An Exploratory Initiative for Improving Low-Cost Housing in Texas

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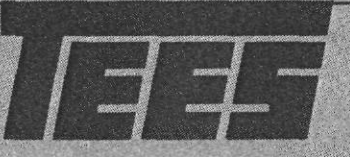
Funded By:

Texas Engineering Experiment Station, Texas A&M University
Center for Housing and Urban Development, Texas A&M University
College of Architecture Research Council, Texas A&M University

January 2000



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Executive Summary

In 1996 *the Real Estate Center* at *Texas A&M University* released a report indicating that the population of Texas would double in the next 30 years and that a majority of the 18 million new Texans would be have low to very-low incomes. In order to house that many low income persons, it is apparent that a significant number of affordable housing units must be built in a relatively short time frame. Based on these predictions, our interdisciplinary team made a proposal in the *Texas Engineering Experiment Station* (TEES) Strategic Initiatives Program to explore technologies related to the production of affordable housing. The purpose of the work is to identify opportunities for research into systems, materials, and processes that might contribute to the development of a low-cost housing industry in Texas that could meet state housing needs and might create export possibilities. The proposal was funded by the *Texas Engineering Experiment Station*, *the Center for Housing and Urban Development*, and *the College of Architecture Research Fund*. This report summarizes the results of the effort.

A two-round Delphi study was conducted by the team to get a range of perspectives from persons active in the housing industry. The conclusions from that study were that opportunities for further research exist relating to the following opportunities / needs, barriers, and constraints for improvements in the low-income housing industry:

Of the technology issues evaluated in Round 1, respondents showed consensus on the following two issues, which received Very Important Ratings:

1. Constraint: Communication between researchers and end users [rating – 45/55]

   This suggests that respondents agreed that there is existing data available on low-cost housing that needs to be gathered and researched to improve housing programs.

2. Barrier: Expense of New Technology [rating – 45/55]

   This suggests that respondents agreed that new technologies already exist and they need to be marketed for low-cost housing programs.

The technologies showing the most opportunity / need for improvement according to the Round-1 data were: *"H.V.A.C. / Environmental Technologies"* and *"Building Envelope."* Secondary opportunities / needs for improvement were: *"Structure," "Interiors,"* and *"Sitework / Foundation."*

The primary constraints for improvement in the field of low-income housing were the current state of *"Research / Education."* Secondary constraints were the current state of *"Construction / Production Processes"*.

Primary barriers to improvement in the low-income housing industry were the *"Administrative / Support"* systems for the industry (e.g., Code restrictions, funding) and *"Construction / Production Processes."*

There were 8 items that moved up in the importance rankings from Round 1 to Round 2, while 7 items received a lower importance ranking in Round 2. There were 19 items that remained at the same level of importance in both Rounds. This indicates that there was a relative consensus among the respondents on the importance of 19 items out of the 34 items that were on both questionnaires, or 56%.

The fact that respondents rated 30 of the 43 issues (70 percent) as important or moderately important opportunities / needs, constraints or barriers, indicates that low-cost housing is a complex issue with many important factors that need to be addressed. No single issue will, by itself, solve the problem — and an atmosphere of strong cooperation and consensus will need to be developed among low-cost housing professionals in all fields in order to make a substantial impact.

It became apparent during the Delphi study that it would be important to extract additional demographic and housing information from data available in the Real Estate Research Center and other sources that might more clearly delineate the potential need and opportunities in the low-cost housing market. This market and demographic analysis revealed the following:

> There is currently a $5 billion potential market for new homes selling for around $30,000 that would meet the more dramatic needs of 157,000 households, and would be sustainable by the building industry as Texas' population grows by 1/3 over the next quarter-century. In addition, there is a much wider range of low-income housing price-ranges that could generate sustainable revenues for housing producers if those new developments homes could be located properly and priced low. The sustainable profit would come from economies of scale and development in target-locations where the need is in greatest numbers, as discussed in detail in the market analysis.
>
> To successfully meet the low-income need through industry initiative: 1) developers would have to procure land for low-cost housing developments in urban centers where the jobs are located and in fast-growing border areas, and to install appropriate and durable infrastructure for housing standards to be met, 2) producers would have to sell homes in those areas for around $30,000, 3) low-income families would have to receive lending assistance and community assistance from Government in addition to Government market-incentives for developers / producers, and 4) technologies which enhance durability would have to be promoted through continual research and development to assure the long-term improvement in low-income housing standards. In short, much cooperation and cross-disciplinary collaboration is needed, but improvement is definitely possible.

The study team decided that in addition to the Delphi study and Market Analysis, another way to identify research opportunities would be to conduct a seminar with a knowledgeable group of housing professionals. That occurred at the annual meeting of the *Texas Society of Architects* in Galveston on October 23, 1999. Forty-seven participants filled out a questionnaire ranking and categorizing the technology issues from the Delphi study. The results can be found in Appendix B. The participants then reviewed the work of the team to date, and offered their concerns and opinions in a wide-ranging discussion.

The discussion at the T.S.A. Convention centered around the problems relating to the acquisition of land for low-cost housing development. Members shared first-hand accounts of community- and government-resistance to innovation and low-cost housing development in urban and border areas in Texas. The statement of emphasis by many T.S.A. members was that the technologies and knowledge are already developed, but cannot be implemented until Code Restrictions and social resistance (commonly called "NIMBYism" — "Not-In-My-Back-Yard-ism") give way and allow for low-cost housing development where the low-income jobs are located.

Two recent promising developments that address some of the concerns mentioned at the T.S.A. Convention are:

1. Texas House Bill 313, Chapter 378, the act creating *Neighborhood Empowerment Zones*, enacted by the Texas Legislature on April 1, 1999. This act allows for a municipality to create a zone in which building impact fees can be temporarily lifted, temporary sales-tax breaks can be instituted, or baseline building performance standards can be temporarily loosened to encourage alternative construction materials and methods which would result in higher durability, reduced energy costs, or improved maintenance — provided the measures would improve, not lower, housing standards.

2. The *International Standards Organization* is engaged in drafting the *"International Building Code,"* which is a performance-based building code intended to be appropriate for universal adoption — and would allow buildings to be evaluated based on their technological performance rather than a restrictive list of traditional materials and methods. This Code would encourage the use of innovative technologies, materials and methods that could allow the building industry to meet the needs of many low-income households.

These two positive developments are only two examples of the many discussed at the meeting. Other examples of progress can be found throughout Texas, and as reported by *T.S.A.* members, by the *Center for Housing and Urban Development at Texas A&M University*, and by the *Texas Department of Housing and Community Affairs* in its *"State of Texas Low-Income Housing Plan and Annual Report."* However, as the results from the Delphi study and the T.S.A. survey show, no one issue will solve the low-cost housing problem in Texas. True and lasting progress will depend on an atmosphere of change, flexibility and renewal from within the low-cost housing industry, cooperation from State and Federal Government and across the disparate fields related to low-cost housing, education of communities and low-income people to reduce the negative impacts of 'NIMBYism,' and continual research and renewal of building technologies that allow homes to be built faster and cheaper with improved durability.

Preface

The goal of this study is to gather consensus among professionals in the various fields of low-cost housing on what the most critical research needs are for improving low-cost housing technology in Texas

Objectives of the study are:

- to pinpoint the most critical issues related to affordable housing that influence improved building technologies,
- to examine the critical issues, identifying specific technological —

  -opportunities / needs for improvement

  -constraints on improvement

  -barriers to improvement,
- to establish a marketplace of ideas for gathering consensus among professionals and experts in the affordable-housing industry,
- to gather consensus on the importance of the proposed issues,
- to develop consensus on methods of capitalizing on opportunities / needs for improvement, overcoming constraints on improvement, and eliminating barriers to improvement, and
- to seek sources of funding and investment for improving building technologies which impact low-cost housing in Texas.

Methodology—the Delphi Process

The Delphi methodology seeks to develop consensus among a selected group of experts in a particular field on issues pertinent to that field through an iterative survey process. Consensus is developed through an iterative process of surveying experts (respondents)—and continually updating the survey to reflect the responses of the participating experts.

To establish the initial consensus topics, the investigators compiled a list of 47 technology issues, which was a first attempt at comprehensive coverage of low-cost housing technologies. The issues were separated into categories based on potential for improvement: opportunities / needs, constraints, barriers. A group of 55 recognized experts, from a variety of disciplines in the field of affordable housing, was chosen as the sample group (respondents). The list of respondents was focused in Texas, but there were individuals from a variety of locations throughout the United States.

A questionnaire was designed to allow experts to rate the importance of improvement on each issue using a 6-point scale (0 – 5), and the respondents completed the questionnaire by mail. Through modifying the questionnaire to reflect the data received from *Round 1*, the *Round 2* questionnaire was developed. The *Round 1* process was then repeated using the revised questionnaire. Through this process, the issues (opportunities / needs, barriers, constraints) were rank-ordered according to importance for improvement based on the *Round 2* responses. *Round 1* and *Round 2* results are shown in Appendix A.

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Part I. The Low-Cost Housing Technology Study

I.01. Goal

- to gather consensus among professionals in the various fields of low-cost housing on what the most critical research needs are for improving low-cost housing technology in Texas

I.02. Objectives

- to pinpoint the most critical issues related to affordable housing that influence improved building technologies
- to examine the critical issues, identifying specific technological—

  -Opportunities / needs for improvement

  -Constraints on improvement

  -Barriers to improvement
- to establish a marketplace of ideas for gathering consensus among professionals and experts in the affordable-housing industry
- to gather consensus on the importance of the proposed issues
- to develop consensus on methods of capitalizing on opportunities / needs for improvement, overcoming constraints on improvement, and eliminating barriers to improvement
- to seek sources of funding and investment for improving building technologies which impact low-cost housing in Texas

I.03. Methodology—the Delphi Process

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A questionnaire was designed to allow experts to rate the importance of improvement on each issue using a 6-point scale (0 – 5). The scale was a modified "Lickert" scale (i.e. 1-5 with labels) Respondents had the option of 'throwing out' an issue they deemed to be of no importance by

giving the issue a rating of '0'. Respondents also had the option of adding their own items to the list using the 'other issues' entry.

Through modifying the survey to reflect the data received from *Round 1*, the *Round 2* questionnaire was developed. The *Round 1* process was then repeated using the revised questionnaire. Through this process, the issues (opportunities / needs, barriers, constraints) were rank-ordered according to importance for improvement based on the *Round 2* responses.

I.04. Results

I.04.a. Delphi —Round 1

A total of 11 completed questionnaires were received from a sample size of 55 participants, yielding an initial response rate of 20%. The participants were professionals and scholars identified as experts from various cities throughout the United States in various fields pertaining to affordable housing. The participants' longevity in the housing industry ranged from 1 to 25 years, with an average of 14.5-years experience in the housing industry.

Table 1 shows the respondents' organizations of affiliation. The organizations were in a variety of disciplines related to affordable housing including Architecture firms, Building Contractors and Planning Firms, Building Code Committees, Engineering Firms, and a variety of other specific technical areas of focus such as Solar Energy and air-conditioning design.

Table 1 – Respondent's Organization of Affiliation

Associated Organization	
Air Conditioning Contractors of America	International Conference of Building Officials
American Institute of Architects	Insurance Institute for Property Loss Reduction
American Planners Association	International Solar energy Society
American Solar Energy Society	International Standards Organization (Building Subcommittee)
American Society of Safety Engineers	National Association of Home Builders
American Society of Heating, Refrigeration, and Air Conditioning Engineers	National Institute of Building Science
Building Officials and Code Administrators National	Fire Protection Association
Civil Engineering Research Foundation	Southern Building Code Congress International
Certified Safety Professional	Texas Association of Builders
IBSPA	Texas Society of Architects

Table 2 shows the positions held by the respondents. Respondents held a variety of positions including management, planning, research, coordinating, and architecture positions.

Table 2 – Respondents' Job Titles

Position	
Construction Coordinator	Managing Partner
Director of Building and Thermal Systems Center	Planner
Director of Research	President/CEO
Economist	Principal Architect
Executive Director	Underwriting Manager
Executive Vice President	

9 out of the 11 organizations represented maintain a library in housing technology. 10 out of the 11 organizations use the World Wide Web. 5 out of the 11 organizations use other electronic databases (i.e., Lexus/Nexus, Wilson Abstracts).

The respondents identified the following items as the most significant innovations made in housing technology in the past ten years?

- Windows/Glazing
- High SEER HVAC
- Development of Building Energy Simulation Tools
- Development of Low-E Glazing
- The interaction of the BCE's program to grade building code departments on a community basis, that will in turn be reflected in insurance rates
- Better insulation
- Structural Insulated Panels for wall and roof construction
- That energy efficiency can be cost-effective in low-income housing and is a solution to housing affordability (being able to pay house expense after move-in)
- Very little. Not doing the known things properly is a huge problem: installation and construction errors.
- Energy Conservation Strategies

The respondents identified the following 'other topics' in low-cost housing they felt were important areas for discussion/research.

- How to ensure quality construction and installation as well as designs that apply what we already know. Why do the same mistakes happen over and over again?
- Health issues (lead, asbestos, sanitation)
- System Engineered Design to include passive solar and rainwater collection. There is no point getting low-income families into buildings where they can't afford the utility bill.
- Role of Engineering/Design/Specifiers
- Hail-Resistant Roof Covers
- Wind-borne debris-resistant doors and windows that are cost efficient
- High-Wind Resistant Roof Covers
- Natural Hazard Resistant Homes (Seismic, Wildfire, High Wind)
- Energy and Resource Efficiency

The respondents gave the following opinions about the questionnaire:

- "Don't forget utility costs for these people and resource efficiency for the planet. Adobe, rammed earth or straw fail in the hot dry areas; improved use recycled building materials everywhere."

The respondents offered the following 'other comments or suggestions':

- "Houston Habitat for Humanity has built a philosophy addressing energy efficiency and environmental concerns. It has been developed around the unique characteristics of our utilization of volunteer resources for some of the construction components, self-imposed cost constraints, in order assure our continuing to serve those at or below 50% of median for our city, and low maintenance costs to maximize the ability of our homeowners to maintain the quality, appearance and efficiencies of the homes they have purchased over the life of their mortgage (typically 20 years)."

  "The framework provides us an easy assessment of the viability of various opportunities with which we are presented to improve the efficiencies if our homes. We currently build our homes 30% beyond the required by the CABO model. We accomplished this with simplicity of design, utilization of easily available and inexpensive materials and most importantly education."

  "I am convinced that is it through education that new technologies, which provide for greater efficiencies will become less costly. This will become true because the customers who buy houses will begin to demand these products at a more reasonable price. Convincing low-income housing builders to construct energy efficient and environmentally safe houses will call for the best business practice available. We demand a simple payback to our homeowners in 8 years for any upgrade that be considered. Low-income homeowners will not care about fancy gadgets or the minutiae of energy related issues being highlighted in their homes if it cost so much to build it that their monthly payments offset any energy savings that might be recognized. This means for them simply less money for food and clothes for the family."

  "When it's all said and done two groups will have to be convinced that what you want to do is worth doing: the builders who build houses and the buyers who must believe that it will save them real money."

Figure 1 and *Figure 2* show the respondents' rank ordering of opportunities/needs for the development and implementation of improved building technologies.

Opportunity/Need	0	1	2	3	4	5	Total
Very Important, Rating: 45 - 55, Frequency: 0							
Important, Rating: 34 - 44, Frequency: 5							
Waterproofing, Moisture Control	0	0	0	2	3	5	43
Heating Systems	0	2	0	1	2	5	38
Structural Frame	0	1	0	3	3	3	37
Enclosure Systems	1	1	0	3	3	3	37
Cool Systems	0	1	0	1	3	4	36
Moderately Important, Rating: 23 - 33, Frequency: 9							
Electrical Systems	0	2	0	4	2	2	32
Appliances	0	1	1	3	2	2	30
Insulation	1	0	3	3	1	2	29
Plumbing	1	1	0	6	1	1	28
Foundation	0	2	1	3	1	2	27
Roofing	0	1	0	3	3	1	27
Interior Partitions	0	2	0	3	0	3	26
Paint & Coating	0	1	2	3	0	2	24
Interior Finish	0	3	1	3	1	1	23
Of Little Importance, Rating: 12 - 22, Frequency: 2							
Fireproofing	0	0	4	3	1	0	21
Sitework	0	1	2	2	1	1	20
Not Important, Rating: 0 - 11, Frequency: 6							
Other: Wholistic "System Design"	0	0	0	0	0	1	5
Energy Efficiency	0	0	0	0	0	1	5
Resource Efficiency	0	0	0	0	0	1	5
Energy Simulation tools	0	0	0	0	0	1	5
Natural Hazard Resistance	0	0	0	0	0	1	5
Education & Training of Builders	0	0	0	0	0	1	5

Figure 1– Delphi I: Ranking of Opportunities / Needs for Improvement in Low-Cost Housing Technology

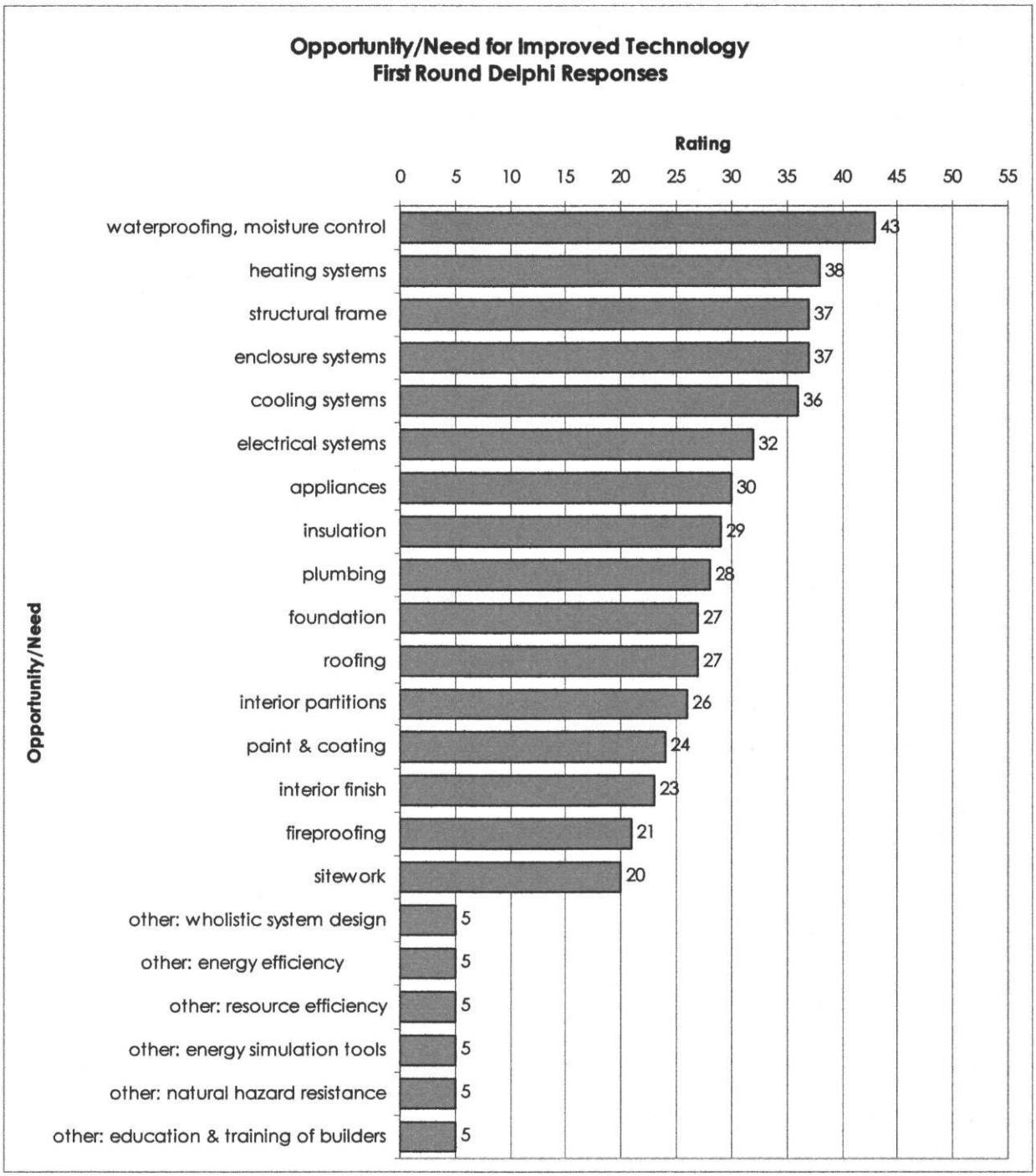

Figure 2 – Delphi I: Ranking of Opportunities / Needs for Improvement in Low-Cost Housing Technology

The ratings are weighted totals based on the frequency of responses ranging from *'least important'* = 0, to *'most important'* = 5. There were 11 respondents, yielding a total possible rating of 55 if everyone rated an issue as *'most important'*. The frequency of responses in each importance range was as follows:

Table 3 – Delphi I: Frequency of 'Opportunity' Importance Ratings

Very important	45 - 55	0
important	34 - 44	5
Moderately important	23 - 33	9
Of little importance	12 - 22	2
Not important	0 - 11	6

Of the building technologies displayed in *Figures 1* and *2*, the respondents identified *"Waterproofing/Moisture Control," "Heating Systems," "Structural Frame," "Enclosure Systems"* and *"Cool Systems"* as important opportunities/needs for improvement.

"Electrical Systems," "Appliances," "Insulation," "Plumbing," "Foundation," "Roofing" and *"Interior Finish"* were all considered areas of moderate importance for improvement.

"Fireproofing" and *"Sitework"* were considered of little importance for improvement.

The other areas – *"Holistic System Design," "Energy Efficiency," "Resource Efficiency," "Energy Simulation tools," "Natural Hazard Resistance" and "Education & Training of Builders"* – were write-ins by individuals who felt these were additional opportunities for improvement not included in the original list of building technologies on the survey.

Figure 3 and *Figure 4* show the respondents' rank ordering of constraints to the development and implementation of improved building technologies.

Constraint	0	1	2	3	4	5	Total
Very Important, Rating: 45 - 55, Frequency: 1							
Communication link between researchers and end users.	0	0	1	1	5	4	45
Important, Rating: 34 - 44, Frequency: 5							
Fragmentation of the building industry.	1	0	0	3	2	5	42
Awareness of the importance of new technologies.	0	0	1	4	4	2	40
Research funds from private and/or public sectors.	1	0	0	5	2	3	38
Definition and coordination of research needs across the industry.	1	2		3	3	3	38
Incentives to undertake research.	0	2	1	4	1	3	35
Moderately Important, Rating: 23 - 33, Frequency: 2							
Management support within organizations and firms for research.	1	0	3	3	2	2	33
Human resources and facilities to carry out research.	1	3	2	3	0	2	26
Of Little Importance, Rating: 12 - 22, Frequency: 0							
Not Important, Rating: 0 - 11, Frequency: 2							
Other: Market Driven Education	0	0	0	0	0	1	5
NAHB	0	0	0	0	0	1	5

Figure 3 – Delphi I: Ranking of Constraints to Improved Low-Cost Housing Technology

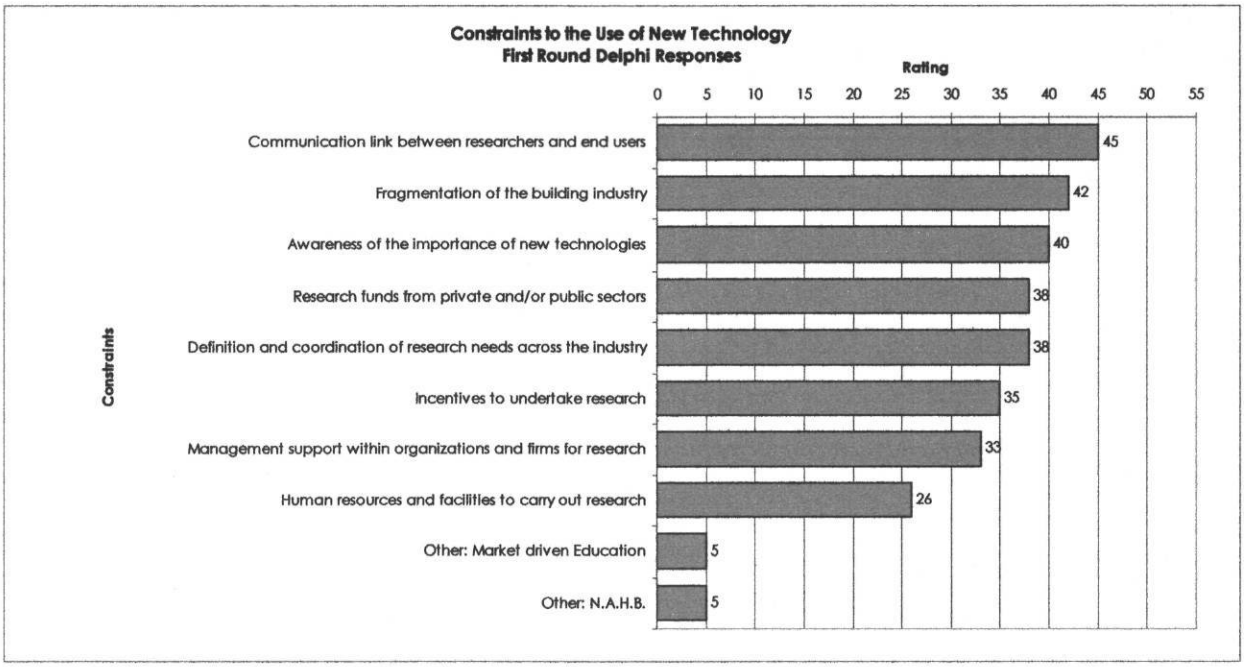

Figure 4 – Delphi I: Ranking of Constraints to Improved Low-Cost Housing Technology

The frequency of responses in each importance range was as follows:

Table 4 – Delphi I: Frequency of 'Constraints' Importance Ratings

Very important	45 - 55	1
important	34 - 44	5
Moderately important	23 - 33	2
Of little importance	12 - 22	0
Not important	0 - 11	2

Of the building technology areas displayed in *Figures 3* and *4*, the respondents identified *"Communication link between researchers and end users"* as very important constraints to be dealt with in improving building technologies.

"Fragmentation of the building industry," "Awareness of the importance of new technologies," "Research funds from private and/or public sectors," "Definition and coordination of research needs across the industry" and *"Incentives to undertake research"* were considered important constraints to be dealt with.

"Management support within organizations and firms for research" and *"Human resources and facilities to carry out research"* were considered areas of moderate constraints for improvement. There were no topic areas that were considered of little constraint to improvement.

The other areas – *"Market Driven Education"* and *"NAHB"* – were write-ins by a single individual who felt these were additional constraints to improvement that were not included in the original list of building technologies on the survey.

Figure 5 and *Figure 6* show the respondents' rank ordering of barriers to the development and implementation of improved building technologies.

Barrier	0	1	2	3	4	5	Total
Very Important, Rating: 45 - 55, Frequency: 1							
Expense of new technology	0	0	0	1	3	6	45
Important, Rating: 34 - 44, Frequency: 4							
Awareness of new technology	0	0	0	4	3	4	44
Standards and building codes	0	0	1	3	4	2	37
Uncertainty (i.e., lack of information)	0	0	0	2	4	3	37
Lending practices	0	0	2	0	3	4	36
Moderately Important, Rating: 23 - 33, Frequency: 3							
Appropriateness of new technology	2	0	0	3	4	1	30
Liability and legal implications	0	2	2	3	1	2	29
Professional self interest (losing control, work, pay or benefits)	2	0	2	3	2	1	26
Of Little Importance, Rating: 12 - 22, Frequency: 2							
Existing building contract agreements	1	3	0	5	0	0	18
Existing labor agreements	1	2	2	4	0	0	18
Not Important, Rating: 0 - 11, Frequency: 7							
Other: NAHB	0	0	0	0	0	1	5
Market Awareness / Education	0	0	0	0	0	1	5
Inertia	0	0	0	0	0	1	5
Lack of Information	0	0	0	0	0	1	5
Education to Users	0	0	0	0	0	1	5
Insurance Industry Acknowledgement	0	0	0	0	1	0	4
Deed Restrictions	0	0	0	0	1	0	4

Figure 5 – Delphi I: Rankings of Barriers to Improved Low-Cost Housing Technology

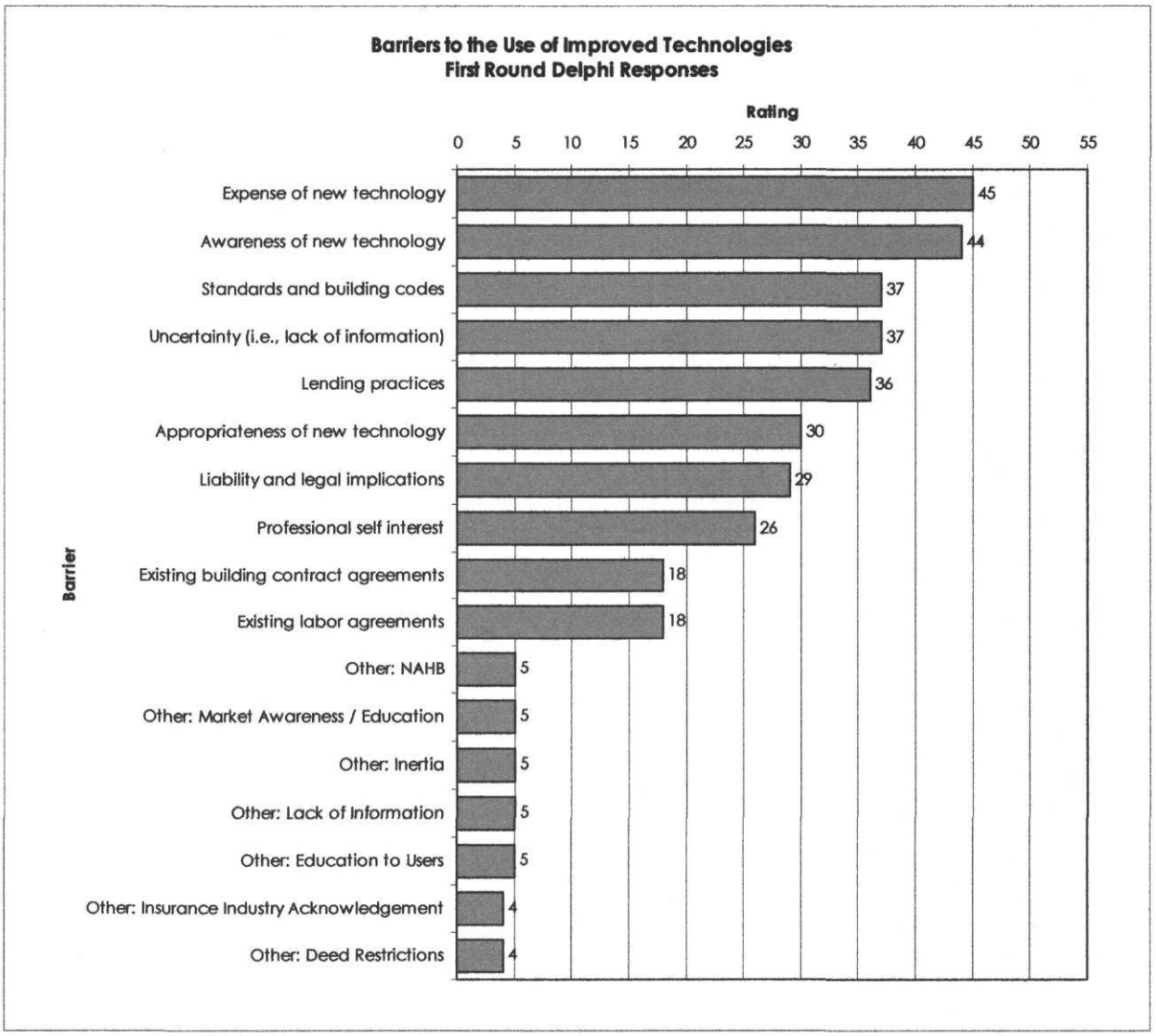

Figure 6– Delphi I: Rankings of Barriers to Improved Low-Cost Housing Technology

The frequency of responses in each importance range was as follows:

Table 5 – Delphi I: Frequency of 'Barriers' Importance Ratings

Very important	45 - 55	1
important	34 - 44	4
Moderately important	23 - 33	3
Of little importance	12 - 22	2
Not important	0 - 11	7

Of the building technology areas displayed in *Figures 5* and 6, the respondents identified *"Expense of new technology"* as a very critical barrier to the improvement of building technologies.

"Awareness of new technology," "Standards and building codes," "Uncertainty (i.e., lack of information)" and *"Lending practices"* were considered important barriers to improvement which need to be overcome.

"Appropriateness of new technology," "Liability and legal implications" and *"Professional self interest (losing control, work, pay or benefits)"* were considered moderate barriers to improvement.

"Existing building contract agreements" and *"Existing labor agreements"* were considered barriers of little import for the improvement of building technologies.

The other areas – *"NAHB," "Market Awareness / Education," "Inertia," "Lack of Information," "Education to Users," "Insurance Industry Acknowledgement"* and *"Deed Restrictions"* – were write-ins by a single individual who felt these were additional barriers to improvement not included in the original list of building technologies on the survey.

I.04.b. Summary of Round 1

Of the technology issues evaluated in Round 1, respondents showed consensus on the following two issues, which received Very Important Ratings:

- Constraint: Communication between researchers and end users [rating – 45/55]

  This suggests that respondents agreed that there is existing data available on low-cost housing that needs to be gathered and researched to improve housing programs.

- Barrier: Expense of New Technology [rating – 45/55]

  This suggests that respondents agreed that new technologies already exist and they need to be marketed for low-cost housing programs.

The Round-1 data shows the following importance rankings categorized by technology area, *Figures 7 - 9*:

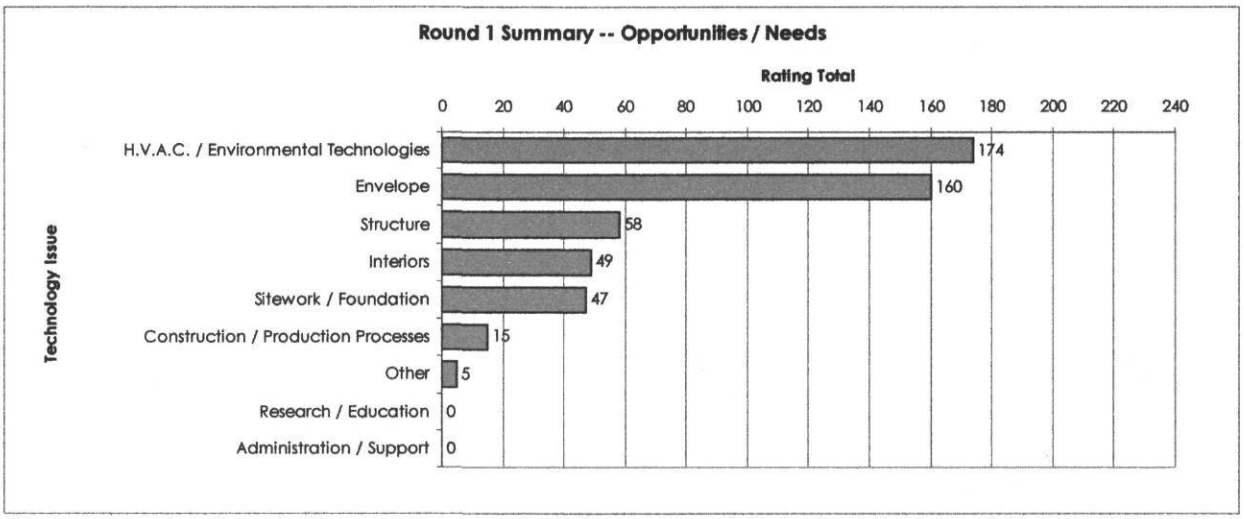

Figure 7 – Delphi I Ranking of Technology Categories, Opportunities / Needs

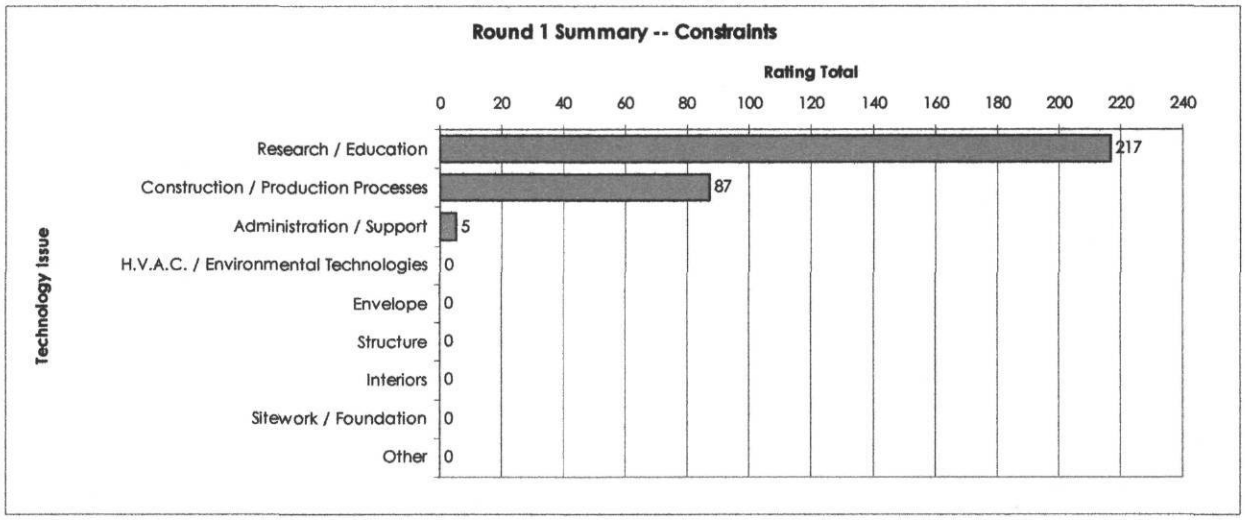

Figure 8– Delphi I Ranking of Technology Categories, Constraints

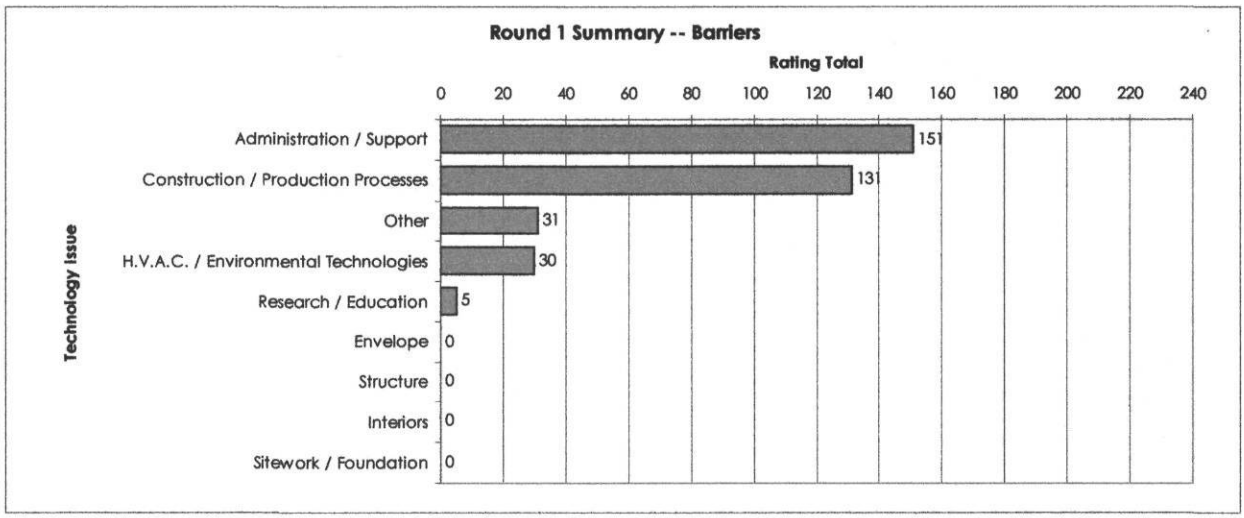

Figure 9– Delphi I Ranking of Technology Categories, Barriers

The technologies showing the most opportunity / need for improvement according to the Round-1 data were: *"H.V.A.C. / Environmental Technologies"* and *"Building Envelope."* Secondary opportunities / needs for improvement were: *"Structure,"* *"Interiors,"* and *"Sitework / Foundation."*

The primary constraints to improvement in the field of low-income housing were the current state of *"Research / Education,"* and secondary constraints were the current state of *"Construction / Production Processes"*.

Primary barriers to improvement in the low-income housing industry were the *"Administrative / Support"* systems for the industry (e.g. Code restrictions, funding) and *"Construction / Production Processes."*

I.04.c. Delphi —Round 2

A total of 19 completed questionnaires were received from a sample size of 55 participants, yielding a response rate of 35 percent. The participants were professionals and scholars identified as experts from various cities throughout the United States in various fields pertaining to affordable housing. The participants' longevity in the housing industry ranged from 4 to 27 years, with an average of 19-years experience in the housing industry.

Table 6 shows the respondents' organizations of affiliation. The firms were in a variety of disciplines related to affordable housing and the construction industry including Architecture firms, Building Contractors and Planning Firms, Building Code Committees, Engineering Firms, Government Agencies and a variety of other specific technical areas of focus.

Table 6 —Respondents' Organizations of Affiliation

Associated Organization	
Air Conditioning Contractors of America	International Standards Organization (Building Subcommittee)
Alliance for Public Technology	National Association of Home Builders
American Institute of Architects	National Institute of Building Science
American Institute of Building Design	National Fire Protection Association
American Society for Testing and Materials	National Low-income Housing Coalition
American Society of Heating, Refrigeration and Air Conditioning Engineers	Texas Association of Builders
Building Officials and Code Administrators	Texas Dept. of Housing and Community Affairs
Insurance Institute for Property Loss Reduction	Used Building Materials Association
International Energy Agency	

Table 7 shows the positions held by the respondents. Respondents held a variety of positions within the above organizations in management, research, construction and architecture.

Table 7 —Respondents' Job Titles

Position	
Associates Executive	President (4)
Codes Analyst	Principal Research Scientist
Director (3)	Program Director
Executive Director	Project Manager
Field Manager	Research Architect
For Profit Builder	Vice President
Owner	Vice President Designer

12 out of the 19 organizations represented maintain a library in housing technology. 18 of the organizations use the World Wide Web. Seven out of the organizations use other electronic databases (i.e., Lexus/Nexus, Wilson Abstracts).

The respondents identified the following items as the most significant innovations made in housing technology in the past ten years:

- Understanding of importance of thermal distribution systems to energy performance
- Reflective roofing systems
- Recycling material for construction
- Improved air tightness in duct systems, building shell (the technology – not the application of same by builders/contractors)
- Energy related products
- Better insulation and energy efficiency
- Geothermal heat pumps
- Simulation software
- Performance codes
- Composite materials which are weather and termite proof
- Recycling of materials
- Energy efficient windows
- Steel framing housing
- Better availability of interim and permanent financing
- Panelized and pre-built construction
- Energy efficient heating and cooling
- Insulation products
- Rammed earth, compressed soil block, steel roofing systems, air-take insulation
- Engineered wood
- Smart houses, energy efficiency and appliance
- Engineered lumber (I joist, LUL beam, studs, OSB, etc.)
- Use of PVC materials in all phases of construction
- Recognition of natural hazards

The respondents identified the following 'other topics' in low-cost housing they felt were important areas for discussion/research:

- Impact of reflective roofing systems in cooling loads
- Lot cost – Development Cost, Government restraints (EPA, OSHA, codes, tariffs, impact fees, etc.)
- How much has the government driven up the cost of housing in the last 50 years?
- Infrastructure for land development
- Development cost in relation to structure costs
- What issues (financing, first cost, zoning) favor mobile homes as entry-level option vs. affordable site-built/ "permanent" structures?

- Catastrophe resistant construction
- "Modular" components (kitchen/bath)
- Energy efficient measures that are low cost/low tech
- Alternative housing design such as clustered, co-housing, etc.
- Longevity of housing built today; houses need to outlast the mortgages. Solar water heating – solar electric generation and rain water collection desperately need to be incorporated into these homes
- Relationship between life cycle cost to total cost (i.e. first cost and life cycle cost)
- Impact of regulatory matters and policy on housing cost (i.e. lumber, municipal ordinances and local amendments to building codes)
- Impact of local government on cost and availability (i.e. impact fees, exclusionary zoning , building codes)
- Earthquakes and hurricane resistant construction must be addressed or be up front and classify low-cost housing as disposable

The respondents gave the following opinions about the questionnaire:

- Thermal mass in homes is one of the most important factors not being considered in building today. U-value instead of R-value has to be considered.

The respondents offered the following 'other comments or suggestions':

- In reading the results from the first round results under the heading "Opinions About Questionnaire" there is a comment that "Adobe Rammed earth and straw fail in hot dry areas." Total False. I feel the need for long lasting indigenous building materials is greatly needed. When incorporating adobe, rammed earth, steel framing, i.e. trusses, metal roof, a superior long lasting home is the result. Rammed earth and adobe homes when "properly" constructed will last for centuries with very little maintenance needed. Energy savings, maintenance savings, insurance savings will allow the homeowner to pay on the mortgage what they would normally spend on heating/cooling, fuel bills, and insurance. on a 30-year mortgage the savings would be dramatic.

Figure 10 and *Figure 11* show the respondents' rank ordering of opportunities / needs for the development and implementation of improved building technologies.

Opportunity/Need	0	1	2	3	4	5	Total
Very Important, Rating: 77 - 95. Frequency: 0							
Important, Rating: 58 - 76. Frequency: 4							
Sitework	0	1	1	4	6	6	69
Foundation	1	1	2	4	6	4	61
Structural Frame	0	2	2	5	5	4	61
Enclosure Systems	1	1	4	3	5	4	58
Moderately Important, Rating: 39 - 57. Frequency: 9							
Interior Finish	0	2	3	5	2	5	56
Interior Partitions	1	1	4	5	5	2	54
Roofing	1	2	5	4	1	5	53
Waterproofing, Moisture Control	1	3	2	7	3	2	50
Plumbing	2	2	2	5	7	0	49
Insulation	1	2	4	4	5	1	47
Paint & Coating	3	0	4	6	5	0	46
Fireproofing	3	2	4	3	4	2	45
Cool Systems	3	2	7	3	1	2	39
Of Little Importance, Rating: 20 - 38. Frequency: 3							
Heating Systems	2	6	5	1	2	2	37
Electrical Systems	3	5	3	4	2	1	36
Appliances	6	4	3	2	2	0	24
Not Important, Rating: 0 19. Frequency: 5							
Other: Design	0	0	0	0	0	1	5
Simulation Software	0	0	0	0	0	1	5
Subdivision Standards	0	0	0	0	0	1	5
Hurricane Resistance	0	0	0	0	0	1	5
Thermal Distribution	0	0	0	0	0	1	5

Figure 10 – Delphi II: Ranking of Opportunities / Needs for Improvement in Low-Cost Housing Technology

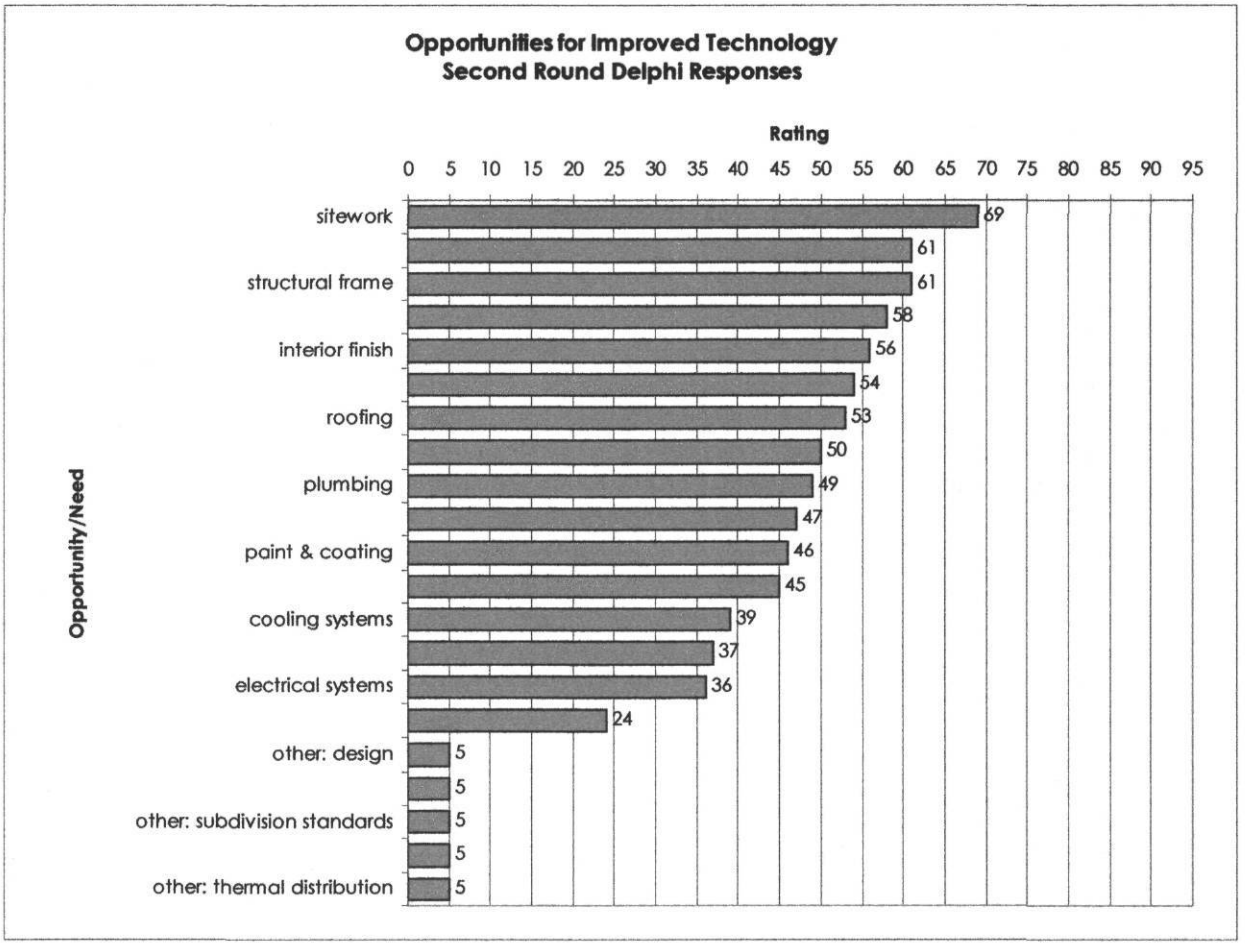

Figure 11 – Delphi II: Ranking of Opportunities / Needs for Improvement in Low-Cost Housing Technology

The ratings are weighted totals based on the frequency of responses ranging from *"least important"* = 0, to *"most important"* = 5. There were 19 respondents, yielding a total possible rating of 95. The frequency of responses in each importance range was as follows:

Table 8– Delphi II: Frequency of 'Opportunity' Importance Ratings

Very important	77 - 95	0
important	58 – 76	4
Moderately important	39 – 57	9
Of little importance	20 – 38	3
Not important	0 – 1	5

Of the building technology areas displayed in *Figures 10* and *10*, the respondents identified *"Sitework," "Foundation," "Structural Frame"* and *"Enclosure Systems"* as important opportunities / needs for improvement.

"Interior Finish," "Interior Partitions," "Roofing," "Waterproofing & Moisture Control," "Plumbing," "Insulation," "Paint & Coating," "Fireproofing" and *"Cool Systems"* were all considered areas of moderate importance for improvement.

"Heating Systems," "Electrical Systems" and *"Appliances"* were considered of little importance for improvement.

The other areas – *"Design," "Simulation Software," "Subdivision Standards," "Hurricane Resistance"* and *"Thermal Distribution"* – were write-ins by a single individual who felt these were additional opportunities for improvement not included in the original list of building technologies on the survey.

Figure 12 and *Figure 13* show the respondents' revised rank ordering of constraints to the development and implementation of improved building technologies.

Constraints	0	1	2	3	4	5	Total
Very Important, Rating: 77 - 95. Frequency: 0							
Important, Rating: 58 - 76. Frequency: 5							
Incentives to undertake research.	0	1	2	4	9	3	68
Fragmentation of the building industry.	0	1	2	2	8	5	68
Communication link between researchers and end users.	1	2	2	4	4	6	64
Definition and coordination of research needs across the industry.	0	1	5	5	4	4	62
Research funds from private and/or public sectors.	1	1	3	6	4	4	61
Moderately Important, Rating: 39 - 57. Frequency: 2							
Awareness of the importance of new technologies.	1	1	4	8	3	2	55
Management support within organizations and firms for research.	2	2	6	3	3	3	50
Of Little Importance, Rating: 20 - 38. Frequency: 1							
Human resources and facilities to carry out research.	4	3	7	3	1	1	35
Not Important, Rating: 0 19. Frequency: 2							
Politics and greed	0	0	0	0	0	1	5
Other: Lack of skilled workers	0	0	0	0	1	0	4

Figure 12 – Delphi II: Ranking of Constraints for Improvement in Low-Cost Housing Technology

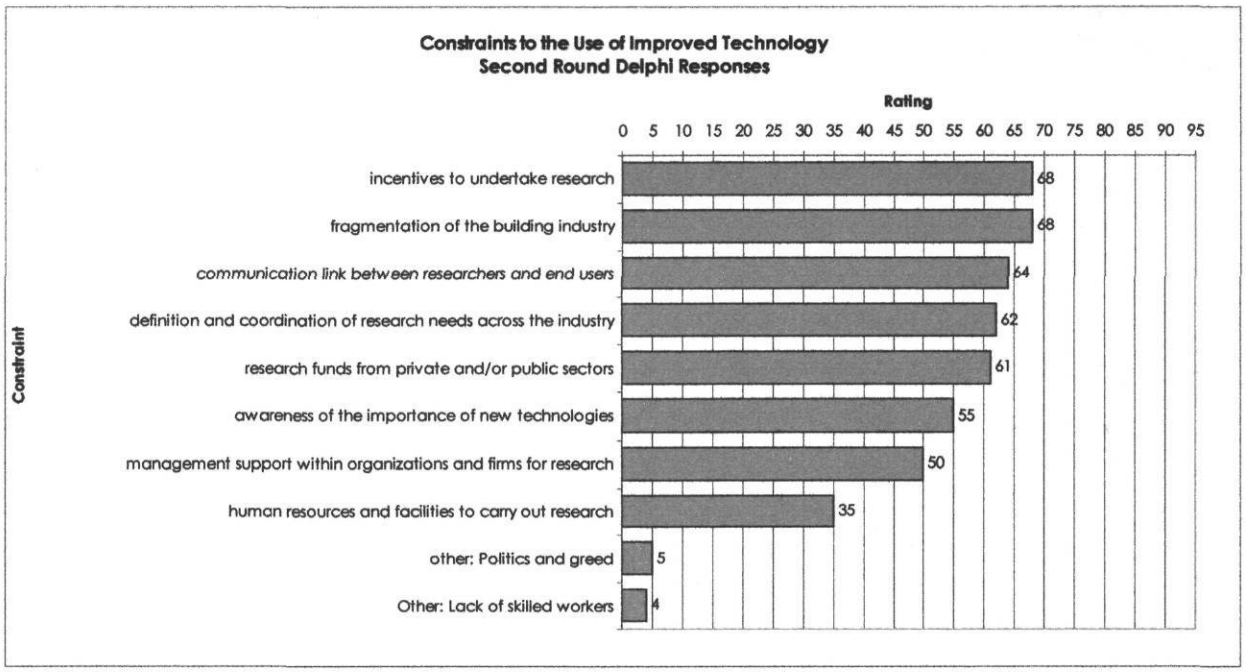

Figure 13 – Delphi II: Ranking of Constraints for Improvement in Low-Cost Housing Technology

The frequency of responses in each importance range was as follows:

Table 9– Delphi II: Frequency of 'Constraint' Importance Ratings

Very important	77 - 95	0
important	58 - 76	5
Moderately important	39 - 57	2
Of little importance	20 - 38	1
Not important	0 -19	2

Of the building technology areas displayed in *Figures 12* and *13*, the respondents identified *"Incentives to undertake research," "Fragmentation of the building industry," "Communication link between researchers and end users," "Definition and coordination of research needs across the industry" and "Research funds from private and/or public sectors"* as important constraints to be dealt with in improving building technologies.

"Awareness of the importance of new technologies" and "Management support within organizations and firms for research" were considered areas of moderate constraints for improvement.

"Human resources" and "facilities to carry out research" were considered of little constraint to improvement.

"Politics and greed" was considered of little or no import as a constraint to improving technology, and *"Lack of skilled workers"* was a write-ins by an individual who felt it was an additional constraint to improvement that was not included in the original list of building technologies on the survey.

Figure 14 and *Figure 15* show the respondents' rank ordering of barriers to the development and implementation of improved building technologies.

Barrier	0	1	2	3	4	5	Total
Very Important, Rating: 77 - 95. Frequency: 0							
Important, Rating: 58 - 76. Frequency: 5							
Expense of new technology	0	1	2	4	5	6	67
Uncertainty (i.e., lack of information)	0	0	1	5	6	5	66
Standards and building codes	2	1	1	3	2	9	65
Awareness of new technology	0	1	4	2	5	6	65
Liability and legal implications	0	3	1	5	3	6	62
Moderately Important, Rating: 39 - 57. Frequency: 5							
Lending practices	0	2	5	3	4	4	57
Existing labor agreements	1	5	5	1	4	2	44
Professional self interest (losing control, work, pay or benefits)	2	4	3	3	2	3	42
Appropriateness of new technology	1	3	7	5	2	0	40
Existing building contract agreements	3	3	3	4	2	2	39
Of Little Importance, Rating: 20 - 38. Frequency: 0							
Not Important, Rating: 0 19. Frequency: 2							
Other: Insurance Costs	0	0	0	0	0	1	5
Politics	0	0	0	0	0	1	5

Figure 14 – Delphi II: Ranking of Barriers to Improvement in Low-Cost Housing Technology

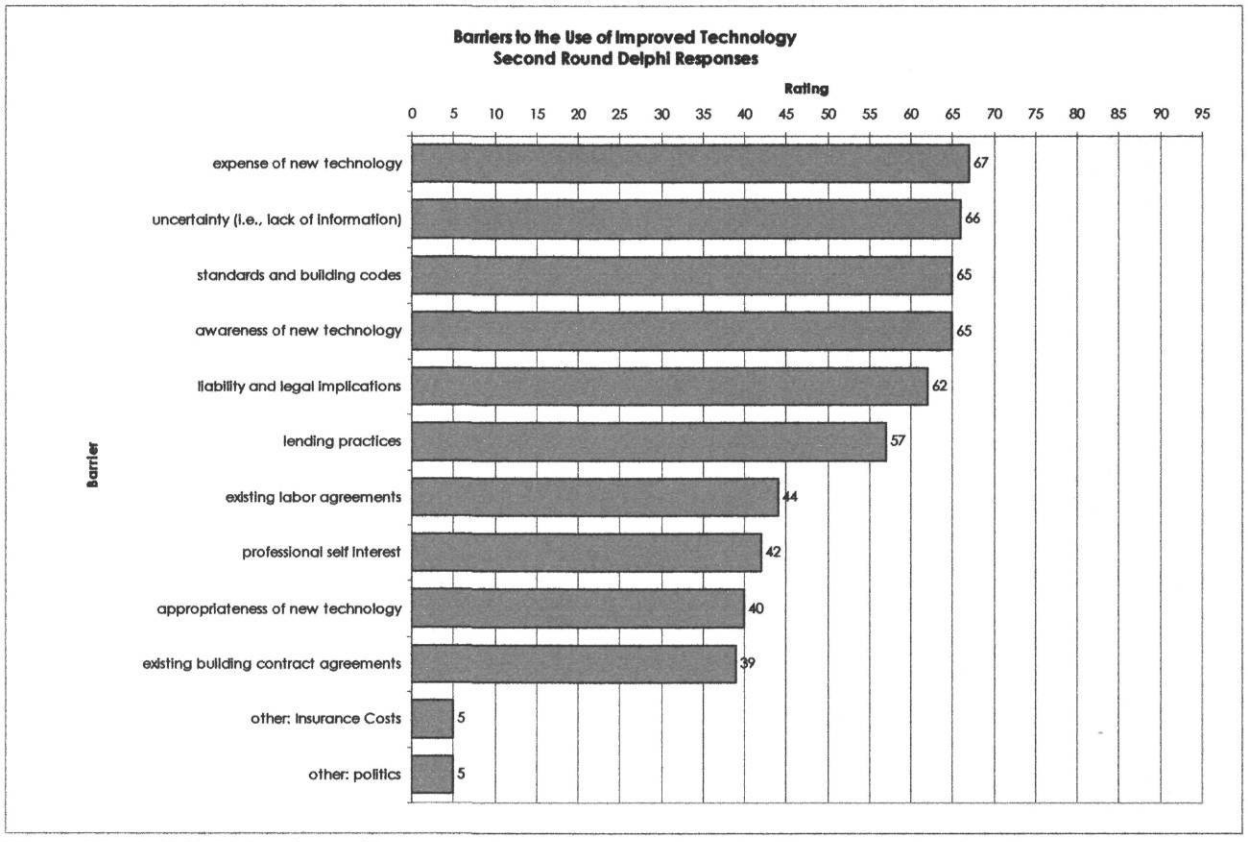

Figure 15 – Delphi II: Ranking of Barriers to Improvement in Low-Cost Housing Technology

The frequency of responses in each importance range was as follows:

Table 10– Delphi II: Frequency of 'Barrier' Importance Ratings

Very important	77 - 95	0
important	58 - 76	5
Moderately important	39 - 57	5
Of little importance	20 - 38	0
Not important	0 -19	2

Of the building technology areas displayed in *Figures 14* and *15*, the respondents identified *"Expense of new technology," "Uncertainty (i.e., lack of information)," "Standards and building codes," "Awareness of new technology"* and *"Liability and legal implications"* as important barriers to improvement which need to be overcome.

"Lending practices," "Existing labor agreements," "Professional self interest (losing control, work, pay or benefits)," "Appropriateness of new technology" and *"Existing building contract agreements"* were considered moderate barriers to improvement.

There were no topic areas that were considered barriers of little import for the improvement of building technologies.

The other areas – *"Insurance Costs"* and *"Politics"* – were write-ins by a individuals who felt these were additional barriers to improvement not included in the original list of building technologies on the survey.

I.04.d. Summary of Round 2

Of the technology issues evaluated in Round 2, there were no issues that received a rating of 'very-important.' However, many low-cost housing issues were considered important or moderately important issues to be dealt with in improving low-cost housing technology.

13 issues were considered 'important' or 'moderately important' opportunities / needs for improvement: *"Sitework," "Foundation," "Structural Frame"* and *"Enclosure Systems," "Interior Finish," "Interior Partitions," "Roofing," "Waterproofing & Moisture Control," "Plumbing," "Insulation," "Paint & Coating," "Fireproofing"* and *"Cool Systems."*

7 issues were considered 'important' or 'moderately important' constraints to improvement: *"Incentives to undertake research," "Fragmentation of the building industry," "Communication link between researchers and end users," "Definition and coordination of research needs across the industry," "Research funds from private and/or public sectors," "Awareness of the importance of new technologies" and "Management support within organizations and firms for research."*

10 issues were considered 'important' or 'moderately important' barriers to improvement: *"Expense of new technology," "Uncertainty (i.e., lack of information)," "Standards and building codes," "Awareness of new technology," "Liability and legal implications," "Lending practices," "Existing labor agreements," "Professional self interest (losing control, work, pay or benefits)," "Appropriateness of new technology"* and *"Existing building contract agreements."*

The *Round 2* data shows the following importance rankings of housing issues, *Figures 16 –18*:

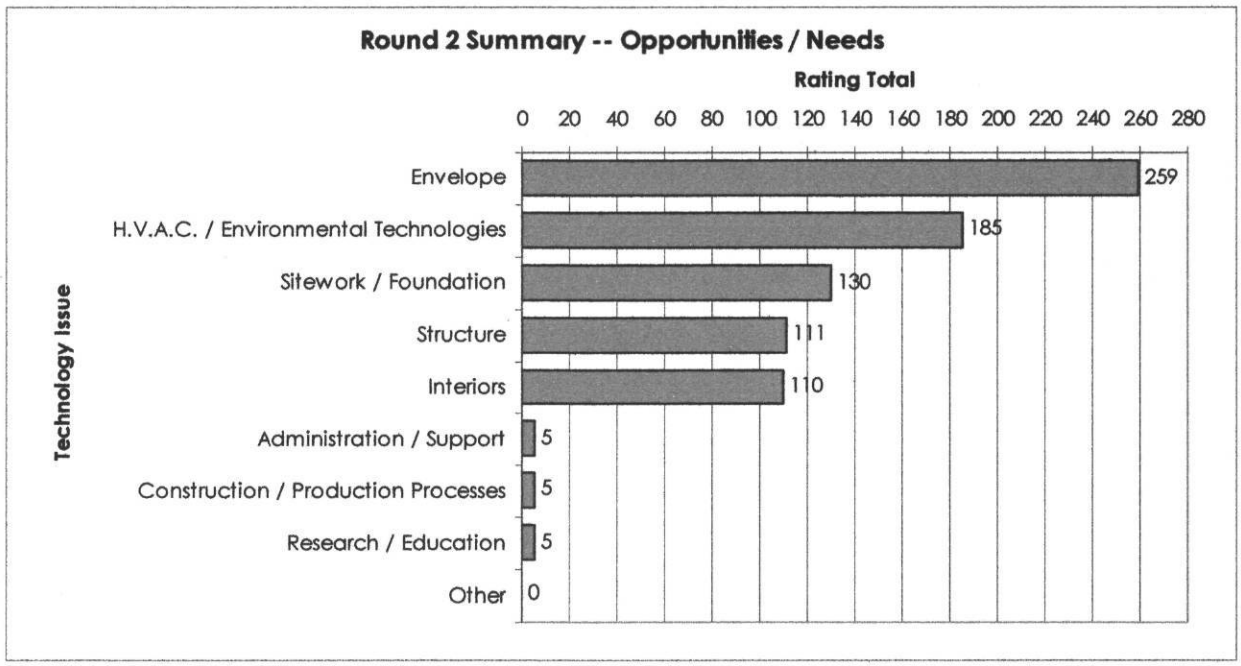

Figure 16 —Delphi II Ranking of Technology Categories, Opportunities / Needs

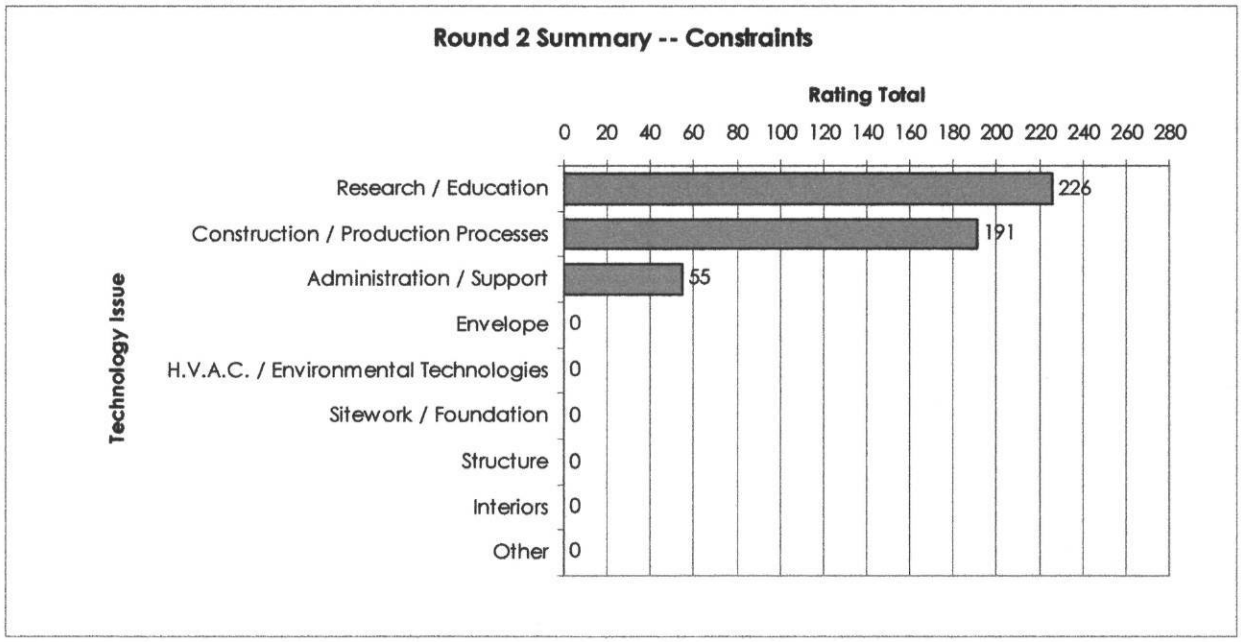

Figure 17 —Delphi II Ranking of Technology Categories, Constraints

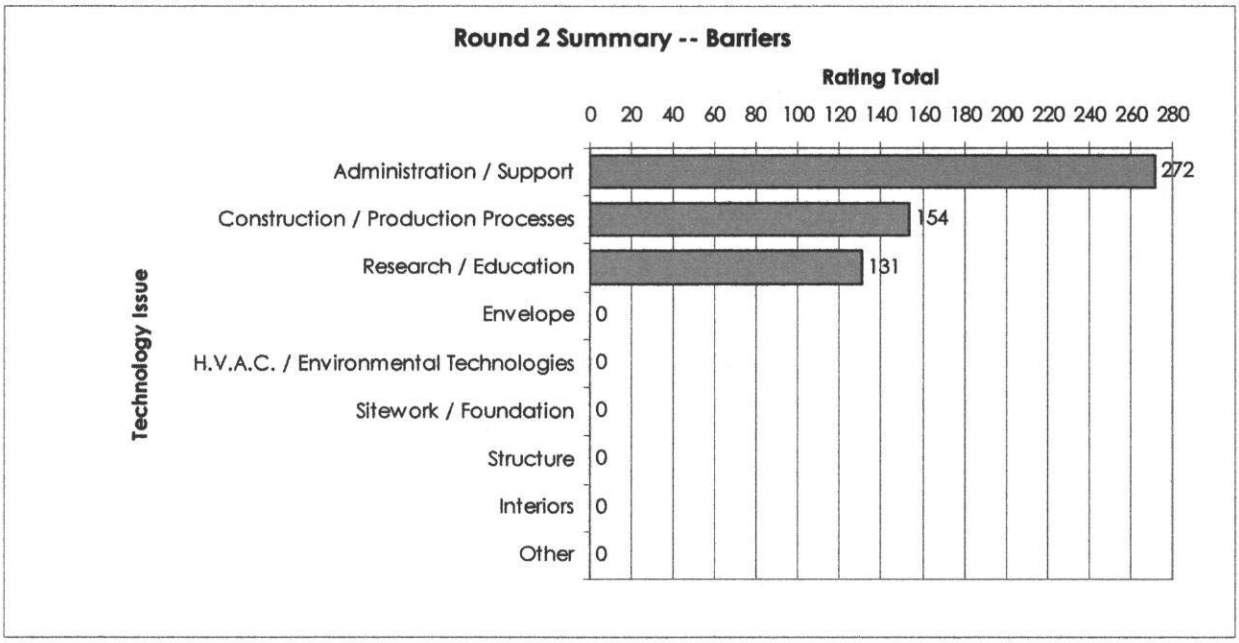

Figure 18 — Delphi II Ranking of Technology Categories, Barriers

I.04.e. Round 2 Item Analysis

I.04.e.i. Opportunities / Needs

The following item-analysis identifies the change between the Round 1 and Round 2 rankings. The 'increased rankings' list shows the 8 items that moved up in the importance rankings from Round 1 to Round 2, while the 'decreased rankings' list shows the 7 items that moved down. The 'Static rankings' list indicates the 19 items that remained at the same level of importance in both Rounds.

- Increased Rankings:

"Sitework" had a Round 1 rating of 20/55 (36%), the lowest-ranked area from the questionnaire. In Round 2 it moved up 15 in the list to become the highest-ranked area with a rating of 69/95 (73%).

"Interior finish" was ranked 14th in Round 1 with a score of 23/55 (42%), and moved up 9 in the Round 2 ranking to become 2nd, with a rating of 56/95 (59%).

"Foundation" was ranked 10th in Round 1 with a score of 27/55 (49%), and moved up 8 in the Round 2 ranking to become 2nd, with a rating of 61/95 (64%).

"Interior partitions" was ranked 11th in Round 1 with a score of 26/55 (47%), and moved up 6 in the Round 2 ranking to become 6th, with a rating of 54/95 (57%).

"Roofing" was ranked 11th in Round 1 with a score of 27/55 (49%), and moved up 4 in the Round 2 ranking to become 7th, with a rating of 53/95 (56%).

"Fireproofing" was ranked 15th in Round 1 with a score of 21/55 (38%), and moved up 3 in the Round 2 ranking to become 12th, with a rating of 45/95 (47%).

- Static Rankings:

"Paint & coating" was ranked 13th in Round 1 with a score of 24/55 (44%), and moved up 2 in the Round 2 ranking to become 11th, with a rating of 46/95 (48%).

"Enclosure systems" was ranked 4th in Round 1 with a score of 37/55 (67%), and again received a ranking of 4th in Round 2 with a rating of 58/95 (61%).

"Plumbing" was ranked 9th in Round 1 with a score of 28/55 (51%), and again received a ranking of 9th in Round 2 with a rating of 49/95 (52%).

"Structural frame" was ranked 3rd in Round 1 with a score of 37/55 (67%), and again received a ranking of 3rd in Round 2 with a rating of 61/95 (64%).

"Insulation" was ranked 8th in Round 1 with a score of 29/55 (53%), and moved down 2 in the Round 2 ranking to become 10th, with a rating of 47/95 (49%).

- Decreased Rankings:

"Waterproofing/moisture control" was ranked 1st in Round 1 with a score of 43/55 (78%), and moved down 7 in the Round 2 ranking to become 8th, with a rating of 50/95 (53%).

"Cool systems" was ranked 5th in Round 1 with a score of 36/55 (65%), and moved down 8 in the Round 2 ranking to become 13th, with a rating of 39/95 (41%).

"Appliances" was ranked 7th in Round 1 with a score of 30/55 (55%), and moved down 9 in the Round 2 ranking to become 16th, with a rating of 24/95 (25%).

"Electrical systems" was ranked 6th in Round 1 with a score of 32/55 (58%), and moved down 9 in the Round 2 ranking to become 15th, with a rating of 36/95 (38%).

"Heating systems" was ranked 2nd in Round 1 with a score of 38/55 (69%), and moved down 12 in the Round 2 ranking to become 14th, with a rating of 37/95 (39%).

- Write-ins:

"Holistic 'system design'," "Education & training of builders," "Energy efficiency," "Natural hazard resistance" and *"Resource efficiency"* were write-ins on the Round 1 questionnaire as "other" technology areas of important opportunity/need for improvement. *"Design," "Hurricane resistance," "Subdivision standards"* and *"Thermal distribution"* were write-ins on the Round 2 questionnaire. *"Energy simulation tools"* was a write-in on the Round 1 questionnaire and *"Simulation software"* was a write-in on the Round 2 questionnaire.

I.04.e.ii. Constraints

- Increased Rankings:

"Incentives to undertake research" was ranked 6th in Round 1 with a score of 35/55 (64%), and moved up 5 in the Round 2 ranking to become 1st, with a rating of 68/95 (72%).

- Static Rankings:

"Definition and coordination of research needs across the industry" was ranked 5th in Round 1 with a score of 38/55 (69%), and moved up 1 in the Round 2 ranking to become 4th, with a rating of 62/95 (64%).

"Fragmentation of the building industry" was ranked 2nd in Round 1 with a score of 42/55 (76%), and again received a ranking of 2nd in Round 2 with a rating of 68/95 (72%).

"Human resources and facilities to carry out research" was ranked 8th in Round 1 with a score of 26/55 (47%), and again received a ranking of 8th in Round 2 with a rating of 35/95 (37%).

"Management support within organizations and firms for research" was ranked 7th in Round 1 with a score of 33/55 (60%), and again received a ranking of 7th in Round 2 with a rating of 50/95 (53%).

"Research funds from private and/or public sectors" was ranked 4th in Round 1 with a score of 38/55 (69%), and moved down 1 in the Round 2 ranking to become 5th, with a rating of 61/95 (64%).

"Communication link between researchers and end users" was ranked 1st in Round 1 with a score of 45/55 (82%), and moved down 2 in the Round 2 ranking to become 3rd, with a rating of 64/95 (67%).

- Decreased Rankings:

"Awareness of the importance of new technologies" was ranked 3rd in Round 1 with a score of 40/55 (73%), and moved down 3 in the Round 2 ranking to become 6th, with a rating of 55/95 (58%).

- Write-ins:

"Market driven education" and *"NAHB"* were write-ins on the Round 1 questionnaire. *"Lack of skilled workers"* and *"Politics and greed"* were write-ins on the Round 2 questionnaire.

I.04.e.iii. Barriers

- Increased Rankings:

"Existing labor agreements" was ranked 10th in Round 1 with a score of 18/55 (33%), and moved up 3 in the Round 2 ranking to become 7th, with a rating of 44/95 (46%).

- Static Rankings:

"Liability and legal implications" was ranked 7th in Round 1 with a score of 29/55 (53%), and moved up 2 in the Round 2 ranking to become 5th, with a rating of 62/95 (65%).

"Uncertainty (i.e. lack of information)" was ranked 4th in Round 1 with a score of 37/55 (67%), and moved up 2 in the Round 2 ranking to become 2nd, with a rating of 66/95 (69%).

"Expense of new technology" was ranked 1st in Round 1 with a score of 45/55 (82%), and again received a ranking of 2nd in Round 2 with a rating of 67/95 (71%).

"Professional self interest (losing control, work, pay or benefits)" was ranked 8th in Round 1 with a score of 26/55 (47%), and again received a ranking of 8th in Round 2 with a rating of 42/95 (44%).

"Standard and building codes" was ranked 3rd in Round 1 with a score of 37/55 (67%), and again received a ranking of 3rd in Round 2 with a rating of 65/95 (68%).

"Existing building contract agreements" was ranked 9th in Round 1 with a score of 18/55 (33%), and moved down 1 in the Round 2 ranking to become 10th, with a rating of 39/95 (41%).

"Lending practices" was ranked 5th in Round 1 with a score of 36/55 (65%), and moved down 1 in the Round 2 ranking to become 6th, with a rating of 57/95 (60%).

"Awareness of new technology" was ranked 2nd in Round 1 with a score of 44/55 (80%), and moved down 2 in the Round 2 ranking to become 4th, with a rating of 65/95 (68%).

- Decreased Rankings:

"Appropriateness of new technology" was ranked 6th in Round 1 with a score of 44/55 (80%), and moved down 3 in the Round 2 ranking to become 4th, with a rating of 40/95 (42%).

- Write-ins:

"Inertia," "Insurance Industry acknowledgement," "Lack of information," "Market awareness / education," "NAHB," "Deed restrictions" and *"Education to users"* were write-ins on the Round 1 questionnaire. *"Insurance costs"* and *"Politics"* were write-ins on the Round 2 questionnaire.

I.05. Conclusions and Recommendations for Future Research

I.05.a. Delphi Study Findings - Rounds 1 and 2

Of the technology issues evaluated in Round 1, respondents showed consensus on the following two issues, which received Very Important Ratings:

Constraint: Communication between researchers and end users [rating – 45/55]

> This suggests that respondents agreed that there is existing data available on low-cost housing that needs to be gathered and researched to improve housing programs.

Barrier: Expense of New Technology [rating – 45/55]

> This suggests that respondents agreed that new technologies already exist and they need to be marketed for low-cost housing programs.

The technologies showing the most opportunity / need for improvement according to the Round-1 data were: *"H.V.A.C. / Environmental Technologies"* and *"Building Envelope."* Secondary opportunities / needs for improvement were: *"Structure," "Interiors,"* and *"Sitework / Foundation."*

The primary constraints to improvement in the field of low-income housing were the current state of *"Research / Education,"* and secondary constraints were the current state of *"Construction / Production Processes"*.

Primary barriers to improvement in the low-income housing industry were the *"Administrative / Support"* systems for the industry (e.g. Code restrictions, funding) and *"Construction / Production Processes."*

There were 8 items that moved up in the importance rankings from Round 1 to Round 2, while 7 items received a lower importance ranking in Round 2. There were 19 items that remained at the same level of importance in both Rounds. This indicates that there was a relative consensus among the respondents on the importance of 19 items out of the 34 items that were on both questionnaires, or 56%.

The fact that respondents rated 30 of the 43 issues (70 percent) as important or moderately important opportunities / needs, constraints or barriers, indicates that low-cost housing is a complex issue with many important factors that need to be addressed. No single issue will, by itself, solve the problem — and an atmosphere of strong cooperation and consensus will need to be developed among low-cost housing professionals in all fields in order to make a substantial impact.

I.05.b. Analysis of Most Important Technologies Identified in Delphi Study

In an effort to identify specific research-items, the investigators examined in detail the *"opportunity / need"* items rated highest in importance by the respondents, identifying specific questions and ideas for future research. Below are the research notes for those opportunities / needs for future research:

I.05.b.i. COOLING SYSTEMS (importance rating: 69)
Goal: To lower temperature and humidity,
and provide air movement, in order to make comfortable conditions.

OPTIONS FOR RESEARCH:

- Most cooling system problems are humidity-oriented. However, most cooling systems don't directly control humidity. Therefore, there is a need to look at inexpensive humidity controlers as a solution.

Some problems with controlling humidity:

1) Educating the public as to what needs to be maintained. Could study how people understand humidity and air movement. (Are there reports on inexpensive humidity and thermostat controls to go in homes?)
2) Having humidity controls in a residence.
   a) 2-stage systems +, involving both 1-ton and 4-ton compressor – where total house load is 5 tons-and a 2-stage thermostat in order to give better humidity control
      i) Raises question of cost and energy efficiency
      ii) Will a low-income house have a cooling system at all? It is not likely to have a dual compressor system, unless it can be shown to create comfort conditions with the small compressor, for longer periods, by pulling the water out of the air.
      iii) If you have a low capacity A/C that can't keep up with the load, it will dry the house air.
   b) Cooling air by pulling it across a cooling coil and dehumidifying; where air movement is created with ceiling fans. System called an induction unit, a system that introduces cool dry air that is stirred with ceiling fans. Air movement alone can improve comfort conditions.
      i) Would people be comfortable enough in an environment like that? The issue is a question of how Warm-Dry A/C Systems compares with Full-Air Cooling Systems
      ii) Complicated control system

- Concept (various participants): First, move the insulation from bottom of attic to the roof slope. Then, seal the attic, so that it is no longer vented. This should decrease humidity-levels. However, various code issues would need to be resolved.
- Another option is hanging the insulation between roof joists and providing air space between the insulation and roof deck. This allows ridge vents that will ventilate and remove heat and moisture from roof; the same way the soffit vents remove the heat.
- Evaluate value of ridge vents. They could be pulling in unwanted humid air.
- Evaluate the combination of insulation and ventilation systems. Where do you put insulation and what does it do in that place? Could research what is happening in that space.
- Important Issues: 1) where do we place ductwork; 2) where do we place the system in relation to the insulation; 3) how do we deliver cooling without penalizing the system because it is in the attic.
- The equipment that most people use for A/C are not meant to be outside (or in the hot, humid attic), since they are not sealed. All rooftop A/C's are insulated and sealed, these should go in the attic as well.

I.05.b.ii. HEATING SYSTEMS (importance rating: 61)

Goal: Develop an improved heating system technology for forced air systems in humid climates

Premature oxidation of the combustion surface in gas-fired heating systems causes early deterioration. With current technology, this surface is deteriorating from its exposure to temperature below the attic air dew point. This makes them rust in 5 - 10 years, as opposed to 30-50 years in drier climates. Replacing the heat exchanger costs $1,000 – $2,000.

OPTIONS FOR RESEARCH:

- Controlling combustion air with a forced air furnace.
- Concept: To eliminate a forced air furnace use a closed cycle heating system. This system involves a blower with filter, a cooling coil and a heating coil. Heating coil will circulate hot water. Domestic water heater is source of heat, which works best in places where potable water doesn't have strong mineral or alkaline content that causes the heater to deteriorate.
- Concept: Use a small package boiler and a water storage tank. The small package boiler has two pumps; one pump that circulates through the water heater and a second pump that circulates through the air distribution coil. This unit would not be exposed to temperatures below the attic air dew point.
  a) Solves some problems that are created when there is a water heater heat source because a flue is removed, which leaves only one penetration from the house.
  b) Problem with concept is that water heaters are only about 75% efficient, as opposed to a small package boiler that is about 95% efficient, (Researchable item: develop roof concept, design it, test it and understand the efficiency improvements and costs.) Also look at who can supply and provide the product.
- Heat Pumps (generally well understood) – technical knowledge has been gathered about ground-coupled heat pumps, but knowledge hasn't gotten to the contractors yet.
- Solar Heating – With an efficient system, would have solar heating that is low cost, low maintenance, and simple. Could be passive system or single panel system used for domestic hot water and space heating. Possibly have utility-owned systems that sell Btus to customers.

I.05.b.iii. STRUCTURAL FRAMES (importance rating: 61)

OPTIONS FOR RESEARCH:

- Much lumber now is man-made lumber, which is formed from wood waste material that is glued together. This kind of lumber was made to counteract the decrease of wood.
- I-joist and flanges are made out of the man-made board. Well developed.
- Recycled steel would make a good structural frame but construction training and labor would be a struggle.
- Is there an effort to have an integrated design? Could use both materials, wood and steel, and have a new system for running ducts and other supply lines. An integrated structural design like this would reduce on-site labor cost.
- Hurricane/Tornado resistant structure – could reduce insurance costs, and save lives.
- Panelized pre-built construction and integrating insulation with the panels.
- Concept: In this area there is expansive soil. Our only resistance to this soil is trying to make foundation as rigid as possible so that the whole house moves together and nothing cracks. Why not make the walls into a truss and use crawl spaces. With this design, there would be only a few points where the house touches the ground, thereby reducing concrete costs.
- There is a movement toward industrialized package verses a mobile home.

I.05.b.iv. ROOFING (importance rating: 58)

Goal: To cut down on cooling cost in low-income homes or to make homes more efficient

OPTIONS FOR RESEARCH:

- Metal roofing verses shingle and composition roof
- Could stretch single-ply membrane over roof deck
- Could use white roofs with anti-fungal coating to reduce cooling load
- Test recycled plastic tiles for efficiency
- Concept: What if roofs for utility companies paid for low-income houses when they were lined with PV, a structurally integrated photovoltaic panel. The utility company would own this and occupants would then lease these panels from them.
- Galvanized white metal roofs
- Design a cooled roof. A roof with an ablative coating which shields the roof from heat
- Concept: Combine a metal roof with PVC tubing affixed to the backside and use it for solar heat. In this system, heat is removed from the roof by trickling water down the tubes and collecting it for domestic water. Could also use it for space heating, or radiant space cooling during the evenings using a second tank.

I.05.b.v. ENCLOSURE SYSTEMS (importance rating: 56)

OPTIONS FOR RESEARCH:

- If you use a truss wall, like the ones mentioned in section *I.05.b.iii. Structural Frames*, the wall would be composed of a box beam with and exterior skin. Called a Structurally Integrated Panel (SIP).
- Vinyl siding is one of the most inexpensive wall types that can be used for homes; though the material's performance characteristics are very important.
- Doors and windows: Plastic Window or Aluminum (cost difference?). Good quality plastic windows are being used more often than aluminum windows. There may be a cost advantage to using plastic windows.
- Concept: Could have clerestory windows in a house and use windows for view or ventilation. Reduces need of interior lighting and maintains privacy. Concept is significant because it may not be necessary to rely on traditional windows and doors.

    a) Probably priced out of this kind of market. Is there an inexpensive way to achieve the effect of a light and airy room?
    b) Maybe there is a less expensive way to make a clerestory; like using a different material or creating light in different ways. For example: Putting a translucent material on the roof gables instead of skylights on the roof slope. (i.e. Cal-wall)

I.05.b.vi. FOUNDATIONS (importance rating: 54)

OPTIONS FOR RESEARCH:

- Known study: Plenaire System. Advocated by wood products people. Practice is to make a plywood box beam out of treated exterior marine-grade plywood. These would be used around the house perimeter to create an air space.

    a) May be impossible to seal plenum; good idea but practical application would be difficult.
    b) Plenaire System, along with truss walls, would create an all wood home. How do you keep bugs out of the wood? Termite treatment would be impossible. Could research whether there are treatment processes in the works.

- Questions to answer: What would be sufficient grade beam depth? How would that influence cost of the building?
- Most old buildings have crawl spaces. Construction practices changed to waffle slabs, but very few of them are designed and built correctly. Today, most waffle slabs have cracks in them.
- Could you go back to crawl spaces with SIP's and/or truss walls? (pier and beam structure)

Common notion is that the slab is cheaper than the pier and beam wood structure. Notion should be explored. If having a crawl space is less expensive, it could be justified. For example: This system would allow ductwork and/or HVAC system to be in the floor, which could save money and extend the life of the system.

Part II. Low-Cost Housing Market and Demographic Analysis

II.01. Texas Low-Income Population

Currently, there is a critical need for affordable housing in Texas, and the need is expected to increase over the next quarter-century due to rapid population growth coupled with a low *per-capita* income level relative to the national average. The following highlights from the *U.S. Bureau of the Census* Population Projections 1995 – 2025 underscore the critical population growth and its impact on housing in Texas over the next quarter century. *(Census, PPL-47)*

II.01.a. Texas Population Projections 1995-2025

Figure 19 shows the fastest growing states by net increase in population over the 30-year projection period. Texas has a population of 18.7 million people as of 1995. Between 1995 and 2005, Texas is expected to increase by 8.5 million people to reach a population of 27.2 million people. During 1994, Texas surpassed New York to become the second most populous state, and is expected to remain in that position throughout the 30-year projection period. Only California has a higher population (31.6 million people in 1995) and higher growth rate (17.1 million people 1995 – 2025) than Texas. Between now and 2025, Texas' rate of population change, at 45.2 percent, ranks as the 10th largest. California, Texas and Florida will account for 45 percent of the net population change in the U.S., with no other state gaining more than 2.7 million people. *(Census, PPL-47)*

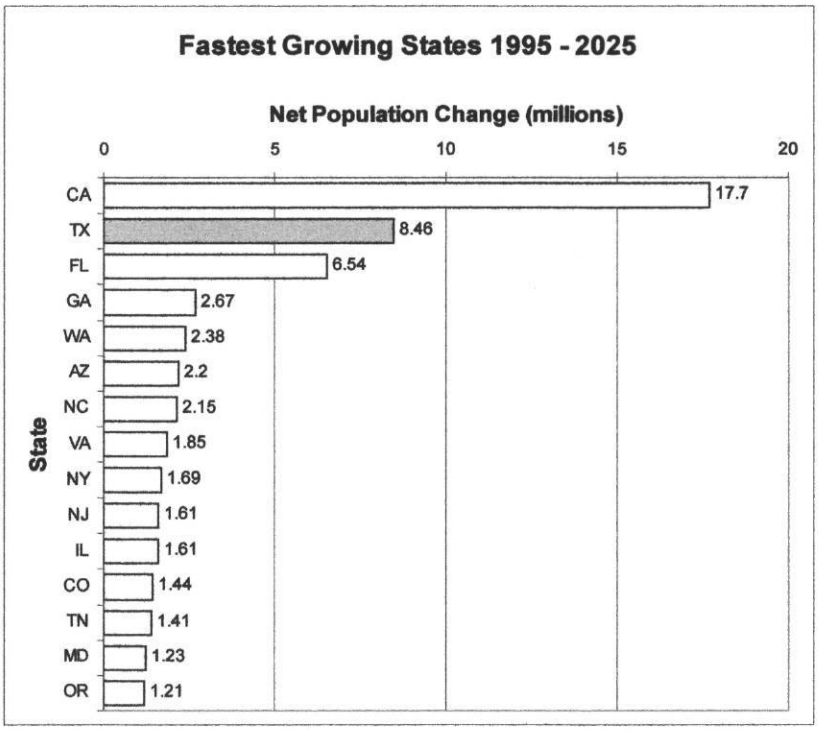

Figure 19 – Fastest Growing States by Net Increase 1995 - 2025 (Census, PPL-47)

As *Figure 20* indicates, Texas is projected to experience the 6th largest increase due to international migration — gaining 1 million people between 1995 and 2025. *(Census, PPL-47)*

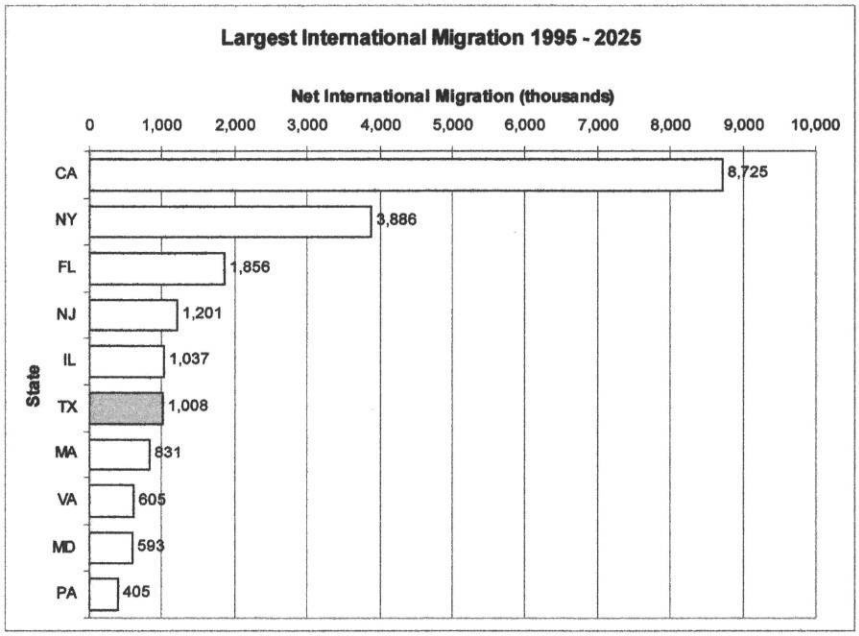

Figure 20 – States with Largest International Migration, 1995 – 2025 (Census, PPL-47)

Figure 21 shows the states with largest projected interstate migration over the 30-year projection period. Texas ranks 2nd largest in the number of persons gained through net interstate migration between 1995 and 2025 — gaining 1.7 million persons. *(Census, PPL-47)*

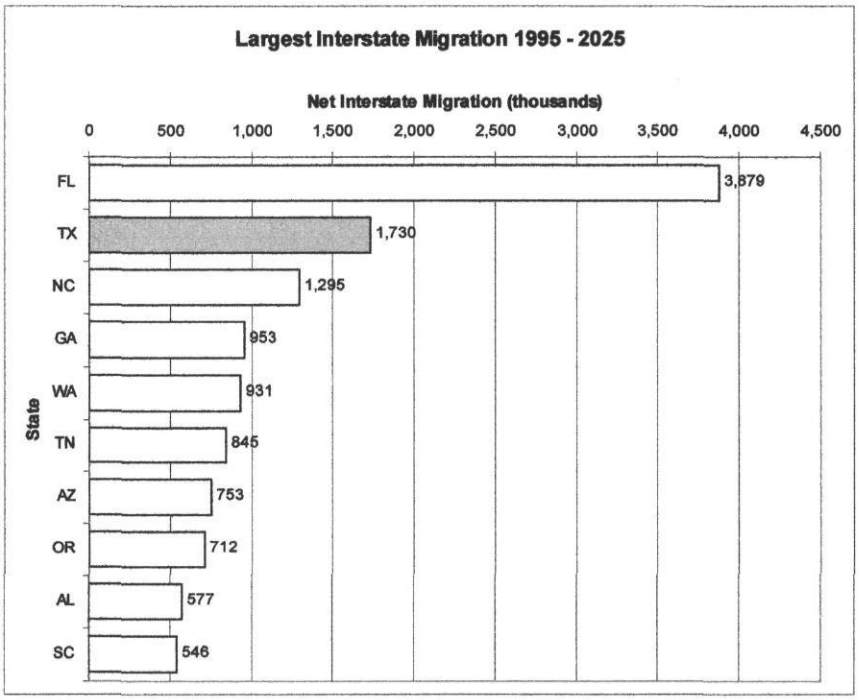

Figure 21 – States with Largest Interstate Migration 1995 – 2025 (Census, PPL-47)

II.01.b. Age Groups

The number and proportion of Texas' population that is aged 18 and over is expected to increase from 13.3 million (or 71.2 percent) in 1995 to 14.4 million (or 71.6 percent) in 2000. This population is expected to increase to 19.8 million (or 73 percent) in 2025. *(Census, PPL-47)*

The percentage of Texas' population classified as youth is projected to decrease from 31.8 percent in 1995 to 30 percent in 2025. Its rank among the 50 states and District of Columbia is expected to be the 5th largest proportion of youth in 1995 and the 4th largest proportion of youth in 2025. *(Census, PPL-47)*

As the Baby Boom generation (those born between 1946 and 1964) reaches retirement age, the growth of the elderly population (65 and over) is expected to accelerate rapidly. The proportion of Texas' population classified as elderly is expected to increase from 10.2 percent in 1995 to 16.1 percent in 2025. Texas' dependency ratio, the number of youth (under age 20) and elderly (ages 65 and over) there would be for every 100 people of working ages (20 to 64 years of age), could rise from 72.5 in 1995 to 85.4 in 2025. *(Census, PPL-47)*

II.01.c. Population Percentages by Race/Ethnic Group

By 2025, non-Hispanic Whites would comprise 46 percent of Texas' population, down from 58.2 percent in 1995. Non-Hispanic African Americans would comprise 12.8 percent of the state population in 2025, up from 11.7 percent in 1995. Non-Hispanic American Indians, Eskimos, and Aleut would comprise 0.3 percent of the 1995 state population and 0.3 percent of the 2025 state population. Non-Hispanic Asians and Pacific Islanders would increase from 2.2 percent of the 1995 state population to 3.3 percent of the 2025 state population. Persons of Hispanic origin, who may be of any race, is projected to increase from 27.6 percent of the 1995 state population to 37.6 percent of the 2025 state population. *(Census, PPL-47)*

During the 30-year period, Texas' non-Hispanic White population is projected to grow by a rate of 14.8 percent. The non-Hispanic African American population will grow by 58.3 percent, the non-Hispanic American Indian, Eskimo, and Aleut population will grow by 32.3 percent, the non-Hispanic Asian and Pacific Islander population will grow by 120.6 percent, and the Hispanic population will grow by 97.7 percent. *(Census, PPL-47)*

II.01.d. Population by Race/Ethnic Group

The number of non-Hispanic Whites residing in Texas is projected to increase by 1.6 million from 1995 to 2025. Persons of Hispanic origin will increase by 5.1 million; Non-Hispanic African Americans will increase by 1.3 million; non-Hispanic American Indians, Eskimos and Aleut by 18 thousand; and non-Hispanic Asians and Pacific Islanders by 498 thousand over the 30-year projection period. *(Census, PPL-47)*

Texas' non-Hispanic White population growth ranks as the 2nd largest gain among the 50 states and District of Columbia from 1995 to 2025. The non-Hispanic African American population change ranks as the 2nd largest gain. The Hispanic population change also ranks as the 2nd largest gain. The non-Hispanic American Indian, Eskimo, and Aleut population change ranks as the 13th largest gain, and the non-Hispanic Asian and Pacific Islander population change the 4th largest gain. *(Census, PPL-47)*

II.01.e. Texas Households by Race / Ethnic Group 1995 – 2025

Figure 22 and *Figure 23* show the potential growth in the number of Texas households by race / ethnic group from 1995 – 2025. The population projections by race and ethnic group listed in the previous section were converted to households based on the average Texas household size. In 1995 there were approximately 6,369,000 households in Texas. If the average household size of Hispanics -at 3.48 persons- and non-Hispanic whites -at 2.77 persons- remains constant over the thirty-year period, the number of households could increase to approximately 9,061,000 households; the average household size would increase from 2.77 persons to 3.0 persons.

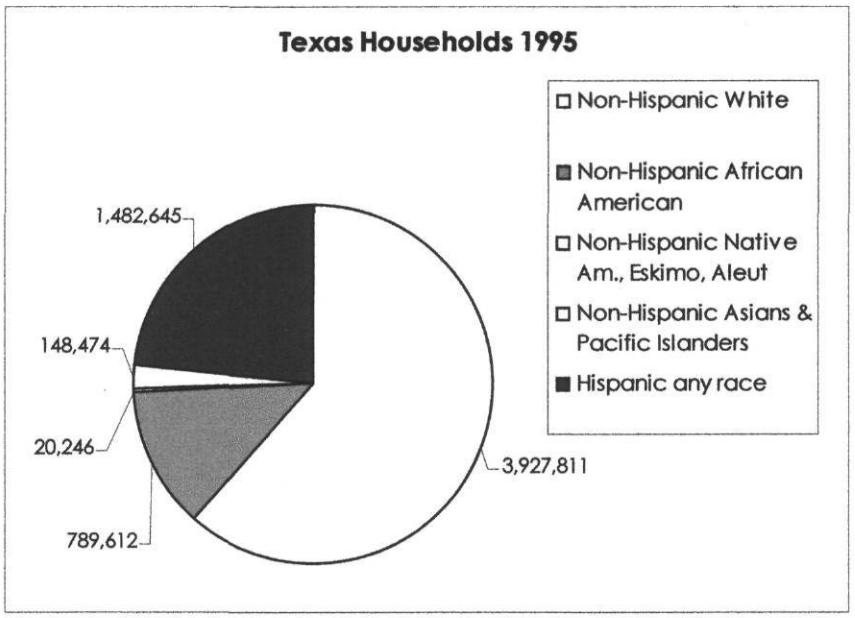

Figure 22 – Texas Households by Race / Ethnic Group 1995 (Census, PPL-47)

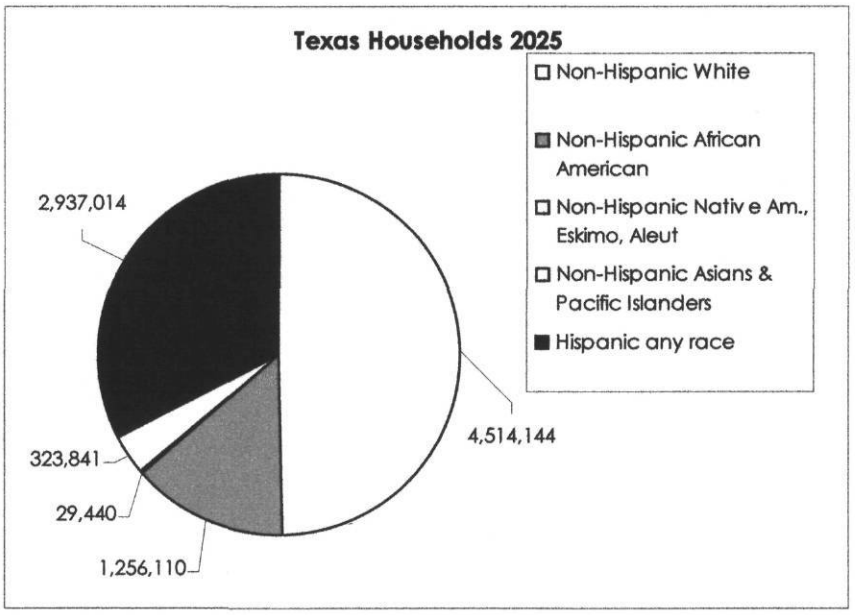

Figure 23 —Texas Households by Race / Ethnic Group 2025 (Census, PPL-47)

II.01.f. Texas Population by County 1996

Table 11 and *Figure 24* show Texas counties by highest population in 1996. The highest population counties are Harris (county seat = Houston), Dallas (Dallas), Bexar (San Antonio), and Tarrant (Fort Worth). The second tier includes three counties: El Paso (county seat = El Paso), Travis (Austin) and Hidalgo (Edinburg). El Paso and Hildago are both in Border areas. All other counties in the top two tiers include the large Texas cities. *(Census, PPL-47)*

The third tier includes 4 counties surrounding Houston (Fort Bend, Montgomery, Jefferson and Galveston), 3 counties surrounding Dallas/Fort Worth (McKinney and Denton), Nueces county (county seat = Corpus Christi), Lubbock county (Lubbock), and one border county: Cameron (Brownsville). *(Census, PPL-47)*

Table 11 - Texas counties by highest population in 1996 (Census, PPL-47)

FIPS Code	Area Name	1996 Pop	1996 Avg. Income	County Seat
48	Texas (state)	19,128,261	$17,062	
201	Harris	3,126,966	$22,990	Houston
113	Dallas	2,000,192	$24,760	Dallas
29	Bexar	1,318,322	$17,916	San Antonio
439	Tarrant	1,305,185	$21,501	Fort Worth
141	El Paso	684,446	$12,790	El Paso
453	Travis	683,967	$21,127	Austin
215	Hidalgo	495,594	$10,085	Edinburg
85	Collin	372,445	$25,666	McKinney
121	Denton	348,453	$20,305	Denton
355	Nueces	315,722	$17,783	Corpus Christi
61	Cameron	315,015	$11,042	Brownsville
157	Fort Bend	306,832	$21,049	Richmond
339	Montgomery	245,845	$19,296	Conroe
245	Jefferson	243,733	$19,224	Beaumont
167	Galveston	240,653	$19,363	Galveston
303	Lubbock	232,035	$17,947	Lubbock

1996 Population
Texas Counties

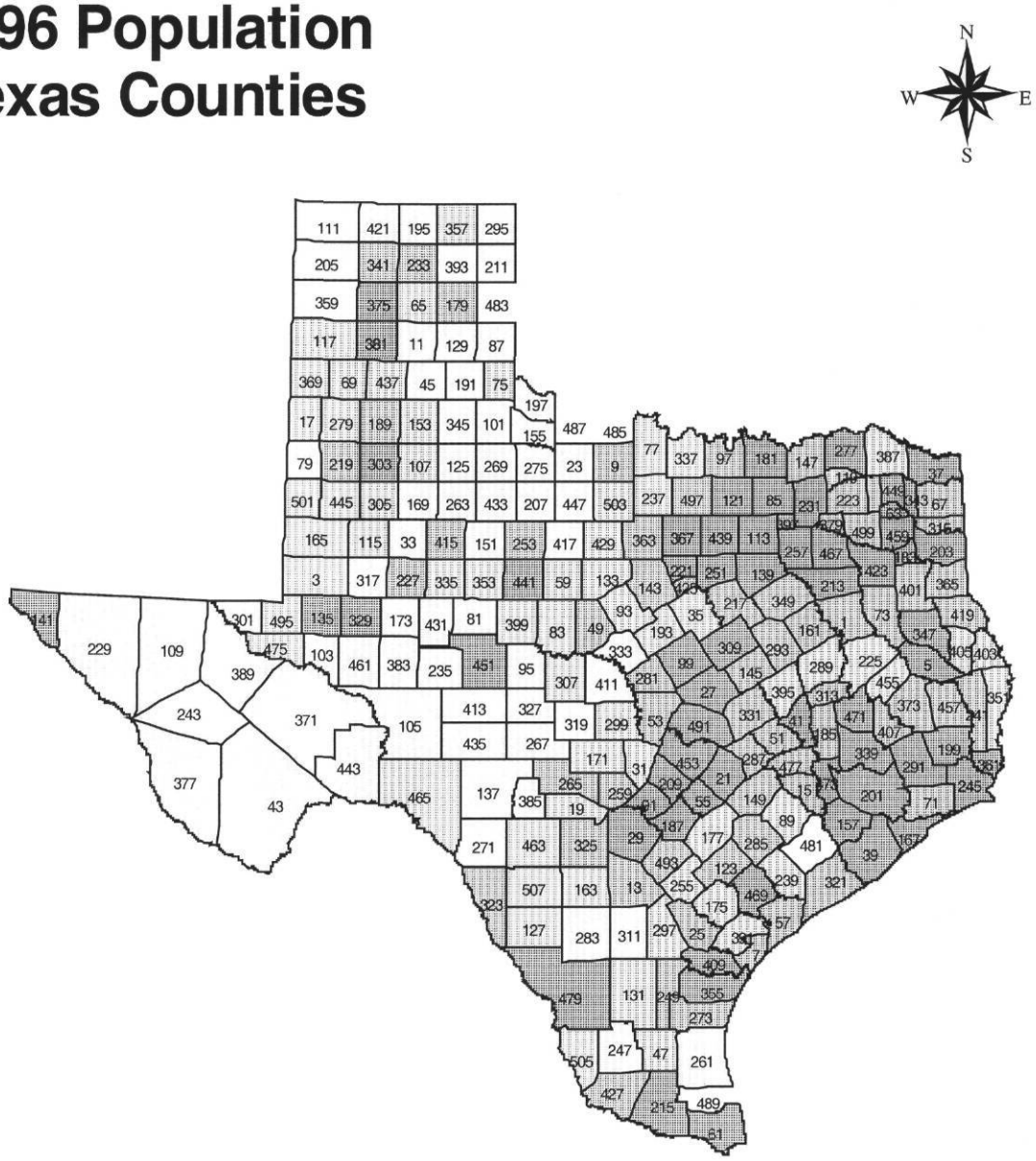

Figure 24– Map of Texas counties by population (Census, PPL-47)

II.01.g. Texas Population Rate by County 1990 - 1998

Table 12 and *Figure 25* show the critical Texas counties by fastest population growth from 1990 to 1998. Of the 32 counties in the fastest growth category, 6 are adjoining Harris county (FIPS Code 201, county seat = Houston); 6 are surrounding Travis county, (FIPS Code 453, county seat = Austin), 4 are surrounding Dallas county (FIPS Code 113, county seat = Dallas) and Tarrant county (FIPS Code 439, county seat = Fort Worth); 5 are surrounding Bexar county (FIPS Code 29, county seat = San Antonio), and 7 are within three counties of the Texas-Mexico border. The 4 counties of fast population growth that are not near the cities mentioned above or in border areas are Hartley (FIPS Code 205), Starr (#427), Loving (#301) and Childress (#75).

Table 12 - Texas counties by fastest population growth from 1990 to 1998 (Census, PPL-47)

FIPS Code	Area Name	1-Jul-98 Population Estimate	Revised 1990 Census	Change Pop. 1990-98	County Seat
137	Edwards	3,779	2,266	0.489	Rocksprings
373	Polk	50,309	30,687	0.463	Livingston
205	Hartley	5,102	3,634	0.434	Channing
491	Williamson	223,910	139,551	0.421	Georgetown
85	Collin	428,803	264,036	0.411	McKinney
157	Fort Bend	337,798	225,421	0.361	Richmond
19	Bandera	15,754	10,562	0.353	Bandera
339	Montgomery	271,788	182,201	0.349	Conroe
259	Kendall	21,222	14,589	0.346	Boerne
397	Rockwall	37,174	25,604	0.334	Rockwall
427	Starr	55,906	40,518	0.332	Rio Grande
479	Webb	188,166	133,239	0.327	Laredo
301	Loving	114	107	0.318	Mentone
53	Burnet	32,195	22,677	0.312	Burnet
91	Comal	73,391	51,832	0.306	New Braunfels
31	Blanco	8,400	5,972	0.302	Johnson City
325	Medina	37,685	27,312	0.295	Hondo
215	Hidalgo	522,204	383,545	0.292	Edinburg
323	Maverick	48,131	36,378	0.280	Eagle Pass
493	Wilson	31,423	22,650	0.275	Floresville
121	Denton	384,020	273,525	0.274	Denton
75	Childress	7,532	5,953	0.273	Childress
281	Lampasas	17,775	13,521	0.269	Lampasas
209	Hays	88,536	65,614	0.246	San Marcos
21	Bastrop	50,390	38,263	0.224	Bastrop
407	San Jacinto	21,768	16,372	0.219	Coldspring
457	Tyler	20,408	16,646	0.219	Woodville
61	Cameron	326,449	260,120	0.211	Brownsville
221	Hood	37,194	28,981	0.207	Granbury
291	Liberty	65,078	52,726	0.200	Liberty
377	Presidio	8,636	6,637	0.200	Marfa
505	Zapata	11,491	9,279	0.196	Zapata

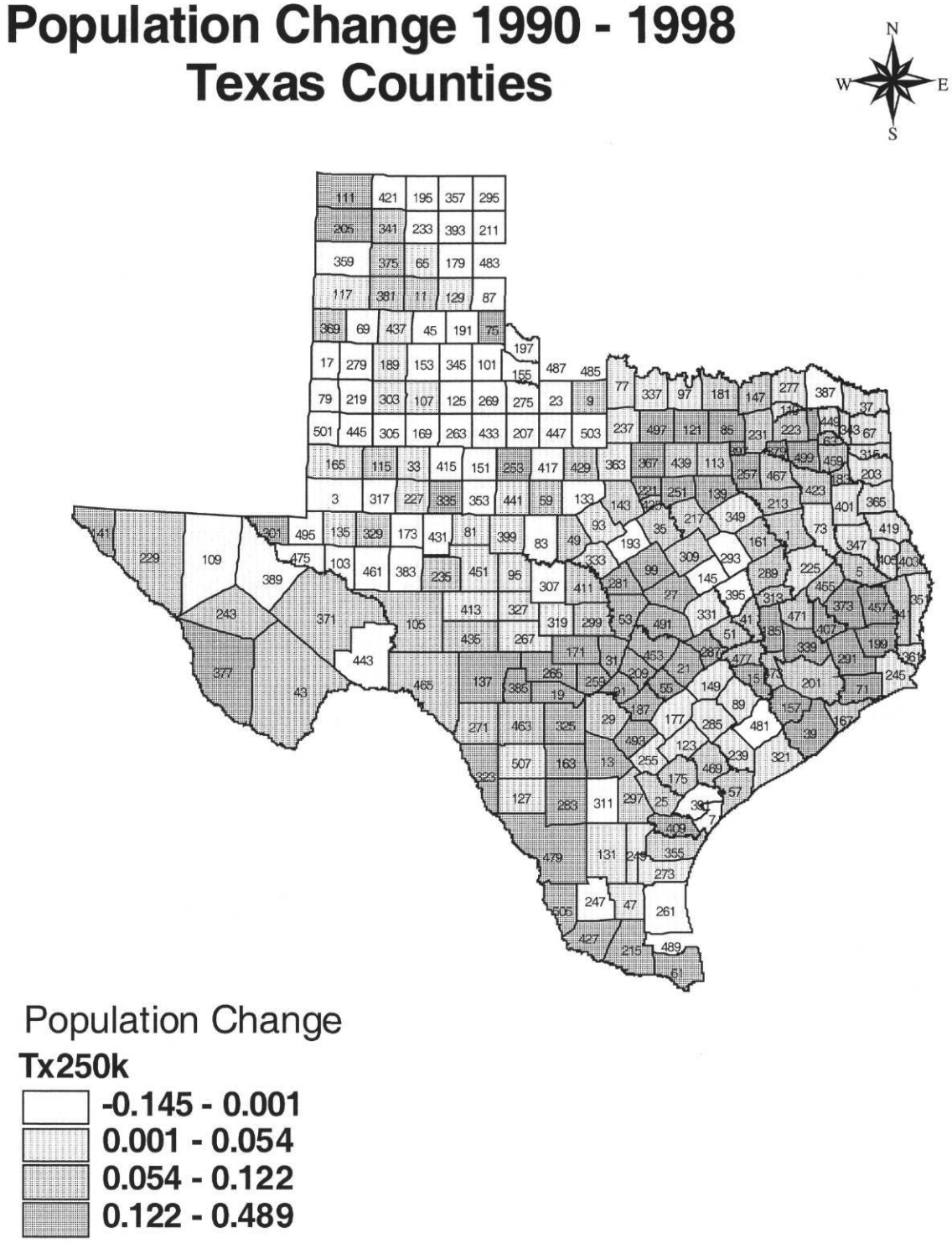

Figure 25 – Map of Texas counties by population growth rate (Census, PPL-47)

II.01.h. Critical Population Growth in South Texas

The *Texas A&M University Real Estate Center's* October 1998 news release, "South Texas Tops Population Charts," highlights the critical population growth along the Texas-Mexico border area and emphasizes the need for the development of a housing market that could be sustained by the expanding real estate market to meet low-income need in those critical areas.

Texas A&M University Real Estate Center

South Texas Tops Population Charts

News Release No. 3, October 1998

Although Houston, Dallas, Austin and San Antonio have most of the state's population growth, South Texas appears destined to be the next major urban conglomerate.

The big growth corridor includes Brownsville-Harlingen-San Benito, Laredo and McAllen-Edinburg-Mission.

The three South Texas metropolitan areas and their connecting counties now represent a major portion of the state's population," says Steve H. Murdock, research fellow with the Real Estate Center and chief demographer with the State Data Center at Texas A&M University. According to the U.S. Census Bureau, in mid-1997 Laredo's population was more than 183,200; Brownsville-Harlingen-San Benito's was 320,800, and McAllen-Edinburg-Mission was nearly 511,000.

Put in perspective, the South Texas population exceeds that of the Austin-San Marcos area. Laredo was the fastest-growing Texas metropolitan area from 1990 to 1997, recording a 37.5 percent increase (nearly 50,000 persons); McAllen-Edinburg-Mission was second with a 33.2 percent increase (almost 127,400); and Brownsville-Harlingen-San Benito was the fourth fastest growing area with an increase of 23.3 percent (nearly 60,700).

In 1990 these areas accounted for 4.5 percent of the state's population. Including Starr and Zapata counties, the total area increased by 30.9 percent from 1990 to 1997. One of every ten new Texans in the 1990s took up residence in South Texas.

Assuming the levels of migration remain similar to 1990-96, metropolitan areas in the region also could be independent growth centers. Laredo will increase to nearly 655,000 persons by 2030, a growth rate of 391 percent since 1990; Brownsville will increase 202 percent with nearly 785,000 persons; and McAllen-Edinburg-Mission will have 1.9 people – 397 percent increase.

Murdock says this area is anticipated to have continual growth. According to projections from the State Data Center, if the growth rates continue, the total area (including Starr and Zapata counties) will have a population of more than 1.7 million by 2010 and nearly 3.6 million by 2030.

"These areas are likely to represent expanding markets for goods and services," says Murdock, "but growth through domestic migration is the key to most rapid-expansion markets. Examination of the 1990-97 population growth in this area shows only 9.1 percent of the area's growth resulted from domestic immigration."

"If income levels increase significantly in the future, this area will represent one of the most rapidly expanding markets in Texas and the nation," says Murdock. If the growth mixture continues, these real estate markets are likely to be based largely on indigenous population growth rather than rapid expansion through migration. In response to these economic data findings, which show generally limited income levels, area real estate practitioners should plan carefully to address market growth.

II.01.i. Texas Personal Income Projections

Texas' growth in personal income is outpacing the U.S. growth rate, as indicated by the May 1999 news release from the Texas A&M University Real Estate Center: "Texas Incomes - Good and Bad News." "Preliminary estimates from the U.S. Department of Commerce show Texans' personal income climbed 7.9 percent last year, compared to a growth of 5.7 percent for the United States as a whole," says Jared Hazleton of the *Real Estate Center* at *Texas A&M University (RECenter, Incomes)*. But this income growth is not demographically or geographically uniform across Texas, as Hazelton explains:

"Despite its recent stellar performance, Texas remains a relatively poor state. Its 1997 per capita personal income totaled $23,656, or 91.2 percent of the national average. New 1994-96 estimates of personal income for 316 local areas reveal disparities in relative income that exist among Texas cities. Dallas and Houston had a per capita income exceeding the 1996 national average, with rankings of 29th and 39th respectively among 316 U.S. areas. In 1996, the state had five of the nation's ten poorest metropolitan areas. Four cities along the Texas-Mexico border ranked at the bottom of the income distribution: McAllen-Edinburg-Mission, Laredo, Brownsville-Harlingen-San Benito and El Paso." *(RECenter, Incomes)*

"According to 1990 U.S. Census data, Texas has the eighth highest poverty rate in the nation, with a rate of 18 percent compared to the national rate of 13 percent. The poverty threshold, determined by the 1990 Census based on 1989 incomes, was $6,310 for a one-person household and $12,575 for a four-person household (with two children). *(SLIHP, p.99)*

"Poverty conditions along the Texas-Mexico border merit special consideration. According to the 1990 U.S. Census, twenty-eight counties along the border have a poverty rate of at least 26 percent. This figure is almost double the national average. Although the entire border region suffers from high poverty rates, conditions in the *colonias*, unincorporated areas lacking infrastructure and decent housing, are particularly acute. It is estimated that 43 percent of *colonia* residents live below the poverty level." *(SLIHP, p.99)*

In 1996, Webb County (county seat = Laredo) had an average income of $10,757; the average income in Cameron County (county seat = Brownsville) was $11,042; Hidalgo County's (county seat = Edinburg) was $10,085, and El Paso county (county seat = El Paso) had an average income of $12,790. Median income in Texas in 1996 was $33,787 and in the United States, $36,097. *(Census, PPL-47)*

Poor households in Texas' largest metropolitan areas are much more likely to live in physically deficient housing than are poor households in other metropolitan areas throughout the United States. Four Texas metropolitan areas - San Antonio, Houston, Dallas and Fort Worth-Arlington - were ranked first through fourth in the Nation in having the highest rates of physically deficient housing among poor homeowners. *(SLIHP, p.110)*

II.01.j. Median Income

The median income for the West in 1997 was $21,905, compared to $37,005 in the U.S.. The 1996-97 moving average median income in Texas was 34,453, and in the U.S. was 36,656. The national median income for all households averaged over 1995-97 was $36,399. The Texas median household income over the same period was $34,216. *(C.P.S.)*

II.01.k. Texas Average Household Income by County 1996

Table 13 and *Figure 26* show the most critical Texas counties according to lowest average household income. 75 percent of the 32 counties in the lowest average household income category are in the Texas-Mexico border area. The other counties are except Willacy, Coryell, Walker, Newton, San Jacinto, Sterling, Anderson and Reagan. *(C.P.S.)*

Table 13 - Texas Average Household Income by County 1996 (C.P.S.)

FIPS Code	Area Name	1996 Pop	1996 Avg. Income	County Seat
427	Starr	53,974	$6,306	Rio Grande
323	Maverick	46,563	$7,925	Eagle Pass
507	Zavala	12,322	$8,658	Crystal City
505	Zapata	11,100	$9,055	Zapata
127	Dimmit	10,475	$9,468	Carrizo Spr.
229	Hudspeth	3,265	$9,526	Sierra Blanca
377	Presidio	7,966	$9,958	Marfa
215	Hidalgo	495,594	$10,085	Edinburg
9	Willacy	19,419	$10,092	Raymondville
109	Culberson	3,210	$10,619	Van Horn
479	Webb	176,792	$10,757	Laredo
61	Cameron	315,015	$11,042	Brownsville
163	Frio	15,824	$11,065	Pearsall
131	Duval	13,383	$11,273	San Diego
271	Kinney	3,402	$11,501	Bracketville
465	Val Verde	43,131	$11,503	Del Rio
99	Coryell	74,446	$11,549	Gatesville
47	Brooks	8,493	$11,551	Falfurrias
137	Edwards	3,374	$11,842	Rocksprings
371	Pecos	16,349	$12,094	Fort Stockton
471	Walker	54,417	$12,315	Huntsville
389	Reeves	14,993	$12,351	Pecos
351	Newton	14,259	$12,415	Newton
283	La Salle	6,063	$12,665	Cotulla
141	El Paso	684,446	$12,790	El Paso
407	San Jacinto	19,957	$12,857	Coldspring
431	Sterling	1,411	$13,033	Sterling City
13	Atascosa	35,044	$13,254	Jourdanton
1	Anderson	52,174	$13,335	Palestine
383	Reagan	4,254	$13,409	Big Lake
249	Jim Wells	39,725	$13,643	Alice
463	Uvalde	25,343	$13,674	Uvalde

1996 Average Household Income
Texas Counties

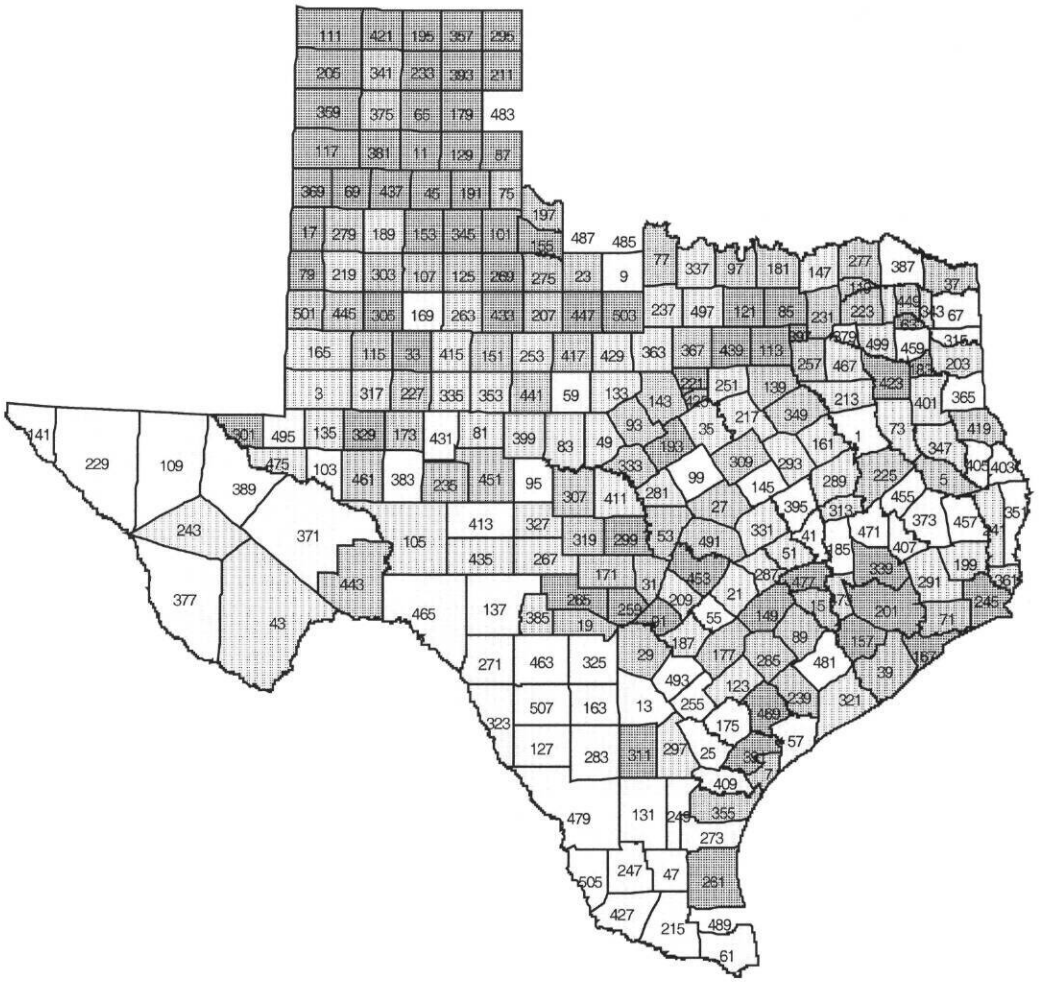

Figure 26 – Map of Texas counties by Average Household Income 1996 (C.P.S.)

II.02. Texas Housing Need

II.02.a. Texas Counties of Most Critical Housing Need

A vast majority of the highest population and fastest growing counties are near the urban centers in Texas: Houston, Austin, San Antonio, Dallas and Fort Worth. There are also 7 counties of high population/fast growth that are in border areas.

The 8 most critical counties that are fast-growth areas coupled with low average income are Edwards, Starr, Webb, Hidalgo, Maverick, San Jacinto, Cameron and Zapata. The 2 most critical counties with greatest population coupled with low average income are Cameron and El Paso. *(C.P.S.)*

Cameron (FIPS Code 61, county seat = Brownsville) is of particular note: it has the 12th lowest average income level (1996), 28th fastest population growth (1998), and 12th highest population (1996). El Paso county (FIPS Code 141, county seat = El Paso) has the 25th lowest average income (1996) coupled with the 6th highest population (1996). *(C.P.S.)*

II.02.b. TDHCA definitions of low-income

Extremely Low-income –	≤ 30% of 'H.U.D.-Adjusted Median Family Income' (HAMFI)
Very Low-income –	31% - 50% of HAMFI
Low-income –	51% - 80% of HAMFI
Moderate Income –	81% - 95% of HAMFI
Above Moderate Income –	Above ninety-five percent (95%) of HAMFI

"The income limits for metropolitan areas may not be less than limits based on the State non-metropolitan median family income level, and must be adjusted upward accordingly. Income limits must be adjusted for family size. Income limits may also be adjusted for areas with unusually high or low family income or housing cost-to-income relationships." *(SLIHP, p.98)*

II.02.c. TDHCA Definitions of Unit Affordability

"Unit affordability compares local housing cost to local area 'H.U.D.-Adjusted Median Family Income', (HAMFI). "Affordable" units are defined to mean units for which a family would pay no more than thirty percent (30%) of their income for rent and no more than two and one-half (2.5) times their annual income to purchase. Since HUD's adjusted median family incomes are estimated for a family of four, affordability levels are also adjusted to control for various-sized units based on the number of people that could occupy a unit without overcrowding. This adjustment is made by multiplying the threshold as described above by seventy-five percent (75%) for a 0-1 bedroom unit, ninety percent (90%) for a two bedroom unit, and 104% for a 3+ bedroom unit."*(SLIHP, p.98)*

II.02.d. TDHCA Housing Assistance Programs

The *Texas Department of Housing and Community Affairs* (TDHCA) submits an annual *State Low-income Housing Plan And Annual Report* (SLIHP) to the Texas legislature in which they outline critical issues and solutions relating to the Texas housing shortage. According to the *State Of Texas Low-Income Housing Plan And Annual Report*, Federal and State housing assistance accounted for $247,126,653 in fiscal year 1998, serving 19,988 households. *Figure 27* shows the total State and Federal housing assistance for Texas households by low-income category in 1998. Income categories are shown as percentages of the household relative to the 'H.U.D.-Adjusted Median Family Income' (HAMFI), as described in section *II.02.b. (SLIHP)*

	Funds Committed in FY 98	Total Households Served	Extremely Low Income (0 - 30%)	Very Low Income (31 - 60%)	Low Income (61 - 80%)
HOME Program	$38,052,860.00	3,173	$8,031,213.00	$10,395,970.00	$19,625,677.00
Housing Trust Fund	$1,583,200.00	358	$25,755.00	$786,277.00	$771,168.00
Section 8	$7,146,242.00	2,057	$5,716,994.00	$1,429,248.00	
Low-Income Tax Credit Program	$58,540,287.00	11,919		$58,540,287.00	
Comm. Dev. Block Grant Housing Fund	$2,156,000.00	125			$2,156,000.00
Single Family Bond Program	$96,123,064.00	1,711	$1,749,637.00	$38,096,716.00	$32,932,374.00
Multifamily Bond Program	$43,525,000.00	645		$43,525,000.00	
TOTAL	$247,126,653.00	19,988.00	$15,523,599.00	$152,773,498.00	$55,485,219.00

Figure 27 – Total State and Federal Housing Assistance for Texas Households by Low-Income Category 1998 (SLIHP, p.215)

II.02.e. Approximate Percentage of Households Receiving Housing Assistance

The 1 July 1998 population was estimated at 19,759,614. Dividing the 1998 population by the estimated Texas average household size of 2.8 people gives an estimated number of households in Texas of 7,057,000 in 1998. As *Figure 27* shows, government programs benefit 19,988 households in Texas in Fiscal Year 1998. Therefore, Federal and State subsidies and programs benefited approximately .2 percent of households in the Texas housing market.

II.02.f. Contributing Factors and Types of Housing Need

The *1999 State of Texas Low Income Housing Plan and Annual Report* enumerates several contributing factors to the low-income housing shortage in Texas: "The seeming availability of affordable housing does not translate into an affordable housing surplus. For a variety of reasons, affordable housing is not available to many low-income families. Major reasons for this include housing size mismatches, the unequal geographic distribution of affordable housing units, and limitations on the supply of affordable housing due to the occupation of affordable housing by higher income groups." *(SLIHP, p.117)*

II.02.f.i. Inequalities in Housing Distribution — Housing Inadequacy and Overcrowding

According to the *1999 State of Texas Low Income Housing Plan and Annual Report*, the U.S. currently faces a severe shortage of apartments and houses that low and moderate-income families can afford. According to figures from the *Comprehensive Housing Affordability Strategy* 1990 analysis *(SLIHP, p.95)*, by the year 2003, the gap between the supply of low-income housing and the number of families needing such housing may increase to 7.8 million units — housing for about 18 million people. *(SLIHP, p.117)*

II.02.f.ii. Renter –vs.- Owner Availability

Figure 28 shows the distribution of housing units in Texas by affordability category. These figures are from the *Comprehensive Housing Affordability Strategy (CHAS)* 1990 analysis *(SLIHP, p.95)* as presented in the *1999 State of Texas Low-Income Housing Plan and Annual Report*. "Estimates of affordable housing supply by income category are actually somewhat inflated because affordability is computed for households at the top of each income range … Only a small percentage of units are affordable to the lowest income households." *(SLIHP, p.117)*

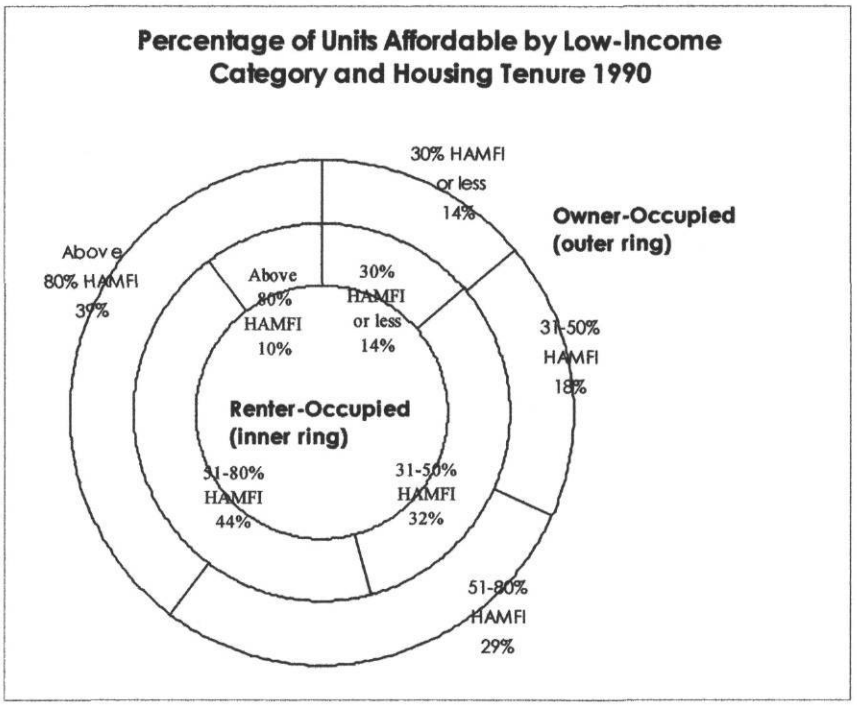

Figure 28 – Unit Availability by Low-Income category and Housing Tenure in Texas 1990 (SLIHP, p.117)

II.02.f.iii. Housing Inadequacy

The *1999 State of Texas Low-Income Housing Plan and Annual Report* outlines the difficulties in accurately measuring the adequacy and quality of housing using available methods:

"The methods used to determine housing conditions used by the census are rudimentary and make it difficult to measure the physical condition of housing. The *American Housing Survey (AHS)*, conducted by the *Bureau of the Census* for *HUD*, contains two composite measures of housing conditions to determine whether units are moderately or severely inadequate. Unfortunately, the *AHS* only provides a nationwide sample survey every two years and a set of forty-four metropolitan surveys." *(SLIHP, p.110)*

"The only measure of physical inadequacy available from the *CHAS* database tabulation of the *1990 Census* is the number of units lacking complete kitchen or plumbing. While this is not a complete measure of physical inadequacy, the lack of plumbing and/or kitchen facilities can serve as a strong indication of one type of housing inadequacy. Therefore, this measure is helpful in locating areas with substandard housing conditions as well as other possible housing problems. Housing experts agree that the number of units lacking kitchen and plumbing facilities has been underreported. For instance, it appears that only approximately 17,500 houses along the

Texas-Mexico border are considered physically inadequate. However, most studies reveal a higher number of houses lacking adequate kitchen or plumbing facilities in this area." *(SLIHP, p.110)*

II.02.f.iv. Overcrowding

The *1999 State of Texas Low-Income Housing Plan and Annual Report* defines overcrowding as "a residence housing more than 1.5 persons per room." The 1990 U.S. Census showed that 469,895 households in Texas live in overcrowded conditions. Overcrowding often occurs in communities where households have been forced to "double up" because housing units are either too expensive for the low-income families living in that community, or are not available at all. Overcrowding is particularly pronounced among poor Hispanic households in Texas. For example, "45 percent of the poor Hispanic households in the Dallas metropolitan area live in overcrowded housing." *(SLIHP, p.114)*

As explained in the *1999 State Of Texas Low-Income Housing Plan And Annual Report*, "While large related family households accounted for only 13 percent of all households in Texas as of 1990, 23 percent of rental units and 72 percent of owner units had three or more bedrooms. Although large units outnumber large families, there is still an unmet demand for affordable three bedroom multifamily units because larger units tend to be more expensive than smaller units. As a result, the disproportionate number of large units leaves the existing housing stock even less accessible to low-income families." *(SLIHP, p.117)*

Although it appears there are enough larger (3+ bedroom) units to accommodate the larger low-income households, many of these larger units are not affordable to those large households of greatest need. *(SLIHP, p.113)*

As reported in the *1999 State of Texas Low-Income Housing Plan and Annual Report*, "Renter households tend to be poorer than owner households. In 1990, 58 percent of renter households were in the low-income category, while only 31 percent of owner households were low-income. This is not surprising, given the income requirements of homeownership, specifically, the escalating tax and insurance payments and home maintenance and repair costs. Assuming that principal and interest payments are roughly equivalent to rents for comparable housing, these additional costs often restrict home ownership for persons and families of very low-income. Additionally, underwriting requirements for home mortgages establish debt ratios as percentages of gross income which very low-income persons find extremely difficult to meet." *(SLIHP, p.101)*

II.02.f.v. Housing Mismatch

Higher-income households often occupy units that could be affordable to the lowest-income households— a condition known as 'housing mismatch.' *Figure 29* depicts the housing-mismatch problem as of 1990 as presented in the *1999 State of Texas Low-Income Housing Plan and Annual Report*. In *Figure 29*, "each affordability category has four figures associated with it— the first bar shows the number of households in that income category, the second bar shows the number of units affordable to households in that income category. The third bar displays the number of units in that income category actually inhabited by households of that category, and the fourth bar displays the number of units affordable to that income category inhabited by households of other income categories." *(SLIHP, p.118)*

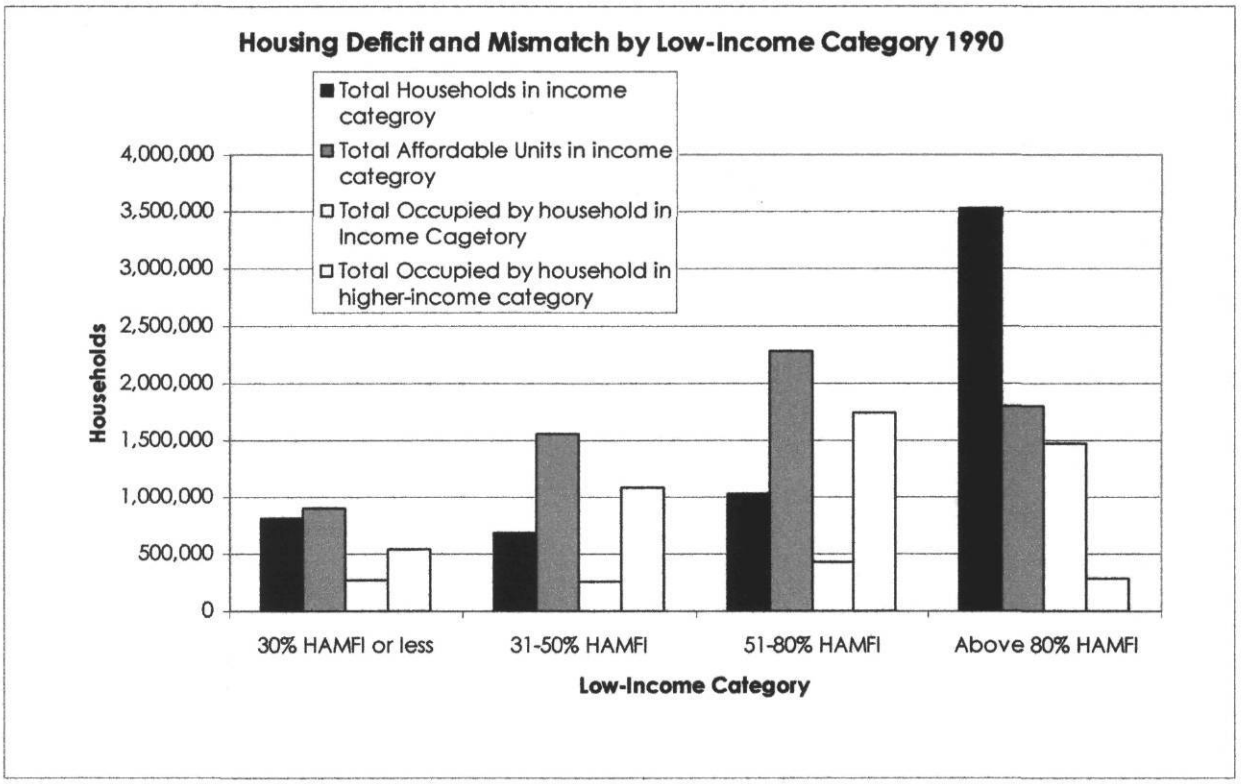

Figure 29 – Housing Deficit and Mismatch by Affordability Category as of 1990 (SLIHP, p.118)

The *1999 State of Texas Low-Income Housing Plan and Annual Report* explains the housing-mismatch problem as it existed in Texas in 1990:

"Although it appears that there is enough affordable housing for low-income populations, this is not always the case. The higher income categories have a tendency to inhabit units below their affordability category. In the 0-30% HAMFI category, only 31 percent reside in housing affordable to them. Likewise, only 16 percent of 31-50% HAMFI households and 19 percent of 51-80% HAMFI households reside in housing affordable to them. There are two major reasons households over 80% HAMFI inhabit units affordable to lower-income groups: 1) there are not enough housing units specifically affordable to their income group, and 2) there is a natural trend in a market economy for individuals to find the least expensive unit for their needs." *(SLIHP, p.118)*

"It is important to note that 28 percent of the units affordable to 0-30% HAMFI are actually occupied by households of incomes greater than 80% HAMFI. Likewise, 37 percent of the units affordable to 31-50% HAMFI and 60 percent of the units affordable to 51-80% HAMFI are actually occupied by households of incomes greater than 80% HAMFI. In addition, it is important to note that the lower income households are forced to seek housing that is not necessarily affordable to them. This housing mismatch leads to incidents of excess housing cost burdens where households are required to pay more than thirty percent (30%) of their income for housing. This problem is further addressed in the following section concerning Excessive Cost Burden." *(SLIHP, p.120)*

II.02.f.vi. Cost Burden

"Housing affordability is the most prevalent and serious problem facing low-income households. Excess cost burden occurs when a household pays more than thirty percent (30%) of its gross income for housing costs. Severe cost burden occurs when a household pays more than fifty percent (50%) of its gross income for housing costs. "Excessive cost burden is the most widespread housing problem facing American households today, and is particularly prevalent among very low-income renters. *Figure 30* "shows the changes in income relative to changes in housing costs. Over the last seven years, the cost of housing has increased dramatically while the median household income, when adjusted for inflation, has declined slightly." *(SLIHP, p.120)*

	1989	1996-Adj.	% Change
Median Monthly Household Income	3,321	3,225	-2.98%
Median Monthly Rent	395	435	9.20%
Median Monthly Mortgage	712	777	8.37%

Figure 30 – Income Decline relative to Housing Costs in Texas 1990 (SLIHP, p.120)

"Excess cost burden affects a greater number of renter households than owner households. While renter households account for only 38 percent of all households, they make up 53 percent of all households with excess cost burden. Renter households earning 0-80% of HAMFI, in turn, account for 95 percent of all renter households with excess housing cost burden. *Figure 31* shows the percentage of households that experience excess cost burden, broken down by income group." *(SLIHP, p.120)*

	Renter Households			Owner Households			Total Households		
Low-Income Category	Total	Low-Income	% Low-Inc.	Total	Low-Income	% Low-Inc.	Total	Low-Income	% Low-Inc.
30% HAMFI or less	494,905	357,356	72.2%	327,183	284,975	87.1%	621,188	562,331	90.5%
31% - 50% HAMFI	363,507	240,011	66.0%	327,310	130,218	39.8%	690,817	370,229	53.6%
51% - 80% HAMFI	502,865	151,385	30.1%	524,912	140,708	26.8%	1,027,777	292,053	28.4%
80% - 95% HAMFI	210,421	20,634	9.8%	275,718	55,753	20.2%	436,138	76,307	17.5%
above 85% HAMFI	765,307	21,307	2.8%	2,289,113	170,880	7.5%	3,053,420	192,587	6.3%
TOTAL	2,337,005	790,693	33.8%	3,744,236	782,534	20.9%	5,829,340	1,493,507	25.6%

Figure 31 – Incidence of Excessive Housing Cost Burden in Texas 1990 (SLIHP, p.120)

"Low-income groups experience a much higher incidence of this housing problem. While approximately 6 percent of non low-income households have excess cost burden, 48 percent of all low-income households, and 69 percent of all extremely low-income households experience this housing problem." *(SLIHP, p.120)*

II.03. 1996 Texas Housing Needs Analysis and Potential Market Solutions

The following analysis seeks to locate the target income-range of a low cost housing initiative to maximize benefit to low-income Texas households, and to be sustainable by the affordable housing market over the period of continued population growth. This analysis does not seek to discover a short-term cure for the housing shortage, but is aimed at finding possible solutions that are do-able within a market framework and can have at least a marginal impact on the low-income housing problem. Long-term, permanent solutions would involve more global and permanent changes in social attitudes and large-scale cooperation among professionals in construction, education and government to improve codes, standards, technologies, market operations and production processes. These topics are beyond the scope of this analysis and need further research on improvement and implementation.

Low cost housing in this analysis is defined by housing affordability standards from the 1999 *Texas Department of Housing and Community Affairs "State of Texas Low-income Housing Plan and Annual Report."* (See section II.02.b.) "Affordable" units are defined as units for which a family would pay no more than 30 percent of their annual income for rent—or 2.5 times their annual income to purchase. *(SLIHP, p.98)*

II.03.a. Barriers to Market Solutions

Discussion at the 1999 *Texas Society of Architects* Convention in October 1999, and in the 1999 *Texas Department of Housing and Community Affairs "State of Texas Low-income Housing Plan and Annual Report"* revealed that efforts to-date at a implementing a low-income housing solution have succeeded marginally at best due to social resistance from higher-income communities (often called "NIMBYism," or Not-In-My-Back-Yard-ism), stringent code requirements, and the lack of market incentives for producers to supply housing at little or no profit — all of which prevent land acquisition and low-cost housing production. Furthermore, government subsidies and charities account for a very small percentage of the low-income housing. (See sections II.02.d. & e.) Because of these barriers and market conditions, a low-cost housing market strategy that calls for increased housing production at price levels well below the market equilibrium point (the point at which the housing supply exactly meets the housing demand) would not be a sustainable strategy and would likely have little impact on the lowest-income need. Market solutions at a larger scale and with specific 'do-able' goals are called for if the building industry is to have a true positive impact on low-income housing need.

II.03.b. "Filtering" as a market strategy for improving housing standards

A potentially more successful strategy, but one that would require large-scale cooperation among low-cost housing professionals and State and Federal Government, would be to increase housing production in the lowest price-range that is still profitable to producers. This would potentially provide a housing surplus in moderate-income price ranges thus driving prices down. This would not immediately benefit the very- and extremely-low income households, but as housing prices fall — if low-cost production can be sustained — over time a process of 'filtering-down' would provide low income households with second-hand but physically adequate housing in price ranges they can afford. *(Lowry, pp.362-4)* Targeting the lowest price profitable for producers increases the likelihood that the filtering-down process will act quickly enough to provide quality second-hand housing that is still 'new' enough to meet livability standards. *(Lowry, p.364)*

II.03.c. Limitations of the filtering process

However, filtering will not benefit the lowest-income households if the market price re-stabilizes too quickly at price levels out of reach for those households. *(Lowry, p.364)* Also, improved technologies must be developed to continually reduce the price of building a housing unit of a given quality level *(Lowry, p.364)* and encourage adequate maintenance of existing housing. *(Lowry, p.370)* If these conditions are met, the optimum target for a low-cost housing initiative (to meet the greatest low-income need) would be income categories that include those renters-by-necessity who would be in the market to purchase the least expensive home that can be built using current building technologies. As those renters are enticed into new owner-occupied housing, and as increased housing supply causes prices to drop, the rental properties would become available to households in the lowest income bracket. *(Lowry, p.364)*

II.03.d. Target Market Size

Figure 32 and *Table 14* show the income distribution according to the *TDHCA* low-income categories. As of 1996, there were an estimated 4.3 million owner-occupied households, 2.5 million renter-occupied, and 157,000 no-cash-rent households in Texas, according to the U.S. Census Bureau. The total number of households was 7 million. *(Census, PPL-47)*

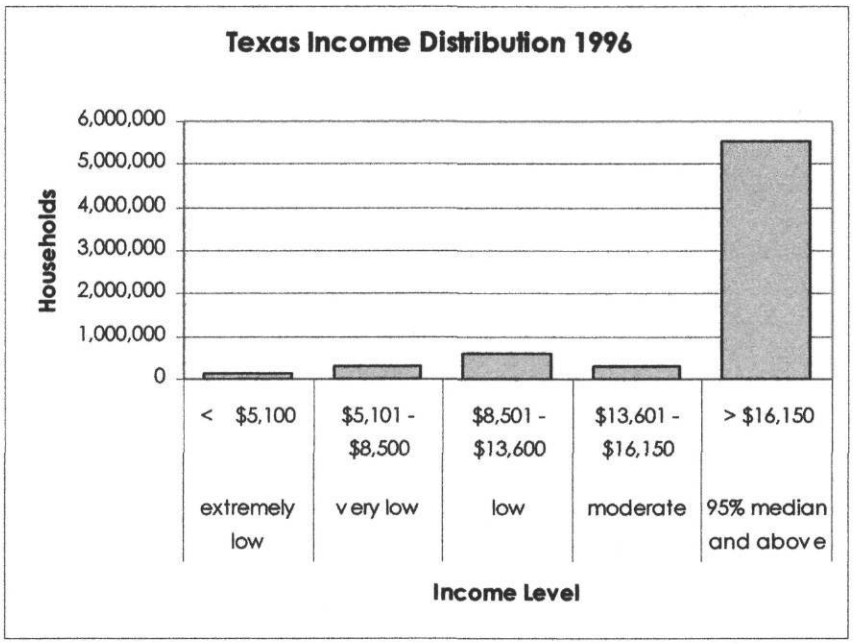

Figure 32 - Household Income distribution according to TDHCA low-income categories (Census, PPL-47)

Table 14—Household Income distribution according to TDHCA low-income categories (Census, PPL-47)

extremely low	< $5,100	144,029
very low	$5,101 - $8,500	280,305
low	$8,501 - $13,600	606,918
moderate	$13,601 - $16,150	312,364
above median income	> $16,150	5,527,148

In Texas in 1996, there were approximately 144,000 extremely low-income households; 280,000 very low-income households; 607,000 low-income households; 312,000 moderate-income households and 5.5 million households that were above moderate-income. Households of moderate-income level or lower numbered 1.3 million—or 23 percent of all households. *(Census, PPL-47)*

The low-income rates are higher in the growth corridor border area, where 28 counties had poverty rates of over 26 percent in 1990. *(SLIHP, p.99)* The population in these areas is projected to increase to 1.7 million by 2010, and 3.5 million by 2030. *(RECenter, Pop.)* For an average household of three persons, the poverty threshold is $13,133 annual household income in 1998 dollars. *(Poverty, p.1)* Over the next quarter century, if the poverty rate remains constant with an average household size of 3 persons in these areas, there will be almost 147,000 households in poverty by 2010 and 300,000 by 2030. *(Census, PPL-47)* The maximum rent affordable to a household living at the poverty threshold is $328 per month, and an affordable home for a household at the poverty threshold would be priced at $32,832 for a two-bedroom home. *(SLIHP, p.99)* However, these units would not be affordable to the vast majority of the 26 percent of households living below the poverty threshold in critical border areas.

Figure 33 shows the housing tenure of Texas households by income distribution in 1996. *(Census, PPL-47)* To arrive at the 1996 data, the *U.S. Census Bureau* used statistical survey data to update the 1990 Census count. For the purposes of this general analysis, 2-percent average trend-lines

were used to simulate smoothing of the curves and give a more accurate picture of the population characteristics.

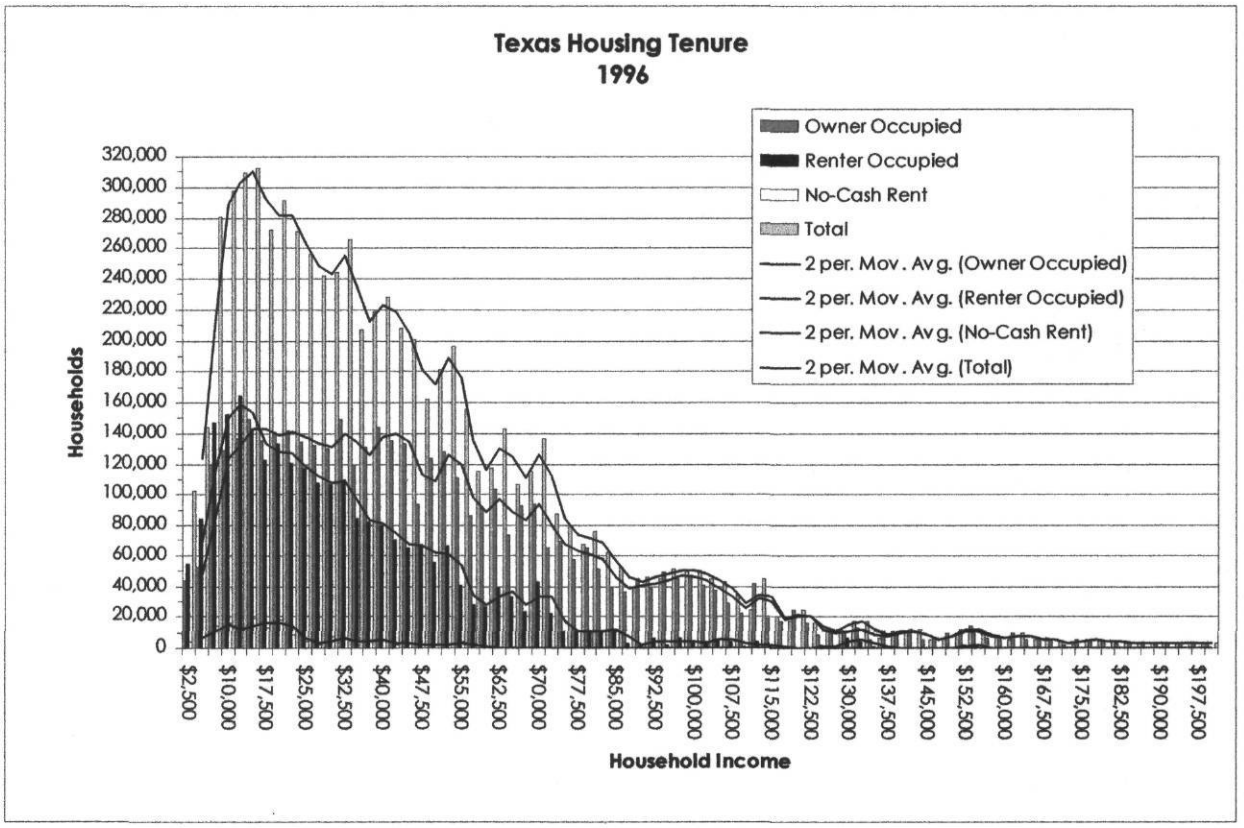

Figure 33—1996 Texas Households: Housing Tenure by Income (Census, PPL-47)

As *Figure 33* reveals, of households with income less than $200,000 a year, 62 percent were owner-occupied, 36 percent were renter-occupied and 2 percent paid no cash rent for their housing. *(Census, PPL-47)*

There were approximately 42,000 owner-occupied households in the $2,500 income category, and the number increased steadily with rising income to level out at approximately 140,000 households between $15,000 and $45,000, then fell steadily with rising income to level again at approximately 15,000 households from $125,000 annual household income and higher. *(Census, PPL-47)*

Rental-occupied housing was prevalent in low-income households, and reached a peak of approximately 165,000 households in the $12,250 income category, then declined with rising income to level out at approximately 3,000 households from $90,000 annual household-income and higher. At approximately $17,500 the majority of households shifted from renter-occupied to owner-occupied. *(Census, PPL-47)*

Non-cash rent households numbered less than 20,000 at income levels below $30,000 annual household income, and less than 10,000 between $30,000 and $60,000. Above $60,000 there were virtually no non-cash rent households. *(Census, PPL-47)*

To identify the target population for maximum potential housing improvement, it would be useful to determine how many households rent by choice for whatever reason. This is an area of potential research for which there is little data. For the purposes of this general exploratory analysis, *Figure 34* uses the percent renting in each category from the *U.S. Census Bureau* 1996 housing tenure data. *(Census)* The trend-line reveals a constant decline in the percentage between $5,000 and $150,000, at which point the slope begins to flatten, stabilizing at approximately 2 percent of rental households at $170,000. This percentage represents a base line of renters who can afford to purchase available housing in their income category, but choose to rent for whatever reason. If we assume this percentage holds true at all income levels, it would be a conservative estimate to subtract the 2 percent renters-by-choice from the renters in each income category. The remainder constitutes those renters who rent by-necessity.

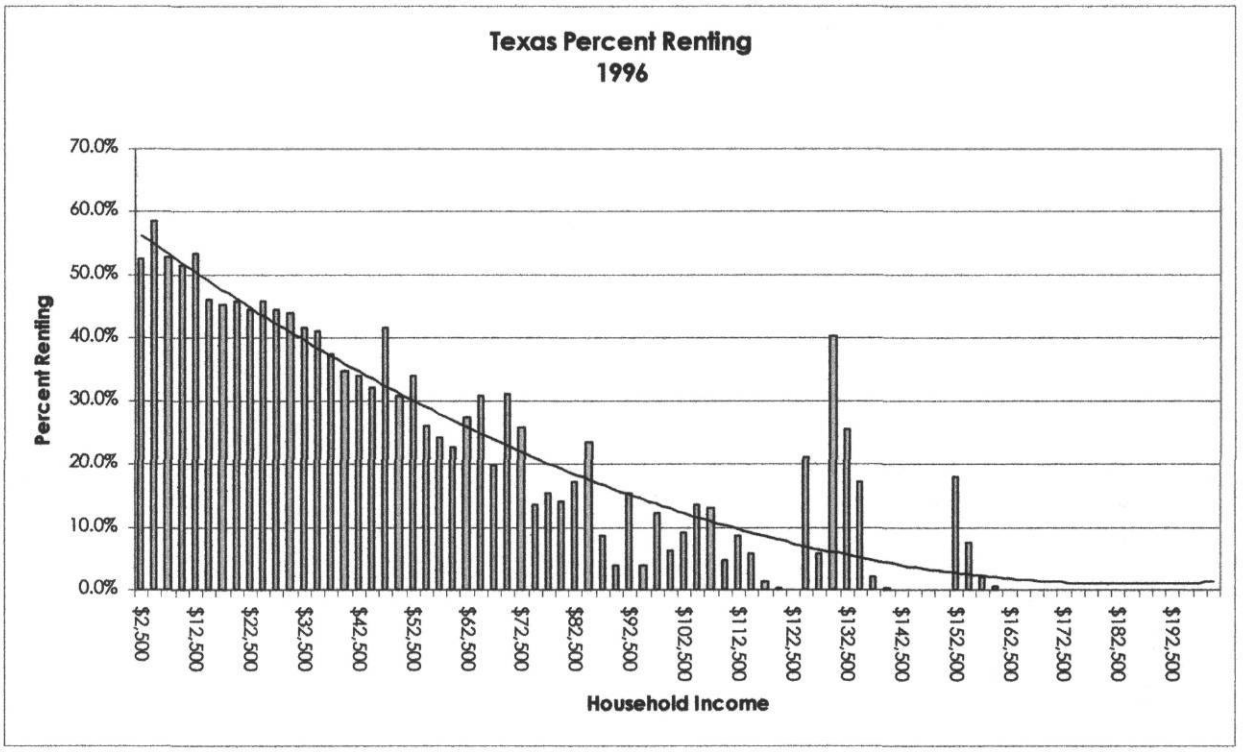

Figure 34—Renter-Occupied Household Distribution by Income (Census, PPL-47)

Once the 2 percent renters-by choice are subtracted from *Figure 33*, one can estimate the rental households in each income category who are renting by-necessity because of a shortage of available housing units in their price range (housing mismatch). This group of renters-by-necessity represents the households that would potentially be in the market for buying a modest home — thus vacating their current home and making it available for lower-income households. *(SLIHP, p.118)* This analysis is particularly concerned with those households in income categories that would qualify them to purchase a home in the lowest price range sustainable by the market.

II.03.e. Potential Target Low-Income Housing Market:

According to the *TDHCA* definition of affordability, a housing unit is affordable to a household if the household would pay no more than 2.5 times their annual income to purchase. *(SLIHP, p.99)* So, in defining the potential target income-level shown in *Figure 35*, Household-$ are computed in [*household income* divided by 2.5, and multiplied by the number of households in each

income category]. This reveals the potential revenue to a housing producer for producing housing in each income category.

Currently, *Habitat for Humanity* is building owner-occupied housing units for approximately $33,000 per unit in Bryan, TX according to the Bryan chapter of Habitat for Humanity (see Appendix D). This suggests that a unit marketed at $31,250 could yield a sustainable profit if improved building technologies were developed which could enable production for under $30,000. As *figure 35* shows, if a producer could produce a house to sell for $31,250 to households with annual income of $12,500 (i.e. $31.250/2.5), the producer could potentially sell 157,000 units (161,000 renters less 2 percent renters-by-choice) for an expected revenue of 5 billion dollars. This potentially translates to a producer-profit of $200-million, or 4% of $5-billion. Government and private lending assistance would be needed to promote a large-scale solution.

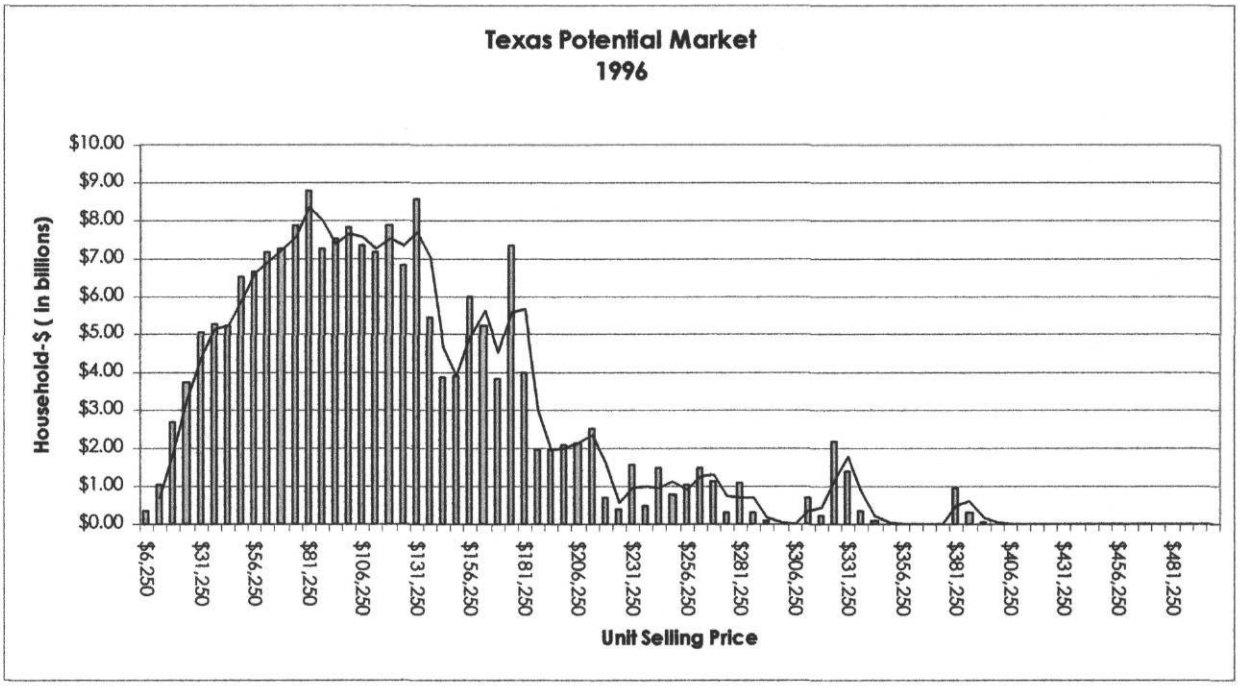

Figure 35—Potential Low-Cost Housing Market measured in Billions of Household-$ (Census, PPL-47)

The above example represents one potentially profitable scenario for housing producers and lending organizations that could have enormous potential to benefit low-income households in Texas, especially if government tax-incentives and lending assistance programs are factored in. If the 157,000 households vacated their rental units in favor of owner-occupied housing, the rental units would become available for occupation by lower-income households. This could set off a rapid, successful and sustainable filtering process if new homeowners are encouraged to maintain their properties through maintenance-incentives. More importantly, *Figure 35* reveals that there is a relatively wide range of low- and very-low income producer target levels that could produce substantial revenues for housing producers if the homes could be supplied in those price ranges. This is an incentive for researchers and producers to push innovations that will decrease production cost while maintaining existing quality standards.

II.04. Summary of Low-Cost Housing Market Analysis

The problem facing the homebuilding industry is two-fold if it is to meet the housing demand. The industry must 1) maintain existing housing supply, and 2) to sustain current rates of increase in new construction. As the housing supply increases over time, the profit margins for producers will fall and it will be less profitable to build new homes. This effect has to be counteracted with an initiative to 1) increase housing durability to maintain current housing supply, and 2) improve technologies to lower the cost of building a home, thus sustaining producer profit margins even as they build cheaper homes. If these conditions are met, increasing supply will remain profitable for producers and the increase in population and gradual rise in per-capita income will sustain the housing market over the next quarter century. In other words, the industry needs to use economies of scale, improved building technologies and streamlined building practices to reduce housing prices to the benefit of the homebuilding industry and low-income Texans alike.

Filtering, as a method of raising housing standards, maximizes the natural level of quality available through market forces and improved building technologies. The filtering method works better as a *natural market strategy initiative* to maximize housing quality *in conjunction with* government policy, than as a legislative policy to control quality. Stated another way – when government programs such as *Section 8* vouchers or tax credits seek to increase demand for housing, increasing housing supply through filtering-based market initiatives works in conjunction to maximize the positive impact of those programs.

If the low-cost housing initiative acted quickly and efficiently to enhance housing-durability and lower building-costs in areas of greatest housing need, this filtering process would entice homeowners of moderate income levels into cheaper-but-better new homes, thus making their previous homes available while the homes are still in adequate condition to meet the needs of lower income households.

The development of such a market initiative will have to be a combined effort in an environment of consensus among building professionals, government and code officials, lending organizations, universities, and other fields related to low-cost housing in order to improve building processes and technologies. The primary goal would be to continually establish and re-establish reduced production costs and housing durability. If a consensus is achieved and the low-cost housing market is continually renewed, the market will have a sustained positive impact on the housing shortage experienced by the growing population of low-income Texans over the next quarter-century.

II.05. References for Part II

U.S. Bureau of the Census, Figures are from Series A (the Preferred Series) as reported in Campbell, Paul R., 1996, "Population Projections for States, by Age, Sex, Race and Hispanic Origin: 1995 to 2025," Report PPL-47, U.S. Bureau of the Census, Population Division. Most of these data are available in files found on the Population Projections section of the World Wide Web's Census Bureau Home Page http://www.census.gov). (Census, PPL-47)

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Lowry, Ira S. Filtering and Housing Standards: A Conceptual Analysis. 1960. (Lowry)

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Part III. Texas Society of Architects Seminar

On October 23, 1999 at the annual meeting of the *Texas Society of Architects* in Galveston, the investigators conducted a seminar with forty-seven T.S.A. members. The purpose was two-fold: 1) to corroborate findings from the Delphi study and 2) to initiate dialogue among influential Texas Architects who can have a substantial impact in promoting low-cost housing to meet low-income needs.

The participants filled out a questionnaire ranking and categorizing the technology issues from the Delphi study. The results can be found below and are summarized in Appendix B. The participants then reviewed the work of the team to date, and offered their concerns and opinions in a wide-ranging discussion.

III.01. T.S.A. Members' Evaluation of Low-Cost Housing Issues

III.01.a. Respondents' Information

Of the 47 members in attendance, 21 completed questionnaires were received, yielding a response rate of 45 percent. The participants' longevity in the housing industry ranged from 2- to 41-years, with an average of 21.1-years' experience in the housing industry.

Table 15 shows the respondents' organizations of affiliation. The organizations were in a variety of disciplines related to affordable-housing.

Table 15 – Respondent's Organization of Affiliation

Associated Organizations	
American Planning Association	National Council of Architectural Registration Boards
A.S.E.S.	R.R.H.H.
American Institute of Architects	Southern Building Code Council
Construction Specifications Institute	Texas Society of Architects
City of Houston Housing Authority	Texas Housing Commission
National Association of Home Builders	United States Air Force

Table 16 shows the positions held by the respondents. Respondents held a variety of positions in architecture, engineering, development, and project management.

Table 16 – Respondents' Job Titles

Respondents' Job Titles
Architect
General Engineer
Principal Developer
Project Manager
Staff Architect
Vice President

The respondents identified the following items as the most significant innovations made in housing technology in the past ten years?

- modular construction, wall components (2)
- computer aided design and world-wide-web
- financing process
- none (3)
- manufactured housing
- increase density and senior housing
- recycled materials (2)
- energy efficiency — lights, water saving, low-E glass, etc.
- electronic systems — including energy
- foam panels

The respondents identified the following 'other topics' in low-cost housing they felt were important areas for discussion/research.

- modular / mass produced
- visualization of "American Dream," demographic segregation by economics
- education of prospective homeowners
- "NIMBYism," homeowner / tenant responsibility & qualifications
- land costs (2)
- state-supported infrastructure

III.01.b. Ranking of Issues

Figure 36 shows the T.S.A. Members' ranking of the low-cost housing issues from the Delphi study, measured in percentages. The smoothness of the curve and the variety of issues indicate a consensus among the respondents that there is no single group of issues that can alleviate the low-cost housing shortage.

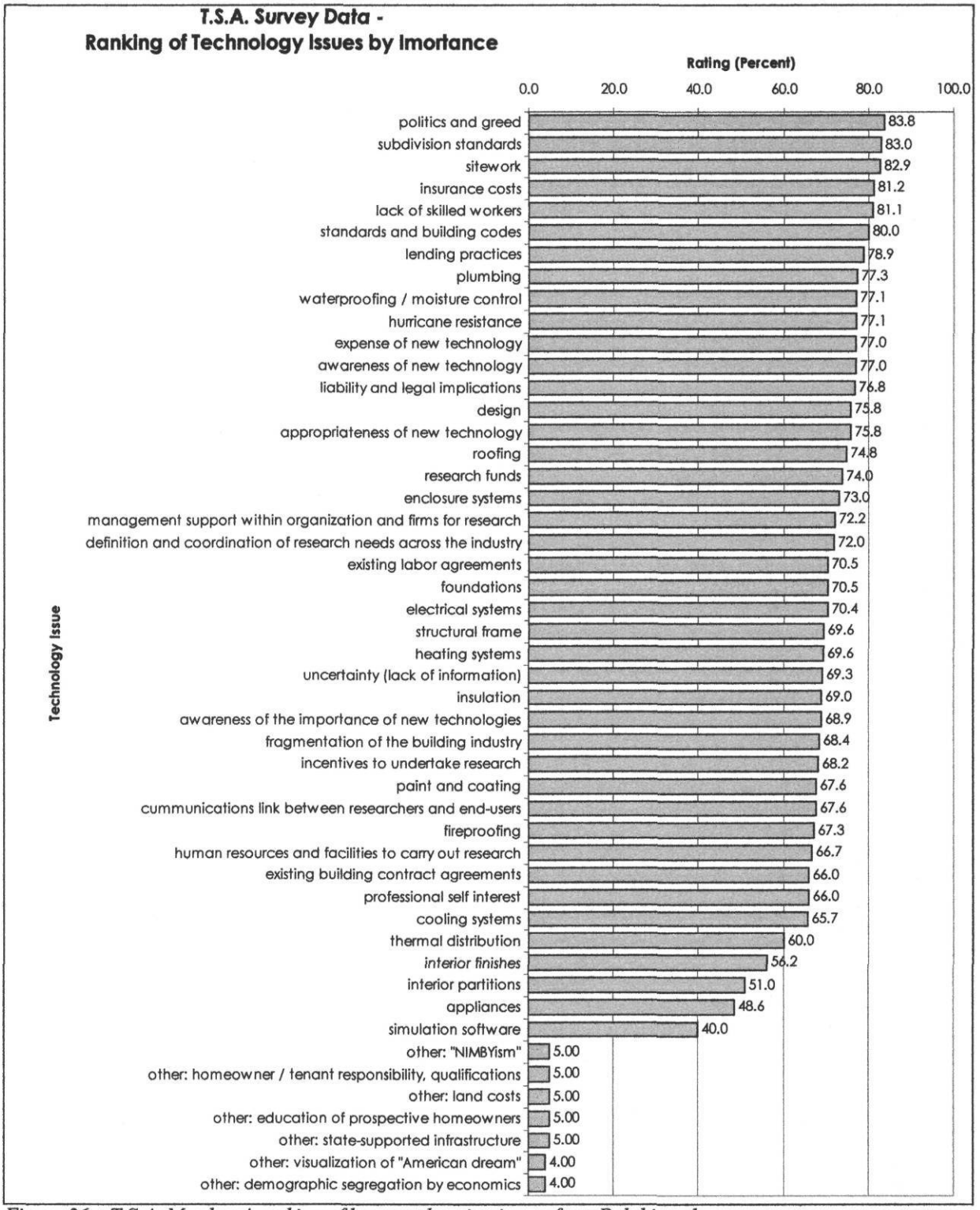


Figure 36 – T.S.A. Members' ranking of low-cost housing issues from Delphi study

III.01.c. Categorizing of Issues

Figure 37 lists the low-cost housing issues from the Delphi study, which the T.S.A. members evaluated. On the questionnaire, the respondents were asked to categorize the issues as either opportunity / need, constraint, or barrier to improvement in low-cost housing. *Table 17* (on pages 63 & 64) shows the results, listed by the item numbers in *Figure 37*.

1 sitework
2 foundations
3 structural frame
4 enclosure systems
5 interior finishes
6 interior partitions
7 roofing
8 waterproofing / moisture control
9 plumbing
10 insulation
11 paint and coating
12 fireproofing
13 cooling systems
14 heating systems
15 electrical systems
16 appliances
17 design
18 simulation software
19 subdivision standards
20 hurricane resistance
21 thermal distribution
22 standards and building codes
23 existing building contract agreements
24 existing labor agreements
25 liability and legal implications
26 uncertainty (lack of information)
27 professional self interest
28 appropriateness of new technology
29 expense of new technology
30 lending practices
31 awareness of new technology
32 insurance costs
33 research funds
34 cummunications link between researchers and end-users
35 definition and coordination of research needs across the industry
36 management support within organization and firms for research
37 human resources and facilities to carry out research
38 incentives to undertake research
39 fragmentation of the building industry
40 awareness of the importance of new technologies
41 lack of skilled workers
42 politics and greed
43 other: modular / mass produced
44 other: visualization of "American dream"
45 other: demographic segregation by economics
46 other: education of prospective homeowners
47 other: "NIMBYism"
48 other: homeowner / tenant responsibility, qualifications
49 other: land costs
50 other: state-supported infrastructure

Figure 37 – List of technology issues from Delphi study

Table 17 – categorizing of low-cost housing issues by T.S.A. members

item #:	1
opportunities/needs	13
constraints	4
barriers	4

item #:	2
opportunities/needs	7
constraints	10
barriers	1

item #:	3
opportunities/needs	11
constraints	6
barriers	2

item #:	4
opportunities/needs	14
constraints	5
barriers	2

item #:	5
opportunities/needs	14
constraints	2
barriers	1

item #:	6
opportunities/needs	13
constraints	4
barriers	2

item #:	7
opportunities/needs	14
constraints	4
barriers	2

item #:	8
opportunities/needs	12
constraints	6
barriers	2

item #:	9
opportunities/needs	10
constraints	8
barriers	3

item #:	10
opportunities/needs	12
constraints	6
barriers	2

item #:	11
opportunities/needs	9
constraints	5
barriers	1

item #:	12
opportunities/needs	9
constraints	7
barriers	2

item #:	13
opportunities/needs	10
constraints	7
barriers	3

item #:	14
opportunities/needs	10
constraints	6
barriers	3

item #:	15
opportunities/needs	11
constraints	6
barriers	3

item #:	16
opportunities/needs	9
constraints	6
barriers	1

item #:	17
opportunities/needs	16
constraints	3
barriers	1

item #:	18
opportunities/needs	8
constraints	3
barriers	2

item #:	19
opportunities/needs	7
constraints	8
barriers	6

item #:	20
opportunities/needs	7
constraints	11
barriers	2

item #:	21
opportunities/needs	9
constraints	7
barriers	2

item #:	22
opportunities/needs	6
constraints	7
barriers	9

item #:	23
opportunities/needs	4
constraints	7
barriers	8

item #:	24
opportunities/needs	4
constraints	7
barriers	8

item #:	25
opportunities/needs	3
constraints	8
barriers	11

item #:	26
opportunities/needs	7
constraints	6
barriers	6

item #:	27
opportunities/needs	6
constraints	6
barriers	6

item #:	28
opportunities/needs	15
constraints	3
barriers	2

item #:	29
opportunities/needs	5
constraints	9
barriers	7

item #:	30
opportunities/needs	6
constraints	10
barriers	7

item #:	31
opportunities/needs	12
constraints	5
barriers	4

item #:	32
opportunities/needs	7
constraints	8
barriers	7

item #:	33
opportunities/needs	11
constraints	1
barriers	6

item #:	34
opportunities/needs	11
constraints	4
barriers	3

item #:	35
opportunities/needs	10
constraints	4
barriers	3

item #:	36
opportunities/needs	11
constraints	5
barriers	2

item #:	37
opportunities/needs	11
constraints	3
barriers	5

item #:	38
opportunities/needs	11
constraints	4
barriers	3

item #:	39
opportunities/needs	7
constraints	10
barriers	4

item #:	40
opportunities/needs	9
constraints	7
barriers	2

item #:	41
opportunities/needs	5
constraints	10
barriers	5

item #:	42
opportunities/needs	6
constraints	8
barriers	9

item #:	43
opportunities/needs	2
constraints	0
barriers	0

item #:	44
opportunities/needs	1
constraints	0
barriers	0

item #:	45
opportunities/needs	0
constraints	1
barriers	0

item #:	46
opportunities/needs	0
constraints	1
barriers	0

item #:	47
opportunities/needs	0
constraints	1
barriers	1

item #:	48
opportunities/needs	0
constraints	1
barriers	1

item #:	49
opportunities/needs	1
constraints	0
barriers	1

item #:	50
opportunities/needs	1
constraints	0
barriers	0

III.02. T.S.A. Discussion

The discussion at the T.S.A. Convention centered around the problems relating to the acquisition of land for low-cost housing development. Members shared first-hand accounts of community- and government-resistance to innovation and low-cost housing development in urban and Texas-Mexico border areas. The statement of emphasis by many T.S.A. members was that the technologies and knowledge are already developed, but cannot be implemented until Code Restrictions and social resistance (commonly called "NIMBYism" — "Not-In-My-Back-Yard-ism") give way and allow for low-cost housing development where low-income jobs are located.

Part IV. Appendices

IV.01. Appendix A. Summary of Delphi Study Results

IV.01.a. Round 1. Respondents' Associated Organizations

Table 18

Associated Organization	
Air Conditioning Contractors of America	International Conference of Building Officials
American Institute of Architects	Insurance Institute for Property Loss Reduction
American Planners Association	International Solar energy Society
American Solar Energy Society	International Standards Organization (Building Subcommittee)
American Society of Safety Engineers	National Association of Home Builders
American Society of Heating, Refrigeration, and Air Conditioning Engineers	National Institute of Building Science
Building Officials and Code Administrators National	Fire Protection Association
Civil Engineering Research Foundation	Southern Building Code Congress International
Certified Safety Professional	Texas Association of Builders
IBSPA	Texas Society of Architecture

IV.01.b. Round 1. Respondents' Job Title

Table 19

Position	
Construction Coordinator	Managing Partner
Director of Building and Thermal Systems Center	Planner
Director of Research	President/CEO
Economist	Principal Architect
Executive Director	Underwriting Manager
Executive Vice President	

IV.01.c. Round 1. Ranking of Opportunities / Needs for Improvement

Table 20

Opportunity/Need	0	1	2	3	4	5	Total
Very Important, Rating: 45 - 55, Frequency: 0							
Important, Rating: 34 - 44, Frequency: 5							
Waterproofing, Moisture Control	0	0	0	2	3	5	43
Heating Systems	0	2	0	1	2	5	38
Structural Frame	0	1	0	3	3	3	37
Enclosure Systems	1	1	0	3	3	3	37
Cool Systems	0	1	0	1	3	4	36
Moderately Important, Rating: 23 - 33, Frequency: 9							
Electrical Systems	0	2	0	4	2	2	32
Appliances	0	1	1	3	2	2	30
Insulation	1	0	3	3	1	2	29
Plumbing	1	1	0	6	1	1	28
Foundation	0	2	1	3	1	2	27
Roofing	0	1	0	3	3	1	27
Interior Partitions	0	2	0	3	0	3	26
Paint & Coating	0	1	2	3	0	2	24
Interior Finish	0	3	1	3	1	1	23
Of Little Importance, Rating: 12 - 22, Frequency: 2							
Fireproofing	0	0	4	3	1	0	21
Sitework	0	1	2	2	1	1	20
Not Important, Rating: 0 - 11, Frequency: 6							
Other: Wholistic "System Design"	0	0	0	0	0	1	5
Energy Efficiency	0	0	0	0	0	1	5
Resource Efficiency	0	0	0	0	0	1	5
Energy Simulation tools	0	0	0	0	0	1	5
Natural Hazard Resistance	0	0	0	0	0	1	5
Education & Training of Builders	0	0	0	0	0	1	5

IV.01.d. Round 1. Ranking of Technological Constraints for Improvement

Table 21

Constraint	0	1	2	3	4	5	Total
Very Important, Rating: 45 - 55, Frequency: 1							
Communication link between researchers and end users.	0	0	1	1	5	4	45
Important, Rating: 34 - 44, Frequency: 5							
Fragmentation of the building industry.	1	0	0	3	2	5	42
Awareness of the importance of new technologies.	0	0	1	4	4	2	40
Research funds from private and/or public sectors.	1	0	0	5	2	3	38
Definition and coordination of research needs across the industry.	1	2		3	3	3	38
Incentives to undertake research.	0	2	1	4	1	3	35
Moderately Important, Rating: 23 - 33, Frequency: 2							
Management support within organizations and firms for research.	1	0	3	3	2	2	33
Human resources and facilities to carry out research.	1	3	2	3	0	2	26
Of Little Importance, Rating: 12 - 22, Frequency: 0							
Not Important, Rating: 0 - 11, Frequency: 2							
Other: Market Driven Education	0	0	0	0	0	1	5
NAHB	0	0	0	0	0	1	5

IV.01.e. Round 1. Ranking of Technological Barriers for Improvement

Table 22

Barrier	0	1	2	3	4	5	Total
Very Important, Rating: 45 - 55, Frequency: 1							
Expense of new technology	0	0	0	1	3	6	45
Important, Rating: 34 - 44, Frequency: 4							
Awareness of new technology	0	0	0	4	3	4	44
Standards and building codes	0	0	1	3	4	2	37
Uncertainty (i.e., lack of information)	0	0	0	2	4	3	37
Lending practices	0	0	2	0	3	4	36
Moderately Important, Rating: 23 - 33, Frequency: 3							
Appropriateness of new technology	2	0	0	3	4	1	30
Liability and legal implications	0	2	2	3	1	2	29
Professional self interest (losing control, work, pay or benefits)	2	0	2	3	2	1	26
Of Little Importance, Rating: 12 - 22, Frequency: 2							
Existing building contract agreements	1	3	0	5	0	0	18
Existing labor agreements	1	2	2	4	0	0	18
Not Important, Rating: 0 - 11, Frequency: 7							
Other: NAHB	0	0	0	0	0	1	5
Market Awareness / Education	0	0	0	0	0	1	5
Inertia	0	0	0	0	0	1	5
Lack of Information	0	0	0	0	0	1	5
Education to Users	0	0	0	0	0	1	5
Insurance Industry Acknowledgement	0	0	0	0	1	0	4
Deed Restrictions	0	0	0	0	1	0	4

IV.01.f. Round 2. Respondents' Associated Organizations

Table 23

Associated Organization	
Air Conditioning Contractors of America	International Standards Organization (Building Subcommittee)
Alliance for Public Technology	National Association of Home Builders
American Institute of Architects	National Institute of Building Science
American Institute of Building Design	National Fire Protection Association
American Society for Testing and Materials	National Low-income Housing Coalition
American Society of Heating, Refrigeration and Air Conditioning Engineers	Texas Association of Builders
Building Officials and Code Administrators	Texas Dept. of Housing and Community Affairs
Insurance Institute for Property Loss Reduction	Used Building Materials Association
International Energy Agency	

IV.01.g. Round 2. Respondents' Job Title

Table 24

Position	
Associates Executive	President (4)
Codes Analyst	Principal Research Scientist
Director (3)	Program Director
Executive Director	Project Manager
Field Manager	Research Architect
For Profit Builder	Vice President
Owner	Vice President Designer

IV.01.h. Round 2. Ranking of Opportunities / Needs for Improvement

Table 25

Opportunity/Need	0	1	2	3	4	5	Total
Very Important, Rating: 77 - 95. Frequency: 0							
Important, Rating: 58 - 76. Frequency: 4							
Sitework	0	1	1	4	6	6	69
Foundation	1	1	2	4	6	4	61
Structural Frame	0	2	2	5	5	4	61
Enclosure Systems	1	1	4	3	5	4	58
Moderately Important, Rating: 39 - 57. Frequency: 9							
Interior Finish	0	2	3	5	2	5	56
Interior Partitions	1	1	4	5	5	2	54
Roofing	1	2	5	4	1	5	53
Waterproofing, Moisture Control	1	3	2	7	3	2	50
Plumbing	2	2	2	5	7	0	49
Insulation	1	2	4	4	5	1	47
Paint & Coating	3	0	4	6	5	0	46
Fireproofing	3	2	4	3	4	2	45
Cool Systems	3	2	7	3	1	2	39
Of Little Importance, Rating: 20 - 38. Frequency: 3							
Heating Systems	2	6	5	1	2	2	37
Electrical Systems	3	5	3	4	2	1	36
Appliances	6	4	3	2	2	0	24
Not Important, Rating: 0 19. Frequency: 5							
Other: Design	0	0	0	0	0	1	5
Simulation Software	0	0	0	0	0	1	5
Subdivision Standards	0	0	0	0	0	1	5
Hurricane Resistance	0	0	0	0	0	1	5
Thermal Distribution	0	0	0	0	0	1	5

IV.01.i. Round 2. Ranking of Technological Constraints to Improvement

Table 26

Constraints	0	1	2	3	4	5	Total
Very Important, Rating: 77 - 95. Frequency: 0							
Important, Rating: 58 - 76. Frequency: 5							
Incentives to undertake research.	0	1	2	4	9	3	68
Fragmentation of the building industry.	0	1	2	2	8	5	68
Communication link between researchers and end users.	1	2	2	4	4	6	64
Definition and coordination of research needs across the industry.	0	1	5	5	4	4	62
Research funds from private and/or public sectors.	1	1	3	6	4	4	61
Moderately Important, Rating: 39 - 57. Frequency: 2							
Awareness of the importance of new technologies.	1	1	4	8	3	2	55
Management support within organizations and firms for research.	2	2	6	3	3	3	50
Of Little Importance, Rating: 20 - 38. Frequency: 1							
Human resources and facilities to carry out research.	4	3	7	3	1	1	35
Not Important, Rating: 0 19. Frequency: 2							
Politics and greed	0	0	0	0	0	1	5
Other: Lack of skilled workers	0	0	0	0	1	0	4

IV.01.j. Round 2. Ranking of Technological Barriers to Improvement

Table 27

Barrier	0	1	2	3	4	5	Total
Very Important, Rating: 77 - 95. Frequency: 0							
Important, Rating: 58 - 76. Frequency: 5							
Expense of new technology	0	1	2	4	5	6	67
Uncertainty (i.e., lack of information)	0	0	1	5	6	5	66
Standards and building codes	2	1	1	3	2	9	65
Awareness of new technology	0	1	4	2	5	6	65
Liability and legal implications	0	3	1	5	3	6	62
Moderately Important, Rating: 39 - 57. Frequency: 5							
Lending practices	0	2	5	3	4	4	57
Existing labor agreements	1	5	5	1	4	2	44
Professional self interest (losing control, work, pay or benefits)	2	4	3	3	2	3	42
Appropriateness of new technology	1	3	7	5	2	0	40
Existing building contract agreements	3	3	3	4	2	2	39
Of Little Importance, Rating: 20 - 38. Frequency: 0							
Not Important, Rating: 0 19. Frequency: 2							
Other: Insurance Costs	0	0	0	0	0	1	5
Politics	0	0	0	0	0	1	5

IV.01.k. Round 2. Item Analysis

IV.01.k.i. Opportunities / Needs

The following item-analysis identifies the change between the Round 1 and Round 2 rankings. The 'increased rankings' list shows the 8 items that moved up in the importance rankings from Round 1 to Round 2, while the 'decreased rankings' list shows the 7 items that moved down. The 'Static rankings' list indicates the 19 items that remained at the same level of importance in both Rounds.

- Increased Rankings:

"Sitework" had a Round 1 rating of 20/55 (36%), the lowest-ranked area from the questionnaire. In Round 2 it moved up 15 in the list to become the highest-ranked area with a rating of 69/95 (73%).

"Interior finish" was ranked 14th in Round 1 with a score of 23/55 (42%), and moved up 9 in the Round 2 ranking to become 2nd, with a rating of 56/95 (59%).

"Foundation" was ranked 10th in Round 1 with a score of 27/55 (49%), and moved up 8 in the Round 2 ranking to become 2nd, with a rating of 61/95 (64%).

"Interior partitions" was ranked 11th in Round 1 with a score of 26/55 (47%), and moved up 6 in the Round 2 ranking to become 6th, with a rating of 54/95 (57%).

"Roofing" was ranked 11th in Round 1 with a score of 27/55 (49%), and moved up 4 in the Round 2 ranking to become 7th, with a rating of 53/95 (56%).

"Fireproofing" was ranked 15th in Round 1 with a score of 21/55 (38%), and moved up 3 in the Round 2 ranking to become 12th, with a rating of 45/95 (47%).

- Static Rankings:

"Paint & coating" was ranked 13th in Round 1 with a score of 24/55 (44%), and moved up 2 in the Round 2 ranking to become 11th, with a rating of 46/95 (48%).

"Enclosure systems" was ranked 4th in Round 1 with a score of 37/55 (67%), and again received a ranking of 4th in Round 2 with a rating of 58/95 (61%).

"Plumbing" was ranked 9th in Round 1 with a score of 28/55 (51%), and again received a ranking of 9th in Round 2 with a rating of 49/95 (52%).

"Structural frame" was ranked 3rd in Round 1 with a score of 37/55 (67%), and again received a ranking of 3rd in Round 2 with a rating of 61/95 (64%).

"Insulation" was ranked 8th in Round 1 with a score of 29/55 (53%), and moved down 2 in the Round 2 ranking to become 10th, with a rating of 47/95 (49%).

- Decreased Rankings:

"Waterproofing/moisture control" was ranked 1st in Round 1 with a score of 43/55 (78%), and moved down 7 in the Round 2 ranking to become 8th, with a rating of 50/95 (53%).

"Cool systems" was ranked 5th in Round 1 with a score of 36/55 (65%), and moved down 8 in the Round 2 ranking to become 13th, with a rating of 39/95 (41%).

"Appliances" was ranked 7th in Round 1 with a score of 30/55 (55%), and moved down 9 in the Round 2 ranking to become 16th, with a rating of 24/95 (25%).

"Electrical systems" was ranked 6th in Round 1 with a score of 32/55 (58%), and moved down 9 in the Round 2 ranking to become 15th, with a rating of 36/95 (38%).

"Heating systems" was ranked 2nd in Round 1 with a score of 38/55 (69%), and moved down 12 in the Round 2 ranking to become 14th, with a rating of 37/95 (39%).

- Write-ins:

"Holistic 'system design'," "Education & training of builders," "Energy efficiency," "Natural hazard resistance" and *"Resource efficiency"* were write-ins on the Round 1 questionnaire as "other" technology areas of important opportunity/need for improvement. *"Design," "Hurricane resistance," "Subdivision standards"* and *"Thermal distribution"* were write-ins on the Round 2 questionnaire. *"Energy simulation tools"* was a write-in on the Round 1 questionnaire and *"Simulation software"* was a write-in on the Round 2 questionnaire.

IV.01.k.ii. Constraints

- Increased Rankings:

"Incentives to undertake research" was ranked 6th in Round 1 with a score of 35/55 (64%), and moved up 5 in the Round 2 ranking to become 1st, with a rating of 68/95 (72%).

- Static Rankings:

"Definition and coordination of research needs across the industry" was ranked 5th in Round 1 with a score of 38/55 (69%), and moved up 1 in the Round 2 ranking to become 4th, with a rating of 62/95 (64%).

"Fragmentation of the building industry" was ranked 2nd in Round 1 with a score of 42/55 (76%), and again received a ranking of 2nd in Round 2 with a rating of 68/95 (72%).

"Human resources and facilities to carry out research" was ranked 8th in Round 1 with a score of 26/55 (47%), and again received a ranking of 8th in Round 2 with a rating of 35/95 (37%).

"Management support within organizations and firms for research" was ranked 7th in Round 1 with a score of 33/55 (60%), and again received a ranking of 7th in Round 2 with a rating of 50/95 (53%).

"Research funds from private and/or public sectors" was ranked 4th in Round 1 with a score of 38/55 (69%), and moved down 1 in the Round 2 ranking to become 5th, with a rating of 61/95 (64%).

"Communication link between researchers and end users" was ranked 1st in Round 1 with a score of 45/55 (82%), and moved down 2 in the Round 2 ranking to become 3rd, with a rating of 64/95 (67%).

- Decreased Rankings:

"Awareness of the importance of new technologies" was ranked 3rd in Round 1 with a score of 40/55 (73%), and moved down 3 in the Round 2 ranking to become 6th, with a rating of 55/95 (58%).

- Write-ins:

"Market driven education" and *"NAHB"* were write-ins on the Round 1 questionnaire. *"Lack of skilled workers"* and *"Politics and greed"* were write-ins on the Round 2 questionnaire.

IV.01.k.iii. Barriers

- Increased Rankings:

"Existing labor agreements" was ranked 10th in Round 1 with a score of 18/55 (33%), and moved up 3 in the Round 2 ranking to become 7th, with a rating of 44/95 (46%).

- Static Rankings:

"Liability and legal implications" was ranked 7th in Round 1 with a score of 29/55 (53%), and moved up 2 in the Round 2 ranking to become 5th, with a rating of 62/95 (65%).

"Uncertainty (i.e. lack of information)" was ranked 4th in Round 1 with a score of 37/55 (67%), and moved up 2 in the Round 2 ranking to become 2nd, with a rating of 66/95 (69%).

"Expense of new technology" was ranked 1st in Round 1 with a score of 45/55 (82%), and again received a ranking of 2nd in Round 2 with a rating of 67/95 (71%).

"Professional self interest (losing control, work, pay or benefits)" was ranked 8th in Round 1 with a score of 26/55 (47%), and again received a ranking of 8th in Round 2 with a rating of 42/95 (44%).

"Standard and building codes" was ranked 3rd in Round 1 with a score of 37/55 (67%), and again received a ranking of 3rd in Round 2 with a rating of 65/95 (68%).

"Existing building contract agreements" was ranked 9th in Round 1 with a score of 18/55 (33%), and moved down 1 in the Round 2 ranking to become 10th, with a rating of 39/95 (41%).

"Lending practices" was ranked 5th in Round 1 with a score of 36/55 (65%), and moved down 1 in the Round 2 ranking to become 6th, with a rating of 57/95 (60%).

"Awareness of new technology" was ranked 2nd in Round 1 with a score of 44/55 (80%), and moved down 2 in the Round 2 ranking to become 4th, with a rating of 65/95 (68%).

- Decreased Rankings:

"Appropriateness of new technology" was ranked 6th in Round 1 with a score of 44/55 (80%), and moved down 3 in the Round 2 ranking to become 4th, with a rating of 40/95 (42%).

- Write-ins:

"Inertia," "Insurance Industry acknowledgement," "Lack of information," "Market awareness / education," "NAHB," "Deed restrictions" and *"Education to users"* were write-ins on the Round 1 questionnaire. *"Insurance costs"* and *"Politics"* were write-ins on the Round 2 questionnaire.

IV.02. Appendix B. Summary of Low-Cost Housing Market and Demographic Analysis

IV.02.a. Counties of Greatest Housing Need

Table 28 shows the critical Texas counties by highest population in 1996. *(Census, PPL-47)*

Table 28

FIPS Code	Area Name	1996 Pop	1996 Avg. Income	County Seat
48	Texas (state)	19,128,261	$17,062	
201	Harris	3,126,966	$22,990	Houston
113	Dallas	2,000,192	$24,760	Dallas
29	Bexar	1,318,322	$17,916	San Antonio
439	Tarrant	1,305,185	$21,501	Fort Worth
141	El Paso	684,446	$12,790	El Paso
453	Travis	683,967	$21,127	Austin
215	Hidalgo	495,594	$10,085	Edinburg
85	Collin	372,445	$25,666	McKinney
121	Denton	348,453	$20,305	Denton
355	Nueces	315,722	$17,783	Corpus Christi
61	Cameron	315,015	$11,042	Brownsville
157	Fort Bend	306,832	$21,049	Richmond
339	Montgomery	245,845	$19,296	Conroe
245	Jefferson	243,733	$19,224	Beaumont
167	Galveston	240,653	$19,363	Galveston
303	Lubbock	232,035	$17,947	Lubbock

IV.02.b. Texas Population Rate by County 1990 - 1998

Table 29 shows the critical Texas counties by fastest population growth from 1990-98. *(Census, PPL-47)*

Table 29

FIPS Code	Area Name	1-Jul-98 Population Estimate	Revised 1990 Census	Change Pop. 1990-98	County Seat
137	Edwards	3,779	2,266	0.489	Rocksprings
373	Polk	50,309	30,687	0.463	Livingston
205	Hartley	5,102	3,634	0.434	Channing
491	Williamson	223,910	139,551	0.421	Georgetown
85	Collin	428,803	264,036	0.411	McKinney
157	Fort Bend	337,798	225,421	0.361	Richmond
19	Bandera	15,754	10,562	0.353	Bandera
339	Montgomery	271,788	182,201	0.349	Conroe
259	Kendall	21,222	14,589	0.346	Boerne
397	Rockwall	37,174	25,604	0.334	Rockwall
427	Starr	55,906	40,518	0.332	Rio Grande
479	Webb	188,166	133,239	0.327	Laredo
301	Loving	114	107	0.318	Mentone
53	Burnet	32,195	22,677	0.312	Burnet
91	Comal	73,391	51,832	0.306	New Braunfels
31	Blanco	8,400	5,972	0.302	Johnson City
325	Medina	37,685	27,312	0.295	Hondo
215	Hidalgo	522,204	383,545	0.292	Edinburg
323	Maverick	48,131	36,378	0.280	Eagle Pass
493	Wilson	31,423	22,650	0.275	Floresville
121	Denton	384,020	273,525	0.274	Denton
75	Childress	7,532	5,953	0.273	Childress
281	Lampasas	17,775	13,521	0.269	Lampasas
209	Hays	88,536	65,614	0.246	San Marcos
21	Bastrop	50,390	38,263	0.224	Bastrop
407	San Jacinto	21,768	16,372	0.219	Coldspring
457	Tyler	20,408	16,646	0.219	Woodville
61	Cameron	326,449	260,120	0.211	Brownsville
221	Hood	37,194	28,981	0.207	Granbury
291	Liberty	65,078	52,726	0.200	Liberty
377	Presidio	8,636	6,637	0.200	Marfa
505	Zapata	11,491	9,279	0.196	Zapata

IV.02.c. Texas Average Household Income by County 1996

Table 30 shows the most critical Texas counties according to lowest average household income. *(Census, PPL-47)*

Table 30

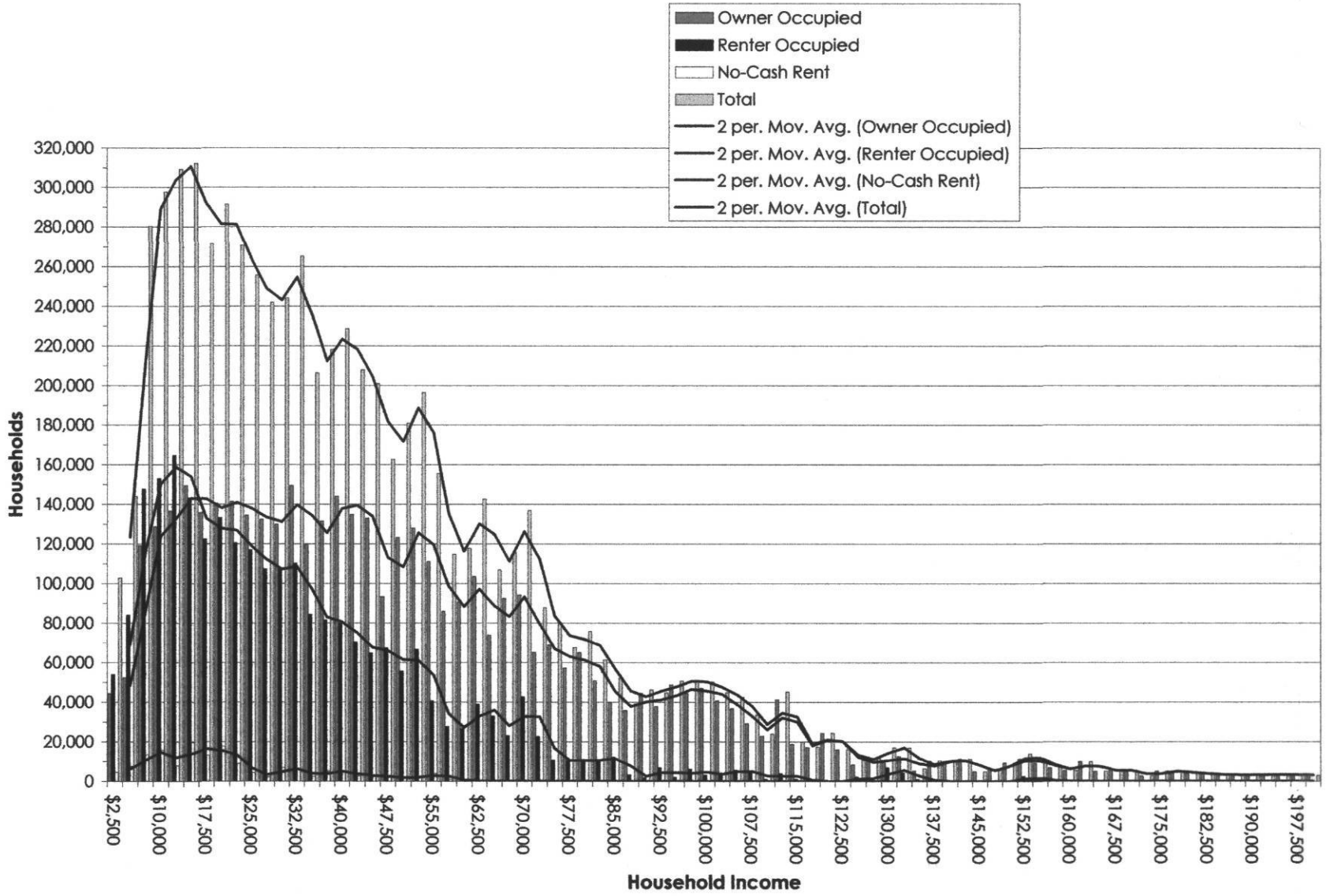
FIPS Code	Area Name	1996 Pop	1996 Avg. Income	County Seat
427	Starr	53,974	$6,306	Rio Grande
323	Maverick	46,563	$7,925	Eagle Pass
507	Zavala	12,322	$8,658	Crystal City
505	Zapata	11,100	$9,055	Zapata
127	Dimmit	10,475	$9,468	Carrizo Spr.
229	Hudspeth	3,265	$9,526	Sierra Blanca
377	Presidio	7,966	$9,958	Marfa
215	Hidalgo	495,594	$10,085	Edinburg
9	Willacy	19,419	$10,092	Raymondville
109	Culberson	3,210	$10,619	Van Horn
479	Webb	176,792	$10,757	Laredo
61	Cameron	315,015	$11,042	Brownsville
163	Frio	15,824	$11,065	Pearsall
131	Duval	13,383	$11,273	San Diego
271	Kinney	3,402	$11,501	Bracketville
465	Val Verde	43,131	$11,503	Del Rio
99	Coryell	74,446	$11,549	Gatesville
47	Brooks	8,493	$11,551	Falfurrias
137	Edwards	3,374	$11,842	Rocksprings
371	Pecos	16,349	$12,094	Fort Stockton
471	Walker	54,417	$12,315	Huntsville
389	Reeves	14,993	$12,351	Pecos
351	Newton	14,259	$12,415	Newton
283	La Salle	6,063	$12,665	Cotulla
141	El Paso	684,446	$12,790	El Paso
407	San Jacinto	19,957	$12,857	Coldspring
431	Sterling	1,411	$13,033	Sterling City
13	Atascosa	35,044	$13,254	Jourdanton
1	Anderson	52,174	$13,335	Palestine
383	Reagan	4,254	$13,409	Big Lake
249	Jim Wells	39,725	$13,643	Alice
463	Uvalde	25,343	$13,674	Uvalde

IV.02.d. Texas Counties of Most Critical Housing Need

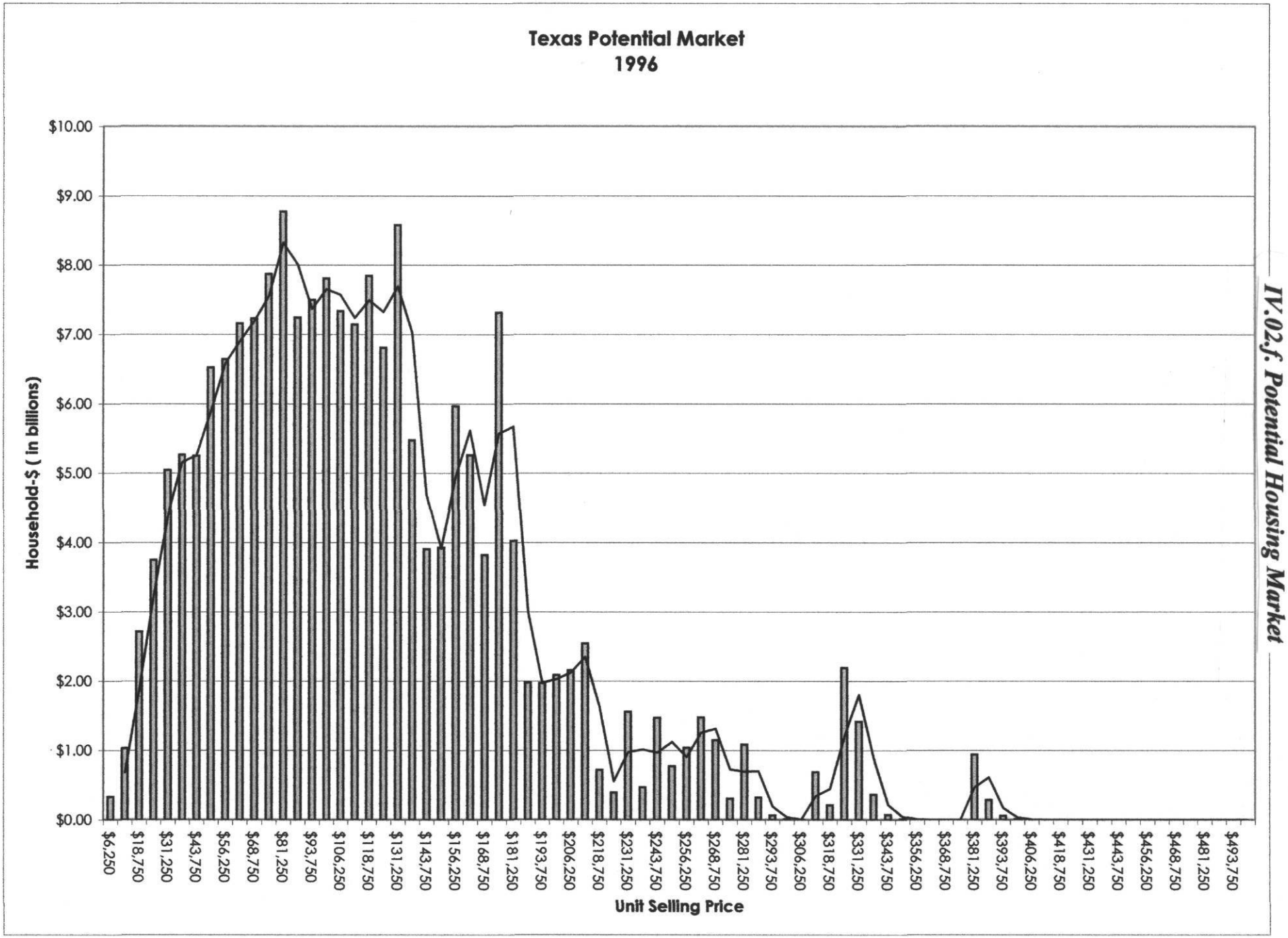
A vast majority of the highest population and fastest growing counties are near the urban centers in Texas: Houston, Austin, San Antonio, Dallas and Fort Worth. There are also 7 counties of high population/fast growth that are in border areas. *(Census, PPL-47)*

The 8 most critical counties that are fast-growth areas coupled with low average income are Edwards, Starr, Webb, Hidalgo, Maverick, San Jacinto, Cameron and Zapata. The 2 most critical counties with greatest population coupled with low average income are Cameron and El Paso. *(Census, PPL-47)*

Cameron (FIPS Code 61, county seat = Brownsville) is of particular note: it has the 12th lowest average income level (1996), 28th fastest population growth (1998), and 12th highest population (1996). El Paso county (FIPS Code 141, county seat = El Paso) has the 25th lowest average income (1996) coupled with the 6th highest population (1996). *(Census, PPL-47)*



IV.02.e. Housing Tenure (i.e. renter- vs. owner-occupied) by Income 1996


Texas Potential Market
1996
Household-$ (In billions)
$10.00
$9.00
$8.00
$7.00
$6.00
$5.00
$4.00
$3.00
$2.00
$1.00
$0.00
$6,250
$18,750
$31,250
$43,750
$56,250
$68,750
$81,250
$93,750
$106,250
$118,750
$131,250
$143,750
$156,250
$168,750
$181,250
$193,750
$206,250
$218,750
$231,250
$243,750
$256,250
$268,750
$281,250
$293,750
$306,250
$318,750
$331,250
$343,750
$356,250
$368,750
$381,250
$393,750
$406,250
$418,750
$431,250
$443,750
$456,250
$468,750
$481,250
$493,750
Unit Selling Price

IV.02.g. Potential Target Low-Income Housing Market:

According to the *TDHCA* definition of affordability, a housing unit is affordable to a household if the household would pay no more than 2.5 times their annual income to purchase. *(SLIHP, p.99)* So, in defining the potential target income-level shown in *Figure 39*, Household-$ are computed in [*household income* divided by 2.5, and multiplied by the number of households in each income category]. This reveals the potential revenue to a housing producer for producing housing in each income category.

Currently, *Habitat for Humanity* is building owner-occupied housing units for approximately $33,000 per unit in Bryan, TX according to the Bryan chapter of Habitat for Humanity (see Appendix E). This suggests that a unit marketed at $31,250 could yield a sustainable profit if improved building technologies were developed which could enable production for under $30,000. As *figure 39* shows, if a producer could produce a house to sell for $31,250 to households with annual income of $12,500 (i.e. $31.250/2.5), the producer could potentially sell 157,000 units (161,000 renters less 2 percent renters-by-choice) for an expected revenue of 5 billion dollars. Government and private lending assistance would be needed to promote a large-scale solution.

IV.03. Appendix C. Summary of T.S.A. Seminar findings

IV.03.a. Respondents' Associated Organizations

Table 31

Associated Organizations	
American Planning Assiciation	National Council of Architectural Registration Boards
A.S.E.S.	R.R.H.H.
American Institute of Architects	Southern Building Code Council
Construction Specifications Institute	Texas Society of Architects
City of Houston Housing Authority	Texas Housing Commission
National Association of Home Builders	United States Air Force

IV.03.b. Respondents' Job Titles

Table 32

Respondents' Job Titles
Architect
General Engineer
Principal Developer
Project Manager
Staff Architect
Vice President

IV.03.c. Ranking of Low-Cost Housing Technology Issues

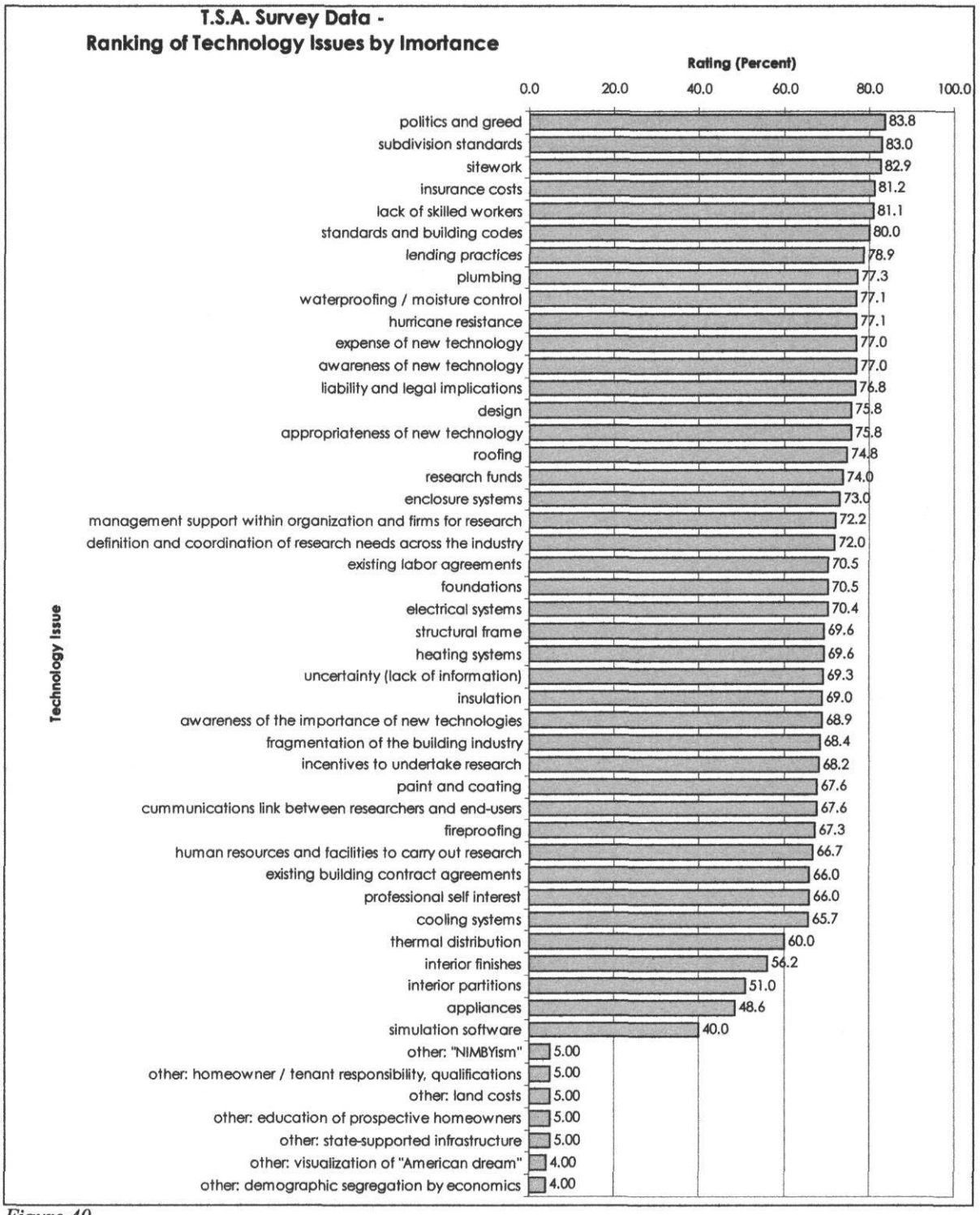


Figure 40

IV.04. Appendix D. Other Items of Interest

IV.04.a. Potential Funding Sources and Affordable Housing Program Listing

SOURCE: Real Estate Center, Texas A&M University, Affordable Housing Programs Resource Guide. October 1998. (RECenter)

Jack C. Harris, Research Economist at the *Texas A&M University Real Estate Center* has produced the *Affordable Housing Programs Resource Guide, Technical Report 1262*, which lists contact information for a variety of affordable-housing programs. Listed below are the *Program Listing,* which lists the affordable-housing programs and the *Housing Assistance Resource Table,* which categorizes the programs. *(RECenter)*

Affordable Housing Program Listing *(RECenter)*

Organization and Program Name	Short Title
Department of Energy (DOE)	
Weatherization Assistance for Low-Income Persons	DOE-Weather
Federal Home Loan Bank (FHLB)	
Affordable Housing Program	FHLB-AHP
Community Investment Program	FHLB-CIP
Federal Home Loan Mortgage Corporation (FHLMC)	
Expanding Markets Program	FHLMC-EM
Federal National Mortgage Association (FNMA)	
Community Lending Program	FNMA-CL
Flexible 97	FNMA-Flex97
Home Improvement Mortgage Loan	FNMA-HIML
Department of Health and Human Services (HHS)	
Low-Income Home Energy Assistance	HHS-Energy
Housing and Urban Development (HUD)	
HOME Investment Partnerships Program	HUD-HOME
Housing Counseling Assistance Program	HUD-HCAP
Manufactured Home and Lot Purchase Loans	HUD-MHL
Section 8 Housing Assistance	HUD-8
Section 202 Supportive Housing for the Elderly	HUD-202
Section 203b Mortgage Insurance	HU203b
Section 203i Mortgage Insurance for Homes in Outlying Areas	HUD-2031
Section 203k Mortgage Insurance	HUD-203k
Section 207(m) Manufactured Home Parks	HUD-207m
Section 221(d) Single Room Occupancy	HUD-221d SRO
Section 221(d)(2) Mortgage Insurance	HUD-221d2
Section 221(d)(3) and (4) Rental and Cooperative Housing	HUD-221d3/4
Section 223(e) Mortgage Insurance for Older, Declining Areas	HUD-223e
Section 223(f) Multi-family Housing	HUD-223f
Section 231 Rental Housing for the Elderly	HUD-231
Section 234(c) Mortgage Insurance for Condominium Units	HUD-234c
Section 245 Graduated Payment Mortgage Insurance	HUD-GPM
Self-Help Homeownership Opportunity Program	HUD-SHOP
Title I Property Improvement Loans	HUD-Improv
Rural Housing Service (RHS)	
Section 502 Direct Rural Housing Loans	RHS-D502

Section 502 Guaranteed Rural Housing Loans	RHS-G502
Section 504 Rural Housing Loans and Grants	RHS-504
Section 515 Rural Rental Housing	RHS-515
Section 523 Rural Self-Help Housing Technical Assistance	RHS-523
Section 523 and 524 Site Loans	RHS-523/4
Section 533 Rural Housing Preservation Grants	RHS-533
Section 538 Rural Rental Housing	RHS-538
Texas Department of Housing and Community Affairs (TDHCA)	
HOME Investment Partnerships Program	TDHCA-HOME
Housing Trust Fund	TDHCA-Trust
Low Income Housing Tax Credits	TDHCA-LIHTC
Mortgage Revenue Bond Program	TDHCA-Bond
Neighborhood Partnerships for Texans	TDHCA-Partners
Texas Veterans Land Board (TVLB)	
Texas Veterans Land Program	TVLB - Land
Texas Veterans Housing Assistance Program	TVLB - VHAP
Texas Veterans Home Improvement Program	TVLB - VHIP

Housing Assistance Resource Table *(RECenter)*

Type of Applicant	Development of Affordable Single-family Homes	Purchase of Single-family Homes	Rehabilitation or Repair of Homes	Acquisition or Development Of Rental Housing	Other Purposes
Individuals and families		FHLMC-EM FNMA-CL FNMA-Flex97 FNMA-CL HUD-MHL HUD-203b HUD-203i HUD-203k HUD-221d2 HUD-234c HUD-GPM RHS-502 TDHCA-Bond TVLB-VHAP	FHLMC-EM HUD-203k HUD-221d2 HUD-lmprov RHS-D502 RHS-G502 RHS-504 TVLB-VHIP HUD-223e		FNMA-CL HUD-Improv TVLB-Land
Developers and investors	TDHCA-Bond	FNMA-HIML TDHCA-Trust		HUD-207m HUD-221d3/4 HUD-22IdSRO HUD-223f TDHCA-Bond TDHCA-LIHTC HUD-231	TDHCA-Partners
Lenders	FHLB-AHP FHLB-CIP	FHLB-AHP FHLB-CIP	FHLB-AHP	FHLB-AHP HUD-221 d3/4	FHLB-CIP HUD-223e
Non-profit organizations	HUD-SHOP TDHCA-Bond TDHCA-Trust	TDHCA-Trust	RHS-523 RHS-533	HUD-221Dsro TDHCA-LIHTC TDHCA-Trust HUD-202 HUD-231	RHS-523/4 TDHCA-Partners HUD-202
Local government units and organizations	HUD-HOME TDHCA-Trust TDHCA-HOME	HUD-HOME TDHCA-HOME TDHCA-Trust	HUD-HOME RHS-523 TDHCA-HOME RHS-533	HUD-HOME HUD-221dSRO HUD-22d3/4 HUD-223f TDHCA-Trust HUD-231	HUD-8 RHS-523/4 TDHCA-Partners
States	HUD-HOME	HUD-HOME	DOE-Weather HUD-HOME	HUD-HOME	HHS-Energy

IV.04.b. Habitat For Humanity Construction Costs

SOURCE: Habitat for Humanity, Bryan Chapter, Bryan Texas, November 1999.

Table 33 – Habitat for Humanity construction costs - Bryan, Texas.

building materials	$12,131.29
foundation	$4,640.00
land	$4,370.00
plumbing	$3,315.94
HVAC	$2,075.98
legal permits / insurance	$1,714.55
driveway	$1,581.50
electrical	$1,393.60
appliances	$863.67
site utilities	$53.10
TOTAL	$32,139.63

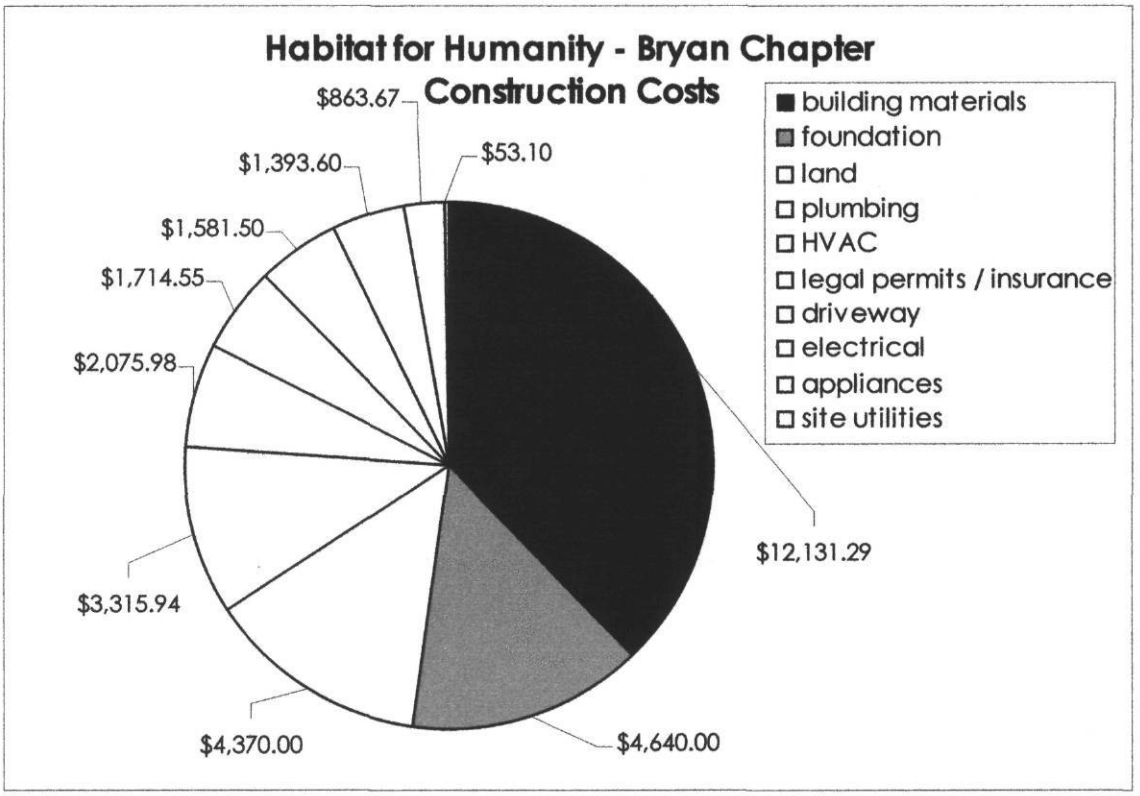


Figure 41 – Habitat for Humanity construction costs, Bryan, TX.

IV.04.c. National Association of Home Builders' "PATH" Durability Research

SOURCE: NAHB Research Center, Inc., March 1999 National Forum on PATH Durability Research. (PATH)

In March 1999, the *National Association of Home Builders Research Center* hosted a National Forum on PATH Durability Research, which was sponsored by the *National Institute of Standards and Technology* and was intended to "expand the development and use of new technologies that will make American homes stronger, safer and more durable; more energy efficient and environmentally friendly; easier to maintain, and less costly to operate." *(PATH, p.i)* Below is the abstract from the *Report of Proceedings and Results* outlining the forum objectives.

ABSTRACT

A National Forum on PATH-Durability Research was held in Upper Marlboro, Maryland, on March 31, 1999. The Forum was sponsored by the National Institute of Standards and Technology and hosted by the NAHB Research Center. Participants were drawn from many sectors of the home building industry including manufacturers, insurers, and practitioners. The objectives of the Forum were to:

- Describe PATH-Durability objectives,
- Set out initial research ideas, and
- Solicit feedback to refine the issues, help allocate resources and guide a longer-term durability plan.

After a plenary session to discuss objectives and identify issues associated with durability, each participant was assigned to one of four working groups. The groups were tasked with identifying the major issues associated with improving durability of the envelope of homes and describing high priority research projects that would address these issues. Two groups dealt with roofing systems and the other two with wall systems. Each working group presented its recommendations in a final plenary session.

Five high priority projects based on results of the working groups were:

- Define a Durability Rating System Concept
- Develop a Framework for a Wall and Roof System Model
- Determine Durability Performance of Current Components, Materials and Systems
- Develop Methods for Evaluating Service Life Performance of Sealants used in Residential Construction
- Develop a Method for Evaluating Service Life of Steep-sloped Roof Coverings Used in Residential Construction

Keywords: residential construction; product durability; PATH-Durability; service life; roofing durability; wall system durability; building envelope; durability rating; forum.

Figure 42 – PATH-Durability abstract (PATH, p.v)

IV.04.d. Useful Internet Sites

SOURCE: Real Estate Center, Texas A&M University, Affordable Housing Programs Resource Guide. Oct. 1998.

List of HUD-approved **Counseling Agencies**
www.hudhcc.org

Search for HUD-approved **Lenders**
www.hud.gov/l1/code/1lslcrit.html

FHA Connection
Entp.hud.gov/clas/

HUD Local **Median Incomes**
www.fanniernae.com/Lender/hudlimit.html

Federal National Mortgage Association **(Fannie Mae)**
www.fanniernae.com

Federal Home Loan Mortgage Corporation **(Freddie Mac)**
www.freddiemac.corn

Federal Home Loan Bank Dallas
www.fhlb.com

Texas Department of Housing and Community Affairs
www.tdhca.state.tx.us

Texas Low Income Housing Information Service
www.texashousing.org

Texas Veterans Commission
www.main.org/tvc

Rural Housing Service
www.rurdev.asda.gov/agency/rhs
