zaldivar in Peru; and, Manuel Salas, Huberth Méndez Hernández, and Roy Barboza in Costa Rica.

My Principal Advisor Jeremy Bowes Professor, Environmental Design, Strategic Foresight & Innovation Program, Faculty of Design, OCADU, for his continued support and advice. Faculty member Nabil Harfoush and external committee member Craig Applegath for their input and encouragement.

And most importantly, my wife Grace for putting up with a crazy travel schedule.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOS

ACCRONYMS

CCAP	Center for Clean Air Policy (NGO specializing in CDM and NAMA mechanisms)
CDM	Clean Development Mechanism (A UN Climate Change mitigation programme centred on carbon credits)
CER	Certified Emissions Reductions (equivalent to one tonne of CO_2e sequestered or abated – the basis for CDM Carbon Credits)
CIDA	Canadian International Development Agency
CO_2	Carbon Dioxide (a common greenhouse gas)
CO_2e	Carbon Dioxide Equivalent (a means to normalize the emissions of various greenhouse gas impacts to those of CO_2)
CONAVI	Comisión Nacional de Vivienda (National Housing Commission, Mexico)
EEEA	Energy Efficiency Exporters Alliance (A Canadian Non-Governmental Organization)
EPA	Environmental Protection Agency (United States)
GHG(s)	Greenhouse Gas(es)
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (Germany's International Development Agency)
GWP	Global Warming Potential
IADB	Inter-American Development Bank
IDP	Integrated Design Process (A multi-disciplinary design approach for high performance buildings)
IEA	International Energy Agency
IFC	International Finance Corporation
IMF	International Monetary Fund
LCH	Low-Carbon Housing
LCDS	Low Carbon Development Strategy (A first step for developing NAMAs)
LDC	Least Developed Countries (As defined by the UNFCCC)
MINAM	Ministerio del Ambiente (Ministry of the Environment, Peru)
MINEM	Ministerio de Energía y Minas (Ministry of Energy and Mines, Peru)

MIVAH	Ministerio de Vivienda y Asentamientos Humanos (Ministry of Housing and Human Settlements, Costa Rica)
MRV	Measurement, Reporting and Verification
MVCS	Ministerio de Vivienda, Construcción y Saneamiento (Ministry of Housing, Construction and Sanitation, Peru)
NAMA	Nationally Appropriate Mitigation Actions (A UN Climate Change programme)
NGO	Non-Governmental Organization
PMCA	Participatory Market Chain Approach
PVCA	Participatory Value Chain Analysis
SD	Sustainable Development
UN	The United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Commission on Climate Change
USAID	United States Agency for International Development

1. INTRODUCTION

> Roadmapping, used for decades in technology-intensive industries has emerged in recent years as a tool to help address complicated issues in a strategic manner at national, regional and global levels. Roadmaps achieve consensus on low-carbon energy milestones, priorities for technology development, policy and regulatory frameworks, investment needs and public engagement. As such, roadmaps can provide solid analytical footing that enables national policy makers and industry to develop specific technologies…with a regional, national or sectoral focus **(IEA, 2010)**.

Approaching climate change mitigation within the housing sector is both a daunting and appealing prospect for governments and national organizations. This is particularly true for developing countries where access to international climate change funding and support can be used to improve housing policy, market and technical capabilities and in turn achieve broader sustainable development goals.

Addressing long-term housing-related greenhouse gas (**GHG**) emissions at a national level cannot be done on a project-by-project basis, but is instead an exercise in market transformation. The objective is to create long-term, sustained changes in the ways that housing is designed, built and operated. This may only be achieved through the implementation of multiple parallel efforts including technological innovations, policy, awareness building, training and incentives, delivered through many different channels. Without an overarching strategic vision, these efforts, developed in organizational silos, can result in the duplication of work and conflicting results that waste precious time and resources.

From 2012-2013, Environment Canada, working bilaterally with partners in Peru, Costa Rica and Mexico, led a project to support national housing market transformation through the creation of Low-Carbon Housing Roadmaps (**the roadmaps**) (Environment Canada, 2013). These projects recognized that the partner countries were moving quickly to develop housing GHG mitigation strategies in response to new support programs, but that market transformation would be more successful if the countries invested the time up

front to map out and set priorities, create stakeholder alignment and coordinate the plethora of project opportunities being considered.

At the time of its inception, there was no structure for these proposed roadmaps other than the requirement that they take a sectoral approach, that the process focus on building local stakeholder capacity, and that roadmap components align with Nationally Appropriate Mitigation Actions (**NAMAs**) as the most promising international mechanism through which to seek support for GHG mitigation.

This paper seeks to demonstrate how, through analyzing the experience and outcomes of the three Low-Carbon Housing roadmaps created for Peru, Costa Rica and Mexico, a process framework could be constructed (**Figure 1**), and how this framework can be used to guide any country through the systematic development of a roadmap for low-carbon housing market transformation. Furthermore, it describes how best practices for stakeholder engagement, market analysis, ideation and systems mapping may be combined through a series of tools and guidance documents to improve the quality and expedience of the roadmap development process.

Figure 1: Roadmap Process for Low-Carbon Housing: a Simplified Framework

Photo 1: Rows of new subsidized housing blocks for the working class in Lima, Peru

Photo 2: Replacing informal housing developments with upgraded structures and infrastructure in San Jose, Costa Rica

Photo 3: Grand opening of an energy efficient housing development featuring solar hot water tanks in Aguascalientes, Mexico

2. BACKGROUND

In Mexico, Costa Rica and Peru along with many other industrializing countries, housing presents a major area of national concern. As a major socio-economic priority sustainable development objectives, including the provision of adequate housing that responds to issues like structural safety, overcrowding, inadequate sanitation, and poor air quality are a major socio-economic priority.

In Peru, for example, the Ministry of Housing, Construction and Sanitation (**MVCS**) states that there is a housing deficit of 1,860,692 units of which 389,745 is a quantitative shortfall and 1,470,947 have qualitative deficiencies such as they are structurally unsound, lack basic sanitation, or fail to provide adequate protection from the elements. This number is increasing by 100,000 units annually. (Culp, 2013)

On the other hand there is tremendous development fueled by urbanization, population growth and economic prosperity. Mexico is projected to grow by 28.8 Million residents between 2010 and 2050 (The World Bank, 2010). The impact of this growth is compounded by the proliferation of home appliances, electronics, and in particular space cooling as disposable income increases and costs decrease. One estimate suggests that energy-use for residential space cooling in Mexico could grow from 0.68 MWh/yr in 2006 to 4.10 MWh/yr in 2050.

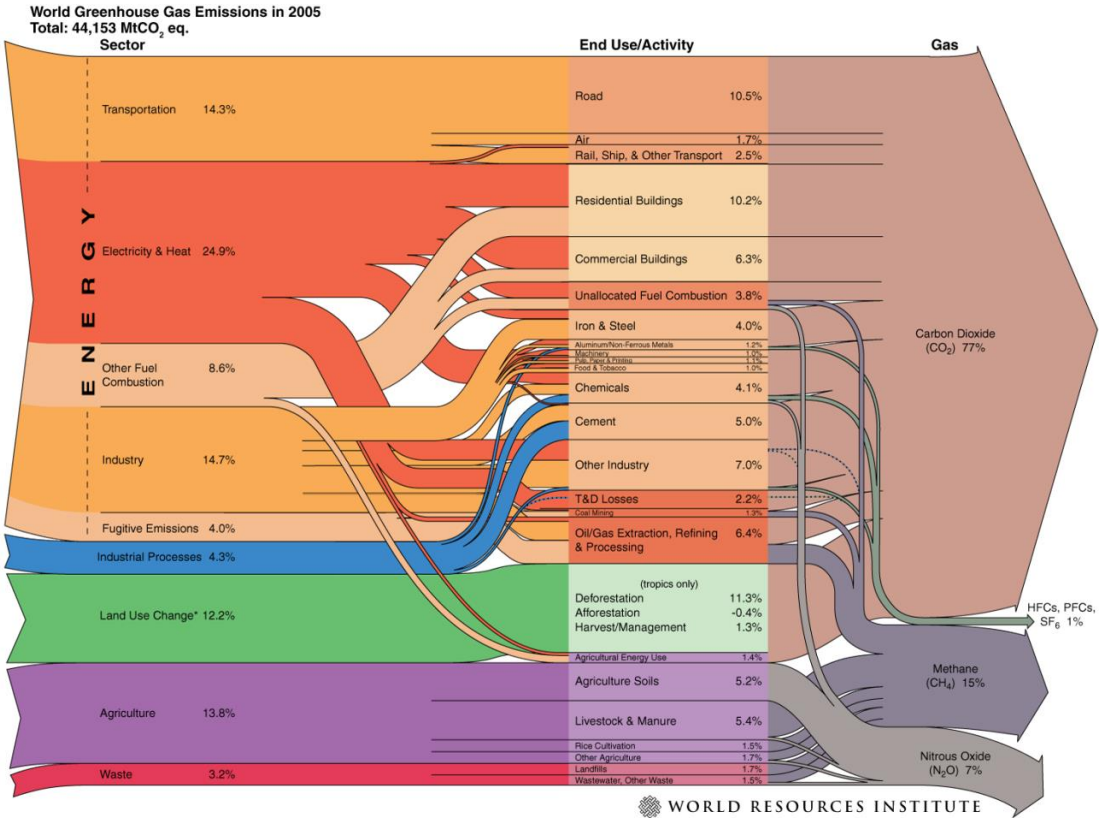
Table 1: Population Projections 2010-2050 (000s)[2]

Country	2010	2050	Increase	Percentage
Costa Rica	4,659	5,891	1,232	26%
Mexico	113,423	142,253	28,830	25%
Peru	29,076	38,197	9,121	31%

[2] From World Bank tables: http://go.worldbank.org/KZHE1CQFA0

This creates a tension between the need for housing, changing consumer demands, and the burden of development on infrastructure, land use, and GHGs. In 2005, the World Resource Institute estimated that the operation of residential buildings accounted for 10.2% of GHG emissions globally (**Figure 2: World GHG Emissions, 2005**).

Figure 2: World GHG Emissions, 2005[3]



At a national level, this translates into a significant amount of emissions. In Mexico for example, emissions from residential buildings amount to over 45,000 KTon CO_2 equivalent per year, (de Buen O. , 2009), roughly equal to that of 9,412,500 U.S. passenger vehicles per year[4].

[3] (World Resource Institute, 2008)
[4] http://www.epa.gov/cleanenergy/energy-resources/calculator.html

Table 2: Residential Building Emissions in Mexico (2006)

	2006 Values	Units
Number of Households in Mexico	24.8	Million
Residential Building Total Emissions (annual)	45,180	Kiloton CO_2 Equivalent
Emissions per Residential Building (annual)	1.822	Tons CO_2 Equivalent

Developing countries have thus far been challenged with housing market transformation due to rapid growth and development, the highly fragmented nature of the sector, and a lack of technical and human resources. If they are to be successful, they will need to rapidly increase the quality of housing construction, while simultaneously increasing production volume (Innovolve Group, 2012).

Past international climate change mechanisms, particularly Clean Development Mechanisms (**CDM**) that offered support for emissions reductions through a Certified Emissions Reduction (**CER**) credit market proved appealing only for select large-scale centralized projects (UNEP Risoe Centre, 2013).[5] In particular, carbon CER credits were only available for projects (i.e. Solar farms, landfill gas capture, etc…) and could not be obtained to support mitigation approaches such as policy creation, research and development, or capacity building activities (Center for Clean Air Policy, 2012). These types of **"sectoral"** approaches could have a significant impact on housing emissions across the housing market but would be difficult to connect to specific project based emissions reductions with sufficient accuracy for certification. Furthermore, CDM prioritized emissions reductions while sustainable development co-benefits were viewed as a bonus (Olsen, NAMAs for Sustainable Development, 2013).

[5] For a review on the failings of CDM in the housing sector, and the transition to NAMAs see Appendix A: The Evolution of International Climate Change Mechanisms and Low-Carbon Housing

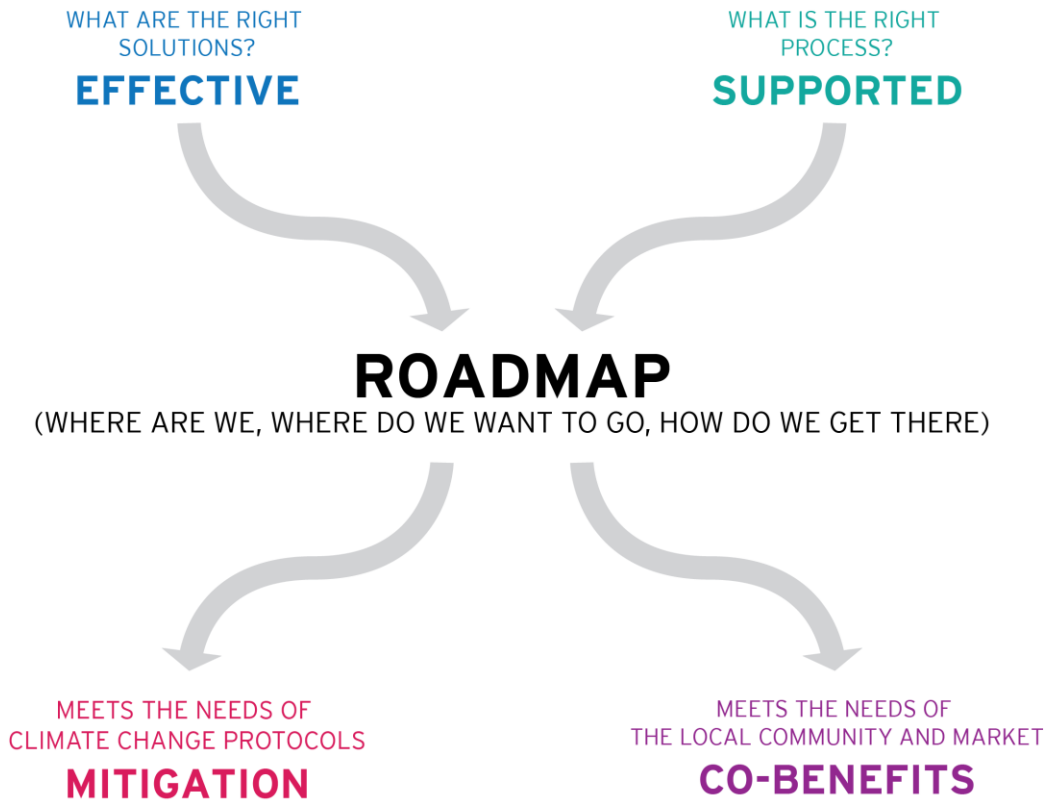
In contrast, Nationally Appropriate Mitigation Actions (**NAMAs**) were created as a 'development first' mechanism that enable developing countries to set their sustainable development priorities for a given sector (i.e. housing) and pursue international support for almost any type of effort that would support those goals and include emissions reductions (Center for Clean Air Policy, 2012; Olsen, NAMAs for Sustainable Development, 2013). Because housing is both a sustainable development priority and has tremendous emissions reduction potential, a Housing NAMA is an appealing concept.

Given the number of market transformation opportunities eligible for inclusion through NAMAs, the limited capacity for implementation, and the unique features of each national housing market, countries must be strategic in their approach to creating an effective housing NAMA. Among other considerations, they must determine:

- How should our housing be built and operated to address both our emissions reduction and sustainable development goals?
- What programs and efforts might support housing market transformation?
- Who is insuring strategic alignment between the various activities?
- How do we ensure support for housing market transformation efforts?

To support this process, a low-carbon housing roadmap is a useful tool for identifying and prioritizing opportunities for sectoral market transformation efforts, creating stakeholder buy-in, and mapping out a strategic course of action towards a housing NAMA (**Figure 3**).

Figure 3: Roadmaps organize actionable strategies around achievable goals



2.1 Canada's Fast Start Financing of the Low-Carbon Housing Roadmaps

Canada has a long history of supporting the development of energy efficient housing around the world since the construction of the Saskatchewan Conservation House by Harold Orr and Rob Dumont of the Saskatchewan Research Council which went on to influence the German Passivhaus standard (Holladay, 2010) through to the establishment of the Super-e program[6].

[6] http://www.super-e.com/

From 2009-2011 a team headed by Environment Canada lead an International Zero-Energy Housing dialogue, under the Asia Pacific Partnership for Clean Development and Climate. Participating countries included the United States, Japan, China, Australia, South Korea and India (Asia Pacific Partnership, 2011). A key outcome of this dialogue was the construction of a number of Zero Energy Home demonstration projects internationally. At this time, a parallel partnership was established with CONAVI in Mexico (the National Housing Commission) to support five developers with the construction of a series of zero-carbon and low-carbon pilot homes. These homes were presented to the public at COP 16 in Cancun in December, 2010 and received significant attention, including a visit from Mexican President Felipe Calderón. Despite the success of the projects, and the demonstrated affordability of many of the design concepts, it was apparent that without the international funding support, developers would be far more likely to adopt these ideas if further policies, standards, and financing programs were in place (Echeverria Aguilar, 2012).

With the emergence of NAMAs, and the strong interest of partner countries in Latin America to develop housing NAMAs, Environment Canada proposed the development of Strategic Roadmaps for Low-Carbon Housing in 2012. Three countries - Peru, Costa-Rica and Mexico – were selected to receive support in the identification of sectoral actions for national or state-level housing market transformation. These actions would comprise a roadmap for low-carbon housing that could serve as a guiding document for a housing NAMA. The housing NAMA in turn could be leveraged to ensure ongoing implementation support toward broader market transformation.

The roadmaps were presented as a way to engage stakeholders in the identification and prioritization of potential housing NAMA activities and build support for the kinds of policy, financial, and capacity building efforts (in addition to the technical improvements) that would result in sustained market transformation.

At the onset of the project, the Canadian Team had the concept of a roadmap which included a number of challenges:

- **No Precedent**: The team had never conducted, nor was it aware of a systematic process for creating a low-carbon housing roadmap at a national level for a developing country.
- **No Methodology:** The team had to create a methodology for developing the roadmap.
- **Limited Market Knowledge:** The Canadian team had extensive technical knowledge, but limited market knowledge in the targeted countries.
- **Condensed Timeline:** The entire project and the three roadmaps needed to be submitted by March 31, 2013 (14 Months).

Despite not having an established methodology for this process, the team established a set of key principles that helped shape the methods used.

Key Principles

I. Local stakeholders know the market best
II. All parts of the housing market value chain should be engaged in the process if possible
III. All parts of the housing market value chain should engage with each other if possible
IV. Local capacity building should be emphasized to improve likelihood of implementation

The result was an evolving process with tools, activities, and methods being developed in real-time and tested through implementation. The Canadian team conducted a series of workshops and stakeholder

interviews in the partner countries, and funded market research and pilot projects between February 2012 and April 2013. What was learned by conducting the process across three countries was that there is a common set of underlying questions that every country must address, and by building on that common structure the process could be systematized and replicated with greater effectiveness and efficiency in other countries looking to develop a Roadmap for low-carbon housing.

3. APPLYING MARKET TRANSFORMATION THEORY TO THE ROADMAPPING PROCESS

Through the earlier pilot projects, it became apparent that international support for low-carbon housing would only be available for the largest housing projects such as the significant social housing project by developer URBI in Mexico funded by Canada through the International Finance Corporation in 2012 (IFC, 2014). These projects are typically government subsidized, regulated, and developed through the country's largest builders. This still leaves a large portion of the housing market under-supported and unsuitable for project based support. Sectoral approaches are relied upon to influence these homes through a process of *market transformation*.

In North America a market transformation theory has arisen from a history of energy conservation efforts in the building sector. In Canada, for instance, we can refer to initiatives such as ENERGY STAR labelling of appliances and homes[7], or provincial building energy codes and Model National Energy Code for Buildings[8] which mandate performance, or utility incentive programs like Enbridge's Savings by Design[9] that train and subsidize builders to adopt new construction practices. Each of these efforts acts on specific market dynamics to contribute to a change in market behavior.

From the preliminary Roadmap development discussions between Canada and the developing country partners, there was clearly interest in emulating projects and measures proven elsewhere but not a clear understanding of the contextual requirements for these programs in order to determine if, in fact, it was a good fit. In one instance, Peru showed a great deal of interest in green mortgages based on Mexico's

[7] http://www.nrcan.gc.ca/energy/products/energystar/12519
[8] https://www.nrcan.gc.ca/energy/efficiency/buildings/eenb/codes/4037
[9] http://residential.savingsbydesign.ca/

Hipoteca Verde program, but had little understanding of how it operated and whether it would be replicable in the Peruvian marketplace.[10]

Too often this is where the analysis stops, and countries pick individual programs that they deem to be successful and seek to duplicate them domestically. Often they are looking for a few "magic bullet" programs that will solve all their problems, and can be frustrated when they can't follow through or don't see results. To understand how these measures might contribute to market transformation, it is important to understand the fundamentals of market transformation theory which was described by Keating et al. (1998):

> The programmatic approaches included: sustained, often large, incentives to gain market share; bulk procurements to bring new generations of technologies to the market or to increase competition and reduce manufacturers' risks; marketing; and codes and standards. While not the only conclusions that we take from these efforts, the most important insights that came from this period may be: (a) that lasting changes in markets may take a sustained effort; and (b) programs in complex markets may work best when multiple interventions be coordinated to meet needs in multiple places in the market.

Fundamentally, it can be said that in a market as complex as housing, no individual measure is likely sufficient, but "market transformation occurs when these policies operate together in a synergistic way to deliver a permanent improvement in the efficiency of [housing] products on the market (Fawcett & Boardman, 2009, p. 225)." The Canadian team knew that the Roadmaps were in fact market transformation strategy documents, and the process for developing the roadmap, while not based on the literature of market transformation theory, would benefit from alignment with documented best practices.

[10] This was discussed at length at the Low-Carbon Housing Finance Forum held in Lima, Peru on Nov 13, 2012, which included Canada, Mexico, Peru and Costa Rica.

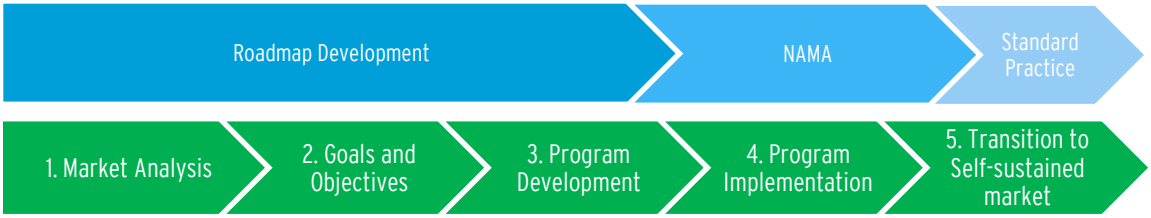
In a study on strategies for market transformation, Nadel and Latham (1998) outlined the following five key elements of a market transformation strategy:

1. A careful analysis of the overall market, including an identification of the particular barriers that are hindering the development, introduction, purchase and use of the targeted measure;
2. A clear statement of the overall goal of the initiative or strategy as well as the specific objectives that will be accomplished along the way by the different initiatives or activities.
3. The development of a set of coordinated activities that will achieve the desired objectives and systematically address each of the identified barriers;
4. Successful implementation of the individual activities, including periodic evaluations and adjustments designed to respond to actual experience; and
5. Development and execution of a plan for transitioning from extensive market intervention activities toward a largely self-sustaining market, i.e., an "exit strategy".

Roadmap development fits well within the first three elements on this list, while the fourth and fifth seem to fall within the scope of NAMA development and implementation (**Figure 4**). This suggests that a roadmap development framework needs to outline the following processes in order to be a useful market transformation strategy document:

6. How to understand the "overall market" for housing in a given country
7. How to set goals and objectives for sectoral approaches
8. How to identify and select measures that will be developed and implemented

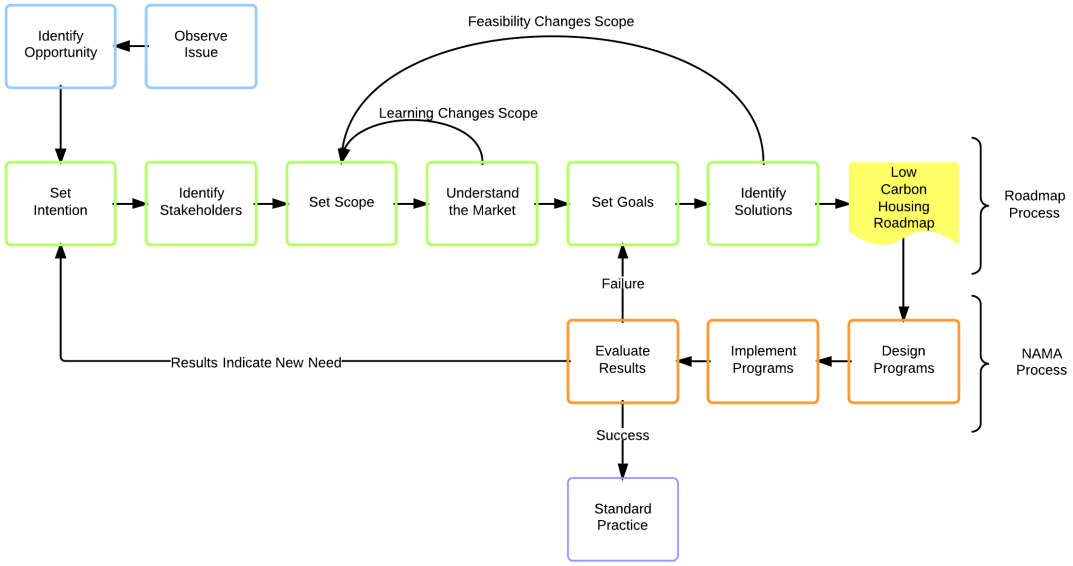
Figure 4: The Roadmap Development Process relative to Nadel & Latham's Market Transformation Strategy Development Process



Looking at the roadmap development process as a market transformation tool, the end result begins to take shape. The roadmap and subsequent NAMA should include a number of complementary large scale sustained measures, coordinated towards a common set of goals that have the possibility of achieving actions that may become self-sustaining. This process can be further broken down to into key stages of activity from the first observation that there is an issue, to the final sustained changes within the market (**Figure 5**). These stages were derived working backwards from the Canadian roadmap development process, in order to streamline information gathering, consensus building, and planning.

The following sections will focus on the Roadmap Development Process activities that can support market transformation, beginning with early stakeholder identification. This assumes that the stake or national body already recognizes the issues and opportunities, and has set the intention to target GHGs in the housing sector through the creation of a housing NAMA.

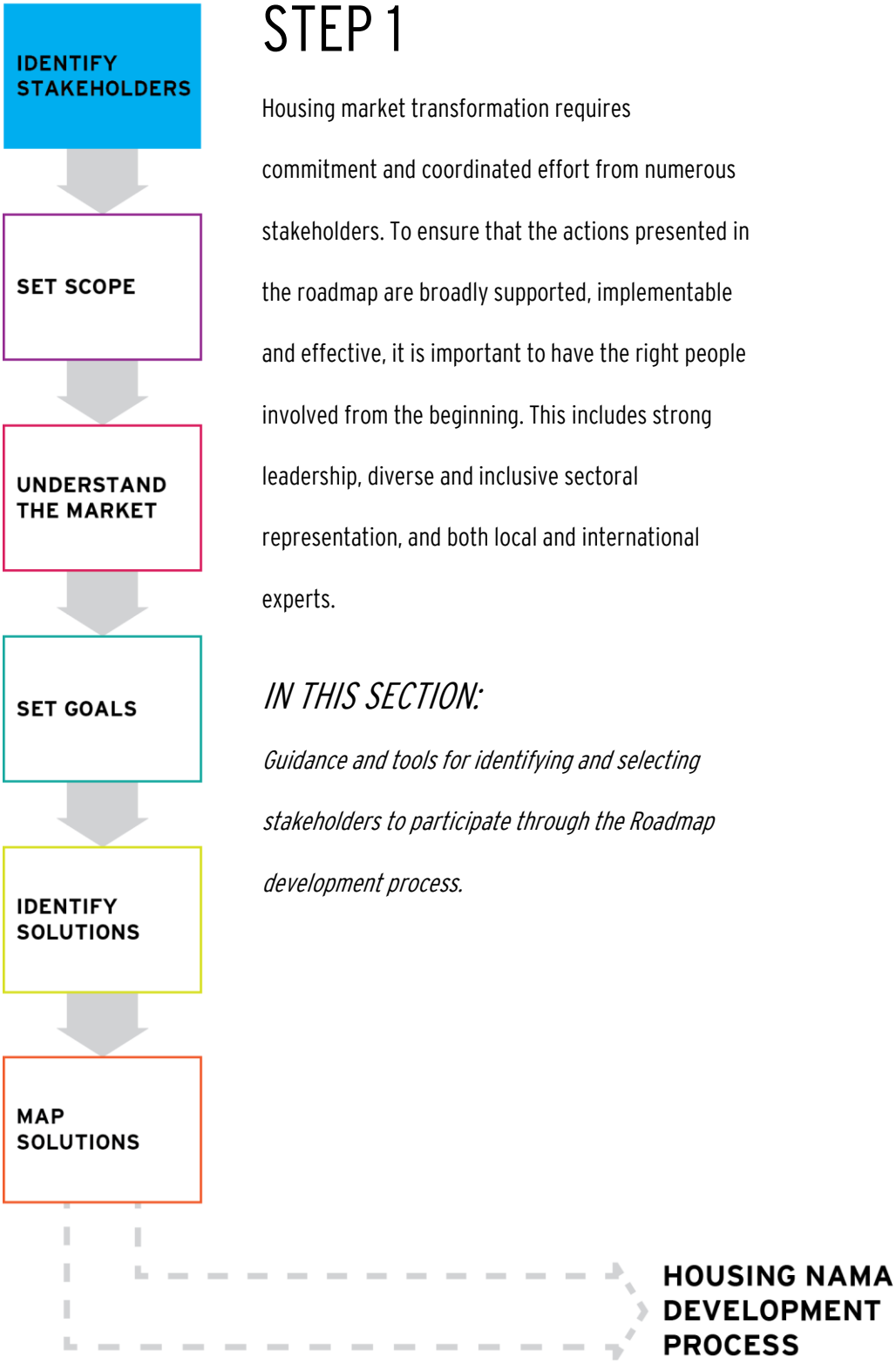
Figure 5: Low-Carbon Housing Market Transformation Process



With this assumption, the first stage for developing the roadmap is the identification of stakeholders, to ensure representation across the market in a way that fosters wide-scale support and the likelihood of implementation.

Photo 4: A Costa Rica Low-Carbon Housing Roadmap working session led by Environment Canada

ROADMAPPING PROCESS



STEP 1

Housing market transformation requires commitment and coordinated effort from numerous stakeholders. To ensure that the actions presented in the roadmap are broadly supported, implementable and effective, it is important to have the right people involved from the beginning. This includes strong leadership, diverse and inclusive sectoral representation, and both local and international experts.

IN THIS SECTION:

Guidance and tools for identifying and selecting stakeholders to participate through the Roadmap development process.

4. DESIGNING A PROCESS – EXPERIENCES IN FOSTERING COLLABORATION

Determining "Nationally Appropriate" mitigation actions in the housing sector implies a level of consensus and wide-spread engagement in the process. While each country will be responsible for choosing its own method of developing a NAMA (and by extension the Low-Carbon Housing Roadmap), the Canadian team believed that a collaborative approach would be most effective, a view shared by many international development groups (IFC, 2007; USAID, 2009; IEA, 2010).

The first requirement, however, is the identification of a project lead to champion roadmap development. Canada evaluated partnerships with several countries in Latin America to develop roadmaps, but a driving motivation for selecting Peru, Costa Rica and Mexico was the high level of commitment from senior officials within government ministries and agencies.

4.1 Selecting a Champion

The roadmap champion will most often be a government ministry or agency. The most likely candidate is an environment ministry, as was the case in Peru (MINAM). However, given the focus on housing, it may be a ministry of housing, construction, or development as in Costa Rica (MIVAH), or a national housing agency such as in Mexico (CONAVI). Where ministerial capacity does not exist the champion may be an inter-governmental committee, an NGO, or an industry coalition.

Certain characteristics of the champion can influence the success of developing and implementing a roadmap. Primary attributes of a champion should include a level of expertise and authority on the subject of climate change and/or housing at the state or national level being addressed, access to high-level decision makers from the public and private sector, and the resources and commitment to see the project through to completion.

The roadmap champion may also assume the role of NAMA lead "proponent" which is a requirement of the NAMA registration process (Lütken, Dransfeld, & Wehner, 2013). If not, then some level of coordination between the roadmap champion and the NAMA proponent is essential.

Table 3 outlines some questions for evaluating organizational suitability for championing the roadmap development process. It is not important (or even likely) that the lead organization fulfill all these requirements, but it helps to address areas of strength and weakness of the organization and where partnerships are needed.

Table 3: Assessing the Suitability of a Roadmap Development Champion

Scope	Yes	No
Does the organization have a mandate on climate change?	☐	☐
Does the organization have a mandate on housing?	☐	☐
Is the organization active in all the regions covered by the Roadmap?	☐	☐
Will the organization be responsible for developing a housing NAMA? (The Housing NAMA Proponent)	☐	☐
Reputation	☐	☐
Can the organization secure support from senior government leadership?	☐	☐
Can the organization successfully engage industry stakeholders?	☐	☐
Does the organization have technical credibility on the topics of climate change mitigation and/or housing?	☐	☐
Resources	☐	☐
Does the organization have resources to fund staff (in part of in full) for the duration of the Roadmap Development Process?	☐	☐
Can the organization access bi-lateral funding or support (Government to Government i.e. fast start financing)	☐	☐
Can the organization access development financing? (Through institutions including IADB, IFC, IMF)	☐	☐
Does the organization have the knowledge/experience to manage the roadmap development process?	☐	☐
Will the organization commit the time to undertake roadmap development?	☐	☐

4.2 Inter-Governmental Collaboration

The advantages of an environmental ministry as champion (or at least a major role player) include a strong mandate to address climate change, capacity for measurement, reporting and verification (MRV) of

GHG Emissions, access to bi-lateral funding such as the fast start funding Canada used to support the Roadmap development, and the likely responsibility for overseeing NAMA development.

Getting commitment of the environment industry, however, will not guarantee success alone. Tompkins and Amundsen addressed this in their 2008 review of the perceived effectiveness of the UNFCC on creating behavior change taken from interviews with state and non-state actors at the UNFCC 8th Conference of Parties (COP 8) in Delhi, India.

> In many countries the Ministry for the Environment is responsible for climate change policies, but this ministry is often perceived to be a weak ministry (Delegate 11, Delegate 13, NGO 14), having less access to resources than Finance, Energy or Transport. These other ministries often have better established links with policy makers, making it difficult for the environment ministry to push their agenda or to compete for funds… To cope with this weakness some countries have established inter-governmental institutions to understand the linkages between climate change, development and environmental issues - *(Delegate 4, Delegate 5, Delegate 6, Delegate 8, Delegate 10)* **(Tompkins & Amundsen, 2008).**

The Canadian experience confirms these observations as the MINAM (the Peruvian Ministry of the Environment) was founded only recently in 2008, and was still building institutional capacity compared to its counterparts at the MVCS (Ministry of Housing Construction and Sanitation) and MINEM (Ministry of Energy and Mining). Political support for implementing the roadmap may hinge on the support of "strong" ministries, so it's worth identifying which ministries have clout in the local market and engage them early.

Low-carbon housing in particular, crosses many ministerial boundaries due to housing's relationship to health and safety, infrastructure, and economy (**Table 4**) and these ministries in turn impact what low-carbon housing means. Ministries may provide valuable insight into an aspect of the housing market that helps shape the roadmap. They may also regulate issues related to housing that impact what gets built or

how. Finally, they may represent significant national priority issues which can be used to gain support for low-carbon housing if there is alignment. This will be covered further in the discussions of Co-Benefits and NAMAs in **Section 7**.

Table 4: Examples of Ministry Overlaps with Low-Carbon Housing

Ministry:	Environment	Energy	Housing	Labour	Health	Finance
Technical Expertise	Quantifying housing related GHGs	Residential energy supply	Construction methods	Trades training	Public health issues	Development financing, homeowner lending
Regulatory Role	Emissions	Energy infrastructure	Construction quality	Workplace safety	Indoor air quality, sanitation	Interest rates
Policy Drivers	Reducing housing related emissions	Improving energy security	Improving housing supply & quality	Creating jobs, Increasing skilled workforce	Improving public health	Supporting residential investment

4.3 Multi-Stakeholder collaboration

Research shows that climate change governance is becoming more and more complex, involving a multitude of different actors (Andonova, Betsill, & Bulkeley, 2009). Governments cannot unilaterally impose market transformation and there is recognition that partnerships are critical, particularly when dealing with complex meta-problems (Selsky & Parker, 2005) such as addressing both climate change and sustainable development goals related to housing. Groups seeking to develop a low-carbon housing roadmap need to consider who *can* and *should* be engaged in the process.

A multi-stakeholder process for low-carbon housing roadmap development involves a broad range of entities, including government agencies and global partners committed to sustainable development and climate change mitigation, as well as the building industry, public interest groups and academia. Stakeholders must play an active role in defining the scope and contents of the roadmap, contributing their expertise and market understanding, voicing their positions on key issues, and collaborating with other stakeholders.

In an excellent overview of the role of multi-stakeholder partnerships in addressing climate change and development goals, Pinkse and Kolk (2012) outline how engaging a wide range of stakeholders can help in overcoming any participation gap, insuring that all relevant perspectives from affected parties have a voice. This should include "dissident" and alternative voices which increases the credibility and quality of the final product. The multi-stakeholder process also serves to balance competing stakeholder demands and serves as a forum for debate and a means to prioritize these demands. In addition, inviting diverse backgrounds and expertise into the partnership can accelerate knowledge transfer and create synergies to address the challenge in new and innovative ways (Pinkse & Kolk, 2012). Outlined below are a few key categories of partners that should be included.

4.3.1 Global Partners

The recognition that technology transfer and market transformation can be supported through global partnership was notably emphasized when "a global partnership for development" was made the 8th Millennium Development Goal.[11] Developing countries are increasingly looking to form partnerships with industrialized countries, transnational organizations, multilateral organizations, and multinational corporations (Pinkse & Kolk, 2012). Since the outcomes of a low-carbon housing roadmap has implications for NAMAs, Millennium Development Goals, and international trade, entities involved in these areas as they relate to housing should be included in the roadmap development process.

In addition to Canada, fast start financing is available bilaterally from many annex II countries, perhaps most notably through Germany and the UK who invested €70 Billion to create the NAMA Facility to fund NAMA support projects (van Tilburg, Bristow, Röser, Escalante, & Fekete, 2013). Additionally, multilateral

[11] http://www.un.org/millenniumgoals/global.shtml

agencies (such as the World Bank, UNIDO, UNDP, UNEP) are increasingly engaged in key roles in climate change program governance including technical advisory, capacity building, research, and financing (Pattberg & Stripple, 2008). In December 2012 , the NAMA Partnership was launched, with the stated aim to "enhance collaboration and complementarity of the activities of multilateral, bilateral and other organizations in order to learn lessons and accelerate support to developing countries in preparing and implementing NAMAs" (The NAMA Partnership, 2013)

Table 5: Official partners in the NAMA Partnership[12]

UN Agencies	Development Banks	Bilateral Organisations	Other Relevant Organisations
- UNEP Risoe Centre - UNFCCC - UNDP - FAO - UNITAR	- World Bank - African Development Bank - Asian Development Bank - Nordic Environment Corporation - Inter-American Development Bank	- Agence Française du Développement - United States Agency for International Development - International Fund for Agricultural Development - Deutsche Gesellschaft für Internationale Zusammenarbeit - KfW - Japan International Cooperation Agency	- World Resources Institute - The Climate Policy Initiative - Climate Markets and Investment Association - Centre for Clean Air Policy - Climate Works Foundation

Not all global partners are from the public sector. New types of transnational organizations are introducing public-private solutions to climate change (Bäckstrand, 2008).

[12] Source: (van Tilburg, Bristow, Röser, Escalante, & Fekete, 2013) http://mitigationpartnership.net/sites/default/files/report_update.pdf

> There are currently thousands of more or less formalized and institutionalized climate partnership networks, ranging from UN registered public-private partnerships to voluntary technology partnerships between industrialized and developed governments. **(Bäckstrand, 2008)**

Multinational corporations are also playing an increased role in driving local mitigation activities in developing countries around the world (Nelson, 2009) either directly, or through their industry associations. These efforts include the dissemination of energy efficient products, risk-sharing on mitigation actions through public-private partnerships, and industry working groups to advance sectoral performance.

4.3.2 Public Private Collaboration

> Sound public policies and investments are central for achieving the MDGs and accelerating economic growth, but they are not enough. The private sector is the engine of innovation and growth providing incomes for rural and urban populations. It is also a tremendous repository of organizational and management expertise that can increase the effectiveness of service delivery. Where possible, countries should draw on the private sector to complement governments in designing, delivering and financing interventions to achieve the MDGs.
>
> The MDG Africa Steering Group
>
> Ban Ki-Moon, United Nations Secretary-General (Chair), Donald Kaberuka, President, African Development Bank, Jean Ping, Chairperson, African Union Commission, José Manuel Barroso, President, European Union, Dominique Strauss-Kahn, Managing Director, International Monetary Fund, Ahmand Mohamed Ali Al-Madani, President, Islamic Development Bank Group, Angel Gurría, Secretary-General, Organisation for Economic Cooperation and Development, Robert B. Zoellick, President, The World Bank Group

Transitioning the housing industry toward low-carbon housing may require performance regulations, changes to construction practices, and new products and materials (Innovolve Group, 2013), all of which have significant impact on practitioners. As such the roadmap development process should include developers, building material industries (such as concrete, timber and steel), architects and engineers, and energy service

providers as they are a significant part of the market that is being transformed. Furthermore, Annex II countries providing development support may increasingly require private sector participation in the process. Public-private partnerships (**PPPs**) are a priority focus of numerous development agencies around the world including USAID (US)[13], CIDA (Canada)[14], and GIZ (Germany)[15] and are implemented directly or through programs such as the IFC Catalyst Fund (Cai & Paradis, 2013).

Large scale public-private partnerships already exist in many countries to address development goals such as municipal infrastructure and social housing development (Phumpiu & Gustafsson, 2009). Existing government-sponsored housing programs represent a tremendous opportunity for low-carbon housing if GHG emissions targets can be added to the required deliverables when the project is tendered.

At the smaller scale there are significant challenges. In developing countries, more so than in developed countries, the housing sector is fragmented, with a significant gap in technical capabilities between large-scale developers and small-scale informal builders. Engaging many small community based builders, suppliers, and product manufacturers who play a significant role in the market place is considerably more challenging. These builders may be hard to identify, not be represented by a trade association, and geographically isolated (Wells, 2007). As such the roadmap development process needs to make additional efforts to engage with this audience, including holding workshops in local communities and collaborating with grassroots NGOs (Albu & Griffith, 2005).

4.3.3 Public Interest Organizations

Evidence has shown that public private partnerships for climate change need to look beyond the relationship between private companies and the state, and engage with local community groups, NGOs, and

[13] http://www.usaid.gov/el-salvador/public-private-partnerships
[14] http://www.acdi-cida.gc.ca/cidaweb%5Ccpo.nsf/projEn/A035235001
[15] http://www.giz.de/en/downloads/giz2011-en-public-private-partnership.pdf

smaller businesses representative of specific communities (Forsyth, 2005). For technology transfer and market transformation to be successful, there needs to be the potential for a local self-sustaining market, and a deep understanding of local socio-economic needs.

Public interest organizations related to housing can include both environmental and social NGOs, community and consumer advocacy groups, public health organizations and local economic development groups. These organizations that have a vested interest in the public benefit can bring valuable insight into the needs of local communities and experience delivering development programming at a local level (Pinkse & Kolk, 2012). Furthermore, NGO's and community based organizations can provide additional support for the implementation of market transformation projects, as well as monitoring the results of project related programs.

One caveat in working with NGOs is to conduct due diligence to ensure that the NGO does in fact represent and is accountable to the community interests to which they lay claim. This may require some initial research on local special interest groups and the power dynamics in the local community[16].

4.3.4 Academia

Academia plays a valuable role in supporting climate change mitigation in the housing sector. Including academia in the roadmap development process can provide insight into the level of technical expertise in the local market, the performance of building materials and components under the local environmental conditions, and the availability of formalized training programs for professionals and trades. Fields of study related to low-carbon housing include architecture, engineering, building science, material science, climate science, sociology, economics, and construction technology to name a few.

[16] For a detailed guide on engaging with community stakeholders in developing countries see (IFC, 2007)

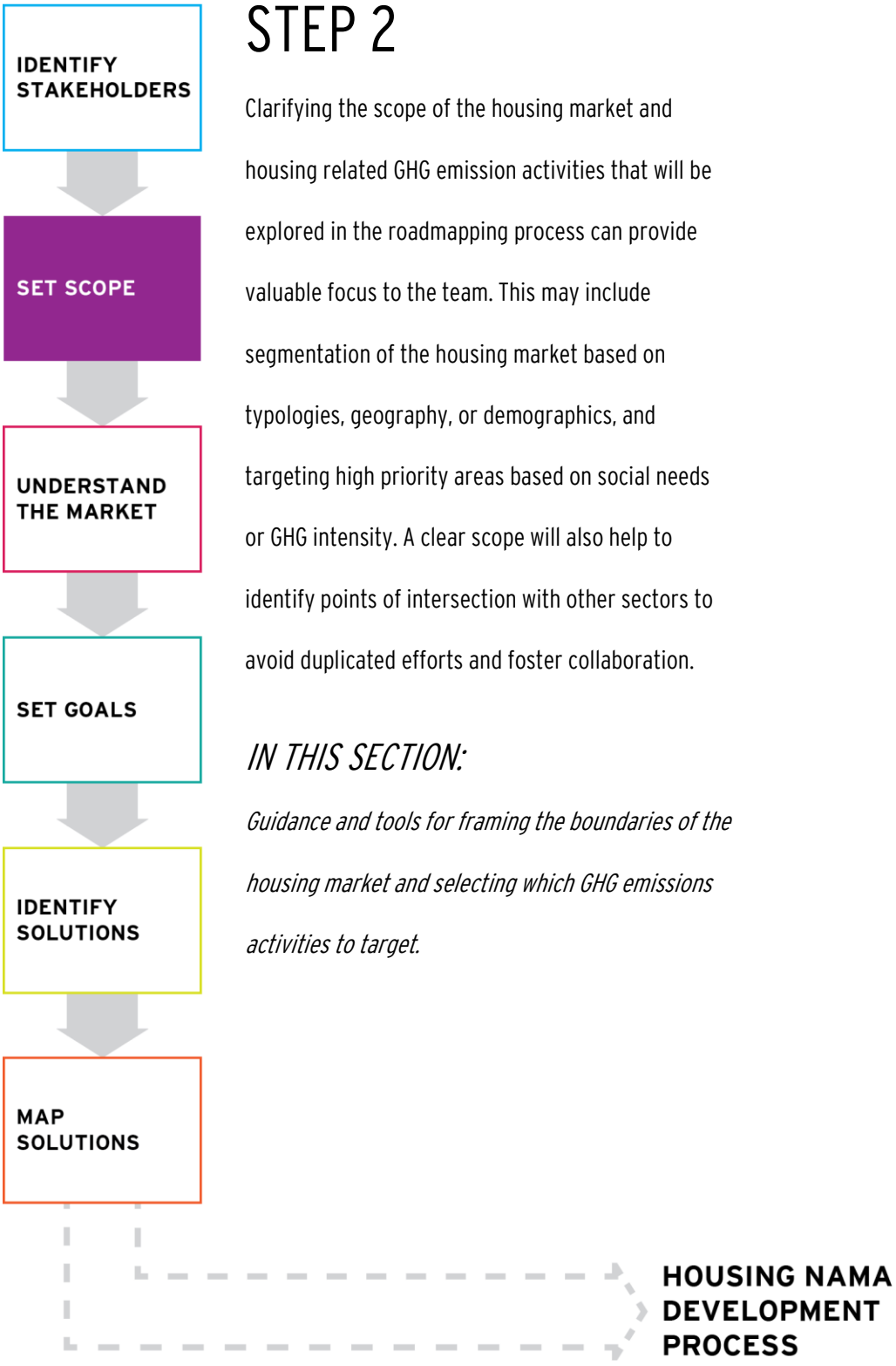
The academic community may also provide a critical role in conducting research as an input to the roadmap. In Costa Rica, Mexico and Peru a number of studies were commissioned to local academics to provide context for the roadmap discussions.

Choosing the Right Partners

It is recommended that the roadmap development team develop a preliminary list of stakeholders to invite into the process. A worksheet such as the one in **Appendix B** can assist in developing an initial list of stakeholders for consultation in the roadmap development process.

Photo 5: The Kick-off Meeting for the Peru Low-Carbon Housing Roadmap Project

ROADMAPPING PROCESS



STEP 2

Clarifying the scope of the housing market and housing related GHG emission activities that will be explored in the roadmapping process can provide valuable focus to the team. This may include segmentation of the housing market based on typologies, geography, or demographics, and targeting high priority areas based on social needs or GHG intensity. A clear scope will also help to identify points of intersection with other sectors to avoid duplicated efforts and foster collaboration.

IN THIS SECTION:

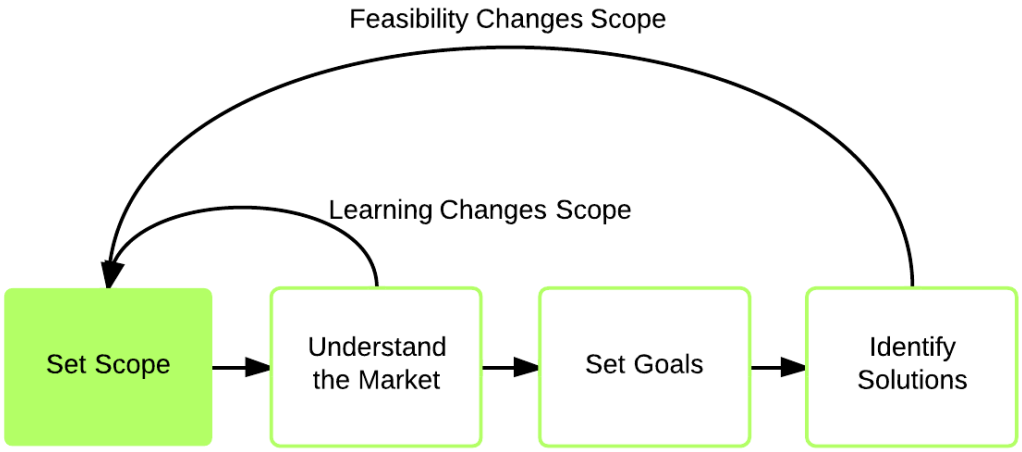
Guidance and tools for framing the boundaries of the housing market and selecting which GHG emissions activities to target.

5. SETTING A PRELIMINARY SCOPE

In developing this initial list of stakeholders, the project team should now have a sufficient representation to begin the roadmapping exercise. A preliminary scope must be established to provide boundaries and to focus the research. These boundaries are defined by the types of emissions and emission producing activities being considered in the roadmap.

The reason that the term "preliminary" is used relates to the fact that roadmap development can be an *iterative process* whereby future discussions and discoveries may influence a change in the scope. Often this change of scope will be caused by changes in the understanding of what is feasible through the process of identifying and fleshing out potential interventions (**Figure 6**), as was experienced throughout the Roadmap development process, with the Canadian team.

Figure 6: Improved Understanding of Feasibility may Influence Overall Roadmap Scope



This phenomenon may widen or narrow the scope. For example, if only emissions related to housing operation were targeted, but a proposed new construction approach reduced both operating emissions, and embodied material emissions, the scope may increase to include these. Conversely, if a niche housing market

segment was deemed either statistically insignificant, too difficult to address due to remoteness, or disappearing through end-of-life obsolescence, the scope may narrow to exclude this type of housing.

Determining the emissions to be evaluated is a complicated process. Traditional quantification and reporting of emissions types is broken down into direct and indirect emissions (***see Sidebar***). Typically, the "reporting entity" is a single entity, such as a government or corporation who takes ownership of the emissions. When looking at a sector such as housing, the boundaries of ownership can be unclear, and therefore must be defined. There are a number of considerations for setting particular boundaries including overlap with other sectoral initiatives, the ability to measure impacts, the significance of impacts, or the relevance to stakeholders.

From an impact standpoint, it is typical for national housing emissions related to operating the houses to far exceed construction emissions. (**Figure 8**) shows the proportional difference in Canada.

Figure 7: Defining GHG Emissions

DEFINING GHG EMISSIONS

The Greenhouse Gas Protocol (GHG Protocol) is the most widely used international accounting tool for government and business leaders to understand, quantify, and manage greenhouse gas emissions

The GHG Protocol defines direct and indirect emissions as follows:

Direct GHG emissions are emissions from sources that are owned or controlled by the reporting entity.

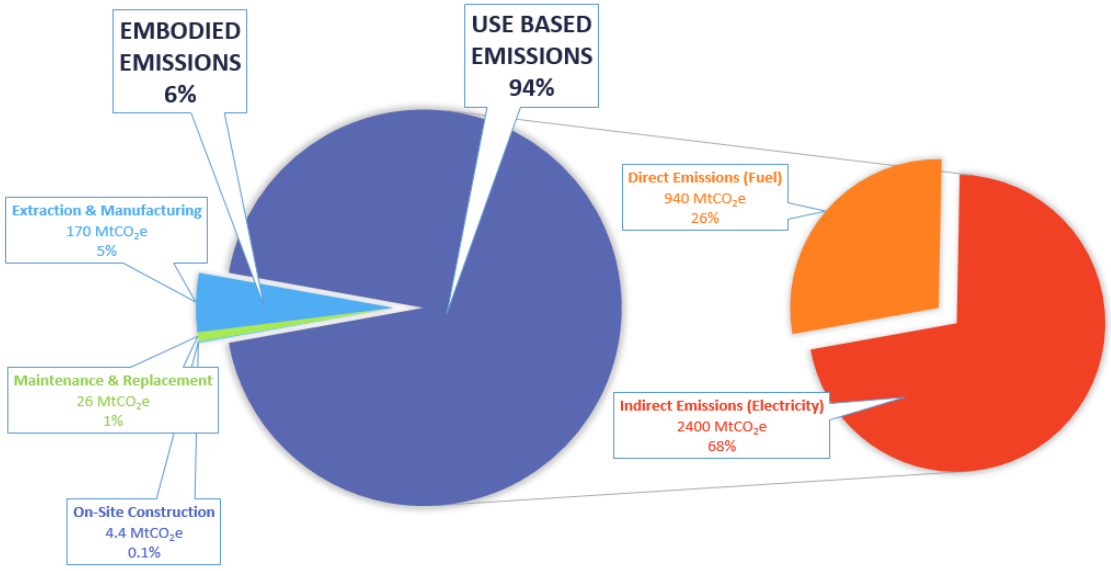
i.e. Fuel combusted on site

Indirect GHG emissions are emissions that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity.

i.e. Fuel combusted to produce purchased electricity, heat or steam

Source:
http://www.ghgprotocol.org/calculation-tools/faq

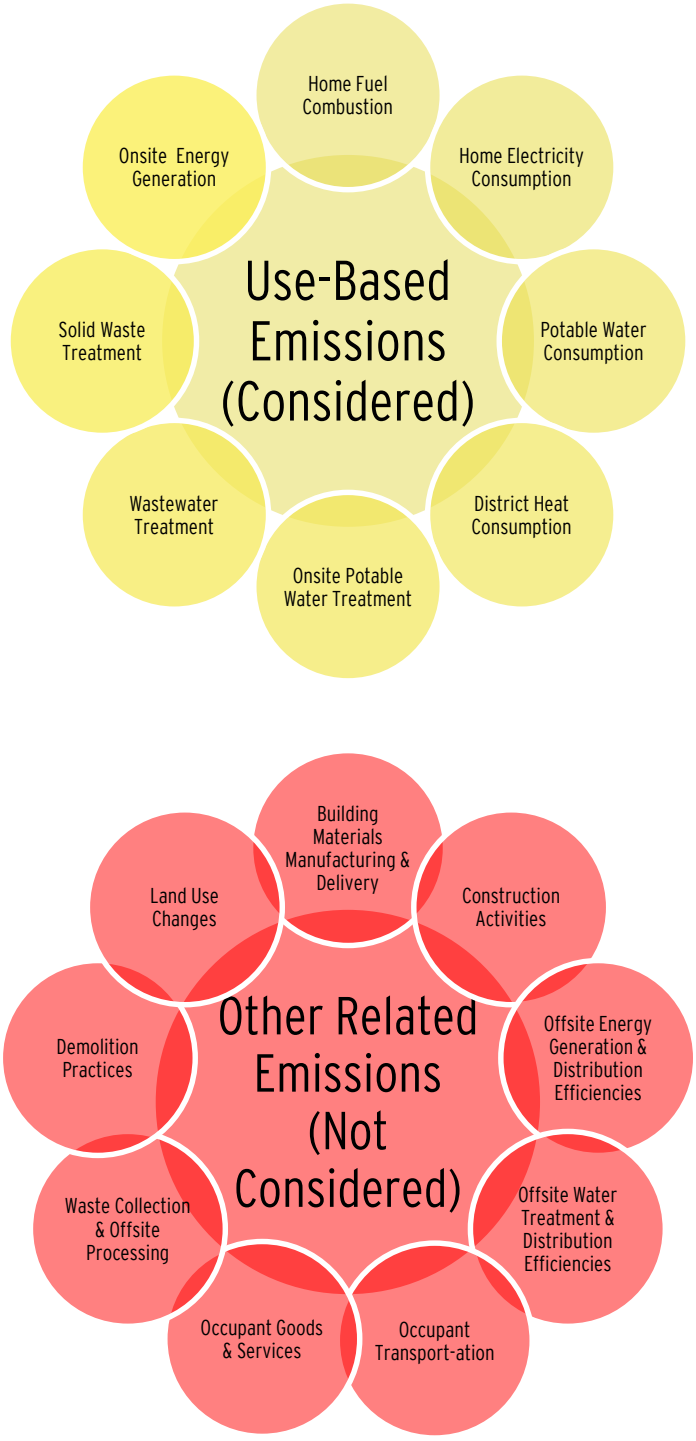
Figure 8: Projected Lifecycle Housing Emissions in Canada[17]



As such, the boundaries of housing may be drawn to exclude the embodied emissions as was done in Mexico (de Buen O. , 2009) and Peru (Lescano L, 2013). There are some exceptions for countries like Costa Rica which has an electricity mix sourced mainly from low-carbon sources (hydroelectric), and who wish to focus more on construction practices and material choice (Salas & Mendez, 2013). For the purposes of this paper, the more common use-based emissions boundaries chosen for the Canada-Mexico partnership will be used, as outlined in (Figure 9).

[17] Source: from chart *Projected Canadian Life-cycle Greenhouse Gas (GHG) Emissions by the Residential Sector during 2004-2025, by Life-cycle Stage & Structure/Activity during 2004-2025, by Life-cycle Stage & Structure/Activity* (Marbek Resource Consultants, 2007)

Figure 9: Housing Related Emissions Considered and Omitted under the Canada-Mexico Partnership[18]



[18] Derived from the Scope Definition for Low-Carbon Housing under the Canada-Mexico Partnership (ClimateCHECK, 2011)

Use-based emissions include all the activities that occur on the housing lot related to residential functions, beginning from the time that the building is completed or occupied (**Table 6**).

Table 6: Residential Use-Based Emissions Considered by the Canada-Mexico Partnership

Emissions Category	Source	Activities
Home Fuel Combustion:	Direct emissions of any fuel source (Wood, Gas, Dung, etc…) burned onsite.	Cooking, Heating, Waste Disposal, Generators
Home Electricity Consumption	Power plant emissions from generating electricity used onsite.	Appliances, Electronics, Lighting, Air Conditioning, Elevators, Fans, Pumps
District Heat Consumption	Heat plant emissions from generating heat used onsite.	Space heating, Water Heating
Potable Water Consumption	Water treatment plant emissions from potable water used onsite.	Cooking, cleaning, bathing, gardening
Clean Energy Generation	Subtracted from Electricity Consumption Emissions	Solar PV, Wind, Waste Heat
Onsite Potable Water Treatment	Subtracted from Water Consumption Emissions	Greywater, living machines, rainwater harvesting, wells
*Solid Waste Treatment**	Emissions from onsite waste decomposition or combustion.	Landfill, burning pits, litter
*Wastewater Treatment**	Emissions from onsite wastewater decomposition or combustion.	Composting toilets, outhouses

Solid waste and wastewater treatment may be omitted where municipal facilities exist and emissions reduction efforts are in place (Table 7**), but should be considered for inclusion where this is addressed onsite.*

What is not included are a number of emissions sources related to housing, that are either a small part of the total contribution, or may be addressed by other sectors, as well as transportation to and from the house, and the emissions related to the purchase and delivery of household goods, groceries, and services (**Table 7**).

Table 7: Housing Lifecycle Emissions Not Considered by the Canada-Mexico Partnership

Emissions Category	Emissions Reduction Sources	Rationale for Omission
Building Materials Manufacturing & Delivery	Process emissions from extracting, manufacturing and delivering building products and materials	Embodied emissions may be better addressed through extractive (mining/forestry), manufacturing, and transportation sector efficiency
Construction Activities	Energy use emissions from construction	Small percentage of total emissions, can be addressed through construction vehicle and equipment manufacturing
Offsite Energy Generation & Distribution Efficiencies	Power plant efficiency, new clean energy developments, and Distribution losses	Better addressed by the energy sector
Offsite Water & Wastewater Treatment & Distribution Efficiencies	Treatment plant efficiency, Leak prevention, methane capture	Better addressed through municipal infrastructure sectors
Occupant Transportation	Travel reduction, consumer vehicle fuel efficiency, public transit, walking, biking	Travel requirement and mode is better addressed through planning. Vehicle efficiency is better addressed through the automotive sector.
Occupant Goods & Services	Process emissions from extracting, manufacturing and delivering consumer products and services (Groceries, furniture, telecommunications, etc…)	Better addressed through the manufacturing, distribution, and retail sectors.
Waste Collection & Offsite Processing	Garbage truck efficiency, recycling programs, methane capture, waste-to-energy plants	Better addressed through the transportation and waste sectors.
Demolition Practices	Process emissions from the demolition of housing	Very small percentage of total impact. Hard to predict if and when housing will be demolished.
Land Use Changes	Preservation of greenfield sites, Tree Protection	Better addressed through planning, agriculture and forestry sectors.

Through the stakeholder conversations between Canada and the partner countries, this was selected as the preferred approach (ClimateCHECK, 2011) and was selected as the basis for the roadmaps. There are some drawbacks to this scoping, particularly in regions where electricity has a very low emissions factor, or where no active groups are addressing other emissions areas such as transportation, waste, or municipal infrastructure (**Table 8**).

Table 8: Benefits and Weaknesses of a Use-Based Emissions Scope

BENEFITS	
Simpler value chain	With use-based consumption you are dealing predominantly with the design, construction and operation of homes, excluding secondary industry groups such as manufacturing and transportation.
Clear boundaries	There is less confusion over attributing external GHG reductions such as power plant efficiencies or line loss reductions.
Often the largest source of emissions	Depending on the power source, operations is most often the largest source of GHG emissions related to housing.
Product emissions reductions can be addressed later	Product emissions may be a result of inefficient manufacturing or importing long distances due to minimal use. If new design recommendations indicate that this product reduces operating emissions then investment can be made to set up local manufacturing or invest in manufacturing efficiencies.
WEAKNESSES	
Clean energy source economies have a different distribution	Countries like Costa Rica which have a very high percentage of electricity generated from low-carbon hydroelectricity and low primary (fuel-burning) emissions will have much higher emissions from material inputs like steel and concrete, and residential transportation
Unintended externalities	If life-cycle emissions are not monitored you may unintentionally increase emissions. Take for instance investing in a new low-energy community which requires clearing rainforest lands, vs investing in existing building retrofits. The new houses may be lower emitting, but the land use change may offset that.
Doesn't account for durability	The longer a home lasts the greater the significance of operating emissions, however if we are not factoring in lifecycle emissions we may end up with short lived, efficient homes that greatly increase construction and demolition emissions.
Other sectors can "steal" emissions reductions	A major source of housing emissions are indirect emissions produced at the electricity or water treatment plants, and targeted through improved end-use efficiency. However if the plants reduce their process emissions, then the homes' indirect emissions factor also decreases, reducing the impact of efficiency measures.

Wherever the emissions scope for housing is set, the roadmap team should consider what mitigation efforts are occurring in sectors related to housing such as energy generation, transportation, and planning. Where there are active programs it is advisable that some level of discussion and coordination take place to delineate and manage the points of intersection and avoid double-dipping when attributing emissions reduction ownership.

ROADMAPPING PROCESS

STEP 3

Successful roadmap are built upon a clear understanding of how the housing market currently functions. Which aspects of the market support the development of low-carbon housing and which do not? How are houses currently built and used? What are the underlying market dynamics that influence housing design and market demand? Through a mix of market research and local expertise a shared understanding of the housing market can enable the roadmap development team to effectively identify what market strengths should be leveraged and where are interventions needed.

IN THIS SECTION:

Guidance and tools for gathering and organizing information about the current housing market.

HOUSING NAMA DEVELOPMENT PROCESS

6. UNDERSTANDING THE MARKET

> In most roadmapping projects it is essential for the participants to have an equal and effective understanding of the current status as a baseline for structuring activities and setting priorities. If such information is not available at the outset of the roadmap process, data collection and analysis should be developed as one of the initial roadmap activities and top roadmap priorities. **(Energy Technology Roadmaps: A Guide to Development and Implementation, IEA, 2010)**

Once the preliminary scope has been established, further strategic planning requires background information on the housing sector being evaluated. The characteristics of housing across the market, the specific emissions sources, and the housing sector value chain should all be considered. The following sections outline focus areas for establishing a good baseline understanding these important considerations for the low-carbon housing roadmap.

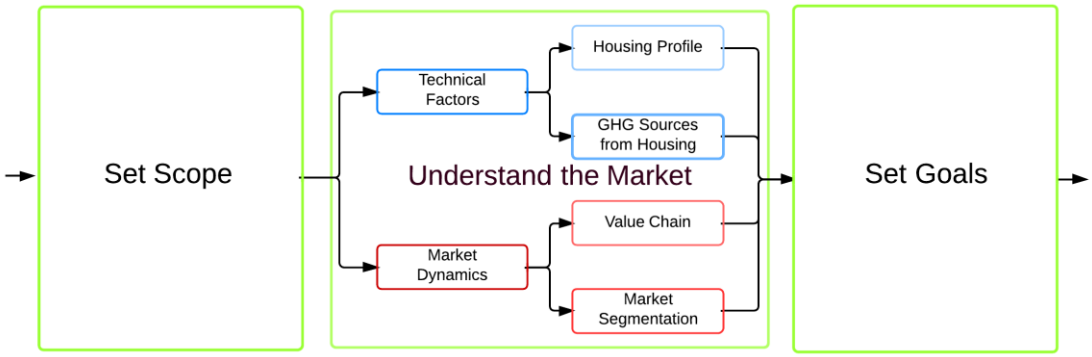
While it is desirable to have complete and representative information for all housing types and emissions sources, data gathering should be evaluated against maintaining project momentum (IEA, 2010). Different countries have a different capacity to provide accurate housing market information (UNFPA, 2014). Some of it may be readily available through a national housing census, previous government or academic reports, or through consultation with industry. In some cases, the data may be limited to certain building types (i.e. High rise residential) or geographic areas (i.e. major cities).

Where there are data gaps, countries can elect to conduct primary research, or make estimates from the data available and established best-practices. They may also choose to omit certain aspects from the overall project scope if the missing segments are estimated to be only a minor contributor overall to housing emissions.

Sections 6.1 and 6.2 outline strategies for low-carbon housing market analysis which may be conducted in parallel during the early stages of roadmap development. It is important to note that the findings of each project may inform the structure analysis of the others, so coordination and multi-stakeholder participation is strongly encouraged.

The first stage of a low-carbon housing roadmap begins by creating a shared understanding of the housing market as a system, to inform the later process of identifying opportunities to intervene in that system to reduce GHG emissions. The process is broken down into two focus areas. The first looks at the technical factors that influence housing emissions, and the second considers the underlying market conditions that define the housing sector (**Figure 10**).

Figure 10: Understanding the Market for Low-Carbon Housing



This should not be viewed solely as an academic exercise, but should be viewed as an opportunity to create a shared understanding between market stakeholders about the current state of the housing market and the underlying market mechanics. The Canadian team used a mix of methods including literature reviews, stakeholder interviews, commissioned research projects, and action research where stakeholders were involved directly in the definition and execution of the market research through participatory workshops. Collaborative models of market analysis used for international development, such as Participatory Value

Chain Analysis (**PVCA**), have shown that active stakeholder participation in the early stages of market development projects are more likely to be self-sustaining and face less stakeholder opposition (Bernet, Devaux, Ortiz, & Thiele, 2011).

> With broad participation, solutions to value chain constraints are generally more appropriate to the local setting, and when stakeholders understand and take ownership of the value chain development process they are more likely to remain actively engaged beyond the life of the project. **(USAID, 2009)**

It is understood that not all countries may pursue a participatory approach to roadmap development. Therefore, while the following outline of data gathering priorities can serve as a tool for participatory methodologies, it is equally applicable under different methodological approaches.

6.1 Technical Factors

Use-based housing emissions are the product of building envelope and equipment performance, energy source and occupant behavior, all of which can be greatly influenced by design choices and construction execution (Gill, Tierney, Pegg, & Allan, 2010). A strong understanding of the current housing stock will help to identify specific design challenges, execution problems, industry capabilities, consumer preferences, and priority target areas to be addressed in the creation of a low-carbon housing market transformation strategy. This can help to establish both current conditions, and the business-as-usual case for use in benchmarking emissions reductions.

6.1.1 Housing Profile

A summary of housing across the region can inform both changes to new construction practices and opportunities for retrofits. Housing at the national or regional scale can vary greatly (**Figure 11**), with each typology having different performance characteristics. A valuable exercise is the creation of housing archetypes that group together common design characteristics of housing. These archetypes can support

program segmentation as described in **Section 6.2.2**, and make stakeholder discussions more effective and accessible by creating a common language for communicating about local housing.

Figure 11: Diversity of Peruvian Housing Typologies[19]

Stilt Houses (Amazon)

Urban Barrios

Steel Frame Modular

Classic Quintas & Villas

Reed Houses (Lake Titicaca)

Rural Adobe

Urban Highrise

Urban Lowrise

Stone (Andes)

[19] Source: Peru Housing Archetype Research Template used by MVCS for Roadmap Development

Working with the idea of a housing archetype, there are several categories of information that are useful including the following:

Geographic information – By understanding where housing is located we can get a sense of what climate impacts it is facing, whether it is geographically concentrated or distributed which may impact program delivery, whether it has access to centralized infrastructure or whether it may have socio-economic boundaries such as being located in informal settlements, conflict zones, or have access to common goods and services.

Physical Characteristics – The way houses are built can help identify design inefficiencies, common elements across typologies, availability of materials, capabilities of the construction industry, and socio-cultural expectations.

Market Characteristics – Statistics on market size and growth can be used to prioritize housing typologies, understand market trends and the socio-economic conditions driving housing type selection.

Table 9 provides a sample worksheet for building a profile for each housing archetype. Housing or Construction Ministries, or local universities may already have local housing profiles or characterizations that can be used to complete this list. Another good source of information may be a national housing survey or census. However, not all countries will have accurate data (UNFPA, 2014), so this information may need to be augmented, assembled from other sources, or estimated.

Table 9: Housing Archetype Profile Template[20]

Type of Housing:	Name to identify the housing type
Description:	Provide a basic summary of the defining characteristics of the housing type
Geographic Information	
Climate Zones:	If the country has multiple climate zones, list the zones where this housing type is present?[21]
Regions:	In which political territories is this type of housing present?
Urban/Suburban/Rural	In which type of settlements is this type of housing found?
Market Characteristics	
Number of Buildings/Units:	Total Number of buildings and/or living units?
Annual Growth:	Is this type of housing currently being produced, static, or disappearing and at what rate?
Average Size of Building/ Unit: (m^2)	What is a typical dwelling size by floor area?
Average Housing Units per Building:	Are there multiple dwelling units in the building? And if so, how many is typical?
Average Occupancy:	What is the typical household size? (i.e. large families, small families, couples, singles, etc…)
Average Cost:	How much does this house cost to build and or purchase?
Construction	
Walls:	Typical wall construction method and materials
Roof:	Typical roof constructions, profile (i.e. flat, sloped) and materials
Windows & Doors:	Typical construction and materials
Space Heating:	What space heating methods are employed?
Ventilation:	What types of passive or mechanical ventilation are employed?
Cooling:	What space cooling methods are employed?
Lighting:	What types/quantities of lighting are used?
Water Source:	Where does potable water come from?
Water Heating:	What types of water heating methods are used (non-cooking)?
Cooking:	What types of cooking fuels are used?
Common Appliances & Electronics:	What types and quantities of appliances and electronics are typically found in this housing type?
Electricity Sources:	What is the source of electricity used? How is the electricity generated?
Fuel Sources:	What types of fuel are commonly used for combustion onsite and where do they come from?
Wastewater treatment:	How is wastewater and sewage typically handled?
Solid waste disposal:	How is garbage typically handled?

[20] This template is derived from sample developed with MVCS in Peru for their research and an integrated design charrette visioning form developed by Sustainable Buildings Canada for Canadian home builders participating in the Enbridge Savings By Design conservation program (Ranson, 2012) http://residential.savingsbydesign.ca/.
[21] This may be done through a system such as Köppen climate classification (Peel, Finlayson, & McMahon, 2007) or national classifications.

6.1.2 GHG Sources from Housing

Countries may or may not have either an established GHG inventory, or a framework for calculating housing related emissions. This information for housing related GHGs is important for prioritizing how to allocate resources and efforts, therefore some level of accurate emissions data collection or estimation will be required. This paper will not focus in detail on the method of calculating GHG emissions as there is much research specifically on this topic[22], however a summary of a GHG calculation formula is included in **Appendix C: Calculating Use-Based GHG Housing Emissions**.

With an understanding of GHG emissions from household activities, including the emissions factor[23] (EF) of utilities such as electricity and potable water in various regions of the country, impacts from different sources can be compared. With this insight, the roadmap team can ask a number of strategic questions to better understand what aspects of the housing market contribute the most to GHG production. This can be particularly insightful when combined with the housing archetypes to identify housing related GHG trends. A simple way of doing this is to create a cross-impact matrix of emissions variables for analysis as illustrated in **Table 10**.

This analysis will help the roadmap team target specific emissions causes and prioritize efforts to maximize impact.

[22] For information on establishing a GHG inventory, consult the IPCC Guidelines for National Greenhouse Gas Inventories: http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html

[23] An emissions factor is the amount of GHG emissions, typically calculated in tCO_2e per unit of the emissions source being measured (i.e. kWh of electricity, BTU of natural gas, or L of potable water)

Table 10: Cross Impact Matrix for Understanding Housing GHG Emissions

	Region	Housing Types	Household Activity	Energy Sources
Region:	*What regions produces the most total GHG emissions? Per Capita?*	What types of houses are common in these regions?	What household activities contribute the most to emissions in these regions?	What are the primary energy sources used in these regions?
Housing Types:	Where are the worst performing houses located?	*What housing types produce the most total GHG emissions? Per m^2? Per occupant?*	What household activities contribute the most to emissions in these houses?	What are the primary energy sources used in these houses?
Household Activity:	Where do residents produce the most emissions for a given activity?	What types of housing produce the most emissions for a given activity?	*What activities generate the highest total GHG emissions? Per use?*	What energy sources produce the most emissions for a given activity?
Energy Sources:	What region uses the most high-EF energy sources?	What housing types use the most high-EF energy sources?	What activities use the most high-EF energy sources?	*What energy types have the highest EF? Which are the most widely used?*

6.2 Market Dynamics

In addition to understanding the profile of housing and the technical factors that contribute to housing related GHG emissions, the roadmap development also needs to understand the dynamics of the housing market. There are many methods for mapping market activities and drivers to choose from. The objective of this research is to understand the underlying market conditions, why design choices are made, how stakeholders influence the process.

6.2.1 Value Chain

> The value chain describes the full range of activities that firms and workers do to bring a product from its conception to its end use and beyond. This includes activities such as design, production, marketing, distribution and support to the final consumer **(Global Value Chains Initiative, 2006)**.

A recommended process includes market-chain or value-chain analysis, which has extensive precedent in use as a tool for development (Kaplinsky & Morris, 2001; USAID, 2009). A modified version of the value chain template used by the Canadian team in Peru, Costa Rica and Mexico is covered in **section 6.2.1**. While value chain analysis may be conducted through literature reviews and interviews, some level of participation in completing the value chain analysis is highly encouraged. Methodologies include Participatory Market Chain Analysis (**PMCA**) or Participatory Value Chain Analysis (**PVCA**) adapted for use by organizations such as Practical Action[24] out of the UK (USAID, 2009).

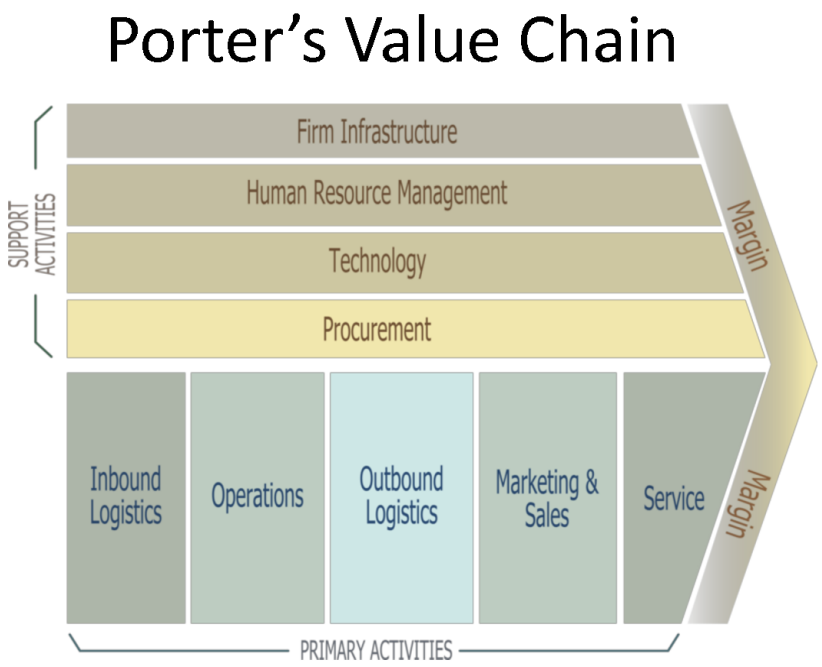
PMCA/PVCA approaches have been extensively implemented in the development of agriculture sectors[25], including successful implementation by Papa Andina in Peru. The organization used a PMCA approach to support market transformation of the potato industry, leveraging local insight and participation to create strong economic development programs for local farmers while respecting local socio-cultural conditions (Bernet, Devaux, Ortiz, & Thiele, 2011). These principles may be widely transferable to the housing sector in developing countries that have high numbers of "informal housing" built by small independent builders who comprise an important part of the housing value chain (Wells, 2007).

Value chain maps are a useful tool for understanding market complexity and providing the comprehensiveness that is required when evaluating a plethora of market intervention opportunities. They

[24] http://practicalaction.org/
[25] For an extensive review of value-chain analysis methods used in agroforestry see: (Nang'Ole, Mithofer, & Franzel, 2011)

can serve as a tool for cataloguing important attributes, relationships, processes, actors and constraints. They also serve to enhance "Market Literacy" to help participants take more strategic and insightful actions (Albu & Griffith, 2005).

Figure 12: Classic Value Chain described by Michael Porter26



Value chains are particularly useful for describing the sub-sector activities linked through market relationships throughout the production process (Nang'Ole, Mithofer, & Franzel, 2011). Traditionally value chains focused on value derived through supply chain management of individual firms (Harwich & Kormawa, 2009). The classic example was developed by Harvard's Michael Porter whose value chain model (**Figure 12**) was comprised of ***primary activities*** which contribute directly to add value in the production of goods and service, and ***support activities***, which indirectly influence the final value of the product (van Tilburg, Bristow, Röser, Escalante, & Fekete, 2013).

[26] (Porter, 1985)

Over time, value chain analysis was adapted to describe market value creation activities outside the individual firm, including market clusters, and later sectoral actors (Harwich & Kormawa, 2009). In taking a sectoral look at low-carbon housing, we wish to understand the activities which impact the emission of GHGs for the duration of a home's operational life.

As discussed earlier, the production of use-based GHGs from housing is a factor of design decisions, construction execution, and occupant behavior. As such the set of primary activities for the housing sector should begin with an entry point where choices begin to affect housing emissions and end when use-based emission end. In this case the value-chain begins with the planning of a housing development and ends when the house is demolished. The distinct stages of this process represent the Primary Activities (**Table 11**).

Table 11: Primary Activities in the Low-Carbon Housing Value Chain

Primary Activities	Select Impacts on Use-Based Emissions
Planning	*Where the building is located influences the need for climate control (heating/cooling), the infrastructure EFs, and access to building materials and products.*
Design	*Design influences the heating & cooling loads, appliances and equipment selected, and ease of operability.*
Construction	*The construction methods and execution influence building envelope performance and equipment operation.*
Sales	*New home sales influence consumers' choices of home type, appliances and equipment, and can influence the homeowners' knowledge of operational requirements.*
Operations	*How the home is operated and maintained influences energy & water consumption, equipment performance, ongoing appliance and equipment selection, and waste and waste water generation.*
Re-Sales	*The transfer of home ownership can influence the knowledge of operational requirements and the termination of non-transferable incentives and equipment leases.*
Retrofits	*Retrofits, renovations and additions can influence the base performance levels of the home through changes to physical space and equipment.*
Demolition	*Demolition requirements can influence emissions by limiting materials and equipment eligible for use in a region.*

While each of the primary activities has a relatively distinct beginning and end, a second set of activities influence the nature and performance of housing throughout the value chain. These support activities are listed in **Table 12**.

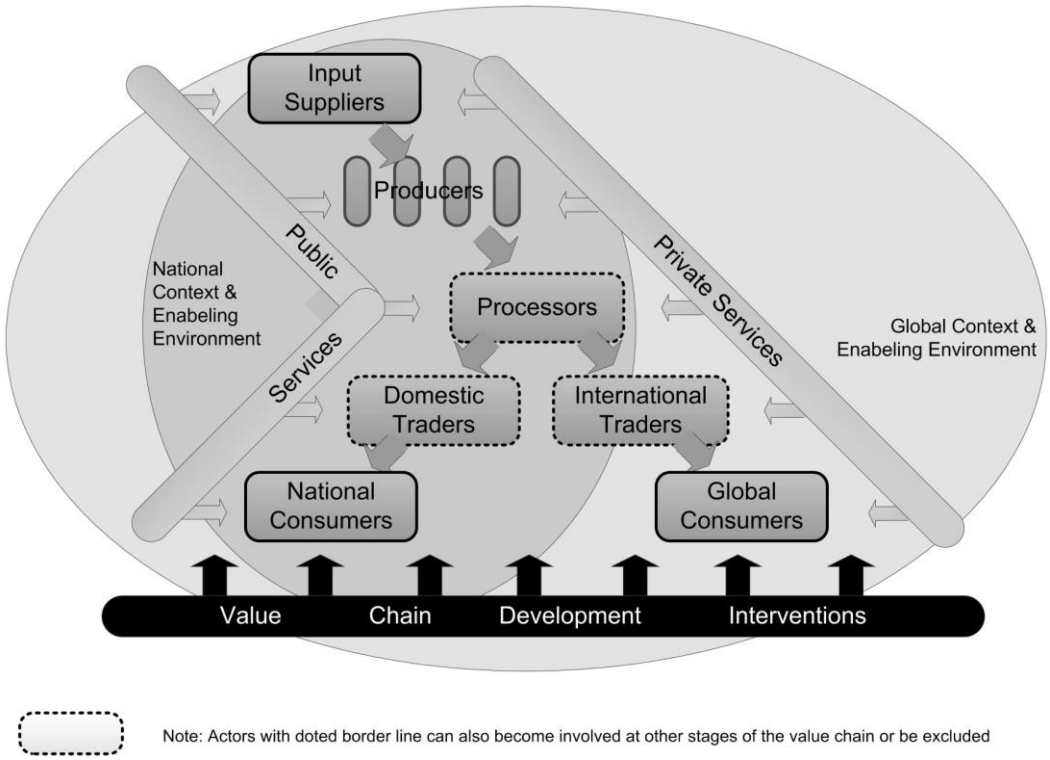
Table 12: Support Activities in the Low-Carbon Housing Value Chain

Support Activities	Select Impacts on Use-Based Emissions
Energy & Infrastructure	*The availability, cost and reliability of infrastructure connection influence design decisions, equipment choices, and consumer behaviours.*
Labour	*The capacity and expertise of labour influence the execution of design concepts, the ability to properly maintain a home and the cost of construction.*
Procurement	*Procurement networks influence the ability to access materials and equipment for building and operating homes.*
Technology	*The status of technology influences the performance and controllability potential for residential equipment.*
Regulation	*Regulations may influence physical home size, construction methods, material use and infrastructure connection.*
Financing	*Financing influences developer choices and purchasing decisions including material, appliances, and equipment,*

More recently value chains have been used to support the innovation systems approach "which focuses on the building of individual and collective competences among value chain actors in networks of knowledge exchange and technological development and the importance of institutional and policy frameworks which create the enabling environment (Harwich & Kormawa, 2009)."

These "Enabling Environments" and global and national contexts (**Figure 13**) are relevant to the sectoral approach which considers policy, social, and fiscal market drivers to sector activities (EuropeAid, 2007).

Figure 13: Map of Generic Value Chain for Industrial Development[27]



To address this, a third section in the value chain template is required to gather information about macro conditions that impact the housing market. Furthermore, an attempt was made to look not only at how these macro conditions affect the housing market today, but also conduct some forward looking analysis to explore how they might shape housing in the future.

A Foresight method such horizon scanning can be useful in addressing the emerging and potential issues in an integrated way (van Rij, 2010). One common framework used in both horizon scanning and current analysis is STEEPV, standing for Social, Technological, Economic, Ecological, Political and Values, which attempts to capture major themes (**Table 13**) to be used as a guide in the investigative process (Loveridge, 2002).

[27] Source: (Harwich & Kormawa, 2009)

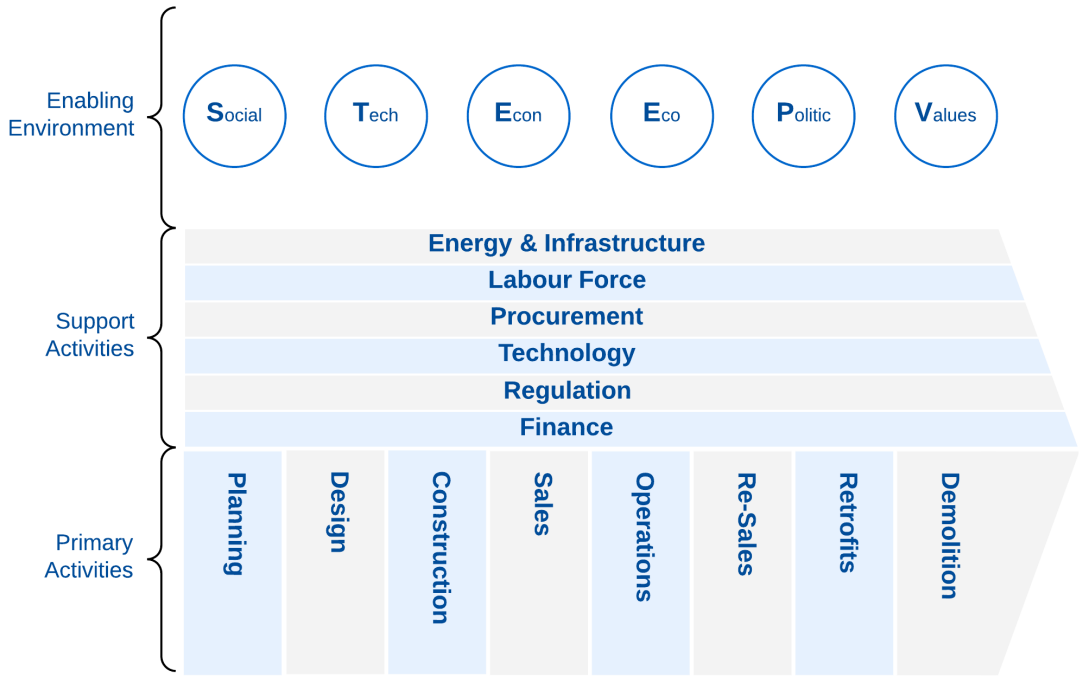
Table 13: STEEPV Categories Descriptions for a Low-Carbon Housing Value Chain

S	Social Including: public health issues, demographics, education
T	Technological Including: changing construction methods, new housing technologies, building performance information systems…
E	Economic Including: income levels, home costs, GDP…
E	Ecological Including: natural resources, climate, environmental health
P	Political Including: housing policy, codes, licencing
V	Values Including: household composition, lifestyle expectations, traditions

In the development of the low-carbon housing value chain, a third section based on STEEPV provides an excellent structure for describing key attributes of the enabling environment. Combined with the primary and secondary activities, a complete low-carbon housing value chain template (**Figure 14**) can be used as a guide for preliminary research, stakeholder discussions and mapping the value chain.

For each STEEPV category, the team should explore both current conditions and future conditions as drivers of the housing market. For example, under "Political" if current building codes are not enforced then that may be a driver of low quality and unsafe housing. It may be beneficial to further segment drivers into housing "demand" drivers, and "supply" drivers to distinguish between the impact of drivers on what housing is wanted, and what is provided.

Figure 14: Low-Carbon Housing Value Chain Framework



Working with the Value Chain Map

The value chain map can be used as a tool for understanding the entire housing market or portions thereof as based on the segmentation analysis that will be discussed in **Section 6.2.2**. The following set of questions (**Figure 15**) may be used to guide to completion of the value chain map(s).

Though not necessary, it is strongly encouraged to include value chain stakeholders directly in the process of completing this map as a basis for roadmap development to ensure that it is both thorough and representative (Bernet, Devaux, Ortiz, & Thiele, 2011).

Figure 15: Low-Carbon Housing Value Chain Questionnaire

Primary Activity Questions – For each activity answer:

- What are the sub-activities taking place?
- What is the current practice?
- Who is involved?
- How is value created for the stakeholders?

Supporting Activity Questions – For each activity answer:

- How does the supporting factor impact each Primary Activity?
- What is the current practice?
- Who is involved?
- How is value created for the stakeholders?

Enabling Environment Questions – For each STEEPV section answer:

- What are the current conditions?
- How do they influence current housing supply?
- How do they influence current housing demand?
- What trends/signals observed?
- How might they influence future housing supply?
- How might they influence future housing demand?

The completed value chain map combines the primary activity areas that impact use-based housing emissions and the STEEPV environmental enabler categories to create a robust picture of the housing market as a system. This framework can and should be used in conjunction with the housing archetypes and emissions profiles to better understand the specific actions and drivers that influence residential GHG emissions.

6.2.2 Market Segmentation

The last step before setting goals and generating solutions is to identify possible market segmenting approaches. Housing market segmentation is often used for "price prediction, formation of appropriate marketing strategy and for understanding housing market structure (Islam & Asami, 2007)." In their review of

housing segmentation methods, Islam and Asami (2007) outline a number of schools of thought for identifying housing submarkets in order to develop a more detailed understanding of housing market dynamics. These include:

- Types of housing
- Housing Attributes/Components/Equipment
- Quality of housing
- Geographic area
- Price of housing
- Occupant incomes
- Ethnicity & racial segregation

In the case of a low-carbon housing roadmap, submarkets may play an important role in program targeting and implementation by identifying unique opportunities and challenges not present across the housing market as a whole. Such strategic approaches may include financial programs for certain economic housing categories, technologies targeted to regional climate conditions, or program delivery in densely populated areas.

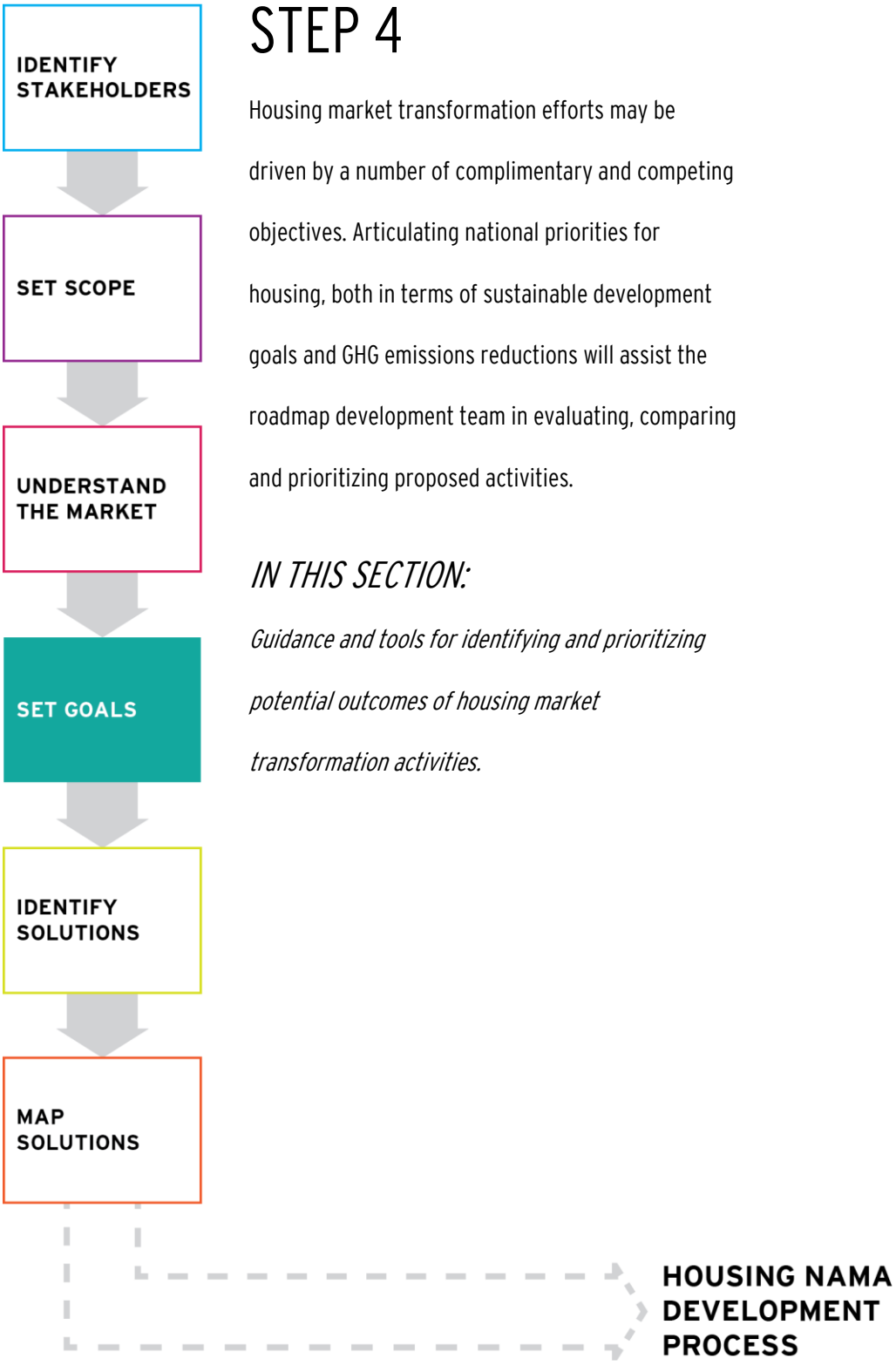
Table 14 is a tool for evaluating different segmentation strategies, and provides a rationale for that potential segmentation strategy.

Table 14: Low-Carbon Housing Segmentation Strategy Worksheet

SEGMENTATION	*RATIONALE*	*What Might Segmentation Look Like?*
Geographic	*Geographic areas may be segmented due to regional capacity differences, access to infrastructure, density, remoteness, etc…*	
Political	*Political support or authority may vary across the region, impacting policy and regulatory approaches.*	
Climate	*Varying climate zone may result in fundamentally different housing types, components, and needs.*	
Income	*Household income may significantly influence how houses are built and operated and which solutions are affordable.*	
Formal/Informal	*Differences in the regulatory oversight of housing may result in varying housing qualities and regulatory intervention opportunities.*	
Urban/Rural	*Urban and rural housing may have differing needs due to access to services and infrastructure, density of housing, and household activities.*	
Components	*Certain pervasive equipment types/building elements resulting in high emissions may justify targeted programs.*	
Public/Private	*Public and private financing of housing development can result in differences in building attributes, market drivers, and leverage for enforcing performance improvements.*	
Building Type	*Different building types (i.e. high rise vs. low rise) may have significant technical and market differences.*	
New/Existing	*Reducing emissions in new construction and existing buildings may require different technological, fiscal, and programmatic solutions.*	
Energy Sources	*Programs may be targeted at homes that use particularly high Emission Factor Energy Sources.*	
Cultural	*Cultural variations can impact household behavior, engagement opportunities, and socio-economic conditions.*	

Photo 6: Concrete blocks going up at a new housing development in San Jose Costa Rica

ROADMAPPING PROCESS



STEP 4

Housing market transformation efforts may be driven by a number of complimentary and competing objectives. Articulating national priorities for housing, both in terms of sustainable development goals and GHG emissions reductions will assist the roadmap development team in evaluating, comparing and prioritizing proposed activities.

IN THIS SECTION:

Guidance and tools for identifying and prioritizing potential outcomes of housing market transformation activities.

7. GOALS AND CO-BENEFITS

Moving from market understanding to roadmap strategy development requires the establishment of goals for emissions and sustainable development co-benefits such as social, health, economic or broader environmental outcomes.

Emissions goals may be dictated by an existing national climate change strategy which provides sectoral targets, or may be determined through the roadmap development process. Targets may be stated as either an overall emissions reduction (total housing emissions), and intensity goal (emissions per home), or may focus on specific attributes of the housing sector (i.e. 50% reduction in emissions from wood burning used for cooking).

The concept of co-benefits is an important requirement of the roadmap to ensure that emission reduction efforts are delivering on sustainable development goals. This is also a requirement for compatibility with a future housing NAMA. NAMAs take a 'sustainable development first' approach, whereby the sustainable development benefits are equally important to the mitigation efforts. This is a shift from the CDM program where emissions reductions were primary and co-benefits were secondary (Olsen, NAMAs for Sustainable Development, 2013). As such the roadmap places co-benefits as a central evaluation criteria of any strategic analysis. This involves both identifying sustainable development criteria relevant to housing, and prioritizing those criteria that most support the "Nationally Appropriate" intention of the NAMA mechanism.

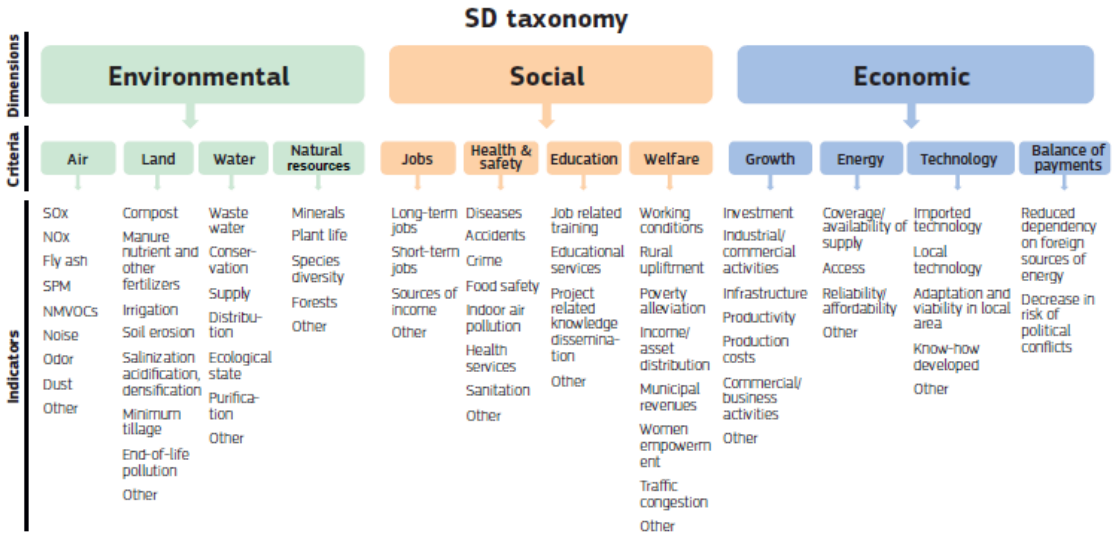
Photo 7: Exploring Market Drivers for Low-Carbon Housing in Mexico

While there is no universally accepted[28] methodology to assess the sustainable development co-benefits of NAMAs (Olsen, Sustainable Development Impact of NAMAs, 2013) there are a number of existing methodologies which can be used as a starting point. These include existing national sustainable development frameworks and international models such as those advocated for by ICLEI (2014) to track sustainable development performance metrics. The most relevant of these organizational taxonomies is the CDM sustainable development Reporting Tool under development and available online by the UNFCCC. Their structure, illustrated in **Figure 16**, uses a classic "triple bottom line" architecture of environmental, social and economic issue categories. Similarly, the Centre for Clean Air Policy (**CCAP**) has produced a NAMA sectoral evaluation matrix[29] for evaluating co-benefits which is also broken down into the triple bottom line categories (Cerqueira, Davis, & Winkelman, 2012).

[28] The UN is working to develop at set of international Sustainable Development Goals. The project is active online at http://sustainabledevelopment.un.org/index.php?menu=1565

[29] The matrix is useful tool available in the CCAP report MRV of NAMAs: Guidance for Selecting Sustainable Development Indicators http://www.ccap.org/docs/resources/1143/MRV-of-NAMAs-Guidance-for-Selecting-Sustainable-Development-Indicators_CCAP-Oct-2012.pdf

Figure 16: The CDM Sustainable Development taxonomy[30]

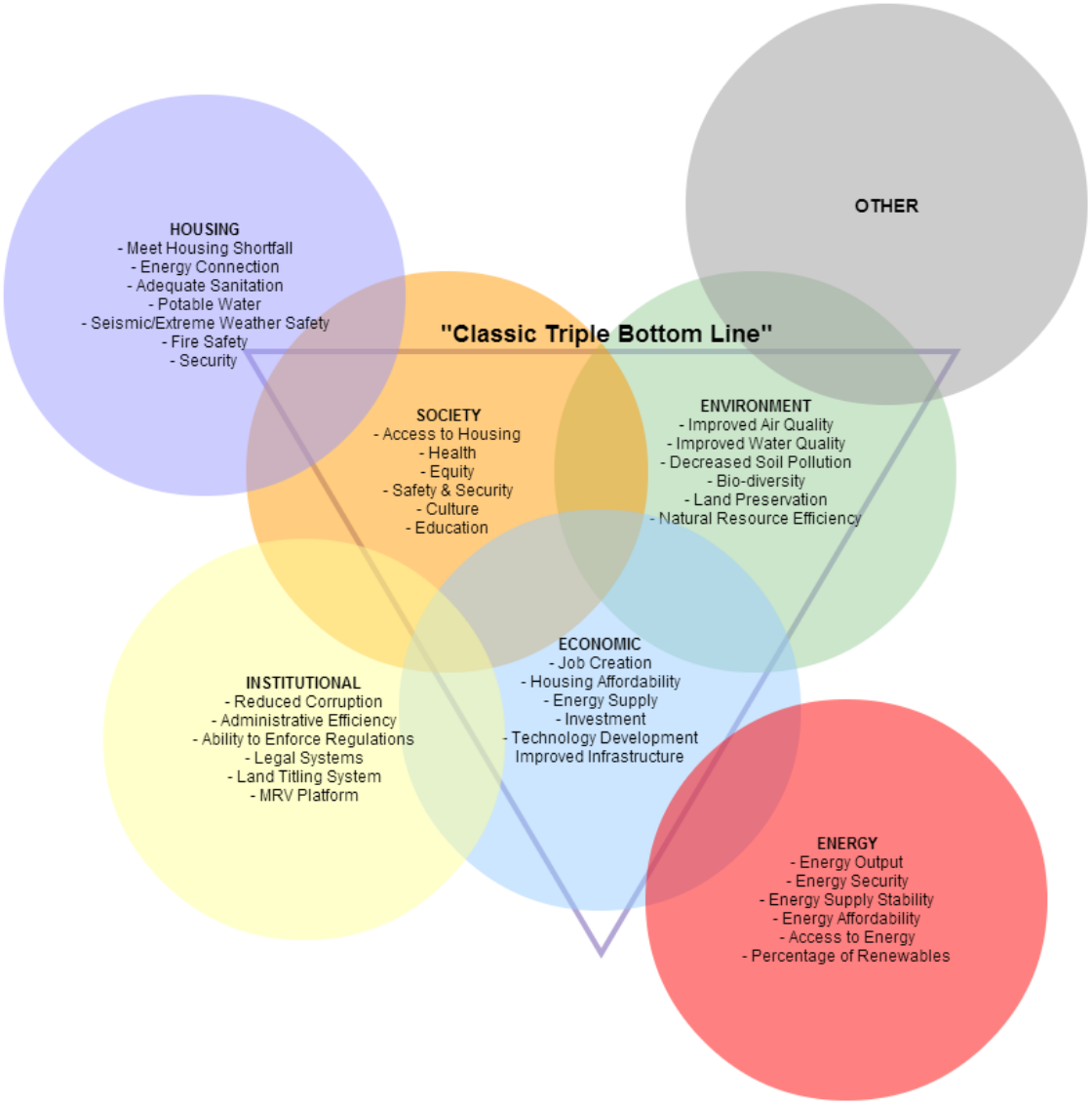


Within any taxonomy of sustainable development benefits is a set of categories proceeded by a set of generic criteria and indicators which are designed to leave flexibility for the selection of nationally appropriate measurement, reporting and verification (**MRV**) methods.

Countries may wish to subdivide the high level categories into smaller categories or add others such as "institutional" which speaks directly to changes in governance and administration (Olsen, Sustainable Development Impact of NAMAs, 2013). In working with Costa Rica, Peru and Mexico, Environment Canada commissioned co-benefits workshops and studies for each country in order to quantify the potential of a housing NAMA to provide co-benefits, and categories of housing, energy, health, environment, and economy were selected (de Buen, Navarro, Cuevas, & de Buen, 2013; 2013; 2013).

[30] Source: From the draft CDM SD Reporting Tool (UNFCCC, 2012)

Figure 17: Triple Bottom Line and Expanded Frameworks for Co-Benefits



Once a structure is set for the top-level co-benefit categories, specific criteria, indicators and metrics must be selected (**Figure 18**). In their evaluation matrix CCAP provides a useful set of guiding questions to determine if a specific metric is both appropriate and implementable as a determinant of sustainable development Co-Benefits for the purposes of a NAMA (**Figure 19**).

Figure 18: Sample Breakdown of a Sustainable Development Benefits Taxonomy

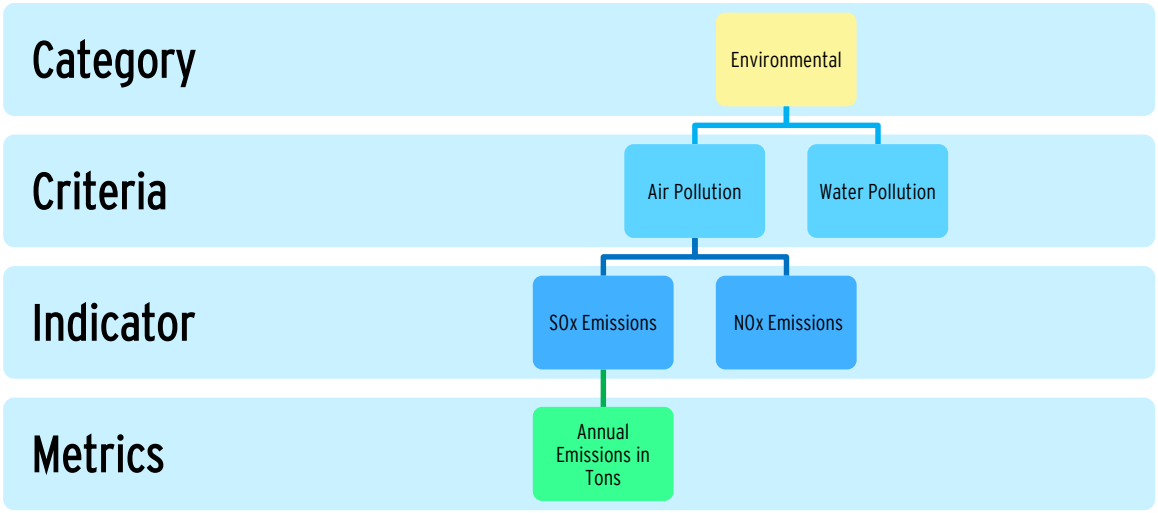


Figure 19: Evaluating Sustainable Development Co-Benefit Metrics[31]

- **Does the metric align with national sustainable development priorities?**
- **Will tracking the metric help build domestic political and/or financial support?**
- **Are the data already collected, or can it be collected at a reasonable cost?**
- **Can the data be collected with reasonable assurance of accuracy?**
- **Will the metric facilitate aggregation across policies and/or comparisons within or across sectors?**
- **Does the metric align with development interests of prospective contributing countries or institutions?**

Typically a country will establish sustainable development criteria nationally as a reference for all prospective NAMAs. Since not all of these sustainable development criteria will be impacted by every NAMA,

[31] Source: (Cerqueira, Davis, & Winkelman, 2012)

different sectors can be evaluated against the criteria list to identify which are relevant to each sectoral NAMA and which metrics will be required for measurement, reporting and verification of NAMA co-benefits. **Table 15** presents a visual tracking tool similar to the CCAP evaluation matrix which could be used to correlate sustainable development co-benefits to NAMA sectors and establish a co-benefits list for the low-carbon housing roadmap.

Table 15: Correlating sustainable development Benefits to NAMA Sectors

		NAMA Sectoral Focus						
	Unit	Housing	Reforestation	Public Transportation	Landfill	Renewable Energy	Manufacturing EE	Agriculture
Environmental								
Environmental Criteria 1		X				X		
Environmental Criteria 2			X		X	X	X	
Environmental Criteria 3		X		X				X
Social								
Social Criteria 1					X			X
Social Criteria 2		X			X	X		
Social Criteria 3			X	X			X	
Economic								
Economic Criteria 1			X				X	X
Economic Criteria 2		X				X		
Economic Criteria 3				X	X		X	

7.1 Weighting Co-Benefits

Once the criteria and metrics for the housing sector sustainable development co-benefits are identified, they may be prioritized which will help with the future evaluation of market transformation solutions. Choosing between alternate co-benefits can be difficult in the moment when evaluating competing solutions. Therefore it is recommended to create a weighting of co-benefits in the early roadmap stages to

prevent future conflicts, and to do it as part of the stakeholder discussions to ensure broad support moving forward.

Table 16: Weighting Sustainable Development Co-benefits

Environmental	Weighting
Environmental Criteria 1	1 – 10
Environmental Criteria 2	1 – 10
Environmental Criteria 3	1 – 10
Social	
Social Criteria 1	1 – 10
Social Criteria 2	1 – 10
Social Criteria 3	1 – 10
Economic	
Economic Criteria 1	1 – 10
Economic Criteria 2	1 – 10
Economic Criteria 3	1 – 10

Table 17: Sample of Weighted Co-Benefits

Environmental	Weighting
Reduce urban smog related to fuel combustion	8
Reduce deforestation from fuel wood gathering	7
Reduce water pollution from inadequate sanitation services	4
Social	
Improve structural safety of houses	9
Increase access to housing	7
Improve indoor air quality	8
Economic	
Promote job creation	9
Use locally manufactured goods	7
Reduce housing production costs	6

ROADMAPPING PROCESS

STEP 5

Achieving sustained housing market transformation will require a number of parallel coordinated activities targeting different functional areas within the sector. A structured ideation process will facilitate the generation of potential solutions and ensure that major functional areas are not missed. A strong organization framework also helps to build focused teams and programs around specific issues in support of housing market transformation.

IN THIS SECTION:

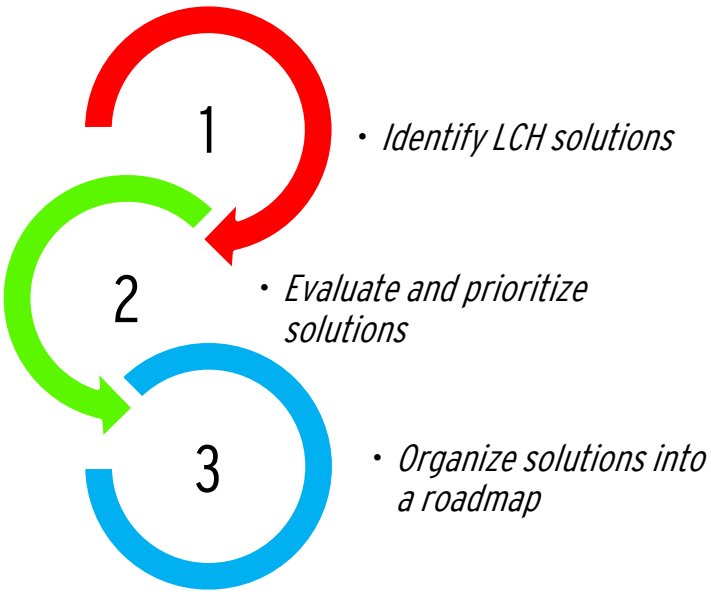
Guidance and tools for exploring market transformation opportunities across all major activity areas within the housing market.

8. MARKET TRANSFORMATION SOLUTIONS

The development of a low-carbon housing roadmap begins with a simple question: "How might we reduce the GHG emissions that result from housing, while meeting our sustainable development goals?" The answer is much more complex as solutions may come from many sides of the housing sector, and multiple, parallel activities are required to support sustained market transformation. The practice of roadmapping is a means to organize the complexity of the transformation process by exploring and communicating the relationships of technologies, markets and program efforts over time (Moehrle, Isenmann, & Phaal, 2013). Simply put, the roadmap outlines ***where we are***, ***where we want to be*** and most importantly ***how do we get there***.

There are three primary steps to developing the low-carbon housing roadmap that may be implemented in an iterative fashion over the several weeks or months:

Figure 20: The Three Stages of Roadmap Development



8.1 Identifying Low-Carbon Housing Solutions

In February 2012 Peruvian experts from government, academia and the private sector were invited to participate in a workshop in Lima along with international experts and a facilitation team from Environment Canada to identify opportunities for emission reduction in the housing sector. When this first roadmap development meeting was held, there was no structure as yet to the roadmap. Through the process of ideation and iteration, a framework for organizing housing sectoral efforts emerged. When used as a starting point it can accelerate the ideation process and ensure the comprehensiveness of the issues covered.

The workshop started with some background information presented by MINAM and MVCS (Peru's Ministries of the Environment and of Housing, Construction and Sanitation respectively) on the current conditions of the market and housing related emissions. Informed by preliminary market research and value chain analysis the group was lead through a SWOT analysis exercise to generate possible low-carbon housing projects and working areas.

Table 18: A Simple SWOT 2x2 Matrix for Low-Carbon Housing

What factors of the housing sector impact the ability to reduce housing related emissions?	
Strengths: What factors are supportive?	Weaknesses: What factors are not supportive?
Opportunities: What factors might improve abilities?	Threats: What factors might worsen abilities?

SWOT analysis is a simple tool to identify the Strengths, Weaknesses, Opportunities and Threats related to a particular effort, in this case the capacity of the housing market to produce low-carbon housing. This is particularly useful as a workshop tool because it is easy to understand and doesn't require advance computation to assist in the analysis process (Ghazinoory, Abdi, & Azadegan-Mehr, 2011).

Photo 8: Applying card sorting to SWOT analysis for the Peru Low-Carbon Housing Roadmap

Following the SWOT activity, an open card sort method[32] was used to group factors into themes for further research and exploration based on common characteristics such as content focus, or stakeholder involvement. The categories included communications and education, technical design, policy and finance.

There were challenges in applying such an open process to such a vast and complex system like a national sector. The group experienced challenges generating ideas, and there were notable gaps in the solutions generated. This raised a number of questions:

Where do you start?

When do you stop?

How do you know if you missed something big?

[32] The OPEN card sort method has no pre-defined grouping categories. The ideas are grouped together based on similarity factors chosen by the participants and then the categories are labelled. For more info visit: http://www.usability.gov/how-to-and-tools/methods/card-sorting.html

While SWOT is a useful generating tool, its dependability for generating the scope of contextual solutions is limited due largely to the complexity of the system being explored (i.e. housing). The result is often an incomplete picture, with gaps in some areas, and either excess or insufficient emphasis on individual factors (Ghazinoory, Abdi, & Azadegan-Mehr, 2011). In analyzing the weaknesses of SWOT applications, George Panagiotou (2003) pointed out that in highly complex systems "the open nature and unstructured method of SWOT offers little help to users. Planners are left without indication as to where to search for such variables, or what to do after finding them in terms of how best to incorporate them in strategy formulation."

One approach to deal with complexity using SWOT is to ***use the focus areas up front*** instead of categorizing into focus areas at the end (Panagiotou, 2003). Well defined and comprehensive focus areas that represent all primary activity areas in the housing market can be used to prompt new ideas, ensure that areas aren't forgotten, and organize results more effectively.

To identify the right focus areas for the low-carbon housing roadmap, the SWOT analysis results from each of the three countries were combined with factors identified through a scan of other international housing market transformation programs. This new broader list of factors were again put through an open card sorting process to come up with **ten primary focus areas** for low-carbon housing market transformation (**Table 19**).

Table 19: Ten Primary Focus Areas for Low-Carbon Housing Market Transformation

1. Localized Building Approaches	*The design of homes, including physical characteristics, materials and technologies to reduce emissions while meeting the needs of the local communities and climate.*
2. Performance Verification	*The frameworks, tools and institutions to assess performance of homes related to emissions and co-benefits.*
3. Finance	*The financial tools and systems to create viable economic drivers in support of low-carbon housing.*
4. The Public	*The public awareness of, demand for, and capability to manage low-carbon housing and low-carbon home activities.*
5. Industry Capacity	*The industry ability to design, construct and support low-carbon housing.*
6. Policy	*The political mandate, vision and legislation to permit, encourage, and enforce low-carbon housing.*
7. Legal	*The legal processes and contractual frameworks to manage risk, ownership and liability around low-carbon housing.*
8. Infrastructure Integration	*The interface with housing related infrastructure to maximize home level emission reduction potential.*
9. Procurement	*The availability and affordability of materials and technologies to support low-carbon housing.*
10. Mobilization & Leadership	*The coordination, promotion and mobilization of stakeholder activities in support of low-carbon housing.*

By applying SWOT analysis to each area of focus (**Table 20**), ideas are prompted more readily, the breadth and depth of the factors identified are improved, and significant gaps are avoided.

Table 20: Adding Focus Areas to SWOT Analysis

AREAS OF FOCUS:	1. Localized Building	2. Performance Verification	3. Finance	4. The Public	5. Industry Capacity	6. Policy	7. Legal	8. Infrastructure Integration	9. Procurement	10. Mobilization & Leadership
Strengths										
Weaknesses										
Opportunities										
Threats										

With the SWOT factors assembled under each area of focus, the group can now begin to identify potential solutions. To make this process more manageable, sub-committees may be formed to address one or more area(s) of focus. Solutions are presented by responding to four questions:

I. How might we enhance our Strengths?

II. How might we address our weaknesses?

III. How might we seize opportunities?

IV. How might we mitigate threats?

Table 21: Identifying Low-Carbon Housing Solutions from SWOT Analysis

	EXAMPLES (Area of focus = Industry capacity)
How might we enhance our strengths?	**Strength** – Strong network of accredited trade schools **Solution –** Develop a low-carbon housing construction curriculum
How might we address our weaknesses?	**Weakness** – High level of informal housing built by unskilled labour performs poorly **Solution** – Develop an affordable housing kit for informal builders which addresses major emission sources
How might we seize opportunities?	**Opportunity** – A major manufacturer is introducing a new energy efficient technology **Solution** – Partner with the manufacturer to train builders on proper installation
How might we mitigate threats?	**Threat** – An increasing number of unregulated, poorly performing, low-cost building products are flooding the market **Solution** – Develop a product certification program to help builders identify quality products.

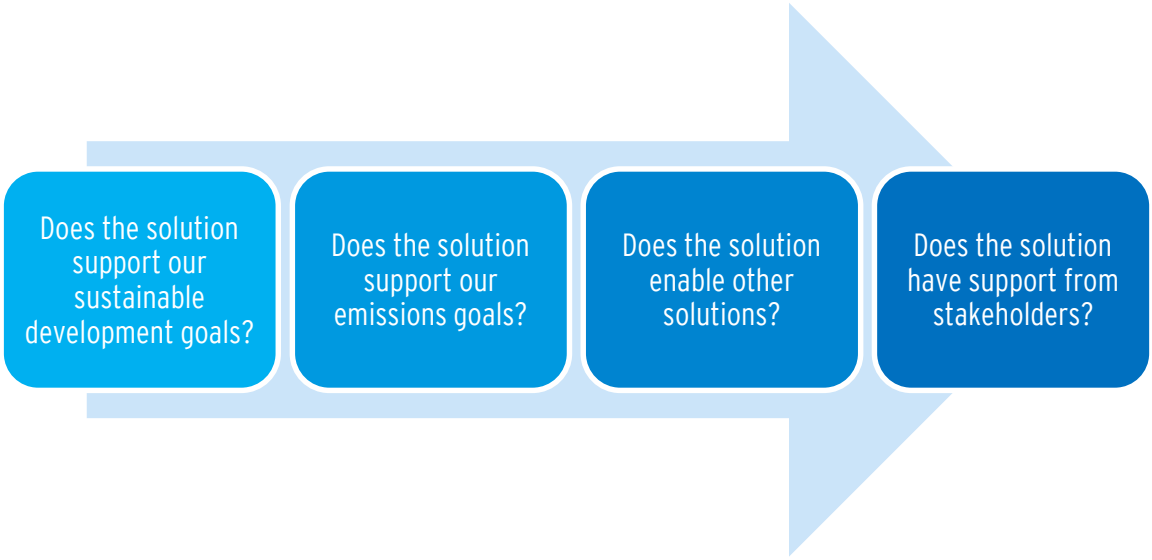
8.2 Evaluating Low-Carbon Housing Solutions

Now that the team has a list of solutions, they must be evaluated and prioritized. It is important to recognize that the solutions that have broad stakeholder support are the most likely to be successfully implemented. Emphasizing continued dialogue is critical through the evaluation period. One approach taken by the Canadian team was to host forums with both local and international experts to explore specific focus area solutions in detail. These sessions included low-carbon housing design charrettes[33], a four nation low-carbon housing finance forum and national policy forums.

Photo 9: A Low-Carbon Housing financing forum convened by Canada, Costa Rica, Mexico and Peru

[33] See for details on integrated design charrettes

Figure 21: Guiding Questions for Low-Carbon Housing Solution Evaluation



To support the evaluation of proposed low-carbon housing solutions, some simple methods of quantifying potential impacts may be used. A co-benefit analysis may be done to demonstrate how the sustainable development goals are supported or hindered. One approach is to directly quantify the co-benefit using absolute metrics (**Table 22**).

Table 22: Co-Benefit Impacts of Solar Powered Electric Lighting in the Amazon Region of Peru[34]

District	Number of Houses	Houses by Lighting Sources Used				
		Electric	Kerosene	Candles	Other	None
Amazonas	90,645	58,588	26,800.52	32,428.05	3,676.28	3,825.43
SOLUTION: Solar powered LED lighting	**PROS** Could bring electric lighting to over 32,000 households in the Amazon Region of Peru which currently have no access to electric lighting. Risk of lighting related house fires would be significantly reduced by X% **CONS** Increase the cost of lighting by $X.00/year (X %) per household on average.					

[34] Household lighting data source: (Lescano L, 2013)

However to compare between solutions with different co-benefits they should be evaluated against the weighted co-benefit criteria discussed in **Section 7.1** as illustrated in **Table 23** below. This will provide a somewhat normalized means of comparison across categories based on a pre-agreed upon prioritization which can help to legitimize roadmap decisions.

Table 23: Evaluating Strategies Based on sustainable development Co-Benefits

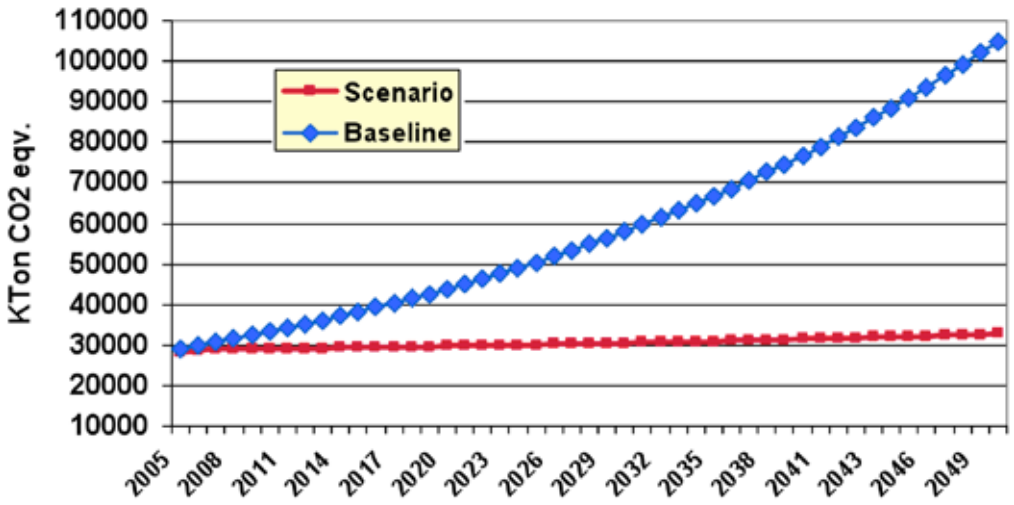
		Housing NAMA Activities						
	Weighting **(1-10)**	Solution 1*	Solution 2	Solution 3	Solution 4	Solution 5	Solution 6	Solution 7
Environmental								
Environmental Criteria 1	**A**	1 * A						
Environmental Criteria 2	**B**	0 * B						
Environmental Criteria 3	**C**	1 * C						
Social								
Social Criteria 1	**D**	1 * D						
Social Criteria 2	**E**	0 * E						
Social Criteria 3	**F**	-1 * F						
Economic								
Economic Criteria 1	**G**	1 * G						
Economic Criteria 2	**H**	0 * H						
Economic Criteria 3	**I**	1 * I						
	TOTAL:	**SUM**						

*The strategy is given a 1 if it supports the criteria and a 0 if it is neutral and -1 if it negatively impacts the metric.

The second step is to estimate the emission reduction potential of the proposed solutions. This is typically done through an avoided emissions calculation (**Table 24**). Avoided emissions are "emissions that would have been emitted under a business-as-usual scenario but were avoided due to the implementation of an emission reduction project" (Climate Action Network, 2014). Avoided emissions can be calculated by

establishing a baseline for housing performance using the formula in **APPENDIX C**, and then adjusting the appropriate emissions variables to account for changes in technology and consumption behaviour,

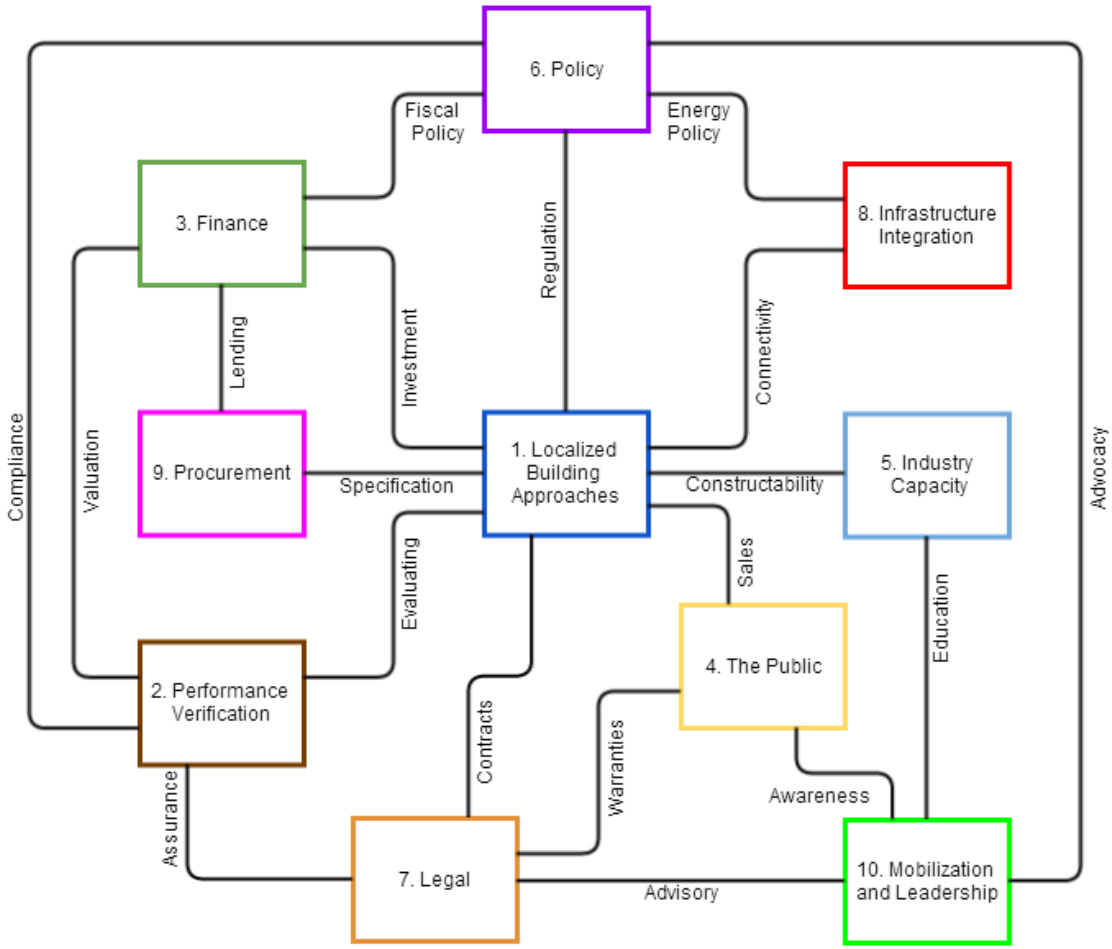
Table 24: Evolution of CO_2 Eqv. Emissions for Baseline and Scenario Conditions for Residential Buildings in Mexico (2006-2050) [35]



At this stage it is also beneficial to explore the relationships between the focus areas (**Figure 22;** and **Appendix E: Low-Carbon Housing Focus Areas and Relationships**). For example, how does regulation impact the building approaches (i.e. by limiting the materials that are permitted)? Or how does the construction industry learn about new building approaches (i.e. through key industry publications or events)? By mapping relationships it is possible to identify solutions that may have little direct emissions impact, but enable many others low-carbon housing solutions.

[35] (de Buen O. , 2009)

Figure 22: The Interconnection of Areas of Focus for Low-Carbon Housing Market Transformation[36]



Finally, the proposed solutions and their analysis should be distributed to the broader stakeholder community for input. This may include public information sessions, and regional events to ensure even greater participation and input. This provides an important opportunity to receive feedback and note concerns, while building a level of consensus to move forward.

[36] A detailed version of this systems diagram showing individual factors, relationships and variables is included in Appendix E: Low-Carbon Housing Focus Areas and Relationships

Photo 10: Mountainside homes in Cusco, Peru

ROADMAPPING PROCESS

STEP 6

A functional plan outlining the prioritized solutions, timing and required resources is the last step in creating the Roadmap. This will provide guidance for implementation of NAMA development and support for communicating the stages and goals of the market transformation process to stakeholders.

IN THIS SECTION:

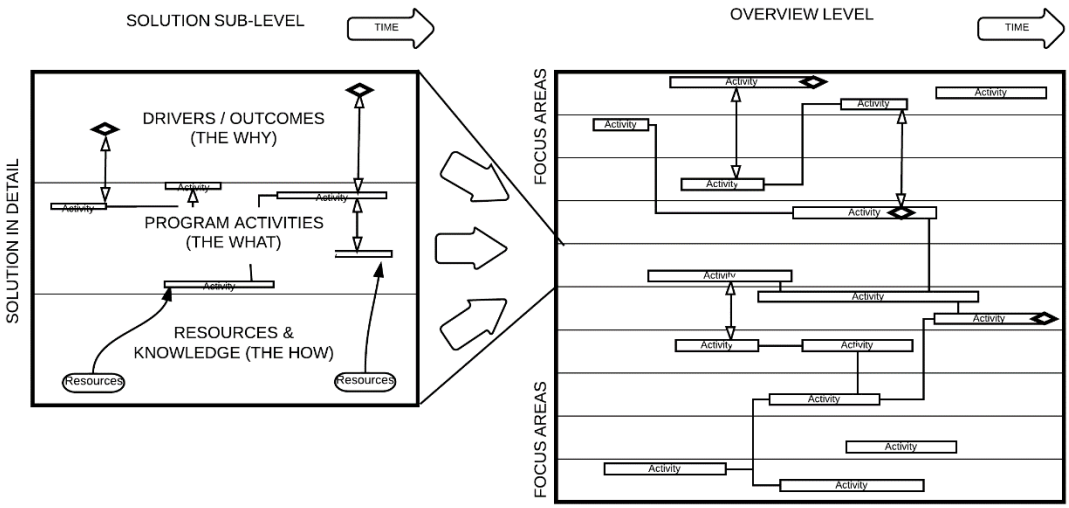
Guidance and tools for contextualizing market transformation solutions and mapping out their implementation.

9. ROADMAPPING LOW-CARBON HOUSING SOLUTIONS

Organizing low-carbon housing Solutions into a strategic roadmap consists of both a theoretical structure and a visual depiction. While this paper does not focus on the nuances of visual depictions in roadmapping, a visual map can be an important tool for providing a high-level overview of the system that supports the strategic dialogue necessary for developing consensus, aligning action, and identifying challenges, risks and tensions (Phaal & Muller, 2009).

The basics of the low-carbon housing roadmap consist of interrelated projects mapped out according to sequence. The roadmap should describe the basic "who, what, when, where, how and why" elements of the plan (Kerr, Phaal, & Probert, 2013). The roadmap can consist of multiple sub-layers, allowing for the team to "zoom-in" to sections of the roadmap (**Figure 23**). However, it is recommended that not too many sub-layers are used as too much detail can bog down the process (Phaal & Muller, 2009). Two levels of detail may suffice: a level for each solution, and an overview level connecting the solutions together and organized across the ten focus areas.

Figure 23: Zooming in on a Low-Carbon Housing Roadmap Focus Area



9.1.1 Framing the Solutions

Figure 24: Framing a Low-Carbon Housing Solution for the Roadmap

FOR EACH SOLUTION ANSWER

The **WHY** – what are the drivers for the solution? What are the proposed outcomes?

The **WHAT** – what are the primary activities needed to help realize the solution?

The **HOW** – what are the physical and knowledge resources required to realize the solution?

The **WHERE** – is the solution targeting a certain segment of the housing market?

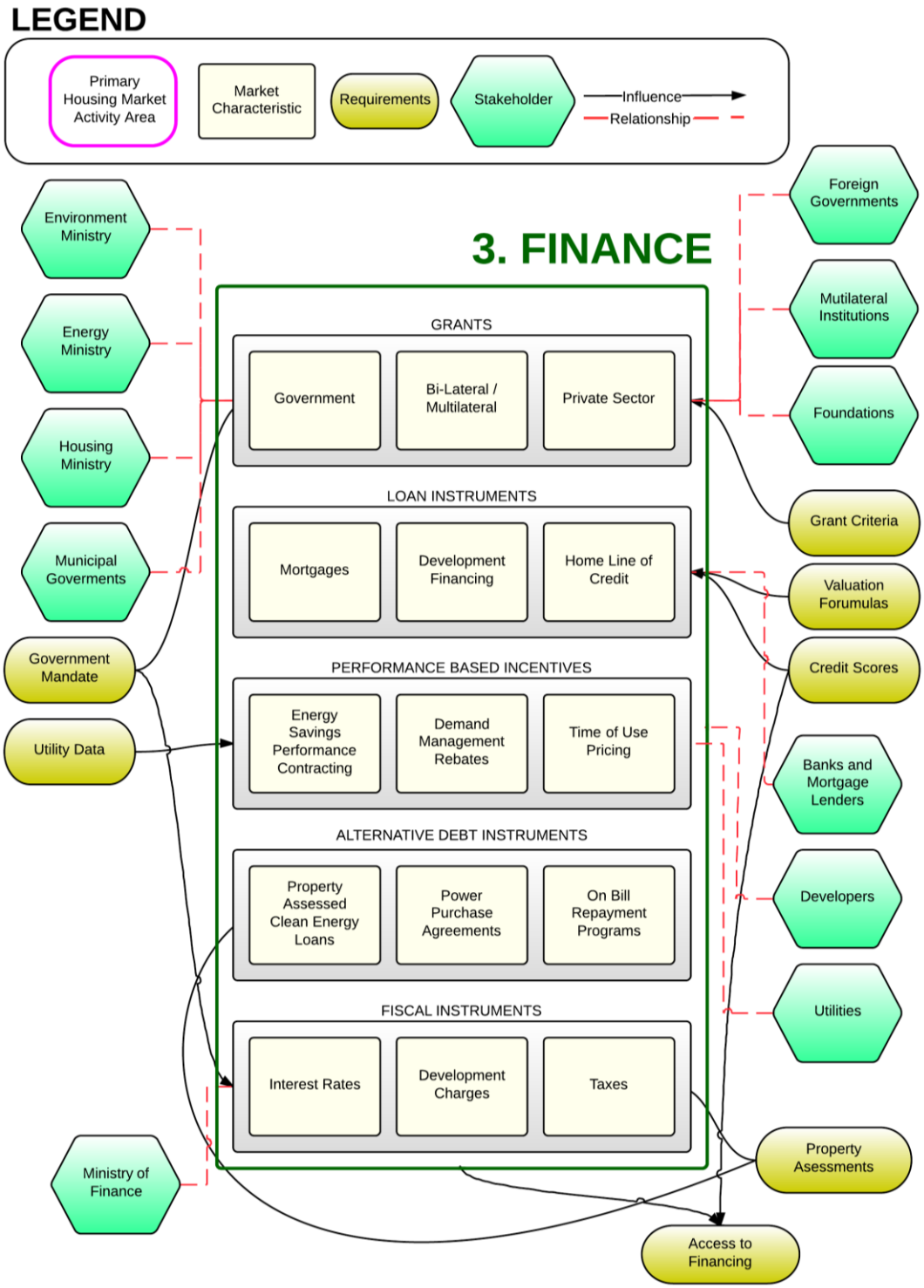
The **WHO** – what stakeholders are involved/impacted by the solution?

The **WHEN** – how long will the solution take?

Beginning with a list of all the preferred solutions, first note which solutions are universal and which are targeting only a sub-section of the market (*the where*) based on the market segmentation that was done in **Section 6.2.2**. Then, list the primary activities required to realize the solution (*the what*). Following this step, stakeholders and resources should be identified for each solution (*the who* & *the how*) along with the expected outcomes (*the why*).

To help complete the above information, it may be useful to revisit the focus area map showing the interconnection of solutions and to add stakeholders and resource requirements. A detailed example of this mapping which was created for Peru is included in **Appendix E**, with a segment including the Finance focus area presented in **Figure 25**.

Figure 25: Stakeholders and Requirements for Low-Carbon Housing Activities



A key insight at this stage of roadmap development may be the identification of required resources that are under-developed or non-existent. These gaps are often due to a lack of data, technical capacity, or an underdeveloped market. If obtaining the missing resources is viewed as mission critical to a solution, it may become its own stop in the roadmap or the solution must be modified to compensate.

To illustrate the example above, consider the proposal of a regulatory requirement for all new houses to include projected energy consumption (in the form of an energy model) with their building permit applications. This would necessitate both an excepted energy modelling tool and sufficient expertise to produce these energy models. If either of these resources is lacking, building that capacity should be added as an action item in the roadmap.

9.1.2 Bringing it all Together

The last stage of the roadmap development consists of timing (*the when*), which includes the duration and sequencing the solutions. This time allocation will not be overly precise, but should provide some scale in months or years. While the scale may just show "near," "mid" and "long" term, it is recommended that an end-date be given for the roadmap as both a frame of reference and a commitment. This timeline may align with national climate change policy, but it must be long enough for the solutions to be realistically achievable. A typical timeline for a technology roadmap is 10 years (Phaal & Muller, 2009).

The duration of the solution may be determined by looking at several factors. These include estimates on the timing required to accomplish certain tasks, projections of market penetration rates, or anticipated delays, as can be seen in the example below for a solution to implement an energy modeler accreditation program.

Table 25: Calculating Solution Durations for the Low-Carbon Housing Roadmap

Solution: Train 100 accredited energy modellers					*TOTAL*
Develop curriculum	**Register for recognized accreditation**	**Accreditation approval**	**Market the accreditation course**	**Train 25 energy modellers per year**	5 Year & 4 Months
6 months	1 month	3 months	6 months	4 years	

Finally, the solutions can be sequenced into the roadmap overview by looking at the relationships between the solutions. The sequencing is dependent of four primary considerations for each solution:

- What other solutions (**X**) feed-in to solution **A**?
- At what stage of solution **A** is the input from **X** required?
- What other solutions (**Y**) depend on the outputs of solution **A**?
- At what stage of solution **A** will those outputs become available to **Y**?

To continue with the example of energy modeling, we can see how solutions interact with one another:

Table 26: Mapping Roadmap Dependencies for Low-Carbon Housing Solutions

	Solution: Train 100 accredited energy modellers				
	Develop curriculum	**Register for recognized accreditation**	**Accreditation approval**	**Market the accreditation course**	**Train 25 energy modellers per year**
Input Projects	(Based on) Energy Modelling Protocols for the country (needed before start)			(market through) A database of training programs for building energy efficiency	
Output Projects			(submit to) A database of training programs for building energy efficiency		Mandated Energy Modelling on Government funded housing Projects (Can begin after year 1)

With all of the dependencies identified, the roadmap is complete and can be adapted to a visual format for easier dissemination.

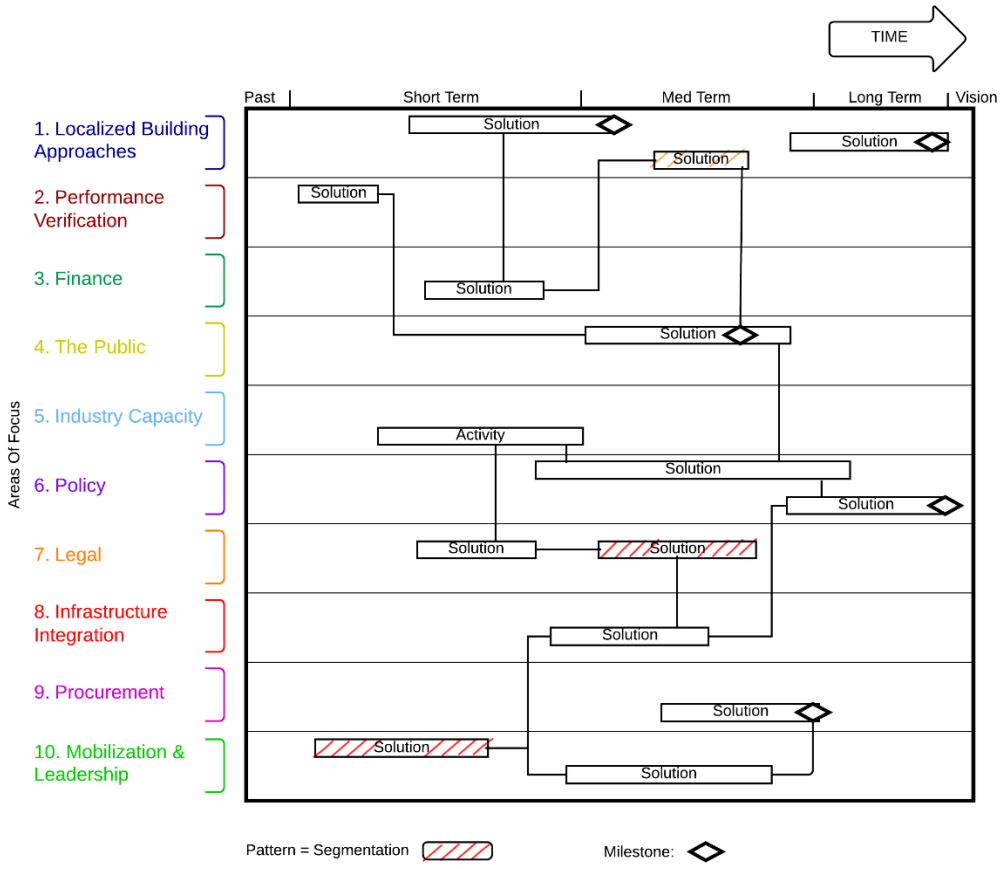
9.1.3 Visualizing the Roadmap

While not the focus of this paper, it is worth providing some guidelines for the visualization of the low-carbon housing roadmap. Since the primary purpose of the roadmap is to serve as a coordinating tool for the development of a housing NAMA and subsequent market transformation of the housing industry, it must be shared and utilized. Providing a simple visualization makes the roadmap accessible to a broader number of stakeholders.[37] A low-carbon housing roadmap should include the following features:

- **Time** - from current state to the future vision (usually on horizontal axis)
- **Focus Areas** – as a means of grouping solutions with common stakeholders and resources (vertical axis)
- **Solutions** – including duration and dependencies
- **Linkages** – showing the relationship between market transformation solutions
- **Key Milestones** – important points in the timeline, possibly decision or evaluation points
- **Segmentation** – a third dimension can be added through colouring or highlighting

[37] For a deeper exploration of visual roadmap design, the author recommends (Phaal & Muller, An architectural framework for roadmapping: Towards visual strategy, 2009)

Figure 26: The Aggregated Low-Carbon Housing Roadmap Template



10. CONCLUSIONS

Housing NAMAs offer developing countries a promising means of achieving their sustainable development goals, while simultaneously addressing GHG emissions within the housing sector. The flexibility of NAMAs allows countries to define local priorities and focus their efforts where they will be most effective at delivering sustained housing market transformation. This transformation will only result from the implementation of a series of mutually-supportive programs, policies and projects, requiring strategic planning and market acceptance.

Planning and coordinating the transformation of an entire housing sector is a daunting task. Typically, projects are developed in silos without an understanding of the whole picture and it can be difficult-to-impossible to determine the overall effectiveness on emissions reductions or sustainable development in general. The resulting outcomes may even be negative if aspects of the market are not considered or understood. Without some level of coordination, countries spend valuable time, money, and expertise on duplicated, incomplete, or even conflicting efforts. This is what makes the development of a low-carbon housing roadmap such an important exercise.

The challenge of building shared understanding around the complexity of a housing market and alignment on market transformation activities is no small task. The process begins with a shared understanding of the housing market and there are countless underlying market conditions and variables that need to be thought-out, processes to be understood and stakeholders to be consulted. Tools like the modified value-chain framework combine different methods for understanding systemic drivers into a succinct market model.

Reflecting upon the experience of developing roadmaps for Peru, Mexico and Costa Rica, it is clear that an organizing framework and toolkit such as the one presented in this paper would have been greatly

beneficial for coordinating the efforts of the many stakeholders that should be engaged throughout the process. One particular innovation is the creation of the housing market focus areas. These ten focus areas offer a means of prompting ideas, organizing opportunities, identifying stakeholders, and building teams while ensuring that no major aspect of the housing market is left unconsidered.

The roadmap itself should seek a balance between providing structure to guide the activation of roadmap activities and allowing for flexibility in the final execution. Solutions that are presented in the roadmap must be grounded in achievability, with a clear understanding of who is involved, how they might be structured and what the impacts will be. Yet, while the roadmap provides strategic direction, it is important to remember that it is not a feasibility study or a business plan. It is a communication tool to provide context for further planning while allowing room for innovation within the roadmap framework.

Choices need to be made. Setting clear boundaries to the housing market, emissions scope, and co-benefits provides focus to the process. These are not always easy decisions and are unique to each local housing market. The answers can only come through a process of deliberation, and the objectives will only be achievable with broad support and understanding.

While a roadmap can be an important tool for guiding the implementation of market transformation activities, the *process* of creating the roadmap is nearly as important as the final product. The effective application of best practices in stakeholder engagement and participatory design is critical to achieving the support for market transformation activities. This support can be just as important as the activity itself for realizing positive outcomes. It is the opinion of the author, that stakeholder participation should be emphasized throughout every phase of roadmap development from stakeholder identification, to value chain mapping, to solutions evaluation. The local market knowledge offered through a participatory approach is the key to putting the "Nationally Appropriate" into a housing NAMA.

Ensuring the inclusion of representative voices from all interest groups takes careful consideration. While this can clearly slow down the process, it also serves to make the process more legitimate and can prevent future obstruction of roadmap efforts by addressing concerns in advance.

The low-carbon housing roadmap is only the first step in the process of housing market transformation for developing countries. It is a powerful tool and symbol of national intention, and a powerful process for mobilizing the industry to take action on critical development goals and climate change issues. Perhaps most importantly, this process for roadmap development may serve as a precedent and model for tackling greenhouse gas emission reduction and critical development goals across any number of sectors beyond housing.

Photo 11: The Working Group of the Low-Carbon Housing Roadmap for Aguascalientes, Mexico

BIBLIOGRAPHY

Albu, M., & Griffith, A. (2005). *Mapping the Market: A Framework for Rural Enterprise Development Policy and Practice.* Bourton-on-Dunsmore: Practical Action.

Andonova, L. B., Betsill, M. M., & Bulkeley, H. (2009). Transnational climate governance. *Global Environmental Politics, 9*(2), 52-73.

Asia Pacific Partnership. (2011). *Project Roster - Buildings and Appliances Task Force*. Retrieved January 7, 2014, from Asia Pacific Partnership: http://www.asiapacificpartnership.org/english/pr_buildings_appliances.aspx#BATF_Project_53

Bäckstrand, K. (2008, August). Accountability of Networked Climate Governance: The Rise of Transnational Climate Partnerships. *Global Environmental Politics, 8*(3), 74-102.

Bernet, T., Devaux, A., Ortiz, O., & Thiele, G. (2011). Participatory Market Chain Approach. In A. Devaux, M. Ordinola, & D. Horton (Eds.), *Innovation for Development: The Papa Andina Experience* (pp. 133-150). Lima, Peru: The International Potato Centre. Retrieved from http://cipotato.org/cipotato/publications/pdf/005850.pdf

Bernet, T., Thiele, G., & Zschocke, T. (2006). *Participatory Market Chain Approach (PMCA) - User Guide.* Lima, Peru: International Potato Center (CIP) – Papa Andina. Retrieved from http://cipotato.org/publications/pdf/003296.pdf

Cai, J.-Y., & Paradis, C. (2013, Nov 8). Public-private partnerships key to global development challenges. *The Globe and Mail*. Retrieved from http://www.theglobeandmail.com/globe-debate/public-private-partnerships-key-to-global-development-challenges/article15345848/

Center for Clean Air Policy. (2012). *Nationally Appropriate Mitigation Actions (NAMAs) and The Clean Development Mechanism (CDM).* Washington: Center Clean Air Policy.

Cerqueira, J., Davis, S., & Winkelman, S. (2012). *MRV of NAMAs: Guidance for Selecting Sustainable Development Indicators.* Washington: Center for Clean Air Policy (CCAP).

Climate Action Network. (2014). *Climate Change Basics: Glossary*. Retrieved from Climate Action Network International: http://www.climatenetwork.org/policy-information/climate-change-basics-glossary

ClimateCHECK. (2011). *Canada-Mexico Partnership: Carbon Methodology for Low Carbon Energy Homes.* Ottawa: Environment Canada.

CSA Standards. (2010). *Carbon Calculator Methodology.* Halifax: Nova Scotia Environment.

Culp, J. (2013). *Low Carbon Housing in Peru.* Woodstock: Energy Efficiency Exporters Alliance.

Davis, D. (2011, 10 15). *The McLeamy Curve*. Retrieved from Daniel Davis: http://www.danieldavis.com/macleamy/

de Buen, O. (2009). *Greenhouse Gas Emission Baselines and Reduction Potentials from Buildings in Mexico.* Paris: United Nations Environment Programme; Sustainable Buildings & Climate Initiative.

de Buen, R., Navarro, J., Cuevas, P., & de Buen, O. (2013). *Co-beneficios de un programa de vivienda energéticamente eficiente en México.* Ottawa: Environment Canada.

de Buen, R., Navarro, J., Cuevas, P., & de Buen, O. (2013). *Co-beneficios de un programa de vivienda energéticamente eficiente en Perú.* Ottawa: Environment Canada.

de Buen, R., Navarro, J., Cuevas, P., & de Buen, O. (2013). *Estimation of GHG reductions and co-benefits of Costa Rica´s new housing and existing retrofit program.* Ottawa: Environment Canada.

Echeverria Aguilar, A. (2012). *Zero Energy Buildings - The Path Forward.* Mexico City: Asociación de Empresas para el Ahorro de la Energía en la Edificación, A.C. (AEAEE). Retrieved January 7, 2014, from http://esci-ksp.org/wp/wp-content/uploads/2012/02/SBN02_Echeverria.pdf

Environment Canada. (2013, November 12). *Climate Financing*. Retrieved from Canada's Action on Climate Change: http://climatechange.gc.ca/finance/details.aspx?id=269

Environmental Protection Agency. (2011, November 7). *Emission Factors for Greenhouse Gas Inventories.* Retrieved from www.epa.gov: http://www.epa.gov/climateleadership/documents/emission-factors.pdf

EPA. (2014). *Greenhouse Gas Equivalencies Calculator*. Retrieved from epa.gov: http://www.epa.gov/cleanenergy/energy-resources/calculator.html

EuropeAid. (2007). *Support to Sector Programmes - Covering the three financing modalities: Sector Budget Support, Pool Funding and EC project procedures .* European Commission.

Fawcett, T., & Boardman, B. (2009). Housing Market Transformation. *ECEEE 2009 Summer Study: Act! Innovate! Deliver! Reducing Energy Demand Sustainably* (pp. 225-235). La Colle sur Loupe: European Council for an Energy Efficient Economy.

Forsyth, T. (2005). Enhancing climate technology transfer through greater public–private cooperation: Lessons from Thailand and the Philippines. *Natural Resources Forum, 29*, 165-176.

Ghazinoory, S., Abdi, M., & Azadegan-Mehr, M. (2011). Swot Methodology: A State-of-the-art Review for the Past, a Framework for the Future. *Journal of Business Economics and Management, 12*(1), 24-48.

GHG Protocol. (2012). *Calculation Tools*. Retrieved from Greenhouse Gas Protocol: http://www.ghgprotocol.org/calculation-tools/faq

Gill, Z. M., Tierney, M. J., Pegg, I. M., & Allan, N. (2010). Low-Energy Dwellings: The Contribution of Behaviours to Actual Performance. *Building Research & Information, 38*(5), 491-508.

Global Value Chains Initiative. (2006). *Concepts and Tools*. Retrieved from Global Value Chains: www.globalvaluechains.org

Harwich, F., & Kormawa, P. (2009). *Value Chain Diagnostics for Industrial Development: Building Blocks for a Holistic and Rapid Analytical Tool.* Vienna: United Nations Industrial Development Organization (UNIDO).

Holladay, M. (2010). The History of Superinsulated Houses in North America. Vancouver: British Columbia Building Envelope Council. Retrieved January 7, 2014, from http://www.bcbec.com/seminar-archive2010.php

Housing for a Changing World: A Sustainable Housing Technology Roadmap for Canada. (2012). Retrieved from Sustainable Housing Technology Roadmap for Canada: http://shtrm.ca/

ICLEI. (2014, February 23). *The world needs an "urban" sustainable development goal to reach global sustainability*. Retrieved from ICLEI: http://www.iclei.org/details/article/the-world-needs-an-urban-sustainable-development-goal-to-reach-global-sustainability.html

IEA. (2010). *Energy Technology Roadmaps: A Guide to Development and Implementation.* Paris: International Energy Agency.

IFC. (2007). Stakeholder Identification and Analysis. In *takeholder Engagement: A Good Practice Handbook for Companies Doing Business in Emerging Markets* (pp. 14-26). Washington: International Finance Corporation (IFC).

IFC. (2014, January 12). *URBI Verde I: Summary of Proposed Investment*. Retrieved from International Finance Corporation: http://ifcext.ifc.org/ifcext/spiwebsite1.nsf/ProjectDisplay/SPI_DP31548

Innovolve Group. (2012, February 16). Peru ICC Meeting Feb 2012. Lima, Peru.

Innovolve Group. (2013). *Aguascalientes Low Carbon Housing Roadmap.* Toronto: Energy Efficiency Exporters Alliance.

Innovolve Group. (2013). *Costa Rica Low Carbon Housing Roadmap.* Toronto: Energy Efficiency Exporters Alliance.

Innovolve Group. (2013). *Peru Low Carbon Housing Roadmap.* Toronto: Energy Efficiency Exporters Alliance.

Intercontinental Exchange. (2014, January 5). *Emissions CER Index*. Retrieved from ICE: https://www.theice.com/marketdata/reports/ReportCenter.shtml#report/94

Islam, K. S., & Asami, Y. (2007). Housing Market Segmentation: A Review. *Review of Urban and Regional Development Studies, 21*(2/3), 93-109.

Kaplinsky, R., & Morris, M. (2001). *A Handbook for Value Chain Research.* Ottawa: International Development Research Centre.

Keating, K. M., Goldstein, D. B., Eckman, T., & Miller, P. (1998). Wheat, chaff, and conflicting definitions in market transformation. *ACEEE Summer Study on Energy Efficiency in Buildings.* ACEEE.

Kerr, C. I., Phaal, R., & Probert, D. R. (2013). Roadmapping as a Responsive Mode to Government Policy: A Goal-Oriented Approach to Realising a Vision. In M. G. Moehrle, R. Isenmann, & R. Phaal (Eds.), *Technology Roadmapping for Strategy and Innovation: Charting the Route to Success* (pp. 67-90). Berlin: Springer.

Lescano L, D. (2013). *Estudio del sector vivienda y su relacion con las emisiones de gases de efecto invernadero en el peru (Study of Housing Related GHG Emissions in Peru).* Woodstock: Canadian Energy Efficiency Exporters Alliance.

Loveridge, D. (2002). *The STEEPV Acronym and Process – a Clarification.* Manchester: PREST.

Lütken, S. E., Dransfeld, B., & Wehner, S. (2013). *Guidance for NAMA Design: Building on Country Experiences.* New York: UNFCC.

Marbek Resource Consultants. (2007). *LIfe-cycle Environmetnal Impacts of the Canadian Residential Sector.* Ottawa: Canada Mortgage and Housing Corporations (CMHC).

Moehrle, M. G., Isenmann, R., & Phaal, R. (2013). Basics of Technology Roadmapping. In M. G. Moehrle, R. Isenmann, & R. Phaal (Eds.), *Technology Roadmapping for Strategy and Innovation: Charting the Route to Success* (pp. 1-9). Springer.

Morris, M. (2001, July). Creating Value Chain Cooperation. *IDS Bulletin, 32*(3), 127-136.

Nadel, S., & Latham, L. (1998). *The role of market transformation strategies in achieving a more sustainable energy future.* Washington: American Council for an Energy-Efficient Economy.

Nang'Ole, E., Mithofer, D., & Franzel, S. (2011). *Review of Guidelines and Manuals for Value Chain Analysis for Agricultural and Forest Products.* Nairobi: World Agroforestry Centre.

Nelson, J. (2009). Corporate action on climate adaptation and development: Mobilizing new business partnerships to build climate change resilience in developing countries and communities. In L. Brainard, A. Jones, & N. Purvis (Eds.), *Climate Change and Global Poverty: A Billion Lives in the Balance?* (pp. 223-259). Washington: Brookins Institution Press.

Nelson, J., & Prescott, D. (2008). *Business and the Millenium Development Goals: A Framework for Action.* New York: International Business Leaders Forum.

Ngalame, E. N. (2013, January 3). *Carbon market woes blunt prospects for Cameroon CDM projects*. Retrieved from Thomson Reuters Foundation: http://www.trust.org/item/20140103121754-72w4z/

OECD. (2006). *Harmonising Donor Practices for Effective Aid Delivery Vol. 2: Budget Support, Sector Wide Approaches and Capacity Development in Public Financial Management.* Paris: OECD.

Olsen, K. H. (2013). NAMAs for Sustainable Development. *Mitigation Talks, 3*(4), 13-18.

Olsen, K. H. (2013). *Sustainable Development Impact of NAMAs.* Roskilde: UNEP Risø Centre.

Panagiotou, G. (2003). Bringing SWOT into focus. *Business Strategy Review, 14*(2), 8-10.

Pattberg, P., & Stripple, J. (2008, December). Beyond the Public and Private Divide: Remapping Transnational Climate Governance in the 21st Century. *International Environmental Agreements: Politics, Law and Economics, 8*(4), 367-388.

Peel, M. C., Finlayson, B. L., & McMahon, T. A. (2007). Updated world map of the Koppen-Geiger climate classification. *Hydrology and Earth System Sciences, 11*, 1633-1644.

Phaal, R., & Muller, G. (2009). An architectural framework for roadmapping: Towards visual strategy. *Technological Forecasting & Social Change, 76*, 39-49.

Phaal, R., Farrukh, C. J., & Probert, D. R. (2004). Technology roadmapping—A planning framework for evolution and revolution. *Technological Forecasting & Social Change, 71*, 5-26.

Phumpiu, P., & Gustafsson, J. (2009). When are partnerships a viable tool for development? institutions and partnerships for water and sanitation service in latin america. *Water Resources Management, 23*(1), 19-38.

Pickton, D. W., & Wright, S. (1998). What's swot in Strategic Analysis. *Strategic Change, 7*, 101-109.

Pinkse, J., & Kolk, A. (2012). Addressing the Climate Change—Sustainable Development Nexus: The Role of Multistakeholder Partnerships. *Business & Society, 51*(1), 176-210.

Popper, R. (2004, January). The STEEPV Method: A Framework for Structured Brainstorming. Retrieved from http://www.csd.bg/fileSrc.php?id=330

Porter, M. E. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance.* New York: The Free Press.

Ranson, J. D. (2012). Savings By Design, Integrated Design Charrette Visioning Form. Toronto: Sustainable Buildings Canada.

Reed, W. G., & Gordon, E. B. (2000). Integrated Design and Building Process: What Research and Methodologies are Needed? *Building Research and Information*, 325-337.

Salas, M., & Mendez, H. (2013). *Canada/Costa Rica Low Carbon Housing Partnership Market Scan.* San Jose: Innovolve Group.

Sawyer, D., Dion, J., Murphy, D., Harris, M., & Stiebert, S. (2013). *Developing Financiable NAMAs: A Practioner's Guide.* Winnipeg: The International Institute for Sustainable Development.

Selsky, J. W., & Parker, B. (2005). Cross-sector partnerships to address social issues: Challenges to theory and practice. *Journal of Management, 31*, 849-873.

The NAMA Partnership. (2013, January 22). Retrieved from The NAMA Partnership: http://www.namapartnership.org/

The World Bank. (2010). *Population Projection Tables.* Retrieved January 6, 2014, from The World Bank: http://go.worldbank.org/KZHE1CQFA0

Todd, J. A., & Lindsey, G. (2013, October 4). *Planning and Conducting Integrated Design (ID) Charrettes*. Retrieved from Whole Building Design Guide: http://www.wbdg.org/resources/charrettes.php

Tompkins, E. L., & Amundsen, H. (2008). Perceptions of the effectiveness of the United Nations Framework Convention on Climate Change in advancing national action on climate change. *Environmental Science and Policy, 11*(1), 1-13.

U.S. Department of Health & Human Services. (2014). *Card Sorting*. Retrieved from Usability.gov: http://www.usability.gov/how-to-and-tools/methods/card-sorting.html

UN. (2014, February 23). *Sustainable Development Goals*. Retrieved from United Nations Sustainable Development Knowledge Platform: http://sustainabledevelopment.un.org/index.php?menu=1565

UN Habitat. (2013). *Revised Compilation for Sustainable Cities & Human Settlements in the Sustainable Development Goals (SDGs) within the Post-2015 Development Agenda*. New York: UN Habitat.

UNEP Risoe Centre. (2013, December 1). *CDM Projects by Type*. Retrieved from UNEP Risoe CDM/JI Pipeline Analysis and Database: http://www.cdmpipeline.org/cdm-projects-type.htm

UNFCCC. (2012). Draft Tool for Highlighting Sustainable Development Co-benefits of CDM Project Activities and Programmes of Activities. *EB 68* (pp. Annex 21, 1-8). Bonn: UNFCCC CDM Executive Board.

UNFCCC. (2013). *What is the CDM*. Retrieved 3 11, 2013, from CDM - UNFCCC: http://cdm.unfccc.int/about/index.html

UNFCCC. (2014, 02 23). *CDM Tools*. Retrieved from UNFCCC Clean Development Mechanism: http://cdm.unfccc.int/Reference/tools/index.html

UNFPA. (2014). *Population and Housing Censuses*. Retrieved from unfpa.org: http://www.unfpa.org/pds/censuses.html

USAID. (2009, Februdary 1). *Participatory Approaches to Value Chain Development: Briefing Paper.* Retrieved from Microlinks: http://www.microlinks.org/sites/microlinks/files/resource/files/participatory_approaches_to_vc_development.pdf

van den Berg, M., Boomsma, M., Cucco, I., Cuna, L., Janssen, N., Moustier, P., . . . van Wijk, S. (2009). *Making Value Chains Work for the Poor: A Toolbook for Practitioners of Value Chain Analysis.* Making Markets Work Better for the Poor (M4P).

van Rij, V. (2010, February). Joint Horizon Scanning: Identifying Common Strategic Choices and Questions for Knowledge. *Science and Public Policy, 37*(1), 7-18. doi:10.3152/030234210X484801

van Tilburg, X., Bristow, S., Röser, F., Escalante, D., & Fekete, H. (2013). *Status Report on Nationally Appropriate Mitigation Actions (NAMAs): Mid-year update June 2013.* Amsterdam: Mitigation Momentum.

Weisser, D. (2007, September). A guide to life-cycle greenhouse gas (GHG) emissions from electric supply technologies. *Energy, 32*(9), 1543-1559.

Wells, J. (2007). Informality in the Construction Sector in Developing Countries. *Construction Management and Economics, 25*, 87-93.

World Resource Institute. (2008). *World Greenhouse Gas Emissions: 2005*. Retrieved 10 29, 2013, from World Resource Institute: http://www.wri.org/resources/charts-graphs/world-greenhouse-gas-emissions-2005

Zhanga, Y., Guoa, Y., Wanga, X., Zhua, D., & Porterb, A. L. (2013). A hybrid visualisation model for technology roadmapping: bibliometrics, qualitative methodology and empirical study. *Technology Analysis & Strategic Management, 26*(6), 707–724.

Zimmerman, A. (2006). *Integrated Design Process Guide.* Ottawa: Canada Mortgage and Housing Corporation.

APPENDIX A: THE EVOLUTION OF INTERNATIONAL CLIMATE CHANGE MECHANISMS AND LOW-CARBON HOUSING

In 1992 the international community joined together at the Earth Summit in Rio to adopt an international treaty to address greenhouse gas (GHG) emissions that contribute to climate change. This treaty, the United Nations Framework Commission on Climate Change (UNFCCC), recognized the necessity for international alignment on climate change goals and collaboration. In the ensuing years, a series of legally binding agreements, programs and mechanisms were created to support these efforts.

At the heart of the development of international climate change policy is a tension created by the link historically between emissions and industrial capacity. This link suggests that restrictions on emissions may significantly impact critical economic growth and development for some countries. In response to this, development support from developed to least developed countries (LDCs) is prioritized in the UNFCCC as illustrated below.

Industrialized vs. Developing Countries

An important convention in the resulting international protocols of the UNFCCC, including Kyoto, is the classification of parties (individual countries plus the European Union) into three Categories[38]:

1. **Annex I: Industrialized countries and economies in transition**
2. **Annex II: OECD members of Annex I, provide financial support to non-annex parties**
3. **Non-Annex I: Developing countries, eligible for financial support**

[38] http://unfccc.int/parties_and_observers/items/2704.php

Through this structure, Annex I parties are obligated to achieve hard mitigation targets, while Non-Annex I parties are not, but may choose to do so. For Annex II parties, not only are they obligated to achieve mitigation targets, but they must also contribute financial resources, technology and expertise to support developing countries' efforts. It was through this process as an Annex II country, that Environment Canada funded the Low-Carbon Housing Roadmap development in Costa Rica, Mexico and Peru.

From CDM to NAMA

One of the primary tools for helping Annex I countries achieve their emissions targets and transfer funding to developing countries is the Clean Development Mechanism (CDM).

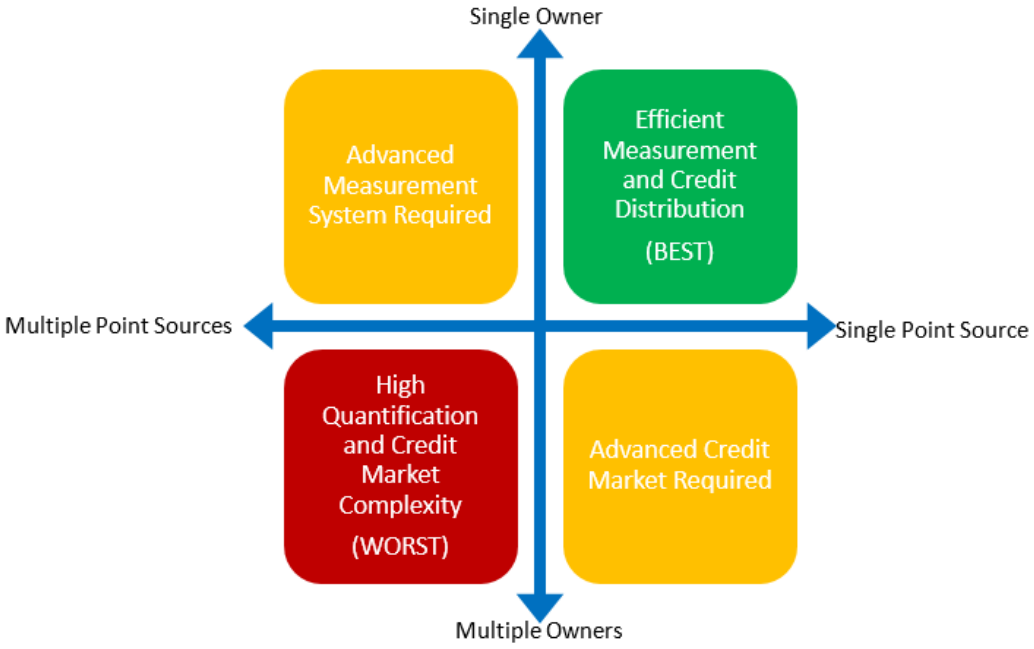
The CDM allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tonne of CO2. These CERs can be traded and sold, and used by industrialized countries to a meet a part of their emission reduction targets under the Kyoto Protocol. (UNFCCC, 2013).

CDM essentially works as a global GHG emissions offset, where ANNEX II countries can invest in emissions reductions in Non-Annex countries in lieu of creating reductions of their own at home. Each CDM project must go through a rigorous design, approval and verification process to ensure accuracy for the allocation of credits.

The CDM Project Cycle

The CDM worked well for easily attributable emissions reductions projects such as clean energy generation projects, afforestation and reforestation, hydroflourocarbon-23 (HFC-23) phase-outs and industrial source controls which represent the majority of project types registered under the CDM (UNEP Risoe Centre, 2013). However the CDM was not effective for distributed emissions reductions across a complex market such as housing, because of the sheer number of small emission reductions and financial allocations that would be required (See Figure Below).

Carbon Credit Feasibility at Different Levels of Market Complexity

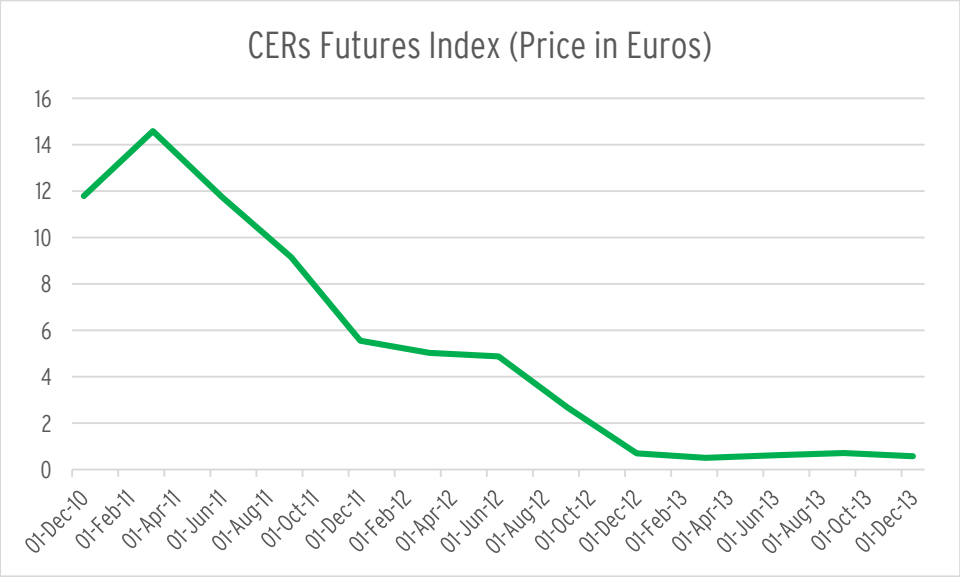


The first obstacle is the incremental effort required to validate CERs from housing projects. As the above 7-step process must be followed for each project, every house registered under the CDM would need to have its emissions forecast, validated, registered, and monitored. Even large volume new construction developments have difficultly leveraging sufficient economies of scale to handle this administration cost effectively. For the existing housing market, it would be nearly impossible to allocate and distribute credits to millions of owners. The value of CER credits are really only worth pursuing if you can aggregate them under

large projects with fewer points of measurement and fewer beneficiaries. The more you dilute the credits, administrative and transactional costs eat away at value.

The second barrier is the falling value of Carbon Emission Reduction (CER) credits. Thompson Reuters reports that in recent years "the price of CERs has dropped from more than 10 Euros in 2011 to below 0.50 Euros, due to over-supply and uncertainty over future demand." (Ngalame, 2013) This has led to the cancelation of even major projects such as landfill gas capture due to a loss of projected earnings. For housing in Mexico for example where average emissions are less than two tons, the creditable benefit is less than a single Euro ($1.50 CAD)[39] per home.

Future Price Index for Certified Emissions Reductions[40]



Whereas the CDM was fundamentally a transactional program to help Annex II countries achieve their emission limits through the purchase of project based CERs, there was still a need for developing countries to make fundamental changes to address their domestic emissions in key sectors such as housing.

[39] February 7th, 2014 exchange rate.
[40] (Intercontinental Exchange, 2014)

This led to the introduction of Nationally Appropriate Mitigation Actions (NAMA) in 2010 which seeks to fill in gaps by supporting capacity building efforts and sector-wide initiatives (Center for Clean Air Policy, 2012).

Comparison of the NAMA action cycle with the CDM project cycle with suggested approach to sustainable development assessment of NAMAs[41]

Action/Project Cycles	NAMAs	CDM
National Development Planning	**Low Carbon Development Strategy (LCDS)** A 'development first', co-benefit approach: Identify national (sustainable) development priorities that NAMAs contribute to (ex-ante)	**None**
Design of action/project	**No format requirements** Include indicators for sustainable development co-benefits in the design format and conduct stakeholder involvement and safeguards for no-harm-done	**Project Design Document (PDD)**
National Approval	NAMA Approver submit mitigation actions to the Registry: To seek support for preparation, to seek support for implementation or to seek recognition (unilateral)	Designated National Authority (DNA) issues Letter of Approval (LoA) for sustainable development contribution
Validation/Registration	NONE	Designated Operational Entity (DOE) and Executive Board (EB)/ Registry
Financing	Supported NAMAs: bilateral, multilateral, private sector, Green Climate Fund, Foreign Direct Investment (FDI) and carbon markets. A mix of sources is possible. Unilateral NAMAs: domestic finance **Explicit sustainable development and climate benefits can help inform investors to get the most benefits for their money**	Investors
Implementation	NAMA developer	Project owner/Coordinating Managing Entity (CME) for Programmes of Activities (PoAs)
Monitoring, Reporting and Verification	**Sustainable development co-benefits and impacts of mitigation actions to be monitored, reported and verified along with GHG metrics (ex-post).** For pledged, international NAMAs there is International Consultation and Analysis (ICA) of Biennial Update	Designated Operational Entity (DOE)

[41] Source: (Olsen, Sustainable Development Impact of NAMAs, 2013)

	Reports (BUR). There are no requirements for MRV of individual NAMAs	
Issuance of CERs/units of GHG reductions	Possible links to New Market Mechanisms (NMMs) and Framework for Various Approaches (FVA) for crediting of NAMAS **Units of GHG reductions to be certified for their sustainable development co-benefits**	Executive Board (EB)/Registry

As the name suggests, NAMAs allow each country to define a "Nationally Appropriate" course of action to reduce GHGs. This includes defining the scope of what's being targeted and the efforts that will be involved. This means that there is no formal definition of what a NAMA can be, but they generally fall into four broad categories:

Generalized Categorization of Registered NAMAs by Approach, 2013

Category	Example
Targets	*Committing to Reduce Residential Energy Use by 10%*
Strategies	*Implementing a low-carbon housing action plan*
Policies or Programmes	*Establishing a residential building energy code*
Projects	*High efficiency social housing developments*

The strength of NAMAs as they relate to housing is the eligibility of process activities that are harder to correlate directly with a specific one-for-one GHG reduction. Once the country has submitted its NAMA plan it can prioritize actions and seek support implementation. Potential activities under a housing NAMA are wide-ranging. They may include individual projects such as a large scale social housing community that integrate renewable energy, or broad energy conservation measures. However, NAMA opportunities may also include technical capacity building, code or policy improvements, program development, or financial mechanisms to name a few.

These actions are known as a "sectoral" approach as they tend to be delivered across the market, are not connected to a specific housing project, and are expected to result in emissions reductions across the housing sector. Because an accurate quantified emissions reduction is hard to attribute to a single action, credit assignment is impossible therefore allocated investment is coordinated through a well-defined sector-wide strategy. A NAMA therefore can be viewed as the mechanism to support sectoral approaches which mitigate GHG emissions (Center for Clean Air Policy, 2012).

What Distinguishes a Sector-wide Approach from a Conventional Approach?[42]

Sector-wide approach		Conventional project approach
Country holistic view on entire sector		Focus on projects to support narrowly defined objectives
Partnerships with mutual trust and shared accountability		Recipient accountable to donor
External partners' co-ordination and collective dialogue		Bilateral negotiations and agreements
Increased use of local procedures		Parallel implementation arrangements
Long-term capacity/system development in sector		Short-term disbursement and success of projects
Process-oriented approach through learning by doing		Blueprint approach

[42] Source: (OECD, 2006)

APPENDIX B: STAKEHOLDER IDENTIFICATION WORKSHEET

Which organizations could serve as the champions for the roadmap development process?	
Which government agencies/ministries are responsible for the following issues related to low-carbon housing?	Climate Change: _____ Construction: _____ Housing: _____ Energy: _____ Infrastructure: _____ Development/Planning: _____ Public Health: _____ Natural Resources: _____ Manufacturing: _____ Economic Development: _____ Development Finance: _____ Labour: _____ Training: _____ Cities: _____ Other: _____
What other major climate change mitigation or adaptation initiatives/programs are underway in the region?	
What other major housing related initiatives or programs are underway in the region?	

Which Development Banks are active in your region?	For a list of development banks visit the World Bank: http://go.worldbank.org/CGC782MDY0
Which International Development Agencies are active in your region?	☐ Australian Agency for International Development ☐ Austrian Development Agency ☐ Canadian International Development Agency ☐ Danish Development Agency ☐ Department for International Development Cooperation (Finland) ☐ Agence francaise de developpement ☐ Deutsche Gesellschaft fur Technische Zusammenarbeit GmbH ☐ Ireland Development Cooperation ☐ Japan Bank for International Cooperation ☐ Japan International Cooperation Agency ☐ Kreditanstalt fur Wiederaufbau ☐ Netherlands Development Cooperation ☐ New Zealand Official Development Assistance ☐ Norwegian Agency for Development Cooperation ☐ Swedish International Development Cooperation Agency ☐ Swiss Agency for Development and Cooperation ☐ Swiss State Secretariat for Economic Affairs ☐ U.K. Department for International Development ☐ U.S. Agency for International Development Other: _____

Who are some leading residential builders in the region?	
Who are the leading design firms for residential development in the region?	Architects: _____ Mechanical engineers: _____ Structural Engineers: _____ Electrical Engineers: _____ Planners: _____
Who are some leading housing product manufacturers/distributors/ importers in the region	Structural Materials: _____ Cladding/Insulation: _____ Mechanical Systems: _____ Electrical Systems: _____ Appliances: _____ Other: _____
Who are the major utilities in the region?	Electricity: _____ Gas: _____ Water: _____ Other: _____
Who are the major professional and trade associations and unions in the region?	Construction Workers: _____ Architects: _____ Engineers: _____ Mechanical Contractors: _____ Electrical Contractors: _____ Carpenters: _____

Who are the major Industry Associations in the region?	Home Builders: _____ Concrete: _____ Timber: _____ Steel: _____ Insulation: _____ Appliances: _____ Renewable Energy: _____ Other: _____
What are the leading research institutes in the region?	Architecture: _____ Engineering: _____ Climate Science: _____ Other: _____
What are the leading training institutions in the regions?	Construction Trades: _____ Architects: _____ Engineers: _____
What Public Interest Groups/NGOs are active in the region for the following issues?	Green Building: _____ Adequate Housing: _____ Housing Related Public Health: _____ Homeowners rights: _____ Other: _____

APPENDIX C: CALCULATING USE-BASED GHG HOUSING EMISSIONS

An emissions factor[43] (EF) represents the amount of GHG emissions produced per unit of what is being measured (i.e. kWh of electricity, m^3 of Natural Gas, L of potable water…). GHGs include a number of different gases, including CH_4 and N_2O, so to normalize the impacts the gases produced in any activity are multiplied by their global warming potential (GWP) to determine its equivalence in tonnes of CO_2 (tCO_2e). Therefore EF can be represented as tCO_2e/unit.

Firstly EFs are determined for the fuel types used in households and for electricity generation. Secondly, an EF for electricity is calculated by multiplying the EF of the fuels used in the generation process by the efficiency of conversion and delivery to the home. An EF must also be determined for the provision of potable water (energy used for pumping and treating), as well as wastewater (energy used for pumping, treating + decomposition) and solid waste (energy used for disposal + decomposition).

It is important to note that while EFs for combusting fuel are constant, those of electricity, water, wastewater and waste may differ by location due to differences in the local infrastructure and fuels used. Electricity EF is also subject to variation by time due to differences between how the electricity is generated for peak load and base load (Weisser, 2007). These differences in EF may be used to target programs where conservation efforts can have the greatest GHG reduction impacts or may be averaged out to simplify calculation.

Once EFs have been calculated, then consumption of fuel, electricity and water and the volume of waste and wastewater is determined. This may be determined from utility meters, bills, or by calculating the

[43] Tools for calculating emissions factors are available through the UNFCCC: http://cdm.unfccc.int/Reference/tools/index.html, and further emissions factor guidance is available through the US EPA: http://www.epa.gov/ttn/chief/ap42/index.html

energy consumption of household activities or equipment if looking at individual homes, or from utility companies and census data if looking at whole markets (CSA Standards, 2010).

Once all consumption and production volumes are determined, each is multiplied by the relevant EF and added together to get a total GHG volume (Lescano L, 2013; de Buen O. , 2009).

Formula for Use-Based Residential GHG Emissions

$$Home_{EUE} = \sum_{Fuels} \{ EF_{FuelType} * FC_{FuelType} \} + EF_{Electricity} * (EC_{Electricity} - REC) + EF_{Heat} * HC_{Heat} + EF_{Water} * (WC_{Water} - OWT) + EF_{Wastewater} * WP_{Wastewater} + EF_{Waste} * WP_{Waste}$$

Where:

- $Home_{EUE}$ = Home use-based GHG emissions
- $EF_{FuelType}$ = Emission factor for primary fuels in tCO_2e per unit (M^3, BTU, L …)
- $FC_{FuelType}$ = Consumption per year of primary fuel in units (M^3, BTU, L …)
- $EF_{Electricity}$ = Emission factor for electricity grid in tCO_2e per kWh
- $EC_{Electricity}$ = Consumption per year of electricity in kWh
- REC = Total amount of renewable energy purchased per year in kWh
- EF_{Heat} = Emission factor for district heat plant in tCO_2e per unit (BTU, GJ …)
- HC_{Heat} = Consumption per year of heat from a central plant in units (BTU, GJ …)
- EF_{Water} = Emissions factor for water in tCO_2e per unit (L, Gallon …)
- WC_{Water} = Consumption per year of water in units (L, Gallon …)
- OWT = Onsite water treated for use per year in units (L, Gallon …)
- $EF_{Wastewater}$ = Emissions factor for wastewater in tCO_2e per unit (L, Gallon …)
- $WP_{Wastewater}$ = Production per year of wastewater in units (L, Gallons …)
- EF_{Waste} = Emissions factor for waste in tCO_2e per unit (Kg, Tonnes …)
- WP_{Waste} = Production per year of solid waste in units (Kg, Tonnes …)

APPENDIX D: INTEGRATED DESIGN CHARRETTES

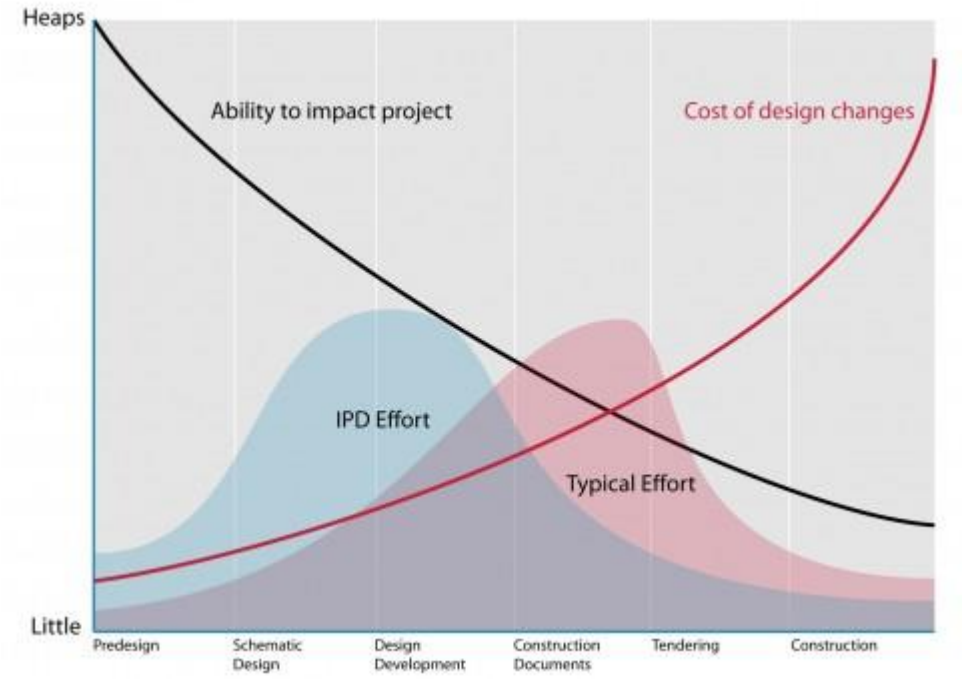
> "The integrated design process [IDP] encompasses cross-disciplinary teamwork enabling the improved integration of building, community, natural and economic systems and therefore is a key to sustainable design (Reed & Gordon, 2000)."

An Integrated Design Charrette is a form of an intensive workshop in which various stakeholders and experts are brought together to address a particular design issue (Todd & Lindsey, 2013). Intrinsic in their use is the notion that it is part of a larger integrated design process (IDP).

The IDP model emphasizes the involvement of a broad interdisciplinary team from the onset, the creation of shared goals and vision, and systematic decision making (Zimmerman, 2006). The IDP process allows design teams to break down traditional silos between disciplines and consider all aspects of a building as a whole system. By having all stakeholders around the table at the onset, IDP ensures that a variety of perspectives and expertise are considered before project details are finalized and more costly to change.

In working with Costa Rica, Peru and Mexico on low-carbon housing strategies, a Canadian team headed by Jeff Culp of the Energy Efficiency Exporters Alliance, conducted integrated design charrettes with local builders to kick off the construction of low-carbon housing pilot projects. By combining local and international technical experts with the local builder and other stakeholders, the team was able quickly to identify energy performance improvements, while ensuring that local market conditions, such as constructability, affordability and cultural acceptance, were considered.

McLeamy Curve: Representing the Impact of IDP on Construction[44]



Looking at housing blueprints with Costa Rican developers

[44] Source: http://www.danieldavis.com/macleamy/

APPENDIX E: LOW-CARBON HOUSING FOCUS AREAS AND RELATIONSHIPS

A full-sized version of this chart is available in the pocket inside the back cover of the MRP or Online at: https://www.lucidchart.com/documents/view/4e8a-e86c-530fe04e-890c-45a20a0055a3