Sustainable Housing Design and Technology Adoption in *Colonias*, Informal Homestead Subdivisions, and the "Innerburbs"

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EXECUTIVE SUMMARY

This study was undertaken as part of a housing seminar through The University of Texas "Sustainable Cities" interdisciplinary graduate program anchored in the School of Architecture, Community & Regional Planning. It included graduate students from the LBJ, CRP, LAS and Sociology programs and the Law and Business schools. Directed by Dr. Peter M. Ward, the seminar class sought to provide a set of recommendations for sustainable housing rehabilitation in low-income and self-help settlements in Latin American and in the USA. Specifically, we wanted to expand our understanding of sustainable housing applications by considering not just the field of energy efficiency and renewable energy, but also the broader arenas of social, juridical and fiscal sustainability that may contribute to the adoption of policies related to "green" housing.

In the U.S., interest in energy savings and efficiency has become more widespread, technologies have improved, and applications have become more affordable. The current Obama administration has made sustainable home retrofitting an important component of its stimulus package. The American Recovery and Reinvestment Act of 2009 is investing over $20 billion towards increasing the energy efficiency of our nation's building stock. Cities throughout the country have pioneered their own plans, through tax incentives and utility programs, to promote similar goals. In Latin America, interest in housing sustainability is also gaining traction. Mexico and Brazil, for example, are actively thinking about housing sustainability through the proliferation of lower energy lighting fixtures, individual solar energy water heaters, and community recycling programs. Most often, however, this occurs in the context of urban sustainability, and is available to middle- or upper-income households.

Because they are often costly, sustainable applications are most easily adopted among the more economically advantaged sectors. As the negative impact of buildings on carbon emissions and total energy consumption continues to be documented, we are increasingly aware of the need to make sustainable housing solutions more widely available. Additionally, when accounting for the social equity component of the sustainable agenda, we must remember that a lack of energy-efficient housing in low-income communities means that low-income households are likely to incur higher costs relative to their incomes and capacity to pay. In fact, the U.S. Department of Housing and Urban Development has recognized that utility bills disproportionately burden the poor. Sustainable technologies must be applied to structurally sound homes in low-income settlements to make them more resource efficient, both to improve quality of life and to benefit the environment.

This study was designed to offer new policy approaches developed in the context of low-income, self-help or self-managed housing environments in the U.S. generally, and in Central Texas specifically. In addition we were interested in exploring how some of these possible housing applications might be applied more widely, especially in Latin America where poverty levels are more acute, and where self-build is the norm.

First, we identify the broad-brush variables that may constrain the application of new technologies or improvements in any context. These included climate and geography; relative poverty levels of the populations; the legal and regulatory environment; government and administrative capacity; social capital and organizational capacities. We present these (in Chapter 2) as important background "predisposition variables" that need to be considered when exploring the viability and appropriateness of any one set of policy applications.

Next we research the range of available options that might be applied at both the household or community level, regardless of income. Chapter 3 details our findings and is accompanied by a set of in-depth appendices of hands-on explanations, and a guide to further reading. Notably, we review four different types of technological interventions that are applicable to low-income, self-built, or self-managed housing:

- Microclimate design and technologies to support energy efficiency
- Renewable energy technologies to support enhanced energy access
- Water and wastewater technologies to promote water conservation and quality
- Waste systems to promote resource reuse and recycling

In the area of microclimate we focus on weatherization and passive solar design as crucial household-level changes that can greatly reduce energy usage and utility bills while promoting health and indoor-air quality. We give weatherization special attention since it has been the focus of the current Obama administration and has been heavily funded by the American Recovery and Reinvestment Act of 2009.

In the area of renewable energy we focus most on those technologies that are practical at the individual household level and affordable for low-income residents. The most accessible sources of renewable energy are individual solar water heaters, which use free solar energy to heat water through small, relatively inexpensive solar collectors.

For water and wastewater management we explore an array of practices, technologies, and systems that range from common-sense behavioral changes to community-wide water catchment, rainwater, or greywater systems. Nowhere is the range of technologies as expansive and diverse as in the field of water savings and reuse. We catalogue the many available options in a set of detailed appendices.

In the recycling and solid waste section, we review several different technological, social, behavioral and economic models for solid waste collection, reuse, and recycling. These include: basic reduction and reuse strategies, composting systems, traditional home recycling, recycling cooperatives, informal recycling businesses, commercial recycling, “upcycling”, and municipal solid waste.

In Chapter 4 we narrow our focus to examine the modest and low-cost approaches that might find more immediate and widespread adoption among lower income residents. We outline the range of housing improvements that exist across the four areas listed above and we documented their relative costs, and the ease of their implementation. We conclude that the primary constraining factors that determine the feasibility of an intervention are the economic investment required, the technological complexity of the proposed intervention, and the labor and human capital involved in its installation. Thus we determined the suitability of different technologies in terms of their cost, their ease of operation, and their ability to be installed using the sweat equity of the homeowner his or herself.

These findings are presented graphically through a series of individual charts for each of the four areas discussed in the preceding chapter: microclimate, renewable energy, water & wastewater, and recycling & solid waste. This series of diagrams rates various technologies according to a rubric in the following categories:

- Ease of Maintenance
- Savings
- Initial Cost Outlay
- Human Capital

We also developed a home energy savings calculator in the form of a spreadsheet. The spreadsheet is meant to be an instrument to help individual households gain a clear understanding of the economic benefit associated with various sustainable interventions in their home. With the help of an energy auditor a household could use the spreadsheet to determine the actual savings on their monthly utility bill for a range of different improvements (or combinations of those improvements).

Together the diagrams and spreadsheet can provide a powerful tool to demonstrate the range of possible technologies for rehab and new development, the contexts in which they are most suited, and the actual benefits to individual households that can result. The graphics depict many low-cost, low-tech options that have the potential to produce significant savings for low-income households.

These technologies cannot be implemented in a vacuum. It is also critical to understand the contexts in which they are applied. The success of any technology to promote energy, water, and other resource conservation will depend significantly on social support and the participation of community members, regulatory constraints and existing legal structures, and fiscal opportunities. To explore the context within which sustainable policies take place, in Chapter 5 we return to our set of precondition variables and discuss these constraining factors more broadly in terms of social, juridical and fiscal sustainability.

For instance, even if a technology is affordable, practical, available, and easy to maintain (i.e. it meets the preconditions outlined in our series of charts and diagrams), homeowners many not implement that technology if they do not know if its existence, are not educated about its benefits, experience social stigma against it, or have difficulty mobilizing advocates on their behalf. To begin to understand how some how some of these potential setbacks might be remedied, we outline key elements of successful community engagement and mobilization in the first part of Chapter 5.

In the juridical (legal and regulatory) arena, Texas Local Government Code explicitly prohibits municipalities from regulating land use and zoning within their extraterritorial jurisdictions. While this ostensibly limits energy-efficiency standards from being implemented in these areas, it can also allow for the development of innovative technologies or community-wide projects that are prohibited within city limits. Working against this flexibility often, are “clouded” titles to land in low-income or informal settlements which generally present obstacles to accessing credit, receiving certain types of federal subsidy or obtaining local funding to undertake improvements.

The economic feasibility and available funding for sustainable upgrades and new development is perhaps the most decisive factor in determining whether these technologies will reach low-income communities. Thus, we pay special attention to the arena of fiscal sustainability by outlining not only current funding sources but also opportunities for “green” jobs training. It is our belief that the benefits of sustainable home improvements come not only from the increased health, comfort and energy-efficiency of the homes themselves but also from the creation of new jobs and sources of sustainable economic development within low-income communities.

In sum, we hope this report will serve as comprehensive guide to developing policy that addresses the many unique challenges of extending sustainable housing applications to low-income populations. If initiatives can be made to address the factors that shape community involvement, education, local leadership, and capacity building while working within existing regulatory and legal frameworks and taking advantage of fiscal opportunities, then a more holistic sustainable housing policy will emerge.

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Chapter 1

Thinking About Housing Sustainability Among Low-income Populations

INTRODUCTION

This study was undertaken as part of an LBJ/CRP/LAS graduate class in the spring semester of 2010. It was offered as part of the "Sustainable Cities" interdisciplinary doctoral program anchored in the School of Architecture (Community & Regional Planning) in which the Instructor (Professor Peter Ward of the LBJ School) is one of the principal participants.[1] The proposition that we should give consideration to "green" applications within low-income housing design and policy, particularly that tied to self-help and self-build, was raised by Ward in an overview paper (2008) that he prepared as a contribution to one year seminar at the MIT on *Ideas in Planning.*[2] In that shortly to be published study Ward describes the emergence of self-help housing policies and their application in developing countries since the early 1950s, and concludes with a discussion of the next generation of housing policies. The paper focused upon two main lines of policy innovation. The first is the need for housing rehab in the older (now) consolidated self-built settlements that began informally 30-40 years ago, and which now often comprise 20-40 per cent of the built-up areas of many cities in Latin America and elsewhere. Originally peripheral, invariably these settlements form part of the intermediate ring of metropolitan areas. Given their lowly origins and the nature of incremental construction typified by self-build, and the intensive use of these dwelling spaces over more than thirty years, the physical structure of the homes themselves as well as the utilities installed are invariably heavily deteriorated. This means that they are in urgent need of rehabilitation and retrofitting in order to bring them into line with contemporary household structures and needs. To date, however, there has been little consideration of how housing policy should respond to take account of these temporal changes and the associated evolution in household and demographic structures. These first suburbs as the Brooking Institution now calls them,, or in our usage "the innerburbs", are the focus of a major comparative study in eleven Latin American cities coordinated by Professor Ward at The University of Texas at Austin (www.lahn.utexas.org).[3] One of the objectives was that the findings of this class will provide a set of inputs that will inform our thinking about housing rehab in self-help settlements, both in Latin American as well as here in the USA.

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[1] The class was supported by a 2009-10 grant to Professor Ward from the Lyndon B. Johnson School of Public Affairs, Policy Research Institute "Urban Sustainability and Renewable Energy Applications for *Colonia*-Type Housing in the Southern US". Class members in alphabetical order: Leticia Aparicio Soriano; Dana Campos; Lauren Flemister; Sherief Gaber; Karina Mallaupoma Povez; Daniela Ochoa González; Christeen Pusch; Danielle Rojas; Jacob Steubing; Mary Esther Sullivan, and Elizabeth Walsh. Esther Sullivan (PhD student in the Dept. of Sociology) served as Research Assistant for Dr Ward and as a TA on the course. She took the lead for integrating and editing this Final Report on behalf of the class participants

[2] "Self-Help Housing Ideas and Practice in the Americas, In (forthcoming) Bish Sanyal and Lawrence Vale, eds. *The History of Planning Ideas.* MIT.

[3] Additional references on this topic include: Katz, Bruce, Robert Lang, Alan Berube. 2006. *Redefining Urban and Suburban America: 3 Volumes Evidence From Census 2000.* (Washington, D.C.: The Brookings Institution Press).

The second line of policy innovation proposed in that chapter on "Ideas in Self-help Housing" was the idea of exploring how sustainable housing applications might begin to target low-income populations, and not just be a preserve for middle and upper income households as they have largely been in the past. If the concept of urban sustainability is ever to become a meaningful one especially in less developed and poorer societies, then "green" and low energy solutions and approaches need to be configured for low income housing production and construction – whether this is formal or informal in nature. Indeed, some societies such and Mexico and Brazil are already actively thinking about housing sustainability albeit primarily in use of solar energy water heaters, recycling, lower energy lighting fixtures, etc. In the USA, too, citizen and household interest and commitment to savings and efficiency in the use of energy (particularly through new forms of renewable energy generation) and urban sustainability have also quickened and become more widespread as technology improves, and as applications are scaled-up and become more affordable.

While such considerations and applications are more easily adopted among the better-off and more economically advantaged sectors, in the US we are also increasingly aware of the need to make sustainable housing solutions more widely available. If not, sustainable housing will be a class-segmented issue in which poorer groups are likely to incur higher costs relative to their incomes and capacity to pay. In part President Obama's Stimulus Package has targeted residential improvements and weatherization programs that are designed to have two major outcomes: first, to put people into the workforce in the production of home grown housing elements that are more energy efficient (e.g. doors, windows, electrical appliances etc.); and second, to promote the demand for these home improvement items through grants, loans, rebates and other incentives. Indeed, in a major weatherization rollout speech that he gave on December 15th 2009 from a Home Depot store, President Obama described insulation as "sexy".[4] Today issues of sustainability and housing improvement are firmly on the urban and housing agenda, with the important difference that it is now being promoted as part of the mainstream for all income groups including those living in modest manufactured (mobile home) and modular homes; no longer is it primarily the preserve of middle income residential America.

The proposition that we need to broaden the availability of housing sustainability and options for the lower income householders was the starting point for the current study. Specifically, we wanted to explore the various arenas of sustainable housing applications, technologies and approaches that exist today, and not just the field of energy efficiency and renewable energy. Thus we were also interested in other arenas of sustainability: water and waste water management, solid waste disposal systems, home composting, micro-climate and garden or micro environmental design applications, etc. As well as exploring the range of applications in each case, we were eager to focus attention upon the more modest and low cost approaches that might find immediate and more widespread adoption among the lower income residents, and not just document the high tech and more expensive solutions that, if for those who can afford it, are always likely to be an easier "sell" and are more amenable to commercialization.

[4] http://firstread.msnbc.msn.com/_news/2009/12/15/4427454-obama-insulation-is-sexy

We believed that the policy agenda would be advanced if we were able to outline the range of options for so-called green and sustainable housing improvements that exist across a number of different arenas, and if we documented their relative costs, and the ease (or not) of their implementation.

We also wished to identify the primary constraints that act to limit sustainable housing applications whether these are legal and regulatory, organizational and human resource-based, knowledge and culture based, or based upon resources and affordability. From the outset it was recognized that if ideas about sustainability are to be meaningful and go beyond simply being practical applications and housing improvement "fixes", then it would be necessary to identify other realms that underpin sustainability. Specifically, these include: first, social organization and community engagement to ensure effective participation, buy-in and maintenance of any housing policy implementation locally. Second, fiscal sustainability is crucial in order to ensure that the wherewithal for continuation and replication exist, even if temporary subsidies and financial incentives are required at the outset. Third, regulatory sustainability is another pre-requisite, ensuring that laws and regulations are conducive to the implementation of policy. All too often codes prevent applications from gaining traction, and while there may be good reasons to prevent particular initiatives from moving forward (where dangerous or sub-standard housing applications might be endorsed), some level of flexibility that will allow progressive movement to code compliance may be necessary to ensure that community initiatives are not "locked -out" or prevented from gaining seed funding. In short, thinking about sustainability goes beyond the realm of practical physical applications, "green" or not.

RANCHO VISTA AND REDWOOD INFORMAL HOMESTEAD SUBDIVISIONS: A CASE STUDY OPPORTUNITY

While the scope of the class was intended to be both theoretical and practical it was never anticipated that we would have sufficient time and resources to explore these practices within the context of a real world example -- at least not in any depth. For those students who were not familiar with low-income residential areas in peri-urban areas of Central Texas, or with the better known *colonias* of the border region, there were one or two ad hoc field excursions and "windshield" visits to nearby settlements, and in one case three students visited the Lower Rio Grande valley area itself. But these visits were largely for the purpose of orientation and were didactic rather than analytic.

However, several weeks into the semester the class instructor (Prof. Peter Ward) received a request from the director of the Community Development Clinic of the Law School to assist in the preparation of a housing survey of two *colonia*-type settlements – informal homestead subdivisions[5] – located adjacent to each other some 35 miles to the south-east of Austin outside of the city of San Marcos. Although many similar low-income subdivisions exist closer to Austin and would have been more convenient for our purposes, the Law School had worked previously

[5] For more on informal homestead subdivisions (IFHS) see: Ward, P. and Peters, P. (2007) "Self-help housing and informal homesteading in peri-urban America: Settlement identification using digital imagery and GIS." *Habitat International*. 31(2): 205-218. See also (Ward 2004).

in these neighborhoods on land titling, and septic tank improvement, and enjoyed a close rapport with community leaders. In addition the Clinic Director (Heather Way) and her graduate students were committed to preparing a joint proposal with the Texas Low Income Housing Organization to work on behalf of the two communities in order to seek Stimulus Packing funding for home improvements and new homes. Each of the two settlements (Rancho Vista and Redwood) comprise around 300 lots, usually one-half to one acre lots, upon which most have erected dwellings that are single or doublewide trailer homes. Most families have lived in their homes for a considerable number of years, are low income and are largely Hispanic (Mexican or Mexican origin).

Ward's previous work and experience in similar surveys persuaded him to agree to undertake the survey in collaboration with the Community Development Clinic, and several members of the housing sustainability class also expressed an interest in being involved. At the same time, we were excited about the opportunity to think through sustainable housing applications in a "real world" case study. It also promised us the opportunity to get us inside people's dwellings (rather than a more superficial external view that one achieves with windshield surveys), and it would give everyone first hand insights about residents' perceived housing needs, their priorities, and their dwelling environments. Moreover, the ultimate aim of the survey – to support and strengthen the two communities in making a proposal for weatherization and home improvement resources and new self-help housing – was central to the goals of the class, so we were pleased to be able to participate.

There is no doubt that the time demands of multiple meeting with community leaders, designing the survey, training ourselves to apply it, and then to code the returns as we received them detracted from the time and energy that we able to dedicate to the preparation of this final report. Indeed, most of the coding and analysis have been undertaken by several of us after the semester had ended (as was the integration of this the final report itself). But on balance, the experience was extremely helpful in making us realize that the possibilities of adopting sustainable housing improvements vary greatly both between, and especially *within***,** communities. Some households are doing fine and already have substantial homes irrespective of whether or not their dwellings are substantially "green"; but many of the other homes are heavily deteriorated and have major problems. Here the opportunities for significant upgrading built around sustainability are likely to be extremely limited, although our view is that some low and minimal cost improvements would yield gains and a palpable improvement in the quality of people's lives relative to their dwelling environment. But for these same people the creation of more genuinely sustainable housing is likely to require the replacement of their current homes with newer manufactured or modular structures that are less deteriorated and conform more closely with sustainable housing standards, as well as new self-built and self managed housing production.

A full description of that study and the survey results are presented elsewhere and are not included in this report (see "The LBJ/Law School Redwood and Rancho Vista Weatherization Survey"). However, we wish to record our thanks to the community leaders and to the 134 households who participated in the study. It was a privilege to have the opportunity to work with members of the two communities, and we greatly benefited from the insights that this real world experience lent to our classroom discussions and to our efforts at making sense of sustainable housing applications.

THE STRUCTURE OF THE REPORT

The current report follows the development of the class research throughout the course of the semester and several of the ":deliverables" that were produced collectively along the way. At the outset we began by identifying the low-income housing contexts and processes at work locally (in Austin and Central Texas) as well as further afield – in the *colonias* of the Texas border region and in Latin American cities more generally. The aim was to develop a broad overview of the nature of self-built and self-managed housing processes in Texas and in Latin America, and to better understand the housing contexts in which we ultimately wished to explore and embed possible sustainable housing actions and applications. In anticipation that these different regions and contexts would face a variety of constraints to the successful application of sustainable housing initiatives we sought to identify the broad-brush variables that, *a priori*, we felt would need to be considered. *Inter alia* these included climate and geography; relative poverty levels of the populations; the legal and regulatory environment; government and administrative capacity; social capital and organizational capacities, etc. We present these as important background "predisposition variables" that would need to be considered when we later sought to explore the viability and appropriateness of any one particular set of policy applications, both generically as well as in the different regional contexts. These initial steps are outlined in the following chapter (two).

The next stage was to explore the various dimensions of sustainability, and to that end we divided into several groups in order to develop a detailed inventory of housing practices and applications that make a contribution to sustainability. Starting with the more familiar areas of renewable energy generation and actions to conserve energy (however it is acquired), insulation and thermal environmental control, we extended our analysis to other arenas such as water and wastewater management practices, including those of less orthodox nature such as dry composting toilets, reuse of grey water, rainwater harvesting, etc. We also examined garden and yard micro-environmental arrangements that could contribute to more sustainable housing (shading and building alignment and exposure to sunlight and natural heating), solid waste disposal, and recycling. Whatever the actual dimension analyzed, our goal was to identify and understand the full range of practices and sustainable housing opportunities, especially those that are low-cost and are underutilized. These data are described in Chapter 3, but because there were so many (often) innovative applications we have opted to provide additional detail in a series of appendices to this report.

One of our earliest insights in class was the fact that there are a large number of effective actions that can be undertaken at very little or only modest costs. This reinforced our initial premise that, once properly understood, sustainable housing has great relevance for many low income populations and different dwelling environments. While solar panel arrays and even single panel water heaters costing hundreds (and sometimes several thousand) dollars are always likely to be the preserve of middle and upper-income homes, other low-cost initiatives such as “passive” water heaters, basic insulation improvements, reflecting foil on exposed windows, properly sealed doors and windows and improved air circulation can often be achieved at two figure sums or less.

Chapter 4 takes these applications further, and together with the inventory compiled in Chapter 3 constitutes the core conclusions of this report. While the original intention was to prioritize the actions within the regional and housing context matrix that we describe in Chapter 2, it became apparent that there were so many possible opportunities and sustainable housing elements, and so much variation in the way in which these can intersect with the “predisposition variables”, that we were obliged to rethink our manner of presentation of the final results. Therefore we developed a framework that would allow us to assess each dimension/action in terms of cost, opportunities for self-help, and the relative ease of implementation. Each application is also analyzed in terms of overall cost, and the scale of savings that can be achieved. These results are described and presented in graphic form in Chapter 4.

Moreover it is desirable that ultimately such applications be thought-through locally by residents and communities themselves, and not be based upon a prescription of applications generated by studies such as this one. Implementation of many of these practices will require a number of considerations: 1) much wider information dissemination; 2) carefully measured energy and savings “audits” tied to typical housing types and arrangements; 3) locally identified priorities for action; and in some cases, 4) a relaxation of standards and regulations (at least on a temporary period as people move incrementally towards compliance). Such considerations will require debate and discussion between residents, communities and policy makers. But our concluding chapter (five) underlines the desirability of encouraging households, communities, NGOs, and government organizations, to explore systematic policy development that will broaden the adoption of sustainable housing practices, both in new home development (where it is often easier to implement but is likely to be more expensive), as well as in home improvement, rebuilds and extensions and in retrofitting. In these latter cases the costs are likely to be much lower, and may be recovered quite quickly in terms of energy and other savings. Many incentives towards sustainable housing applications exist already, and a number of others are expected to come on line in the short and medium term. Some of those already on the books in the USA and Texas are outlined and/or are included in an additional appendix to Chapter 5, together with an energy audit/model that was developed by one of the students in collaboration with his colleagues, and which we hope will prove useful to those householders and NGOs who wish to gain a more precise estimate of the savings/benefits ratio to the costs of making an investment. If this study can contribute to a broadening of awareness about the opportunities for more sustainable housing, and about the real gains that can be achieved from even the most modest home improvements and DIY initiatives, then the outcome will have been very worthwhile. And if this report engenders the same level of excitement and interest among householders as it did among class participants, then that will be an added cause for satisfaction.

Chapter 2.

Self-help, Low-Income Housing, and the Contexts in Which Policies of Sustainability May be Applied

Our first major task was to identify the housing contexts in which we would explore sustainable housing applications. As already mentioned, this study was expected to offer new policy approaches developed in the context of self-help and self managed low income housing environments in the USA, and in Central Texas specifically. But in addition we were interested in exploring how such a “baseline” of possible housing applications might be applied more widely, especially in Latin America where poverty levels are more acute, and where self-build is the norm. In short, what insights could be gained from the state of the art in the USA, and what potential did such applications have for wider implementation elsewhere?

Much of our understanding about self-help and self-managed housing has actually been developed in Latin America, as have the housing policies towards such settlements that include land title regularization, infrastructure provision, community organization, technical supports for self build etc.[6] However, apart from some “low tech” policy solutions and approaches to sustainability in Latin America, so-called “green” solutions, as well as interest and commitment to urban and housing sustainability were not as well developed as in the United States (albeit largely a preoccupation of middle income residential development). Recent initiatives in Mexico and elsewhere have indicated that middle developing countries are also becoming invested in issues of sustainability, global warming, and renewable energy usage as part of the global debate. In November 2009 Mexico’s principal workers’ housing agency (INFONAVIT) organized the “first international conference on sustainable housing” in which Mexico’s President Calderón made a major speech advocating the need for a broadening and deepening of sustainable housing applications both within formal housing projects as well as for self-build settlements.[7]

THE REALMS OF SELF-BUILD AND SELF-MANAGED HOUSING IN LATIN AMERICA AND THE USA

In Latin America

Since the 1960s informal self-help housing has been the primary way in which low income populations have acquired housing. Often called “irregular” or “spontaneous” settlement, different mechanisms of illegal land capture (invasion of lot sales without services) are the first step in a gradual dwelling construction process in which the household takes primary responsibility for building the home. Services, infrastructure, formal recognition by the authorities and the provision of land titles to lots all come later and incrementally (Gilbert and Ward 1985, 2008). This occupation – building -- servicing – planning (OBSP) is the reverse of what usually occurs in developed societies which start with planning, followed by servicing and

[6] See: Gilbert Alan, and Peter Ward. (1985 and 2008) *Housing the State and the Poor, Policy and Practice in Latin American Cities.* Cambridge University Press.

[7] 1er Foro Internacional de Vivienda Sustentable, INFONAVIT, Mexico City, Sept. 10-11.

building and only then does occupation take place (PSBO).[8] The names for these settlements varies, but in less developed countries such informally developed settlements form the bulk of the built up areas of cities. Alternatively, low-income government (project) housing is scarce. Since the late 1970s housing policy has evolved to support these informal self-build and community developed initiatives, through policies such as upgrading, sites and services, title regularization, etc. By the 1990s such policies were the conventional wisdom and were widely accepted and sponsored by governments and by multilateral organizations.

Not only was self-build widespread, it was a relatively successful form of housing production given the poverty levels of these nations and the inability to cope with the rapid rate of urbanization that they experienced. While new land captures and peripheral self-help settlements continue to form, the pace of illegal land development has slowed in most countries, but there continues to be an urgent need for intervention to provide basic infrastructure and to support self-help technologies and resident upgrading efforts. However, many of the older settlements that developed in the 1970s are now fully integrated into the cities and most observers would not imagine that they had begun as shacks and squatter settlements. Often they comprise two and three storey dwellings with all services; population densities are high and families have often subdivided their lots and housing units among (now) grown children and grandchildren. In these areas there are urgent needs for the rehabilitation of the residential environment in order to retrofit and recast the space and services to contemporary needs.

This broad scenario of the nature of contemporary self-help allows us to identify three dwelling environment contexts in which we believe new sustainable housing applications will be important.

Plate 1: New settlement on the periphery of Lima, Peru

[8] Baross, P. 1990. "Sequencing Land Development: The Price Implication of Legal and Illegal Settlement Growth." In Paul Baross and Jan van der Linden (eds.), pp. 57-82. The Transformation *of Land Supply Systems in Third World Cities*. Aldershot: Avebury.

In addition to the gamut of policies already embodied in squatter settlement upgrading supports and the priority needs for water, electricity and drainage, if sustainable housing options were to be promoted and encouraged then they could have an important role in reducing energy and other housing costs. Such applications can be promoted by local authorities to target the community wide level to dovetail with the high levels of social capital normally found in such incipient and "consolidating" settlements, as well as to support home building and self-help initiatives by the families themselves.

Plate 2: Sponsored self-help projects (wet core project)

In a similar vein, where government, non-government organizations, and multilateral agencies seek to intervene and sponsor upgrading programs, or to lay-out lots with basic services installed (sites and services), then there is considerable scope for sustainable housing options to be implemented in the planning phase as well as in the technical supports offered to self-help home builders. For example in Plate 2, the inclusion of a single solar panel water heater integrated into the tank could readily provide 80 per cent of a households needs for warm water. "Passive" water heaters would also work partially to reduce energy costs.

Plate 3: Self-help rehabilitation and retrofitting, Mexico City, Colonia Isidro Fabela

Mention has already been made about the need for creative thinking related to policy making for rehab and retrofitting homes, especially those that have been built over a protracted period of time by low-income self-builders. "*La casa que crece*" (the house that grows) enables the original families to build at a pace and rhythm that meets available resources and household needs, especially that of sleeping space for a growing family. A primary motive for most households is create a place in which to live, raise a family, as well as to offer an asset (a "patrimony" [inheritance]) for the children. Thirty years on this inheritance function is now being realized, and these new household structure have a new dynamic with different housing needs, and the dilapidated and intensively used dwelling itself is often in urgent need of refurbishment.

At a community-wide level, also, the drainage and water pipes installed twenty years earlier may no longer be adequate, and the early strong community activism has usually dissipated. Location of this former periphery is now in the intermediate or inner ring of the city, comprising the innerburbs, (as against the "suburbs" or "exurbs"). While there may be some modest gentrification and inflow of new owner families into these innerburbs, and renting is much more likely and is associated with higher turnover and mobility, these areas actually show very little "churn" and in the majority of cases the dwelling continues to be occupied by the original self-builder of by their (now) adult children. For them, "a home is forever."[9]

Each of these three housing arenas are predicated upon substantial levels of self-help either in the actual process of home building, or in the self-management and decision making regarding the housing process. This is where creative thinking about sustainable housing applications is most needed –whether in new building or in retrofitting and home improvement associated with rehab.

[9] Gilbert, Alan. 1999. "A home is forever? Residential Mobility and Homeownership in Self Help Settlements". *Environment and Planning*. 31, 1073-91. See also www.lahn.utexas.org

In the Southern USA

Homesteading at the rural frontier was traditionally the way in which housing was built through self-help and mutual aid. In the 1950s and 1960s some policy experimentation with self-help also occurred in Appalachia and elsewhere, and in Texas and the border region self-help continues to be widespread in the so called "colonias".[10] Some of the early 1950s Levittown suburbs were laid out and developed using manufactured pre-fabricated "kits" that also required labor on the part of the homeowner. Such do-it-yourself (DIY) practices are common today, although usually primarily for working in the garden/yard and for home improvement and redecoration. A number of building and DIY suppliers exist nationwide -- chains such as Home Depot, Lowes, etc. As sustainability gains traction, and as awareness about, and incentives to buy, appliances that are energy efficient, these chains will play and increasing important role in making sustainable housing applications more widely adopted.

While our interest in this study is primarily low-income housing applications, in order to better understand the full range of sustainable housing options that exist and are being promoted, we began by looking at the most widely known discussions relating to high cost renewable energy (solar panels), central air conditioning, insulation, etc.

Plate 4: America's "First Suburbs" – East Austin 2009.

Urban analysis in the USA is now beginning to focus on the "first suburbs" which, like their innerburbs counterparts in Latin America, now form part of the inner city or first ring of the city beyond the central core, and that developed in the south and sunbelt metropolitan areas in the 1950s and 1960s.[11] Largely white middle-income former suburban neighborhoods, these are

[10] Harris, Richard. 1998. "The Silence of the Experts: 'Aided Self-help Housing', 1939-54. *Habitat International*, 22, 2, 165-189. See also . 1999. "Slipping through the Cracks: The origins of aided self-help housing 1918-1953." *Housing Studies* 14, 3, 281-309. Ward., Peter M. 1999. *Colonias and Public Policy in Texas and Mexico: Urbanization by Stealth.* Austin: University of Texas Press.

[11] Puentes, Robert and David Warren. *One-Fifth of America: A Comprehensive Guide to America's First Suburbs.* (Washington, D.C.: The Brookings Institution Press, February 2006), Ward, Peter. 2011. Housing and Urban Regeneration in the First Suburbs and "Innerburbs" of the Americas.

today the focus of major land use changes attracting a range of income groups and ethnicities attracted by in-city location and the new-found amenities associated with downtown redevelopment and regeneration. Unlike their Latin American counterparts these areas are marked by large scale "churn" as poorer households are displaced, and as better-off (sometimes) gentrifiers buy "fixer-upper" homes, or clear lots and start afresh. In addition, housing associations and high density condominium developments are building and rebuilding in these neighborhoods, and some home owners are building backyard "granny" or "alley" flats (apartments), either for rental or to accommodate upsizing or downsizing needs without physically have to leave the neighborhood.

Given that these areas are largely middle and even upper income, it is here that one finds the greatest level of adoption of high-end sustainable housing applications: solar panel arrays; high r-value insulation; high ultra violet reflecting glass and energy efficient windows; reflecting roofs; tree planning for shade, rainwater harvesting, xeriscape planting, etc. As land use changes and demographic infilling quickens in these first suburbs, this is likely to become the U.S. frontier for urban sustainability predicated upon higher use of public transportation (minimal commutes); new home building that is energy efficient and "green" consciousness; back-to the roots gardens and composting, etc. Thus by studying housing changes and dynamics in these U.S. innerburbs we may begin to develop an inventory of sustainable housing practices that can inform our thinking about possible applications that might work at the lower income end of the market.

Plate 5: Mike's Colonia, Starr County, Texas

In Texas and the USA, *colonias* are quite clearly low- and very low-income, with households earning on average $15,000 or less per year. Largely Hispanic, this is the only option for such households to break into the housing market, and they do so by turning to informality – albeit in ways that are different from their Latin American worker counterparts.[12] Specifically, lots are purchased without services in the peri-urban area outside of the city limits; settlements are smaller; private means of transport is essential; and the actual housing unit is more likely to be a manufactured home (trailer) transported to the site than self built (although this is also common). Services are acquired privately, and in Texas since the early 1990s increased governmental intervention has targeted these areas for water and wastewater provision in order to improve conditions, and reduce health risks. The major constraint in thinking about housing sustainability in *colonia* environments is that of poverty, of course. But even here, to the extent that there is substantial self-help in house construction, and/or the need to use DIY to finish out "modular" (prefabricated site-erected) homes, there are a number of ways in which more sustainable housing applications can potentially make sense. In addition, rainwater harvesting, "passive" water heating, insulation and improved air quality, low water toilets, dual grey and black water septic tanks systems etc, also offer significant opportunities.

Plate 6a: Aerial Photograph of an Informal Homestead Subdivision

Less well known or recognized by local authorities these housing arrangements are similar to *colonias* except that they are found beyond the border region and are located 10-20 miles outside of metropolitan areas.[13] Nor are they quite so poor: average household incomes are likely to be around $25,000, and affordability is achieved through the informal and self-financed

[12] Ward., Peter M. 1999. *Colonias and Public Policy in Texas and Mexico: Urbanization by Stealth.* Austin: University of Texas Press. See also Ward, Peter. 2003. Informality of housing production at the urban-rural interface: the not-so-strange case of colonias in the US: Texas, the border and beyond" In *Urban Informality* Editors, Annanya Roy and Nezar AlSayyad, Lexington/Center for Middle Eastern Studies, UC Berkeley. (pp. 243-70)

[13] Ward, Peter and Peters, Paul. 2007. "Self-help housing and Informal Homesteading in Peri-Urban America: Settlement Identification Using Digital Imagery and GIS", *Habitat International,* pp. 141-64.

mechanisms of acquiring housing, as well as through self-help and "sweat equity". Most households are Hispanic albeit not quite as high a percentage as in the border. Dwellings are more likely to be manufactured homes (single or doublewide trailers) that vary greatly in age, some being the older pre-1986 trailers built before HUD standards were implemented. Other homes are much more substantial modular structures that are erected on site, and in other cases one sees also quite substantial custom homes being built where homeowners trade off poor location for low land costs and a much larger lot.

Plate 6b: Manufactured Home in Rancho Vista, San Marcos County, Texas

Two important points break out of this housing category. First is the high level of heterogeneity of house types that exist in such settlements; and second is the fact that these are significantly better off, even though most households are below or around the poverty line.
This range of housing types, combined with the slightly higher income levels among what is a poor population, offers the most potential for trying to understand the appropriateness and feasibility of sustainable housing applications to informal settlements.

Whether one is considering *colonias* or informal homestead subdivisions outside of the major metropolitan areas, the fact remains that such settlements have little to commend them as the "way to go" when thinking about urban sustainability. Their peri-urban location, miles outside of town, and the need for each household to have at least one vehicle to get to work, the long commutes, the low densities, and so on, are highly inefficient and make high demands upon non-renewable energy sources. But many of these platted settlements already exist and in some cases they are proliferating; elsewhere unsold or previously unoccupied lots are being occupied. Therefore we see little alternative other than to try to make them as sustainable as possible.

A MATRIX OF HOUSING SCENARIOS AND PREDISPOSITION VARIABLES ASSOCIATED WITH SUSTAINABLE HOUSING APPLICATIONS

Table 2.1: Predisposition Variables for Sustainable Housing Development and Implementation

Latin America	Geography and Physical Topography	Government Capacity and Disposition	Tenure	Legal Framework	Availability & Access to Information	Household Typology	Community Organizations	Access to Services & Infrastructure	Built Environment Typology	Market Performance	Financial Incentives
a) Peripheral new irregular settlements											
b) State aid self-help programs											
c) Innerburbs, rehab of consolidated settlements											
USA & Texas											
a) Border "colonias"											
b) Interior Informal Homestead Subdivisions											
c) Innerburbs											

Six types of housing in the two regions form the basis for the vectors outlined in Table 2.1. Once established and understood, the class set about identifying the background variables that a priori could be expected to impinge upon sustainable housing applications in each context. We refer to these as "predisposition variables" -- things to think about when considering housing development and rehab. They are listed below in bullet format and with explanation via footnotes where necessary.

Predisposition Variables for Sustainable Housing Application Development

Geography and Physical Topography:

- Climate[14]
- Humidity[15]
- Thermal[16]
- Temperature[17]
- Rainfall levels (for rainwater harvesting, compacted soil, etc.)
- Watershed (e.g. location within a watershed)

[14] The climate will affect the type of solutions that are feasible and desirable. Various climates will also call for varying solutions in terms of architecture (overhangs, porches, etc).

[15] The humidity level will affect the types of building materials used as well as the implementation of other solutions. Certain materials may not withstand high humidity and should not be used in these climates.

[16] The amount of sun will affect the viability of various solutions such as solar panels and solar water heaters.

[17] Various temperatures and climates will affect design and architecture as well as the viability and desirability of various solutions like insulation and attic ventilation. Differences in temperature can also affect the efficiency of certain solutions such as the heat pump system.

Government Capacity and Disposition to Sustainable Housing through Public, Private, or mixed:

- Strong dispositions to sustainable housing
- Clearly mapped city and county jurisdictions
- Elected officials committed to affordable housing
- Public subsidies for sustainable low income housing
- Private companies with a mission for new energy, green housing, sustainable growth, community development
- Available Low-Income housing to meet demand needed
- County/State budget to include rebuilding, development of these housing types

Tenure:

- Occupied/Vacant
- Owner occupied/renter occupied/shared ownership
- Length of tenure/lease
- Homesteader or absentee owner

Legal Framework:

- Design mechanisms for formalization and remove impediments to regularization of land title
- Lower levels of regulatory codes and minimum standards
- Promote "progressive compliance" whereby poorer communities commit to moving gradually towards meeting codes and standards.
- Mechanisms of mediation and negotiation applied to housing provision and serviced land.
- Foster private initiatives for housing production through guarantees and new financing schemes. Reduce monopolies to make affordable housing and services (such as transportation) accessible to economically and socially disadvantaged communities.
- Decentralize the decision-making authority from national government to local authorities to enhance participatory democracy.
- Strengthen transparency.
- Planning and construction permissions and effective land use controls.
- Property tax assessments.
- Incorporation of irregular settlements into property tax register.
- Reduce direct state intervention.

Availability and Access to Information & Resources:

- Physical Resources (Local and/or Imported Materials)
- Pre-manufactured
  - Requires assembly
  - Reusability
- Knowledge and Information
  - Professional Expertise (Government Provided, NGO Provided, etc.)
    Local Knowledge (Communally Shared, Home-by-home basis)

- "Institutionalized" knowledge
    - Communal best practices
    - Expert best practices

Household Typology:

- Size
- Household composition (family structure, resource levels and types, and related demographic information)
- Cultural practices (extended cohabitation, multigenerational property inheritance, etc.
- Language/ethnicity

Community Organization:

- NGO´s (Active NGO´s and non-profits based or with a local offices)
- Local cultural practices
- Density/level of interaction or level of horizontal integration[18]
- Social/Human Capital (workshops for specific skills, courses, sport/hobby/social clubs, etc.)
- Level of security/insecurity in the region
- Religious spaces[19]

Access to Services and Infrastructure:

- Existence and access to primary & secondary networks (power, water & drainage; road networks)[20]
- Nature of provision to infrastructure (public; private; mixed)[21]
- Relative costs of public or private provision to those services[22]
- Conventional wisdoms and public policies towards service provision[23]
- Status of public transportation[24]

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[18] Communities with cultural, familiar ties tend to interact more in different activities such as holidays and special events. Green areas and favorable climate and cultural centers or other opportunities for joint activities also promote the interaction and horizontal integration of a community.

[19] Religious spaces provide complementary activities in addition to their regular services that influence the value of the entire community as: daycares, community garden's, cleaning/recycling campaigns, etc.

[20] Proximity to primary and secondary grid is a precondition for the ease with which and domestic networks can be extended. For example, if no gas or mains drainage collectors are nearby then, the likelihood of other supply systems are heightened (propane tanks, septic and other systems). Similar, even where electricity is the principal power source, uploading solar energy to the grid is often not feasible – there solar energy would be stand-alone systems. = High Access

[21] This will shape who is the target for making policy suggestions and initiatives. Note that sometimes things change: public services become privatized, (and may even move back).

[22] Will shape the relative interest from consumers and providers to engage in (or explore) alternative policies and servicing solutions. Also, the predicted curve (medium and long term) of changing costs is important to assess.

[23] Current policy making directions regarding servicing and infrastructure in any context are important to nail down, since any proposed changes will impact upon existing interests and inertia. For example, antipathy towards intermediate technology or septic and dry-composting waste disposal may run against local and regional policies and received ideas.

[24] Most settlements are served by roads and are accessible. But there is likely to be great variation in the extent and adequacy of public transportation systems. This will affect indirect costs of residence in particular localities; disposable income for home improvements; interaction and engagement with other communities, and the optimum location of service providers, materials suppliers etc. In areas with poor accessibility, dirt roads, etc. it may impede service delivery (and or heighten costs of the same).

Built Environment Typology:

- Lot/Dwelling Size[25]
- Orientation[26]
- Arrangement/positioning of dwellings in the neighborhood development[27]
- Population density of the neighborhood[28]
- Neighborhood placement in the region relative to density[29]
- Resources
- Home type[30]
-

Market Performances:

- Equity[31]
- Affordability[32]
- Security and stability[33]
- Inter-generational transferability[34]
- Devalorization[35]

[25] The ratio of the dwelling to the lot can have several different implications. If high, this could reduce flexibility in placement of some types of individually controlled solar panel systems, could create flooding problems if there is significant impervious cover in the area, and could limit the space available for individual garden plots or rain gardens/alternative stormwater management. If lots are clustered together there may be opportunities for shared infrastructure systems – larger shared cisterns, or trellis-walkways for solar panels.

[26] Orientation has significant implications for positioning of solar arrays as well as for passive ventilation and lower heat gain.

[27] If the dwellings are clustered closer together but there is significant underdeveloped land around them, this could be used for community garden plots and innovative collective sewerage systems.

[28] If there is a critical mass of people, there may be economies of scale for more service delivery (group-transit, convenience store, day care, gathering place)

[29] If the neighborhood is far removed from other population centers and the neighborhood itself is low-density, this could constrain local economic opportunities. It may also make group transportation options more difficult (more people may need to own their own cars)

[30] If homes are significantly irregular it may be difficult to fit them to off the shelf technologies. Different types of building materials also have implications for indoor environmental health – formaldehyde in pressed wood products tends to release over time and threats could be exaggerated after weatherization. Some types of buildings and ventilation systems are also more prone to mold, so when weatherizing it is important to consider additional interventions needed to protect air quality.

[31] Equity in a property may increase the availability of credit for the purchase of improvements/technologies

[32] "Hot markets" may effectively remove properties from a pool of affordability for prospective owners, and rising property taxes could threaten displacement and discourage investment in homes. Alternately, greater efficiency through sustainable technologies could lower net housing costs and preserve affordability.

[33] Rising property values arguably discourage renters, trailer park residents, and others not owning the land from implementing improvements to their homes.

[34] Durable, sustainable improvements may benefit second and third generation owners to maintain and remain on properties.

[35] Sustainable technologies may encourage reinvestment by low-income occupants into aging housing stock and afford novel, cost-effective ways to rehabilitate.

Financial Incentives:

- Financing: government entity acts as intermediary between beneficiary and private capital markets (bond programs, loan programs, tax credits).[36]
- Tax Incentives: government entity will reward certain purchases or investments by reducing tax burden (often applies to individual or corporate income tax, property or excise taxes)
- Direct Subsidy: includes leasing programs and grants and rebates for investment or purchase
- PACE: "Property Assessed Clean Energy" Financing[37]
- Production Incentives: incentives based on the production of kWH from renewable sources.[38]

Appreciation of how these variables may shape implementation of sustainable housing technologies and approaches will inform the materials presented in the next chapter, which offers a more specific description of the different applications that exist.

[36] In the case of bond and loan programs the government will secure preferential terms on debt capital; in the case of tax credits a government will guarantee certificates of equity and issue them to project managers to raise capital.

[37] Under PACE, a program generally authorized by the state, local municipalities will provide capital for renewable investment in a permanent feature of the property. The debt is settled over a term by a special assessment on the property.

[38] Feed-in Tariffs and various net metering regimes are production incentives. These exist within a larger context of interconnection standards and related distribution grid regulation governed by state Public Utility Commissions and local utility oversight bodies.

Chapter 3

Sustainable Technologies for Low-income Communities

INTRODUCTION AND OVERVIEW

The concept of sustainability implies smart development that considers the environment, economy and equity. Sustainable technologies, then, must be understood as interventions that bring benefits for all people with minimal environmental impact. In low-income communities – whether informal homestead settlements or neighborhoods in the innerburbs – households need affordable homes that are resource efficient, healthy, and comfortable.

Unfortunately, many homes in these communities are in substandard condition. Not only does this mean that families often suffer from unsafe and uncomfortable indoor environments; it also means that their energy and water bills tend to be disproportionately high relative to their income and the comfort provided. Holes in roofs or gaps in doorways allow hot air to get inside in the summer and to flow out in the winter. The U.S. Department of Housing and Urban Development recognizes that utility bills burden the poor and can even cause homelessness.[39] High utility bills and the threat of shutoff leads households on tight budgets to make difficult trade-offs, purchasing heat or electricity for air-conditioning instead of food or medications.[40] Sustainable technologies must be applied to structurally sound homes in low-income settlements to make them more resource efficient, both to improve quality of life and to benefit the environment.

Another key challenge to sustainable provision of resource efficient, healthy, and comfortable housing is posed by the location of communities on affordable land outside of city jurisdictions. While families may be able to afford to purchase the land and build or place a house on the lot, transportation cost and the costs of securing quality water, energy, and waste collection are typically greater per household. While this is generally a constraint, it may be more possible for informal settlements located outside of urban jurisdictions to adopt innovative sustainable technologies that support "off-grid" living. Use of renewable energy technologies and innovative wastewater treatment systems may be more feasible. The distinctive character of informal and self-built settlements that are most often developed in the extra-territorial jurisdiction (ETJ) of cities, creates unique challenges and opportunities for implementing sustainable technologies and retro-fitting homes.

Understanding the Context: Informal settlements and manufactured home

Before exploring the various techniques involved in energy efficiency retrofits, it is important to understand the housing stock of low-income, informal settlements. In the United States there are a variety of housing types that require different kinds and levels of intervention. It is important to note that in informal settlements many homes consist partially or entirely of manufactured housing. Thus, the performance and constraints of manufactured housing determine what interventions deliver the most return on the capital invested, what construction

[39] HUD. (2009, June 15). Utility Bills Burden the Poor and Can Cause Homelessness. Retrieved May 12, 2010, from HUD Homes and Communities: Community Planning and Development: http://www.hud.gov/offices/cpd/library/energy/homelessness.cfm

[40] Wolfe, M. (2007, November 26). LIHEAP Issue Brief: Providing Heating and Cooling Assistance to Low Income Families. Retrieved May 12, 2010, from http://www.neada.org/publications/issuebriefs/2007-11-26.pdf

methods work best in retrofitting, and how much energy and comfort the residents can attain through minimal sweat equity and capital outlays.

Informal Settlement Housing Typologies: As previously noted, we were especially interested in low-income and informal settlements in this study. Much of the housing stock in these areas, and in other peri-urban and rural areas throughout the country, consists of manufactured housing stock. According to some estimates, as many as 17 million Americans live in manufactured housing, and there are residents in manufactured housing in Texas than in any other state. Into the late 1990s, manufactured housing remained the largest source of unsubsidized affordable housing, supplying 66% of the new affordable housing produced in the United States.[41] Thus in this study of the sustainable technologies most appropriate to low-income residents we pay special attention to the possibilities and limitations of applications in manufactured housing.

There are few structural elements that differentiate mobile, modular, and manufactured homes from conventional site-built homes. Over time, the gap between these housing types and site-built homes has narrowed, in terms of construction technique and life expectancy. At one time, trailers and mobile homes were intended to last about as long as the automobiles that towed and transported them -- approximately 15 years. Mobile homes, larger and more functional versions of trailers, were initially made for transportation on the road to their eventual site. With their wheel-based chassis and light construction, transporting them from one site to another is feasible and was common in the USA.. However, some differences still remain and appreciating theses differences is important to determining how to best retrofit this housing stock. We detail the structural differences between manufactured, modular, and site-built homes in the first part of **Appendix A, section A1, "Informal Settlement Housing Types."**

This chapter reviews four different types of technological interventions that are applicable to low-income, self-managed and manufactured housing:

- Microclimate design and technologies to support energy efficiency
- Renewable energy technologies to support enhanced energy access
- Water and wastewater technologies to promote water conservation and quality
- Waste systems to promote resource reuse and recycling

In considering these technologies it is also critical to understand the social and ecological contexts in which they are applied. The success of any technology to promote energy, water, and other resource conservation will depend significantly on social support: people must first find the technology socially acceptable and then commit to adapting their behavior. Thus, throughout this report we consider both the human and ecological dimensions of various energy-saving technologies. Other important contextual factors, such as financial and regulatory constraints related to the implementation of these technologies, are reviewed in Chapter 5 of this report.

Here we provide recommendations within the four areas of sustainable applications listed above. Throughout we reference a set of appendices on the various topics covered here to provide additional in-depth information. We do this in order not to overly bog-down our discussion with the minutiae, but we do see the need to make these links available for those who need to follow up in more detail. In this section, the techniques and technologies are

[41] CFED Manufactured Housing Factsheet: www.cfed.org/assets/pdfs/Manufactured_Housing_Fact_Sheet_4_08.pdf

summarized below, with more detailed information provided as **Appendix A, sections A2 – A14**.

SUSTAINABLE TECHNOLOGIES FOR MICROCLIMATE DESIGN

In the case of home microclimates in the hot environs of Texas and much of Latin America, sustainable technologies must be used to help provide residents shelter from intense heat. This section reviews key techniques and technologies that can be employed at minimal cost to increase energy savings and quality of life for low-income households in hot climates, with a focus on healthy homes principles, weatherization interventions, and site and building design strategies to reduce solar heat gain.

The microclimate of a home is crucial to the physical health and safety of its residents. Safe and healthy home environments are often beyond the reach of low-income families. This is especially apparent in many of the informal settlements existing at the periphery of thriving U.S. cities where land is cheap and basic service delivery is difficult. When retrofitting homes, it is important to consider the health and safety of homes as well. Proper weatherization is an important component of this process. In **Appendix A2, "Principles for Healthy and Safe Homes,"** we provide an overview of low-cost, self-help strategies to keep homes comfortable, safe, and healthy.

Weatherization: An Overview

In the U.S, weatherization has been in the spotlight since the presidential campaigns of 2008. The topic of weatherization and insulation has become An important focus. It is not hard to see why it would be attractive to a political leader: in theory, rapid, broad expansion of weatherization interventions in existing residential housing stock has the *potential* to generate crucial "green building" benefits:

- Reduced household energy costs,
- Improved health and safety through enhanced indoor environmental quality (IEQ),
- Lower greenhouse gas emissions and pollution from dirty coal, and
- Expanded local job opportunities.

With these purported benefits in mind, U.S. leaders made expansion of the energy efficiency retrofit industry a pillar of the American Recovery and Reinvestment Act of 2009 (ARRA), an investment plan designed to meet the nation's greatest challenges: the global climate crisis, the health crisis, and the economic recession. In total, ARRA is investing over $20 billion towards increasing the energy efficiency of our nation's building stock.[42] Recognizing that these three crises disproportionately burden increasing numbers of low-income households, ARRA's authors specifically targeted funding to those most in need. For instance, ARRA is investing $5 billion over the next year in the Weatherization Assistance Program (WAP), a Department of Energy (DOE) program that has invested roughly $6 billion over the last 30 years to weatherize over 6 million low-income homes. Texas alone is receiving $326 million for weatherization investments. Never before has there been so much funding available for weatherization. While

[42] This includes $5 billion for the Weatherization Assistance Program (DOE), $3.2 billion for the Energy Efficiency and Conservation Block Grant Program (DOE), $3.1 billion for the DOE's State Energy Program, $5 billion to the Low-Income Home Energy Assistance Program (LIHEAP), and over $4.98 billion for workforce training focused on green jobs and service.

these investments are intended to provide immediate relief for low-income families, they are also intended to catalyze long-term job growth in the energy efficiency retrofit sector.

Ideally, in the case of informal settlements, residents will be able to access *all* of the benefits promised by weatherization. In the related appendices, this report offers a variety of tools and strategies to help identify how to maximize energy savings benefits, improve indoor environmental quality for residents, reduce overall green house gas emissions, and create family supporting employment opportunities.

Codes and Standards. The U.S. Department of Housing and Urban Development (HUD) and the Department of Energy (DOE) have developed several programs, policies and codes aimed specifically toward rural and particularly, manufactured homes and their upkeep, maintenance, and weatherization. HUD has an entire division devoted to manufactured housing with a Construction and Safety Program, Dispute Resolution Program, and a Manufactured Home Installation Program.[43] In addition to ongoing and financial baseline programs, HUD and DOE have a great deal of data, programming, codes, and instructional material on weatherization and other energy saving interventions at all cost levels. **Appendix A3, "Manufactured Home Codes and Standards,"** provides an overview of the construction, safety, and building codes/standards that must be considered during retrofits and renovations. It includes HUD's standards for mobile home construction and provides a basic understanding of what measures need to be accounted for, especially those necessary by region. Emphasis is placed on those that deal with the hot and often humid climatic e conditions along the border and most peri-urban Texan environments.

"Weatherization 101": Audits and Interventions. The first step of any energy efficient retrofit is a detailed audit of existing conditions and housing needs. This background information is essential to designing interventions that directly address the needs of the household. Ideally, a whole-home approach to repair and retrofit would include audits that consider health and safety factors as well as energy efficiency factors.

In Texas today, most weatherization interventions funded by the Weatherization Assistance Program include some health and safety repair items, but the required audit process recommends interventions based almost entirely on cost effectiveness related to energy savings.[44] In fact, a 2008 performance evaluation of weatherization in Texas homes concluded that "judgments based on more than simple cost-effectiveness are needed to guide the selection of health, safety, and repair measures, but no automated tools like energy audits are available to provide such guidance."[45] Still these audits remain the primary way to assess the performance of a home's energy efficiency. **Appendix A4, "Audits and Assessments in Weatherization,"** provides an overview of audits involved with weatherization, especially in Texas.

In manufactured housing the main energy problem remains insulation. Duct leakage and inadequate insulation can cause major energy loss and moisture problems within homes. Weatherization of homes seeks to minimize these issues, increase residents' comfort, prolong the life span of finishes and furnishing, and produce significant energy savings. Weatherizing on

[43] "HUD- Office of Manufactured Housing Programs," http://www.hud.gov/offices/hsg/ramh/mhs/mhshome.cfm.

[44] McCold, L., Goeltz, R., Ternes, M., & Berry, L. (2008). "Texas Field Experiment: Performance of the Weatherization Assistance Program in Hot-Climate Low-Income Homes." UT-Battelle for the Department of Energy. Oak Ridge National Laboratory

[45] Ibid, pg. xv

older mobile home can produce 40% savings and the homeowner can do most of the necessary retrofits.[46] In **Appendix A5, "Home Weatherization Technologies,"** we provide an overview of weatherization interventions including air infiltration reduction, various methods of insulation, and vapor retarders.

Self-Help & Training Opportunities. Home improvements, in most cases, do not come cheaply. Due to material expenses, labor costs, and the level of expertise required in many building techniques, changes come at a premium. One major way to minimize costs is through volunteerism, self-help, and community-wide initiatives. In fact, there are government funding mechanisms to encourage housing stock upgrading and rehabilitation. Additionally, there are hundreds of non-profits who either build from the ground up or fix up homes in need of basic updating and maintenance.

The USDA offers several funding programs, and one in particular is tailored toward rural, communal self-help. There are also many similar programs to update housing stock on a community level, through loans to developers and loans and grants to homeowners. Habitat for Humanity, the most well-known housing-related non-profit, employs volunteer labor on most construction tasks, thereby cutting the labor costs of home construction. The least tapped-into volunteer effort deals with experts volunteering time and knowledge to extremely low-income and low-income households, but Architecture for Humanity, as well as many other non-profits, puts architects on the ground through individual chapters to strategize about using design to increase quality of life.

All of these efforts, while helpful, have not yet reached a critical mass. However, through education and coordination of service delivery, funding and volunteering could have a much greater impact moving forward. In communities where there are already residents with strong backgrounds in the building and construction trades, it is likely that these individuals could be trained to deliver professional weatherization services and lead teams of volunteers for a reduced-cost, community-oriented retrofit program.

The U.S. Department of Energy offers many weatherization training resources through the Technical Assistance Program of its Weatherization Assistance Program, many of which are available online: http://www.waptac.org/sp.asp?mc=training_resources. This site also includes standardized curricula for weatherization technicians serving mobile homes in particular: http://www.waptac.org/sp.asp?id=10055. We provide an overview of weatherization training opportunities for individuals with a construction background in **Appendix A6, "Weatherization Training Opportunities."**

Passive Solar Design

Another important component of a home's microclimate is its orientation and passive solar gain. While weatherization focuses primarily on creating a tight building envelope that keeps cold air in during the summer and out during the winter, passive solar design focuses on letting sun rays in during the winter and keeping them out during the summer.

Those who have lived through a Texas summer know the formidable strength of the summer sun and have developed strategies for comfort. We look for the shady, tree-lined side of the street. In the noonday sun, we wear caps that shade our eyes from sunrays. We wear light

[46] Krigger, J. (2006). Your Mobile Home: Energy and Repair Guide for Manufactured Housing. Saturn Resource Management.

colored clothing that reflects the suns intense rays. We seek out cool breezes. Yet, when we design our homes, we often forget these basic sun-wise principles. We clear the existing trees and vegetation on lots in order to build homes, depriving them of natural shade. Often too little thought is given to the alignment of the dwelling in order to reduce the impact of the sun's heating in the afternoon hours of summer, but to allow heating in the winter when the sun is on a more southerly trajectory and is lower in the sky. We often neglect to provide overhangs for windows to keep the noontime sun from overheating our homes. We cover our roofs in dark shingles, absorbing extra heat. We neglect to place and use our windows to create natural cross breezes. As a result, our homes gain a tremendous amount of solar heat throughout the day, which we combat through energy-intensive air conditioning.

With passive solar design, a home's windows, walls, and floors can be "designed to collect, store, and distribute solar energy in the form of heat in the winter and reject solar heat in the summer."[47] Passive solar home design offers many valuable tips on site design and architectural design for creating these comfortable, healthy and efficient homes in hot, humid climates.

Sun-smart homes in hot and humid climates generally have a long, narrow shape aligned along an east-west axis, maximizing northern and southern exposure of the thermal building envelope (the exterior walls and roof) to the sun, and minimizing east and west exposure. In this sense, a trailer oriented east-west would be perfectly oriented: there would be minimal wall exposure in the east and west, and maximum exposure along the north and south walls. Strategic shading with porches and overhangs prevents much of the solar gain costs of south facing walls and windows. Sun-smart homes generally follow these key recommendations for passive solar design:

- Use overhangs and porches on south and southwestern walls to minimize solar gain in the summer when the sun is mostly overhead, especially around solar noon.
- Minimize windows on east and west sides, but allow them in the north and south as long as they are properly shaded with emphasis on the south facade. Ideally set up windows to enable cross-breezes from prevailing winds.
- Strategically plant trees to manage the sun – a tall mature tree in good health and good position can offer the equivalent of 2 to 3 tons of air conditioning capacity because of the shade it provides and the ambient cooling it offers from evapotranspiration.

(Additional information on passive solar design can be found in **Appendix A7, "Passive Solar Design.")**

RENEWABLE ENERGY TECHNOLOGIES FOR LOW-INCOME COMMUNITIES

The Energy Efficiency and Renewable Energy Sectors is the fastest growing sector in the "green economy" and public investments and policies have been supporting this growth. While the technologies are becoming more widely available in markets, are renewable energy and renewable energy technologies appropriate to the context of low-income communities? This section reviews options suitable for this context.

Renewable energy is one of the most costly sustainability technologies and therefore is largely inaccessible to low-income households. Many renewable energy technologies have high

[47] http://www.energysavers.gov/your_home/designing_remodeling/index.cfm/mytopic=10250

upfront costs and it can take long periods of time for the consumer to recoup them. In addition, energy is often delivered on a large scale rather than individual basis. Many technologies may not be available to residents in peri-urban and rural areas, and households may have limited choices as to the type of energy they use. Despite these limitations, the use of renewable energy can save homeowners money in some cases.

In looking at the costs of renewable energy, it is important to first have an understanding of costs of traditional forms of energy that it might replace. Two traditional forms of energy that are commonly used and have minimal effects on the environment are natural gas and propane. Renewable forms of energy include wind and solar. Wind energy involves the utilization of wind turbines and the conversion of this wind energy into electricity. There is a great deal of wind in Texas and it is therefore also an excellent source of wind energy. Although this technology will usually be too expensive for low-income households, there may be exceptions in which small-scale applications are feasible. In general, the ideal location to maximize benefits of wind turbines would be on large lots with relatively large amounts of energy consumption. Transmission and storage are still problematic. Some basic information about various sources of energy and related pricing and usage is provided in **Appendix A8, "Forms of Energy, Pricing, and Usage**."

Solar energy offers even greater promise in Texas. Among several types of solar energy are photovoltaic panels and water heaters. Photovoltaic panels use diffuse solar radiation and convert light energy directly into electricity. They are relatively expensive but in some cases it can be the least expensive option such as when applications are located away from existing power lines and require larger amounts of electricity. The price of PV systems can vary greatly depending on many factors such as load size, available sunlight, PV array size, battery bank size, and whether or not a DC to AC inverter is needed (as is the case of capture for most households appliances). As with wind energy, transmission and storage of energy remain problematic. However, it seems likely that advancements in technology will make solar energy more accessible for low-income households in the future.

The most accessible sources of renewable energy are solar water heaters, which use the sun to heat water. There are both active and passive systems. Passive systems do not require any external energy sources other than the sun itself and are often more appropriate for places that rarely have freezing temperatures. Active water heaters, which rely on other equipment such as collectors, sensors, pumps, and controllers, are more common and efficient than passive systems but they are also often more expensive. Solar water heaters can cost anywhere from $800-$3,500, but can also reduce water bills by 50-80%. More information on this topic can be found in **Appendix A8, "Forms of Energy, Pricing, and Usage**."

In addition to producing renewable energy on-site, residents may also obtain renewable energy through utilities or other sources. It may, therefore, also be important to look at renewable energy programs in the area. Austin Energy, for example, is a leader in providing renewable energy. Residents in its service area may choose to receive wind and solar energy at slightly higher rates. Bluebonnet, the service provider in the San Marcos area, also has several renewable energy programs. These are explored in **Appendix A8, "Forms of Energy, Pricing, and Usage**." In addition to these considerations, funding opportunities and programs may make renewable energy more accessible to low-income households.

WATER CONSERVATION AND WASTE WATER MANAGEMENT TECHNOLOGIES

Water conservation is central to sustainability. A significant portion of water consumption is tied to everyday activities, such as showering, washing dishes, and watering the yard and garden. Water consumption can be reduced by buying new water efficient machines (such as dual flush toilets) or by adding simple technologies (such as low flow sink aerators) to existing showers, sinks, pipes, etc. The largest reductions in water consumption are, however, tied to behavior. Attention to personal as well as mechanical water consumption is crucial. Conservational behaviors, such as such as turning off the faucet or hose while washing (car, hands, dishes, face, etc.) and waiting to wash clothes or dishes until there is a full load, can significantly reduce consumption. These technologies and water conservation habits are reviewed in more depth in **Appendix A9, "Household Water Conservation."**

There is also a multitude of options for water reuse and innovative water supply strategies. Some water re-use is as simple as collecting water left running while the shower temperature heats up, or washing the dog on the lawn. More sophisticated systems include rainwater harvesting (see **Appendix A10, "Harvesting Rainwater"**) and grey water systems (see **Appendix A11, "Greywater Systems"**).

SOLID WASTE AND RECYCLING SYSTEMS

Wastewater system management is also a key factor in sustainable water consumption. While the alternatives for initial collection are rather limited, there are a plethora of options for treatment, disposal, and reuse. Starting with the toilet, there are many innovative technologies available to reduce the amount of water used and/or the need for infrastructure-intensive treatment (see **Appendix A12, "Innovative Toilet Technologies"**). Once the waste leaves the toilet for the pipes, other technologies may come into play. After collecting solid waste in a tank (Imhoff, septic, etc.) water can be filtered and treated using terrestrial, mechanical, and aquatic systems. In addition to the more conventional methods, such as drainage fields or sand mounds, there are a number of non-conventional treatment options, such as recycled, shredded tire filters or constructed wetlands. There are also an increasing number of technologies that reuse wastewater (as in drip irrigation) or that integrate water supply, stormwater, and wastewater, such as the system proposed by Engineer/Planner David Vehuizen. The range of possible wastewater systems is described in more depth in **Appendix A13, "Wastewater Management Technologies."**

There is an abundant amount of material on sustainable water practices and this review only outlines the main ideas. There are several universities that offer valuable water infrastructure resources: The University of Colorado, Texas A&M, University of Texas El Paso, and University of Oregon have all done extensive work in the Texas *colonias* and low-incoming housing communities.

Solid waste and recycling systems are essential for sustainable communities. In the ideal scenario, most waste can be reused relatively close to where it is consumed and can provide some economic benefit to community members. In this section, we reviewed several different technological, social, behavioral and economic models for solid waste collection, reuse, and recycling: basic reduction and reuse strategies, compost systems, traditional home recycling, recycling cooperatives, informal recycling businesses, commercial recycling, upcycling, and municipal solid waste. We reviewed each of these approaches in terms of technological sophistication, suppliers, public acceptance, regulatory challenges, and education. The details of this review are provided in **Appendix A14**, **"Sustainable Recycling and Solid Waster Technologies and Practices,"** and a brief overview of each category is provided below.

Reduction and Reuse

Reducing the amount of waste produced by a household is perhaps the single most cost-effective and environmentally conscious technique for solid-waste related sustainability. On the other hand, it is the most often overlooked and it can be difficult for people to be convinced to change their routine purchasing and consumptive practices.

Compost Systems

Composting increases plant growth, and replaces the need for chemical fertilizers and pesticides in gardens and lawns. Organic materials and certain types of waste can be used in a much more beneficial way through composting than deposition into a landfill. Composting also serves as a neat alternative to using an in-sink garbage disposal or throwing away kitchen scraps. Typical approaches include vermiculture (worm-based composting), active (hot) composting, passive composting, piggeries, and biogas/biodigesters.

Traditional Home Recycling

70% of the millions of tons of garbage Americans produce each year, could be recycled. Buy products with little or no packaging (called precycling) can reduce what goes into the waste stream. Home recycling is a valuable means of diverting much of this waste, however it requires pickup and processing.

Recycling Cooperatives

Another technique of providing sustainable recycling is through collaborative work through cooperative efforts, typified by some work in Curritiba, Brazil. These types of efforts can be organized privately or as a public-private partnership between an organized group that works jointly in the collection of recyclable waste within a certain area. The cooperative members accumulate recyclable materials disposed by households in a warehouse loaned by the government (or possibly owned jointly or individually by one of the members). They then separate them by type and mechanically compress them (in machines provided by a government or again, owned by the cooperative) to produce commercial standardized bricks suitable for sale to the major buyers of recyclables.

Informal recycling as a business opportunity

In developing countries such as Peru, there are people who work as recyclers in districts where municipalities are not able to provide garbage collection services. Most of them work in the informal sector but recently there are initiatives to help them become formal. This model consists of teaching householders to separate their garbage at home and allowing recyclers to visit each household and collect the separated garbage bags for free. Both communities and recyclers benefit from the service. The households dispose of garbage and keep their houses and streets clean and the recycler can sell the materials and make a profit. The main purpose of this initiative is to keep recyclers physically healthy since once families separate the garbage, recyclers do not have to scavenge inside the trashcans. This model also provides a more formalized market for recyclers.

Commercial Recycling

Commercial recycling has limited use in the residential context of most low-income informal homestead subdivisions. Once again, 70% of the millions of tons of garbage produced in the United States could be recycled. Extending commercial recycling oppurtunities to low-income areas would help divert some of this waste from landfills as well as help low-income households dispose of some of the waste they often must manage through privately contracted – and often expensive – solid waste companies.

Upcycling

Upcycling is a catch-all term to describe types of reuse of otherwise waste materials by repurposing them. One potential use for a lot of waste plastics, packaging, etc. can be the production of crafts and other "quirky" objects like purses, wallets etc.[48]

Municipal Solid Waste

Trash collection within cities and counties may be organized by the jurisdiction or a corporate entity. The sustainability relevance here is relatively limited, as the removal of waste to a landfill in a traditional context is only nominally better than burning or illegal dumping of household waste.

SUMMARY

The range of sustainable applications for low-income communities is extensive. We organized these applications into the four key areas of weatherization and microclimate, renewable energy, water and wastewater, and recycling and solid waste. The accompanying appendices are meant to provide the reader with an in-depth guide to the many possibilities out there when considering green rehab and development in low-income or informal settlements. However, there are also many constraints to implementing these technologies. In the next chapter we narrow our focus to provide an up-close view of those applications that are most feasible within this network of constraints.

[48] Six examples of upcycling, all "crafting" projects can be found at: http://blog.sustainablog.org/six-creative-upcycling-projects/. Although these products are currently en vogue, it's probably unlikely that these sorts of crafting practices could be a widely applicable practice.

Chapter 4

Optimal Sustainable Interventions for Low-income Households and for Self-Help

INTRODUCTION AND OVERVIEW

As noted in the introductory chapter, we began this project under the belief that the benefits of green housing rehabilitation could be extended to low-income households if we were able to: 1) outline the range of possible sustainable housing interventions across a number of different arenas; 2) document their relative costs;, and 3) quantify their ease of implementation.

In the previous chapter we summarized a wide variety of available technologies in the areas of microclimate, renewable energy, water and wastewater, and solid waste. While the interventions listed in Chapter 3 and the accompanying appendices are meant to cover the whole scope of what is currently available in terms of sustainable home improvements, in this chapter we narrow our focus to examine only those interventions that are most appropriate for low-income households.

To this end we account for the economic and social feasibility of implementing various sustainable technologies. While we originally organized our exploration of possible retrofits according to the matrix presented in Chapter 2, we came to realize that the primary constraining factors that might determine the feasibility of an intervention are the economic investment required, the technological complexity of the proposed intervention, and the labor and human capital involved in its installation. Thus we determined the suitability of different technologies in terms of their cost, their ease of operation, and their ability to be installed using the sweat equity of the homeowner his or herself.

We developed a framework that would allow us to assess each technology or intervention in terms of cost, savings, opportunities for self-help, and the relative ease of implementation. These results are described and presented in graphic form in the following five diagrams.

In order to further assist households in realizing the benefits of sustainable retrofits, and to demonstrate the actually monetary savings these retrofits can provide them, we also created a household energy saving model spreadsheet that calculates saving on utilities based on various interventions.

Coupled with the diagrams and the comprehensive chart below, this spreadsheet offers a tool that can help households determine the feasibility and payback of retrofitting their homes.

METHOD

We first developed a home energy calculator in the form of a spreadsheet. The spreadsheet and user-guide are attached (see Appendix B1, **"Household Energy Saving Model Spreadsheet,"** and Appendix B2, **"Rough Valuation of Energy Saving Model User Guide"**). The spreadsheet is designed for use by an energy auditor. It uses the input of household energy consumption to estimate the future savings possible with weatherization. The spreadsheet is meant to be a tool to help individual households gain a clear understanding of the actual savings associated with various sustainable interventions in their home. If the household can see positive returns on the initial investment, they may be more likely to make such an investment.

To develop the microclimate, renewable energy, water and wastewater, and solid waste diagrams we first reviewed technical materials on each of the sustainable technologies or interventions presented here. Much of this material is reprinted in the various sections of Appendix A of this report. We then developed a standardized rating scale to rank each intervention in terms of: i) ease of maintenance, ii) cost savings to homeowner once installed, iii) initial cost outlay or investment, and iv) the amount of sweat equity or professional expertise required for its implementation.

These diagrams are broken down into the four areas as outlined in the previous chapter, namely: microclimate, renewable energy, water and wastewater, and solid waste management. In the following analysis we first assess the economic and practical feasibility of select technologies within each of these four areas on individual charts. We then present the various interventions in relation to each other in a single graphic overview.

Rubric

A key to our assessment of the interventions is included in each of the following four charts: Weatherization and Microclimate, Recycling and Solid Waste, Water and Wastewater, and Renewable Energy. We also review the components of the key here.

For "*Ease of Maintenance*" we ranked each intervention on a scale of 1 to 10, with 1 indicating that the technology needs minimal to no maintenance once installed and 10 indicating that the technology must be consistently or precisely maintained.

For *"Savings*" we indicated the amount of savings made possible by the intervention. For ease of comparison across the four areas we interpret savings to mean total savings on utility bills made possible by the intervention. Again we used a scale of 1-10 with 1 indicating minimal savings and 10 indicating savings of about 50% of energy or water used, or money spent. Often this was a qualitative assessment based the percent of total water, energy or expenditure that could be offset if the intervention were made. Precise figures of how much the various technologies can save homeowners are included in the sections of Appendix A.

For "*Initial Cost Outlay*" we created six categories to represent different levels of initial capital investment. The majority of the technologies are captured in categories that range from one to four dollar signs. A key to these symbols is included in each chart. Those interventions that require less than $20 in initial investment are denoted by a 1-cent symbol and those that require more than $5000 are denoted by a diamond symbol.

For "*Human Capital*" (denoted by hammers in the diagram), we use a visual representation of a composite variable that attempts to capture three things: i) the amount of time and labor necessary to implement or install the technology; ii) the opportunity for the homeowner to use his or her own sweat equity; and iii), the need for professional assistance or expertise. Here the number of hammers is the amount of labor necessary: one hammer indicates minimal labor, two hammers indicate moderate labor, three hammers indicate intensive labor and four hammers indicate that the amount of labor needed may be prohibitive to some households. The hammers are also color-coded to represent the level of expertise required to implement the upgrade: green means a novice can do the work, yellow means some skill is required, and red means expertise or professional assistance is required. A circle in place of hammers means that negligible labor is required (as in the case of installing compact florescent bulbs, for instance).

PRESENTATION OF FINDINGS

As noted, we created a valuation of each intervention across the four categories of: ease of maintenance, cost savings, initial cost outlay or investment, and amount of sweat equity or professional expertise required for implementation and present these valuations in the following four charts.

Weatherization and Microclimate

The weatherization chart on the next page demonstrates that there are more potential interventions in the area of weatherization and microclimate than in any of the other areas that we studied. It is also clear based on the chart that many of these interventions are quite affordable and can produce significant savings (savings rated over 5 on a scale of 1-10). It is also clear that the majority of these interventions require significant labor on the part of the householder as well as some degree of technical proficiency or the help of a professional.

Recycling and Solid Waste

In the area of recycling and solid waste there is the most opportunity for self help (i.e. the most interventions rated with one green hammer). The key exception here is recycling cooperatives, which require a large human capital investment and a moderate degree of expertise. The use of biodigestors (see Appendix A14: "Sustainable Recycling and Solid Waste Technologies and Practices") also stands out as an intervention that requires more economic and human capital investment but produces significant savings.

Water and Wastewater

The water and wastewater chart demonstrates that there are both very high and very low cost interventions that produce comparable water savings relative to their use. There are also several effective uses of greywater technologies (see **Appendix A11: "Greywater Systems")**.

Renewable Energy

Interventions in the area of renewable energy are some of the most expensive and require the most labor and expertise for installation and the most maintenance. The saving these technologies provide to households varies greatly and investment might be best directed to other channels, such as weatherization, before these interventions are made.

These charts are presented in the following four pages.

Intervention	Ease of Maintenance (1-10)	Savings (1-10)	Initial Cost/ Outlay (1-6)	Human Capital (1-4)	Notes
Foil/Reflective film in window(s)	3		¢	Minimal labor (no skill)	
Simple Cross-Ventilation	1	3	¢	Minimal labor (no skill)	
Replacing Filters	3	2	¢	Minimal labor (no skill)	
Weatherstripping	3	3	$	Minimal labor (no skill)	
Kitchen Ventilation	1	1	$$	Moderate labor (no skill)	
Bathroom Ventilation	1	2	$$	Moderate labor (some skill)	
Shading Devices/ Overhang	3	4	$$	Moderate labor (some skill)	
Sealing Joints	2	3	$	Moderate labor (some skill)	
Patching Holes	1	3	¢	Moderate labor (some skill)	
Repairing Doors/ Windows	2	4	$	Moderate labor (some skill)	
Patching External Cladding	1	4	$$	Moderate labor (some skill)	
Spray Foam Insulation	1	6.5	$$$$	Labor intensive (some skill)	
Batt/Blanket Insulation	1	4	$$$	Labor intensive (some skill)	
Foam/Rigid Board Insulation	1	4	$$$	Labor intensive (some skill)	
Loose-Fill Insulation	1	6	$$$$	Labor intensive (some skill)	
Changing House Orientation	1	7	$$	Labor intensive (some skill)	
Replacing Doors/ Windows	2	4	$$	Labor intensive (some skill)	
Sealing Ductwork	2	5	$$	Labor intensive (some skill)	

KEY ¢ = ≤20 $ = ≤100 $$ = 100-500 $$$ = 500-1000 $$$$ = 1000-5000, [diamond] = more than 5000

[1 hammer] = Minimal labor; [2 hammers] = Moderate labor; [3 hammers] = Labor intensive; [4 hammers] = Very Labor intensive

[green] = no skill; [yellow] = some skill; [red] = expertise

Intervention	Ease of Maintenance (1-10)	Savings (1-10)	Initial Cost/ Outlay (1-6)	Human Capital (1-4)	Notes
Contract Recycling	1	1	$$	Almost no labor (no skill)	
Passive Composting	1	1	¢	Minimal labor (no skill)	
Active Composting	2	2	$	Minimal labor (no skill)	
Vermiculture	1.5	1.5	$	Minimal labor (no skill)	
Pigs, Chickens, Etc.	4	2	$$	Moderate labor (some skill)	
Biodigesters	6	7	$$	Labor intensive (some skill)	
Recycling Co-operatives	7	5	more than 5000	Very Labor intensive (some skill)	

KEY ¢ = ≤20 $ = ≤100 $$ = 100-500 $$$ = 500-1000 $$$$= 1000-5000, = more than 5000

O = Almost no labor
= Minimal labor
= Moderate labor
= Labor intensive
= Very Labor intensive

= no skill
= some skill
= expertise

Intervention	Ease of Maintenance (1-10)	Savings (1-10)	Initial Cost/ Outlay (1-6)	Human Capital (1-4)	Notes
In-sink aerators	1	5	¢	1 hammer (green)	
Water-efficient Showerheads	1	8	$	1 hammer (green)	
Toilet Lid Sink	3	2	$$	1 hammer (yellow)	
Water Pipe Insulation	3	4	$	2 hammers (green)	
Rainwater Harvesting	3	4	$$	2 hammers (green)	
High-efficiency Toilets	5	5	$$	2 hammers (yellow)	
"Aqus" Sink-to-Toilet Greywater Connection	3	2	$$	2 hammers (yellow)	
Plumbed Greywater Reuse	7	6	$$	3 hammers (yellow)	
Composting Toilet	6	9	$$$	3 hammers (red)	
Solar-Assisted Composting Toilet	7	9	$$$$	3 hammers (red)	
Aerobic Treatment Units	9	4	diamond	3 hammers (red)	
New Septic System	8	4	diamond	4 hammers (red)	

KEY ¢ = ≤20 $ = ≤100 $$ = 100-500 $$$ = 500-1000 $$$$ = 1000-5000, diamond = more than 5000

1 hammer = Minimal labor; 2 hammers = Moderate labor; 3 hammers = Labor intensive; 4 hammers = Very Labor intensive

green = no skill; yellow = some skill; red = expertise

Intervention	Ease of Maintenance (1-10)	Savings (1-10)	Initial Cost/ Outlay (1-6)	Human Capital (1-4)	Notes
Compact Fluorescent Bulbs	1	6	¢	○ (green)	
Passive Water Heating	3	varies	¢	○ (yellow)	
Active Water Heating	7	varies	$$$$	2 hammers (yellow)	
Solar Water Heater (Active)	7	7	$$$$	4 hammers (red)	
Solar P/V System	10	varies	◇	4 hammers (red)	
Rooftop P/V System	10	9	◇	4 hammers (red)	

KEY ¢ = ≤20 $ = ≤100 $$ = 100-500 $$$ = 500-1000 $$$$ = 1000-5000, ◇ = more than 5000

○ = Almost no labor
1 hammer = Minimal labor
2 hammers = Moderate labor
3 hammers = Labor intensive
4 hammers = Very Labor intensive

Green = no skill
Yellow = some skill
Red = expertise

Comprehensive Graphic

The comprehensive graphic depicts all of the above findings on a single graph. A single circle represents each technology or intervention. These circles are color-coded to show the area of sustainable applications to which they belong:

Green Circles: Recycling and Solid Waste interventions

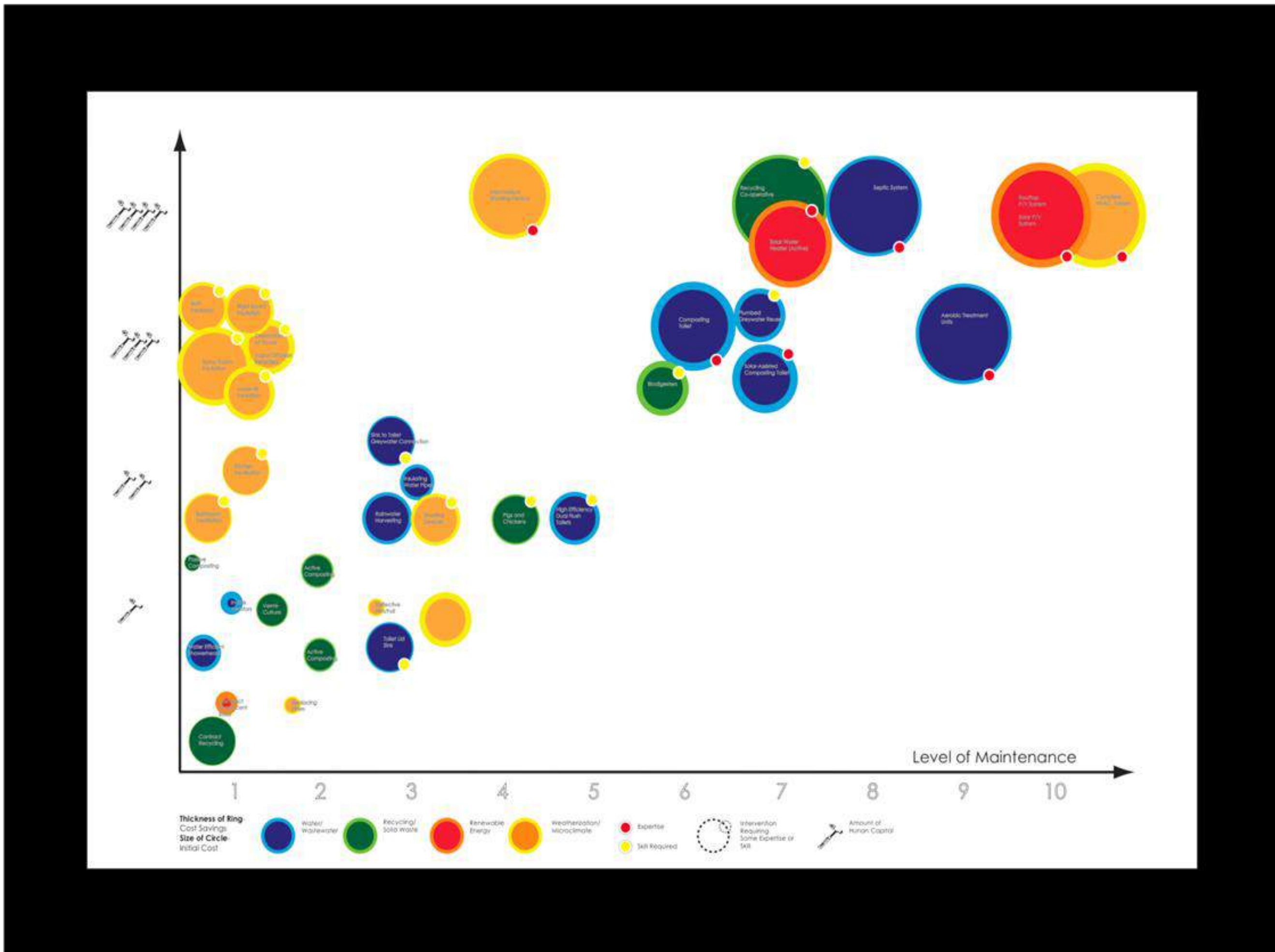
Blue Circles: Water and Wastewater interventions

Red Circles: Renewable Energy interventions

Yellow Circles: Weatherization and Microclimate interventions

The X-axis of the graph depicts ease of maintenance for each intervention while the Y-axis represents the amount of human capital/labor investment (represented again with 1 to 4 hammers). The need for professional expertise, which was included in the human capital symbol in the four separate charts, is indicated here by a yellow or red ring around the circumference of each circle.

Each intervention is represented by a different-sized circle.. The total size represents the initial cost of the intervention. Thus, the circles are of ten different sizes that correspond to the 1-10 value designated in the ‘Initial Cost’ column on the above charts. The thickness of the ring at the circumference of each circle represents the ‘Cost Savings’ category from the above charts. Again it is a graphic depiction of the 1-10 value awarded on the basis of the cost savings made available by each intervention. Thus, when each circle is viewed in terms of its total size relative to the width of the ring around its circumference this indicates the total savings a household can achieve from a retrofit in relation to the initial investment they must make.



SUMMARY

Consistent with our initial assessment we discovered that there are many low-cost, low-tech options that have the potential to produce significant savings for low-income households and which stand out in the diagrams.

We found an array of interventions that had high cost savings to initial cost ratios (i.e. thick circumference rings relative to small total circle size). We also found that many of these interventions were located in a zone of the chart that represents low levels of maintenance and low need for labor and human capital investment. This means that these technologies should be relatively easy to implement in low-income communities.

Because the interventions are color-coded according to the area of sustainability to which they belong, you can see that some sustainable retrofits -- especially those dealing with weatherization and microclimate (the yellow circles) -- are clustered in the advantageous zone that represents low maintenance and relatively low human capital requirements.

This graph might be most effectively used by households, community leaders and policy makers that wish to rehabilitate current homes, develop new low-income housing more sustainably, or create programs that utilize sweat-equity. Together the diagrams and spreadsheet should provide a powerful tool to demonstrate the range of possible technologies for rehab and new development, the contexts they are most suited to, the outcomes they can best produce and the actual benefits to individual households that can result.

Chapter 5:

Holistic Sustainability: Juridical, Social and Fiscal Approaches to Sustainability in Low-income Communities

OVERVIEW

In the last two chapters we provided an in-depth account of the sustainable technologies and interventions that may produce more energy-efficient and healthy homes for low-income households. The focus on available technologies and their implementation might produce the misleading impression that extending sustainable practices to low-income communities means applying technological "fixes" that alone can improve the lives of residents in those communities. Returning to the matrix outlined in Chapter 2 of this report highlights the need to think about these strategies for housing development and rehab within the broader context of sustainability. The "predisposition variables" we set forth in Chapter 2 provide a more comprehensive look at the broader arenas of sustainability. Using the phrase "predisposition variables" to mean the set of constraints they might affect the large-scale implementation of sustainable practices, we categorize these constraints into three distinct yet interdependent arenas: social, juridical, and fiscal. In this way we attempt to capture what we call the three crucial "E's" that make up the sustainability triangle: namely ecology, economy, and equity. The "sustainability triangle"[49] has been at the center of the academic discourse on sustainability. This triangle (**see Appendix C1, "The Sustainability Pyramid**) represents the inter-reliant relationship between ecology, economy, and equity.

Rather than narrow our focus to include only those aspects that relate to the use and expenditure of resources, we wish to include the interrelation of the social, juridical and fiscal aspects of a sustainable policy agenda. In this chapter we briefly cover these three arenas as they relate to the task of extending household sustainability to low-income and self-built communities.

SOCIAL

Central to our conception of social sustainability is the idea that the benefits of sustainable housing might begin to target low-income populations rather than being reserved for middle and upper income households as they have largely been in the past. Beyond this guiding principle the arena of social sustainability includes issues of social equity, inclusivity, community participation, local leadership, and environmental justice. While we do not attempt to cover all these critical issue here, we do highlight the need for community participation and "buy-in" in relation to the goals of this project.

To implement strong sustainable practices it is important to look at the social and organizational structure of a community. Social organization and mobilization in low-income housing communities presents unique challenges. Best practices for successful community engagement are the subject of an entire academic literature. We use Mattessich and Monsey's summary to

[49] Scott Campbell, "Green Cities, Growing Cities, Just Cities?" APA Journal (Summer 1996): 296-312. See also, Harsha Padmal Munasinghe, "Environmental Economics and Sustainable Development," (paper presented at the UN Earth Summit, Rio de Janeiro, 1992.)

identify seven main characteristics of successful community building: "awareness of an issue, motivation from within a community, small geographic area, flexibility in community, pre-existing social cohesion, existing identifiable leadership, and positive previous experiences with community building." [50]

Low-Income housing subdivisions and communities have unique challenges with their civic infrastructure that make community building and more mobilization difficult (Ward 1999). Specifically border *colonias*, have three main challenges which are: the lack of already existing leadership in a community, the lack of time to advocate, and a struggle to build national and local collaborators.[51] U.S. settlements are also quite small compared with their Latin American counterparts, and while they are often poorly serviced, their founding is legal with some sort of title claims. Thus they do not start with high levels of spontaneous mobilization: instead the sense of community must be forged. These same challenges can be found in IFHS and other self-managed communities. Overall when mobilizing in a low-income community it is important to facilitate access to information, to provide capacity-building opportunities, to help local leaders develop their own leadership skills.

Information: Government agencies have aggressively ramped up programs that offer funding sources for homeowners for sustainable home rehab. We cover some of these funding opportunities in the final section of this chapter. However, many homeowners remain unaware both of these funding opportunities and of the personal and social benefits of sustainable improvements. Homeowners will not adopt energy technologies if they do not know these programs exist, understand how they can afford to implement them, appreciate their impact on society-at-large, and perhaps most importantly, understand how money can be saved in the short- and long-term.

Capacity Building: Oftentimes low-income or self-managed communities fail to organize for collective goals because they lack experience and organizational know-how.[52] In their book on community development in border *colonias,* Esparaza and Donelson stress the need for a capacity building approach when organizing in such communities. They claim that organizing efforts should strive to "strengthen the skills and organizational capabilities of the civil sector, so that local leaders can better manage their own affairs."[53] This leads to a more general point. When attempting to implement a socially sustainable agenda it is important that much of the initiative come from within the community, rather than being imposed from outside.

Community Involvement: Building local autonomous leadership is crucial to social sustainability. Again in reference to border *colonias,* Esparaza and Donelson suggest: "Colonia leaders have basic needs… such as learning how to run a meeting, to deliberate, and to define public issues, [these] skills are essential to helping break the strongholds of elites, who often gain the benefits of development."[54]

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[50] Mattessich, P., Monsey, B., with assistance from Roy, C. Community Building: What Makes it Work. Amherst Wilder Foundation. Saint Paul, Minnesota: 1997, Second Printing November 2001.

[51] Esparza and Donelson, Colonias in Arizona and Mexico: Border Poverty and Community Development, University of Arizona Press, 2008. Pg. 114.

[52] Ibid. pp. 119

[53] Ibid. pp. 127

[54] Ibid. pp. 129.

Existing civic structure or social capital will vary widely throughout the six types of communities identified in Chapter 1. Sources of social capital and community bonds can be transitory and must often be renewed. New organizations may be energized or created by a cause and then lose momentum due to lack of resources or dwindling interest. In these communities it is all the more important to help community members and organizations (incorporated or otherwise) establish the skills to set up a long-term mission plan, resources and knowledge of how to mobilize and strategize for change, and long-standing relationships with consultants.[55]

Appendix C2, "Training and Capacity Building Programs" presents case studies of programs focused on implementing sustainable practices in low-income communities through community participation and jobs training. They are mean to provide concrete examples of the many benefits that can result when aforementioned aspects of social sustainability are made the focus of a program.

JUDICIAL

Background: Zoning in Context

The majority of land use regulation within the United States remains a function of zoning and building codes. These codes are constitutionally derived from the States' residual authority under the United States Constitution to regulate the health, safety and welfare of their citizenry. In response to the industrialization and urbanization of the late 19th and early 20th century and the general increase in municipal services and government involvement in social welfare and economic development—over both the built and social environment—zoning codes arose to attempt to rationalize processes of land use development. This type of land use planning through zoning codes was famously tried and validated in the landmark *Village of Euclid Ohio v. Ambler Realty, Co.* 272 U.S. 365 (1926), where the Supreme Court found that legislatures had a broad power to regulate land use, effectively only limited by 14th Amendment considerations of rational basis for legislation. This conventional "Cartesian" zoning model continues to dominate contemporary urban planning.

The basic legislative document informing most land use policy in the U.S. remains the Standard Zoning Enabling Act (SZEA). SZEA is a model law, drafted in the 1920s by the department of commerce and adopted, with variations, by the several states over the years. Though it looks different in different states, SZEA sets guidelines by which states will use and delegate their zoning authority to subjurisdictions. Most importantly, in Texas, a distinction is made for the purposes of the Zoning Enabling Act (TX Local Government Code Chapter 211) between "home rule" jurisdictions and "general law" areas (TX Constitution, Article XI, §§4, 5). Home rule jurisdictions are cities and towns with populations greater than 5,000 people; general law areas are all those lower than 5,000 people that have adopted a charter. Home rule jurisdictions are generally the cities and towns that we imagine possessing robust zoning and land use codes;

[55] Ibid. pp. 133-135.

governed by the Enabling Act, these jurisdictions are allowed to regulate land use in accordance with a comprehensive land use plan, and have additional powers by those plans over areas outside their territorial limits scheduled for annexation, their Extra Territorial Jurisdiction (although Texas places steeper limits than some states on municipal zoning power within the ETJ). The only limitations on Home Rule municipality zoning powers are that they cannot promulgate codes on issues that are either expressly prohibited or preempted by state or Federal law.

General Law jurisdictions, perhaps more relevant in the case of informal homestead subdivisions that exist outside municipal ETJs (for both market and regulatory reasons), are significantly more restricted in their abilities to establish land-use regulation. These jurisdictions are limited to default provisions within the state local government code and not enabled to promulgate their own zoning and land use regulations, subject to only those forms of regulation expressly authorized by state law. While Counties and other general law areas do have some controls over land use and development, the majority of tools available to cities under a traditional zoning framework are absent. It should be evident that such lax regulation remains a significant enabling factor for the development of informal subdivisions and *colonias* in Texas. It is in this context—that of lax restriction on landowners' ability to dispose of their property, but also of minimal and sometimes inadequate ability to regulate land-use and development—that we should consider the deployment of certain sustainable technologies in low-income informal housing subdivisions.

Regulatory Powers within Local Jurisdictions of Texas

Unincorporated Areas: Unincorporated areas in Texas have no zoning powers; their governmental abilities are limited to road maintenance and policing. Though this may often lead to locally unwanted land uses (LULU's) proliferating in these areas, with respect to sustainable construction, renovation and improvement of properties this lack of regulation allows for a diversity of interventions impossible in the city. Additionally, low population densities should be considered a factor for many technologies.

General Law Municipalities: For general law municipalities, limited by the express allowances of the state, the Texas local government code §211.003 has given the following zoning powers to all municipalities generally: the height and size of buildings, percentage of a lot that may be occupied, size of yards and open spaces, population density, location and use of buildings, groundwater controls, and historical designations This may seem extensive, but compared to a home rule municipalities that may regulate even aesthetic characteristics it is quite limited. The localized nature of the zoning process, even within general law municipalities, necessitates a case-by-case basis to ensure that zoning codes are being met or that certain improvements are compliant.

Extraterritorial Jurisdictions: Texas Local Government Code §212.003 explicitly prohibits municipalities from regulating land use and zoning within their extraterritorial jurisdictions. They may only minimally regulate water and access to public roads. These prohibitions include regulations on septic and wastewater systems that may be relevant to low-income sustainable housing technology. Again, the lack of regulation in this area putatively allows for greater flexibility and the potential deployment of technologies that might otherwise be considered illegal under traditional land-use codes (e.g. composting toilets, certain types of septic systems, etc). New construction or additions may have to follow building permitting procedures and site plan approval of the parent municipality. For a more in-depth discussion of specific regulations applicable to the Extraterritorial Jurisdiction of San Marcos, TX (the area containing Rancho Vista and Redwood) see **Appendix D1: "Sample Land Regulations: San Marcos ETJ."**

Title Issues: Contract for Deed

Title to land generally presents obstacles for homeowners within informal areas in Texas. Without title to land, homeowners may be unable to access credit, receive certain types of federal subsidy or access funding or undertake improvements on their property. The system of contract for deed presents a unique set of issues in the renovation and upgrading of homes where title is at issue.

To recall, contract for deed is a type of real property transaction, originally favored for agricultural land sales, whereby payments are made on a contract for the land until the contract amount is paid in full. Aside from many of the other issues related to contract for deed (very high interest rates, low-amount of security in investment) this system is problematic because title remains in the possession of the seller until the final payment is made. Practically as well, sellers may never transfer title property even after the contract has been paid off--whether by omission or as an attempt to defraud the purchaser.

There have been some successes made in this arena, however. The contract for deed statute within the Texas Property Code, §§5.061-080 addresses some of the worst problems related to these sales and §5.081 provides for the means of converting a contract for deed into legal recordable title. This may happen either through the purchaser paying the balance of the contract amount in full, or the conversion of the contract interest into a deed and a mortgage lien upon delivery from the buyer to the seller of a promissory amount for the full amount remaining on the contract that contains the same interest rates, late fees and due dates as the contract.[56] A contract for deed having been converted into a warranty deed to be recorded allows a homeowner to benefit from the equity that they have built in the land, enjoy greater security of ownership, and access subsidies and many important federal programs.[57]

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[56] See Texas CBar's Converting Contracts for Deed, available at: http://www.texascbar.org/legal_library/real_estate/contract_deed.php).

[57] It should be noted that another somewhat common obstacle to recording proper title for homeowners, particularly within poor, minority and agricultural communities, is the issue of heir properties. In situations where property owners die intestate or other

Statewide Water and Wastewater Regulations

Several of the water, wastewater and composting systems discussed in the preceding chapters are also constrained by the regulatory environment in Texas. Here we offer a few examples as evidence of how laws shape the implementation of such technologies. The Texas Commission on Environmental Quality (TCEQ) is in charge of enforcing state regulations having to do with on-site sewage facilities (OSSFs) such as septic systems. A general FAQ and information on local permitting agents can be found on their website: http://www.tceq.state.tx.us/nav/permits/on-site.html. Additionally, there is information on the specific parameters that all septic systems must meet. The majority of actual law on the subject comes from Texas Admin. Code Title 30, Part 1, Chapter 285, "On-Site Sewage Facilities." The specific regulations are highly technical, and individual septic systems must be built according to various site and soil conditions among other ad-hoc considerations. Furthermore, all septic systems must be permitted and inspected by a professional inspector. Although the regulations are relatively silent on the specific type of septic systems that may be employed, most of the statute is targeted towards traditional septic systems; the regulations should be consulted when attempting to deploy a novel or innovative sewage treatment system to ensure that it does not come into conflict. It should be noted that cluster septic systems are not authorized by §285.6, however "Cluster systems may be authorized under other chapters of this title including Chapter 331 of this title (relating to Underground Injection Control)."

It is notable as well that within Chapter 285, Subchapter H is entirely dedicated to "Disposal of Greywater" allowing certain greywater reuse systems.§285.81(a) allows for the use of up to 400 gallons of greywater a day by a family without a permit. This usage is subject to some restrictions ensuring the sanitary aspects of such operations, nonetheless many of the conceivable uses for graywater (gardening, composting, landscaping) are expressly permitted by the statute. For more information on TCEQ permitting as found in the Administrative Code, see **Appendix D2, "Texas Commission on Environmental Quality Administrative Code."**

Texas State Legislative Efforts and Critiques

During the 1980s, Texas policy-makers began to focus on issues in *colonias*, as activists expressed concerns about living conditions in these communities and the location of *colonias* moved closer to border city limits. This led legislators to take some action at the end of that decade, since it was clear that the *colonias* were not changing or disappearing without intervention. Since 1989, many laws have been passed that deal directly with *colonias* and many more that deal with sub-standard and rural housing conditions. However, these laws poorly address *colonias* in non-traditional locations. These pieces of legislation can be divided by the issue(s) they attempted to tackle, as well as the agencies responsible for administering the aid. In **Appendix D3, "Texas State Legislative Efforts in *Colonias* and Rural and Peri-**

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situations where the transfer of property to an heir was never recorded, Owners may fill out an affidavit of heirship (TX Probate Code, Part III, §§48-56) in order to secure proper title.

urban Areas," we provide a summary of significant legislation passed regarding *colonias* through 2005 divided into three main topic areas: those pertaining to waste and wastewater service and management; those pertaining to land regulation; and those pertaining to education and assistance.

FISCAL

In this section we inventory the types of funding available to subsidize sustainability expenditures. We include funding opportunities at the federal, state and private utility levels.

Federal Funding Sources

The structure of federal income incentives can be broken down by income level, region typology (urban or rural), and scale of the housing (single- or multi-family). Here we outline six federal programs that provide funds for sustainable rehabilitation or development.

USDA Direct Housing Loans: The USDA funds several grant and loan programs that focus on rural housing and community development. Though they do not specifically deal with sustainability, there is room to include technologies and interventions through education and additional funding through other means. USDA funding is primarily broken down by single-family and multi-family housing opportunities. There are direct loan and loan guarantee programs that provide low, affordable interest rates to families that may not otherwise qualify and pay for loans when a family is in danger of defaulting. Families typically qualify if they are 80% of area median income (AMI) and can use the loans for home purchase (existing or new construction). Under the loan guarantee program, future homeowners can also borrow up to 100% of the value of a home, so that the barrier of having a down payment is eliminated.[58] A guide to the income limits and eligibility criteria for USDA direct housing loans can be found in **Appendix E1, "Eligibility for USDA Direct Housing Loans."**

[58] http://www.rurdev.usda.gov/RHS/sfh/indiv_sfh.htm#Mutual%20Self-Help%20Housing%20Program%20(Section

Home Repair Loan and Grant Program: Other USDA programs exist to maintain and upgrade the existing housing stock in low-income communities, including *colonias* and informal homestead subdivisions. The Home Repair Loan and Grant Program offers loans and grants for renovation for very low income owners of homes in need of repairs or interventions to make a home accessible to someone with disabilities. For example, funds can be used to repair a leaking roof, replace a wood stove or unvented heater with central heating, construct a front-door wheelchair ramp, or to replace an outhouse and pump with running water, a bathroom, and a waste disposal system. Direct home improvement grants are only available to homeowners 62 years and older. Low-interest loans (1%) are available to low-income families and individuals through the HCFP.[59] The loans are repaid over twenty years and to qualify, the household must make less than 50% of AMI. Additionally, the loans are a maximum of $20,000, while grants are capped at $7,500.[60] This program seems most appropriate for declining, but not dilapidated homes. As an example, this would be ideal for a post-1978 mobile home that is in overall decent shape, but needs one or two significant repairs.

Mutual Self-Help Housing Program: This program is targeted at low- and very low-income households, who cannot afford to purchase or construct clean, safe, livable housing. The premise is that communities, broken down into smaller groups, will contribute labor or "sweat equity" to the home construction process in order to make overall home costs attainable. Sweat equity would comprise 65 percent of the construction labor costs on everyone in the group's homes. Like most of the USDA programs, the homeowners must be in the 50-80% AMI range, but must be able to make payments of around 22-26% of household income. There is a subsidy that covers whatever the homeowner cannot pay in excess of the 26% of income cap and there is a consideration for total family debt. Homes are to be modest in size, cost, and design. This modesty certainly would not exclude conservation fixtures, such as low-flow faucets and toilets and energy-efficient appliances and many other sustainable technologies. The Mutual Self-Help Housing Program gives guidelines about how a community with little financial capital can greatly improve their home stakes, communities, and property values by providing most or all labor through sweat equity.[61]

Housing Preservation Grant: Funds from this program must be used in an area where there is a documented need for very-low and low-income housing. Funds must be used in a 2-year period and can be used on either single-family and multi-family housing, as long as it is targeted toward very-low and low-income residents and in a town/city with 20,000 residents or less.[62]

Multi-Family Housing: While most of the USDA's grants are for single-families and home owners, there are also several programs available for multi-family housing, which is directed mostly at developers. Anyone, from individuals to non-profits to public agencies, is eligible to apply for financing and must have tenants in the very low- to low-income bracket. Individuals with disabilities are also targeted. In order to be competitive, the housing suggested must be in certain communities that are published yearly in the *Federal Register*. Loans can be approved on the state level up to $1.5 million; in excess of that amount is approved at the HCFP national

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59 Ibid.

60 http://www.rurdev.usda.gov/RHS/sfh/brief_repairloan.htm

61 http://www.rurdev.usda.gov/RHS/sfh/indiv_sfh.htm#Mutual%20Self-Help%20Housing%20Program%20(Section).

62 http://www.rurdev.usda.gov/RHS/mfh/brief_mfh_hpg.htm

office.[63] There is also a loan guarantee program available to developers that make providing loans more beneficial to lenders. The USDA is interested in increasing very low to moderate priced housing in rural areas. New construction and intense rehabilitations are covered and the housing must have a minimum of five dwelling units. The government guarantees the loans up to 90%, gives credit towards the Community Reinvestment Act, and the loans are exempted from the lender's lending limits.

Weatherization Assistance Program: At the behest of the Obama administration, energy efficiency incentives have become a cornerstone of the economic recovery and the green jobs drive. At the center of this agenda, the Weatherization Assistance Program is a federally-funded and state-administrated program designed to reduce green house gas emissions, provide economic relief to low-income households faced with rising electricity and fuel costs, and stimulate local economic growth. To meet these objectives the program provides free weatherization services to low-income homes. Most often, local contractors are hired to tighten the building envelope of a home so that it is more energy efficient. The U.S. Department of Energy funds and manages the WAP federally.[64]

In Texas, the Texas Department of Housing and Community Affairs' (TDHCA's) Weatherization Assistance Program has typically received roughly $13 million per year through DOE, the Low Income Home Energy Assistance Program (LIHEAP), and IOUs. In 2009, the TDHCA received $43 million ($12.2M regular DOE, $6.9 M Supplemental DOE, and $23.9M). The American Recovery and Reinvestment Act authorized a dramatic surge in federal funding for local energy efficiency projects and Texas is receiving $326.9 million on top of existing funding. Despite this rapid increase in funding, the level of investment still only reaches a fraction of the total need for such assistance. In Austin, over 4,000 households would be income eligible for WAP but even with the Stimulus money, there is only capacity to reach 1,000. The need is as broad as it is deep. In Texas, WAP income-eligible households pay roughly 12.2% of their annual income on home energy costs. In comparison, households that are not WAP income eligible tend to pay only 3.7% of their income on home energy costs.[65]

Please see **Appendix E2, "Guidelines for Weatherization Assistance Program Funds"** for a complete list of the weatherization services provided once TDHCA allocates WAP funds and for household eligibility requirements.

Other Federal Programs

There are several federal programs that fund low-income and/or sustainable housing outside of the rural context.

Energy-Efficient Mortgages Program: The Energy-Efficient Mortgages Program, targeted at moderate and lower-income households, finances energy efficiency measures, particularly renewable energy, in a new or existing home. These mortgages are insured through the Federal

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[63] Ibid.

[64] Funds from this program are typically coupled with funds from the Low Income Home Energy Assistance Program (LIHEAP) and support from Investor Owned Utility program (IOU) funds to expand the toolkit of energy efficiency interventions available to each household. While WAP funding tends to focus more on building related interventions, LIHEAP provides funding directly for appliance replacement.

[65] http://168.39.88.72/ea/wap.htm

Housing Authority or the Veterans Affairs Programs. Loan amounts are capped at 5% of the value of the property; 115% of the median area price of a single-family home or; 150% of the Freddie Mac conforming loan program. Perhaps most important in determining a loan amount is that they cannot exceed the projected savings of the improvements. This makes projecting future savings and determining which technologies deliver the greatest savings at the lowest costs a necessary and desirable part of the process of applying for these monies.[66]

Residential Energy Subsidies and Tax Credits: A program that can be used in tandem with the mortgages program is the Residential Energy Conservation Subsidy Exclusion, which states that gross income should not include the value of any subsidy provided by a public utility for customer purchase or installation of an energy conservation measure, which might include solar water heat, solar space heat, or photovoltaics.[67] In relation to the above incentives, a home owner can also apply for the Residential Energy Efficiency and Residential Renewable Energy Tax credits, which allow for a $1500 dollar two-year and a 30% of expenditure tax breaks, respectively. This creates considerable up-front and first year savings for a household considering such improvements.

State and Local Funding Sources: Texas Case Study

There are several incentive programs occurring on a state and local level in all 50 states. Public utilities are at the center of these incentives in Texas. On a residential level, as mentioned previously, the utilities often offer rebates for specific renewable or efficient energy technologies to be purchased and/or installed. Additionally, localities have begun piggybacking on the local utilities and increasing the overall cost benefits available to homeowners or landlords.

PACE Financing: Property Assessed Clean Energy (PACE) financing is an innovative funding structure administered by the State Energy Conservation Office. It allows businesses, landlords, and homeowners to borrow money for energy-efficient improvements and pay them back via a special assessment on the property over a series of years. While the state provides the funding, local municipalities determine the terms and what technologies are eligible. Since May 2009, the state requires the following information from local municipalities to determine how it handles PACE:

- Eligible renewable-energy systems and energy-efficient technologies;
- A method for ranking requests from property owners for financing through contractual assessments if requests exceed the authorization amount;
- Specification of whether the property owner may purchase the equipment directly or contract for the installation;
- The maximum aggregate dollar amount of contractual assessments;
- A map of the boundaries within which contractual assessments will be offered;
- A draft contract specifying the terms to be agreed upon by the municipality and a property owner;
- A method for ensuring that property owners who request financing have the ability to fulfill financial obligations; and
- A plan for raising the capital required to pay for work performed. The law allows municipalities to fund these directly or use proceeds from bonds. Furthermore, the plan

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66 http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US03F&re=1&ee=1

67 Ibid.

must include information on how the interest rate and repayment schedule is determined, and whether or not a reserve fund will be created (and how).

Homeowners at this point can option into the program and a lien is placed on their property until the assessment is paid.[68]

Property Tax Incentives: Property tax incentives exist in Texas to remove the property value increase from property appraisals, further encouraging homeowners to adopt solar or wind-powered energy alternatives without concern of an increased tax bill. This also includes devices used to store energy generated from any eligible wind- or solar-powered equipment. Technology categories for this tax exemption include:

- Passive Solar Space Heat
- Solar Water Heat
- Solar Space Heat
- Solar Thermal Electric
- Solar Thermal Process Heat
- Photovoltaics
- Wind
- Biomass
- Storage Technologies
- Solar Pool Heating
- Anaerobic Digestion

Sales Tax Incentives: Over Memorial Day Weekend, the state of Texas offers a sales tax weekend for energy efficient appliances. This covers both the state and local portions of the tax, up to 2% over the state tax of 6.25%. While specific items have price caps, the overall costs and number of appliances purchased is unlimited. This means that a complete home gut or a new build could purchase their appliances on this weekend and save a couple to a few hundred dollars, depending on the size of the house and the scope of the project. It is essentially effortless, free money that never leaves the pocket of a homeowner that can be redirected to other parts of the home. The only conditions are that the appliances are Energy Star compliant and that they fall into the falling categories of appliances:

- Air conditioners with a sales price of less than $6,000
- Refrigerators with a sales price of less than $2,000
- Clothes washers
- Dishwashers
- Dehumidifiers
- Ceiling fans
- Incandescent or fluorescent light bulbs

[68] Ibid.

Local Utility Incentive Programs: The largest and most varied forms of state and local funding are the local utility incentive programs. These are often structured either as rebate or loan programs, which essentially give grants or financing to differing customer types (residential, commercial, etc.) for energy-efficient or renewable energy technologies. The eligibility requirements almost always include specifications about the type and performance of the equipment, which often affects the amount of the rebate or loan amount.

We have included a comprehensive list of these Local Utility Incentive Programs in a chart in **Appendix D3, "Local Utility Incentive Programs."** The chart shows all of the currently registered local utility incentive programs in the state of Texas and each link has a description of who is eligible, what requirements must be met, and how much money is at stake.

SUMMARY

In this final chapter we have begun explore what is ultimately needed if green housing rehabilitation and development is to positively impact low-income communities. For this to occur several interrelated areas of sustainability must be addressed. Here we organized them according to social, juridical and fiscal approaches to sustainability but elsewhere they may appear under different names. What is important however is that policies and programs attempt to account for this more holistic view of sustainability. Ultimately we must address these social, regulatory, and economic opportunities and constrains as we extend sustainable technologies and interventions to communities where they are greatly needed.