

GREEN CITIES:

Sustainable Low-Income Housing in Brazil



May 2011

Urban, Water and Disaster Risk Management Unit
 Sustainable Development Department
 Latin America and the Caribbean Region
 The World Bank Group

Currency Equivalents

(Exchange Rate Effective August 4, 2010)

Currency Unit = BRL (Brazilian Real)

BRL 1 = US\$ 0.57

US\$ 1 = BRL 1.76

ABBREVIATIONS AND ACRONYMS

AQUA	Brazilian “High Environmental Quality” Rating System
BGBC	Brazilian Green Building Council
BNH	National Housing Bank of Brazil
BREEAM	BRE Environmental Assessment Method
CAIXA	Caixa Econômica Federal
CDM	Clean Development Mechanism
CES	Center for Sustainability Studies at FGV
DOF	Forest Origin Document
EASCS	China & Mongolia Sustainable Development Unit, World Bank
EEM	Efficient Energy Mortgage
ENCE	National Energy Conservation Label
ETWTR	Transport Unit, World Bank
FEUR	Urban Development Unit, World Bank
FGV	Fundação Getulio Vargas
FINEP	Brazilian Innovation Agency
GHG	Greenhouse Gas
GRIHA	Green Rating for Integrated Habitat Assessment in India
GTZ	German Development Agency
HOPE VI	Public Housing Revitalization Program in the United States
HQE	French “High Environmental Quality” Rating System
IBAMA	Brazilian Institute of Environment and Renewable Natural Resources
INFONAVIT	National Worker’s Housing Fund Institute in Mexico
INMETRO	National Institute of Metrology, Standardization and Industrial Quality
INPE	National Institute for Space Research
LabEEE	Federal University of Santa Catarina’s Building Energy Efficiency Laboratory
LCSEG	Energy Unit, Latin America and the Caribbean Region, World Bank
LEED	Leadership in Energy and Environmental Design
MCMV	Minha Casa, Minha Vida – National Low-Income Housing Program
PAC	National Growth Acceleration Program
PBQP-H	Brazilian Program for Quality and Productivity for Habitat
PROCEL	National Electricity Conservation Program
PVC	Polyvinyl Chloride (vinyl)
SEHAB	City of São Paulo Secretariat of Housing
SiAC	Certification of Construction Firm Quality Processes
SiMAC	Certification of Material Quality
SINAPI	National Research System
SiNAT	Certification of Technology Innovation
SNHIS	National Social Interest Housing System
UNFCCC	United Nations Framework Convention on Climate Change

ACKNOWLEDGEMENTS

This Note was prepared by Carlos Martin (Urban Specialist, Consultant) and Catherine Lynch (Young Professional) with inputs from Catalina Marulanda (Sr. Environmental Specialist, LCSEN), Ming Zhang (Lead Urban Economist, LCSUW) and Teresa Serra (Energy and Urban Development Consultant).

The development of this Policy Note involved collaboration with the Secretariat of Housing within the Ministry of Cities, the Secretariat of Housing and Urban Development of the Municipality of São Paulo, the Secretariat of Housing of the Municipality of Rio de Janeiro, and Caixa Econômica Federal.

The authors would like to acknowledge the valuable contributions from Peer Reviewers at the World Bank, including Daniel Hoornweg (Lead Urban Specialist, FEUUR), Peter Ellis (Sr. Urban Economist, EASIS), Janina Franco (Energy Specialist Consultant, LCREG), Jas Singh (Sr. Energy Specialist, SEGES), and Feng Liu (Sr. Energy Specialist, SEGES), which greatly strengthened this Note.

The authors would also like to recognize the contributions provided by the World Bank's Energy and Sector Management Assistance Program (ESMAP), who supported the preparation of this Policy Note, a companion piece on Cities and Climate Change in Brazil, and the organization of the seminar *Financial and Technical Solutions for Sustainable Cities*, held in Brasilia from June 8-9, 2010. The purpose of the seminar was to bring together technical experts from the World Bank, *Caixa Economica Federal*, Brazilian government officials from the federal, state and municipal levels, and representatives from non-governmental organizations and research institutes to share knowledge and experiences about climate change and the challenges and opportunities facing Brazilian cities.

Table of Contents

Executive Summary	6
A. INTRODUCTION	7
A.1 Context	7
A.2 Organization of Policy Note	8
B. HOUSING CONSTRUCTION IN BRAZIL	8
B.1 Context	8
B.2 Direct Environmental Impact of Housing Construction	9
B.3 Indirect Environmental Impact of Housing Construction	11
C. GREEN CONSTRUCTION IN BRAZIL	11
C.1 Product Certification Programs	11
C.2 Supply Chain Programs	12
C.3 Research & Development Programs	13
C.4 Green Building Programs	13
D. EXAMPLES OF LOW-INCOME HOUSING CONSTRUCTION IN BRAZIL	17
D.1 Minha Casa, Minha Vida (MCMV)	17
D.2 Social Housing in São Paulo	22
D.3 Social Housing in Rio de Janeiro	24
E. OPPORTUNITIES TO IMPROVE SUSTAINABILITY OF HOUSING SECTOR	26
F. RECOMMENDATIONS	30
Bibliography	34

List of Figures

Figure 1: Informal Housing in Rio de Janeiro	8
Figure 2: Formal Social Housing in Brasilia	8
Figure 3: Conceptual Ranking of Embodied Emissions in Common Construction Materials in Brazil	9
Figure 4: Sample <i>Selo Procel</i> Label	12
Figure 5: Sample ENCE Rating Label	12
Figure 6: Model MCMV Single-Family Unit Plan	18
Figure 7: Model MCMV Multifamily Unit Plan	18
Figure 8: Example of a <i>Minha Casa, Minha Vida</i> Development	19
Figure 9: Promotional Materials for Rio's <i>Novas Alternativas</i> Program	25
Figure 10: Description of Rainwater Harvesting Techniques at a Rio Hardware Store	26
Figure 11: Label on a Sample Dual-Flush Water-Efficient Toilet	26
Figure 12: Solar Water Heater Kit Available at Rio Hardware Store	27
Figure 13: Preparatory Wall Opening for Air Conditioning in a Rio MCMV Development	27
Figure 14: Cellular Concrete Block Readily Available at a Rio Hardware Store	28

List of Tables

Table 1: Construction Waste in Municipalities of São Paulo	10
Table 2: <i>Selo Casa Azul</i> Scoring Criteria.....	15
Table 3: <i>Selo Casa Azul</i> Scoring Value Criteria	16
Table 4: Summary of Possible Green Technologies for Low-Income Housing in Brazil	29

List of Boxes

Box 1: Casa AQUA	14
Box 2: Solar Water Heating for housing under MCMV	18
Box 3: SEHAB Design Innovations.....	22
Box 4: Example of design improvement program in the U.S.	23
Box 5: Reducing construction waste through innovation	24
Box 6: Novas Alternativas Program	25
Box 7: Energy Efficiency Initiatives in Low-Income Housing in Mexico	30

Executive Summary

Housing development has direct and indirect impacts on the environment. Through its design, construction, and operation, housing represents a significant point of direct consumption of natural materials, water, and energy. Therefore, greenhouse gas emissions embodied in housing can be very significant. Moreover, in Brazil, civil construction is responsible for the largest percentage of solid waste volume generated in cities, resulting in additional environmental impacts. The housing sector also has substantial indirect environmental impacts associated with extended commuting distances from residents of housing developments and their resulting greenhouse gas emissions.

The housing sector in Brazil offers substantial opportunities to improve environmental performance. Housing developments, particularly large-scale low-cost programs, provide opportunities to minimize local and global environmental impacts through the use of energy efficient materials, design and construction guidelines, as well as performance standards. Many of these technologies and practices are appropriate to Brazilian conditions, and a number of them are already in use.

Low-cost housing programs can be designed to incorporate sustainable materials and guidelines, with potentially large-scale impacts. With the launch of the *Minha Casa, Minha Vida* (MCMV) economic stimulus program to subsidize the construction of 1 million low-income housing units (and recent approval of a second round of subsidies for 2 million homes), Brazil is in a unique position to achieve the triumvirate of sustainable growth – the social goal of reducing the national housing deficit, the economic stimulus goal of creating jobs in the construction industry, and the environmental goal of developing healthy homes and communities. Centralized funding sources like MCMV provide can be also used as models for other assisted housing programs and, potentially, market-rate housing developments as cities, developers and construction product manufacturers become more experienced in green housing technologies.

Many green construction and technology programs are already in place. Brazil has a history of promoting programs and policies related to sustainable housing design construction and maintenance, such as product certification, supply-chain, research and development, and Green Building programs. The *Selo Azul* Program, launched by CAIXA in 2010 with the goal of promoting green housing development in Brazil, is particularly promising.

Enhancements to current programs can greatly improve sustainability of housing sector. With increasing awareness on sustainable construction, there are currently major opportunities to promote the incorporation of green construction technologies, as well as hazard-resistant technologies for climate adaptation, within formal and informal low-income housing in Brazil. Based on a review of current practices at the national and international level, as well as on interviews with public and private sector practitioners, this Policy Note presents recommendations aimed at enhancing the sustainability of low-income housing approaches in Brazil, through the provision of high quality, energy-efficient housing with minimal environmental impacts.

A. INTRODUCTION

A.1 Context

Housing development has direct and indirect impacts on the environment. Through its design, construction, and operation, housing represents a significant point of direct consumption of natural materials, water, and energy. In an attempt to reduce upfront construction costs, especially for low-income housing, the selection of materials and quality of assembly does not always go hand-in-hand with reducing long-term operations and maintenance costs, or with minimizing environmental impacts.

As the primary use of land in most cities, the location of residential development has an indirect impact on the efficiency of the urban system – especially the provision of basic services and transportation. **The search for cheap land at the edge of urban areas to make the construction of low-income housing financially feasible has the potential of creating a greater cost burden for the local government, as well as a global environmental burden, through the emission of greenhouse gases caused by extended vehicle commuting distances.**

With the launch of the *Minha Casa, Minha Vida* (MCMV) economic stimulus program to subsidize the construction of 1 million low-income housing units (and recent approval of a second round of subsidies for 2 million homes), Brazil is in a unique position to achieve the triumvirate of sustainable growth – the social goal of reducing the national housing deficit, the economic stimulus goal of creating jobs in the construction industry, and the environmental goal of developing healthy homes and communities. While the first two pillars have received great attention, the third is often characterized as an obstacle to achieving social and economic goals, rather than as an opportunity.

The objective of this Policy Note is thus to better illustrate the relationship between low-income housing and sustainable or “green” design, and to provide an overview of opportunities for improving the sustainability of the low-income housing sector in Brazil. There are increasingly known and available, cost-effective techniques that incorporate sustainability elements in the design, construction, and planning of housing, many of which are appropriate to Brazilian climates, which can be integrated into housing production supply chains.

Though urban residential construction sector is not the highest contributor to greenhouse gases in Brazil, there are currently cost-effective and readily-implementable opportunities to reduce its contribution. Centralized funding sources like MCMV provide an opportunity to not only make headway towards this goal in the housing stock it produces, but also to serve as a model for other assisted housing programs and, potentially, market-rate housing developments as cities, developers and construction product manufacturers become more experienced in green housing technologies. There is a potentially major (positive) spillover effect from placing emphasis and resources towards the sustainability of housing built within MCMV as one channel for promoting urban sustainability.

This Policy Note presents recommendations aiming at supporting the Brazilian government in its efforts towards developing sustainable cities, and specifically efforts to provide high quality, energy-efficient housing with minimal environmental impacts. The Municipalities of São Paulo and Rio de Janeiro, as well as *Caixa Econômica Federal* (CAIXA), have expressed interest in defining and better understanding the implications of developing “green housing” and “green communities” in the Brazilian urban context.

The Note is based on interviews with staff from national and local organizations, national and municipal government, and private industry leaders held in Brasília, São Paulo, and Rio de Janeiro in 2010. Site visits to social housing developments and construction material retail stores were also included. Public and organizational literature was reviewed, along with international professional literature in the disciplines of design, construction, and land use planning. In addition to an assessment of current low-

income housing construction policies, practices, and available technologies, the Note provides a set of recommendations for Brazilian policy-makers on ways to optimize existing programs and practices in order to increase the sustainability of the low-cost housing sector.

A.2 Organization of Policy Note

Section B presents an overview of the low-income housing sector in Brazil, and summarizes its direct and indirect environmental impacts. Following this, Section C provides an overview of the green (sustainable) construction sector in Brazil, including a description of certification programs, green building programs, green supply-chain initiatives and ongoing research and development efforts. Section D provides specific examples of housing programs in Brazil, including MCMV, and the housing programs of Rio de Janeiro and Sao Paulo. Section E highlights opportunities to improve the sustainability of the housing construction sector, and finally, section F provides some overall recommendations from the analysis presented.

B. HOUSING CONSTRUCTION IN BRAZIL

B.1 Context

Most homes in Brazil, formal and informal, are built from pre-fabricated concrete blocks and/or ceramic bricks. These blocks are laid on top of a poured concrete foundation using an interlocking method with mortar to hold each block in place. Once the wall is constructed, some of the hollow blocks are filled with concrete in the cells that hold vertical steel rebar. The top of the wall consists of a cast-in-place concrete lintel that ties everything together. Exterior walls are typically finished with a layer of cement. Roofs are constructed of concrete slab, wood or steel frame with ceramic or PCV shingles, or sometimes of sheets of corrugated zinc in the case of informal housing. In formally constructed social housing, windows are generally made of aluminum or iron; in informal housing, a variety of window types are used. Multi-family developments are constructed using a similar method and palette of materials, the main difference being the use cast-in-place concrete stairwells and concrete slab roofs.



The primary difference between formal and informal construction of low-income housing is generally the quality of assembly and suitability of the land, more than the type of materials. Although informal housing is often referred to as self-built housing, the concept that it is the owner of the house that performs the works is not always the case in Brazilian cities, where there is an active informal

construction industry. Formally built housing tends to benefit from a higher craftsmanship level, better laid foundations, better air and moisture sealing, and better design (ventilation and lighting). Many of these benefits are derived from the fact that formal housing is usually built as a whole and delivered to the occupant as a finished product (details such as internal finishings and appliances may be left for the owner/occupant to provide). Conversely, informal housing may be built incrementally over time, exposing the construction to weather conditions, and often includes the demolition and rebuilding of portions to facilitate a change in the design plan.

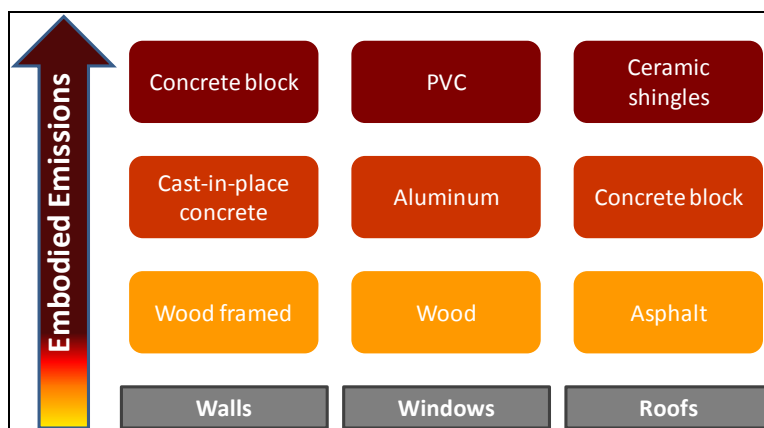
B.2 Direct Environmental Impacts of Housing Construction

Through its design, construction, and operation, housing represents a significant point of direct consumption of natural materials, water, and energy. The most significant environmental impacts resulting from housing constructions are discussed in the following sections.

Embodied Greenhouse Gas Emissions

The greenhouse gas (GHG) emissions embodied in the production of low-income housing in Brazil are relatively high because of the use of materials resulting from energy-intensive processes such as cement products, aluminum windows, PVC ceilings, ceramic bricks, and shingles. The impact of concrete use on the emissions embodied in construction of a home depends on both the type of concrete walls used in the design, and on the content of recycled waste materials in the concrete (*e.g.* fly ash). Cast-in-place concrete walls, for instance, have higher embodied energy emissions than wood framed walls, and concrete block walls have even higher embodied emissions. Increasing the fly ash content in concrete reduces embodied emissions by a small amount. Aluminum frame windows have higher embodied emissions than wooden windows, but less than PVC framed windows. Ceramic shingles have higher embodied emissions than asphalt or concrete tiles (See Figure 3).

Figure 3: Conceptual Ranking of Embodied Emissions in Common Construction Materials in Brazil



Source: Author based on data from NAHB 2008.

There is a lack of research on the embodied emissions of housing construction Brazil. However, based on an analysis of formal social housing in the State of Paraná, it was estimated that the embodied emissions per 40 square meter house is roughly 9.8 metric tons of CO₂ equivalent (Stachera and Casagrande 2008). This would imply that the 3 million housing units to be built as part of *Minha Casa, Minha Vida* represent almost 30 million MtCO₂e, or about two year's worth of emissions for the Municipality of Sao Paulo. For

the sake of comparison, the estimate of embodied emissions in an average house of 225 square meters in Los Angeles, California, is 51.4 MtCO_{2e} – slightly less than the emissions per square meter of the social housing unit (NAHB 2008). This is primarily due to the use of cement and ceramic bricks in the social housing unit (high embodied emissions) and wood stud frames with vinyl siding in the Los Angeles home (low embodied emissions).¹

Solid Waste Generation

In Brazil, civil construction is responsible for the largest percentage of solid waste volume generated in cities. A study by SindusCon (Construction Industry Association) in São Paulo, showed that construction waste accounts for 50 to 70% of solid waste in urban areas (see Table 1). It is estimated that 75% of this waste comes from informal activities, especially the construction, demolition, and rehabilitation of informal housing (SINDUSCON –SP 2005). Separate estimates show that as much as 20 percent of the bricks and ceramic blocks at social housing construction sites are disposed of as debris (Borges de Souza 2005).

Table 1: Construction Waste in Municipalities of São Paulo

Municipality	Daily Construction Waste (tons)	As % of Total Urban Waste
São Paulo	17,240	55%
Guarulhos	1,308	50%
Diadema	458	57%
Campinas	1,800	64%
Piracicaba	620	67%
São José dos Campos	733	67%
Ribeirão Preto	1,043	70%
Jundiaí	712	62%
São José do Rio Preto	687	58%
Santo André	1,013	54%

Source: SINDUSCON – São Paulo, 2005

Construction waste in Brazil does not contribute significantly to GHG emissions in landfills because of its low level of organic material. However, construction waste impacts the environment through the loss of material whose creation involved GHG emissions, occupation of landfill space, and hazard when it is not properly disposed.

The National Policy on Solid Waste (Nº 354 de 1989), sanctioned in August 2010 after 20 years of debate, emphasizes the concept of shared responsibility in relation to waste disposal. This means that each link along the supply chain - manufacturers, importers, distributors, retailers and even consumers - will be responsible for the complete life cycle of products. One of the articles of the law provides that manufacturers, importers, distributors and retailers must invest in the development, manufacture and marketing of products that can be recycled and result in the least amount of solid waste. It is anticipated that this law will promote the recycling industry in Brazil, including the manufacture of building products that use recycled construction and demolition waste.

¹ Based on CAIT 2005 data for national emissions – 2,842 MtCO_{2e}.

B.3 Indirect Environmental Impacts of Housing Construction

Land use and planning

As the primary use of land in most cities, the location of residential development has an indirect impact on the efficiency of the urban system – especially the provision of basic services and transportation. The search for cheap land at the edge of urban areas to make the construction of low-income housing financially feasible has the potential of creating a greater cost burden for the local government, as well as a global environmental burden, through the emission of greenhouse gases caused by extended vehicle commuting distances.

The lack of well-located land for low-income housing in Brazil is not a new problem. In 1985, an assessment of land purchased by the National Housing Bank (BNH) revealed that less than 10 percent of the land acquired to build housing complexes was located within, or immediately adjacent to the urban footprint. Purchase of parcels was often done on a one-off basis, and driven predominately by price and availability. As a result, the land financed by BNH was increasingly more distant from urban centers, in areas that were not always a priority for the physical growth of cities, and required additional investments by the public sector for the provision of basic services (Rolnik et al. 2008). Although new tools have been provided to municipalities through the City Statute of 2001 such as the implementation of ZEIS (social interest zones) and Progressive IPTU (property tax), the description of land acquisition under BNH is similar to the current characterization of the land being used for *Minha Casa, Minha Vida* developments.

In terms of environmental sustainability, the best location for new housing is an infill site or a lot that is being redeveloped. The use of greenfield land at the urban periphery has the potential to destroy natural habitats, increase storm water runoff, encourage automobile use, and require significant investment in infrastructure. Therefore, independently of how sustainable the construction of the building is, its location may have a negative impact on the environment. In the Brazilian context, it could be argued that informal housing in favelas in core urban areas is sustainable, given the fact that it is compact and well connected to public transport. However, its location in risky areas and/or poor ventilation could make it very unsustainable in terms of personal safety, indoor air quality, and impact on the natural habitat. Incorporating consideration of social and environmental trade-offs is an important step in the long-term evaluation of the sustainability of low-cost housing development, and of the overall urban plan.

C. GREEN CONSTRUCTION IN BRAZIL

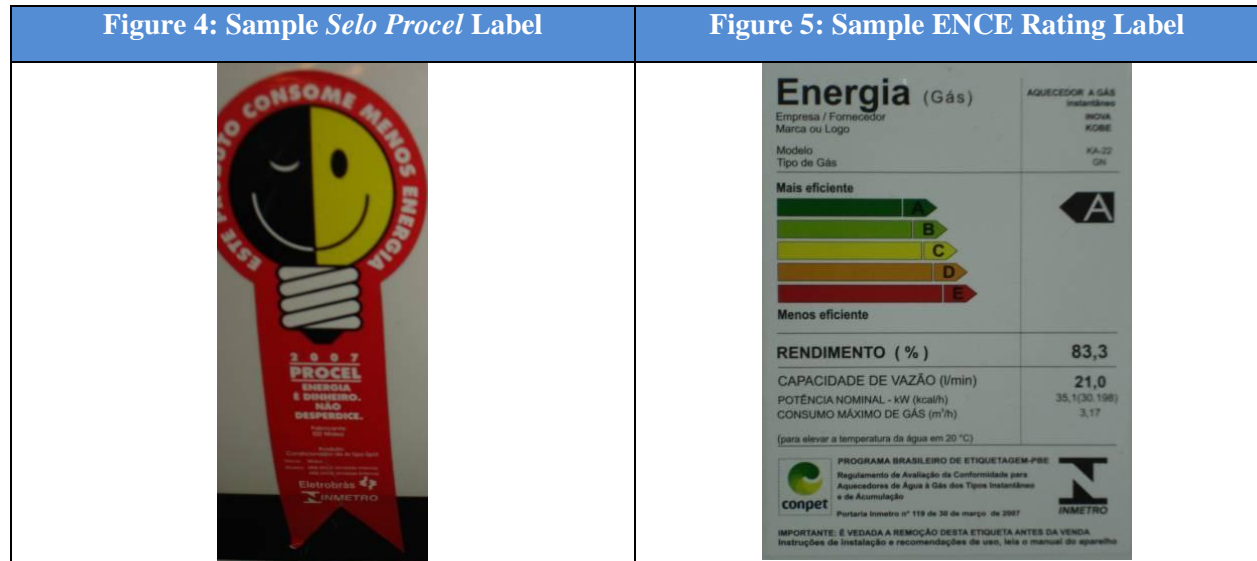
Brazil has a history of promoting programs and policies related to sustainable housing design, construction, and maintenance, as illustrated in the following sections:

C.1 Product Certification Programs

The National Electricity Conservation Program in Brazil, known as PROCEL, was established in 1985 with the goal of reducing waste in the production and use of electrical energy. It is managed by *Eletrobrás*, the largest power utility company in Brazil that is majority owned by the Brazilian government. In addition to a variety of energy-efficiency funding mechanisms and R&D efforts, PROCEL developed the *Selo Procel* in 1993, a labeling program to inform consumers, influence purchasing decisions and induce manufacturers to make efficient products. The awarding of the *Selo Procel* is coordinated by the Ministry of Mines and Energy, *Eletrobrás*, and *Inmetro* (the National Institute of Metrology, Standardization and Industrial Quality). The voluntary seal is granted to products ranging from air conditioning units to light bulbs that have undergone laboratory testing and met PROCEL specifications. The awarding of the *Selo Procel* takes place annually. In 2009, for example, 160 companies and 3,054 products received the label.

In 2006, a *Selo Procel* program for public and commercial buildings was approved and plans for developing one for residential buildings have been discussed. The *Selo Procel* is a recognized label for consumer products and a successful vehicle for energy-efficient incentives.

A non-voluntary seal maintained by *Inmetro* is the ENCE (National Energy Conservation Label), which provides energy consumption information to consumers on all products. A product with *Selo Procel*, for example, would presumably have an “A” ENCE rating. Figures 5 and 6 show examples of these two types of labels. The ENCE label indicates the type of energy used by the appliance. In this case, the label, for a water heater, indicates that the appliance uses natural gas, has the highest efficiency level (scale of A to E), an efficiency ratio of 83.3%², and a capacity of 21 liters per minute.



Another relevant program is the *Ação Madeira Legal* of IBAMA (the Brazilian Institute of Environment and Renewable Natural Resources), created to control the storage and transport of native timber products in Brazil. Since 2009, CAIXA has required a DOF (or Forest Origin Document) from IBAMA for all housing developments receiving financing.

C.2 Supply Chain Programs

A federal program that has significant impact on technological change and quality improvement within the Brazilian housing industry is the PBQP-H, or Brazilian Program for Quality and Productivity for Habitat, currently based in the Secretariat of Housing in the Ministry of Cities. Established in 1996, the program’s goal is to organize the construction industry around two main issues: improving housing quality and modernizing housing productivity. The program offers voluntary programs that establish performance criteria and bestow certifications at a variety of links along the construction supply chain, including: material quality (SiMaC), construction firm quality processes (SiAC), individual professional certifications, and technology innovation (SiNAT).

² The efficiency of the heater is defined as the ratio between the amount of heat energy actually absorbed by a body of water to cause a certain positive change in temperature of that body, and the amount of heat energy available from complete combustion of gas due to its calorific value.

Through these initiatives, PBQP-H has inserted itself into sustainable housing practices by promoting construction quality levels at all points of production—higher quality arguably being one of the most critical components of long-term sustainability because of reduced operations and maintenance costs and increased lifecycle from the improvements in construction industry—rather than just construction performance. In an important step towards potentially improving the quality of low-income housing nationwide, CAIXA requires all builders and developers involved with MCMV to have undergone firm certification through PBQP-H’s SiAC and all new technologies used in the construction of MCMV unit to go through SiNAT review.

C.3 Research & Development Programs

FINEP, the Brazilian Innovation Agency, supports research and development related to sustainable housing through the *Habitare* program. The overall objective of *Habitare*, established in 1994, is to contribute to the advancement of knowledge in the field of technology for the built environment, supporting scientific research, technology and innovation in order to modernize the housing sector and contribute to meeting the housing needs of the country. The program works along three thematic areas: (i) Technology for the Rehabilitation and Adaptation of Buildings; (ii) Innovative Technologies for Residential Construction; and (iii) Technologies for Building More Sustainable Housing. The latter includes research centers at universities, including the Federal University of Santa Catarina’s Building Energy Efficiency Laboratory (LabEEE), the University of São Paulo, and Campinas State University.

The *Fundação Getulio Vargas* (FGV), through the Center for Sustainability Studies (CES), does applied research on issues related to sustainable development (e.g. corporate responsibility, sustainability index for the São Paulo stock exchange, climate change policies, sustainable finance), especially in partnership with private companies. In 2008, CES, in partnership with *Banco Real*, launched the Sustainability Catalogue, an online tool that stores information about products and services developed according to sustainability standards.³ The Catalogue brings together technical data, features and assessments of the environmental impact of products at all stages of their lifecycle –raw materials, production process, use and final disposal. The Catalogue is not a certification program, but rather a means of making environmental information public to consumers. In regard to housing development, the Catalogue includes ratings of construction materials, appliances, and electronics.

C.4 Green Building Programs

There are three major green building certification programs in Brazil – Leadership in Energy & Environmental Design, AQUA and *Selo Casa Azul*:

- i) The **Leadership in Energy & Environmental Design (LEED)** rating system was adopted almost entirely from the United States by the Brazilian Green Building Council (BGBC), and has been promoted in the commercial building sector for over five years with certification performed by the US-based Green Building Certification Institute. The BGBC underwent a national consensus process to tailor the rating system to the Brazilian context, but this resulted in only a few changes to score weighting among the different categories’ points rather than changes in categories or measures.
- ii) **AQUA**, is a similar building certification process whose categories were adopted from the French HQE (both meaning “High Environmental Quality”) retailored its rating system to the Brazilian context, and has a growing market share. In February 2010, the first version of the AQUA process for residential buildings was launched, and in April a prototype AQUA house for low-

³ www.catalogosustentavel.com.br

income families was exhibited in São Paulo (see Box 1). Whereas LEED buildings must be certified in the United States, AQUA buildings are certified by Brazilian agents. Other national rating systems, like the UK's BREEAM, Canada's Green Globes, South Africa's Green Star or India's GRIHA, have not been created or adopted for Brazilian commercial buildings.

Box 1: Casa AQUA

In April 2010, a prototype AQUA house for low-income families was exhibited in São Paulo. It measures 40 square meters and has a construction cost of R\$45,000. Some of the sustainable solutions adopted include a rainwater reuse system, consisting of a cistern and permeable soil; a solar water heater; fiber-cellulose shingles; and soil-cement bricks, which are dimensioned and prefabricated to allow for faster assembly and do not use mortar, thereby reducing costs. A sloped roof with skylights was designed to take advantage of natural light and ventilation.



The interior of the house also includes environmentally friendly products such as cement board made from mineralized wood, which does not require finishing, and the use of recycled Tetra Pak packaging on some walls. The house has a dual-flush toilet, which reduces water usage, and fluorescent light bulbs.

The construction of the Casa AQUA takes between 30-60 days to complete. According to the developers, the use of eco-efficient solutions in the construction of the house had an additional cost of only R\$5,000.

Source: Fundação Vanzolini; PINIWeb

- iii) The *Selo Casa Azul* (“Blue House Seal”) rating system was launched by CAIXA in 2010 with the goal of promoting green housing development in Brazil. It is a voluntary set of guidelines developed by a team of Brazilian experts, including faculty involved in FINEP’s sustainable housing research programs. In contrast, the LEED and AQUA rating systems were created by consensus. The *Selo Casa Azul* process has not yet been piloted. Similar to the early promotion of other green rating systems, *Selo Casa Azul* offers great symbolic value in advocacy, awareness, and in technological possibility.

Selo Casa Azul follows a similar set of scoring criteria, performance categories, and technological measures as other foreign green rating systems like LEED. A development can score at the Bronze, Silver, or Gold levels only after fulfilling a given number of measures out of the total of 53 possible points – 19 mandatory measures, mandatory plus 6 additional measures, and mandatory plus 12 additional measures, respectively for each certification level (See table 3). Currently, CAIXA requires that any development requesting the *Selo* have some kind of CAIXA financing, though CAIXA does not offer special financing terms or incentives for green building.

An additional criterion placed on the certification level is the property’s value, depending on geographic location. Properties over a specified value must achieve at least a Silver level. Presumably, this is a means to require higher income developments to include more green construction measures, or conversely, a way of incentivizing basic green design measures in low-income housing.

Table 2: Selo Casa Azul Scoring Criteria

Categories / Criteria	Rating		
	BRONZE	SILVER	GOLD
1. URBAN QUALITY			
1.1 Site Quality – Infrastructure	mandatory		
1.2 Site Quality – Impact	mandatory		
1.3 Site improvements			
1.4 Restoration of degraded areas			
1.5 Rehabilitation of buildings			
2. DESIGN AND COMFORT			
2.1 Landscaping	mandatory		
2.2 Design flexibility			
2.3 Relationship with the neighborhood			
2.4 Alternate transportation solution			
2.5 Selective garbage collection area	mandatory		
2.6 Leisure facilities (social and sports)	mandatory		
2.7 Thermal performance – air sealing	mandatory		
2.8 Thermal performance – sun and wind orientation	mandatory		
2.9 Natural illumination of common areas			
2.10 Natural ventilation and illumination of bathrooms			
2.11 Physical adaptation/customization to the site			
3. ENERGY EFFICIENCY			
3.1 Energy-saving lamps (private areas)	mandatory for < 3 MW		
3.2 Energy-saving devices (common areas)	mandatory		
3.3 Solar water heating system			
3.4 Gas water heating systems			
3.5 Individual measurement (gas)	mandatory		
3.6 Efficient elevators			
3.7 Efficient appliances			
3.8 Alternative energy sources			
4. CONSERVATION OF MATERIAL RESOURCES			
4.1 Modular coordination	mandatory		
4.2 Quality of materials and components			
4.3 Industrialized or prefabricated components			
4.4 Reusable forms and anchors	mandatory		
4.5 Construction and demolition waste management	mandatory		
4.6 Optimum dosage concrete			
4.7 Fly ash (CPIII) and Pozolanic (CP IV) cement			
4.8 Pavement with recycled construction and demolition waste			
4.9 Easy maintenance of facade			
4.10 Planted or certified wood			
5. WATER MANAGEMENT			
5.1 Individual metering of water	mandatory		
5.2 Efficiency devices - flushing system	mandatory		
5.3 Efficiency devices – aerators			
5.4 Efficiency devices –flow regulator			
5.5 Rain water utilization			
5.6 Rain water retention			
5.7 Rain water infiltration			
5.8 Permeable areas	mandatory		
6. SOCIAL PRACTICES			
6.1 Construction and demolition waste management education			
6.2 Environmental education of employees			
6.3 Personal development of employees			
6.4 Capacity building of employees			
6.5 Inclusion of local workers			
6.6 Community participation in project design			

Mandatory criteria + 6 optional measures

Mandatory criteria + 12 optional measures

Categories / Criteria	Rating	
6.7 Training for residents	mandatory	
6.8 Environmental education of residents		
6.9 Management training		
6.10 Actions for mitigation of social risks		
6.11 Actions to generate employment and income		

Source: Selo Casa Azul, Boas Práticas para Habitação Mais Sustentável, Caixa Econômica Federal, 2010.

Table 3: Selo Casa Azul Scoring Value Criteria

Location	Value of the Residential Unit
Federal District	Up to R\$ 130,000
Municipalities of São Paulo and Rio de Janeiro	
Municipalities with a population equal or above 1,000,000 that are part of metropolitan regions in the States of São Paulo and Rio de Janeiro	
Municipalities with a population equal or above 250,000	Up to R\$ 100,000
Metropolitan Region of the Federal District (RIDE/DF) and other metropolitan regions and municipalities within the urban area of state capitals (except São Paulo and Rio de Janeiro)	
All other municipalities	Up to R\$ 80,000

Source: Selo Casa Azul, Boas Práticas para Habitação Mais Sustentável, Caixa Econômica Federal, 2010.

All of these measures are in addition to any municipal building code requirements, physical accessibility minimums (at 3% of all units if not higher by local ordinance), and energy and water utility permits whose satisfactory fulfillment must all be demonstrated to CAIXA. No inspection fees will be charged except for a single application fee of R\$ $40+7(n-1)$ where n is the number of units. This fee cannot exceed R\$328. A penalty of 10% of the development value is assessed for those submissions that do not accomplish their originally proposed measures. Certification will rely on CAIXA's existing network of engineers who make field visits during the construction process to check on the status of works and a small internal staff at headquarters in Brasília.

Limitations and challenges associated with the Selo Casa Azul program

A number of questions arise from the review of the 53 measures in the *Selo Casa Azul* criteria, specifically:

- i) The measures are specifications that are satisfied absolutely—that is, there is no nuance or gradation in the score; the development either accomplishes it or not. This framework removes some flexibility from the developer to satisfy an environmental or social goal, and also removes incentives to take the intended reason for a measure beyond the minimum level. While such a framework is the only alternative for some measures (like installation of energy-efficient appliances), it is not the preferred structure for those measures with the potential for varying levels of implementation (like rainwater utilization);
- ii) There is a limited amount of quantitative measurements for indicators, even for those that are more easily measured in absolutes, such as the energy-efficient appliance requirement. Quantitative measures facilitate the developers' understanding of the expectations for their projects as well as subsequent certification processes. There are a few exceptions (for example, the required distances to mandatory community services), but the majority of measures do not contain numerical goals. The lack of direct (and also quantitative) linkage to environmental

benefits for each measure — or broader environmental performance goals for each category — poses a challenge;

- iii) The cumulative initial cost of the construction-related measures (Categories 3-5) is substantial, though not prohibitive for middle- to higher-income markets: an approximate addition of 0.5-1.0% of the overall construction hard costs to reach the Bronze level (authors' estimate). Because of energy subsidies for low-income households, the payback term for low-income housing would be longer and somewhat more difficult to justify than for higher income housing. Some of the voluntary measures for reaching Silver and Gold certifications are also much more expensive for all income levels, like on-site renewable energy production, cement substitutes, and stormwater treatment;
- iv) The measures that may be the most difficult to meet in the Brazilian context are not the building design and construction ones, but rather the community and site selection measures (Category 1 and some of Category 2). While voluntary measures reward infill, rehabilitation, and brownfields redevelopment, the mandatory requirements for infrastructure, transit, and community amenities are strenuous; this is true both in urban core areas where there is little land, and in suburban areas where there may be limited infrastructure or public transport. In contrast to other green building rating systems, *Selo Casa Azul* makes many of these community and site selection measures mandatory. In this way, it is a hybrid between green community systems (like LEED for Neighborhood Development) and those focused solely on buildings (similar to the other LEED rating systems) — a particularly complicated proposition for most developers; and
- v) *Selo Casa Azul* proposes a set of technologies and practices more innovative than those with which residential builders are likely to feel comfortable at the moment. Though the program requires the developer to provide training and capacity building in certain mandatory and voluntary measures (Category 6), the program itself does not provide any training or capacity building. Similarly, there are mandatory requirements for owner and occupant manuals, but no ongoing maintenance or operation requirements.

D. EXAMPLES OF LOW-INCOME HOUSING CONSTRUCTION IN BRAZIL

D.1 Minha Casa, Minha Vida (MCMV)

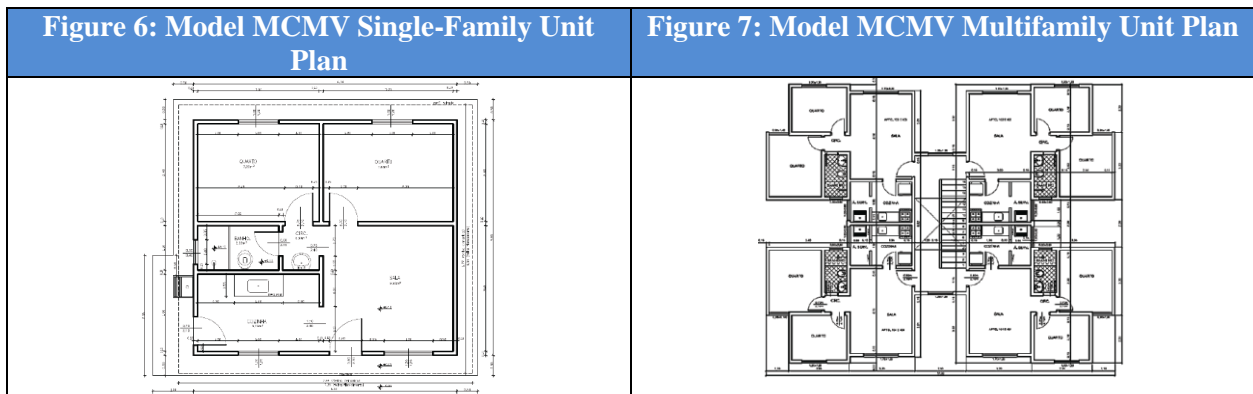
With the launch of the *Minha Casa, Minha Vida* (MCMV) economic stimulus program to subsidize the construction of 1 million low-income housing units (and recent approval of a second round of subsidies for 2 million homes), Brazil is in a unique position to achieve the triumvirate of sustainable growth – the social goal of reducing the national housing deficit, the economic stimulus goal of creating jobs in the construction industry, and the environmental goal of developing healthy homes and communities. The construction of these 3 million homes and their subsequent use will consume a significant amount of materials, energy, and water. There is an opportunity to act now to reduce and partially neutralize these future environmental impacts.

MCMV Design Specifications

Developments for the lowest-income households (up to 3 minimum wages) for the MCMV Program have a number of design specifications. Specifically, requirements include:

- Projects cannot be larger than 500 units if single-family development, or 250 if multifamily (per phase of development);
- A single-family unit lot is set to 35 square meters with 32 of that being usable space, a multifamily unit is set at 42 square meters with 37 being an individual unit's usable space;

- The standard floor plan for both consists of a living room, kitchen, bathroom, two bedrooms, and—for the single-family unit—a small outdoor area with water tank;
- An indoor height of 2.2 meters in the kitchen and bathroom with a 2.5 meter height in the remaining rooms (2.4 for multifamily) is fixed for both types;
- The single-family unit must have a 0.5 meter concrete slab perimeter outside, and a 0.5 meter walkway around that, along with a 0.8 meter-wide sidewalk in front;
- The multifamily building is limited to four floors and 16 units total, with an option of going to five floors and 20 units with strict accessibility provisions;
- A space of 4.5 meters minimum must be set between 3-story multifamily buildings, 4 meters for those with 4-5 stories, and 6 meters for more than 5 stories;
- Entrances to the buildings, particularly in multifamily sites, should be easily identified and on higher elevations; and
- Accessibility standards must be applied both in public areas (for example, a minimum width of 0.8 meters for public doorways) and in individual units designed for households with handicapped members, the number of units being dictated by national and local law.



Source: Caixa 2010

With the exception of some of the accessibility requirements, there have been few complaints from private developers regarding the design requirements, though the height, land coverage, and site usage requirements do not always lead to the maximum potential return for each parcel of land. This lack of criticism may be due to the production benefits of having a predictable design template.

Box 2: Solar Water Heating for housing under MCMV

The first phase of the MCMV program included the voluntary installation of solar water heating systems with the stated goal of reducing the consumption of electricity and CO₂ emissions. Developers can receive a subsidy of R\$2,500 per unit for multifamily developments and R\$1,800 for single-family units to provide and install the solar water heaters. The goal for the first phase is to reach 10% of the lowest income segment (40,000 units). It is estimated that the system could reduce household utility costs by up to R\$60 per month. Preliminary feedback on this attempt to include this “new” technology in low-income housing is that there has been resistance from developers. The second phase of MCMV will require solar water heating systems in all units.

Figure 8: Example of a *Minha Casa, Minha Vida* Development



Source: Bairro Novo 2010.

MCMV Building Materials Specifications

With regards to construction materials, both single-family and multi-family units have additional specifications (below). Any new materials or technological innovations must be reviewed and approved by PBQP-H prior to submission to participate in the MCMV program.

- Appropriate water sealing, particularly between foundation-wall and wall-roof connections;
- Ceramic tile flooring is required in kitchens and bathrooms, with finished cement for the remaining floor areas;
- Wall tile in bathroom up to a minimum height of 1.5 meters, with waterproofed sealing around the sink and drain;
- Individual water tank for single-family homes, and an elevated tank with two dedicated water pumps;
- Internal plastering with latex indoor paint and acrylic exterior paint;
- Concrete, wood, or PVC ceilings for single-family, and concrete slab for multifamily;
- Ceramic shingled roofs on a wooden or steel frame for single-family, and concrete tile for multifamily;
- Metal window frames (aluminum for coastal areas, steel in interior regions) and wooden doors;
- Detailed electrical outlet locations per room (including a connection for the electric showerhead even with solar heating);
- Detailed dimension and finish appearance specification for kitchens and bathrooms (with no water consumption requirements);
- Illegal woods and timber are prohibited, and must be demonstrated with a DOF from IBAMA.
- Dedicated water and electrical lines for future washing machines; and
- Individual water and electrical meters, including in multifamily units.

Overall, no major complaints have been noted by developers and builders with regard to these specific materials requirements. The wood origin certification requirement is not viewed as onerous, though this is likely due to the fact that there is little to no wood utilized in the housing. The requirement to provide tiling in the bathroom and kitchen is a new requirement for social housing developments, and is an important improvement in terms of ensuring waterproofing.

There is concern, however, regarding the requirement for new materials and construction assembly innovations to receive PBQP-H review and approval rather than just having them meet local building codes and/or general performance thresholds. While the PBQP-H approval requirement is a positive element of the MCMV program in terms of ensuring a minimum level of quality in the construction of the homes, it may also serve as a deterrent to innovation.

MCMV Site Specifications

There are several requirements for community and site planning that are placed on MCMV projects. Many of these focus on minimizing soil and land disturbance or restricting the use of environmentally sensitive lands. Others are not directly related to energy consumption or environmental performance, but could have significant indirect impacts on the environment through additional transportation demand.

These requirements include:

- Land that is contaminated, in protected habitat for endangered species, part of a historic preservation effort, in wetlands, in high-erosion zones, or with extreme slopes (above 45 degrees) is either off-limits or permissible with adequate, locally-determined mitigation and restoration;
- Selected sites should be provided with infrastructure, including transportation (streets and throughways), telephone, intercom (for multifamily), energy, potable water, waste water, and stormwater drainage (including appropriate natural and enhanced slopes) connections. Feasible garbage collection should also be anticipated. This should consider the location of buildings within the sites as well;
- Security gates of 1.8 meters are required for developments, along with full lighting of public areas;
- Parking must be provided per usual local requirement and with usual construction (in minimally sloped areas with paved access to city streets); and
- For developments with more than 60 units, community and recreational facilities such as community centers, playgrounds, sports fields, or reception halls must be built to the equivalent of 1% of the construction costs of the site and building.

It should be noted that MCMV generally relies on the local zoning, planning, and impact analysis carried out by municipal or state authorities to dictate both the terms of additional requirements as well as the proof of compliance. Many of these are more significant than those imposed directly by MCMV, particularly with respect to impact fees and land set-asides for educational facilities and other infrastructure by municipalities and transportation and water infrastructure requirements by public authorities and utilities. MCMV has actually helped to standardize these requirements nationally, though, arguably for municipal authorities, this standardization is not sufficiently restrictive or detailed enough to ensure that MCMV developments are sufficiently serviced and connected to adjacent communities.

Opportunities to improve the environmental performance of MCMV Program

Aside from the direct construction and design specifications of the program, there are a number of opportunities within the administration of the program that could positively influence the final quality of the constructed products, and that have the potential for incorporating additional green design and construction techniques. Some suggestions for improvement include the following items:

- i) CAIXA uses the National Research System's (SINAPI) Civil Construction Indices to set cost ceilings. According to developers, the cost ceilings are slightly inaccurate geographically — that is, they do not account for nuances within regions and, occasionally, even between regions. Moreover, developers state that the Indices provide such tight margins that additional design, construction, and site requirements would be financially feasible. This is one reason, for instance, why the solar water heating component of the MCMV program is offered as an additional subsidy.
- ii) The turnaround time for review and approvals of projects is also an opportunity that influences the environmental performance of projects. First, the MCMV review period (two week) is expedited in comparison to traditional finance reviews. Though probably optimistic, the

expedited review timeframes could make it difficult to incorporate any kind of innovative design or technology beyond a standard floor plan without jeopardizing the approval, despite the benefit of reduced processing time for the developers. The two week-period, though, does not include the other national (PBQP-H, DOF-IBAMA) and local regulatory reviews which are typically much longer. Because they are the source of most development delays, many municipalities have agreed to reduce their processing times in support of MCMV. For example, the Municipality of Rio de Janeiro instituted a “fast track” process for licenses related to MCMV, including housing and urban planning departments.

A corollary to this procedural review is the field inspections that CAIXA (or outsourced) engineers perform during project construction. As noted earlier, any project applying for *Selo Casa Azul* would have its “green” components inspected through the same process. This would be true for any green design elements or innovative technologies incorporated into MCMV. As such, there is a need for inspectors/engineers to receive capacity building on green design and new materials and technologies.

- iii) The fact that the MCMV program finances both developers and households may influence adoption of new technologies. Homebuyers take long-term loans on units that will likely be held by the original occupant households for their duration, therefore increasing the opportunity to include technologies with a reasonable payback of up to 10 years for the lowest-income (up to 3 minimum wages) and 25 years for the 4 to 10 minimum wage group. The development of the optional solar water heating package demonstrates an effective channel for linking financing to construction elements that, in this case, also have environmental benefits.
- iv) MCMV offers an opportunity to influence building performance through its social outreach and education requirements for the lowest-income households (estimated at 0.5% of the construction value for developments over R\$40 million). Similar to the kinds of social work performed by local housing agencies for their developments, MCMV requires a training module for educating households (many of whom have never lived in a modern, formally constructed building) on how to use community facilities, collaborate with neighbors on building maintenance, and operate their homes. This outreach could be supplemented with energy-efficiency, water-efficiency, and other green training.
- v) Though partially introduced through the community and site requirements, a lack of coordination of land purchases and investments from cities has been noted as a significant barrier to incorporating more sustainable land use techniques into MCMV. The program will produce units that will relieve the demand for housing in many cities but will not necessarily incorporate that housing into broader municipal—and for that matter, environmental—considerations or best utilize the selected lands for maximum returns. Proposed projects in cities that offer land or infrastructure for development are prioritized, but it remains unclear how many cities have such resources to offer and, if so, have chosen to use them for alternative uses. For the 4 to 10 minimum wage units where there is less incentive for cities to provide land and infrastructure than the up to 3 minimum wage segment, in particular, developers are concerned with land availability and are building at the urban margins of larger cities. In turn, there is a concern among municipal and regional housing officials about the reproduction of mass housing, the concentration of poverty, and the lack of sufficient consideration to non-housing community development concerns.
- vi) There is a data collection opportunity through the MCMV registration and intake process in states and municipalities to ask questions about current living conditions, appliances, and mechanical systems so as to better understand residents’ quality of life before and after occupancy, their

specific energy, water, and material consumption, and the changes in environmental impact from the program.

D.2 Social Housing in São Paulo

The Municipality of São Paulo's Secretariat for Housing and Urban Development (SEHAB) is responsible for five major programmatic areas: (i) construction of new housing units by self-help groups or private developers; (ii) regularization and upgrading of slums; (iii) resettlement housing and infrastructure works for populations living in hazardous zones; (iv) housing construction and improvement in areas close to employment hubs; and (v) urban rehabilitation of the historic center. SEHAB's slum action plan, in particular, recognizes the link between poverty, housing and the environment.

The design and construction quality of many of the last decade's resettlement apartments in São Paulo by SEHAB has been the subject of some concern, both in terms of overall design as well as environmental impact. While more recent developments have improved on previous designs (see Box 3), a more comprehensive effort is currently underway, in which revised design and construction guidelines that account for occupant needs and behaviors (e.g. occupants' potential for maintenance of housing unit, building and conservation of water, energy) would be provided to developers.

Box 3: SEHAB Design Innovations

In a step towards innovation in the design of social housing, SEHAB contracted Ruy Ohtake, an architect known for utilizing curves and strong colors, to design a resettlement housing complex with 71 buildings adjacent to the favela called Heliópolis in the City of São Paulo. The round form is intended to increase the circulation space between the buildings and eliminate notions of "front" and "back" of traditional buildings.



Each building has four floors and eighteen apartments of 52 m². Two units on the ground floor are reserved for elderly or handicapped occupants. The first phase with 23 buildings will be delivered in late 2010. The construction of the remaining 48 buildings is scheduled to begin in early 2011.

Also in *Heliópolis*, renowned Brazilian architect, Hector Vigliecca, designed *Condomínio Bolsão II*. This development has an integrated kitchen and dual orientation, meaning that the layout of the unit is such that the apartments will receive direct sunlight for at least four hours per day. Moreover, the windows are designed so as to promote natural ventilation.

In the southern part of the city, *Condomínio Mata Virgem*, was designed by architect Joseph Tabitha. The units have a flexible floor plan that allows for two or three bedrooms within the 50 square meter space. The bathroom and kitchen are fully waterproofed. All external finishes are covered with natural grass and no asphalt is used. The unit design tries to maximize environmental comfort, with concerns ranging from the internal circulation of air to the permeability of the soil.

Source: SEHAB, Folha de São Paulo

Through consultations with developers, designers and housing advocates, SEHAB has identified the following three areas that are critical to good design of the city's low-income housing:

- a) *Technology considerations* - Including different construction and building techniques, such as: (i) green buildings (e.g. both passive techniques and products); (ii) industrialization (e.g. prefabricated, panel, and modular); and (iii) other new materials and assemblies (e.g. open plans);
- b) *Occupant needs* - This includes the techniques and physical arrangements that best suit the functional and behavioral needs of the occupants, for instance,: (i) aesthetics; (ii) appropriate layouts for various family types; (iii) universal accessible design for the elderly and handicapped; (iv) maintenance awareness and capacity; (v) anticipation of furniture and appliance needs; and (vi) the ability to individualize units and surroundings;
- c) *Community connections* - The isolating effects of site and building designs could have a significant impact on residents, and therefore provisions need to be incorporated in the design to: (i) better connect sites with their surroundings (e.g. mixed-income developments, reduced parking, street and visual connectivity, better transit access); (ii) provide needed services for the occupants and neighbors (e.g. more open and recreational space, improved defensible space techniques and patrolled areas); and (iii) create opportunities for economic self-sufficiency (e.g. mixed-use developments, live-work spaces, ground-floor commercial areas).

In an effort to improve the quality and design of informal housing, in partnership with ABCP (the Brazilian Association of Cement Manufacturers), SEHAB launched the *Magia da Reforma* (Magic of Rehabilitation) initiative in the *Paraisópolis* favela in 2007. The program provided technical assistance for building repairs. Based on that experience ABCP has also launched the *Clube da Reforma* (Renovations Club) in partnership with 37 other organizations including Ashoka and Habitat for Humanity. The objective of the initiative is to improve the living conditions of low-income people by assisting 1 million families in the next five years.

Box 4: Example of design improvement program in the U.S.

Performance recommendations and best practices can be effective tools to promote creativity and innovation in design. For example, the U.S. Department of Housing and Urban Development (HUD) put numerous design tools into place in the early 2000s that, in unison, dramatically improved building and site designs. These included:

- The Affordable Housing Design Advisor (www.designadvisor.org) which served as a clearinghouse of good examples of design, and a toolkit for the process of designing in which guidelines were embedded (rather than having guidelines for the design product);
- Funding of the Association of Community Design (www.communitydesign.org) and the National Charrette Institute (www.charretteinstitute.org) to promote community involvement in design and train design professionals in these outreach techniques;
- Technology demonstrations with participating universities and research centers on actual building sites, often with donated products from manufacturers (www.pathnet.org/sp.asp?mc=techpractices);
- Outreach and training to professional designers and builders to adopt new techniques;
- Market research to better track current occupant behaviors and future occupant needs;
- Competitions among university students who produce significant design innovations, usually at no cost;
- Awards programs for good design with different professional associations and press organizations (www.huduser.org/portal/research/secaward.html); and

- Prioritizing design and construction bids or development funding based on the satisfaction of explicit guidelines or rating systems (for example, green building rating systems), or providing another financial incentives for experimenting and innovating.

D.3 Social Housing in Rio de Janeiro

The MCMV program allows for municipalities to put additional requirements on housing developments. The Municipality of Rio de Janeiro published voluntary guidelines for sustainable design and construction within their administrative boundaries. While not readily enforceable because of their general, qualitative language, the “*Recommendations, Guidelines and Specifications for Sustainable Housing*” provide an orientation for builders and a framework for city officials to approve and prioritize developer submissions. The categories of techniques covered include:

- Rainwater harvesting;
- Non-toxic materials;
- Materials with reduced embodied energy;
- Recycled-content material;
- Material-efficient construction assemblies to reduce construction waste;
- Constructing recycling facilities for occupants;
- Maintaining natural site features;
- Energy-efficient equipment and appliances;
- Passive design for energy conservation and daylighting;
- Locally-sourced materials and labor;
- Durable and moisture-managing construction; and
- Accessibility and universal design.

Federal Law 6.766/1979 delegates control over subdivision regulations to the municipal governments. The Municipality of Rio, through Law 4931/2008 requires that 40 percent of the land in a subdivision be allocated to public use (minimum of 15 percent for green open space, 20 percent for public right-of-way, and 5 percent for community facilities). This is a higher allocation than the 35 percent contribution that was previously required by federal law. Because subdivision laws are the responsibility of the municipal government, this is an area of great opportunity for innovation in creating more compact neighborhoods and customization to the local context.

The Municipality has planned for builder and developer training design and construction guidelines, but this capacity building program has not yet been implemented. With the release of national green residential building recommendations through *Selo Casa Azul*, though, there appears to be some opportunity to standardize or at least develop parallel efforts between these green construction guides. In an additional move towards transforming the MCMV program locally, CAIXA and the German Agency for Development (GTZ) signed an agreement to provide 500 solar water heaters in Rio’s MCMV developments.

Box 5: Reducing construction waste through innovation

One large development company that is active in constructing MCMV housing in the metropolitan area of Rio de Janeiro, *PDG Realty*, recently purchased a stake in a pre-fabricated panel manufacturing company called *Jet Casa*. The system of construction is based on the concept of using the least expensive ceramic bricks, while also providing greater thermal comfort than precast concrete. The panels are framed with steel, and come off the production line with all electrical and plumbing lines inserted. The result of this

industrialized system is a reduction of construction waste, decrease in housing production time, and lower utilization of manpower at the construction site. In 2009, the company built 2,500 housing using this system nationwide. In 2010 they estimate an increase to 10,000 units. The reduction in construction waste is definitely a positive consequence of this type of process innovation, and there could be further opportunities for incorporating more environmentally sustainable materials.

Construction of MCMV units is reshaping the footprint of Rio de Janeiro. In fact, in the first quarter of 2010, *Barra da Tijuca* – after at least 20 years leading the ranking of licensed square meters in the city and the epicenter of the 2016 Olympic Games – came in second to the North Zone of the city in terms of square meters licensed. According to a survey by the Municipal Secretariat of Urbanism, the North Zone licensed 460,590 square meters, compared to 317,303 during the same period in 2009, an increase of 45%. *Barra da Tijuca* (and *Recreio*) finished second, with 343,592 square meters, compared to 366,667 in 2009 (down 6.29%). The West Zone came in third both years, but recorded substantial growth of over 75% (ADEMI). This market data strengthens the argument for the need for additional attention on the location of MCMV developments, not just in terms of how it affects the quality of low of low-income residents, but also how it is reshaping the urban form as a whole.

Box 6: Novas Alternativas Program

The Municipality's *Novas Alternativas* (New Alternatives) Program aims at promoting infill development. The program identifies vacant properties in the downtown area, undertakes the lengthy process of acquiring (or taking) the property, and then rehabilitates the property for low-income housing. With only 119 units produced since its creation in 1996, though, the program is more of an innovative model of environmentally-preferable infill development than a productive contributor of housing units. MCMV funding, however, has been suggested as a potential vehicle for identifying additional purchasers since the registration office for the program in Rio de Janeiro noted that about 50 percent of households with completed applications for MCMV in Rio would prefer to be located in the urban core – *Centro*, *Zona Sul* and *Zona Norte* (Secretary of Housing as of August 2010).

Figure 9: Promotional Materials for Rio's *Novas Alternativas* Program



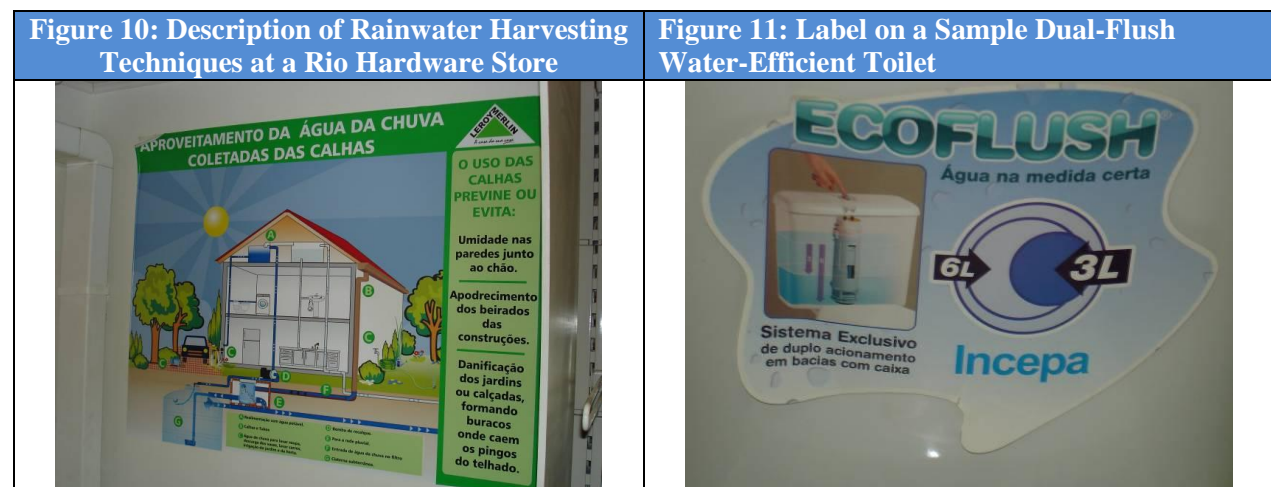
E. OPPORTUNITIES TO IMPROVE SUSTAINABILITY OF HOUSING SECTOR

With increasing awareness on sustainable construction and active low-income housing construction in Brazil, there are currently major opportunities to promote the incorporation of green construction technologies, as well as hazard-resistant technologies for climate adaptation, within formal and informal low-income housing in Brazil. The following is a review of selected technologies from *Selo Casa Azul*, professional literature, and existing Brazilian construction practices that may be most applicable, as well as possible channels for their widespread introduction.

Water Conservation and Water-Efficient Technologies

The following water-conserving and water-efficient technologies can be effectively incorporated into low-income housing construction:

- Rainwater harvesting, which can provide water for irrigation, flushing, and mechanical use (such as washing sidewalks, cars, or equipment not destined for human consumption);
- Greywater reuse systems that can use shower and sink wastewater for similar purposes;
- Individual water metering promotes water conservation and penalizes excessive consumption by tracking and charging individual households more effectively;
- Low-flow and double-flush toilets are readily available and generally cost effective products and;
- Water-efficient fixtures such as sinks, faucets, and showerhead aerators can deliver lower volumes of water with higher pressure.



Energy efficiency

Since the primary points of electricity consumption in Brazilian homes are water heaters and appliances, some promising energy-efficient technologies include:

- Energy-efficient appliances and equipment (*Selo Procel* labeled or better);
- Solar water heaters;
- Effective passive design (responding to local climactic analysis of solar orientation and wind patterns), including includes landscaped shading and built amenities like overhangs, solar chimneys, window coverings, and green and white roofs to reduce heat and temperature variations (and the need for additional mechanical systems);
- Individual gas and electric metering. The former is already common in many multifamily housing developments because of propane deliveries;

- Where applicable, increased attention to building envelope insulation and sealing (including higher-performance windows) where there is an expected purchase of window air conditioning units. In fact, many low-income housing developments provide partially finished envelope “holes” with the expectation that the households can and will install a window unit. While such structural provision foresees the future use in those units, the actual construction of the unit and building is generally not similarly prepared for conditioned air. In those circumstances, some additional insulation or other treatment will be needed to ensure the efficient use of energy by the equipment.



Indoor Air Quality

Given that most low-income housing relies heavily on direct natural ventilation, indoor environments could be improved using the following techniques:

- Ensuring spot ventilation requirements for combustible equipment beyond or in coordination with local building codes would reduce pollutants and smoke from cooking or other sources;⁴
- Integrated pest management techniques, which include occupant training on appropriate food storage and unit cleaning, may also be necessary in some developments; and
- When used, paints should be selected based on their toxicity and base ingredients, though most housing is constructed with minimal finishes and, consequently, fewer non-toxic finishes (occupant training on this is necessary).

Materials & Assemblies

There are a variety of strategies for improving the environmental performance of construction materials in Brazil’s low-income housing. Interestingly, one of the most commonly cited is the prefabrication and industrialization of building assemblies, though there is no clear environmental gain from these techniques; rather, the benefit of these stems from their productivity, manufacturing speed, and more efficient use of materials. Likewise, there are few recycled-content construction materials and products on

⁴ While rural housing is not a focus of this paper, an important consideration for rural housing is indoor air pollution from firewood burning stoves. Ideally, these should not be present in any confined space or, at the very least, located with sufficient ventilation.

the market that would be feasible for low-income housing. As such, the **best alternatives for reducing material impacts from low-income housing include:**

- **Increasing the use of substitutes for traditional cement and alternatives to traditional cement-production and installation (like insulated concrete forms, fly ash concrete, autoclaved aerated concrete, and concrete aggregate substitutes) would be the most effective and comprehensive change in material specification given the quantity of concrete used in Brazilian construction;**
- **For informal housing (and formal single-family housing), the use of renewable earthen structural components and mixtures (such as adobe, soil-cement brick, and agricultural waste) may be a viable and inexpensive option that reduces environmental impact significantly; and**
- **Increasing construction material waste recycling, particularly when it can be reused on-site, is another significant and cost-effective technique.**

Figure 14: Cellular Concrete Block Readily Available at a Rio Hardware Store



Lot Development

Aside from the community amenities and infrastructure planning that are required in the MCMV program, there are some clear opportunities to incorporate technology alternatives and alternative approaches to lot construction and design:

- Flexible, performance-based landscaping and lot requirements can provide public green spaces, manage stormwater (e.g. through the use permeable pavement), and increase density while increasing universal accessibility;
- Replacing current design specifications with performance attributes can increase overall environmental performance while maintaining basic occupant health and sanitation; for example, overall unit numbers, size, and material requirements but no set floor plan can improve aesthetic and passive-climate design;
- While landscaping is required by MCMV and most municipal authorities for large developments, there are no requirements on the kinds of planting, their placement, or the preservation of existing flora. Indigenous plants that require minimal additional irrigation or maintenance and that are better integrated into the built environment could supplement current recommendations.

Table 4: Summary of Possible Green Technologies for Low-Income Housing in Brazil

Category	Technologies and Techniques
Water	<ul style="list-style-type: none"> • Rainwater harvesting • Greywater reuse systems • Individual water metering • Low-flow and double-flush toilets • Water-efficient fixtures
Energy	<ul style="list-style-type: none"> • Energy-efficient appliances • Solar water heaters; • More effective passive design • Individual gas and electric metering • Improved building envelope insulation and sealing
Indoor Air Quality	<ul style="list-style-type: none"> • Spot ventilation requirements • Integrated pest management • Low-toxicity paints
Materials & Assemblies	<ul style="list-style-type: none"> • Cement substitutes • Renewable earthen structural components and mixtures • Construction material waste recycling
Lot Development	<ul style="list-style-type: none"> • Performance-based landscaping and lot requirements • Permeable pavement and landscaping • Indigenous plants

Financial and regulatory incentives to promote sustainable housing and green technologies

The use of regulatory measures to promote sustainable design and construction has been often used by low-income housing programs and providers to incorporate green construction and planning techniques in their funding and eventual housing. For example, the U.S. Department of Housing and Urban Development required “smart” planning in its HOPE VI funding stream for public housing authorities as early as 1994 and has since added additional energy-efficiency and green building requirements to other funding streams. A US housing technical assistance and funding intermediary, Enterprise Community Partners, created a green rating system solely for affordable housing construction entitled “Green Communities.” The increased popularity of green building rating systems has further increased the use of these techniques especially within assisted housing. For market-rate homes, affordability has also been addressed by offsets, rebates, and other incentives that reduce the burden of the initial costs of these technologies. For example, Canada’s Mortgage and Housing Corporation offers a 10% mortgage insurance premium refund and an extended amortization up to 35 years for the purchase or renovation of a home to specific energy-efficiency performance standards.

Financial incentives like energy-efficient mortgages (EEMs) are becoming common in middle-income countries as well. The “*Hipoteca Verde*”⁵ (Green Mortgage) offered by Mexico’s INFONAVIT uses similar methods of determining construction performance in exchange for a loan-to-value ratio with the expectation of longer-term utility savings. In addition, the National Housing Commission in Mexico has developed a model housing code that includes green building techniques (See box 7).

⁵ The *Hipoteca Verde* is a mortgage product developed by INFONAVIT in 2007 for the financing of eco-technologies (that seek energy efficiency in energy and water use, and solid waste management) by providing an additional 20 percent of capital on the basis that the savings from the eco-technologies will provide a better cash-flow for mortgage repayment.

Box 6: Energy Efficiency Initiatives in Low-Income Housing in Mexico

Housing has a key role in increased energy demand and the potential generation of a large share of GHGs in Mexico. According to the National Housing Commission (*Comision Nacional de Vivienda*, CONAVI), Mexico currently has 24.8 million houses, which are expected to increase by about 7 million new housing construction in the next decade, and to 45 million houses by 2030. CONAVI estimates that a poorly designed house in a warm climate has an additional consumption of 1,000kWh per year, which represents about 600kg of CO₂ emissions. Given that a large share of the population lives in warm areas, in a business as usual scenario it is expected that 2.1 million tons of CO₂ emissions are currently produced by the housing sector only. The impact of the housing sector in Mexico's emission inventory will therefore increase substantially over time.

The government aims to integrate housing policies, programs and instruments which are capable of abatement of direct and indirect GHG emissions, and at the same time take advantage of the international carbon market opportunities for the housing sector. In this context, in December 2009, CONAVI issued a sustainable housing program within a climate change context (*Programa Especifico para el Desarrollo Habitacional Sustentable ante el Cambio Climatico*, PEDHSSC) that sets the ground for incorporating energy efficiency technologies and CDM financial benefits into housing. In addition, in October 2009 CONAVI also developed the technical criteria for the development of sustainable subsidized housing (*Caracteristicas Paquete Basico para Programa de Subsidios*), which are consistent with criteria used for the existing "green mortgages" (*hipoteca verde*). This allows the housing subsidy program "*Esta es Mi Casa*" to be eligible for the "green mortgage" and thus receive better financing to overcome upfront costs of energy efficient technology. Similarly, CONAVI has developed a CDM methodology (AMS-II.AE)⁶ for efficiency and renewable energy measures in new residential buildings, which are expected to provide further financial incentives for green housing.

In the mid-term, the Mexican government aims to move to a low carbon development in cities through the establishment of concrete regulatory and financial frameworks that lead to the reduction of residential energy demand. In this context, it is expected that by the end of 2012, CONAVI will have developed a green housing policy that includes the adoption of a green building code, the adoption, monitoring and verification of sustainable housing CDM methodology, and the consolidation of the use of the housing subsidies coupled with green mortgages. These measures are expected to lead to GHG emissions mitigation of 1.2 MT/Co₂e/year.

Source: Comisión Nacional de Vivienda (CONAVI). 2009. *Programa Especifico para el Desarrollo Habitacional Sustentable ante el Cambio Climático*; *Características Paquete Básico para Programa de Subsidios*, CONAVI, October 2009.

F. RECOMMENDATIONS

On the basis of the information presented in this Note, recommendations are included below, aimed at enhancing the sustainability of low-income housing approaches, which can be particularly relevant in the current context of the expanded MCMV program. Recommendations range from simple improvements to existing guidelines, to more complex policy reforms:

Selo Casa Azul could be used as a preliminary framework from which technical assistance can be provided to cities for developing their own local sustainability addenda to MCMV requirements, as is the

⁶ Approved by UNFCCC July 17, 2009.

case of Rio de Janeiro. Better coordination of individual federal, state, and municipal policies is needed to ensure effective implementation.

Some of the more cost-effective specifications of the Selo Casa Azul could be incorporated into the MCMV Program. While in many cases specification-based guidelines may limit innovation, such guidelines are relevant for the low-income housing sector because of the builders' limited ability to explore new and often costly techniques. A sliding rule approach could be developed, for instance, where a number of green construction/design specifications would be required for the 4 to 10 minimum wage developments, with a smaller number of measures (possibly with developer incentives) for the lowest-income units.

Incorporating more flexible spatial and planning requirements in the MCMV specifications will allow for better incorporation of passive solar and ventilation appropriate to each specific development's site. The current MCMV design specifications do not pose a barrier to more environmentally-appropriate alternatives. In fact, their compactness arguably follows good green design principles. However, they do pose an additional challenge for designers wishing to incorporate passive solar and wind orientation techniques. Moreover, constrained sites and limited household areas (particularly with explicit uniform dimensions) make reacting to local climate conditions difficult, if not impossible. Alternative floor configurations could take advantage of natural ventilation and lighting in each unit. Establishing alternative metrics to reach basic occupancy health and safety needs could eliminate this problem, though these would be more complicated for municipalities to review, CAIXA to inspect, and for developers to implement.

Streamlining the processes for MCMV's technological submissions and reviews of both technical and non-technical requirements (including the PBQP-H and IBAMA's DOF) may reduce the opportunity costs to proposing project improvements like green building technologies, along with improving the likelihood of additional innovative designs and technologies into the process.

Providing technical assistance to developers, builders, and designers through third-party coursework, unbiased technical information (such as green technology reviews and inventories), and design reviews would speed up the learning curve among building professionals, making them more likely to incorporate green technologies on their designs. This would consequently decrease the costs of incorporating green design and technologies as a result of increased knowledge and availability. With increased professional experience in the field, technological measures could be incorporated into MCMV requirements (and even municipal building codes) with little to no additional cost and time burden.

MCMV could require additional household training programs regarding the operation and maintenance of green technologies. This could include technical assistance for residents through municipal current outreach programs (e.g. training of households on green technologies and energy- and water-conserving behaviors). Effective training and awareness-building would ensure that the expected environmental performance is achieved as well as teach an entire segment of the population about conservation behaviors.

CAIXA could be involved in developing bulk-purchase agreements with manufacturers and retailers for those households that wish to purchase green building products (particularly appliances). This could serve as incentive to developers who would otherwise not provide energy-efficient appliances. This could be coordinated in the same manner as the current solar water heating unit subsidy and could be specifically targeted to such items as refrigerators and window-unit air conditioning in the appropriate regions.

CAIXA could expand the solar water heating financing pilot to allow for a broader range of higher-performance appliances and equipment and, even, construction techniques in a “green finance package”. Municipal MCMV registration offices could bundle households requesting more sustainable homes (and capable of affording them) to streamline the specifications for developers. CAIXA could offer “energy-efficient” or “green” mortgages. The mortgage product could be expanded into the lowest-income units in the form of micro-finance tied to the purchase of appliances. For example, rather than simply expect the lowest-income households to purchase appliances after occupancy, CAIXA could provide them at reduced cost (through bulk purchase) to developers and as a charge to interested households through local microfinance institutions or product suppliers.

Beyond MCMV, a similar financing structure could be applied to existing home retrofits and informal housing improvements, with the latter including both green improvements as well as the climate adaptation techniques of structural reinforcements and disaster-resistant housing. Household incentives could include, for instance, direct construction grants, land title, or another household subsidy—possibly energy-efficient appliances.

Additional efforts could be implemented in non-assisted, market-rate housing that are likely to have significant impact on low-income housing. Though more complex, these would lead to decreased initial costs for most technologies as well as an improvement in the overall professional knowledge of these techniques. These include:

- Modifying the requirements of *Selo Casa Azul* such that they are more readily quantified, have specific environmental benefits that are also quantifiable, and eventually lead to a performance-based framework. The current structure and certification requirements, though laudable in their introduction of green building into the Brazilian housing market, will likely go through some refinement once the documentation and certification process commences;
- CAIXA could consider piloting a financing product aligned with *Selo Casa Azul* similar to energy-efficient mortgages that may initially involve just basic incentives (e.g. interest rate reduction) and eventually lead to genuine mortgage incentives (such as increased loan-to-value ratios);
- Additional supply-chain subsidies and incentives could be provided to specific green building manufacturers to increase research and development activities as well as develop builder and designer training and implementation materials. This could be coordinated with the federal research and construction productivity programs in FINEP and PBQP-H program and non-federal channels (such as the FGV Sustainability Catalogue), so that there is a continued vehicle for adopting and piloting; and
- Building code advocacy could be used as a lever to require higher-income households to improve their units’ environmental performance.

Carbon finance could be an opportunity for implementing sustainability improvements in the low-income housing sector. UNFCCC approved methodologies exist for housing components like that distribution of efficient light bulbs to households (AM0046) , manufacturing of energy efficient domestic refrigerators (AM0070), use of less carbon intensive fuels in cement manufacture (ACM0003), and increasing the blend in cement production (ACM0005). In addition, there is a proposed new methodology for energy efficiency and fuel switching measures in new buildings (NM0328) as part of the Masdar City development in Abu Dhabi. The methodology proposes that energy efficiency would be maintained through actions such as passive solar design, high efficiency equipment and lighting, and intelligent metering. Should this methodology be accepted by UNFCCC, it is plausible that “greened” MCMV developments could be aggregated in order to achieve the scale necessary to make a CDM project viable.

Provide additional subsidies and elevated price ceilings to projects that are developed on infill or redevelopment sites in the urban core. One of the fundamental issues regarding the environmental sustainability of the MCMV program is the location of the projects. In the second phase of the program, additional subsidy and elevated price ceilings will be provided for houses developed in large urban areas to reflect that fact that land and construction cost are higher. An even further step down this path would be to allow the subsidy plus loan package to be used for the purchase of existing units. The “greenest” housing unit is one that already exists and that would otherwise be vacant, representing a loss of materials and a loss of opportunity to redevelop the already urbanized site.

Bibliography

- . 2009. Moderators' Report on E-Debate on Inclusive Sustainable Urbanization. World Bank.
- Anauate, M. 2010. A Norma de Desempenho e as Inovações Tecnológicas para Habitação de Interesse Social--Posicionamento da CAIXA. Encontro sobre Habitação de interesse social : programas e inovações tecnológicas.
- Bairro Novo. 2010. Presentation. Encontro sobre Habitação de interesse social : programas e inovações tecnológicas.
- Barros, M. and R. Castro Souza. 1997. Residential Electrical Energy Consumption Profile in Brazil. PUC-RIO.
- Borges de Souza, V. 2005. Avaliação da Geração de Entulho em Conjunto Habitacional Popular – Estudo de Caso. Universidade Federal de Uberlândia.
- Caixa. 2009. Minha Casa Minha Vida (ESPECIFICAÇÕES PARA EMPREENDIMENTOS ATÉ 3SM- APARTAMENTOS). Caixa.
- Caixa. 2009. Minha Casa Minha Vida (ESPECIFICAÇÕES PARA EMPREENDIMENTOS ATÉ 3SM-- CASAS). Caixa.
- Caixa. 2009. Minha Casa Minha Vida (Explanatory Materials). Caixa.
- Caixa. 2010. Selo Casa Azul: Boas Práticas para Habitação Mais Sustentável. Caixa.
- CTE. 2010. « Programa Minha Casa Minha Vida :Avaliação qualitativa da fase 1 e Perspectivas da fase 2. » Encontro sobre Habitação de interesse social : programs e inovações tecnológicas.
- de Azevedo Cardoso, L.R. et al. 2002. Productive Chain Modelling in Housing Construction in Brazil, Aiming at a Prospective Study. World Congress of Housing.
- de Oliveira, A. and T. Laan. 2010. Lessons Learned from Brazil's Experience with Fossil-Fuel Subsidies and their Reform. International Institute for Sustainable Development.
- de Souza, R.. 2010. Sustentabilidade – Conceitos gerais e a realidade no mercado brasileiro da construção. Presentation at CTE Inteligencia 360.
- Elétrabras. 2009. Catálogo do Selo Procel. Programa Nacional de Conservação de Energia Elétrica.
- Empresa de Pesquisa Energética (Ministério de Minas e Energia). 2009. Balanço Energético Nacional. <http://www.mme.gov.br/mme/galerias/arquivos/publicacoes/BEN/2 - BEN - Ano Base/1 - BEN 2009 Portugues - Inglxs - Completo.pdf>
- Escola Politécnica Da Universidade De São Paulo. 2003. O Futuro Da Construção Civil No Brasil-- Resultados De Um Estudo De Prospecção Tecnológica Da Cadeia Produtiva Da Construção Habitacional. Secretaria De Tecnologia Industrial Ministério Do Desenvolvimento, Industria E Comércio Exterior
- Ferguson, B. and J. Navarrete, A financial framework for reducing slums: lessons from experience in Latin America. Environment and Urbanization 2003; 15; 201.
- International Energy Agency. 2006. World Energy Outlook 2006. Ch. 16: Focus on Brazil. Pp 447-485.
- Jha, A.K.. 2010. Safer Homes, Stronger Communities: A Handbook for Reconstructing after Natural Disasters," World Bank.
- Lamberts, R. and J. Carlo. 2004. Uma discussão sobre a regulamentação de EEE. Mercofrio 2004 - IV Congresso de Ar Condicionado, Refrigeração, Aquecimento e Ventilação do Mercosul.

- Lamberts, R. et al. 1997. Eficiência energética na arquitetura. São Paulo: PW Editores.
- Lamberts, R. et al. 2007. Regulamentação de etiquetagem voluntária de nível de eficiência energética de edifícios comerciais e públicos. ENAC 2007. ANAIS. Ouro Preto.
- Lamberts, R. 2009. Brazilian Energy Efficiency Policies.
http://www.cstc.be/homepage/download.cfm?dtype=services&doc=13_Agopyan_Brazilian_presentation_final.pdf&lang=en
- LaBEE. 2007. Regulamentação para Etiquetagem Voluntária de Nível de Eficiência Energética de Edificações Residenciais. Versão aprovada para testes pelo GT edificações.
- La Rovere, E. 2002. Climate Change and Sustainable Development Strategies: A Brazilian Perspective. OECD.
- McKinsey & Company. 2009. Caminhos para uma economia de baixa emissão de carbono no Brasil. Available at http://www.mckinsey.com.br/São_paulo/carbono.pdf.
- Machado, H. 2001. Brazilian Efforts Towards Reducing Greenhouse Gas Emissions in the Transport Sector and in the Energy Intensive Industry. Workshop on Good Practices in Policies and Measures, 8-10 October 2001, Copenhagen
- Ministerio de Vivienda y Urbanismo de Chile. 2009. Primera Reunión del Programa de Calidad y Productividad en Vivienda MINURVI.
- MRV Engenharia. 2010. Presentation. Encontro sobre Habitação de interesse social : programas e inovações tecnológicas.
- Poole, A. D. et al. 1998, Energy Conservation and Greenhouse Gas Emissions in Brazil. Instituto Nacional de Eficiência Energética.
- Prado, T. 2008. AQUA: primeiro referencial técnico brasileiro para construções sustentáveis. Planeta Sustentável.
- Programa País Eficiencia Energética. 2010. Guía de Diseño--VIVE CON BUENA ENERGÍA. Ministerio de Vivienda y Urbanismo de Chile.
- Rolnik, R. et al. 2008. Solo Urbano e Habitação de Interesse Social: A Questão Fundiária na Política Habitacional e Urbana do País
- Soares, L.A. 2010. « Programa Habitacional Do Estado De São Paulo 2007-2010 » Encontro sobre Habitação de interesse social : programas e inovações tecnológicas.
- Statcher, T. and E. Casagrande. 2007. *Desenvolvimento e a Aceleração do Crescimento de Emissões de Co2 no Brasil: Cenário de um Projeto do PAC no Paraná*. Presented during Tenth International Conference on Non-Conventional Materials and Technologies in Cali, Colombia, November 12-14, 2008.
- Statcher, T. and E. Casagrande. 2007. Avaliação de Emissões de CO2 na Construção Civil: Um Estudo de Caso da Habitação de Interesse Social No Paraná. Presented during IX Engema - Encontro Nacional sobre Gestão Empresarial e Meio Ambiente in Curitiba, November 19-21, 2007.
- UNEP. 2006. Eco Housing Guidelines for Tropical Regions. UNEP.
- UNEP. 2006. Eco-Housing in Asia and the Pacific Region. Presentation at Training Workshop on Eco-housing in Bhutan 21 – 25 March 2006.
- Villagarcia, S. and F. Cardoso. 1999. New Supply Chain Network In Brazil's House Construction Industry. IGLC 7.

World Bank. 2010. "Cities and Climate Change in Brazil."