METHODOLOGY FOR EVALUATING AND RANKING MANUFACTURED HOUSES BASED ON CONSTRUCTION VALUE

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Construction Management Program

June 2003

ABSTRACT

Methodology for Evaluating and Ranking Manufactured Houses Based On Construction Value

As a manufactured housing homebuyer or any other homebuyer, ones desire would be to have a house that lasts forever. While this is impossible, it is plausible that one may find a house with a capacity to last longer and have a decent resale price. It is known that all manufacturers do not produce a similar product and there are many variations. There are variations mainly in the quality of materials used, construction techniques, and installation procedures, etc. This makes the decision of purchasing, given the variety of homes, difficult for the homebuyer. Within a specific price range, most homebuyers decide the purchase of a house based on its appearance or the reputation of the manufacturer, rather than on technical aspects, which later causes buyer's remorse.

This study focuses on the construction value of a manufactured house which is defined as the proportion of the overall value of the house that is obtained from the construction materials; the processes involved in putting them in place and the post construction assurances against structural or functional damages caused by materials and/or poor craftsmanship, excluding normal wear and tear. For a more realistic approach towards decision-making, this study provides a framework for evaluation of manufactured houses based on a defined robust goal, which is its construction value and utilizes numerical scoring that translates the qualitative information into a quantitative approach. This scoring model facilitates the decision making process which was used on a case study for comparing and ranking five manufactured homes of different brands of the same level.

To My Dearest Parents

ACKNOWLEDGEMENT

My initial and sincere thanks to GOD for nourishing my mind with right thoughts, providing me with patience, and generating the perseverance required for this accomplishment. I offer my deepest gratitude and appreciation to my dearest parents who have always encouraged and supported me in pursuing my ambitious dreams.

I am very thankful to Professor Tariq Abdelhamid, my advisor and major professor, who has always been a cheerful friend, a guardian and a mentor. His ever-motivating attitude and thought provoking advices have always inspired me to bring out the best within me. Dr. Tariq has always encouraged my skepticism and allowed me to fulfill my research desires. He has been a rock I held on to during all my academic and personal rough times at school. I could write a book narrating many experiences with him but would certainly fall short of words of gratitude for him.

I wish to thank my committee members, Professor Matt Syal and Professor Srinivas Talluri, who provided me with advice and encouragement in all the stages of this dissertation. Dr. Syal has been a source of encouragement and support not only for this research but also throughout my graduate studies. His timely suggestions have given a professional touch to my dissertation. Dr. Talluri helped me in understanding the AHP model and always found time for my queries although he always had a busy schedule.

A special thanks to Mr. Richard Holman (PFS), Mr. Adam. Holman (PFS), and Mr. Nick Yost (TRA) for willing to participate in this research by providing information and their expertise in the Manufactured Housing Industry. Finally I am thankful to my department faculty and staff, the CMID staff and all the friends I have made at Michigan State University and back home, for creating a delightful ambience, which helped me to smoothly and successfully complete my Masters in Construction Management.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

1 INTRODUCTION

1.1 Motivation

Shelter has taken various forms since the Stone Age. It began with man trying to seek dwelling in caves created from available tools. If a person from the Stone Age was to be brought to the twenty first century, it simply cannot be explained how the person would feel viewing the current styles of shelter.

With time, techniques and materials adopted to create shelter have also changed. Shelter is now termed 'house' and is aesthetically and functionally different from the earlier caves. These homes have typically been built on site. It was a commendable achievement of the twentieth century to manufacture houses in a factory environment. What once was a dream is now a very practical process. A Manufactured House that is built in factories and installed at site. Born as trailer coaches before World War II, manufactured homes have come a long way to acquire a recognizable position in the housing industry.

Prior to 1974, manufactured homes were known as mobile homes and were provided with an intention for temporary and recreational housing. There was a high demand of mobile homes in the 1960s and 1970s. These mobile homes were then transformed into Manufactured Houses in 1974, after Congress passed the National Mobile Home construction and Safety Act, also known as the HUD code.

In the 1990s, there was a very high demand for manufactured homes, although it has shown a downward trend in recent years. Various types of factory-built homes and their share in the housing sector are indicated in Table 1.1. As the table illustrates, in 1998, manufactured housing formed 22.7% of the housing sector, followed by modular,

panelized, and pre-cut housing sectors. Affordability and a variety of choices available to the homebuyer are the major factors for this success.

Housing Type	1986	1993	1998	2001
Precut	3.0%	3.3%	3.3%	3.2%
Panelized	7.0%	6.7%	6.3%	6.2%
Modular	2.4%	3.3%	3.4%	2.9%
Manufactured	16.3%	18%	22.7%	18.9%

Table 1.1 Share of factory built homes in the total housing sector (Willenbrock 1998, AUTOB 2002)

Table 1.2 provides census information of manufacturers and manufactured homes produced during the period of 1994 to 1999.

Year	Total Units Produced	Number of Plants Producing Units
1994	290,900	269
1995	319,400	285
1996	337,700	313
1997	336,300	323
1998	373,700	330
1999	338,200	337

Table 1.2 Increase in units produced and plants (Census, 2000; MHI-3)

A close examination of Tables 1.1 and 1.2 indicates that the demand trend is gradually declining despite an increase in the number of plants. There are different reasons behind this decline. Some analysts have concluded that it is because of the world wide economic crunch, while some are of the opinion that the site-built homes are now equally cost competitive with similar or better features for a homebuyer's choice. Negative publicity is also one of the other reasons leading to the declining sales of manufactured houses. There are large numbers of homes that have been repossessed due to the homeowners breaching their mortgage agreements. These situations have lead the financial institutions to be wary of providing loans as there are myriad of manufactured houses that lying as repossessed stock.

With changing trends in civilization, the perception of an individual towards quality has also changed considerably. Today, quality plays a significant role in all processes of any industry. With the changing trends in construction materials and techniques expectations of consumers have risen with time and they seek the best available product in market. Competition has also increased with time and every manufacturer or site builder tries to bring out the best within their scope. One thing is clear that multifarious options have left a consumer confused to decide in selecting the best option.

1.2 Need Statement

A manufactured house has many factors that affect its value over a period of time. As a manufactured housing homebuyer or any other homebuyer, ones desire would be to have a house that lasts forever. While this is impossible, it is plausible that one may find a house with a capacity to last longer and have a decent resale price.

There is a myriad of manufacturers and manufacturing plants that produce houses. It is known that all manufacturers do not produce a similar product and there are many variations. There are variations mainly in the quality of materials used, construction techniques, and installation procedures, etc. It should be noted that all manufacturers use materials conforming to Federally promulgated specifications, known as the HUD code. According to the HUD's code, specifications could be met as a minimum requirement, which lowers the durability and reliability aspect of a product. This makes the decision of purchasing, given the variety of homes, difficult for the homebuyer.

Within a specific price range, most homebuyers decide the purchase of a house based on its appearance or the reputation of the manufacturer, rather than on technical

aspects. However, a manufactured house is completed only with a combination of materials and techniques, and special processes, transportation and installation. In addition to cosmetic, aesthetic, and amenity items provided in a house the factors mentioned also affect the value of the house. The manufactured homebuyer should take all these aspects, from chassis fabrication to the installation of the house on site, into consideration.

What is the value of any house? Clearly there are many facets to the value of a house. But the customer perception of the value of house is mainly the potential appreciation value. This value is related to the dollar value of the house and governing economic conditions. What goes unnoticed is the 'construction value' of any house, which is affected by the parameters of the manufacturing process as well as the installation of the house and associated warranty. Construction value also contributes to the appreciation value of the house. Construction value can be defined as the proportion of the overall value of the house that is obtained from the construction materials; the processes involved in putting them in place and the post construction assurances against structural or functional damages caused by materials and/or poor craftsmanship, excluding normal wear and tear.

Because a house is made up of different subsystems such as, structural, mechanical, electrical and so on, each sub-system contributes differently to the construction value of the house. In addition, each sub-system is itself further affected by the choice of items that are combined to produce it.

For a homebuyer it is a very difficult task to evaluate a house based on all the parameters governing the construction value of a manufactured house. Literature on

factors that need to be considered while buying a manufactured house in the form of checklists is available (Burnside, 2002). There are also comparisons between homes made based on three levels of construction – low, average and quality construction (Eaton, 2002). These levels have been primarily used for assessment of material quality, thus overlooking other subsystems that need to be considered in making a decision about the construction value of a house. The relative importance of these sub-systems needs to be determined and factored in the decision of buying a particular house versus another. A model is needed to enable the assessment of a manufactured house based on all sub-systems and their relative contribution towards the construction value of a house.

For a given level of manufactured house, entry, median or luxury, it should be possible to make a comparison between several manufacturers producing the same level of homes. The construction value of a house should be evaluated quantitatively and not only qualitatively. The consumer should be able to carry out a fair quantitative comparison between houses based on their construction values to gain more information upon which to make decisions during the purchase of a manufactured house.

1.3 Research Goal and Objectives

The goal of this research is to formulate a model for the homebuyers that will rank manufactured houses based on their construction value.

To attain this goal the following objectives were proposed and performed:

1. Map the manufactured house construction process and collect comprehensive data on construction value of a manufactured house.
2. Develop a model to rank homes of a similar level based on their construction values. This objective involves:

Step 1: Organizing the entire process of manufactured houses into relevant sub-systems and relate various attributes contributing to these sub-systems as items.

Step 2: Generating a checklist based on these sub-systems and items that contribute or affect the construction value of a manufactured house.

Step 3: Establishing a methodology to determine the relative importance of each sub-system contributes towards the construction value of a manufactured house.

1.4 Research Scope

The scope of this research was limited to developing a model that would help comparing manufactured houses based on their construction values. This research does not address economic value of a house represented by its cost, appreciation and resale value. A detailed manufactured house process was studied on manufactured homes. "Middle of the line" level houses were considered for the purpose of comparison between houses based on their construction values. A checklist was formulated based on the study and each item within the checklist was numerically weighted. The cumulative ranking for individual manufactured homes was obtained by using a quantitative model based on the Analytical Hierarchical Process (AHP). Five manufactured houses from different manufacturers were compared based on the construction values that were obtained from the model.

Parts of this research overlapped with a research project sponsored by the Ford Foundation through Consumers Union.

1.5 Dissertation Overview

This research thesis is presented in five chapters. Chapter 1 introduced the evolution of manufactured homes. Decline in the sales of manufactured homes, and its causes were discussed. A need statement was formulated. The research goal and objectives were also presented along with the research scope.

In Chapter 2, a background on the manufactured housing industry and processes is discussed. The chapter also presents the Analytic Hierarch Process model.

Chapter 3 outlines the methods and tools that were used to achieve the set goal of the research. Detailed methodology and approach for each objective is presented. A trial model is demonstrated using information on two house brands.

A comprehensive ranking model, which includes all important systems and sub-systems in a manufactured housing process, is provided in Chapter 4. A detailed checklist, which encompasses items in a manufactured house contributing to the construction value of the manufactured house, is also presented. Finally, the five different manufactured house brands of the same level (medium level) are compared and ranked based on their construction value.

Chapter 5 concludes this research by providing contributions of this research and outlines the areas of future research.

CHAPTER 2

2 LITERATURE REVIEW

In Chapter 1, it was proposed to develop a model to evaluate manufactured houses based on their construction value. It was argued that the existing literature on comparison of manufactured houses is not satisfactory and insufficient, as the comparison does not consider all the sub-systems of the manufactured house. Also, existing methods only provide qualitative comparisons and neglect other significant aspects of a manufactured house, which could be quantitatively compared.

This chapter introduces the reader to frequently used terminology in the manufactured housing industry, the components of a manufactured house, the manufacturing process, existing literature on comparison of manufactured homes and the Analytic Hierarchy Process (AHP) developed by Saaty (1980) on which the final model for evaluating manufactured homes will be based.

2.1 Terminology

Following are standard terms used in the manufactured housing process.

2.1.1 Housing and Urban Development (HUD)

HUD is the government authority that regulates the manufactured housing industry. It is because of the existence of this body that the manufactured housing has come up to standards similar to site built homes. All homes manufactured after 1976, have to follow the HUD code and it is mandatory to have a HUD seal on every house prior to leaving the plant.

2.1.2 State Administrative Agency (SAA)

It is the agency of a state, which has been approved or conditionally approved to carry out the state plan for enforcement of the standards laid down by the HUD in section 623

of the Act, 42 U.S.C. 5422 and subpart G of HUD code 3282. This agency represents HUD in every State and is responsible for the inspection procedures and consumer complaints regarding manufactured homes for any particular State.

2.1.3 Design Approval Primary Inspection Agency (DAPIA)

This is an agency that evaluates manufactured house designs and quality control procedures. Their main role is to certify that designs conform to the HUD requirements.

2.1.4 Production Inspection Primary Inspection Agency (IPIA)

This agency evaluates the ability of manufactured house manufacturing plants to follow approved quality control procedures and provides ongoing surveillance of the manufacturing process. They are regarded as the 'police' in the manufactured housing industry. They are responsible for inspecting every unit being manufactured before leaving the plant and provide HUD labels indicating that the house is inspected and ready for installation.

2.1.5 Manufacturer

Any person involved in manufacturing or assembling manufactured homes, including any person engaged in importing manufactured homes for resale. Manufacturer is the most responsible person or firm for the product leaving the manufactured house plant.

2.1.6 Retailer

Any person engaged in the sale, leasing, or distribution of new manufactured homes primarily to persons who in good faith purchase a manufactured house for purposes other than resale.

2.1.7 Consumer

It is the first person purchasing a manufactured house in good faith for purposes other than resale. This person is the one who invests money in anticipation of a house that meets his/her expectations and desires in terms of usability, durability and reliability.

2.1.8 Manufactured House

It is defined as a structure, transportable in one or more sections, which in the traveling mode, is eight body feet or more in width or forty body feet or more in length, or, when erected on site, is three hundred twenty or more square feet, and which is built on a permanent chassis and designed to be used as a dwelling with or without a permanent foundation when connected to the required utilities, and includes the plumbing, heating, air-conditioning, and electrical systems contained therein.

2.1.9 Installation

The process of placing a manufactured house on its foundation, removing the axles, tires and hitches, and closing it to the weather is the definition of installation. Some installations may further involve connecting utility crossovers and finishing wall joints along the marriage line inside the house.

2.2 Materials, components and appliances of a manufactured house

Both site-built and manufactured houses make use of the same materials with respect to their functionality. The appliances and devices used are also typically comparable to each other. All materials used either in site-built or manufactured houses conform to applicable codes and specifications.

Figure 2.1 represents all the major components of a manufactured house. There are a few materials that are not covered in Figure 2.1 but are, nonetheless described

below because they are also important to the overall construction value of a manufactured house. Information about the materials, components and appliances described below are excerpts from the Consumers Union – South West Regional Office report on Manufactured Homes Construction Quality Guidelines (Barshan et.al, 2003).

1 Chassis

This is the framework of steel beams on which the manufactured house is built and moved on wheels to its final location. It becomes a permanent part of the house after the house is installed. Typically all manufacturers use the same type of steel for chassis except that the fabrication quality varies. The size of the beams varies from 8"-12" depending on the DAPIA approved designs.

2 Bottom board

Bottom board also called the belly wrap, the second layer of the manufactured house, supports floor insulation and protects the house from moisture. A tarpaulin type jute knitted fabric and is typically used by most manufacturers. The bottom board must be tightly stretched to insure its specified life span. Proper "Patchwork" of intentionally or unintentionally made tears (for repairs) is also important.

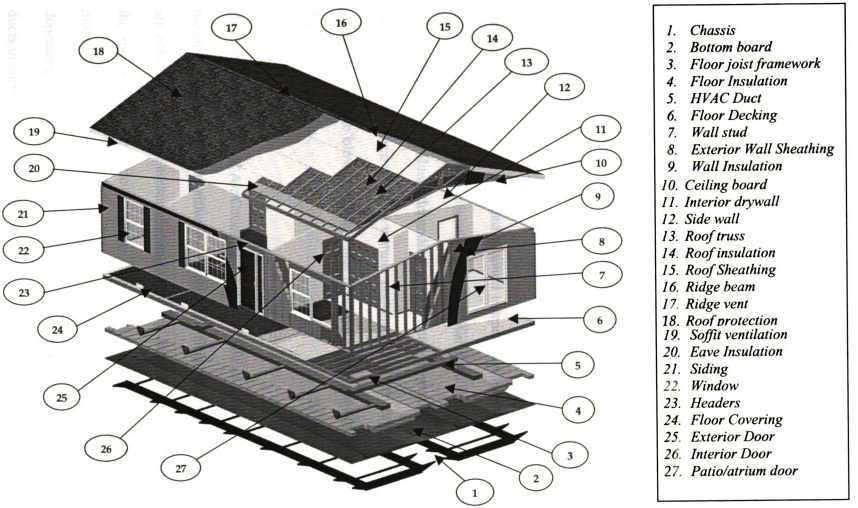


Figure 2.1 Components of a Manufactured House (Modified from Fall Creek Homes poster)

3 Floor Joist Framework

The joist system supports the floor decking, all the loads acting on the floor and the exterior and interior walls. The joists are either placed longitudinally or transversely - the latter being more typically used. Uniform joist spacing usually varies from 16" to 24" on centers (o.c.). Depending on the design and the level of house, the size of the floor joists vary from 2"X6" (entry to middle) to 2"X8" (usually in luxury homes). In general, using a larger floor joist size will provide a stiffer floor (less creaking, sagging, and bouncing) and the potential to increase thermal performance by having thicker insulation.

4 Floor Insulation

Insulation in the floor is provided to avoid temperature losses through the floor system. Typically fiberglass batt-type insulation is used for floor insulation with varying energy efficiency levels (R-values) depending on the final geographical location of the house. The R-values vary from R-11 in warmer regions to R-32 in colder regions. Some of the plants also use the blown cellulose that is used for roof insulation as insulation for the floor.

5 HVAC duct

Heating, Ventilating and Air Conditioning (HVAC) ducts provide both hot and cold air to the entire house. The ducts either run through the floor or through the attic. The registers are either located in the center of rooms (typically for entry/middle level homes) or along the inside perimeter (also popularly known as "perimeter heating and cooling") for middle/luxury level homes. Materials for the ducts vary from sheet metal to fiberglass depending on each manufacturer's choice of material. Flex pipes are used as branch ducts in entry/middle level homes.

6 Floor Decking

Floor decking is a layer of wooden board attached to the joist framework and creates the floor of the house. There are many varieties of floor decking materials with cost directly proportional to the thickness and quality level of the decking materials. The material composition of the floor decking varies from OSB (oriented strand board) in entry / middle level homes to water resistant plywood in middle/luxury level homes The most common thickness used for the floor decking is 5/8" or 3/4".

7 Wall Stud

Wall studs are vertical wooden members that are attached to the floor system. Wall panels consisting of studs and dry wall on one face are typically assembled off the main production line and then moved to the floor deck location. This panelized framework is attached to the floor system.

The wood used for studs must conform to the HUD code. The size and spacing of the studs vary for internal walls, external walls and shear walls[1]. In most of the plants visited, the size and spacing of internal wall studs was 1"X 3" at 24" o.c., the size of internal shear walls was 2"X3" at 16" o.c. External walls were typically 2"X4" spaced at 16" o.c. Exceptions observed were 2"X4" studs used for internal walls and 2"X6" studs used for external walls. In order to achieve higher insulation values, it becomes necessary to use 2"X6" studs for external walls.

8 Exterior Wall Sheathing

After the rough electrical and plumbing is completed and the wall insulation is installed, the external wall exposed to the outside weather is typically covered with either

[1] Shear walls are provided as a wind zone design requirement to integrate the home for it to act as one unit in case of storms and tornados.

plywood/OSB or with insulation board panels. Most manufacturers do not use a layer of exterior sheathing if Hardi-Board type panels are used for the siding material. The exterior wall sheathing serves as backing material for the siding and it protects the insulation from the ambient moisture present in the air.

9 Wall Insulation

Similar to floors, the walls must also be insulated to avoid temperature losses. The insulation observed in the walls was typically fiberglass batts with varying thickness for different R-values. The R-values usually range from R-11 to R-32 (commonly R-19 is used), depending upon the region to where the homes will be shipped.

10 Ceiling board

Ceiling board is the ceiling surface below the roof trusses that divides the attic area from the living space below. Typically sheetrock (drywall) with varying thickness is used. The finish provided to the ceiling is either a vinyl coating pre-installed on the sheetrock or a sprayed on popcorn paint. In higher end homes, the manufacturers provide a tape and textured finish. The thickness of the ceiling board is usually 5/16"- ½".

11 Interior Drywall

Similar to the ceiling board, sheetrock (drywall) also provides a covering to the wall stud framework. As mentioned above the finish of the material varies from vinyl coated sheetrock to tape and textured finishes. The thickness of the drywall typically observed during the plant visits was 5/16"- ½".

12 Exterior Sidewalls

The materials used in exterior sidewalls vary considerably in all houses. As the name implies, these walls are located on the sides of the house. The height ranges from 84" for

entry-level homes to 96" for Luxury homes. The materials used for these walls are the same as the ones discussed for exterior walls.

13 Roof Trusses

Roof trusses are the structural members, which transfer the live loads (snow, wind etc.) imposed on the roof and the dead loads (sheathing, insulation, ceiling board and shingles) to the load-bearing walls. Most of the manufacturers use prefabricated trusses that are engineered to the slope of the roof that typically varies from a 3/12 to a 7/12 pitch. The trusses are made of lumber and each truss member is connected by steel gusset plates to provide the proper rigidity and load carrying capacity. The quality of the lumber and the fabrication process used to build the truss basically determine the life of a roof truss.

14 Attic Insulation

In order to reduce the rate of energy transmission through the attic space, a layer of insulation is provided between the ceiling board and the roof sheathing. In all the manufactured plants visited, blown-in cellulose was used as the insulation material. The insulation is blown-in over the ceiling board in layers to a thickness, which will provide the R-value that is required. For a roof, the R-values range from R-21 to R-33 depending on the location to which it is shipped. The standard roof insulation is R-21 but there are options available to upgrade it at a higher cost.

15 Roof Sheathing

After the insulation is placed, the roof truss is covered with either plywood or OSB panels to complete the exterior skin of the house. Plywood or OSB boards of typically 1/2" to 3/4" thickness are used as roof sheathing. The thicker the sheathing material, the longer the roof life.

16 Ridge Beam

In case of double section homes where there are large openings at the connection of two sections, a ridge beam must be provided where the two sections meet to ensure the structural stability of the roof framing system. This beam is either fabricated using plywood or OSB by workers in the plant or prefabricated laminated wooden beams (also called 'microlam' beams) are used. While both types of beams can perform the required structural functions, laminated beams are produced by machines giving them more consistent dimensions and structural properties compared to in-plant fabricated beams.

17 Ridge vent

This feature is provided in most manufactured homes in order to improve the ventilation to the attic.

18 Roof Protection

Roof protection must be provided over the roof sheathing, to prevent damage from weather in form of wind, rain or snow. Commonly used roof protection materials include a sheet metal covering or asphalt fiberglass shingles. Sheet metal is rarely used anymore by the manufactured housing industry, but when it is, its typically used on single section homes purchased by cost conscious consumers. Asphalt or fiberglass shingle quality rises with price and warranty period. Shingles usually have warranty periods from 15 to 30 years. A rule of thumb in judging shingle quality is the longer warranty period the higher the shingle quality.

19 Soffit ventilation

Some of the manufacturers provide bathroom and toilet ventilation through the soffit of the roofs in the eaves portion. They do this mainly in order to minimize the number of

roof penetrations for the vent outlets that can later result in leakage problems through the roof. This feature could be problematic if proper arrangements for vents are not made.

20 Eave Insulation

Because the roof is sloping, the blown cellulose tends to slide down towards the eave portion of the roof, thus causing a potential blockage of the ventilation through the soffit. In order to provide uniform ventilation along the eave soffit, a dam of fiberglass batt insulation is often provided at the roof edge near the eave to prevent this blockage from occurring.

21 Siding

Siding provides the final layer of exterior skin to the house and can either enhance or degrade the aesthetic appearance of the house. Sheet metal, wooden or vinyl sidings can be provided. Metal sidings, similar to metal roofs, are slowly fading out from use. The wooden board siding (popularly called Hardi panel or Smart Panel) requires regular maintenance (painting) to protect it from weather conditions. Vinyl siding requires much less maintenance and is typically offered with a 10-15 year warranty. "Hardi" panels are more commonly used in the southwest region of the United States while vinyl siding is more typically used in the northeast regions. Regardless of the siding material used, material called "house wrap" is required under the siding for thermal protection.

22 Windows

Three main elements influence the performance of windows. These are the frame, the window glass itself and the final trim. Window frames are typically either plain aluminum or vinyl. The window itself is differentiated by the type of windowpane (i.e. window glass) that is used. Some dual pane windows contain argon (or similar) gas,

which provides a higher R-value than single pane windows. On lower quality windows, the gas slowly escapes over several years thus reducing the R-value and leaving the pane with a yellowish undesirable color. The trim around the windows is usually wood or vinyl, but there are a few manufacturers that leave the exposed aluminum flange as is.

23 Headers

These are lintels (small beams) above windows and doors, which carry the load above the door and window openings to the wall forming the system. Typically, the headers are of the same material and size as the frame studs. The number of headers varies from single to triple depending upon the manufacturer. Triple-headers significantly reduce problems of windows or doors not closing properly.

24 Floor Covering

The choice of floor covering is dependent on the usage zone in the house. The wet areas, such as the kitchen, and bathrooms, have vinyl floor covering in various designs. Other rooms (e.g. living or bedrooms) typically have carpets that range from 16 oz for entry level to 52 oz for luxury homes. Most of the manufacturers also provide vinyl in the entryway.

25 Exterior Door

Most of the manufacturers provide a 3' wide exterior door made of steel with insulated core. The height of the door varies from 6.5 to 7 ft depending upon the height of the exterior sidewall.

26 Interior Doors

Interior doors are available in various widths, heights, and styles. The widths of the interior doors typically vary from 28" to 32". The height varies from 6.5' to 7.0'. They

are available as either plain (LUAN) or paneled doors. The material used is either wood, Medium Density Fiber (MDF) board or Masonite (which is becoming popular because of its durability). In most homes, the doors are hung using 2 or 3 surface mounted hinges. In some luxury homes doors are hung using fully mortised hinges. The trim around the interior doors is either wood or vinyl.

27 Patio/Atrium door

This is a feature provided by some manufacturers for middle/luxury level homes wherein they provide 6 – 9 feet wide doors that are glazed and open to the patio or the atrium.

28 Plumbing

A number of plumbing system features that are not detailed in Figure 2.4 are presented below:

Water pipes and fittings: The materials for these vary with the level of homes. PVC is used for most entry-level homes. A new material called PEX is used in the middle of the line houses. Luxury homes are typically provided with copper piping and copper fittings. Some manufacturers also use brass or copper fittings in middle of the line homes.

Sanitary, Drainage and Vent pipes: Most of the manufacturers use ABS pipe, which is a thick plastic pipe. ABS pipe is also considered to be more durable and flexible than a PVC pipe by many manufacturers.

Shut-off valves: In the plumbing system, shut-off valves are either provided at a single junction or under every sink. Having shut-off valves under every sink facilitates later maintenance.

Vanity Sinks: Entry/Middle of the line level homes use plastic sinks while luxury homes use porcelain sinks. Porcelain sinks are more durable and are easier to clean and maintain.

Faucets: Plastic faucets are typically used for Entry/Middle of the line level homes while metal faucets are used in luxury homes.

Bathtub and Shower: Most manufacturers use a two-piece PVC bathtub and shower while a few manufacturers provide one-piece fiberglass bathtub and shower units.

Water Heater: The capacity and energy efficiency of the water heater is the main distinguishing factors for different homes. Capacity varies from 30 gallons in entry-level homes to 50 gallons in luxury homes.

29 Electrical

A number of electrical system features that are not added in Figure 2.4 are presented below:

Wiring: Copper wires were used as the wiring material in all of the plants visited.

GFI's[2]: Although GFI's are a mandatory feature under HUD code the number of GFI's provided can vary. The minimal requirement is one but there are manufacturers that also provide two GFI's.

Boxes: There are typically two types of electrical boxes used namely, drywall mounted or stud mounted. Stud-mounted boxes are preferred to wall-mounted boxes, because the latter are more likely to be pulled out during occupancy, thus causing damage to the wall.

[2] A special type of circuit breaker designed to protect against ground faults in addition to overloads and short circuits (Stein and Reynolds 1992).

30 Mechanical (HVAC)

Registers: These are openings provided for heating/cooling and ventilation. Their location varies depending upon the level of the house. They are centrally located for entry/middle level homes (and a few middle level homes). All luxury homes have the registers located along the interior perimeter because it's an expensive option.

31 Cabinets

A considerable variation in the design and materials for kitchen cabinets was observed. Some manufacturers use hardwood, but most use particleboard or medium density fiber (MDF) as the base material. A combination of hardwood and particleboard/MDF, with hardwood for exposed parts and the remaining made up of particleboard/MDF was also observed. The design of the cabinets varies too from ordinary to modular. The shelves are either fixed or adjustable. The rollers used for the drawers are either plastic or metal. Typically most manufacturers use particleboard with non-adjustable shelves and plastic rollers for drawers. The other options are used for higher-level homes.

32 Appliances

Appliances are amenities provided with the manufactured house. Depending on the house level, the size, brand energy efficiency and type of appliances provided vary. The following is the list of appliances that are typically provided (optional ones are indicated) in the houses that were observed:

- Refrigerator
- Microwave
- Dishwasher
- Electrical Fixtures

- Cooking range
- Fireplace (optional)
- Garbage Disposal (optional)
- Air Conditioner (optional)
- Clothes Washer and Dryer (optional)

2.3 Manufactured House Construction Process

A manufactured house, as defined earlier, is a house on a permanent chassis built in a controlled factory environment and is designed for use with or without a permanent foundation. Depending upon the requirements of the homebuyer, the manufacturer can provide either a single-section or a multi-section manufactured house.

2.3.1 Station Classification

The manufactured housing plant is typically divided into major construction areas depending upon the type of activities being performed in these areas. These areas in a manufactured housing construction plant are further divided into multifarious stations along the assembly line of the plant. The stations can be classified into main assembly stations, sub-assembly stations, feeder stations, and internal and external storage areas, based on the type of activity taking place at that station/area (Mehrotra, 2002).

Main assembly stations are the major stations (sometimes referred to as primary stations) on the assembly line, and the location where sub-assemblies (components) are installed. The roofing station, for example, is a main assembly station where the roof truss from a roofing sub-assembly station is installed over the house. Sub-assembly stations are secondary stations that fabricate sub-assembly components for installation at

main assembly stations. For example, interior and exterior walls are first assembled at a sub-assembly station, and then they are installed at the walls main stations.

Feeder stations are stations that provide individual components to the main assembly stations, i.e., the raw material stored at the feeder station itself is installed directly. For example, kitchen appliances are stored adjacent to the assembly line near the interior finishes and cleanup main assembly stations, and the appliances are supplied directly to the interior finishes main activity stations, as and when needed.

Internal or external storage areas are provided, depending upon the inventory maintained for different kinds of material, weather conditions, the bulk/size of the material, and the cost of the material. Some of the materials that are stored externally are chassis, roof shingles, and trusses, whereas material like drywall boards, foam, and carpets are stored internally.

2.3.2 Construction Process in Plant

The construction process of a manufactured house consists of repetitive and methodical practices of interrelated tasks that are carefully coordinated so as to construct a house. At most manufacturing plants the activities on an assembly line are well planned to ensure continuous production.

Typically the major areas in a manufactured housing construction plant are as follows (Senghore, 2001):

1. Floor
2. Wall
3. Roof
4. Finishes

5. Final Inspection and Closeout

The plant layout for various areas and the stations included under each area is shown in Figure 2.2. Each of these areas is described in the following sections.

2.3.2.1 Floor Area

The production process typically begins with the fabrication of the chassis, or the structural frame on which the house is built, at a subassembly area mostly involving welding. The chassis is then moved to a separate paint area. Some manufacturers outsource their chassis from specialized suppliers. As shown in Figure 2.2, the floor area typically covers station 1 and 2.

The floor joists are fabricated according to structural requirements at a sub-assembly station where fiberglass/cellulose insulation is laid on a bottom board. The ductwork for HVAC and plumbing pipes are also provided at this sub-assembly area. The chassis sub-assembly is then placed over the floor sub-assembly and fixed with the help of lugs. The entire chassis and the floor joist system assembly are rotated so that the chassis rests on the ground while supporting the joist system. Few manufactured house plants build the floor system directly over the chassis instead of building it separately and then attaching it.

At the next station, still part of the floor area, the floor joist is covered with decking. Decking is usually in the form of 5/8"-3/4" floorboards made of plywood or OSB and is glued and nailed/stapled in place. The areas that would be exposed to water are usually sanded at this station, so that the vinyl for the wet areas sticks well on a smooth surface.

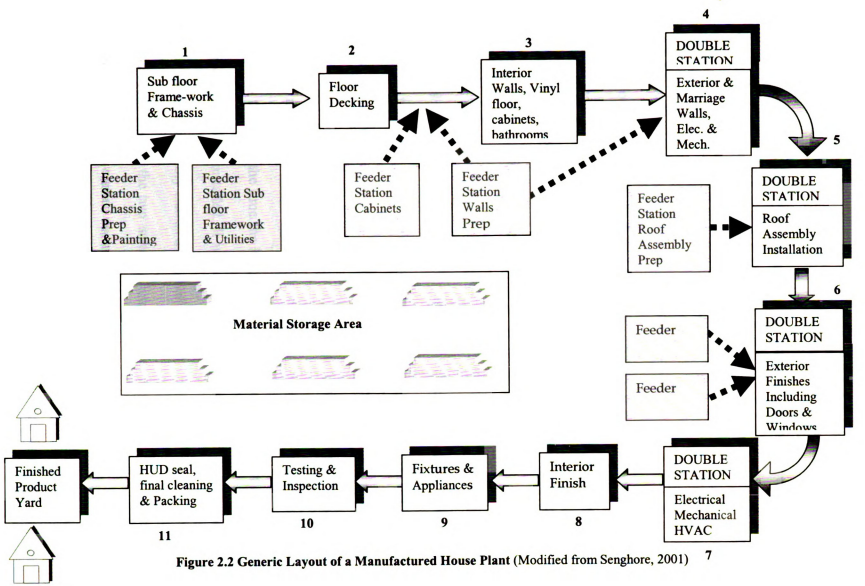


Figure 2.2 Generic Layout of a Manufactured House Plant (Modified from Senghore, 2001)

2.3.2.2 Wall Area

The chassis then moves to a station where vinyl pieces of the correct size are cut and installed in wet areas namely the bathrooms and kitchen. The interior walls/ partitions are placed next at stations 3 and 4, as shown in Figure 2.2. These stations make up the wall area.

2.3.2.3 Roof Area

In most production plants, the fabrication of roof trusses is sub-contracted and trusses are supplied from a loading dock near the roof assembly station. The roof is then assembled using these trusses and other raw material at the roof sub-assembly station. Station 5, as shown in Figure 2.2, is the roof area.

At station 5, the individual trusses are positioned on the ceiling boards based on the spacing specified in the plans. The ceiling boards are then glued at the base of the assembled truss. The glue is applied on any one face of the truss that fall in between the span of the ceiling board and on both faces at the seams of the ceiling boards.

At the next sub-assembly station, the truss is filled with both rigid and loose insulation, and finally the ceiling boards are taped together and typically popcorn paint is applied on them. By the time the house comes to the roof installation station, the roof is dry and ready to be installed. It is then mechanically lifted from the roof sub-assembly station to main assembly station and installed over the external sidewalls. In the case of a double-section house the two units are joined before installation. The insulation activity in some plants is also carried out at the main assembly station.

The next step involves the installation of roof sheathing (Oriented Strand Board). The boards are nailed in place. Installation of shingles is the next major activity in the

roof section. Once the shingles are installed, the house is ready to move to the exterior finishes section.

2.3.2.4 Finish Area

In Figure 2.2, stations 6 to 9 represent the finish area. For a broader understanding of finishes, finishes can be further classified into external and internal finishes. These finish types are explained in the following two sections.

2.3.2.4.1 Exterior Finishes

Some of the exterior finishes activities are carried out simultaneously with the roofing activities. The first major activity at this station is to make provision for the doors and windows by cutting openings in the exterior wallboard. Doors and windows are supplied from a feeder station. The installation of doors and windows involves checking the spacing, installing of the frame, and finally installing of the door and window units as specified in the drawings. Finally, the exterior sidings, exterior lamps, and doorbell are installed.

2.3.2.4.2 Interior Finishes

By the time the house comes to the interior finishes station, the two sections of the double-section house have been separated again. The interior finishes and final cleanup activities are the last set of activities taking place on the assembly line. This section also involves testing and inspection activities. The final electrical, plumbing, HVAC, and mechanical work are carried out at station seven. The installation of foam and carpet happens next. These activities happen at station eight. The toilet is also installed at this station. The heavy kitchen appliances like the refrigerator and cooking range are placed typically towards the last station. The house is vacuumed and all cabinets are cleaned.

Finally, the material to be installed in the house after installation on the site is placed inside the house.

2.3.2.5 Final Inspection and Closeout Area

The production process described above is a typical production process and the areas mentioned are typical production areas. There are other stations after the interior finish area where cleaning and final touch ups are done, inspection of all systems are carried out, the loose accessories are loaded that have to be fixed after the installation, covering the marriage wall section[3] with white plastic sheets and making it ready for transportation and the HUD label affixed. Stations 10 and 11, shown in Figure 2.2 represent the final inspection and closeout area.

Finally the house moves out of the plant and is ready for delivery to the customer. Different manufacturers may have similar process details but the number of main assembly stations or sub-assembly stations varies on their production line.

2.4 Existing Literature on Manufactured Homes

A general guideline of terminology and planning of manufactured homes was provided by Hullibarger (2001). This literature is basically house-developer oriented and makes the reader conversant with the terminologies, the site planning aspects and other site requirements for a manufactured housing community development.

Table 2.1 is a quality-based comparison of manufactured homes based on structural and aesthetic features and various construction materials (Eaton, 2000). Eaton rated manufacturers based on the category they fall under according to Table 2.1 and has

[3] Marriage wall section is the common wall section for multi-section manufactured houses. It is that section of the house where the two sections are connected.

devised upgrade costs for homes classified under average or poor construction to be upgraded to quality construction homes.

Table 2.1 Comparison based on level of construction of Manufactured Homes (Eaton, 2000)

POOR CONSTRUCTION	AVERAGE CONSTRUCTION	QUALITY CONSTRUCTION
2x6 floor joists 16" on center placed on a longitudinal floor system	2x6 floor joists 16" on center placed on a transverse floor system using rigid steel I-beams	2x8 floor joists 16" on center placed on a transverse floor system using rigid steel I-Beams
Sub-floor 5/8" or 1/2" using standard yellow particleboard that is not treated.	Sub-floor 5/8" Plywood T/G, OSB Board, or treated particle board like Cresdeck or Novadeck	Sub-floor 3/4" or thicker using: plywood, T/G, OSB. (Particle board which is treated to be water resistant like Cresdeck)
2x4 exterior walls 16" O.C. using 2x4 top and bottom plates. 2x3 interior walls 16" O.C.	2x6 exterior walls 16" O.C. using 2x6 top and bottom plates. 2x3 interior walls 16" O.C.	2x6 exterior walls 16" O.C. using 2x6 top and bottom plates. 2x4 interior walls 16" O.C.
No plywood exterior wall sheathing and inexpensive siding with 10 year warranty or less	No plywood exterior wall sheathing but quality exterior siding with 25 or 30 year warranty or longer	Plywood sheathing on exterior walls 3/8", 5/8" or thicker. Lap siding for residential appeal.
R-19 in walls, R-19 in floors and R-21 in roof	R-21 in walls, R-19 in floors and R-33 in roof	R-21 in walls, R-33 in floors and R-38 to R-49 in roof
20 lb. snow load per square foot	30 lb. snow load per square foot	40 lb. snow load per square foot or better
3-12 roof pitch using a 20 year shingle	3-12 or 4-12 roof pitch using a 25 year shingle	5-12 to 7-12 roof pitch using a 30 year shingle or better
Eaves that only overhang 3" on front and back of home. Ends of home only 6" overhang	Eaves that overhang 6" to 8" on all sides of home	Full size eaves 12" or better on all sides of home. (Helps prevent stain on windows and siding)
PVC or Polleane with plastic fittings and no shut off valves at every fixture	PVC or Polleane with metal fittings and shut off valves at every fixture	Copper plumbing or PVC with metal fittings and shut off valves at every fixture
Two-piece tub and shower stalls, plastic sinks, 30 gallon hot water tank and plastic faucets	Two-piece tub and shower stalls, porcelain sinks, 40 gallon hot water tank and metal faucets, brand names	Quality plumbing fixtures like: one-piece tub and shower stalls, porcelain sinks, 50 gallon hot water tank and metal facets and brand name products
28" or less interior doors with only two hinges and plastic moldings	28" interior door with three mortise hinges and plastic moldings around doors	32" or 36" interior doors with three mortise hinges. Solid wood molding around doors typically Hemlock or Fir

POOR CONSTRUCTION	AVERAGE CONSTRUCTION	QUALITY CONSTRUCTION
All 3/8" sheet rock with a vinyl covering on all walls	1/2" sheet rock on walls in part of the home with 3/8" vinyl covered sheet rock in wet areas and other parts of the home	Sheet rock on all interior walls. 1/2" on walls and 5/8" on ceilings
Particleboard cabinets with a veneer covering. No adjustable shelves and plastic roller guides	Particleboard cabinets with a veneer covering. Adjustable shelves with metal roller guides	Solid wood cabinets like: Oak, maple, pine and alder. Adjustable shelves with metal roller grooves
Aluminum double pane windows	Vinyl windows, double pane, no low "E"	Standard size vinyl windows on 6" intervals. Double pane with low "E"

As observed from the Table 2.1, only a few material and structural related aspects are covered, neglecting other major and significant aspects of a manufactured house such as the installation, warranties, chassis, etc. Also, the upgrade costs were not based on any robust criteria. A poor construction house can be upgraded to a quality construction at a cost much less than the original cost of a quality-constructed house. This method of comparison is not comprehensive according to this classification because a quality construction house as quoted by Eaton may not satisfy all the requirements listed in Table 2.1.

Burnside (1999) has suggested the use of checklist for homebuyers, which is very detailed as it encompasses all the aspects of the manufactured house and also includes the financial aspects. The checklist makes a customer aware of the product being purchased. However, there may be instances where two different homes may satisfy equal number of points listed in the checklist. This situation would make it difficult for the homebuyer to decide which house to choose, as both appear to be equal.

The Consumers Union organization, a United States based non-profit organization, publishes bulletins and articles on the problems faced by consumers and the

steps to consider prior to buying a manufactured house (Consumers Union, 1991, 2000, 2001).

All literature discussed above, develops a sense of awareness for a homebuyer, but none of them satisfactorily help a consumer decide on the right choice of a manufactured house when a number of manufacturers or houses are considered.

2.5 Relevant Literature on Quality in Construction and Decision-making Models

2.5.1 Quality practices in Construction

One of the definitions of quality is *"totality of features and characteristics of a product or service that bear on its ability to satisfy implied or stated functions"* (Besterfield, 1995). This also implies that *quality is conformance to specifications*, which is the most trivial definition. Following are few other definitions of quality:

- Fitness for use (Juran)
- Conformance to requirements (Crosby)
- Degree to which a specific product conforms to a design or specification (Gilmore)
- Is that, which meets the customer's expectations (Guaspari)
- Meeting customers needs and reasonable expectations (Berry)
- Meeting or exceeding customer expectations at a cost that represents value to them (Harrington)
- Surpassing customer needs and expectations throughout the life of the product (Gitlow and Gitlow)
- Putting the right product or service in the hands of the customer at the right time and at the right price (Mills)

It can be observed that quality has several definitions with each of them focusing on specification conformance (performance criteria), customer satisfaction or both. In recent years, customer satisfaction is of prior importance as trends regarding the perception of quality are changing considerably. There tends to be more focus on reducing after sale services of a product by providing a product based on durability and reliability criteria, which exceed the code criteria, which has always been persistent as the performance based definition of quality.

Quality is still an under-researched area in the construction industry where researchers struggle to develop robust models for successful implementation. Total Quality Management (TQM) is currently the latest approach towards consumer quality satisfaction and is adopted by many companies. Torbica and Stroh (1999) performed an empirical study to find the impact of TQM on homebuyer satisfaction. This was the first study that linked TQM practices with single-family detached homebuyer satisfaction. The objective of the study was to increase understanding of the effects of TQM on homebuyer satisfaction. The research confirmed that implementation of TQM was positively related to the homebuyer satisfaction. The results of this study revealed that builders with well-established TQM programs had more success towards delivering better homebuyer satisfaction.

Improving quality of any product is not directly proportional to the increase in the cost of that product. Value Engineering (VE) is one of the methods used to reduce the cost of a product without affecting the quality and improving the value of that product. Value Engineering in the field of construction has developed without the benefit of academic scrutiny (Palmer et al. 1996). A research on a holistic appraisal of VE being

practiced in the construction industries was conducted by Palmer et al. (1996). The research evaluated VE construction projects and calculated the resulting savings. The paper discusses the evolution and practice of VE in the form of 40-hour workshops, which is loosely planned around a job schedule. The research concludes that function analysis is the only area where VE is noticeable and construction practitioners consider it unimportant as they achieve success in terms of cost reduction without function analysis. Lastly, Palmer et al. (1996) recommended the need for more development in VE by performing greater examination of important factors relevant to VE as well as conduct studies to document the successful implementation of function analysis for construction projects.

Constant search for tools to facilitate innovative design and competitive building products is an evergreen research topic. a research by Rosowsky and Ellingwood (2002) proposed performance-based design methodology as one such tool that can be applied to the residential construction. The findings of the research reveal that performance-based design methodology for residential construction could provide a general framework for assessing the probable response of construction exposed to various levels of natural and man-made hazards. This methodology also support enhancements in durability and reduction in maintenance costs, facilitate reduction in risk of injury, death, and property damage from extreme natural hazards. The performance-based design methodology could also facilitate innovative uses of wood in home construction, which would lead to safer and more affordable housing.

Salem et al (2003) focused on estimating life-cycle costs and evaluating infrastructure rehabilitation and construction alternatives. The life-cycle model

developed for determining life-cycle costs of civil infrastructure construction and rehabilitation was derived from reliability and simulation applications. It utilized a risk-based approach to predict different life cycle costs of constructing/rehabilitating an infrastructure unit. The output of the model was in the form of probability plots and cumulative density functions (CDFs). The probability distributions could provide valuable information regarding the probability of executing a construction/rehabilitation alternative at or below a certain life-cycle budget. The analysis of the generated CDFs could help decision makers specify margins of contingency for the levels of budget required.

2.5.2 Multicriteria Decision-making

The act of choosing an alternative is decision making. The decision making process involves the following five steps (Anderson et al. 1995):

Identifying and defining the problem.

Determining the set of alternative solutions.

Determining the criterion or criteria that will be used to evaluate the alternatives.

Evaluate the alternatives.

Choose an alternative.

To have a better understanding of the definition of decision-making process with respect to this research an example will be used. Consider seeking, a consumer wants to purchase a television and has to make a choice from three popular television brands. This is the first step of the decision making process where the problem is identified as making a choice for the purchase of a television.

The next step within the decision making process is to determine the criterion or criteria that will be used to evaluate the three brand alternatives. Cost of the television will obviously be the governing criterion for most of the consumers. However, if cost were the only criterion with respect to which a decision has to be made regarding the best purchase, this situation would be referred to as single-criterion decision problem and methods such as linear programming, forecasting, etc., can be used to solve such single-criterion problems.

Assume, however, that the consumer is also considering two other criteria, namely, the screen size and menu options. Such problems that involve more than one criterion are known as multicriteria decision-making problems.

The next step in this process is evaluating each of these alternatives with respect to each criterion. For example, to evaluate each alternative relative to the television cost criteria, the cost for each brand of television is recorded. Similarly the other alternatives are evaluated as indicated in Table 2.2. After each alternative is evaluated against each criterion, the consumer is ready to make a choice from the available alternatives.

Table 2.2 Data for Television Evaluation Decision-making.

TV Brand	Cost	Screen Size	Menu options
A	$250	27"	Good
B	$235	25"	Excellent
C	$245	27"	Fair

The difficulty in making a choice is mainly due to the fact that the criteria probably are not all equally important and no one alternative is best with regard to that criteria.

Techniques such as goal programming, and analytic hierarchy process (AHP) deal with such situations. A brief description of each follows.

Ziara and Ayyub (1999) introduced an implementation of a decision-making process for reducing the cost of housing in countries with limited resources. The paper discussed the important cost influencing factors and also explained the development of a methodology based on decision analysis using a systems framework for effective uses of available resources. The methodology simultaneously considers the options and constraints of relevant socioeconomic factors in the planning and construction of urban housing-project developments. According to this methodology, decision analysis allows decision makers to make a final selection regarding housing developments in a systematic manner despite system complexity and the magnitude of various significant cost-influencing factors. However, the methodology is not sensitive to small variations in values assigned to the levels of importance and their weight factors corresponding to different options.

In another research by Dozzi et al. (1996), a bidding model was developed based on utility theory applied to several bidding criteria to arrive at a bid markup. An expected utility value was obtained for a newly tendered project and was compared to a markup utility function to obtain a bid markup. This model uses subjective analysis to evaluate the numerous criteria in a bidding decision to determine the bidding markup. The bidding model developed in this research demonstrated an application of a multicriteria analysis that used subjective and quantitative information in completing an objective. The model successfully determined a bid markup for a construction project considering all types of bidding criteria.

Chinyio et al. (1998) used psychometric technique to quantify clients' construction project needs. The research involved the pairwise comparison and ranking of eight project needs: aesthetics, economy, function, quality, working relationships, safety, lack of surprises, and time by 60 clients. There are two major advantages of psychometric scaling, namely, (i) provides more accurate descriptions of people and their behaviors, and (ii) assists in making decisions about people. Psychometric scaling attains its objectives through observations, projective techniques, sorting, and self-inventories. The research by Chinyio et al. (1998) quantified clients' needs so that their priorities could be reflected adequately in project formulation. The research also recognized that one's chosen needs are partly a function of one's psyche; therefore a psychometric instrument was adopted in scaling clients' project needs. The paired comparison method revealed that clients' highest-priority needs were, in decreasing order of magnitude, quality, safety, and function.

A study by Farghal (1999) introduced a framework for evaluating alternatives based on a rational goal oriented procedure and used numerical scoring to translate subjective information into a quantitative approach. The research was concerned with the problem of selecting buildings for conservation programs. The buildings were evaluated with respect to their value, condition, and feasibility of implementation. Ranking models were developed based on AHP technique with goal programming (GP) used to select the most suitable buildings for conservation. The advantages for using GP in this and similar decision-making problems are (Farghal, 1996): "(i) GP provides flexibility for the decision-maker to develop the best plan, (ii) It gives the ability to the decision-maker to set preferences or priority levels and rank those according to the current needs, (iii) GP

involves setting targets for goals and trying to achieve those targets, thus allowing the decision maker to perform sensitivity analysis by changing the targets and continuously modifying the solution to reflect those changes, (iv) GP does not require excessive information from the decision maker, and (v) GP considers all existing constraints when producing a solution."

Chua et al. (1999) identified critical success factors for different construction project objectives using the AHP method. A hierarchical model for success of construction projects was formulated in this paper. A questionnaire was developed to facilitate systematic data collection for this study. Experts with an average experience of 20 years in the construction industry participated in the survey. Critical success factors (CSF) addressing budget performance, schedule performance, quality performance, and overall project success were identified. The results of the study revealed that experts did agree to the fact that there were different sets of CSFs for different project objectives. Also, the results were compared with the findings of previous studies using a neural network approach concluding that the CSFs were consistent with those previously obtained. However, the AHP method was not only viable for identifying CSFs, but it also allowed intangible factors to be considered.

Sarkis and Talluri (2002) developed a vendor selection model for the purchasing departments of manufacturing industries. A model using the Analytic Network Process (ANP) was developed for supplier evaluation and selection of suppliers considering multiple factors that included strategic, operational, tangible, and intangible measures. Input from a variety of managerial decision making levels, and the model considered dynamic aspects of the competitive environment in evaluating suppliers. ANP does not

require complex mathematical models, but provides a more robust solution than simple scoring methods. ANP model explicitly considers the interrelationships among various decision-making factors through pairwise comparisons. ANP is a modification of the AHP model but includes a number of interdependent relationships among various factors and evaluation criteria that did not exist in the AHP model. This decision making model considers importance of various factors based on a short term and long term planning horizon and is not viable for the purposes of the current research as the factors affecting the construction value are based on long term considerations only.

The techniques discussed above represent the typical ways in which they are used for decision making and evaluating different aspects of the construction and manufacturing industries. The most viable technique for developing the rank model is the AHP technique as it considers tangible and intangible factors and also focuses only on the long term planning horizon. The AHP procedure is explained in the following section.

2.6 Analytic Hierarchy Process

A method for modeling unstructured problems in the economic, social, and management sciences was developed by Saaty in 1980 and is known as Analytic Hierarchy Process (AHP). While money serves as a basis of measurement of all kinds of goods and services, it cannot be used to measure the utility of consumers towards certain parameters, i.e. the value they associate with their choices (Saaty, 1980).

AHP uses pairwise comparisons to compare the elements of a certain level of a hierarchy with respect to an element in a higher level of the same hierarchy to show the relative importance of each element of the lower level with respect to that element in the

higher level. According to Saaty, the pairwise comparison process can be an asset for problems where there is no scale to validate the result. Pairwise comparison is the process of comparing pairs of elements as opposed to comparing all the elements in a single step. The steps involved to develop a scale using AHP are discussed in the following sections.

2.6.1 Matrix of Comparisons

A matrix of comparisons is a matrix in which the pairwise comparison process is performed. Assume that there is a certain criterion, say x, which is divided into three sub-criteria, and the objective is to find the strength of those sub-criteria on the main criterion. The sub-criteria; say a, b, and c; are pairwise compared in their strength of influence on the main criterion, x. The matrix of comparisons is constructed as shown in Figure 2.2.

	a	b	c
a	1	(a, b)	(a, c)
b	(b, a)	1	(b, c)
c	(c, a)	(c, b)	1

Figure 2.3 Matrix of Comparisons

Numbers are then entered through pairwise comparisons in the white cells of the matrix. For example, if (a) and (b) are compared, the question to be asked is: how much is (a) more important than (b) in affecting (x)? The answer will be inserted in the position (a, b), i.e. when the row of (a) meets the column of (b). The answer will follow the following scale from 1 to 9 (Saaty, 1980).

If (a) and (b) are equally important, insert 1

If (a) is weakly more important than (b), insert 3

If (a) is strongly more important than (b), insert 5

If (a) is demonstrably or very strongly more important than (b), insert 7

If (a) is absolutely more important than (b), insert 9

An element is equally important when compared to itself; thus, the main diagonal of the matrix must consist of ones. The rest of the shaded elements in the matrix will contain the reciprocals of the corresponding elements in the white cells, i.e. cell (b, a) is the reciprocal of cell (a, b), and so on. The numbers 2, 4, 6, and 8 and their reciprocals are used to facilitate comparisons between slightly different judgments.

The next step after the pairwise comparisons is the computation of a vector of priorities from the given matrix. The vector of priorities will determine the relative strengths of a, b, and c in affecting the main criterion x. In mathematical terms, the vector of priorities is obtained by computing and normalizing the principal eigen vector of the matrix of comparisons.

2.6.2 Vector of Priorities

The normalized principal eigen vector is the vector of priorities for any matrix of comparisons. The vector of priorities delineates the relative weights of the elements of the matrix considering their strength on influencing the main criterion with respect to which they are being compared. Estimates of that vector can be obtained in the following four ways (Saaty 1980):

The crudest: Sum the elements in each row and normalize by dividing each sum by the total of all the sums, thus the results add up to unity. The first entry of the resulting vector is the priority of the first element; the second of the second element and so on.

Better: Take the sum of the elements in each column and obtain the reciprocals of these sums. To normalize so that these numbers add to unity, divide each reciprocal by the sum of the reciprocals.

Good: Divide the elements of each column by the sum of that column (i.e., normalize the column) and add the elements in each resulting row and divide this sum by the number of elements in the row. This is a process of averaging over the normalized columns.

Good: Multiply the n elements in each row and take the nth root. Normalize resulting numbers.

Method three was used for this research to calculate the vector of priorities (the solution vector) from the matrix of comparisons.

2.6.3 Consistency

Since the decision maker is comparing between all the elements a pair at a time, inconsistencies may occur. Those inconsistencies maybe of the type (a) is more important than (b) and (b) is more important than (c) but (c) is more important than (a). Another inconsistency may be the weights assigned for the importance of the elements. For example if (a) is twice as important as (b) and (b) is twice as important as (c), then (a) should be four times as important as (c). Although consistency can be forced on the decision maker, forced consistency is not desirable. The reason is that it is desirable to make a comparison between each pair of elements without having other elements in mind to capture the decision maker's true preferences. However, the entries in the matrix of comparisons should be consistent to a certain limit to prevent errors in judgment or having meaningless results (Farghal, 2000).

The measure of consistency is called the consistency ratio (Saaty, 1980). To obtain this ratio, the matrix of comparisons is multiplied on the right by the estimated solution vector obtaining a new vector. If the first component of this vector is divided by

the first component of the estimated solution vector, the second component of the new vector by the second component of the estimated solution vector and so on, another vector is obtained. If the sum of the components of this vector is divided by the number of components, an approximation to a number λ_{max} (called the maximum or principal eigen value) is obtained to use in estimating the consistency as reflected in the proportionality of preferences. The closer λ_{max} is to N (the number of elements in the matrix) the more consistent is the result.

Deviation from consistency may be represented by $(\lambda_{max} - N)/ (N - 1)$ which is called the consistency index (C.I.). The random index (R.I.) is the consistency index of a randomly generated reciprocal matrix from the scale 1 to 9, with reciprocals forced. At Oak Ridge National Laboratory an average R.I. for matrices of order 1-15 was generated using a sample size of 100. R.I. is expected to increase as the order of the matrix increases. .Because the sample size was only 100, there remained statistical fluctuations in the index from one order to another. Because of these, the calculations were repeated at the Wharton School for a sample size 500 up to 11 by 11 matrices and the Oak Ridge results were used for N = 12, 13, 14, 15. Table 2.3 gives the order of the matrix (first row) and the average R.I. (second row) determined as described above.

Table 2.3 Average R.I. for Matrices with Different Orders

Matrix	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Avg. RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

The ratio of C.I. to the average R.I. for the same order matrix is called the consistency ratio (C.R.). A consistency ratio of 0.10 or less is considered acceptable.

An example using AHP is provided in Chapter 3 and the comprehensive AHP model, which forms the result of this dissertation, is discussed in Chapter 4. The method of pair wise comparisons and the matrix of comparisons will be used to develop scales for different sub-systems and items for evaluating the construction value of a manufactured house.

2.7 Conclusion

This chapter provided the current status of literature available with respect to this research. Description of manufactured housing industry terminology, its construction process, existing literature and the AHP method was the crux of this chapter. It can be seen that the literature available on manufactured house comparison is not only insufficient but also unsatisfactory as it is not comprehensive and quantitative.

Chapter 3 describes the methodology used to achieve the ultimate goal of the research. A checklist is developed for Manufactured Housing systems using a combination of points from the comparison table developed by Eaton shown in Table 2.1 along with the checklist format formulated by Burnside. An example model based on AHP is provided in Chapter 3.

CHAPTER 3

3 RANKING MANUFACTURED HOUSE ACCORDING TO CONSTRUCTION VALUE

In chapter 1, an introduction to the Manufactured Housing Industry was presented. The construction value of the manufactured house was also discussed. The need for a model that enables consumers to compare manufactured homes based on construction value was identified. Chapter 2 discussed manufactured homes with respect to the construction processes. The Analytic Hierarchy Process, which will be used to formulate the ranking model for manufactured homes, was also presented.

3.1 Methodology and tools for objectives

The main goal of this research is to formulate a model that will rank manufactured houses, based on the construction value. Construction value was defined as the proportion of the overall value of a house that is obtained from the construction materials; the processes involved in putting them in place and the post construction assurances against structural or functional damages caused by materials and/or poor craftsmanship, excluding normal wear and tear. Two main objectives were proposed to achieve this goal. To accomplish these objectives, the methods, tools and procedures used are explained in the following sections.

3.1.1 Objective 1

The first objective of this research was to map the Manufactured Housing construction process and collect comprehensive data on what constitutes the construction value of a manufactured house.

To accomplish this objective, site visits and interviews were used. The focus was on collecting the aspects affecting the construction value of a manufactured house. Figure 3.1 shows the phases during which the construction value of a manufactured house

could be positively or negatively impacted. These phases are explained in the following sections.

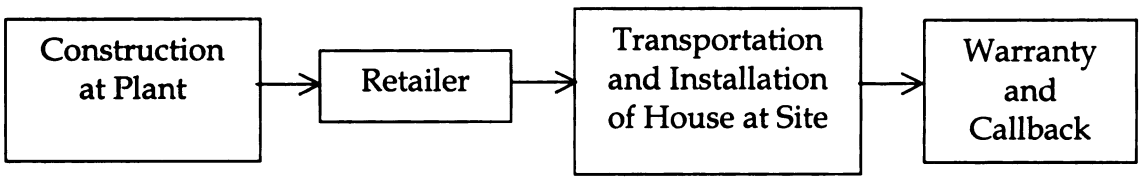


Figure 3.1 Phases contributing to the construction value of a Manufactured House

3.1.1.1 Construction of House at Manufacturing Plant

Mapping the process of construction inside a manufacturing plant was achieved by visiting five manufacturing plants in Texas. Personnel from, and related to the manufacturing plant were interviewed to collect data on critical factors affecting the construction value of a manufactured house. The construction process was observed during the plant visits and generic station arrangements were formulated based on all the visits. In addition, plant visits were conducted along with the third party agencies as described in Chapter 2. Three third party inspectors were interviewed to identify what constitutes a good manufactured house from a construction standpoint.

3.1.1.2 Retailer

Input from the retailers is essential because of the role they play in the manufactured housing process. Retailers were interviewed to understand the marketing and selling process. Their views on common problems contributing to the construction value of a manufactured house were solicited.

3.1.1.3 Transportation and Installation

It is important to have information on transportation and installation procedures as these phases play a significant role in the overall construction process of a manufactured house.

An installer's perspective was sought regarding transportation and installation, through interviews. From the retailer or manufacturer's lot, the transportation of homes to site was observed and factors affecting the construction value during the transportation stage were determined. Site visits for the installation of homes were made to collect information relating factors affecting the construction value of the manufactured house during the installation stage.

3.1.1.4 Warranty and Callback

The after sale service of a manufactured house also needs to be researched as it gives a measure of durability and reliability aspects of the house. The information regarding this was obtained from the interviews with the manufacturers, third party inspectors, retailers and installers. The critical issues during the warranty period was studied and analyzed to determine the most common issues that affect the construction value of a manufactured house.

3.1.2 Objective 2 – Step 1

The second objective of this research was to develop a model to rank homes of a similar level based on their construction values. This objective involved three steps and this section explains the first step, i.e. to organize the entire process of manufactured homes into relevant sub-systems and relate the various factors to these sub-systems as items and/or sub-items.

This step was achieved using inputs from objective 1. The mapping of the manufactured housing construction process lead to divisions and further subdivision of the components that would contribute to the construction value of the house and are

explained in Chapter 4. Figure 3.2 shows an example of division of the construction process of a manufactured house.

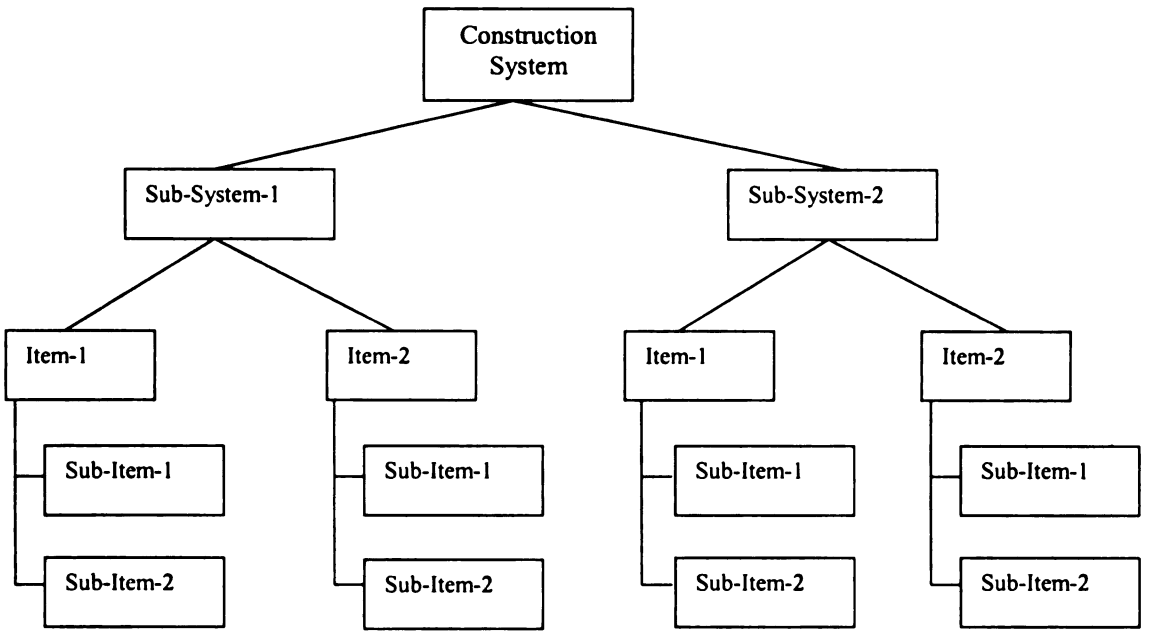


Figure 3.2 Construction System Tree for a Manufactured House

The construction process tree as shown in Figure 3.2 is an example of the comprehensive system tree discussed in Chapter 4, which is based on the literature review, site visits and interviews to break down the construction process of a manufactured house into sub systems, items, and sub items. A sample construction tree was formulated, as indicated in Figure 3.3, to help understand and formulate the actual system process tree for this research. Brief descriptions of the various divisions and subdivisions are provided in the sections below with a few examples as compiled in Figure 3.3.

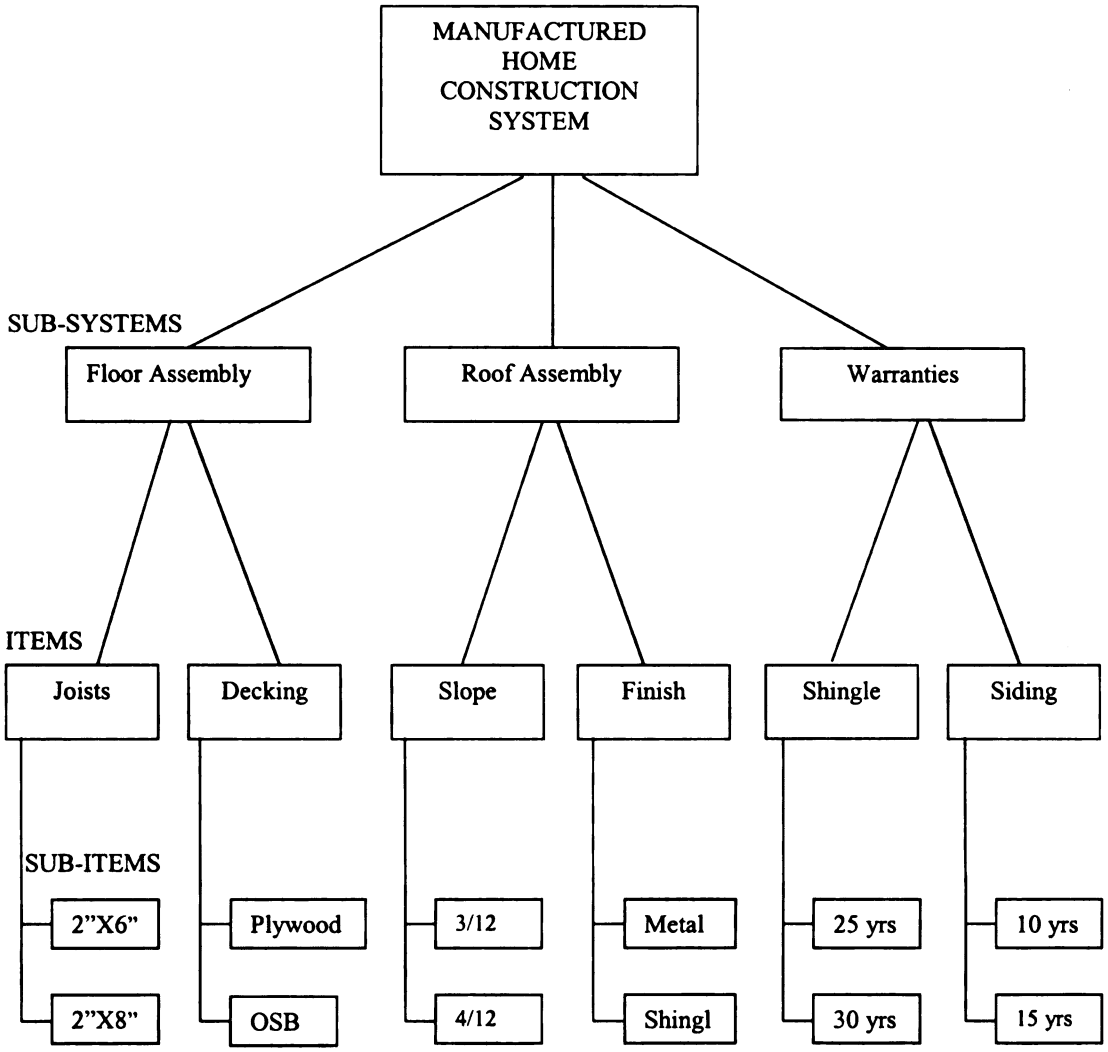


Figure 3.3 Sample Construction System Tree for a Manufactured House

3.1.2.1 Manufactured House Construction System

A common misconception with the phrase 'construction system' is that it is most often considered only to denote the actual construction phase, i.e., the manufacturing of the house at the plant. However, the construction system of a manufactured house should include plant operations, transportation and installation at the desired location, and the warranty services provided during the warranty and callback period.

3.1.2.2 Sub-Systems

The first level of classification for the construction process tree is called sub-systems. These are the different parts of the manufactured house that uniquely contribute to the construction value of the house. Therefore the contribution of all the sub-systems under the construction system for the manufactured house will determine the overall construction value for that house.

Figure 3.4 is an excerpt from Figure 3.3, which shows only the sub-systems for the example construction process tree. The three sub-systems portrayed as an example are: floor assembly, roof assembly, and warranties.

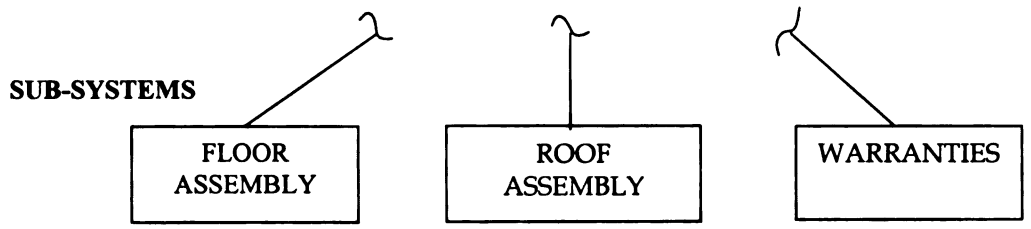


Figure 3.4 Sub-systems for sample Construction System Tree

Floor assembly and roof assembly are important structural related components of a manufactured house that are design and material driven, whereas warranties are service related components that are quality driven with respect to the reliability and durability of the house. Because each of these components provides a major contribution to the construction value of the house, they are classified as sub systems. There were nine such sub-systems that were identified during the course of this research and are explained in Chapter 4. These sub-systems are further subdivided into items and sub-items as discussed in the next sections.

3.1.2.3 Items

Items are components of a sub-system that form a complete sub-system. Every item under a sub-system independently contributes towards adding value to its sub system. Moreover it is assumed that the items of one sub system are independent of the items of another sub system. This means that an item under a particular sub-system, e.g., joists under the floor assembly is neither affected nor being affected by an item under another sub-system with respect to the contribution the former has on the sub-system. This assumption is made for the purpose of using the AHP model. In addition, every item of a sub-system has a different level of contribution to make towards the construction value of the manufactured house.

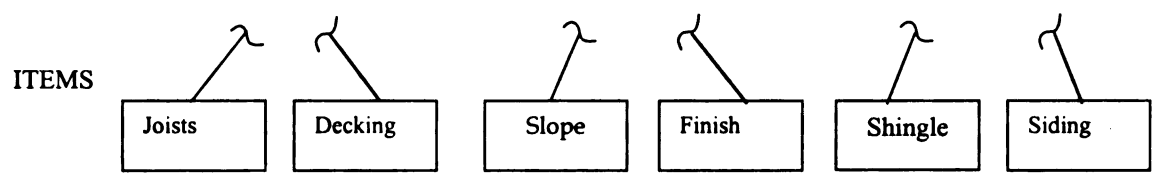


Figure 3.5 Items for sample Construction System Tree

Figure 3.5 above, shows items of various sub-systems for the construction process of a manufactured house. It can be observed from Figure 3.3 and 3.5, that joists and decking are components of a floor system (a sub-system discussed in the earlier section) that when attached together will form a successful floor system for a manufactured house. Both these items are material and design driven, where different combinations could be used for different materials. Similarly slope and finish are components of a roof system that are also design and material driven. Shingle and siding, items for warranties, are time and material driven as the durability and service of the product would depend upon the type used and its useful life. Also, shingles and siding are required as items for roof

and external wall protection respectively. Manufacturers provide different warranty durations on these items and hence it becomes essential to consider these as items adding to the construction value of the manufactured house.

3.1.2.4 Sub-items

Sub-items are the last breakdown level on the Construction System Tree. Sub- items represent the possible components that are used in constructing an item. The choice of sub-item to be used depends on the manufacturer and the type of homes produced. The final choice of sub-item to use directly impacts the quality of the constructed item, which in turn affects the sub-system level.

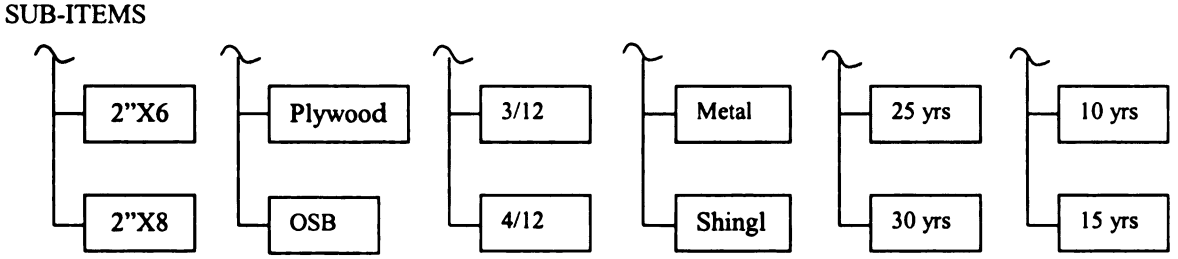


Figure 3.6 Sub-items for sample Construction System Tree

Figure 3.6 shows the sub-items for various items for the sample construction system tree (see Figure 3.3 for corresponding items). The definition of sub-items is clearly reflected in the figure. For example, the item "joists" can be constructed using 2"X6" or 2"X8" members depending on the design as well as the manufacturer's choice. Also the material options for the decking item are plywood or oriented strand board (OSB). In general the choice of sub-items is driven by the requirement set for the item (design, material, aesthetics, time, etc.).

3.1.3 Objective 2 – Step 2

The second step of objective 2 in this research was to develop a checklist comprised of the sub-systems, items, and sub-items that contribute or affect the construction value of a manufactured house.

To achieve this objective, the output from objective II is utilized as an input for this objective. The system tree was used mainly to classify the various aspects of the manufactured house construction process garnered from objective I, into sub systems, items and sub items. The construction system tree provides a framework to organize the construction process. However this does not facilitate documentation of the process detail and therefore a checklist is needed. A checklist will also facilitate the development of the analytical model in step 3. Figure 3.7 shows the format proposed for the checklist. The checklist uses the same classification levels used in the construction system tree.

SUB SYSTEM-1:
Item-1 ☐ Sub item-1 ☐ Sub item-2
Item-2 ☐ Sub item-1 ☐ Sub item-2

SUB SYSTEM-2:
Item-1 ☐ Sub item-1 ☐ Sub item-2
Item-2 ☐ Sub item-1 ☐ Sub item-2

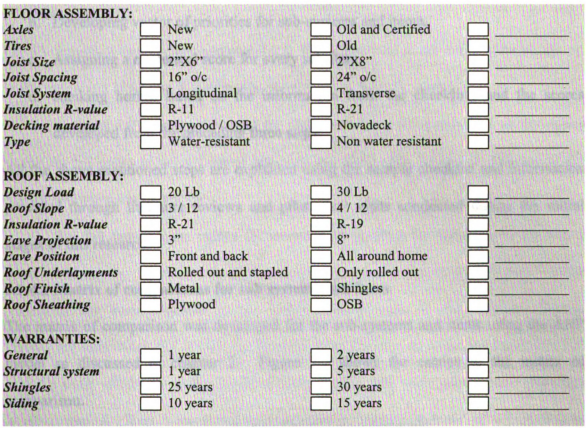
SUB SYSTEM-3:
Item-1 ☐ Sub item-1 ☐ Sub item-2
Item-2 ☐ Sub item-1 ☐ Sub item-2

Figure 3.7 Checklist format for Construction Systems of a Manufactured House

The categories as seen in Figure 3.7 are sub systems that are further classified into items, against which a selection of sub-items are available. The blank boxes are provided for checking the appropriate sub-item relevant to the item being considered. A sample checklist is shown in Figure 3.8 was prepared for the three sub-systems; floor assembly,

roof assembly, and warranties. A detailed checklist was synthesized from the data collected from manufactured house plant visits and literature reviews on manufactured homes and is illustrated in Chapter 4 of this dissertation. Using the checklist, a manufactured house of any brand can be evaluated based on its construction related attributes.

As illustrated in Figure 3.8, the sample checklist, a space for an additional sub-item is provided in case the manufacturer uses a sub-item different from those listed. Once completed, the checklist is a very useful tool for systematically recording information about manufactured homes.



FLOOR ASSEMBLY:			
Axles	☐ New	☐ Old and Certified	☐ _____
Tires	☐ New	☐ Old	☐ _____
Joist Size	☐ 2"X6"	☐ 2"X8"	☐ _____
Joist Spacing	☐ 16" o/c	☐ 24" o/c	☐ _____
Joist System	☐ Longitudinal	☐ Transverse	☐ _____
Insulation R-value	☐ R-11	☐ R-21	☐ _____
Decking material	☐ Plywood / OSB	☐ Novadeck	☐ _____
Type	☐ Water-resistant	☐ Non water resistant	☐ _____
ROOF ASSEMBLY:			
Design Load	☐ 20 Lb	☐ 30 Lb	☐ _____
Roof Slope	☐ 3 / 12	☐ 4 / 12	☐ _____
Insulation R-value	☐ R-21	☐ R-19	☐ _____
Eave Projection	☐ 3"	☐ 8"	☐ _____
Eave Position	☐ Front and back	☐ All around home	☐ _____
Roof Underlayments	☐ Rolled out and stapled	☐ Only rolled out	☐ _____
Roof Finish	☐ Metal	☐ Shingles	☐ _____
Roof Sheathing	☐ Plywood	☐ OSB	☐ _____
WARRANTIES:			
General	☐ 1 year	☐ 2 years	☐ _____
Structural system	☐ 1 year	☐ 5 years	☐ _____
Shingles	☐ 25 years	☐ 30 years	☐ _____
Siding	☐ 10 years	☐ 15 years	☐ _____

Figure 3.8 Sample checklist for Construction Systems of a Manufactured House

Checklists for five different brands of manufactured houses of the same level were filled during the plant visits. The information from the checklist was compiled and synthesized

for ranking these five houses and is described in Chapter 4. The ranking process for the sample data is explained in detail for Step 3 in the following section.

3.1.4 Objective 2 – Step 3

The last and final step towards achieving the goal of this research was to establish a methodology to determine the relative importance of contribution each sub-system provides towards the construction value of a manufactured house and develop a model to rank homes of a similar level based on their construction values. This step was accomplished the following procedure:

a. Developing a matrix of comparisons for sub-systems and items.
b. Developing vector of priorities for sub-systems and items.
c. Assigning a numerical score for every sub-item.
d. Ranking homes based on the information from the checklists and the scores developed from the preceding three steps.

All the above-mentioned steps are explained using the sample checklist and information provided through literature reviews and pilot plant visits conducted during the initial stages of this research.

3.1.4.1 Matrix of comparisons for sub systems and items

The matrix of comparison was developed for the sub-systems and items using the AHP model as discussed in chapter 2. Figure 3.9 shows the entries to the matrix of comparison.

	A	B	C
A	1	(A,B)	(A,C)
B	(B,A)	1	(B,C)
C	(C,A)	(C,B)	1

Figure 3.9 Entries to the Matrix of Comparisons

(A, B) represents the value of comparison between A and B that is based on the following criteria discussed earlier in chapter 2 (Saaty 1980):

If A and B are equally important, then insert value for (A, B) as 1.

If A is weakly more important than B, then insert value for (A, B) as 3.

If A is strongly more important than B, then insert value for (A, B) as 5.

If A is demonstrably or very strongly more important than B, then insert value for (A, B) as 7.

If A is absolutely more important than B, then insert value for (A, B) as 9.

(A, A) is a diagonal element representing the comparison between A and itself and thus (A, A) is always 1.

(B, A) represents the element opposite to (A, B) with respect to the main diagonal. (B, A) is the reciprocal of (A, B). For example, if (A, B) is 5, then (B, A) is 1/5.

In figure 3.9 only the values in the white cells have to be provided, as the values in the shaded cells are the reciprocal values of the white cells. The main diagonal of the matrix is always equal to unity.

For this research the values for comparison matrices for sub-systems and items were obtained by interviewing three third-party agency inspectors (IPIAs). IPIA inspectors are knowledgeable in the construction process of manufactured houses. During the interviews, the IPIAs were introduced to the term construction value first and then for every white cell in the matrix of comparisons, they were asked "How important is sub-system A / item A compared to sub-system B / item B in terms of contributing to the construction value of the manufactured house (for sub-systems) or contributing towards the value of sub-systems (for items)".

For the sample sub-systems and items shown in Figure 3.3, the author has used values based on pilot plant visit experiences and from the literature reviewed on manufactured house construction. Figure 3.10 is a sample matrix of comparisons developed for sub systems.

	Floor assembly	Roof assembly	Warranty
Floor assembly	*1*	*1/5*	*1/3*
Roof assembly	*5*	*1*	*1/3*
Warranty	*3*	*3*	*1*

Figure 3.10 Matrix of Comparisons for Sub-systems

It can be observed from Figure 3.10 that the comparisons between floor system and roof system have a value of 1/5, which means that the floor system is strongly less important than the roof system in terms of contributing towards the overall construction value of a manufactured house. Similarly, other comparisons are made between the different sub-systems. Figure 3.11 shows a similar matrix of comparisons for the various items comprising the sub-systems shown in Figure 3.10.

The values shown in Figure 3.11 are provided for demonstration purposes only. For example the comparisons between axles and tires indicate that axles is strongly more important than tires in contributing to the overall construction value of the manufactured house. The reader should avoid any rationalization of these values. The values obtained from the IPIA inspectors are presented in Chapter 4. It should also be noted that the intent during obtaining values sub-systems and items was not to capture the decision criteria or the thought process of the experts, as this was not an effort to develop an expert system. Rather the intent was to elicit the judgment of these experts with regard to the construction value of a manufactured house.

FLOOR ASSEMBLY:		1	2	3	4	5	6	7	8
Axles	1	*1*	*5*	*1/5*	*1/3*	*1/7*	*1/5*	*1/5*	*1/3*
Tires	2	*1/5*	*1*	*1/7*	*1/7*	*1/9*	*1/3*	*1/7*	*1/5*
Joist Size	3	*5*	*7*	*1*	*1*	*1/3*	*3*	*5*	*7*
Joist Spacing	4	*3*	*7*	*1*	*1*	*1/3*	*3*	*5*	*7*
Joist System	5	*7*	*9*	*3*	*3*	*1*	*5*	*7*	*9*
Insulation R-value	6	*5*	*3*	*1/3*	*1/3*	*1/5*	*1*	*5*	*7*
Decking material	7	*5*	*7*	*1/5*	*1/5*	*1/7*	*1/5*	*1*	*3*
Type	8	*3*	*5*	*1/7*	*1/7*	*1/9*	*1/7*	*1/3*	*1*

ROOF ASSEMBLY:		1	2	3	4	5	6	7	8
Design Load	1	*1*	*5*	*7*	*9*	*9*	*7*	*9*	*5*
Roof Slope	2	*1/5*	*1*	*3*	*5*	*7*	*1/3*	*1/3*	*1/3*
Insulation R-value	3	*1/7*	*1/3*	*1*	*3*	*5*	*1*	*3*	*3*
Eave Projection	4	*1/9*	*1/5*	*1/3*	*1*	*1*	*1/5*	*1/3*	*1/7*
Eave Position	5	*1/9*	*1/7*	*1/5*	*1*	*1*	*1/5*	*1/3*	*1/7*
Roof Underlayments	6	*1/7*	*3*	*1*	*5*	*5*	*1*	*5*	*1*
Roof Finish	7	*1/9*	*3*	*1/3*	*3*	*3*	*1/5*	*1*	*1/5*
Roof Sheathing	8	*1/5*	*3*	*1/3*	*7*	*7*	*1*	*5*	*1*

WARRANTIES:		1	2	3	4
General	1	*1*	*5*	*7*	*9*
Structural system	2	*1/5*	*1*	*5*	*7*
Shingles	3	*1/7*	*1/5*	*1*	*1*
Siding	4	*1/9*	*1/7*	*1*	*1*

Figure 3.11 Matrices of Comparisons for Items

3.1.4.2 Vector of Priorities for sub systems and items

The next step of Step 3 is to compute the vector of priorities from the matrix of comparisons obtained in the first step of Step 3. As explained in Chapter 2, the normalized principal eigen vector is the vector of priorities for any matrix of comparisons. The vector of priorities delineates the relative weights of the elements of the matrix considering their strength on influencing the main criterion with respect to which they are being compared. Estimates of that vector can be obtained by dividing the elements of each column by the sum of that column (i.e., normalize the column) and add the elements in each resulting row and divide this sum by the number of elements in the

row. This is a process of averaging over the normalized columns. This method is recommended by Saaty (1980).

Figure 3.12 is an example for column normalization and vector of priorities for sub systems and Figure 3.13 is an example for column normalization and vector of priorities for items.

	Floor assembly	Roof assembly	Warranty
Floor assembly	0.11	0.05	0.20
Roof assembly	0.56	0.24	0.20
Warranty	0.33	0.71	0.60

Vector of Priority
0.12
0.33
0.55

Figure 3.12 Column normalization and vector of priorities for sub systems

In figure 3.12 the vector of priorities was calculated as follows:

1. Divide the elements of each column of the matrix of comparison by the sum of that column (see Figure 3.10). Hence, the first element in the new matrix after normalization will be $\frac{1}{1+5+3}$=0.11. This is the first value as observed in the matrix of normalization shown in Figure 3.12. Other values were obtained in a similar way.

2. Add the elements in each resulting row of the normalized matrix and divide this sum by the number of elements in the row. Thus, the first value for the vector of priorities for the first sub system in Figure 3.12 is computed as $\frac{0.11+0.05+0.20}{3} = 0.12$.

The same approach is used to build the vectors of priorities shown in Figure 3.13 for items. The matrices shown in Figure 3.12 and 3.13 provide evidence that the most contributing subsystem to the construction value of a manufactured house is warranties (at 55%), followed by roof assembly (33%) and floor assembly (12%). In addition, within warranties, the item 'general' warranties is the most contributing factor to

warranties (at 62%) followed by 'structural system' (26%), and siding and shingles at 6% each.

FLOOR ASSEMBLY:		1	2	3	4	5	6	7	8	Vector of Priority
Axles	1	0.03	0.11	0.03	0.05	0.06	0.02	0.01	0.01	0.04
Tires	2	0.01	0.02	0.02	0.02	0.05	0.03	0.01	0.01	0.02
Joist Size	3	0.17	0.16	0.17	0.16	0.14	0.23	0.21	0.2	0.18
Joist Spacing	4	0.1	0.16	0.17	0.16	0.14	0.23	0.21	0.2	0.17
Joist System	5	0.24	0.2	0.5	0.49	0.42	0.39	0.3	0.26	0.35
Insulation R-value	6	0.17	0.07	0.06	0.05	0.08	0.08	0.21	0.2	0.12
Decking material	7	0.17	0.16	0.03	0.03	0.06	0.02	0.04	0.09	0.08
Type	8	0.1	0.11	0.02	0.02	0.05	0.01	0.01	0.03	0.05

ROOF ASSEMBLY:		1	2	3	4	5	6	7	8	Vector of Priority
Design Load	1	0.5	0.32	0.53	0.26	0.24	0.64	0.38	0.46	0.42
Roof Slope	2	0.1	0.06	0.23	0.15	0.18	0.03	0.01	0.03	0.10
Insulation R-value	3	0.07	0.02	0.08	0.09	0.13	0.09	0.13	0.28	0.11
Eave Projection	4	0.06	0.01	0.03	0.03	0.03	0.02	0.01	0.01	0.02
Eave Position	5	0.06	0.01	0.02	0.03	0.03	0.02	0.01	0.01	0.02
Roof Underlayments	6	0.07	0.19	0.08	0.15	0.13	0.09	0.21	0.09	0.13
Roof Finish	7	0.06	0.19	0.03	0.09	0.08	0.02	0.04	0.02	0.06
Roof Sheathing	8	0.1	0.19	0.03	0.21	0.19	0.09	0.21	0.09	0.14

WARRANTIES:		1	2	3	4	Vector of Priority
General	1	0.69	0.79	0.5	0.5	0.62
Structural system	2	0.14	0.16	0.36	0.39	0.26
Shingles	3	0.1	0.03	0.07	0.06	0.06
Siding	4	0.08	0.02	0.07	0.06	0.06

Figure 3.13 Column normalization and vector of priorities for items

3.1.4.3 Assign numerical scores to sub items

For a given item, there could be many sub-items. Hence the checklist was designed with a blank third option for any other sub-item used by the manufacturer. Because the number of sub-items for any item is not fixed, developing a matrix of comparison is not feasible. By fixing the number of sub-items in a checklist, the options would be limited

and if a manufacturer happens to use a sub-item different from the ones mentioned in the checklist, the comparison is not possible. Also pairwise comparison for several sub-items is a tedious task.

A different approach to assigning values to sub-items is adopted in this research. A numerical scale from 1 to 10 is used, with 1 being a lower score and 10 being the highest. The scores for all sub-items in the checklist was assigned by third-party agency inspectors (IPIAs). As an illustration, an example of a completed checklist for sub-items is shown in Figure 3.14. These scores are based on the author's judgment and provided only for illustration purposes.

FLOOR ASSEMBLY:						
Axles	10	New	8	Old and Certified		
Tires	10	New	6	Old		
Joist Size	6	2"X6"	8	2"X8"		
Joist Spacing	10	16" o/c	6	24" o/c		
Joist System	6	Longitudinal	10	Transverse		
Insulation R-value	6	R-11	8	R-21		
Decking material	10/6	Plywood / OSB	8	Novadeck		
Type	10	Water-resistant	5	Non water resistant		
ROOF ASSEMBLY:						
Design Load	6	20 Lb	8	30 Lb		
Roof Slope	5	3 / 12	6	4 / 12		
Insulation R-value	8	R-21	6	R-19		
Eave Projection	4	3"	8	8"		
Eave Position	6	Front and back	10	All around home		
Roof Underlayments	10	Rolled out and stapled	5	Only rolled out		
Roof Finish	6	Metal	10	Shingles		
Roof Sheathing	9	Plywood	6	OSB		
WARRANTIES:						
General	6	1 year	8	2 years		
Structural system	6	1 year	10	5 years		
Shingles	6	25 years	8	30 years		
Siding	6	10 years	8	15 years		

Figure 3.14 Numerical scores for sub-items

The main criteria used for this scoring was durability, which means, longevity of use for any particular sub-item. The IPIA inspectors were asked "What according to you is the

value of sub-item A on a 1 to 10 scale in terms of its durability". The scoring can be explained with an example from the sample checklist. Consider the item 'roof slope' under the sub-system 'roof assembly'. The sub-items for this item are 3/12 and 4/12 and the respective scores assigned are 5 and 6, indicating that 4/12 is better. As mentioned earlier there can be a number of options for an item and in this case the slopes could start from a minimum of 1/12 to a maximum of 8/12 or more and so the scores would be 1 and 10 respectively for these slopes. All other sub-items were scored on the same durability criteria but this is a sample scale that is used just as an illustration of the scale formulated from the feedback through interviews conducted with the IPIA inspectors.

Here again it should be realized that the numerical scoring for these sub-items was not developed with an intention of developing a scale for sub-items for every item. Developing such scales is a research within itself.

3.1.4.4 Model for ranking Homes

This is the last step in Step 3. The following steps were performed to arrive at the model for ranking:

1. Developing a hierarchical composition of priorities.
2. Evaluating information on sub-items from checklists received from different manufacturers and calculating the weighted average score for every sub-system of the checklist for each house.
3. Formulating matrix of comparisons and vector of priorities for houses under every sub-system.
4. Ranking the manufactured houses.

3.1.4.4.1 Hierarchical composition of priorities

A hierarchy is a particular type of system, which is based on the assumption that the entities, which have been identified, can be grouped into disjoint sets, with the entities of one group influencing the entities of only one other group, and being influenced by the entities of only one other group (Saaty, 1980). Figure 3.15 illustrates the complete hierarchy for construction value of manufactured homes.

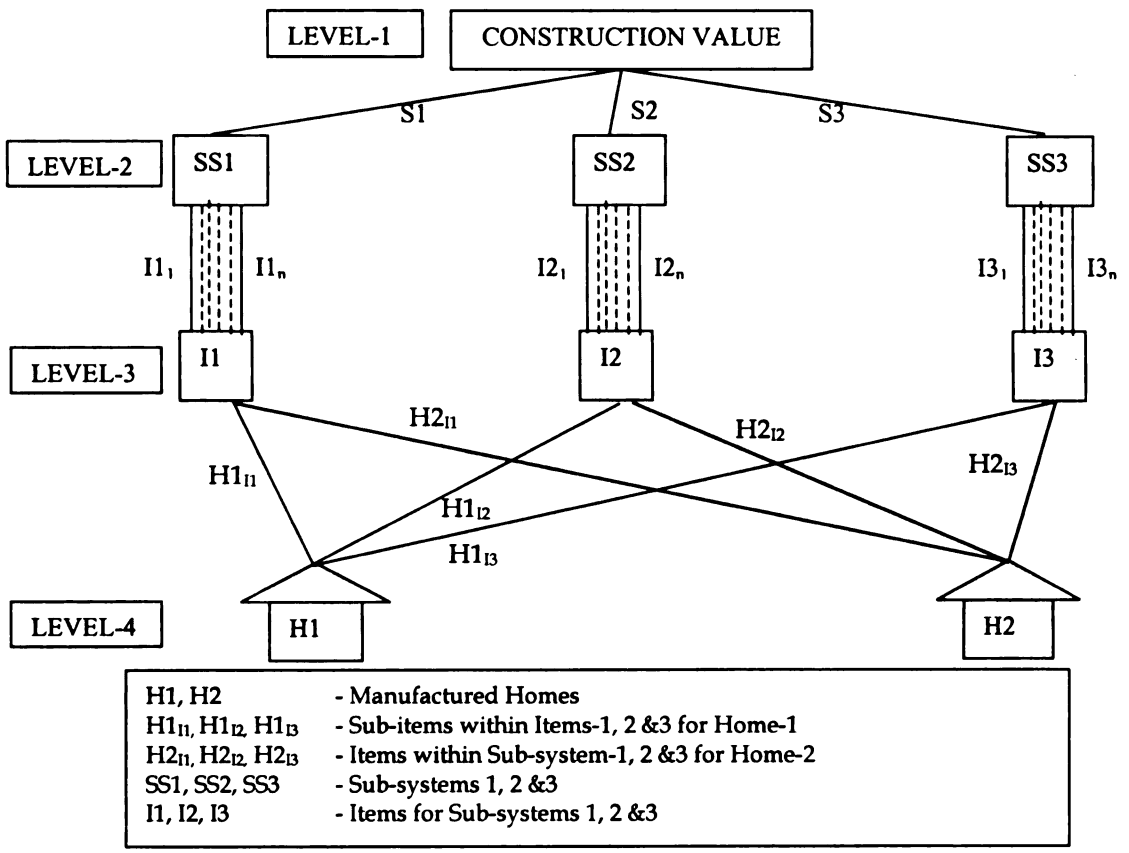


Figure 3.15 Hierarchy for priorities of Construction value

The first hierarchy level has a single objective; the construction value of a manufactured house. Its priority value is assumed to be equal to unity. The second hierarchy level has three objectives, the different sub-systems S1, S2, and S3. Their priorities are derived from a matrix of comparisons with respect to the objective of the first level. The third

hierarchy level objectives are the items for every sub-system. Their priorities are derived from a matrix of comparisons with respect to the objective of the second level. The fourth and final level of classification is the manufactured house and mainly focuses on the type of sub-items utilized under each item. The object of this classification is to determine the impact of use of different sub-items, used in various brands of manufactured houses of the same level (low, median, luxury), on the construction value of manufactured house through the intermediate level of sub-systems. Thus their priorities with respect to each objective in the third level are obtained by assigning a manual scale with respect to that objective, and the resulting three priority vectors are then weighted by the priority vector of the second and third level to obtain the desired composite vector of priorities of the manufactured houses (H1 and H2).

After assigning the hierarchical composition of priorities for the construction value of a manufactured house, the remaining steps to develop the ranking model can be continued and are described in the sections below.

3.1.4.4.2 Weighted item scores for sub-systems

To calculate weighted averages for different sub-systems, information for items and sub-items was collected in a checklist format. A sample is indicated in Figure 3.16 a and b. Figure 3.16a is a sample checklist used to determine the sub-items used in a particular brand of a median level manufactured house H1. Similarly Figure 3.16b represents a sample checklist for a manufactured house H2.

MANUFACTURED HOUSE- H1					
FLOOR ASSEMBLY:					
Axles	☐	New	☐	Old and Certified	☐
Tires	☐	New	☐	Old	☐
Joist Size	☐	2"X6"	☐	2"X8"	☐
Joist Spacing	☐	16" o/c	☐	24" o/c	☐
Joist System	☐	Longitudinal	☐	Transverse	☐
Insulation R-value	☐	R-11	☐	R-21	☐
Decking material	☐	Plywood / OSB	☐	Novadeck	☐
Type	☐	Water-resistant	☐	Non water resistant	☐
ROOF ASSEMBLY:					
Design Load	☐	20 Lb	☐	30 Lb	☐
Roof Slope	☐	3 / 12	☐	4 / 12	☐
Insulation R-value	☐	R-21	☐	R-19	☐
Eave Projection	☐	3"	☐	8"	☐ 6"
Eave Position	☐	Front and back	☐	All around home	☐
Roof Underlayments	☐	Rolled out and stapled	☐	Only rolled out	☐
Roof Finish	☐	Metal	☐	Shingles	☐
Roof Sheathing	☐	Plywood	☐	OSB	☐
WARRANTIES:					
General	☐	1 year	☐	2 years	☐
Structural system	☐	1 year	☐	5 years	☐
Shingles	☐	25 years	☐	30 years	☐ 20 years
Siding	☐	10 years	☐	15 years	☐ 8 years

Figure 3.16a Checklist for Manufactured House 1

MANUFACTURED HOUSE-H2					
FLOOR ASSEMBLY:					
Axles	☐	New	☐	Old and Certified	☐
Tires	☐	New	☐	Old	☐
Joist Size	☐	2"X6"	☐	2"X8"	☐
Joist Spacing	☐	16" o/c	☐	24" o/c	☐
Joist System	☐	Longitudinal	☐	Transverse	☐
Insulation R-value	☐	R-11	☐	R-21	☐
Decking material	☐	Plywood / OSB	☐	Novadeck	☐
Type	☐	Water-resistant	☐	Non water resistant	☐
ROOF ASSEMBLY:					
Design Load	☐	20 Lb	☐	30 Lb	☐
Roof Slope	☐	3 / 12	☐	4 / 12	☐
Insulation R-value	☐	R-21	☐	R-19	☐
Eave Projection	☐	3"	☐	8"	☐
Eave Position	☐	Front and back	☐	All around home	☐
Roof Underlayments	☐	Rolled out and stapled	☐	Only rolled out	☐
Roof Finish	☐	Metal	☐	Shingles	☐
Roof Sheathing	☐	Plywood	☐	OSB	☐
WARRANTIES:					
General	☐	1 year	☐	2 years	☐
Structural system	☐	1 year	☐	5 years	☐
Shingles	☐	25 years	☐	30 years	☐
Siding	☐	10 years	☐	15 years	☐

Figure 3.16b Checklist for Manufactured House 2

The shaded boxes represent the sub-items used in each brand of house. After developing the checklist for each house, the next step is to calculate the average weighted score for each sub-system as shown in Figure 3.17.

	SUBSYSTEMS	WEIGHTS	MANUFACTURER-1		MANUFACTURER-2	
			Manual	*Weighted*	*Manual*	*Weighted*
	FLOOR SYSTEMS:					
1	*Axles*	*0.04*	8	0.33[4]	8	0.33
2	*Tires*	*0.02*	6	0.12	6	0.12
3	*Joist Size*	*0.18*	6	1.09	6	1.09
4	*Joist Spacing*	*0.17*	10	1.72	10	1.72
5	*Joist System*	*0.35*	10	3.49	10	3.49
6	*Insulation R-value*	*0.12*	5	0.58	5	0.58
7	*Decking material*	*0.08*	8	0.60	10	0.75
8	*Type*	*0.05*	5	0.23	10	0.45
	Normalized scores		0.76	0.82	0.79	0.85
	ROOF SYSTEMS:					
1	*Design Load*	*0.42*	6	2.49	6	2.49
2	*Roof Slope*	*0.10*	5	0.50	5	0.50
3	*Insulation R-value*	*0.11*	8	0.88	8	0.88
4	*Eave Projection*	*0.02*	6	0.15	8	0.19
5	*Eave Position*	*0.02*	10	0.22	10	0.22
6	*Roof Underlayments*	*0.13*	5	0.63	10	1.26
7	*Roof Finish*	*0.06*	10	0.65	10	0.65
8	*Roof Sheathing*	*0.14*	6	0.83	9	1.24
	Normalized scores		0.7	0.63	0.825	0.74
	WARRANTIES:					
1	*General*	*0.59*	6	3.52	6	3.52
2	*Structural system*	*0.29*	6	1.75	6	1.75
3	*Shingles*	*0.06*	4	0.24	6	0.37
4	*Siding*	*0.06*	4	0.24	6	0.37
	Normalized scores		0.50	0.58	0.60	0.60

Figure 3.17Average weighted scores for sub-systems for H1 and H2

Figure 3.17 is compiled by the combination of the checklists shown in Figure 3.16 a and b, the numerical scores assigned to every sub-item from Figure 3.14, and vectors of

[4] 8 X 0.04 = 0.33

priorities for items calculated in Figure 3.13. The two columns 'average' and 'weighted' in Figure 3.17 represent the average score and the weighted average scores for each sub-system respectively.

The normalized average manual scores are calculated by using the mean formula $(\sum x_i/n)/10$, where, x_i is the score of individual sub-items and n is the number of sub-items. The purpose of dividing the entire average by 10 is because it is the highest score for any sub-item and dividing by the highest score normalizes the average manual score. For example in the sub-system 'warranties', the average score for House H1 is (6+6+4+4)/4 = 5. Hence the normalized average manual score is 5/10 = 0.5. The normalized weighted average score for every sub-system is obtained by multiplying the scores of every sub-item with their respective weights under the column of 'weights' shown in Figure 3.17 and dividing the sum of the scores for the sub-system by 10. For example the weighted average score for warranties can be obtained as follows; (6*0.59+6*0.29+4*0.06+4*0.06) = 5.76. The normalized average score will be 5.76/10 = 0.576.

It can be observed from Figure 3.17 that there is a significant difference between the normalized average manual score and the weighted average scores. For this research, normalized weighted average scores will be used for calculating the vector of priorities since they are more accurate and realistic.

3.1.4.4.3 Matrix of comparisons and Vector of priorities for Houses

Figure 3.18 shows the matrix of comparisons and vector of priorities (as explained in section 3.1.4.1 and 3.1.4.2) for the three sub-systems considered in the example.

Floor assembly

House	H1	H2
Score	0.82	0.85

Matrix of Comparisons

	H1	H2
H1	1.00	0.96
H2	1.04	1.00
	2.05	1.96

Normalization

	H1	H2
H1	0.4887	0.4887
H2	0.5113	0.5113

Vector of Priorities
0.4887
0.5113

Roof assembly

House	H1	H2
Score	0.63	0.74

Matrix of Comparisons

	H1	H2
H1	1.00	0.85
H2	1.17	1.00
	2.17	1.85

Normalization

	H1	H2
H1	0.4604	0.4604
H2	0.5396	0.5396

Vector of Priorities
0.46
0.54

Warranties

House	H1	H2
Score	0.58	0.60

Normalization

	H1	H2
H1	1.00	0.96
H2	1.04	1.00
	2.04	1.96

Vector of Priority

	H1	H2
H1	0.4896	0.4896
H2	0.5104	0.5104

Vector of Priorities
0.49
0.51

Figure 3.18 Matrix of comparisons and Vector of priorities for homes for a sub-system

For the pairwise comparisons between the two brands of houses for every sub-system, the weighted average score is normalized and used as the scale for comparison instead of the scales described in section 3.1.4.1 (the 1 to 9 scale).

In Figure 3.18, for the sub-system 'floor assembly', the weighted average scores are considered as the scale score for the matrix of comparisons i.e. 0.82 for H1 and 0.85 for H2. Consider the matrix of comparison for sub-system 'floor assembly'. The value of cell for (H1, H1) is 1, as explained in section 3.1.4.1. The value of (H1, H2) is determined by normalizing i.e. 0.82/0.85 = 0.96. This means that for the construction value of the manufactured house, the importance factor of the sub-system 'warranties' for H1 compared to H2 is 0.96 i.e. H2 has a higher value compared to H1 for this particular sub-system. The value of cell (H2, H1) is the reciprocal of the value in cell (H1, H2) i.e. 1/0.96 = 1.04.

The vector of priorities is calculated using the same method as discussed in section 3.1.4.2. After calculating the vector of priorities for all sub-systems, the last step is to calculate the ranking of the manufactured homes as explained in the following section.

3.1.4.4.4 Ranking Manufactured Houses

This is the last step in the model for ranking the manufactured homes. Using simple matrix multiplication, ranks can be obtained as shown in Figure 3.19. Data for matrix multiplication is available from the vector of priorities developed for sub-systems and those developed for manufactured homes in Figure 3.18.

As observed in Figure 3.19, there are two matrices (A and B) developed from the values obtained as the vector of priorities for sub-systems shown in Figure 3.12, and vector of priorities for sub-systems for different houses from Figure 3.18. Cumulative ranks or the construction value of the manufactured house are determined as the resultant

matrix C that is obtained by the multiplication of matrix A and matrix B[5]. The rank values are then multiplied by 1000 to have a better appreciation of the relative ranking difference between houses.

Weights for manufacturers for different subsystems (A)

	Floor assembly	*Roof assembly*	*Warranty*
H1	0.4887	0.4604	0.4896
H2	0.5113	0.5396	0.5104

Weights for different subsystems (B)

Floor assembly	0.1196
Roof assembly	0.3312
Warranty	0.5492

Cumulative ranking for manufacturers (C)
Matrix C = Matrix A * Matrix B

House	*Rank*
H1	479.823
H2	520.177

Figure 3.19 Ranking model for Homes

It can be concluded from the ranks obtained in Figure 3.19 that the manufactured house H2 has a higher construction value as compared to house H2 and hence is an appropriate choice for a homebuyer.

5 The procedure for matrix multiplication is as follows:
Matrix A is a 2 X 3 matrix (rows X columns) and matrix B is a 3 X 1 matrix. Thus the resultant matrix c is a 2 X 1 matrix as per the rules of matrix multiplication.

CHAPTER 4

4. RESULTS

In Chapter 3 a detailed methodology for ranking the manufactured houses was illustrated by an example using two houses. The elements of the manufactured house construction process were described and categorized as Sub-systems, Items and Sub-items, which was also depicted in the form of a Construction System Tree (Figure 3.2). A hierarchy of importance of these elements based on their contribution towards the construction value of the house was also presented in Figure 3.15. The pairwise comparison for sub-systems and items, using the AHP technique, was demonstrated for ranking the manufactured houses and manual numerical scoring for sub-items in the checklist was also explained.

Based on the sample model for ranking manufactured houses described in Chapter 3, a case study was performed where five manufactured houses were compared and ranked based on their construction value. A comprehensive Construction System Tree encompassing all major sub-systems, items, and sub-items was compiled in the form of a checklist and is presented in this chapter. As mentioned in Chapter 1, this research is part of a research project on Manufactured Housing Construction Quality Guidelines (Barshan et al, 2003), which was funded by the Ford Foundation through Consumers Union- South West Regional Office. The checklist was compiled by using information garnered from the six plant visits and interviews conducted with participants of the manufactured housing industry in Texas.

Figure 4.1 is a flowchart, which represents the AHP methodology used to develop the rank model for this research. The flowchart is explained in the subsequent sections of this chapter.

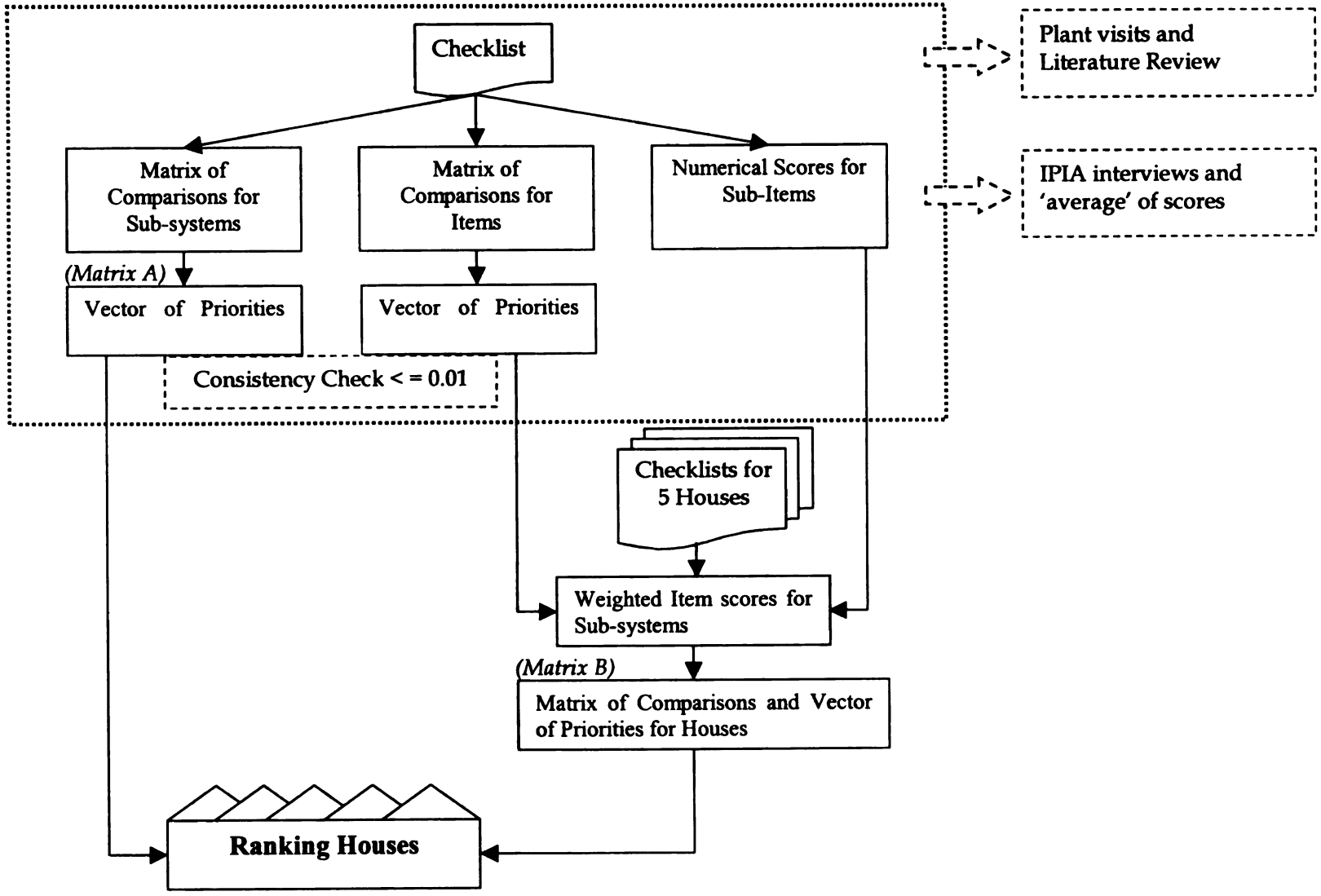


Figure 4.1 Flowchart for developing the ranking model based on AHP model

4.1 Construction System Tree and Checklist

In Chapter 3, Figure 3.2 was the foundation for developing a comprehensive construction system tree. The full system tree developed during this research had many branches for the sub-systems, the items, and the sub-items and it was not feasible to show this tree in a diagrammatic form due to its large size. However, the construction system tree was modified as a 'checklist' format as discussed in Section 3.1.3 and indicated in Figure 3.7 and is also the first step of the process as shown in Figure 4.1. Same classification levels, i.e. sub-systems, items, and sub-items indicated in the construction system tree were used to formulate the checklist.

The sub-systems, items, and sub-items which are classified for the manufactured housing process are organized with respect to the proportion of the overall value of the house that is obtained from the construction materials; the processes involved in putting them in place and the post construction assurances against structural or functional damages caused by materials and/or poor craftsmanship, excluding normal wear and tear. This is also termed as the 'Construction Value' of a manufactured house.

The checklist shown in Figure 4.2 encompasses all the possible and important sub-systems, items, and sub-items of a manufactured house that would affect the construction value of the house. The checklist also accounts for the transportation and installation, and warranty attributes of the manufactured house. Most of the materials, components and appliances specified as items or sub-items in the checklist have been described in Section 2.2 of this report.

1. MATERIALS:			
Cabinets	☐ Hardwood	☐ Particleboard / MDF	☐ _____
Rollers	☐ Plastic	☐ Metal	☐ _____
Bathtub and Shower	☐ Fiberglass	☐ PVC	☐ _____
Vanity	☐ Plastic	☐ Porcelain	☐ _____
Faucets	☐ Plastic	☐ Metal	☐ _____
Ceiling Board Type	☐ Vinyl coated	☐ Tape and Textured	☐ _____
Wall Sheetrock type	☐ Vinyl coated	☐ Tape and Textured	☐ _____
Interior door style	☐ Plain Face, LUAN	☐ Paneled	☐ _____
Window Frame	☐ Vinyl	☐ Aluminum (metal)	☐ _____
Electrical Devices	☐ J-boxes	☐ Self- Contained	☐ _____
2. FLOOR ASSEMBLY:			
Axles	☐ New	☐ Old and Certified	☐ _____
Tires	☐ New	☐ Old	☐ _____
Joist Size	☐ 2"X6"	☐ 2"X8"	☐ _____
Joist Spacing	☐ 16" o/c	☐ 24" o/c	☐ _____
Joist System	☐ Longitudinal	☐ Transverse	☐ _____
Insulation R-value	☐ R-11	☐ R-21	☐ _____
Decking material	☐ Plywood / OSB	☐ Novadeck	☐ _____
Decking Thickness	☐ 3/4"	☐ 1/2"	☐ _____
3. WALL ASSEMBLY:			
Stud size (Interior)	☐ 2"X3"	☐ 2"X4"	☐ _____
Exterior Bottom Plate size	☐ 1"X3"/ 1"X4"	☐ 2"X3"/ 2"X4"	☐ _____
Exterior Stud spacing	☐ 16" o/c	☐ 24" o/c	☐ _____
Stud size (Exterior)	☐ 2"X6"	☐ 2"X4"	☐ _____
Insulation R-value	☐ R-11	☐ R-19	☐ _____
Headers above openings	☐ Single	☐ Double	☐ _____
Exterior Sheathing	☐ OSB	☐ Insulation Board	☐ _____
Electrical wires pass	☐ Through notch in stud covered by metal plate	☐ Through a hole in Stud cased by a metal pipe	☐ _____
Electrical Boxes	☐ Fixed t Studs	☐ Fixed on sheet rock	☐ _____
Wall Sheetrock thickness	☐ 5/16"	☐ 1/2"	☐ _____
House Wrap	☐ Tyvek	☐ None	☐ _____
Exterior Siding	☐ Vinyl	☐ Hard board	☐ _____
4. ROOF ASSEMBLY:			
Design Load	☐ 20 Lb	☐ 30 Lb	☐ _____
Roof Slope	☐ 3 / 12	☐ 4 / 12	☐ _____
Insulation R-value	☐ R-21	☐ R-19	☐ _____
Eave Projection	☐ 3"	☐ 8"	☐ _____
Eave Position	☐ Front and back	☐ All around home	☐ _____
Ceiling board thickness	☐ 1/2"	☐ 5/8"	☐ _____
Roof Finish	☐ Metal	☐ Shingles	☐ _____
Roof Sheathing	☐ Plywood	☐ OSB	☐ _____
Valley flashing	☐ Shingles	☐ Metal	☐ _____
Roof opening waterproofing	☐ Flashing Provided	☐ No Flashing	☐ _____

Figure 4.2 Manufactured House Construction Checklist

5. UTILITIES:					
Water pipe	☐	PVC	☐	PEX	☐
Pipe fittings	☐	Copper	☐	Brass	☐
Pipefitting fastenings	☐	Copper ring	☐	Steel Ring	☐
Drainage pipe	☐	PVC	☐	ABS	☐
HVAC System	☐	In floor	☐	In attic	☐
HVAC Duct	☐	Sheet metal	☐	Fiber Glass	☐
Register Positions	☐	Central Floor	☐	Perimeter	☐
Bathtub and Shower	☐	1 piece unit	☐	2 piece unit	☐
Shutoff valves	☐	Under every sink	☐	At any one junction	☐
20 amp GFI's	☐	1	☐	2	☐
6. DOORS AND WINDOWS:					
Interior door width	☐	28"	☐	32"	☐
Interior Door Height	☐	6.5 ft	☐	7 ft	☐
Exterior door width	☐	32"	☐	36"	☐
Number of Hinges Int doors	☐	2	☐	3	☐
Hinge type	☐	Full Mortise	☐	Surface Mounted	☐
Window glass	☐	Double pane "plain"	☐	Double pane-low "E"	☐
Exterior door Type	☐	Aluminum	☐	Insulated Metal Core	☐
Exterior door height	☐	6.5'	☐	7.0'	☐
7. COSMETICS:					
Carpets	☐	25 oz	☐	18 oz	☐
Shelves	☐	Non adjustable	☐	Adjustable	☐
Water Heater	☐	30-gallon	☐	40-gallon	☐
Sheetrock finish	☐	Tape and Textured	☐	Vinyl sheetrock	☐
Sidewall height	☐	7 ft	☐	7.5 ft	☐
Ceiling paint finishes	☐	Popcorn	☐	Tape and textured	☐
Trim around Interior doors	☐	Vinyl	☐	Wood	☐
Trim around Exterior doors and windows	☐	Exposed aluminum flange	☐	Hardi board/vinyl	☐
Mini-blinds	☐	Provided in all rooms	☐	Not provided in any room	☐
Refrigerator	☐	18 cu. ft.	☐	20 cu. ft.	☐
Microwave	☐	Built-in	☐	Separate unit	☐
Dishwasher	☐	Yes	☐	No	☐
Fireplace	☐	Yes	☐	No	☐
Modular cabinet system	☐	Yes	☐	No	☐
Outside water faucets	☐	1	☐	2	☐
Plumbing for icemaker	☐	Yes	☐	No	☐
Garbage Disposal	☐	Yes	☐	No	☐

Figure 4.2 Manufactured House Construction Checklist (Contd.)

8. TRANSPORTATION & SETUP:			
Setup on site responsibility	☐ Manufacturer	☐ Retailer	☐
Transportation to site	☐ Self owned	☐ Contracted	☐
Setup contractor	☐ Fixed	☐ Keeps changing	☐
Orientation and walk through	☐ Yes	☐ No	☐
Special walkthrough programs	☐ Yes	☐ No	☐
9. WARRANTIES:			
General	☐ 1 year	☐ 2 years	☐
Structural system	☐ 1 year	☐ 5 years	☐
Shingles	☐ 25 years	☐ 30 years	☐
Siding	☐ 10 years	☐ 15 years	☐

Figure 4.2 Manufactured House Construction Checklist (Contd.)

4.1.1 Sub-Systems

This is the first level of classification for the manufactured house construction process. Sub-systems are the different components of a manufactured house that uniquely contribute to the construction value of the house. Therefore the contribution of all the sub-systems under the construction system for the manufactured house is significant and will determine the overall construction value for that house.

As indicated in Figure 4.2, there are nine sub-systems that were classified based on the data extracted and synthesized from the construction quality guideline report (Barshan et al., 2003). Following are the nine sub-systems, which represent a manufactured house construction process in its entirety:

1. Materials
2. Floor Assembly
3. Wall Assembly
4. Roof Assembly
5. Utilities

6. Doors and Windows
7. Cosmetics
8. Transportation and Setup
9. Warranties

These sub-systems are components, aesthetic features, structural systems, installation requirements, and post construction assurances provided for a manufactured house. The criterion for selecting a sub-system was a combination of information received from the interviews with manufactured housing industry participants and the frequent homeowner complaints (AARP 1999).

4.1.2 Items

Items are components of a sub-system that form a complete sub-system. Every item under a sub-system independently contributes towards adding construction value to its respective sub-system. The number of items under every sub-system is different and depends upon the requirement of a combination of different items to form a complete sub-system.

In Figure 4.2, the items are represented in an italic font under every sub-system on the left hand side of the checklist. For example, the items for the sub-system 'materials' are; *cabinets, rollers, bathtub and shower, vanity, faucets, ceiling board type, wall sheetrock type, interior door style, window frame, and electrical devices.*

There could be two items with the same title e.g. *bath and shower* which is mentioned under the sub-system 'materials' as well as the sub-system 'utilities'. However, the implication of these items under both sub-systems is different. Under the sub-system 'materials', the item *'bathtub and shower'* represents the type of material

from which this item is produced (PVC, fiberglass, etc.) whereas for the sub-system 'utilities', it implies the structural composition (1 piece unit, 2 piece unit, etc.).

4.1.3 Sub-items

Sub-items are the last level of classification on the Construction System Tree. Sub- items represent the possible components out of which an item can be constructed. There could be multifarious sub-items for an item, but the choice of a sub-item to be used for an item depends on the manufacturer and the level of houses produced. The final choice of sub-item to use directly impacts the quality of the constructed item, which in turn affects the sub-system level, and finally the house.

In the checklist shown in Figure 4.2, it should be noted that the sub-items are placed on the same line as the items with check boxes next to each sub-item, which is used for selecting the appropriate sub-item for a house under comparison. There are typically two sub-items choices provided for every item. Each sub-item meets the performance criteria required by the HUD code. However, some sub-items are more durable than others and would last longer and contribute more towards the construction value of a manufactured house. For example, in Figure 4.2, for the sub-system 'doors and windows', and the item *'exterior door type'*, the corresponding sub-items are 'aluminum' and 'insulated metal core'. Aluminum doors are required per the HUD code specifications to satisfy the performance requirement. However, some manufacturers provide an insulated metal core doors which are much more durable than the lightweight aluminum doors and require less maintenance.

Another feature of the checklist regarding the sub-items is the empty space for a third choice. This is provided because all houses may not have one of the two choices

provided for every item and so a choice, other than the two choices provided for every item, can be provided in that space.

4.2 Scoring Sub-systems, Items, and Sub-items

As explained in Chapter 3, the sub-systems and items are rank scored using a pairwise comparison while the sub-items are scored on a manual numerical scale. The scale used for pairwise comparison was the AHP scale developed by Saaty (1980) and is described in Section 3.1.4.1 of this report.

Three IPIA inspectors were interviewed and scoring for the sub-systems, items and sub-items was sought based on the AHP scale. The reason for interviewing IPIA inspectors was that they are experienced quality control professionals in the field of construction of manufactured houses and also because they are third party agencies they do not have bias towards any particular brand of manufactured house as they inspect construction of various brands of manufactured houses. Their understanding of this product in terms of a construction value is expected to be higher and more unbiased compared to understanding of any other participant of the manufactured housing industry.

The scoring for sub-systems and items involves two steps, namely, developing a matrix of comparison (refer section 3.1.4.1 for procedure) and calculation of the vector of priorities (refer section 3.1.4.2 for procedure). From this matrix of comparison, the sub-items are scaled using manual numerical scores as described in Section 3.1.4.3. Individual IPIA scorings were established for every sub-system, item, and sub-item. Also an average of the scorings provided by the three IPIA inspectors was calculated.

4.2.1 Matrix of Comparisons for Sub-systems and Items

Figure 4.3 shows a matrix of comparison for sub-systems and a similar procedure was used to formulate the matrices of comparisons for items. Appendix A contains the matrices of comparisons for sub-systems and items formulated from the scoring provided by three IPIA inspectors and also an average of the three matrix of comparisons is provided.

SUB-SYSTEMS		1	2	3	4	5	6	7	8	9
Materials	1	1	1/5	1/3	1/5	1/7	1/3	3	1/5	1/7
Floor Assembly	2	5	1	3	1	1/3	3	5	1/3	1/7
Wall Assembly	3	3	1/3	1	1/3	1/5	1/3	1/7	1/3	1/7
Roof Assembly	4	5	1	3	1	1/3	1/5	1/7	1/5	1/7
Utilities	5	7	3	5	3	1	5	9	1/3	1/7
Doors and Windows	6	3	1/3	3	5	1/5	1	1/9	1/3	1/7
Cosmetics	7	1/3	1/5	7	7	1/9	9	1	1/9	1/9
Transportation and Setup	8	5	3	3	5	3	3	9	1	1/7
Warranties	9	7	7	7	7	7	7	9	7	1

Figure 4.3 IPIA-1 matrix of comparison for sub-system

As an example of how the matrix of comparisons was developed, let us consider the matrix cell (1,2), i.e. (materials, floor assembly) in Figure 4.3. The IPIA inspectors were asked to scale by asking a them the following question: "How much is sub-system 1 more/less important than sub-system 2 in terms of contributing towards the construction value of a manufactured house?" They were asked to quantify their assessment it using the following criteria (explained previously in Chapter 2 and 3):

- If 1 and 2 are equally important, then insert value for (1, 2) as 1.
- If 1 is weakly more important than 2, then insert value for (1, 2) as 3.
- If 1 is strongly more important than 2, then insert value for (1, 2) as 5.
- If 1 is demonstrably or very strongly more important than 2, then insert value for (1, 2) as 7.

- If 1 is absolutely more important than 2, then insert value for (1, 2) as 9

It can be observed from Figure 4.2 that the comparison between materials and floor assembly has been allocated a value of 1/5 by IPIA-1. This means that 'materials' is strongly less important than the floor assembly in terms of contributing towards the overall construction value of a manufactured house. The values in the shaded cells of the matrix are reciprocals of values provided in the white cells of the same matrix. In the example above the value in the cell (2,1) is 5, which is the reciprocal of 1/5. Similarly other comparisons are made between the different sub-systems and items.

The 'average' matrix of comparisons for sub-systems and items was calculated by using the conventional mean formula $\sum mc_i/n$, where, mc_i is the score of individual sub-systems or items and n is the number of inspectors interviewed, three in this case. Consider the cell (1,2) for the average matrix of comparisons for sub-systems provided in Appendix A (refer Figure A7). For the average matrix of comparison, the value of that cell was calculated as: $\frac{1/5+5+5}{3}$ = 3 2/5. The shaded area of the matrix is the reciprocal of the values in the white cells as described earlier and it is not the average of the shaded cells of the three matrices of comparisons. A similar approach was used to calculate average values for the other cells of the matrix of comparisons for the sub-systems and the items (refer Appendix A).

4.2.2 Vector of Priorities for Sub-systems and Items

After formulating the matrices of comparisons for the sub-systems and items, the vector of priorities was computed, i.e., the normalized principal eigen vector from the matrix of comparisons obtained in section 4.2.1. The vector of priorities provide the relative weights of the elements of the matrix considering their strength on influencing the main

criterion with respect to which they are being compared. Using the method described in section 3.1.4.2, Table 4.1 provides a summary of the vector of priorities for the matrix of comparisons of sub-systems for the three IPIA inspectors, and their averaged input. Appendix B provides column normalization and vector of priorities for sub-systems and items for the IPIA inspectors' inputs and an average vector of priority. It should also be noted that the average vector of priorities shown in Table 4.1 is calculated using the same procedure as described earlier in this section and is not merely the average of the vector of priorities for the three IPIAs.

Table 4.1 Summary of Vector of priorities for sub-systems

SUB-SYSTEMS	Vector of Priorities			
	IPIA 1	IPIA 2	IPIA 3	Average
Materials	0.03	0.20	0.21	**0.17**
Floor Assembly	0.08	0.04	0.05	**0.06**
Wall Assembly	0.03	0.04	0.05	**0.04**
Roof Assembly	0.05	0.05	0.06	**0.05**
Utilities	0.14	0.07	0.14	**0.14**
Doors and Windows	0.06	0.06	0.05	**0.05**
Cosmetics	0.10	0.08	0.12	**0.08**
Transportation and Setup	0.15	0.12	0.17	**0.15**
Warranties	0.37	0.32	0.15	**0.25**

It is interesting to observe that even though the IPIA inspectors are experienced and unbiased, their judgments regarding construction value adding sub-systems and/or items are significantly different. For example, in Table 4.1, the eigen vector for the sub-system 'material' is 0.03 for IPIA 1 and 0.20, and 0.21 for IPIA2 and IPIA 3, respectively. Hence, according to IPIA 1 the sub-system 'materials' contribute only 3% towards the overall construction value of the manufactured house, whereas, IPIAs 2 and 3 have nearly the same judgment regarding the contribution of 'materials' to the construction value of

the house at 20% and 21%, respectively. This implies that there is a vast difference in the perceptions and knowledge of the IPIA inspectors regarding the contribution of sub-systems and items towards the construction value of a manufactured house.

The 'average' vector of priorities provided in Table 4.1 indicates that the highest percentage of construction value is contributed by the sub-system 'warranties' (at 25%) This is followed by 'materials', 'transportation and setup', and 'utilities' with a contribution of 17%, 15%, and 14%, respectively.

4.2.3 Consistency

The measure of consistency is called the consistency ratio (Saaty, 1980). Because the decision maker is comparing between all the elements a pair at a time, inconsistencies may occur. Although consistency can be forced on the decision maker, forced inconsistency is not desirable. The reason is that it is desirable to make a comparison between each pair of elements without having other elements in mind to capture the decision maker's true preferences. However, the entries in the matrix of comparisons should be consistent to a certain limit to prevent errors in judgment or having meaningless results (Farghal, 1996).

Table 4.2 shows a summary of consistency ratios for matrices of comparisons of sub-systems and items for the three IPIA and the 'average' scores. A step-by-step procedure for determining consistency in the matrix of comparisons is explained using an example of matrix of comparison for items of the sub-system 'warranties' as scored by IPIA 3 (refer appendix A and B for matrix of comparisons and vector of priorities).

Table 4.2 Summary of Consistency Ratios for sub-systems and Items

ITEMS	Consistency Ratio			
	IPIA 1	IPIA 2	IPIA 3	Average
Materials	0.194	0.131	0.065	**0.074**
Floor Assembly	0.074	0.120	0.050	**0.067**
Wall Assembly	0.323	0.230	0.138	**0.144**
Roof Assembly	0.222	0.130	0.054	**0.072**
Utilities	0.150	0.142	0.091	**0.047**
Doors and Windows	0.067	0.130	0.213	**0.077**
Cosmetics	0.191	0.145	0.113	**0.083**
Transportation and Setup	0.007	0.673	0.062	**0.053**
Warranties	0.197	0.212	0.027	**0.143**
SUB-SYSTEMS	0.397	0.070	0.028	**0.043**

1. Multiply the matrix of comparisons of sub-system 'warranties' by its estimated vector of priorities to obtain a new vector.

$$\begin{pmatrix} 1 & 5 & 7 & 7 \\ 1/5 & 1 & 3 & 3 \\ 1/7 & 1/3 & 1 & 1 \\ 1/7 & 1/3 & 1 & 1 \end{pmatrix} \begin{pmatrix} 0.65 \\ 0.20 \\ 0.08 \\ 0.08 \end{pmatrix} = \begin{pmatrix} 2.723 \\ 0.795 \\ 0.314 \\ 0.314 \end{pmatrix}$$

2. Divide the first component of this new vector by the first component of the estimated vector of priority and so on to obtain another vector.

$$\begin{pmatrix} 2.723/0.65 \\ 0.795/0.20 \\ 0.314/0.08 \\ 0.314/0.08 \end{pmatrix} = \begin{pmatrix} 4.206 \\ 4.052 \\ 4.019 \\ 4.019 \end{pmatrix}$$

3. Obtain λ_{max} (called the maximum or principal eigen value) by taking the sum of the components of this new and dividing it by the total number of components (4 in this case).

$$\lambda_{max} = \frac{0.4.206 + 4.052 + 4.019 + 4.019}{4} = 4.074$$

The closer the value of λ_{max} to the number of elements in the matrix, the more consistent is the result. In this example the value of λ_{max} is very close to the number of elements.

4. Obtain consistency index (C.I.), which represents deviation from consistency.

$$C.I. = \frac{\lambda max - n}{n-1} = \frac{4.074-4}{4-1} = 0.02$$

5. Finally calculate the consistency ratio (C.R.) between C.I. and the average random index (R.I.) for the same order of matrix (refer Table 2.3 for values)

$$C.R. = \frac{CI}{\text{Average R.I. for same order matrix}}$$

From Table 2.3, the average R.I. for a matrix of order 4 is 0.9. Therefore,

$$C.R. = \frac{0.02}{0.9} = 0.027$$

A consistency ratio of 0.1 or less is considered acceptable (Saaty 1980). Hence for the given example the matrix of comparisons is very consistent. From Table 4.2, it can be observed that there is a lot of inconsistency in the scoring of IPIA 1 and IPIA 2 and IPIA 3 also has three inconsistent values. However, the average matrix of comparisons for items has only two inconsistent values.

The results obtained depend on how the interviewees are questioned for acquiring a score for every sub-system or item. The question asked in this research was standard for all three IPIA inspectors. However, the number of years of experience of the three IPIAs was different. For example, IPIA 2 had only two years of experience in this profession, which appears to have lead to the inconsistency results shown in Table 4.2. It

can be concluded that the consistency of the matrix of comparison is more accurate for experienced IPIA inspectors.

4.2.4 Numerical Scores for Sub-items

As mentioned in section 4.1.3, there could be multifarious sub-items for every item. Developing a matrix of comparison is not feasible, because the number of sub-items for any item is not fixed. By fixing the number of sub-items in a checklist, the options would be limited and if a manufacturer happens to use a sub-item different from the ones mentioned in the checklist, the comparison is not possible. Also pairwise comparison for several sub-items is a tedious task.

The approach used to assign values to sub-items was a numerical scale. A numerical scale from 1 to 10 was used, with 1 being a lower score and 10 being the highest. The three IPIA inspectors interviewed were asked to assign points to every sub-item in the checklist. The criteria they had to follow was based on their knowledge about material and process of manufactured houses and were supposed to assign points depending upon the durability of the material or the features of the process that would increase the construction value of the manufactured house on the long run. They considered all possible sub-item options available for an item and then rated the two sub-items against every item provided in the checklist.

The IPIA scored sub-items and the average scoring checklist are provided in Appendix C (p 144) of this report. Figure 4.4 is an excerpt from the checklist that was scored by IPIA 1, which shows scoring for the sub-items of the items under the sub-system 'warranties'.

WARRANTIES:						
General	*6*	1 year	*8*	2 years		------
Structural system	*5*	1 year	*8*	5 years		------
Shingles	*6*	25 years	*8*	30 years		------
Siding	*6*	10 years	*8*	15 years		------

Figure 4.4 IPIA 1 scoring for sub-items in warranties

For the given sub-system 'warranties', the sub-items have been scored on a scale from 1 to 10. For example, consider the item shingles in the Figure 4.4. The choices are 25 years and 30 years and the points assigned are 6 and 8, respectively. It can be observed that there is a provision for scoring for a shingle warranty less than 25 years and also for more than 30 years, facilitated by the blank space provided. A similar approach was adopted by the IPIAs to score all the sub-items in the checklist. An average score was developed for these sub-items by using the average formula $(SI_{IPIA\ 1}+SI_{IPIA\ 2,}+SI_{IPIA\ 3})/3$, where $SI_{IPIA\ 1}$, $SI_{IPIA\ 2,}$ $SI_{IPIA\ 3}$ are the scores for sub-items scored by the three IPIAs (refer Appendix C).

4.3 Computing Ranks for the Case Study

As a case study, five manufactured houses of the same level (median) were compared and ranked based on their construction value using the AHP model. The procedure for the AHP model explained in Section 3.1.1.4 was used for ranking the houses in the case study and is explained below:

1. Developing a hierarchical composition of priorities.
2. Evaluating information on sub-items from checklists received for different house brands and calculating the weighted average score for every sub-system of the checklist for each house.

3. Formulating matrix of comparisons and vector of priorities for houses under every sub-system.
4. Ranking the manufactured houses.

4.3.1 Hierarchical composition of priorities

In Section 3.1.4.4.1, hierarchy is defined as a particular type of system, which is based on the assumption that the entities, which have been identified, can be grouped into disjoint sets, with the entities of one group influencing the entities of only one other group, and being influenced by the entities of only one other group (Saaty, 1980). A complete hierarchy for construction value of five manufactured houses in the case study is illustrated in Figure 4.5.

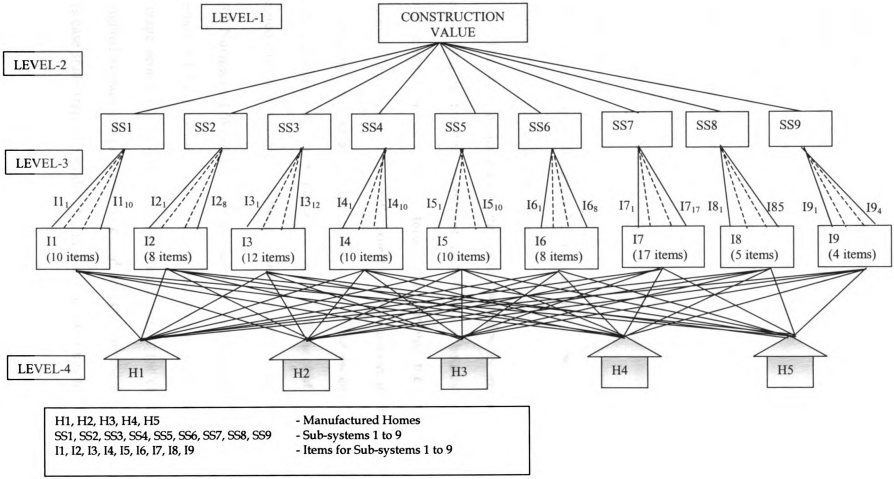


Figure 4.5 Hierarchy for priorities of Construction Value for the case study

The first hierarchy level for the case study remains the same and has a single objective as explained in Section 3.1.4.4.1and that is the construction value of a manufactured house. Its priority value is assumed to be equal to unity. The second hierarchy level has nine objectives, the different sub-systems SS1, SS2, ..., SS9. Their priorities are derived from a matrix of comparisons with respect to the objective of the first level (construction value). The third hierarchy level objectives are the various items under every sub-system (e.g. 10 items for SS1, 8 items for SS2, etc.). Their priorities are derived from a matrix of comparisons with respect to the objective of the second level (sub-systems). The fourth and final level of classification is the manufactured house and mainly focuses on the type of sub-items utilized under each item.

The object of this classification is to determine the impact of use of different sub-items, used in the five brands of manufactured houses of median level, on the construction value of a manufactured house through the intermediate level of sub-systems. Thus their priorities with respect to each objective in the third level are obtained by assigning a manual scale with respect to that objective, and the resulting nine priority vectors are then weighted by the priority vector of the second and third level to obtain the desired composite vector of priorities for the five manufactured houses (H1 to H5).

4.3.2 Normalized Weighted Average Score for Sub-systems

Section 3.1.4.4.2 explains the detailed procedure to obtain the normalized weighted average scores for sub-systems. The data required for calculating these normalized weighted average scores is the completed checklist for the five manufactured houses of this case study (refer Appendix D), the vector of priorities for items (refer Appendix B),

and the numerical manual scores for sub-items (refer Appendix C). The normalized weighted average score is then calculated for every sub-system.

Figure 4.6, an excerpt from Appendix E, indicates the normalized weighted scores for the sub-system 'warranties' using the average of the scores and vector of priorities provided by the three IPIA inspectors.

SUBSYSTEMS	Vector of Priorities	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
WARRANTIES:											
General	0.644	3.333	2.148	3.333	2.148	3.333	2.148	3.333	2.148	3.333	2.148
Structural system	0.238	3.000	0.714	8.000	1.904	3.000	0.714	3.000	0.714	8.000	1.904
Shingles	0.067	5.333	0.358	4.000	0.268	4.000	0.268	6.000	0.402	6.000	0.402
Siding	0.050	6.000	0.303	8.000	0.404	6.000	0.303	8.000	0.404	8.000	0.404
Normalized Scores		0.442	**0.352**	0.583	**0.472**	0.408	**0.343**	0.508	**0.367**	0.633	**0.486**

Figure 4.6 Normalized weighted scores for sub-system 'warranties' for 'average' vector of priorities

From the completed checklists (Appendix D), the shaded boxes are scored according to the score available under 'average' numerical score (Appendix C) and provided in column titled 'M' (which stands for manual) for every house brand. For example 'M' for the item 'siding' is 6 for house 2 and 3. The normalized average manual score for every sub-system is obtained by taking an average of the column 'M' for every house for every sub-system and dividing that average by the highest assignable sub-item score value, which is 10 for this research. For example, in Figure 4.6, the normalized average manual score for house 1 is calculated as follows:

$$[\frac{3.333+3+5.33+6}{4}]/10 = 0.442$$

To calculate the normalized weighted average score, multiply the score values in column 'M' by the vector of priorities of items (Appendix B) and divide it by the highest assignable sub-item score value (which is 10). In Figure 4.6, the column 'W' represents

the weighted scores of items. Considering house 1, the normalized weighted average score is calculated as follows:

$$[\frac{0.644*3.333+0.238*3+0.067*5.33+0.050*6}{10}] = 0.352$$

Similarly normalized weighted average scores are determined using the same procedure and are provided in Appendix E. As discussed in section 3.1.4.4.2, for this research, normalized weighted average scores will be used for calculating the vector of priorities for houses since they are more accurate and realistic.

4.3.3 Matrix of comparisons and Vector of priorities for Houses

As explained in section 3.1.4.4.3, the pairwise comparisons between the two brands of houses for every sub-system, the normalized weighted average score is used as the scale for comparison instead of the AHP scales described in section 3.1.4.1 (the 1 to 9 scale). Figure 4.7 shows the matrix of comparisons and vector of priorities for the sub-system 'warranties' for normalized weighted average scores calculated for 'average scoring'[6].

In Figure 4.7, for the sub-system warranties, the normalized weighted average scores (as indicated in Figure 4.6) are considered as the scale for the matrix of comparisons i.e. 0.35 for H1, 0.47 for H2, 0.34 for H3, 0.37 for H4 and 0.49 for H5. The procedure for column normalization and calculation of vector of priorities remains consistent with the procedure explained in section 4.2.2. To explain how the matrix of comparisons is compiled, an example considering the cell (H1, H2) in matrix of

[6] 'Average Scoring' is the average vector of priorities calculated from the average matrix of comparisons formulated from the matrix of comparisons provided by the three IPIA inspectors for sub-systems and items.

comparison for sub-system 'warranties' shown in Figure 4.7, is illustrated. The value of cell for (H1, H1) is 1, as explained in section 3.1.4.1.

Warranties

Homes	H1	H2	H3	H4	H5
score	0.35	0.47	0.34	0.37	0.49

Matrix of Comparisons

	H1	H2	H3	H4	H5
H1	1.00	0.75	1.03	0.96	0.73
H2	1.34	1.00	1.38	1.29	0.97
H3	0.97	0.73	1.00	0.94	0.71
H4	1.34	0.78	1.07	1.00	0.76
H5	1.38	0.73	1.42	1.32	1.00
	6.04	3.98	5.89	5.51	4.16

Column Normalization

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1657	0.1876	0.1743	0.1743	0.1743	**0.1752**
H2	0.2222	0.2515	0.2338	0.2338	0.2338	**0.2350**
H3	0.1615	0.1828	0.1699	0.1699	0.1699	**0.1708**
H4	0.2222	0.1953	0.1815	0.1815	0.1815	**0.1924**
H5	0.2285	0.1828	0.2404	0.2404	0.2404	**0.2265**

Figure 4.7 Matrix of comparison and Vector of Priorities for sub-system 'warranties' for 'average scoring'

The value of (H1, H2) is determined by normalizing i.e. 0.35/0.47 = 0.75. This implies that for the construction value of the manufactured house, the importance factor of the sub-system 'warranties' for H1 compared to H2 is 0.75 i.e. H2 has a higher value compared to H1 for this particular sub-system. The value of cell (H2, H1) is the reciprocal of the value in cell (H1, H2) i.e. 1/0.75 = 1.34. A similar approach was used to compile the matrix of comparisons for the all sub-systems and all IPIA inspector scorings (IPIA 1, IPIA 2, and IPIA 3).

The vector of priorities is calculated using the same procedure as explained in section 4.2.2. From Figure 4.7, it can be concluded that the manufactured house H2 has the highest vector of priority, i.e. 0.235. This implies that for the same level (median) of the five manufactured houses that are compared for this case study, the sub-system 'warranties' is better for house H2 as its value is 0.235 which is greater than the value of all the other houses, for the same sub-system. Matrix of comparisons and vector of priorities for all sub-systems for all scorings is attached as Appendix F of this dissertation.

4.3.4 Ranking Manufactured Houses

The last step in the process of ranking is to formulate two matrices, namely the matrix of eigen values (vector of priorities) for the five houses (refer Appendix F), and matrix of eigen values for sub-systems (refer Appendix B) and then multiplying these two matrices (refer section 3.1.4.4.4) to obtain a resultant matrix. The values of this resultant matrix are the ranks for the houses. The two matrices are multiplied by using simple matrix multiplication to obtain the resultant rank matrix for the manufactured houses. Figure 4.9 is an illustration for calculating the ranks for the case study manufactured houses which based on the 'average scoring'.

The calculation procedure of ranks for manufactured house H1 is explained in this section as below. In Figure 4.8, the values for matrix A are the 'average scoring' vector of priorities for the nine sub-systems of the five different manufactured houses. The values for the vector of priorities, for the sub-system 'warranties', for the five houses can be compared with the values in Figure 4.7 (refer Appendix F for vector of priorities for

the remaining sub-systems). Matrix B is compiled from the vector of priorities of the nine sub-systems (refer Appendix B) for 'average scoring'.

MATRIX A

	Materials	Floor Assembly	Wall Assembly	Roof Assembly	Utilities	Doors& Windows	Cosmetics	Transport & Setup	Warranty
H1	0.187	0.201	0.202	0.199	0.203	0.179	0.191	0.147	0.175
H2	0.298	0.206	0.238	0.194	0.211	0.216	0.236	0.208	0.235
H3	0.146	0.187	0.167	0.198	0.194	0.176	0.162	0.147	0.171
H4	0.189	0.213	0.242	0.201	0.202	0.216	0.207	0.265	0.192
H5	0.180	0.193	0.194	0.208	0.191	0.213	0.205	0.233	0.227

X

MATRIX B

Eigen Values for Sub-systems
0.17
0.06
0.04
0.05
0.14
0.05
0.08
0.15
0.25

=

MATRIX C

Final Ranking

H1	182.045
H2	233.123
H3	167.980
H4	210.688
H5	207.978

Figure 4.8 Rank calculations for manufactured houses based on 'average scoring'

Rank for house H1 is calculated as follows:

1 Multiply the first row cell of house H1 (matrix A) with first column cell of sub-system eigen value (matrix B) e.g. 0.187*0.17. A similar procedure is followed for multiplication of the remaining cells.

2. Add all the products and multiply by 1000 to obtain the rank.

Rank for H1

=[0.187*0.17+0.201*0.06+0.202*0.04+0.199*0.05+0.203*0.14+0.179*0.05+0.191*0.08 +0.147*0.15+0.175*0.25] * 1000

= 182.045

A similar procedure was adopted to calculate the ranks for the remaining manufactured houses (refer Appendix G). Table 4.3 is a summary of ranks obtained for the five manufactured houses in the case study, which were scored, based on the scoring provided by the three IPIA inspectors (IPIA 1, IPIA 2, and IPIA 3) and the 'average' scores.

Table 4.3 Rank summaries for the case study manufactured houses

	IPIA 1	IPIA 2	IPIA 3	AVERAGE
H1	175.58	175.09	182.57	182.05
H2	231.32	242.05	229.64	233.12
H3	166.33	155.87	172.22	167.98
H4	214.74	210.16	209.78	210.69
H5	213.68	217.35	207.08	207.98

The summary of ranks from Table 4.3 reveal that the manufactured house H2 is the best with the highest construction value. It is interesting to see that despite significant variations in the decision makers (IPIAs) perception regarding scoring the sub-systems,

items, and sub-items, the house H2 has a consistently highest rank. However, the judgmental discrepancy between the three IPIA inspectors is evident for houses H4 and H5. According to scoring from three sources (i.e. IPIA 1, IPIA 3, and Average), house H4 is ranked second and house H5 is ranked third. But according to the scoring from IPIA 2, house H5 has a second rank and house H4 has the third rank. This is mainly due to the inconsistency of the scores provided by the IPIA inspectors presented in section 4.2.3. The scores for sub-systems and items provided by the IPIA 2 are inconsistent compared to the other IPIA scores and the average scores. As explained in section 4.2.3, the inconsistencies are mainly due to experience of IPIA 2 and thus the rank order is also affected.

Another point that should be noted is the value of the ranks. These values differ because of the difference in scoring judgments of the IPIA inspectors. It is practically impossible to have the same value of ranks for all houses from all the IPIA inspectors interviewed.

CHAPTER 5

5. CONCLUSION, CONTRIBUTIONS, AND FUTURE RESEARCH

5.1 Conclusion

Decision-making is a very challenging and difficult task for any individual especially when it's a decision to be made concerning a house. A house is an expensive investment for any homebuyer and this product requires careful research before its purchase. For an average homebuyer, the research before purchase of a house mainly focuses on the aesthetics of the house as opposed to considering the other important attributes that govern the structural stability affecting longevity of the house.

This study focused on construction value of manufactured houses. Construction value of a manufactured house is defined as the proportion of the overall value of the house that is obtained from the construction materials; the processes involved in putting them in place and the post construction assurances against structural or functional damages caused by materials and/or poor craftsmanship, excluding normal wear and tear.

To focus on a more realistic approach towards decision-making, this study provides a framework for evaluation of manufactured houses based on a defined robust goal, which is its construction value and utilizes numerical scoring that translates the qualitative information into a quantitative approach. This scoring model facilitates the decision making process.

This research presented a decision-making problem concerned with the selection of the best manufactured house, based on its construction value. The factors and attributes governing the construction value of a manufactured home were presented as a construction system tree. This allowed the further classification of the construction systems into sub-systems, items and sub-items. The research then developed a model for ranking manufactured houses considering the factors and attributes, which contribute to

the overall construction value of a manufactured house. The Analytic Hierarchy Process (AHP) was used for developing scores based on a pairwise comparison for sub-systems and items and later for rank ordering the manufactured houses.

In general, the following conclusions can be made from studying the problem statement and the technique used to solve the problem:

- Construction value of a manufactured house is one of the important factors to be considered in making a decision regarding a house purchase. Aesthetics is not the only factor that should be considered. Other important factors that have to be considered for a manufactured house selection are construction materials; the processes involved in putting them in place and the warranties against structural or functional damages. The combination of all these factors forms the construction value of the manufactured house.
- A 'checklist' provides a very systematic instrument for compiling all the attributes (sub-systems, items and sub-items) that contribute to the construction value of a manufactured house. During a house selection from a number of manufactured houses, the use of a checklist makes it easier to check the availability or lack thereof of the various house components.
- The attributes that affect the construction value of the manufactured house, which eventually affects the decision of the house selection, may vary in different locations. Thus a decision model that handles this problem should be flexible enough to compensate for variations, otherwise the rank outputs will not be reasonable.
- AHP is a good technique for developing scales for different sub-systems and items that capture the decision maker's preferences and the uniqueness of each component adding to the construction value of the manufactured house.

- The most contributing three sub-systems towards the construction value of a manufactured house are warranties, materials, and transportation and setup, respectively. The most contributing items under these sub-systems are *general warranties* for the sub-system 'warranties', *electrical devices* for 'materials' and *setup on site responsibility* for the sub-system 'transportation and setup'.

5.2 Discussion

In decision-making models, which involve decision from more than one decision maker, there arises a conflict of opinion. This certainly applies to the decisions regarding the factors affecting the construction value of a manufactured house that relates to this research.

There could be decision conflicts of various natures, such as, the number and type of sub-systems selected, the type of items classified for every sub-system, the sub-items decided for every item, the weights assigned to the sub-systems and items, and the numerical scores allotted to the sub-items. The model, which was developed in this research, has an advantage of giving the decision maker the flexibility regarding the choice of the factors mentioned above and the ability to change the scores depending upon the choice of attributes. The decision-maker can modify or change these attributes as well as determine the relative weights (vector of priorities) among them.

Thus the problem of conflict resolution among several decision-makers was not tackled in this research. However, depending upon their nature, conflicts can be classified into two categories, namely, conflict in the model inputs, and conflicts regarding knowledge.

5.2.1 Conflict in Model Inputs

The inputs required for the model that was developed in this research were mainly the major sub-systems that form the complete construction process of a manufactured house, the type of items required to form a complete sub-system, the variety of sub-items for every item, and the weights/scores assigned to sub-systems, items, and sub-items. There could be varied opinions regarding these inputs. To reach to a consensus, group decision making theories (Saaty, 1980) can be applied prior to using the model where the decision makers can decide which sub-system, item, and sub-item to use, how to scale each of these attributes, and the relative weight assignable to each variable. The model can be used once the consensus is reached and the model inputs provide acceptable solution.

There is another approach to solve this problem and that is to use an averaging technique to average the conflicting inputs of different decision makers and use the average as the input. For this research, the consensus for inputs like sub-systems, items, and sub-items were sought by interviewing with three IPIA inspectors and seeking modifications or suggestions to the pre-formatted checklist that was developed through literature review and manufacturing plant visits. Based on the changes and suggestions, a final checklist was prepared (Figure 4.1) that encompassed all the major sub-systems, items, and sub-items.

The averaging technique was used to average the scores in the matrix of comparisons provided by the three IPIA inspectors and developing an average matrix of comparisons for sub-system and items (refer Appendix A, Figure A7 and A8). A similar technique was used to average the manual numerical scores to the sub-items of the checklist (refer Appendix C, Figure C4). Although ranks for houses were calculated

using scores from three IPIA inputs and the average scores, the ranks that were obtained by using the average scores can be considered as the final ranks for the case study in this research.

5.2.2 Conflicts regarding Knowledge

Knowledge is mainly acquired through work experiences. For scoring the sub-systems, items, and sub-items, the decision makers selected were the third party inspectors to manufactured housing plants (IPIAs). The IPIAs provided scores applying using knowledge, accumulated from experiences in the field of construction quality of manufactured houses.

However, there were inconsistencies in the matrix of comparisons as discussed in section 4.2.3. These inconsistencies are due to the lack of knowledge for particular attributes. Although the IPIA is required to be well-rounded in the field of inspection, the IPIAs may have their own areas of expertise, e.g., an IPIA inspector could be specialized in inspection of utilities in a manufactured house construction process, whereas another IPIA could be specialized in the structural aspects of the manufactured house. There could also be inconsistencies due to lack of industry experience. For example, in this research case study, IPIA 2 was most inconsistent, and was also the IPIA with an experience of only two years. It can also be observed from the final rank summary (Table 4.2) that IPIA 2 had the only different rank order compared to the other two IPIAs (IPIA 1 and IPIA 3).

The solution to this problem is to form a panel of IPIA inspectors that covers experienced experts in all the sub-systems of a manufactured house construction process mentioned in this research. The purpose of this panel is to provide accurate information

regarding the sub-systems, items and sub-items and also assigning relative weights consistently.

5.3 Limitations

This research has the following limitations:

1. The ranking model is suitable for of manufactured houses of the same level. Ranks cannot be obtained across different levels, e.g. houses of different levels, namely, entry, median, and luxury cannot be compared because the quality for every level of manufactured house is cost driven and consequently, the luxury house will have a better construction value than the median level house which in turn is much better that the entry level houses.
2. This research does not address the economic value of a house, which is represented by purchase price, appreciation value, and resale value.
3. Rank reversal is a limitation of the AHP model. The ranks of a particular set of houses that have been compared are likely to change either by introducing a new house into the selection set or deletion of any house from the set. The order of ranks or the rank values change by such variations and is commonly referred to as rank reversal.

5.4 Contributions

The model developed in this research is successful in providing a method to select a manufactured house based on its construction value. The comparison was made using quantitative analysis, which helped in making the subjective task of decision-making more realistic and practical. Following are the contributions of this research:

1 Enhancing the literature on manufactured housing to include construction materials, processes, transportation and installation, and post construction assurances.

2 Introducing construction value of a manufactured house as an essential factor in the house purchase decision-making.

3 Forming a checklist which provides not only extensive information about the construction systems of manufactured houses but also facilitate the use of the ranking model that helps in selecting from many houses of the same level.

4 Defining the attributes that represent the construction value of a manufactured house and quantifying those attributes by developing scales using AHP.

5 Introducing a method of combining all these attributes in a systematic way (AHP) to arrive at the manufactured house ranking.

6 Providing a spreadsheet that automatically produces rankings based on inputs from the homebuyer or any decision maker.

7 Enabling homebuyers to evaluate among various options of manufactured house brands and helping them in deciding the best house purchase.

8 A model to solve a subjective problem with an objective approach.

9 Providing a model that uses a combination of evaluation and selection procedures in a unique way that can be used for various applications.

10 Providing a model that allows manufacturers to improve their product by focusing more on the attributes that are critical to the construction value and spending less time and energy on non-critical ones.

5.5 Areas of Future Research

Assigning scores to the various attributes of the manufactured house construction system (sub-system, item, and sub-item) was achieved using three IPIA inspectors. A larger sample size of IPIA inspectors can be considered as an area of future research. By increasing the sample size there would be a wide variety of experience and knowledge contribution to the development of scores for the ranking model. Group decision-making theories (Saaty, 1980) can be applied by using a larger sample size of experienced professionals.

Site built houses is another area of future research, where the model developed in this research can be applied. Site built houses are similar to manufactured houses except they are not built in a factory environment and are not transported and installed on site. They are typically built on permanent foundations on site itself and thus eliminating the transportation and installation phase. The other construction systems remain similar to the manufactured house construction systems. However, the inspections and standards governing the site-built house quality are different as they follow the International Residential Code (IRC). This model can be modified according to the requirement of the IRC standards and modified using inputs from building inspectors.

While AHP provides an ideal ranking process for manufactured houses, it does not consider relevant constraints that exist in the decision environment such as cost and budget limitations, type of foundations, etc. Using the Goal Programming (GP) technique as a decision analysis tool can further enhance this research. The following are the reasons for using GP (Farghal, 1996): "(i) GP provides flexibility for the decision-maker to develop the best plan, (ii) It gives the ability to the decision-maker to set

preferences or priority levels and rank those according to the current needs, (iii) GP involves setting targets for goals and trying to achieve those targets, thus allowing the decision maker to perform sensitivity analysis by changing the targets and continuously modifying the solution to reflect those changes, (iv) GP does not require excessive information from the decision maker, and (v) GP considers all existing constraints when producing a solution."

APPENDIX A

MATRIX OF COMPARISONS FOR SUB-SYSTEMS AND ITEMS

SUB-SYSTEMS		1	2	3	4	5	6	7	8	9
Materials	1	*1*	*1/5*	*1/3*	*1/5*	*1/7*	*1/3*	*3*	*1/5*	*1/7*
Floor Assembly	2	*5*	*1*	*3*	*1*	*1/3*	*3*	*5*	*1/3*	*1/7*
Wall Assembly	3	*3*	*1/3*	*1*	*1/3*	*1/5*	*1/3*	*1/7*	*1/3*	*1/7*
Roof Assembly	4	*5*	*1*	*3*	*1*	*1/3*	*1/5*	*1/7*	*1/5*	*1/7*
Utilities	5	*7*	*3*	*5*	*3*	*1*	*5*	*9*	*1/3*	*1/7*
Doors and Windows	6	*3*	*1/3*	*3*	*5*	*1/5*	*1*	*1/9*	*1/3*	*1/7*
Cosmetics	7	*1/3*	*1/5*	*7*	*7*	*1/9*	*9*	*1*	*1/9*	*1/9*
Transportation and Setup	8	*5*	*3*	*3*	*5*	*3*	*3*	*9*	*1*	*1/7*
Warranties	9	*7*	*7*	*7*	*7*	*7*	*7*	*9*	*7*	*1*
		36.3	16.1	32.3	29.5	12.3	28.87	36.4	9.84	2.11

Figure A1 IPIA-1 Matrix of Comparisons for sub-system

MATERIALS:		1	2	3	4	5	6	7	8	9	10
Cabinets	1	*1*	*5*	*1/3*	*1*	*5*	*5*	*7*	*9*	*1/3*	*1/9*
Rollers	2	*1/5*	*1*	*1/9*	*1/3*	*1*	*1/7*	*1 1/3*	*1/3*	*1/5*	*1/9*
Bathtub and Shower	3	*3*	*9*	*1*	*7*	*3*	*7*	*7*	*7*	*3*	*1/9*
Vanity	4	*1*	*3*	*1/7*	*1*	*3*	*1/3*	*3*	*3*	*1/3*	*1/9*
Faucets	5	*1/5*	*1*	*1/3*	*1/3*	*1*	*1/5*	*1/5*	*5*	*1/3*	*1/9*
Ceiling Board Type	6	*1/5*	*7*	*1/7*	*3*	*5*	*1*	*7*	*7*	*1*	*1/9*
Wall Sheetrock type	7	*1/7*	*3/4*	*1/7*	*1/3*	*5*	*1/7*	*1*	*3*	*1/5*	*1/9*
Interior door style	8	*1/9*	*3*	*1/7*	*1/3*	*1/5*	*1/7*	*1/3*	*1*	*1/5*	*1/9*
Window Frame	9	*3*	*5*	*1/3*	*3*	*3*	*1*	*5*	*5*	*1*	*1/9*
Electrical Devices	10	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*1*
		17.9	43.8	11.7	25.3	35.2	24	40.9	49.3	15.6	2

FLOOR ASSEMBLY:		1	2	3	4	5	6	7	8
Axles	1	*1*	*5*	*1/3*	*1/5*	*1*	*1/3*	*1/5*	*1/5*
Tires	2	*1/5*	*1*	*1/5*	*1/5*	*1/7*	*1/5*	*1/7*	*1/7*
Joist Size	3	*3*	*5*	*1*	*1*	*1*	*5*	*1*	*1*
Joist Spacing	4	*5*	*5*	*1*	*1*	*1*	*3*	*1*	*1*
Joist System	5	*1*	*7*	*1*	*1*	*1*	*3*	*1*	*1*
Insulation R-value	6	*3*	*5*	*1/5*	*1/3*	*1/3*	*1*	*1/5*	*1/3*
Decking material	7	*5*	*7*	*1*	*1*	*1*	*5*	*1*	*3*
Decking Thickness	8	*5*	*7*	*1*	*1*	*1*	*3*	*1/3*	*1*
		23.2	42	5.73	5.73	6.48	20.5	4.88	7.68

WALL ASSEMBLY:		1	2	3	4	5	6	7	8	9	10	11	12
Stud size (Interior)	1	*1*	*1*	*1*	*1/5*	*1/5*	*1/9*	*1/7*	*1*	*1/5*	*3*	*1/3*	*1/5*
Exterior Bottom Plate size	2	*1*	*1*	*1/3*	*1/5*	*1/5*	*1/9*	*1/7*	*1*	*1/7*	*1/5*	*1/3*	*1/5*
Exterior Stud spacing	3	*1*	*3*	*1*	*1*	*3*	*1/9*	*1/3*	*1*	*1/7*	*5*	*5*	*1/5*
Stud size (Exterior)	4	*5*	*5*	*1*	*1*	*3*	*1/7*	*1/3*	*1*	*1/5*	*5*	*5*	*1/3*
Insulation R-value	5	*5*	*5*	*1/3*	*1/3*	*1*	*1/7*	*1/3*	*1*	*9*	*5*	*5*	*1*
Headers above openings	6	*9*	*9*	*9*	*7*	*7*	*1*	*3*	*3*	*5*	*9*	*5*	*3*
Exterior Sheathing	7	*7*	*7*	*3*	*3*	*3*	*1/3*	*1*	*9*	*7*	*9*	*7*	*1*
Electrical wires pass	8	*1*	*1*	*1*	*1*	*1*	*1/3*	*1/9*	*1*	*7*	*1/3*	*1/5*	*1/5*
Electrical Boxes	9	*5*	*7*	*7*	*5*	*1/9*	*1/5*	*1/7*	*1/7*	*1*	*7*	*5*	*1/5*
Wall Sheetrock thickness	10	*1/3*	*5*	*1/5*	*1/5*	*1/5*	*1/9*	*1/9*	*3*	*1/7*	*1*	*1/3*	*1/7*
House Wrap	11	*3*	*3*	*1/5*	*1/5*	*1/5*	*1/5*	*1/7*	*5*	*1/5*	*3*	*1*	*1/3*
Exterior Siding	12	*5*	*5*	*5*	*3*	*1*	*1/3*	*1*	*5*	*5*	*7*	*3*	*1*
		43.3	52	29.1	22.1	19.9	3.13	6.79	31.1	35	54.5	37.2	7.81

Figure A2 IPIA-1 Matrix of Comparisons for Items

ROOF ASSEMBLY:		1	2	3	4	5	6	7	8	9	10
Design Load	1	1	9	9	9	9	9	9	9	9	9
Roof Slope	2	1/9	1	1/7	1/5	1/5	1/7	1/3	1/5	1/5	1/5
Insulation R-value	3	1/9	7	1	3	7	1	3	3	3	3
Eave Projection	4	1/9	5	1/3	1	5	1/3	1/3	1/3	1/3	1/3
Eave Position	5	1/9	5	1/7	1/5	1	1/9	1/7	1/7	1/7	1/7
Roof Underlayments	6	1/9	7	1	3	9	1	1/3	1/3	1/3	1/5
Roof Finish	7	1/9	3	1/3	3	7	3	1	1	1/3	1/5
Roof Sheathing	8	1/9	5	1/3	3	7	3	1	1	3	3
Valley flashing	9	1/9	5	1/3	3	7	3	3	1/3	1	1/3
Roof opening waterproofing	10	1/9	5	1/3	3	7	5	5	1/3	3	1
		2	52	13	28.4	59.2	25.6	23.1	15.7	20.3	17.4

UTILITIES:		1	2	3	4	5	6	7	8	9	10
Water pipe	1	1	1/3	1/3	1	1/3	1/3	1	1/3	5	1/5
Pipe fittings	2	3	1	1	3	1/3	1/3	1/3	1/5	5	1/5
Pipefitting fastenings	3	3	1	1	1/5	1/5	1/5	1/3	1/5	1	1/9
Drainage pipe	4	1	1/3	5	1	1	1	3	1/3	5	1/5
HVAC System	5	3	3	5	1	1	1	3	3	9	3
HVAC Duct	6	3	3	5	1	1	1	1	1/3	5	1/5
Register Positions	7	1	3	3	1/3	1/3	1	1	1/9	3	1/7
Bathtub and Shower	8	3	5	5	3	1/3	3	9	1	9	1/3
Shutoff valves	9	1/5	1/5	1	1/5	1/9	1/5	1/3	1/9	1	1/9
20 amp GFI's	10	5	5	9	5	1/3	5	7	3	9	1
		23.2	21.9	35.3	15.7	4.98	13.1	26	8.62	52	5.5

DOORS / WINDOWS:		1	2	3	4	5	6	7	8
Interior door width	1	1	1	1/3	3	3	1/7	1/9	1/3
Interior Door Height	2	1	1	1/5	3	3	1/9	1/5	1
Exterior door width	3	3	5	1	5	5	1/3	1/3	1
Number of Hinges Int doors	4	1/3	1/3	1/5	1	1/3	1/7	1/7	1/5
Hinge type	5	1/3	1/3	1/5	3	1	1/7	1/9	1/7
Window glass	6	7	9	3	7	7	1	1	5
Extrior door Type	7	9	5	3	7	9	1	1	3
Exterior door height	8	3	1	1	5	7	1/5	1/3	1
		24.7	22.7	8.93	34	35.3	3.07	3.23	11.7

Figure A2 IPIA-1 Matrix of Comparisons for Items (contd)

COSMETICS:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Carpets	1	*1*	*3*	*1/7*	*3*	*1/9*	*3*	*3*	*1/3*	*1*	*3*	*3*	*3*	*3*	*1/3*	*1/3*	*5*	*3*
Shelves	2	*1/3*	*1*	*1/7*	*1*	*1/9*	*1/3*	*1*	*1/5*	*1*	*1/3*	*1/3*	*1/3*	*1/3*	*1/3*	*1/3*	*1/3*	*1/3*
Water Heater	3	*7*	*7*	*1*	*3*	*3*	*3*	*7*	*5*	*9*	*5*	*3*	*5*	*5*	*3*	*7*	*9*	*5*
Sheetrock finish	4	*1/3*	*1*	*1/3*	*1*	*1/5*	*1*	*1*	*1/5*	*1*	*1/3*	*1/3*	*1/3*	*1/5*	*1/3*	*1*	*3*	*1/3*
Sidewall height	5	*9*	*9*	*1/3*	*5*	*1*	*5*	*7*	*1/3*	*7*	*5*	*5*	*5*	*5*	*3*	*7*	*7*	*5*
Ceiling paint finishes	6	*1/3*	*3*	*1/3*	*1*	*1/5*	*1*	*1*	*1/5*	*3*	*3*	*3*	*3*	*3*	*1/3*	*3*	*3*	*3*
Trim around Interior doors	7	*1/3*	*1*	*1/7*	*1*	*1/7*	*1*	*1*	*1/7*	*1*	*1/3*	*1/3*	*1/3*	*1/5*	*1/7*	*1/3*	*1/3*	*1/3*
Trim Exterior doors & windows	8	*3*	*5*	*1/5*	*5*	*3*	*5*	*7*	*1*	*5*	*3*	*3*	*3*	*1/3*	*1*	*5*	*5*	*5*
Metal mini-blinds	9	*1*	*1*	*1/9*	*1*	*1/7*	*1/3*	*1*	*1/5*	*1*	*1/3*	*1/3*	*1/3*	*1/5*	*1/5*	*1/3*	*1/3*	*1/3*
Refrigerator	10	*1/3*	*3*	*1/5*	*3*	*1/5*	*1/3*	*3*	*1/3*	*3*	*1*	*3*	*1/3*	*1/5*	*1/5*	*3*	*3*	*1*
Microwave	11	*1/3*	*3*	*1/3*	*3*	*1/5*	*1/3*	*3*	*1/3*	*3*	*1/3*	*1*	*1/3*	*1/7*	*7*	*1/3*	*1/3*	*1/3*
Dishwasher	12	*1/3*	*3*	*1/5*	*3*	*1/5*	*1/3*	*3*	*1/3*	*3*	*3*	*3*	*1*	*1/5*	*1/3*	*3*	*3*	*1*
Fireplace	13	*1/3*	*3*	*1/5*	*5*	*1/5*	*1/3*	*5*	*3*	*5*	*5*	*7*	*5*	*1*	*3*	*5*	*5*	*5*
Modular cabinet system	14	*3*	*3*	*1/3*	*3*	*1/3*	*3*	*7*	*1*	*5*	*5*	*1/7*	*3*	*1/3*	*1*	*7*	*7*	*5*
Outside water faucets	15	*3*	*3*	*1/7*	*1*	*1/7*	*1/3*	*3*	*1/5*	*3*	*1/3*	*3*	*1/3*	*1/5*	*1/7*	*1*	*1*	*1/3*
Plumbing for icemaker	16	*1/5*	*3*	*1/9*	*1/3*	*1/7*	*1/3*	*3*	*1/5*	*3*	*1/3*	*3*	*1/3*	*1/5*	*1/7*	*1*	*1*	*1/3*
Garbage Disposal	17	*1/3*	*1/3*	*1/5*	*3*	*1/5*	*1/3*	*3*	*1/5*	*3*	*1*	*3*	*1*	*1/5*	*1/5*	*3*	*3*	*1*
		30.2	52.3	4.46	42.3	9.53	25	59	13.2	57	36.3	41.5	31.7	19.7	20.7	47.7	56.3	36.3

TRANSP& SETUP:		1	2	3	4	5
Setup on site responsibility	1	*1*	*1*	*1*	*1/3*	*1/5*
Transportation to site	2	*1*	*1*	*1*	*1/3*	*1/5*
Setup contractor	3	*1*	*1*	*1*	*1/3*	*1/5*
Orientation and walk through	4	*3*	*3*	*3*	*1*	*1*
Special walkthrough programs	5	*5*	*5*	*5*	*1*	*1*
		11	11	11	3	2.6

WARRANTIES:		1	2	3	4
General	1	*1*	*7*	*9*	*9*
Structural system	2	*1/7*	*1*	*9*	*9*
Shingles	3	*1/9*	*1/9*	*1*	*1*
Siding	4	*1/9*	*1/9*	*1*	*1*
		1.37	8.22	20	20

Figure A2 IPIA-1 Matrix of Comparisons for Items (contd)

SUB-SYSTEMS		1	2	3	4	5	6	7	8	9
Materials	1	*1*	*5*	*3*	*3*	*3*	*5*	*5*	*3*	*1/7*
Floor Assembly	2	*1/5*	*1*	*1*	*1*	*1/3*	*1/3*	*1/3*	*1/3*	*1/5*
Wall Assembly	3	*1/3*	*1*	*1*	*1*	*1/3*	*1*	*1/3*	*1/3*	*1/5*
Roof Assembly	4	*1/3*	*1*	*1*	*1*	*1*	*1*	*1*	*1/3*	*1/5*
Utilities	5	*1/3*	*3*	*3*	*1*	*1*	*1*	*1*	*1/3*	*1/5*
Doors and Windows	6	*1/5*	*3*	*1*	*1*	*1*	*1*	*1*	*1/3*	*1/5*
Cosmetics	7	*1/5*	*3*	*3*	*1*	*1*	*1*	*1*	*1*	*1/3*
Transportation and Setup	8	*1/3*	*3*	*3*	*3*	*3*	*3*	*1*	*1*	*1/3*
Warranties	9	*7*	*5*	*5*	*5*	*5*	*5*	*3*	*3*	*1*
		9.93	25	21	17	15.7	18.3	13.7	9.67	2.81

Figure A3 IPIA-2 Matrix of Comparisons for Sub-systems

MATERIALS:		1	2	3	4	5	6	7	8	9	10
Cabinets	1	*1*	*5*	*1/5*	*3*	*1/3*	*3*	*1*	*1*	*1/3*	*1/9*
Rollers	2	*1/5*	*1*	*1/5*	*1/7*	*1/7*	*1/3*	*1/5*	*1/3*	*1/7*	*1/9*
Bathtub and Shower	3	*5*	*5*	*1*	*3*	*3*	*5*	*7*	*7*	*5*	*1/7*
Vanity	4	*1/3*	*7*	*1/3*	*1*	*1/5*	*1*	*1/3*	*1/5*	*1/5*	*1/9*
Faucets	5	*3*	*7*	*1/3*	*5*	*1*	*5*	*3*	*3*	*5*	*1/7*
Ceiling Board Type	6	*1/3*	*3*	*1/5*	*1*	*1/5*	*1*	*1/5*	*1/3*	*1/5*	*1/9*
Wall Sheetrock type	7	*1*	*5*	*1/7*	*3*	*1/3*	*5*	*1*	*1*	*1*	*1/9*
Interior door style	8	*1*	*3*	*1/7*	*5*	*1/3*	*3*	*1*	*1*	*1/3*	*1/9*
Window Frame	9	*3*	*7*	*1/5*	*5*	*1/5*	*5*	*1*	*3*	*1*	*1/9*
Electrical Devices	10	*9*	*9*	*7*	*9*	*7*	*9*	*9*	*9*	*9*	*1*
		23.9	52	9.75	35.1	12.7	37.3	23.7	25.9	22.2	2.06

FLOOR ASSEMBLY:		1	2	3	4	5	6	7	8
Axles	1	*1*	*1*	*1/7*	*1/7*	*1/7*	*1/7*	*1/9*	*1/7*
Tires	2	*1*	*1*	*1/7*	*1/7*	*1/7*	*1/7*	*1/9*	*1/7*
Joist Size	3	*7*	*7*	*1*	*1*	*1*	*1*	*1/5*	*1/5*
Joist Spacing	4	*7*	*7*	*1*	*1*	*5*	*5*	*1*	*1*
Joist System	5	*7*	*7*	*1*	*1/5*	*1*	*5*	*1*	*1*
Insulation R-value	6	*7*	*7*	*1*	*1/5*	*1/5*	*1*	*1/5*	*1/3*
Decking material	7	*9*	*9*	*5*	*1*	*1*	*5*	*1*	*5*
Decking Thickness	8	*7*	*7*	*5*	*1*	*1*	*3*	*1/5*	*1*
		46	46	14.3	4.69	9.49	20.3	3.82	8.82

WALL ASSEMBLY:		1	2	3	4	5	6	7	8	9	10	11	12
Stud size (Interior)	1	*1*	*3*	*1*	*1/5*	*1/3*	*1/7*	*1/5*	*1/9*	*1/9*	*1*	*1/3*	*1/5*
Exterior Bottom Plate size	2	*1/3*	*1*	*1/5*	*1/5*	*1/5*	*1/7*	*1/7*	*1/9*	*1/9*	*5*	*3*	*1/5*
Exterior Stud spacing	3	*1*	*5*	*1*	*3*	*3*	*1*	*1*	*1/5*	*1/5*	*7*	*7*	*5*
Stud size (Exterior)	4	*5*	*5*	*1/3*	*1*	*1/3*	*1/3*	*1*	*1/7*	*1/7*	*7*	*7*	*1/3*
Insulation R-value	5	*3*	*5*	*1/3*	*3*	*1*	*1/3*	*5*	*1/7*	*1/5*	*7*	*7*	*5*
Headers above openings	6	*7*	*7*	*1*	*3*	*3*	*1*	*5*	*1/5*	*1/5*	*7*	*7*	*7*
Exterior Sheathing	7	*5*	*7*	*1*	*1*	*1/5*	*1/5*	*1*	*1/5*	*1/5*	*5*	*5*	*5*
Electrical wires pass	8	*9*	*9*	*5*	*7*	*7*	*5*	*5*	*1*	*1*	*9*	*9*	*7*
Electrical Boxes	9	*9*	*9*	*5*	*7*	*5*	*5*	*5*	*1*	*1*	*9*	*9*	*7*
Wall Sheetrock thickness	10	*1*	*1/5*	*1/7*	*1/7*	*1/7*	*1/7*	*1/5*	*1/9*	*1/9*	*1*	*3*	*5*
House Wrap	11	*3*	*1/3*	*1/7*	*1/7*	*1/7*	*1/7*	*1/5*	*1/9*	*1/9*	*1/3*	*1*	*1/5*
Exterior Siding	12	*5*	*5*	*1/5*	*3*	*1/5*	*1/7*	*1/5*	*1/7*	*1/7*	*1/5*	*5*	*1*
		49.3	56.5	15.4	28.7	20.6	13.6	23.9	3.47	3.53	58.5	63.3	42.9

Figure A4 IPIA-2 Matrix of Comparisons for Items

ROOF ASSEMBLY:		1	2	3	4	5	6	7	8	9	10
Design Load	1	*1*	*7*	*1*	*5*	*5*	*7*	*5*	*7*	*3*	*1*
Roof Slope	2	*1/7*	*1*	*1/5*	*5*	*5*	*7*	*1/5*	*5*	*3*	*1/3*
Insulation R-value	3	*1*	*5*	*1*	*7*	*7*	*5*	*3*	*5*	*5*	*1*
Eave Projection	4	*1/5*	*1/5*	*1/7*	*1*	*1*	*5*	*1/3*	*5*	*1*	*1/3*
Eave Position	5	*1/5*	*1/5*	*1/7*	*1*	*1*	*5*	*1/3*	*5*	*1*	*1/5*
Roof Underlayments	6	*1/7*	*1/7*	*1/5*	*1/5*	*1/5*	*1*	*1/5*	*1/3*	*1/7*	*1/7*
Roof Finish	7	*1/5*	*5*	*1/3*	*3*	*3*	*5*	*1*	*7*	*1*	*1*
Roof Sheathing	8	*1/7*	*1/5*	*1/5*	*1/5*	*1/5*	*3*	*1/7*	*1*	*1/7*	*1/7*
Valley flashing	9	*1/3*	*1/3*	*1/5*	*1*	*1*	*7*	*1*	*7*	*1*	*1/5*
Roof opening waterproofing	10	*1*	*3*	*1*	*3*	*5*	*7*	*1*	*7*	*5*	*1*
		4.36	*22.1*	*4.42*	*26.4*	*28.4*	*52*	*12.2*	*49.3*	*20.3*	*5.35*

UTILITIES:		1	2	3	4	5	6	7	8	9	10
Water pipe	1	*1*	*1*	*1*	*5*	*3*	*5*	*5*	*5*	*7*	*9*
Pipe fittings	2	*1*	*1*	*1*	*5*	*5*	*7*	*7*	*3*	*7*	*9*
Pipefitting fastenings	3	*1*	*1*	*1*	*5*	*5*	*7*	*7*	*3*	*7*	*9*
Drainage pipe	4	*1/5*	*1/5*	*1/5*	*1*	*1/5*	*1/5*	*1/5*	*1/5*	*1/3*	*3*
HVAC System	5	*1/3*	*1/5*	*1/5*	*5*	*1*	*5*	*5*	*1*	*7*	*5*
HVAC Duct	6	*1/5*	*1/7*	*1/7*	*5*	*1/5*	*1*	*1/5*	*1/7*	*3*	*3*
Register Positions	7	*1/5*	*1/7*	*1/7*	*5*	*1/5*	*5*	*1*	*1/7*	*3*	*5*
Bathtub and Shower	8	*1/5*	*1/3*	*1/3*	*5*	*1*	*7*	*7*	*1*	*7*	*9*
Shutoff valves	9	*1/7*	*1/7*	*1/7*	*3*	*1/7*	*1/3*	*1/3*	*1/7*	*1*	*5*
20 amp GFI's	10	*1/9*	*1/9*	*1/9*	*1/3*	*1/5*	*1/3*	*1/5*	*1/9*	*1/5*	*1*
		4.39	4.27	4.27	39.3	15.9	37.9	32.9	13.7	42.5	58

DOORS / WINDOWS:		1	2	3	4	5	6	7	8
Interior door width	1	*1*	*3*	*1*	*7*	*5*	*5*	*1*	*1*
Interior Door Height	2	*1/3*	*1*	*1/3*	*7*	*5*	*1/3*	*1/3*	*1/5*
Exterior door width	3	*1*	*3*	*1*	*7*	*7*	*9*	*7*	*1*
Number of Hinges Int doors	4	*1/7*	*1/7*	*1/7*	*1*	*1*	*1/5*	*1/7*	*1/7*
Hinge type	5	*1/5*	*1/5*	*1/7*	*1*	*1*	*1/5*	*1/7*	*1/7*
Window glass	6	*1/5*	*3*	*1/9*	*5*	*5*	*1*	*1/5*	*1/9*
Extrior door Type	7	*1*	*3*	*1/7*	*7*	*7*	*5*	*1*	*1/3*
Exterior door height	8	*1*	*5*	*1*	*7*	*7*	*9*	*3*	*1*

Figure A4 IPIA-2 Matrix of Comparisons for Items (contd)

COSMETICS:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Carpets	1	*1*	*5*	*1/5*	*1*	*1/5*	*1*	*3*	*1/3*	*5*	*5*	*7*	*1/7*	*5*	*3*	*1/5*	*3*	*3*
Shelves	2	*1/5*	*1*	*1/9*	*1/5*	*1/9*	*1*	*1*	*1/5*	*1/5*	*1/3*	*3*	*1/7*	*5*	*1*	*1/5*	*1/5*	*3*
Water Heater	3	*5*	*9*	*1*	*7*	*1*	*7*	*7*	*5*	*7*	*5*	*7*	*1*	*7*	*7*	*7*	*7*	*7*
Sheetrock finish	4	*1*	*5*	*1/7*	*1*	*1/7*	*1*	*5*	*3*	*1/3*	*3*	*5*	*1/5*	*5*	*3*	*1/3*	*1/3*	*5*
Sidewall height	5	*5*	*9*	*1*	*7*	*1*	*7*	*7*	*7*	*7*	*9*	*9*	*1*	*9*	*7*	*5*	*5*	*7*
Ceiling paint finishes	6	*1*	*1*	*1/7*	*1*	*1/7*	*1*	*1/3*	*1/5*	*1/5*	*1/3*	*3*	*1/7*	*5*	*3*	*1/5*	*1/5*	*3*
Trim around Interior doors	7	*1/3*	*1*	*1/7*	*1/5*	*1/7*	*3*	*1*	*1/5*	*1/5*	*3*	*5*	*1/5*	*3*	*5*	*1/3*	*1/3*	*3*
Trim Exterior doors & windows	8	*3*	*5*	*1/5*	*1/3*	*1/7*	*5*	*5*	*1*	*1*	*5*	*5*	*1/3*	*5*	*5*	*1/3*	*1*	*5*
Metal mini-blinds	9	*1/5*	*5*	*1/7*	*3*	*1/7*	*5*	*5*	*1*	*1*	*5*	*5*	*1/3*	*7*	*5*	*1*	*1*	*5*
Refrigerator	10	*1/5*	*3*	*1/5*	*1/3*	*1/9*	*3*	*1/3*	*1/5*	*1/5*	*1*	*1*	*1/7*	*5*	*3*	*1/3*	*1/5*	*3*
Microwave	11	*1/7*	*1/3*	*1/7*	*1/5*	*1/9*	*1/3*	*1/5*	*1/5*	*1/5*	*1*	*1*	*1/7*	*5*	*5*	*1/5*	*1/5*	*3*
Dishwasher	12	*7*	*7*	*1*	*5*	*1*	*7*	*5*	*3*	*3*	*7*	*7*	*1*	*9*	*9*	*5*	*7*	*9*
Fireplace	13	*1/5*	*1/5*	*1/7*	*1/5*	*1/9*	*1/5*	*1/3*	*1/5*	*1/7*	*1/5*	*1/5*	*1/9*	*1*	*3*	*1/5*	*1/7*	*3*
Modular cabinet system	14	*1/3*	*1*	*1/7*	*1/3*	*1/7*	*1/3*	*1/5*	*1/5*	*1/5*	*1/3*	*1/5*	*1/9*	*1/3*	*1*	*1/5*	*1/7*	*1*
Outside water faucets	15	*5*	*5*	*1/7*	*3*	*1/5*	*5*	*3*	*3*	*1*	*3*	*5*	*1/5*	*5*	*5*	*1*	*1/3*	*5*
Plumbing for icemaker	16	*1/3*	*5*	*1/7*	*3*	*1/5*	*5*	*3*	*1*	*1*	*5*	*5*	*1/7*	*7*	*7*	*3*	*1*	*7*
Garbage Disposal	17	*1/3*	*1/3*	*1/7*	*1/5*	*1/7*	*1/3*	*1/3*	*1/5*	*1/5*	*1/3*	*1/3*	*1/9*	*1/3*	*1*	*1/5*	*1/7*	*1*
		30.3	62.9	5.14	33	5.04	52.2	46.7	25.9	27.9	53.5	68.7	5.46	83.7	73	24.7	27.2	73

TRANSP& SETUP:		1	2	3	4	5
Setup on site responsibility	1	*1*	*1/7*	*1*	*7*	*9*
Transportation to site	2	*7*	*1*	*1/5*	*1/3*	*3*
Setup contractor	3	*1*	*5*	*1*	*7*	*7*
Orientation and walk through	4	*1/7*	*3*	*1/7*	*1*	*5*
Special walkthrough programs	5	*1/9*	*1/3*	*1/7*	*1/5*	*1*
		9.25	9.48	2.49	15.5	25

WARRANTIES:		1	2	3	4
General	1	*1*	*9*	*9*	*9*
Structural system	2	*1/9*	*1*	*5*	*7*
Shingles	3	*1/9*	*1/5*	*1*	*3*
Siding	4	*1/9*	*1/7*	*1/3*	*1*
		1.33	10.3	15.3	20

Figure A4 IPIA-2 Matrix of Comparisons for Items (contd)

SUB-SYSTEMS		1	2	3	4	5	6	7	8	9
Materials	1	*1*	*5*	*5*	*5*	*1*	*3*	*3*	*1*	*1*
Floor Assembly	2	*1/5*	*1*	*1*	*1*	*1/3*	*1*	*1/3*	*1/3*	*1/3*
Wall Assembly	3	*1/5*	*1*	*1*	*1*	*1/3*	*1*	*1/3*	*1/3*	*1/3*
Roof Assembly	4	*1/5*	*1*	*1*	*1*	*1*	*1*	*1/3*	*1/3*	*1/3*
Utilities	5	*1*	*3*	*3*	*1*	*1*	*3*	*1*	*1*	*1*
Doors and Windows	6	*1/3*	*1*	*1*	*1*	*1/3*	*1*	*1/3*	*1/3*	*1/3*
Cosmetics	7	*1/3*	*3*	*3*	*3*	*1*	*3*	*1*	*1/3*	*1*
Transportation and Setup	8	*1*	*3*	*3*	*3*	*1*	*3*	*3*	*1*	*1*
Warranties	9	*1*	*3*	*3*	*3*	*1*	*3*	*1*	*1*	*1*
		5.27	21	21	19	7	19	10.3	5.67	6.33

Figure A5 IPIA-3 Matrix of Comparisons for Sub-systems

MATERIALS:		1	2	3	4	5	6	7	8	9	10
Cabinets	1	*1*	*5*	*1*	*1*	*3*	*5*	*1*	*3*	*7*	*1/5*
Rollers	2	*1/5*	*1*	*1/5*	*1/5*	*1/3*	*1/3*	*1/7*	*1/3*	*1/3*	*1/9*
Bathtub and Shower	3	*1*	*5*	*1*	*3*	*7*	*3*	*1*	*3*	*3*	*1/7*
Vanity	4	*1*	*5*	*1/3*	*1*	*3*	*1*	*1*	*1*	*1*	*1/9*
Faucets	5	*1/3*	*3*	*1/7*	*1/3*	*1*	*1/3*	*1/3*	*1*	*1*	*1/7*
Ceiling Board Type	6	*1/5*	*3*	*1/3*	*1*	*3*	*1*	*1/3*	*3*	*1*	*1/7*
Wall Sheetrock type	7	*1*	*7*	*1*	*1*	*3*	*3*	*1*	*5*	*3*	*1/7*
Interior door style	8	*1/3*	*3*	*1/3*	*1*	*1*	*1/3*	*1/5*	*1*	*1*	*1/9*
Window Frame	9	*1/7*	*3*	*1/3*	*1*	*1*	*1*	*1/3*	*1*	*1*	*1/9*
Electrical Devices	10	*5*	*9*	*7*	*9*	*7*	*7*	*7*	*9*	*9*	*1*
		10.2	44	11.7	18.5	29.3	22	12.3	27.3	27.3	2.22

FLOOR ASSEMBLY:		1	2	3	4	5	6	7	8
Axles	1	*1*	*1/5*	*1/5*	*1/5*	*1/5*	*1/5*	*1/5*	*1/3*
Tires	2	*5*	*1*	*1/3*	*1/3*	*1/3*	*1/3*	*1/3*	*1*
Joist Size	3	*5*	*3*	*1*	*1*	*1*	*1/3*	*1*	*1*
Joist Spacing	4	*5*	*3*	*1*	*1*	*1*	*1/3*	*1*	*1*
Joist System	5	*5*	*3*	*1*	*1*	*1*	*1*	*1*	*1*
Insulation R-value	6	*5*	*3*	*3*	*3*	*1*	*1*	*3*	*5*
Decking material	7	*5*	*3*	*1*	*1*	*1*	*1/3*	*1*	*3*
Decking Thickness	8	*3*	*1*	*1*	*1*	*1*	*1/5*	*1/3*	*1*
		34	17.2	8.53	8.53	6.53	3.73	7.87	13.3

WALL ASSEMBLY:		1	2	3	4	5	6	7	8	9	10	11	12
Stud size (Interior)	1	*1*	*1*	*1/3*	*1/3*	*1/5*	*1/9*	*1/9*	*1/7*	*1/7*	*1/5*	*1/3*	*1/5*
Exterior Bottom Plate size	2	*1*	*1*	*1/3*	*1/5*	*1/7*	*1/7*	*1/7*	*1/7*	*1/7*	*1/5*	*1/3*	*1/5*
Exterior Stud spacing	3	*3*	*3*	*1*	*1*	*1*	*1/3*	*1*	*1/3*	*1/3*	*1*	*1/3*	*1/3*
Stud size (Exterior)	4	*3*	*5*	*1*	*1*	*1*	*1/3*	*1*	*1/3*	*1/3*	*1*	*1/3*	*1/3*
Insulation R-value	5	*5*	*7*	*1*	*1*	*1*	*1/3*	*3*	*1/3*	*1/3*	*1*	*1/3*	*1/5*
Headers above openings	6	*9*	*7*	*3*	*3*	*3*	*1*	*5*	*3*	*1*	*5*	*7*	*7*
Exterior Sheathing	7	*9*	*7*	*1*	*1*	*1/3*	*1/5*	*1*	*1/3*	*1/3*	*1*	*3*	*5*
Electrical wires pass	8	*7*	*7*	*3*	*3*	*3*	*1/3*	*3*	*1*	*1/3*	*3*	*5*	*7*
Electrical Boxes	9	*7*	*7*	*3*	*3*	*3*	*1*	*3*	*3*	*1*	*5*	*7*	*7*
Wall Sheetrock thickness	10	*5*	*5*	*1*	*1*	*1*	*1/5*	*1*	*1/3*	*1/5*	*1*	*3*	*1*
House Wrap	11	*3*	*3*	*3*	*3*	*3*	*1/7*	*1/3*	*1/5*	*1/7*	*1/3*	*1*	*1/3*
Exterior Siding	12	*5*	*5*	*3*	*3*	*5*	*1/7*	*1/5*	*1/7*	*1/7*	*1*	*3*	*1*
		58	58	20.7	20.5	21.7	4.27	18.8	9.3	4.44	19.7	30.7	29.6

Figure A6 IPIA-3 Matrix of Comparisons for Items

ROOF ASSEMBLY:		1	2	3	4	5	6	7	8	9	10
Design Load	1	*1*	*3*	*1*	*5*	*7*	*3*	*5*	*5*	*5*	*5*
Roof Slope	2	*1/3*	*1*	*1/3*	*3*	*3*	*1*	*3*	*3*	*3*	*1*
Insulation R-value	3	*1*	*3*	*1*	*5*	*5*	*3*	*3*	*5*	*3*	*1*
Eave Projection	4	*1/5*	*1/3*	*1/5*	*1*	*1/3*	*1/3*	*1/3*	*1/5*	*1/5*	*1/5*
Eave Position	5	*1/7*	*1/3*	*1/5*	*3*	*1*	*1/3*	*1/3*	*1/3*	*1/3*	*1/3*
Roof Underlayments	6	*1/3*	*1*	*1/3*	*3*	*3*	*1*	*1*	*1*	*1*	*1*
Roof Finish	7	*1/5*	*1/3*	*1/3*	*3*	*3*	*1*	*1*	*1*	*1*	*1*
Roof Sheathing	8	*1/5*	*1/3*	*1/5*	*5*	*3*	*1*	*1*	*1*	*1*	*1*
Valley flashing	9	*1/5*	*1/3*	*1/3*	*5*	*3*	*1*	*1*	*1*	*1*	*1*
Roof opening waterproofing	10	*1/5*	*1*	*1*	*5*	*3*	*1*	*1*	*1*	*1*	*1*
		3.81	*10.7*	*4.93*	*38*	*31.3*	*12.7*	*16.7*	*18.5*	*16.5*	*12.5*

UTILITIES:		1	2	3	4	5	6	7	8	9	10
Water pipe	1	*1*	*1*	*3*	*3*	*1*	*1*	*5*	*1*	*1*	*1/3*
Pipe fittings	2	*1*	*1*	*3*	*1*	*1*	*1*	*5*	*1*	*1*	*1/3*
Pipefitting fastenings	3	*1/3*	*1/3*	*1*	*3*	*3*	*3*	*7*	*3*	*1*	*1*
Drainage pipe	4	*1/3*	*1*	*1/3*	*1*	*1*	*1*	*5*	*3*	*1*	*1*
HVAC System	5	*1*	*1*	*1/3*	*1*	*1*	*1*	*3*	*3*	*1*	*1*
HVAC Duct	6	*1*	*1*	*1/3*	*1*	*1*	*1*	*3*	*3*	*1*	*1*
Register Positions	7	*1/5*	*1/5*	*1/7*	*1/5*	*1/3*	*1/3*	*1*	*1/3*	*1/5*	*1/7*
Bathtub and Shower	8	*1*	*1*	*1/3*	*1/3*	*1/3*	*1/3*	*3*	*1*	*1/3*	*1/5*
Shutoff valves	9	*1*	*1*	*1*	*1*	*1*	*1*	*5*	*3*	*1*	*1/3*
20 amp GFI's	10	*3*	*3*	*1*	*1*	*1*	*1*	*7*	*5*	*3*	*1*
		9.87	10.5	10.5	12.5	10.7	10.7	44	23.3	10.5	6.34

DOORS / WINDOWS:		1	2	3	4	5	6	7	8
Interior door width	1	*1*	*5*	*1*	*1/3*	*1/5*	*1*	*1/3*	*1/3*
Interior Door Height	2	*1/5*	*1*	*1/5*	*1*	*1/3*	*1/3*	*1/5*	*1/3*
Exterior door width	3	*1*	*5*	*1*	*5*	*3*	*1*	*1*	*1*
Number of Hinges Int doors	4	*3*	*1*	*1/5*	*1*	*5*	*1/3*	*1/5*	*1/3*
Hinge type	5	*5*	*3*	*1/3*	*1/5*	*1*	*1/7*	*1/3*	*1/3*
Window glass	6	*1*	*3*	*1*	*3*	*7*	*1*	*1*	*3*
Extrior door Type	7	*3*	*5*	*1*	*5*	*3*	*1*	*1*	*3*
Exterior door height	8	*3*	*3*	*1*	*3*	*3*	*1/3*	*1/3*	*1*
		17.2	26	5.73	18.5	22.5	5.14	4.4	9.33

Figure A6 IPIA-3 Matrix of Comparisons for Items (contd)

COSMETICS:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Carpets	1	1	7	3	1	1/3	1/3	3	3	7	5	9	5	5	1	5	5	7
Shelves	2	1/7	1	1/9	1/7	1/7	1/7	1/5	1/5	1/5	1/5	1/5	1/5	1/7	1/7	1/3	1/3	1/5
Water Heater	3	1/3	9	1	1/3	1/5	1/3	1	1	5	3	1/3	3	5	3	5	3	3
Sheetrock finish	4	1	7	3	1	1/3	3	1	1	5	3	7	3	5	5	7	5	5
Sidewall height	5	3	7	5	3	1	5	3	3	9	3	7	5	5	5	7	7	5
Ceiling paint finishes	6	3	7	3	1/3	1/5	1	1	1	5	1	3	1	1	1/3	3	3	3
Trim around Interior doors	7	1/3	5	1	1	1/3	1	1	1	5	1	3	1	1/3	1/3	3	3	1
Trim Exterior doors & windows	8	1/3	5	1	1	1/3	1	1	1	5	1	3	1	1/3	1/3	3	3	1
Metal mini-blinds	9	1/7	5	1/5	1/5	1/9	1/5	1/5	1/5	1	1/5	1/3	1/5	1/7	1/9	1	1	1/3
Refrigerator	10	1/5	5	1/3	1/3	1/3	1	1	1	5	1	3	1	1	1	5	5	3
Microwave	11	1/9	5	3	1/7	1/7	1/3	1/3	1/3	3	1/3	1	1/3	1/5	1/5	1	1	1/3
Dishwasher	12	1/5	5	1/3	1/3	1/5	1	1	1	5	1	3	1	1	1	3	3	1
Fireplace	13	1/5	7	1/5	1/5	1/5	1	3	3	7	1	5	1	1	1	5	7	5
Modular cabinet system	14	1	7	1/3	1/5	1/5	3	3	3	9	1	5	1	1	1	9	7	3
Outside water faucets	15	1/5	3	1/5	1/7	1/7	1/3	1/3	1/3	1	1/5	1	1/3	1/5	1/9	1	1	1/5
Plumbing for icemaker	16	1/5	3	1/3	1/5	1/7	1/3	1/3	1/3	1	1/5	1	1/3	1/7	1/7	1	1	1/5
Garbage Disposal	17	1/7	1/7	1/3	1/5	1/5	1/3	1	1	3	1/3	3	1	1/5	1/3	5	5	1
		11.5	88.1	22.4	9.76	4.55	19.3	21.4	21.4	76.2	22.5	54.9	25.4	26.7	20	64.3	60.3	39.3

TRANSP& SETUP:		1	2	3	4	5
Setup on site responsibility	1	1	7	5	5	5
Transportation to site	2	1/7	1	1/3	1	1
Setup contractor	3	1/5	3	1	5	5
Orientation and walk through	4	1/5	1	1/5	1	1
Special walkthrough programs	5	1/5	1	1/5	1	1
		1.74	13	6.73	13	13

WARRANTIES:		1	2	3	4
General	1	1	5	7	7
Structural system	2	1/5	1	3	3
Shingles	3	1/7	1/3	1	1
Siding	4	1/7	1/3	1	1
		1.49	6.67	12	12

Figure A6 IPIA-3 Matrix of Comparisons for Items (contd)

SUB-SYSTEMS		1	2	3	4	5	6	7	8	9
Materials	1	*1*	*3 2/5*	*2 7/9*	*2 3/4*	*1 3/8*	*2 7/9*	*3 2/3*	*1 2/5*	*3/7*
Floor Assembly	2	*2/7*	*1*	*1 2/3*	*1*	*1/3*	*1 4/9*	*1 8/9*	*1/3*	*2/9*
Wall Assembly	3	*1/3*	*3/5*	*1*	*7/9*	*2/7*	*7/9*	*1/4*	*1/3*	*2/9*
Roof Assembly	4	*3/8*	*1*	*1 2/7*	*1*	*7/9*	*3/4*	*1/2*	*2/7*	*2/9*
Utilities	5	*5/7*	*3*	*3 1/2*	*1 2/7*	*1*	*3*	*3 2/3*	*5/9*	*4/9*
Doors and Windows	6	*1/3*	*2/3*	*1 2/7*	*1 1/3*	*1/3*	*1*	*1/2*	*1/3*	*2/9*
Cosmetics	7	*2/7*	*1/2*	*3 5/7*	*2*	*2/7*	*2*	*1*	*1/2*	*1/2*
Transportation and Setup	8	*5/7*	*3*	*3*	*3 1/2*	*1 4/5*	*3*	*2*	*1*	*1/2*
Warranties	9	*2 1/3*	*4 3/7*	*4 3/7*	*4 3/7*	*2 1/4*	*4 3/7*	*2*	*2*	*1*
		6.42	17.7	22.6	18.1	8.42	19.2	15.6	6.76	3.75

Figure A7 Average Matrix of Comparisons for Sub-system

MATERIALS:		1	2	3	4	5	6	7	8	9	10
Cabinets	1	*1*	*5*	*1/2*	*1 2/3*	*2 7/9*	*4 1/3*	*3*	*4 1/3*	*2 5/9*	*1/7*
Rollers	2	*1/5*	*1*	*1/6*	*2/9*	*1/2*	*1/4*	*5/9*	*1/3*	*2/9*	*1/9*
Bathtub and Shower	3	*2*	*5 7/8*	*1*	*4 1/3*	*4 1/3*	*5*	*5*	*5 2/3*	*3 2/3*	*1/8*
Vanity	4	*3/5*	*4 3/7*	*1/4*	*1*	*2*	*7/9*	*1 4/9*	*1 2/5*	*1/2*	*1/9*
Faucets	5	*1/3*	*2*	*1/4*	*1/2*	*1*	*1 5/6*	*1 1/6*	*3*	*2 1/9*	*1/8*
Ceiling Board Type	6	*1/4*	*3 5/7*	*1/5*	*1 2/7*	*1/2*	*1*	*2 1/2*	*3 4/9*	*3/4*	*1/8*
Wall Sheetrock type	7	*1/3*	*1 4/5*	*1/5*	*2/3*	*6/7*	*2/5*	*1*	*3*	*1 2/5*	*1/8*
Interior door style	8	*1/4*	*3*	*1/6*	*5/7*	*1/3*	*2/7*	*1/3*	*1*	*1/2*	*1/9*
Window Frame	9	*2/5*	*4 3/7*	*2/7*	*2*	*1/2*	*1 1/3*	*5/7*	*2*	*1*	*1/9*
Electrical Devices	10	*7 1/9*	*9*	*7 5/9*	*9*	*7 5/9*	*8 2/9*	*8 2/9*	*9*	*9*	*1*
		12.4	40.3	10.6	21.4	20.4	23.5	24	33.1	21.7	2.09

FLOOR ASSEMBLY:		1	2	3	4	5	6	7	8
Axles	1	*1*	*2*	*2/9*	*1/6*	*4/9*	*2/9*	*1/6*	*2/9*
Tires	2	*1/2*	*1*	*2/9*	*2/9*	*1/5*	*2/9*	*1/5*	*3/7*
Joist Size	3	*4 3/7*	*4 3/7*	*1*	*1*	*1*	*2 1/9*	*3/4*	*3/4*
Joist Spacing	4	*5 1/2*	*4 3/7*	*1*	*1*	*2 1/3*	*2 7/9*	*1*	*1*
Joist System	5	*2 1/4*	*4 5/6*	*1*	*3/7*	*1*	*3*	*1*	*1*
Insulation R-value	6	*4 3/7*	*4 3/7*	*1/2*	*1/3*	*1/3*	*1*	*1 1/8*	*1 8/9*
Decking material	7	*5 7/8*	*5 1/9*	*1 1/3*	*1*	*1*	*8/9*	*1*	*3 2/3*
Decking Thickness	8	*4 3/7*	*2 1/3*	*1 1/3*	*1*	*1*	*1/2*	*2/7*	*1*
		28.4	28.7	6.65	5.19	7.32	10.8	5.51	9.94

WALL ASSEMBLY:		1	2	3	4	5	6	7	8	9	10	11	12
Stud size (Interior)	1	*1*	*1 2/3*	*7/9*	*1/4*	*1/4*	*1/8*	*1/7*	*3/7*	*1/7*	*1 2/5*	*1/3*	*1/5*
Exterior Bottom Plate size	2	*3/5*	*1*	*2/7*	*1/5*	*1/6*	*1/8*	*1/7*	*3/7*	*1/8*	*1 4/5*	*1 2/9*	*1/5*
Exterior Stud spacing	3	*1 2/7*	*3 1/2*	*1*	*1 2/3*	*2 1/3*	*1/2*	*7/9*	*1/2*	*2/9*	*4 1/3*	*4 1/9*	*1 5/6*
Stud size (Exterior)	4	*4*	*5*	*3/5*	*1*	*1 4/9*	*1/4*	*7/9*	*1/2*	*2/9*	*4 1/3*	*4 1/9*	*1/3*
Insulation R-value	5	*4*	*5 1/2*	*3/7*	*2/3*	*1*	*1/4*	*2 7/9*	*1/2*	*3 1/6*	*4 1/3*	*4 1/9*	*2*
Headers above openings	6	*8 2/9*	*7 5/9*	*2*	*3 5/7*	*3 5/7*	*1*	*4 1/3*	*2*	*2*	*7*	*6 1/3*	*5 2/3*
Exterior Sheathing	7	*6 3/5*	*7*	*1 2/7*	*1 2/7*	*1/3*	*1/4*	*1*	*3 1/6*	*2 1/2*	*5*	*5*	*3 2/3*
Electrical wires pass	8	*2 2/5*	*2 2/5*	*2*	*2*	*2*	*1/2*	*1/3*	*1*	*2 7/9*	*4 1/9*	*4 3/4*	*4 3/4*
Electrical Boxes	9	*6 3/5*	*7 5/9*	*4 3/7*	*4 3/7*	*1/3*	*1/2*	*2/5*	*1/3*	*1*	*7*	*7*	*4 3/4*
Wall Sheetrock thickness	10	*5/7*	*5/9*	*1/4*	*1/4*	*1/4*	*1/7*	*1/5*	*1/4*	*1/7*	*1*	*2 1/9*	*2*
House Wrap	11	*3*	*4/5*	*1/4*	*1/4*	*1/4*	*1/6*	*1/5*	*1/5*	*1/7*	*1/2*	*1*	*2/7*
Exterior Siding	12	*5*	*5*	*1/2*	*3*	*1/2*	*1/6*	*2/7*	*1/5*	*1/5*	*1/2*	*3 1/2*	*1*
		43.6	47.5	13.9	18.7	12.6	3.95	11.3	9.6	12.8	41.3	43.5	26.8

Figure A8 Average Matrix of Comparisons for Items

ROOF ASSEMBLY:		1	2	3	4	5	6	7	8	9	10
Design Load	1	*1*	*6 1/3*	*3 2/3*	*6 1/3*	*7*	*6 1/3*	*6 1/3*	*7*	*5 2/3*	*5*
Roof Slope	2	*1/6*	*1*	*2/9*	*2 3/4*	*2 3/4*	*2 5/7*	*1 1/6*	*2 3/4*	*2*	*1/2*
Insulation R-value	3	*2/7*	*4 3/7*	*1*	*5*	*6 1/3*	*3*	*3*	*4 1/3*	*3 2/3*	*1 2/3*
Eave Projection	4	*1/6*	*3/8*	*1/5*	*1*	*2 1/9*	*1 8/9*	*1/3*	*1 5/6*	*1/2*	*2/7*
Eave Position	5	*1/7*	*3/8*	*1/6*	*1/2*	*1*	*1 4/5*	*1/4*	*1 5/6*	*1/2*	*2/9*
Roof Underlayments	6	*1/6*	*3/8*	*1/3*	*1/2*	*5/9*	*1*	*1/2*	*5/9*	*1/2*	*4/9*
Roof Finish	7	*1/6*	*6/7*	*1/3*	*3*	*3 5/7*	*2*	*1*	*3*	*7/9*	*3/4*
Roof Sheathing	8	*1/7*	*3/8*	*1/4*	*1/2*	*5/9*	*1 4/5*	*1/3*	*1*	*1 3/8*	*1 3/8*
Valley flashing	9	*1/6*	*1/2*	*2/7*	*2*	*2*	*2*	*1 2/7*	*5/7*	*1*	*1/2*
Roof opening waterproofing	10	*1/5*	*2*	*3/5*	*3 1/2*	*4 3/7*	*2 1/4*	*1 1/3*	*5/7*	*2*	*1*
		2.57	*16.5*	*7.02*	*25*	*30.5*	*24.8*	*15.6*	*23.7*	*18*	*11.8*

UTILITIES:		1	2	3	4	5	6	7	8	9	10
Water pipe	1	*1*	*7/9*	*1 4/9*	*3*	*1 4/9*	*2 1/9*	*3 2/3*	*2 1/9*	*4 1/3*	*3 1/6*
Pipe fittings	2	*1 2/7*	*1*	*1 2/3*	*3*	*2 1/9*	*2 7/9*	*4 1/9*	*1 2/5*	*4 1/3*	*3 1/6*
Pipefitting fastenings	3	*2/3*	*3/5*	*1*	*2 3/4*	*2 3/4*	*3 2/5*	*4 7/9*	*2*	*3*	*3 3/8*
Drainage pipe	4	*1/3*	*1/3*	*3/8*	*1*	*3/4*	*3/4*	*2 3/4*	*1 1/6*	*2 1/9*	*1 2/5*
HVAC System	5	*2/3*	*1/2*	*3/8*	*1 1/3*	*1*	*2 1/3*	*3 2/3*	*2 1/3*	*5 2/3*	*3*
HVAC Duct	6	*1/2*	*1/3*	*2/7*	*1 1/3*	*3/7*	*1*	*1 2/5*	*1 1/6*	*3*	*1 2/5*
Register Positions	7	*2/7*	*1/4*	*1/5*	*3/8*	*2/7*	*5/7*	*1*	*1/5*	*2*	*1 3/4*
Bathtub and Shower	8	*1/2*	*5/7*	*1/2*	*6/7*	*3/7*	*6/7*	*5 1/9*	*1*	*5 4/9*	*3 1/6*
Shutoff valves	9	*1/4*	*1/4*	*1/3*	*1/2*	*1/6*	*1/3*	*1/2*	*1/5*	*1*	*1 4/5*
20 amp GFI's	10	*1/3*	*1/3*	*2/7*	*5/7*	*1/3*	*5/7*	*4/7*	*1/3*	*5/9*	*1*
		5.77	5.05	6.46	14.9	9.66	15	27.5	11.9	31.5	23.3

DOORS / WINDOWS:		1	2	3	4	5	6	7	8
Interior door width	1	*1*	*3*	*7/9*	*3 4/9*	*2 3/4*	*2*	*1/2*	*5/9*
Interior Door Height	2	*1/3*	*1*	*1/4*	*3 2/3*	*2 7/9*	*1/4*	*1/4*	*1/2*
Exterior door width	3	*1 2/7*	*4*	*1*	*5 2/3*	*5*	*3 4/9*	*2 7/9*	*1*
Number of Hinges Int doors	4	*2/7*	*2/7*	*1/6*	*1*	*2 1/9*	*2/9*	*1/6*	*2/9*
Hinge type	5	*3/8*	*1/3*	*1/5*	*1/2*	*1*	*1/6*	*1/5*	*1/5*
Window glass	6	*1/2*	*3 6/7*	*2/7*	*4 3/7*	*6 1/6*	*1*	*3/4*	*2 5/7*
Extrior door Type	7	*2*	*4*	*1/3*	*6 1/6*	*5 1/9*	*1 1/3*	*1*	*2 1/9*
Exterior door height	8	*1 4/5*	*2*	*1*	*4 3/7*	*4 5/6*	*3/8*	*1/2*	*1*
		7.64	18.6	4.05	29.3	29.8	8.87	6.07	8.31

Figure A8 Average Matrix of Comparisons for Items (contd)

COSMETICS:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Carpets	1	*1*	*5*	*1 1/9*	*1 2/3*	*2/9*	*1 4/9*	*3*	*1 2/9*	*4 1/3*	*4 1/3*	*6 1/3*	*2 5/7*	*4 1/3*	*1 4/9*	*1 5/6*	*4 1/3*	*4 1/3*
Shelves	2	*1/5*	*1*	*1/8*	*4/9*	*1/8*	*1/2*	*3/4*	*1/5*	*1/2*	*2/7*	*1 1/6*	*2/9*	*1 5/6*	*1/2*	*2/7*	*2/7*	*1 1/6*
Water Heater	3	*8/9*	*8 2/9*	*1*	*3 4/9*	*1 2/5*	*3 4/9*	*5*	*3 2/3*	*7*	*4 1/3*	*3 4/9*	*3*	*5 2/3*	*4 1/3*	*6 1/3*	*6 1/3*	*5*
Sheetrock finish	4	*3/5*	*2 1/4*	*2/7*	*1*	*2/9*	*1 2/3*	*2 1/3*	*1 2/5*	*2 1/9*	*2 1/9*	*4 1/9*	*1 1/6*	*3 2/5*	*2 7/9*	*2 7/9*	*2 7/9*	*3 4/9*
Sidewall height	5	*4 2/3*	*8 2/9*	*5/7*	*4 3/7*	*1*	*5 2/3*	*5 2/3*	*3 4/9*	*7 2/3*	*5 2/3*	*7*	*3 2/3*	*6 1/3*	*5*	*6 1/3*	*6 1/3*	*5 2/3*
Ceiling paint finishes	6	*2/3*	*2*	*2/7*	*3/5*	*1/6*	*1*	*7/9*	*1/2*	*2 3/4*	*1 4/9*	*3*	*1 3/8*	*3*	*1 2/9*	*2*	*2*	*3*
Trim around Interior doors	7	*1/3*	*1 1/3*	*1/5*	*3/7*	*1/6*	*1 2/7*	*1*	*4/9*	*2*	*1 4/9*	*2 7/9*	*1/2*	*1 1/6*	*1 5/6*	*1 2/9*	*1 2/9*	*1 4/9*
Trim Exterior doors & windows	8	*5/6*	*5*	*2/7*	*5/7*	*2/7*	*2 1/7*	*2 1/4*	*1*	*3 2/3*	*3*	*3 2/3*	*1 4/9*	*1 8/9*	*2 1/9*	*2 7/9*	*3*	*3 2/3*
Metal mini-blinds	9	*1/4*	*2 1/7*	*1/7*	*1/2*	*1/8*	*3/8*	*1/2*	*2/7*	*1*	*1 5/6*	*1 8/9*	*2/7*	*2 4/9*	*1 7/9*	*7/9*	*7/9*	*1 8/9*
Refrigerator	10	*1/4*	*3 1/2*	*1/4*	*1/2*	*1/6*	*2/3*	*2/3*	*1/3*	*1/2*	*1*	*2 1/3*	*1/2*	*2*	*1 2/5*	*2 7/9*	*2 3/4*	*2 1/3*
Microwave	11	*1/6*	*6/7*	*2/7*	*1/4*	*1/7*	*1/3*	*1/3*	*2/7*	*1/2*	*3/7*	*1*	*1/4*	*1 7/9*	*4*	*1/2*	*1/2*	*1 2/9*
Dishwasher	12	*3/8*	*4 3/7*	*1/3*	*6/7*	*2/7*	*5/7*	*2*	*2/3*	*3 1/2*	*2*	*3 5/7*	*1*	*3 2/5*	*3 4/9*	*3 2/3*	*4 1/3*	*3 2/3*
Fireplace	13	*1/4*	*5/9*	*1/6*	*2/7*	*1/6*	*1/3*	*6/7*	*1/2*	*2/5*	*1/2*	*5/9*	*2/7*	*1*	*2 1/3*	*3 2/5*	*4*	*4 1/3*
Modular cabinet system	14	*2/3*	*2*	*1/4*	*1/3*	*1/5*	*4/5*	*5/9*	*1/2*	*4/7*	*5/7*	*1/4*	*2/7*	*3/7*	*1*	*5 2/5*	*4 5/7*	*3*
Outside water faucets	15	*1/2*	*3 1/2*	*1/6*	*1/3*	*1/6*	*1/2*	*5/6*	*1/3*	*1 2/7*	*1/3*	*2*	*2/7*	*2/7*	*1/5*	*1*	*7/9*	*1 5/6*
Plumbing for icemaker	16	*1/4*	*3 1/2*	*1/6*	*1/3*	*1/6*	*1/2*	*5/6*	*1/3*	*1 2/7*	*3/8*	*2*	*1/4*	*1/4*	*1/5*	*1 2/7*	*1*	*2 1/2*
Garbage Disposal	17	*1/4*	*1/4*	*1/5*	*2/7*	*1/6*	*1/3*	*2/3*	*2/7*	*1/2*	*3/7*	*4/5*	*2/7*	*1/4*	*1/3*	*1/2*	*2/5*	*1*
		12.1	53.7	5.92	16.4	5.18	21.7	28	15.4	39.7	30.3	46	17.5	39.5	34	43	45.6	49.5

TRANSP& SETUP:		1	2	3	4	5
Setup on site responsibility	1	*1*	*2 5/7*	*2 1/3*	*4 1/9*	*4 3/4*
Transportation to site	2	*3/8*	*1*	*1/2*	*5/9*	*1 2/5*
Setup contractor	3	*3/7*	*2*	*1*	*4 1/9*	*4*
Orientation and walk through	4	*1/4*	*1 4/5*	*1/4*	*1*	*2 1/3*
Special walkthrough programs	5	*1/5*	*5/7*	*1/4*	*3/7*	*1*
		2.25	8.19	4.33	10.2	13.5

WARRANTIES:		1	2	3	4
General	1	*1*	*7*	*8 1/3*	*8 1/3*
Structural system	2	*1/7*	*1*	*5 2/3*	*6 1/3*
Shingles	3	*1/8*	*1/6*	*1*	*1 2/3*
Siding	4	*1/8*	*1/6*	*3/5*	*1*
		1.38	8.33	15.6	17.3

Figure A8 Average Matrix of Comparisons for Items (contd)

APPENDIX B

COLUMN NORMALIZATION AND VECTOR OF PRIORITIES FOR SUB-SYSTEMS AND ITEMS

SUB-SYSTEMS		1	2	3	4	5	6	7	8	9	*Vector of*
Materials	1	*0.03*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.08*	*0.02*	*0.07*	**0.03**
Floor Assembly	2	*0.14*	*0.06*	*0.09*	*0.03*	*0.03*	*0.10*	*0.14*	*0.03*	*0.07*	**0.08**
Wall Assembly	3	*0.08*	*0.02*	*0.03*	*0.01*	*0.02*	*0.01*	*0.00*	*0.03*	*0.07*	**0.03**
Roof Assembly	4	*0.14*	*0.06*	*0.09*	*0.03*	*0.03*	*0.01*	*0.00*	*0.02*	*0.07*	**0.05**
Utilities	5	*0.19*	*0.19*	*0.15*	*0.10*	*0.08*	*0.17*	*0.25*	*0.03*	*0.07*	**0.14**
Doors and Windows	6	*0.08*	*0.02*	*0.09*	*0.17*	*0.02*	*0.03*	*0.00*	*0.03*	*0.07*	**0.06**
Cosmetics	7	*0.01*	*0.01*	*0.22*	*0.24*	*0.01*	*0.31*	*0.03*	*0.01*	*0.05*	**0.10**
Transp. and Setup	8	*0.14*	*0.19*	*0.09*	*0.17*	*0.24*	*0.10*	*0.25*	*0.10*	*0.07*	**0.15**
Warranties	9	*0.19*	*0.44*	*0.22*	*0.24*	*0.57*	*0.24*	*0.25*	*0.71*	*0.47*	**0.37**
											1.00

Figure B1 IPIA 1 Column normalization and Vector of Priorities (EV) for Sub-systems

MATERIALS:		1	2	3	4	5	6	7	8	9	10	Vector of
Cabinets	1	*0.06*	*0.11*	*0.03*	*0.04*	*0.14*	*0.21*	*0.17*	*0.18*	*0.02*	*0.06*	0.10
Rollers	2	*0.01*	*0.02*	*0.01*	*0.01*	*0.03*	*0.01*	*0.03*	*0.01*	*0.01*	*0.06*	0.02
Bathtub & Shower	3	*0.17*	*0.21*	*0.09*	*0.28*	*0.09*	*0.29*	*0.17*	*0.14*	*0.19*	*0.06*	0.17
Vanity	4	*0.06*	*0.07*	*0.01*	*0.04*	*0.09*	*0.01*	*0.07*	*0.06*	*0.02*	*0.06*	0.05
Faucets	5	*0.01*	*0.02*	*0.03*	*0.01*	*0.03*	*0.01*	*0.00*	*0.10*	*0.02*	*0.06*	0.03
Ceiling Board	6	*0.01*	*0.16*	*0.01*	*0.12*	*0.14*	*0.04*	*0.17*	*0.14*	*0.06*	*0.06*	0.09
Sheetrock thk	7	*0.01*	*0.02*	*0.01*	*0.01*	*0.14*	*0.01*	*0.02*	*0.06*	*0.01*	*0.06*	0.04
Interior door style	8	*0.01*	*0.07*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.02*	*0.01*	*0.06*	0.02
Window Frame	9	*0.17*	*0.11*	*0.03*	*0.12*	*0.09*	*0.04*	*0.12*	*0.10*	*0.06*	*0.06*	0.09
Electrical wires	10	*0.50*	*0.21*	*0.77*	*0.36*	*0.26*	*0.38*	*0.22*	*0.18*	*0.58*	*0.50*	0.39
												1.00

FLOOR ASSEMBLY:		1	2	3	4	5	6	7	8	Vector of
Axles	1	*0.04*	*0.12*	*0.06*	*0.03*	*0.15*	*0.02*	*0.04*	*0.03*	0.06
Tires	2	*0.01*	*0.02*	*0.03*	*0.03*	*0.02*	*0.01*	*0.03*	*0.02*	0.02
Joist Size	3	*0.13*	*0.12*	*0.17*	*0.17*	*0.15*	*0.24*	*0.21*	*0.13*	0.17
Joist Spacing	4	*0.22*	*0.12*	*0.17*	*0.17*	*0.15*	*0.15*	*0.21*	*0.13*	0.16
Joist System	5	*0.04*	*0.17*	*0.17*	*0.17*	*0.15*	*0.15*	*0.21*	*0.13*	0.15
Insulation R-value	6	*0.13*	*0.12*	*0.03*	*0.06*	*0.05*	*0.05*	*0.04*	*0.04*	0.07
Decking material	7	*0.22*	*0.17*	*0.17*	*0.17*	*0.15*	*0.24*	*0.21*	*0.39*	0.22
Decking Thick	8	*0.22*	*0.17*	*0.17*	*0.17*	*0.15*	*0.15*	*0.07*	*0.13*	0.15
										1.00

WALL ASSEMBLY:		1	2	3	4	5	6	7	8	9	10	11	12	Vector of
Stud size (Interior)	1	*0.02*	*0.02*	*0.03*	*0.01*	*0.01*	*0.04*	*0.02*	*0.03*	*0.01*	*0.06*	*0.01*	*0.03*	0.02
Exterior Bottom Plate size	2	*0.02*	*0.02*	*0.01*	*0.01*	*0.01*	*0.04*	*0.02*	*0.03*	*0.00*	*0.00*	*0.01*	*0.03*	0.02
Exterior Stud spacing	3	*0.02*	*0.06*	*0.03*	*0.05*	*0.15*	*0.04*	*0.05*	*0.03*	*0.00*	*0.09*	*0.13*	*0.03*	0.06
Stud size (Exterior)	4	*0.12*	*0.10*	*0.03*	*0.05*	*0.15*	*0.05*	*0.05*	*0.03*	*0.01*	*0.09*	*0.13*	*0.04*	0.07
Insulation R-value	5	*0.12*	*0.10*	*0.01*	*0.02*	*0.05*	*0.05*	*0.05*	*0.03*	*0.26*	*0.09*	*0.13*	*0.13*	0.09
Headers above openings	6	*0.21*	*0.17*	*0.31*	*0.32*	*0.35*	*0.32*	*0.44*	*0.10*	*0.14*	*0.17*	*0.13*	*0.38*	0.25
Exterior Sheathing	7	*0.16*	*0.13*	*0.10*	*0.14*	*0.15*	*0.11*	*0.15*	*0.29*	*0.20*	*0.17*	*0.19*	*0.13*	0.16
Electrical wires pass	8	*0.02*	*0.02*	*0.03*	*0.05*	*0.05*	*0.11*	*0.02*	*0.03*	*0.20*	*0.01*	*0.01*	*0.03*	0.05
Electrical Boxes	9	*0.12*	*0.13*	*0.24*	*0.23*	*0.01*	*0.06*	*0.02*	*0.00*	*0.03*	*0.13*	*0.13*	*0.03*	0.09
Wall Sheetrock thk	10	*0.01*	*0.10*	*0.01*	*0.01*	*0.01*	*0.04*	*0.02*	*0.10*	*0.00*	*0.02*	*0.01*	*0.02*	0.03
House Wrap	11	*0.07*	*0.06*	*0.01*	*0.01*	*0.01*	*0.06*	*0.02*	*0.16*	*0.01*	*0.06*	*0.03*	*0.04*	0.04
Exterior Siding	12	*0.12*	*0.10*	*0.17*	*0.14*	*0.05*	*0.11*	*0.15*	*0.16*	*0.14*	*0.13*	*0.08*	*0.13*	0.12
														1.00

Figure B2 IPIA 1 Column normalization and Vector of Priorities (EV) for Items

ROOF ASSEMBLY:		1	2	3	4	5	6	7	8	9	10	Vector of
Design Load	1	*0.50*	*0.17*	*0.69*	*0.32*	*0.15*	*0.35*	*0.39*	*0.57*	*0.57*	*0.57*	0.39
Roof Slope	2	*0.06*	*0.02*	*0.01*	*0.01*	*0.00*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	0.02
Insulation R-value	3	*0.06*	*0.13*	*0.08*	*0.11*	*0.12*	*0.04*	*0.13*	*0.19*	*0.19*	*0.19*	0.11
Eave Projection	4	*0.06*	*0.10*	*0.03*	*0.04*	*0.08*	*0.01*	*0.01*	*0.02*	*0.02*	*0.02*	0.04
Eave Position	5	*0.06*	*0.10*	*0.01*	*0.01*	*0.02*	*0.00*	*0.01*	*0.01*	*0.01*	*0.01*	0.03
Roof Underlayments	6	*0.06*	*0.13*	*0.08*	*0.11*	*0.15*	*0.04*	*0.01*	*0.02*	*0.02*	*0.01*	0.07
Roof Finish	7	*0.06*	*0.06*	*0.03*	*0.11*	*0.12*	*0.12*	*0.04*	*0.06*	*0.02*	*0.01*	0.07
Roof Sheathing	8	*0.06*	*0.10*	*0.03*	*0.11*	*0.12*	*0.12*	*0.04*	*0.06*	*0.19*	*0.19*	0.08
Valley flashing	9	*0.06*	*0.10*	*0.03*	*0.11*	*0.12*	*0.12*	*0.13*	*0.02*	*0.06*	*0.02*	0.08
Roof opening waterprf	10	*0.06*	*0.10*	*0.03*	*0.11*	*0.12*	*0.20*	*0.22*	*0.02*	*0.19*	*0.06*	0.10
												1.00

UTILITIES:		1	2	3	4	5	6	7	8	9	10	Vector of
Water pipe	1	*0.04*	*0.02*	*0.01*	*0.06*	*0.07*	*0.03*	*0.04*	*0.04*	*0.10*	*0.04*	0.04
Pipe fittings	2	*0.13*	*0.05*	*0.03*	*0.19*	*0.07*	*0.03*	*0.01*	*0.02*	*0.10*	*0.04*	0.07
Pipefitting fastenings	3	*0.13*	*0.05*	*0.03*	*0.01*	*0.04*	*0.02*	*0.01*	*0.02*	*0.02*	*0.02*	0.03
Drainage pipe	4	*0.04*	*0.02*	*0.14*	*0.06*	*0.20*	*0.08*	*0.12*	*0.04*	*0.10*	*0.04*	0.08
HVAC System	5	*0.13*	*0.14*	*0.14*	*0.06*	*0.20*	*0.08*	*0.12*	*0.35*	*0.17*	*0.55*	0.19
HVAC Duct	6	*0.13*	*0.14*	*0.14*	*0.06*	*0.20*	*0.08*	*0.04*	*0.04*	*0.10*	*0.04*	0.10
Register Positions	7	*0.04*	*0.14*	*0.08*	*0.02*	*0.07*	*0.08*	*0.04*	*0.01*	*0.06*	*0.03*	0.06
Bathtub and Shower	8	*0.13*	*0.23*	*0.14*	*0.19*	*0.07*	*0.23*	*0.35*	*0.12*	*0.17*	*0.06*	0.17
Shutoff valves	9	*0.01*	*0.01*	*0.03*	*0.01*	*0.02*	*0.02*	*0.01*	*0.01*	*0.02*	*0.02*	0.02
20 amp GFI's	10	*0.22*	*0.23*	*0.25*	*0.32*	*0.07*	*0.38*	*0.27*	*0.35*	*0.17*	*0.18*	0.24
												1.00

DOORS / WINDOWS:		1	2	3	4	5	6	7	8	Vector of
Interior door width	1	*0.04*	*0.04*	*0.04*	*0.09*	*0.08*	*0.05*	*0.03*	*0.03*	0.05
Interior Door Height	2	*0.04*	*0.04*	*0.02*	*0.09*	*0.08*	*0.04*	*0.06*	*0.09*	0.06
Exterior door width	3	*0.12*	*0.22*	*0.11*	*0.15*	*0.14*	*0.11*	*0.10*	*0.09*	0.13
Number Hinges Int doors	4	*0.01*	*0.01*	*0.02*	*0.03*	*0.01*	*0.05*	*0.04*	*0.02*	0.02
Hinge type	5	*0.01*	*0.01*	*0.02*	*0.09*	*0.03*	*0.05*	*0.03*	*0.01*	0.03
Window glass	6	*0.28*	*0.40*	*0.34*	*0.21*	*0.20*	*0.33*	*0.31*	*0.43*	0.31
Extrior door Type	7	*0.36*	*0.22*	*0.34*	*0.21*	*0.25*	*0.33*	*0.31*	*0.26*	0.28
Exterior door height	8	*0.12*	*0.04*	*0.11*	*0.15*	*0.20*	*0.07*	*0.10*	*0.09*	0.11
										1.00

Figure B2 IPIA 1 Column normalization and Vector of Priorities (EV) for Items (contd)

COSMETICS:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	*Vector of*
Carpets	1	*0.03*	*0.06*	*0.03*	*0.07*	*0.01*	*0.12*	*0.05*	*0.03*	*0.02*	*0.08*	*0.07*	*0.09*	*0.15*	*0.02*	*0.01*	*0.09*	*0.08*	0.06
Shelves	2	*0.01*	*0.02*	*0.03*	*0.02*	*0.01*	*0.01*	*0.02*	*0.02*	*0.02*	*0.01*	*0.01*	*0.01*	*0.02*	*0.02*	*0.01*	*0.01*	*0.01*	0.01
Water Heater	3	*0.23*	*0.13*	*0.22*	*0.07*	*0.31*	*0.12*	*0.12*	*0.38*	*0.16*	*0.14*	*0.07*	*0.16*	*0.25*	*0.14*	*0.15*	*0.16*	*0.14*	0.17
Sheetrock finish	4	*0.01*	*0.02*	*0.07*	*0.02*	*0.02*	*0.04*	*0.02*	*0.02*	*0.02*	*0.01*	*0.01*	*0.01*	*0.01*	*0.02*	*0.02*	*0.05*	*0.01*	0.02
Sidewall height	5	*0.30*	*0.17*	*0.07*	*0.12*	*0.10*	*0.20*	*0.12*	*0.03*	*0.12*	*0.14*	*0.12*	*0.16*	*0.25*	*0.14*	*0.15*	*0.12*	*0.14*	0.14
Ceiling paint finishes	6	*0.01*	*0.06*	*0.07*	*0.02*	*0.02*	*0.04*	*0.02*	*0.02*	*0.05*	*0.08*	*0.07*	*0.09*	*0.15*	*0.02*	*0.06*	*0.05*	*0.08*	0.05
Trim Interior doors	7	*0.01*	*0.02*	*0.03*	*0.02*	*0.01*	*0.04*	*0.02*	*0.01*	*0.02*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	0.01
Trim Exterior doors	8	*0.10*	*0.10*	*0.04*	*0.12*	*0.31*	*0.20*	*0.12*	*0.08*	*0.09*	*0.08*	*0.07*	*0.09*	*0.02*	*0.05*	*0.10*	*0.09*	*0.14*	0.11
Metal mini-blinds	9	*0.03*	*0.02*	*0.02*	*0.02*	*0.01*	*0.01*	*0.02*	*0.02*	*0.02*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	0.01
Refrigerator	10	*0.01*	*0.06*	*0.04*	*0.07*	*0.02*	*0.01*	*0.05*	*0.03*	*0.05*	*0.03*	*0.07*	*0.01*	*0.01*	*0.01*	*0.06*	*0.05*	*0.03*	0.04
Microwave	11	*0.01*	*0.06*	*0.07*	*0.07*	*0.02*	*0.01*	*0.05*	*0.03*	*0.05*	*0.01*	*0.02*	*0.01*	*0.01*	*0.34*	*0.01*	*0.01*	*0.01*	0.05
Dishwasher	12	*0.01*	*0.06*	*0.04*	*0.07*	*0.02*	*0.01*	*0.05*	*0.03*	*0.05*	*0.08*	*0.07*	*0.03*	*0.01*	*0.02*	*0.06*	*0.05*	*0.03*	0.04
Fireplace	13	*0.01*	*0.06*	*0.04*	*0.12*	*0.02*	*0.01*	*0.08*	*0.23*	*0.09*	*0.14*	*0.17*	*0.16*	*0.05*	*0.14*	*0.10*	*0.09*	*0.14*	0.10
Modular cabinet system	14	*0.10*	*0.06*	*0.07*	*0.07*	*0.03*	*0.12*	*0.12*	*0.08*	*0.09*	*0.14*	*0.00*	*0.09*	*0.02*	*0.05*	*0.15*	*0.12*	*0.14*	0.09
Outside water faucets	15	*0.10*	*0.06*	*0.03*	*0.02*	*0.01*	*0.01*	*0.05*	*0.02*	*0.05*	*0.01*	*0.07*	*0.01*	*0.01*	*0.01*	*0.02*	*0.02*	*0.01*	0.03
Plumbing for icemaker	16	*0.01*	*0.06*	*0.02*	*0.01*	*0.01*	*0.01*	*0.05*	*0.02*	*0.05*	*0.01*	*0.07*	*0.01*	*0.01*	*0.01*	*0.02*	*0.02*	*0.01*	0.02
Garbage Disposal	17	*0.01*	*0.01*	*0.04*	*0.07*	*0.02*	*0.01*	*0.05*	*0.02*	*0.05*	*0.03*	*0.07*	*0.03*	*0.01*	*0.01*	*0.06*	*0.05*	*0.03*	0.03
																			1.00

TRANSP& SETUP:		1	2	3	4	5	*Vector of*
Setup responsibility	1	*0.09*	*0.09*	*0.09*	*0.11*	*0.08*	0.09
Transportation to site	2	*0.09*	*0.09*	*0.09*	*0.11*	*0.08*	0.09
Setup contractor	3	*0.09*	*0.09*	*0.09*	*0.11*	*0.08*	0.09
Orientation walk through	4	*0.27*	*0.27*	*0.27*	*0.33*	*0.38*	0.31
Special walkthrough	5	*0.45*	*0.45*	*0.45*	*0.33*	*0.38*	0.42
							1.00

WARRANTIES:		1	2	3	4	*Vector of*
General	1	*0.73*	*0.85*	*0.45*	*0.45*	0.62
Structural system	2	*0.10*	*0.12*	*0.45*	*0.45*	0.28
Shingles	3	*0.08*	*0.01*	*0.05*	*0.05*	0.05
Siding	4	*0.08*	*0.01*	*0.05*	*0.05*	0.05
						1.00

Figure B2 IPIA 1 Column normalization and Vector of Priorities (EV) for Items (contd)

SUB-SYSTEMS		1	2	3	4	5	6	7	8	9	EV
Materials	1	*0.10*	*0.20*	*0.14*	*0.18*	*0.19*	*0.27*	*0.37*	*0.31*	*0.05*	**0.20**
Floor Assembly	2	*0.02*	*0.04*	*0.05*	*0.06*	*0.02*	*0.02*	*0.02*	*0.03*	*0.07*	**0.04**
Wall Assembly	3	*0.03*	*0.04*	*0.05*	*0.06*	*0.02*	*0.05*	*0.02*	*0.03*	*0.07*	**0.04**
Roof Assembly	4	*0.03*	*0.04*	*0.05*	*0.06*	*0.06*	*0.05*	*0.07*	*0.03*	*0.07*	**0.05**
Utilities	5	*0.03*	*0.12*	*0.14*	*0.06*	*0.06*	*0.05*	*0.07*	*0.03*	*0.07*	**0.07**
Doors and Windows	6	*0.02*	*0.12*	*0.05*	*0.06*	*0.06*	*0.05*	*0.07*	*0.03*	*0.07*	**0.06**
Cosmetics	7	*0.02*	*0.12*	*0.14*	*0.06*	*0.06*	*0.05*	*0.07*	*0.10*	*0.12*	**0.08**
Transportation and Setup	8	*0.03*	*0.12*	*0.14*	*0.18*	*0.19*	*0.16*	*0.07*	*0.10*	*0.12*	**0.12**
Warranties	9	*0.70*	*0.20*	*0.24*	*0.29*	*0.32*	*0.27*	*0.22*	*0.31*	*0.36*	**0.32**
											1.00

Figure B3 IPIA 2 Column normalization and Vector of Priorities (EV) for Sub-systems

MATERIALS:		1	2	3	4	5	6	7	8	9	10	EV
Cabinets	1	*0.04*	*0.10*	*0.02*	*0.09*	*0.03*	*0.08*	*0.04*	*0.04*	*0.02*	*0.05*	0.05
Rollers	2	*0.01*	*0.02*	*0.02*	*0.00*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.05*	0.02
Bathtub and Shower	3	*0.21*	*0.10*	*0.10*	*0.09*	*0.24*	*0.13*	*0.29*	*0.27*	*0.23*	*0.07*	0.17
Vanity	4	*0.01*	*0.13*	*0.03*	*0.03*	*0.02*	*0.03*	*0.01*	*0.01*	*0.01*	*0.05*	0.03
Faucets	5	*0.13*	*0.13*	*0.03*	*0.14*	*0.08*	*0.13*	*0.13*	*0.12*	*0.23*	*0.07*	0.12
Ceiling Board	6	*0.01*	*0.06*	*0.02*	*0.03*	*0.02*	*0.03*	*0.01*	*0.01*	*0.01*	*0.05*	0.02
Sheetrock thickness	7	*0.04*	*0.10*	*0.01*	*0.09*	*0.03*	*0.13*	*0.04*	*0.04*	*0.05*	*0.05*	0.06
Interior door style	8	*0.04*	*0.06*	*0.01*	*0.14*	*0.03*	*0.08*	*0.04*	*0.04*	*0.02*	*0.05*	0.05
Window Frame	9	*0.13*	*0.13*	*0.02*	*0.14*	*0.02*	*0.13*	*0.04*	*0.12*	*0.05*	*0.05*	0.08
Electrical wires	10	*0.38*	*0.17*	*0.72*	*0.26*	*0.55*	*0.24*	*0.38*	*0.35*	*0.41*	*0.48*	0.39
												1.00

FLOOR ASSEMBLY:		1	2	3	4	5	6	7	8	EV
Axles	1	*0.02*	*0.02*	*0.01*	*0.03*	*0.02*	*0.01*	*0.03*	*0.02*	0.02
Tires	2	*0.02*	*0.02*	*0.01*	*0.03*	*0.02*	*0.01*	*0.03*	*0.02*	0.02
Joist Size	3	*0.15*	*0.15*	*0.07*	*0.21*	*0.11*	*0.05*	*0.05*	*0.02*	0.10
Joist Spacing	4	*0.15*	*0.15*	*0.07*	*0.21*	*0.53*	*0.25*	*0.26*	*0.11*	0.22
Joist System	5	*0.15*	*0.15*	*0.07*	*0.04*	*0.11*	*0.25*	*0.26*	*0.11*	0.14
Insulation R-value	6	*0.15*	*0.15*	*0.07*	*0.04*	*0.02*	*0.05*	*0.05*	*0.04*	0.07
Decking material	7	*0.20*	*0.20*	*0.35*	*0.21*	*0.11*	*0.25*	*0.26*	*0.57*	0.27
Decking Thickness	8	*0.15*	*0.15*	*0.35*	*0.21*	*0.11*	*0.15*	*0.05*	*0.11*	0.16
										1.00

WALL ASSEMBLY:		1	2	3	4	5	6	7	8	9	10	11	12	EV
Stud size (Interior)	1	*0.02*	*0.05*	*0.07*	*0.01*	*0.02*	*0.01*	*0.01*	*0.03*	*0.03*	*0.02*	*0.01*	*0.00*	0.02
Exterior Bottom Plate	2	*0.01*	*0.02*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.03*	*0.03*	*0.09*	*0.05*	*0.00*	0.02
Exterior Stud spacing	3	*0.02*	*0.09*	*0.07*	*0.10*	*0.15*	*0.07*	*0.04*	*0.06*	*0.06*	*0.12*	*0.11*	*0.12*	0.08
Stud size (Exterior)	4	*0.10*	*0.09*	*0.02*	*0.03*	*0.02*	*0.02*	*0.04*	*0.04*	*0.04*	*0.12*	*0.11*	*0.01*	0.05
Insulation R-value	5	*0.06*	*0.09*	*0.02*	*0.10*	*0.05*	*0.02*	*0.21*	*0.04*	*0.06*	*0.12*	*0.11*	*0.12*	0.08
Headers above openings	6	*0.14*	*0.12*	*0.07*	*0.10*	*0.15*	*0.07*	*0.21*	*0.06*	*0.06*	*0.12*	*0.11*	*0.16*	0.11
Exterior Sheathing	7	*0.10*	*0.12*	*0.07*	*0.03*	*0.01*	*0.01*	*0.04*	*0.06*	*0.06*	*0.09*	*0.08*	*0.12*	0.07
Electrical wires pass	8	*0.18*	*0.16*	*0.33*	*0.24*	*0.34*	*0.37*	*0.21*	*0.29*	*0.28*	*0.15*	*0.14*	*0.16*	0.24
Electrical Boxes	9	*0.18*	*0.16*	*0.33*	*0.24*	*0.24*	*0.37*	*0.21*	*0.29*	*0.28*	*0.15*	*0.14*	*0.16*	0.23
Wall Sheetrock thk	10	*0.02*	*0.00*	*0.01*	*0.00*	*0.01*	*0.01*	*0.01*	*0.03*	*0.03*	*0.02*	*0.05*	*0.12*	0.03
House Wrap	11	*0.06*	*0.01*	*0.01*	*0.00*	*0.01*	*0.01*	*0.01*	*0.03*	*0.03*	*0.01*	*0.02*	*0.00*	0.02
Exterior Siding	12	*0.10*	*0.09*	*0.01*	*0.10*	*0.01*	*0.01*	*0.01*	*0.04*	*0.04*	*0.00*	*0.08*	*0.02*	0.04
														1.00

Figure B4 IPIA 2 Column normalization and Vector of Priorities (EV) for Items

ROOF ASSEMBLY:		1	2	3	4	5	6	7	8	9	10	EV
Design Load	1	*0.23*	*0.32*	*0.23*	*0.19*	*0.18*	*0.13*	*0.41*	*0.14*	*0.06*	*0.02*	0.23
Roof Slope	2	*0.03*	*0.05*	*0.05*	*0.19*	*0.18*	*0.13*	*0.02*	*0.10*	*0.06*	*0.01*	0.09
Insulation R-value	3	*0.23*	*0.23*	*0.23*	*0.27*	*0.25*	*0.10*	*0.25*	*0.10*	*0.10*	*0.02*	0.20
Eave Projection	4	*0.05*	*0.01*	*0.03*	*0.04*	*0.04*	*0.10*	*0.03*	*0.10*	*0.02*	*0.01*	0.05
Eave Position	5	*0.05*	*0.01*	*0.03*	*0.04*	*0.04*	*0.10*	*0.03*	*0.10*	*0.02*	*0.00*	0.05
Roof Underlayments	6	*0.03*	*0.01*	*0.05*	*0.01*	*0.01*	*0.02*	*0.02*	*0.01*	*0.00*	*0.00*	0.02
Roof Finish	7	*0.05*	*0.23*	*0.08*	*0.11*	*0.11*	*0.10*	*0.08*	*0.14*	*0.02*	*0.02*	0.11
Roof Sheathing	8	*0.03*	*0.01*	*0.05*	*0.01*	*0.01*	*0.06*	*0.01*	*0.02*	*0.00*	*0.00*	0.02
Valley flashing	9	*0.08*	*0.02*	*0.05*	*0.04*	*0.04*	*0.13*	*0.08*	*0.14*	*0.02*	*0.00*	0.07
Roof opening waterprf	10	*0.23*	*0.14*	*0.23*	*0.11*	*0.18*	*0.13*	*0.08*	*0.14*	*0.10*	*0.02*	0.15
												1.00

UTILITIES:		1	2	3	4	5	6	7	8	9	10	EV
Water pipe	1	*0.23*	*0.23*	*0.23*	*0.13*	*0.19*	*0.13*	*0.15*	*0.36*	*0.16*	*0.16*	0.20
Pipe fittings	2	*0.23*	*0.23*	*0.23*	*0.13*	*0.31*	*0.18*	*0.21*	*0.22*	*0.16*	*0.16*	0.21
Pipefitting fastenings	3	*0.23*	*0.23*	*0.23*	*0.13*	*0.31*	*0.18*	*0.21*	*0.22*	*0.16*	*0.16*	0.21
Drainage pipe	4	*0.05*	*0.05*	*0.05*	*0.03*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.05*	0.03
HVAC System	5	*0.08*	*0.05*	*0.05*	*0.13*	*0.06*	*0.13*	*0.15*	*0.07*	*0.16*	*0.09*	0.10
HVAC Duct	6	*0.05*	*0.03*	*0.03*	*0.13*	*0.01*	*0.03*	*0.01*	*0.01*	*0.07*	*0.05*	0.04
Register Positions	7	*0.05*	*0.03*	*0.03*	*0.13*	*0.01*	*0.13*	*0.03*	*0.01*	*0.07*	*0.09*	0.06
Bathtub and Shower	8	*0.05*	*0.08*	*0.08*	*0.13*	*0.06*	*0.18*	*0.21*	*0.07*	*0.16*	*0.16*	0.12
Shutoff valves	9	*0.03*	*0.03*	*0.03*	*0.08*	*0.01*	*0.01*	*0.01*	*0.01*	*0.02*	*0.09*	0.03
20 amp GFI's	10	*0.03*	*0.03*	*0.03*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.00*	*0.02*	0.01
												1.00

DOORS / WINDOWS:		1	2	3	4	5	6	7	8	EV
Interior door width	1	*0.21*	*0.16*	*0.26*	*0.17*	*0.13*	*0.17*	*0.08*	*0.25*	0.18
Interior Door Height	2	*0.07*	*0.05*	*0.09*	*0.17*	*0.13*	*0.01*	*0.03*	*0.05*	0.07
Exterior door width	3	*0.21*	*0.16*	*0.26*	*0.17*	*0.18*	*0.30*	*0.55*	*0.25*	0.26
Number Hinges Int doors	4	*0.03*	*0.01*	*0.04*	*0.02*	*0.03*	*0.01*	*0.01*	*0.04*	0.02
Hinge type	5	*0.04*	*0.01*	*0.04*	*0.02*	*0.03*	*0.01*	*0.01*	*0.04*	0.02
Window glass	6	*0.04*	*0.16*	*0.03*	*0.12*	*0.13*	*0.03*	*0.02*	*0.03*	0.07
Extrior door Type	7	*0.21*	*0.16*	*0.04*	*0.17*	*0.18*	*0.17*	*0.08*	*0.08*	0.14
Exterior door height	8	*0.21*	*0.27*	*0.26*	*0.17*	*0.18*	*0.30*	*0.23*	*0.25*	0.23
										1.00

Figure B4 IPIA 2 Column normalization and Vector of Priorities (EV) for Items (contd)

COSMETICS:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	*EV*
Carpets	1	*0.03*	*0.08*	*0.04*	*0.03*	*0.04*	*0.02*	*0.06*	*0.01*	*0.18*	*0.09*	*0.10*	*0.03*	*0.06*	*0.04*	*0.01*	*0.11*	*0.04*	0.06
Shelves	2	*0.01*	*0.02*	*0.02*	*0.01*	*0.02*	*0.02*	*0.02*	*0.01*	*0.01*	*0.01*	*0.04*	*0.03*	*0.06*	*0.01*	*0.01*	*0.01*	*0.04*	0.02
Water Heater	3	*0.17*	*0.14*	*0.19*	*0.21*	*0.20*	*0.13*	*0.15*	*0.19*	*0.25*	*0.09*	*0.10*	*0.18*	*0.08*	*0.10*	*0.28*	*0.26*	*0.10*	0.17
Sheetrock finish	4	*0.03*	*0.08*	*0.03*	*0.03*	*0.03*	*0.02*	*0.11*	*0.12*	*0.01*	*0.06*	*0.07*	*0.04*	*0.06*	*0.04*	*0.01*	*0.01*	*0.07*	0.05
Sidewall height	5	*0.17*	*0.14*	*0.19*	*0.21*	*0.20*	*0.13*	*0.15*	*0.27*	*0.25*	*0.17*	*0.13*	*0.18*	*0.11*	*0.10*	*0.20*	*0.18*	*0.10*	0.17
Ceiling paint finishes	6	*0.03*	*0.02*	*0.03*	*0.03*	*0.03*	*0.02*	*0.01*	*0.01*	*0.01*	*0.01*	*0.04*	*0.03*	*0.06*	*0.04*	*0.01*	*0.01*	*0.04*	0.02
Trim Interior doors	7	*0.01*	*0.02*	*0.03*	*0.01*	*0.03*	*0.06*	*0.02*	*0.01*	*0.01*	*0.06*	*0.07*	*0.04*	*0.04*	*0.07*	*0.01*	*0.01*	*0.04*	0.03
Trim Exterior doors	8	*0.10*	*0.08*	*0.04*	*0.01*	*0.03*	*0.10*	*0.11*	*0.04*	*0.04*	*0.09*	*0.07*	*0.06*	*0.06*	*0.07*	*0.01*	*0.04*	*0.07*	0.06
Metal mini-blinds	9	*0.01*	*0.08*	*0.03*	*0.09*	*0.03*	*0.10*	*0.11*	*0.04*	*0.04*	*0.09*	*0.07*	*0.06*	*0.08*	*0.07*	*0.04*	*0.04*	*0.07*	0.06
Refrigerator	10	*0.01*	*0.05*	*0.04*	*0.01*	*0.02*	*0.06*	*0.01*	*0.01*	*0.01*	*0.02*	*0.01*	*0.03*	*0.06*	*0.04*	*0.01*	*0.01*	*0.04*	0.03
Microwave	11	*0.00*	*0.01*	*0.03*	*0.01*	*0.02*	*0.01*	*0.00*	*0.01*	*0.01*	*0.02*	*0.01*	*0.03*	*0.06*	*0.07*	*0.01*	*0.01*	*0.04*	0.02
Dishwasher	12	*0.23*	*0.11*	*0.19*	*0.15*	*0.20*	*0.13*	*0.11*	*0.12*	*0.11*	*0.13*	*0.10*	*0.18*	*0.11*	*0.12*	*0.20*	*0.26*	*0.12*	0.15
Fireplace	13	*0.01*	*0.00*	*0.03*	*0.01*	*0.02*	*0.00*	*0.01*	*0.01*	*0.01*	*0.00*	*0.00*	*0.02*	*0.01*	*0.04*	*0.01*	*0.01*	*0.04*	0.01
Modular cabinet system	14	*0.01*	*0.02*	*0.03*	*0.01*	*0.03*	*0.01*	*0.00*	*0.01*	*0.01*	*0.01*	*0.00*	*0.02*	*0.00*	*0.01*	*0.01*	*0.01*	*0.01*	0.01
Outside water faucets	15	*0.17*	*0.08*	*0.03*	*0.09*	*0.04*	*0.10*	*0.06*	*0.12*	*0.04*	*0.06*	*0.07*	*0.04*	*0.06*	*0.07*	*0.04*	*0.01*	*0.07*	0.07
Plumbing for icemaker	16	*0.01*	*0.08*	*0.03*	*0.09*	*0.04*	*0.10*	*0.06*	*0.04*	*0.04*	*0.09*	*0.07*	*0.03*	*0.08*	*0.10*	*0.12*	*0.04*	*0.10*	0.07
Garbage Disposal	17	*0.01*	*0.01*	*0.03*	*0.01*	*0.03*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.00*	*0.02*	*0.00*	*0.01*	*0.01*	*0.01*	*0.01*	0.01
																			1.00

TRANSP& SETUP:		1	2	3	4	5	*EV*
Setup responsibility	1	*0.11*	*0.02*	*0.40*	*0.45*	*0.36*	0.27
Transportation to site	2	*0.76*	*0.11*	*0.08*	*0.02*	*0.12*	0.22
Setup contractor	3	*0.11*	*0.53*	*0.40*	*0.45*	*0.28*	0.35
Orientation walk thro	4	*0.02*	*0.32*	*0.06*	*0.06*	*0.20*	0.13
Special walkthrough	5	*0.01*	*0.04*	*0.06*	*0.01*	*0.04*	0.03
							1.00

WARRANTIES:		1	2	3	4	*EV*
General	1	*0.75*	*0.87*	*0.59*	*0.45*	0.66
Structural system	2	*0.08*	*0.10*	*0.33*	*0.35*	0.21
Shingles	3	*0.08*	*0.02*	*0.07*	*0.15*	0.08
Siding	4	*0.08*	*0.01*	*0.02*	*0.05*	0.04
						1.00

Figure B4 IPIA 2 Column normalization and Vector of Priorities (EV) for Items (contd)

SUB-SYSTEMS		1	2	3	4	5	6	7	8	9	*EV*
Materials	1	*0.19*	*0.24*	*0.24*	*0.26*	*0.14*	*0.16*	*0.29*	*0.18*	*0.16*	**0.21**
Floor Assembly	2	*0.04*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.03*	*0.06*	*0.05*	**0.05**
Wall Assembly	3	*0.04*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.03*	*0.06*	*0.05*	**0.05**
Roof Assembly	4	*0.04*	*0.05*	*0.05*	*0.05*	*0.14*	*0.05*	*0.03*	*0.06*	*0.05*	**0.06**
Utilities	5	*0.19*	*0.14*	*0.14*	*0.05*	*0.14*	*0.16*	*0.10*	*0.18*	*0.16*	**0.14**
Doors and Windows	6	*0.06*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.03*	*0.06*	*0.05*	**0.05**
Cosmetics	7	*0.06*	*0.14*	*0.14*	*0.16*	*0.14*	*0.16*	*0.10*	*0.06*	*0.16*	**0.12**
Transportation and Setup	8	*0.19*	*0.14*	*0.14*	*0.16*	*0.14*	*0.16*	*0.29*	*0.18*	*0.16*	**0.17**
Warranties	9	*0.19*	*0.14*	*0.14*	*0.16*	*0.14*	*0.16*	*0.10*	*0.18*	*0.16*	**0.15**
											1.00

Figure B5 IPIA 3 Column normalization and Vector of Priorities (EV) for Sub-systems

MATERIALS:		1	2	3	4	5	6	7	8	9	10	EV
Cabinets	1	*0.10*	*0.11*	*0.09*	*0.05*	*0.10*	*0.23*	*0.08*	*0.11*	*0.26*	*0.09*	0.12
Rollers	2	*0.02*	*0.02*	*0.02*	*0.01*	*0.01*	*0.02*	*0.01*	*0.01*	*0.01*	*0.05*	0.02
Bathtub and Shower	3	*0.10*	*0.11*	*0.09*	*0.16*	*0.24*	*0.14*	*0.08*	*0.11*	*0.11*	*0.06*	0.12
Vanity	4	*0.10*	*0.11*	*0.03*	*0.05*	*0.10*	*0.05*	*0.08*	*0.04*	*0.04*	*0.05*	0.06
Faucets	5	*0.03*	*0.07*	*0.01*	*0.02*	*0.03*	*0.02*	*0.03*	*0.04*	*0.04*	*0.06*	0.03
Ceiling Board	6	*0.02*	*0.07*	*0.03*	*0.05*	*0.10*	*0.05*	*0.03*	*0.11*	*0.04*	*0.06*	0.06
Sheetrock thickness	7	*0.10*	*0.16*	*0.09*	*0.05*	*0.10*	*0.14*	*0.08*	*0.18*	*0.11*	*0.06*	0.11
Interior door style	8	*0.03*	*0.07*	*0.03*	*0.05*	*0.03*	*0.02*	*0.02*	*0.04*	*0.04*	*0.05*	0.04
Window Frame	9	*0.01*	*0.07*	*0.03*	*0.05*	*0.03*	*0.05*	*0.03*	*0.04*	*0.04*	*0.05*	0.04
Electrical wires	10	*0.49*	*0.20*	*0.60*	*0.49*	*0.24*	*0.32*	*0.57*	*0.33*	*0.33*	*0.45*	0.40
												1.00

FLOOR ASSEMBLY:		1	2	3	4	5	6	7	8	EV
Axles	1	*0.03*	*0.01*	*0.02*	*0.02*	*0.03*	*0.05*	*0.03*	*0.03*	0.03
Tires	2	*0.15*	*0.06*	*0.04*	*0.04*	*0.05*	*0.09*	*0.04*	*0.08*	0.07
Joist Size	3	*0.15*	*0.17*	*0.12*	*0.12*	*0.15*	*0.09*	*0.13*	*0.08*	0.13
Joist Spacing	4	*0.15*	*0.17*	*0.12*	*0.12*	*0.15*	*0.09*	*0.13*	*0.08*	0.13
Joist System	5	*0.15*	*0.17*	*0.12*	*0.12*	*0.15*	*0.27*	*0.13*	*0.08*	0.15
Insulation R-value	6	*0.15*	*0.17*	*0.35*	*0.35*	*0.15*	*0.27*	*0.38*	*0.38*	0.28
Decking material	7	*0.15*	*0.17*	*0.12*	*0.12*	*0.15*	*0.09*	*0.13*	*0.23*	0.14
Decking Thickness	8	*0.09*	*0.06*	*0.12*	*0.12*	*0.15*	*0.05*	*0.04*	*0.08*	0.09
										1.00

WALL ASSEMBLY:		1	2	3	4	5	6	7	8	9	10	11	12	EV
Stud size (Interior)	1	*0.02*	*0.02*	*0.02*	*0.02*	*0.01*	*0.03*	*0.01*	*0.02*	*0.03*	*0.01*	*0.01*	*0.01*	0.02
Exterior Bottom Plate	2	*0.02*	*0.02*	*0.02*	*0.01*	*0.01*	*0.03*	*0.01*	*0.02*	*0.03*	*0.01*	*0.01*	*0.01*	0.02
Exterior Stud spacing	3	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.08*	*0.05*	*0.04*	*0.08*	*0.05*	*0.01*	*0.01*	0.05
Stud size (Exterior)	4	*0.05*	*0.09*	*0.05*	*0.05*	*0.05*	*0.08*	*0.05*	*0.04*	*0.08*	*0.05*	*0.01*	*0.01*	0.05
Insulation R-value	5	*0.09*	*0.12*	*0.05*	*0.05*	*0.05*	*0.08*	*0.16*	*0.04*	*0.08*	*0.05*	*0.01*	*0.01*	0.06
Headers above openings	6	*0.16*	*0.12*	*0.15*	*0.15*	*0.14*	*0.23*	*0.27*	*0.32*	*0.23*	*0.25*	*0.23*	*0.24*	0.21
Exterior Sheathing	7	*0.16*	*0.12*	*0.05*	*0.05*	*0.02*	*0.05*	*0.05*	*0.04*	*0.08*	*0.05*	*0.10*	*0.17*	0.08
Electrical wires pass	8	*0.12*	*0.12*	*0.15*	*0.15*	*0.14*	*0.08*	*0.16*	*0.11*	*0.08*	*0.15*	*0.16*	*0.24*	0.14
Electrical Boxes	9	*0.12*	*0.12*	*0.15*	*0.15*	*0.14*	*0.23*	*0.16*	*0.32*	*0.23*	*0.25*	*0.23*	*0.24*	0.19
Wall Sheetrock thick	10	*0.09*	*0.09*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.04*	*0.05*	*0.05*	*0.10*	*0.03*	0.06
House Wrap	11	*0.05*	*0.05*	*0.15*	*0.15*	*0.14*	*0.03*	*0.02*	*0.02*	*0.03*	*0.02*	*0.03*	*0.01*	0.06
Exterior Siding	12	*0.09*	*0.09*	*0.15*	*0.15*	*0.23*	*0.03*	*0.01*	*0.02*	*0.03*	*0.05*	*0.10*	*0.03*	0.08
														1.00

Figure B6 IPIA 3 Column normalization and Vector of Priorities (EV) for Items

ROOF ASSEMBLY:		1	2	3	4	5	6	7	8	9	10	*EV*
Design Load	1	*0.26*	*0.28*	*0.20*	*0.13*	*0.22*	*0.24*	*0.30*	*0.27*	*0.27*	*0.27*	0.24
Roof Slope	2	*0.09*	*0.09*	*0.07*	*0.08*	*0.10*	*0.08*	*0.18*	*0.16*	*0.16*	*0.05*	0.11
Insulation R-value	3	*0.26*	*0.28*	*0.20*	*0.13*	*0.16*	*0.24*	*0.18*	*0.27*	*0.16*	*0.05*	0.22
Eave Projection	4	*0.05*	*0.03*	*0.04*	*0.03*	*0.01*	*0.03*	*0.02*	*0.01*	*0.01*	*0.01*	0.03
Eave Position	5	*0.04*	*0.03*	*0.04*	*0.08*	*0.03*	*0.03*	*0.02*	*0.02*	*0.02*	*0.02*	0.04
Roof Underlayments	6	*0.09*	*0.09*	*0.07*	*0.08*	*0.10*	*0.08*	*0.06*	*0.05*	*0.05*	*0.05*	0.08
Roof Finish	7	*0.05*	*0.03*	*0.07*	*0.08*	*0.10*	*0.08*	*0.06*	*0.05*	*0.05*	*0.05*	0.06
Roof Sheathing	8	*0.05*	*0.03*	*0.04*	*0.13*	*0.10*	*0.08*	*0.06*	*0.05*	*0.05*	*0.05*	0.07
Valley flashing	9	*0.05*	*0.03*	*0.07*	*0.13*	*0.10*	*0.08*	*0.06*	*0.05*	*0.05*	*0.05*	0.07
Roof opening waterproof	10	*0.05*	*0.09*	*0.20*	*0.13*	*0.10*	*0.08*	*0.06*	*0.05*	*0.05*	*0.05*	0.10
												1.00

UTILITIES:		1	2	3	4	5	6	7	8	9	10	*EV*
Water pipe	1	*0.10*	*0.09*	*0.29*	*0.24*	*0.09*	*0.09*	*0.11*	*0.04*	*0.09*	*0.05*	0.12
Pipe fittings	2	*0.10*	*0.09*	*0.29*	*0.08*	*0.09*	*0.09*	*0.11*	*0.04*	*0.09*	*0.05*	0.11
Pipefitting fastenings	3	*0.03*	*0.03*	*0.10*	*0.24*	*0.28*	*0.28*	*0.16*	*0.13*	*0.09*	*0.16*	0.15
Drainage pipe	4	*0.03*	*0.09*	*0.03*	*0.08*	*0.09*	*0.09*	*0.11*	*0.13*	*0.09*	*0.16*	0.09
HVAC System	5	*0.10*	*0.09*	*0.03*	*0.08*	*0.09*	*0.09*	*0.07*	*0.13*	*0.09*	*0.16*	0.09
HVAC Duct	6	*0.10*	*0.09*	*0.03*	*0.08*	*0.09*	*0.09*	*0.07*	*0.13*	*0.09*	*0.16*	0.09
Register Positions	7	*0.02*	*0.02*	*0.01*	*0.02*	*0.03*	*0.03*	*0.02*	*0.01*	*0.02*	*0.02*	0.02
Bathtub and Shower	8	*0.10*	*0.09*	*0.03*	*0.03*	*0.03*	*0.03*	*0.07*	*0.04*	*0.03*	*0.03*	0.05
Shutoff valves	9	*0.10*	*0.09*	*0.10*	*0.08*	*0.09*	*0.09*	*0.11*	*0.13*	*0.09*	*0.05*	0.09
20 amp GFI's	10	*0.30*	*0.28*	*0.10*	*0.08*	*0.09*	*0.09*	*0.16*	*0.21*	*0.28*	*0.16*	0.18
												1.00

DOORS / WINDOWS:		1	2	3	4	5	6	7	8	*EV*
Interior door width	1	*0.06*	*0.19*	*0.17*	*0.02*	*0.01*	*0.19*	*0.08*	*0.04*	0.09
Interior Door Height	2	*0.01*	*0.04*	*0.03*	*0.05*	*0.01*	*0.06*	*0.05*	*0.04*	0.04
Exterior door width	3	*0.06*	*0.19*	*0.17*	*0.27*	*0.13*	*0.19*	*0.23*	*0.11*	0.17
Number Hinges Int doors	4	*0.17*	*0.04*	*0.03*	*0.05*	*0.22*	*0.06*	*0.05*	*0.04*	0.08
Hinge type	5	*0.29*	*0.12*	*0.06*	*0.01*	*0.04*	*0.03*	*0.08*	*0.04*	0.08
Window glass	6	*0.06*	*0.12*	*0.17*	*0.16*	*0.31*	*0.19*	*0.23*	*0.32*	0.20
Extrior door Type	7	*0.17*	*0.19*	*0.17*	*0.27*	*0.13*	*0.19*	*0.23*	*0.32*	0.21
Exterior door height	8	*0.17*	*0.12*	*0.17*	*0.16*	*0.13*	*0.06*	*0.08*	*0.11*	0.13
										1.00

Figure B6 IPIA 3 Column normalization and Vector of Priorities (EV) for Items (contd)

COSMETICS:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	EV
Carpets	1	*0.09*	*0.08*	*0.13*	*0.10*	*0.07*	*0.02*	*0.14*	*0.14*	*0.09*	*0.22*	*0.16*	*0.20*	*0.19*	*0.05*	*0.08*	*0.08*	*0.18*	0.12
Shelves	2	*0.01*	*0.01*	*0.00*	*0.01*	*0.03*	*0.01*	*0.01*	*0.01*	*0.00*	*0.01*	*0.00*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	0.01
Water Heater	3	*0.03*	*0.10*	*0.04*	*0.03*	*0.04*	*0.02*	*0.05*	*0.05*	*0.07*	*0.13*	*0.01*	*0.12*	*0.19*	*0.15*	*0.08*	*0.05*	*0.08*	0.07
Sheetrock finish	4	*0.09*	*0.08*	*0.13*	*0.10*	*0.07*	*0.16*	*0.05*	*0.05*	*0.07*	*0.13*	*0.13*	*0.12*	*0.19*	*0.25*	*0.11*	*0.08*	*0.13*	0.11
Sidewall height	5	*0.26*	*0.08*	*0.22*	*0.31*	*0.22*	*0.26*	*0.14*	*0.14*	*0.12*	*0.13*	*0.13*	*0.20*	*0.19*	*0.25*	*0.11*	*0.12*	*0.13*	0.18
Ceiling paint finishes	6	*0.26*	*0.08*	*0.13*	*0.03*	*0.04*	*0.05*	*0.05*	*0.05*	*0.07*	*0.04*	*0.05*	*0.04*	*0.04*	*0.02*	*0.05*	*0.05*	*0.08*	0.07
Trim Interior doors	7	*0.03*	*0.06*	*0.04*	*0.10*	*0.07*	*0.05*	*0.05*	*0.05*	*0.07*	*0.04*	*0.05*	*0.04*	*0.01*	*0.02*	*0.05*	*0.05*	*0.03*	0.05
Trim Exterior doors	8	*0.03*	*0.06*	*0.04*	*0.10*	*0.07*	*0.05*	*0.05*	*0.05*	*0.07*	*0.04*	*0.05*	*0.04*	*0.01*	*0.02*	*0.05*	*0.05*	*0.03*	0.05
Metal mini-blinds	9	*0.01*	*0.06*	*0.01*	*0.02*	*0.02*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.02*	*0.02*	*0.01*	0.01
Refrigerator	10	*0.02*	*0.06*	*0.01*	*0.03*	*0.07*	*0.05*	*0.05*	*0.05*	*0.07*	*0.04*	*0.05*	*0.04*	*0.04*	*0.05*	*0.08*	*0.08*	*0.08*	0.05
Microwave	11	*0.01*	*0.06*	*0.13*	*0.01*	*0.03*	*0.02*	*0.02*	*0.02*	*0.04*	*0.01*	*0.02*	*0.01*	*0.01*	*0.01*	*0.02*	*0.02*	*0.01*	0.03
Dishwasher	12	*0.02*	*0.06*	*0.01*	*0.03*	*0.04*	*0.05*	*0.05*	*0.05*	*0.07*	*0.04*	*0.05*	*0.04*	*0.04*	*0.05*	*0.05*	*0.05*	*0.03*	0.04
Fireplace	13	*0.02*	*0.08*	*0.01*	*0.02*	*0.04*	*0.05*	*0.14*	*0.14*	*0.09*	*0.04*	*0.09*	*0.04*	*0.04*	*0.05*	*0.08*	*0.12*	*0.13*	0.07
Modular cabinet system	14	*0.09*	*0.08*	*0.01*	*0.02*	*0.04*	*0.16*	*0.14*	*0.14*	*0.12*	*0.04*	*0.09*	*0.04*	*0.04*	*0.05*	*0.14*	*0.12*	*0.08*	0.08
Outside water faucets	15	*0.02*	*0.03*	*0.01*	*0.01*	*0.03*	*0.02*	*0.02*	*0.02*	*0.01*	*0.01*	*0.02*	*0.01*	*0.01*	*0.01*	*0.02*	*0.02*	*0.01*	0.02
Plumbing for icemaker	16	*0.02*	*0.03*	*0.01*	*0.02*	*0.03*	*0.02*	*0.02*	*0.02*	*0.01*	*0.01*	*0.02*	*0.01*	*0.01*	*0.01*	*0.02*	*0.02*	*0.01*	0.02
Garbage Disposal	17	*0.01*	*0.00*	*0.01*	*0.02*	*0.04*	*0.02*	*0.05*	*0.05*	*0.04*	*0.01*	*0.05*	*0.04*	*0.01*	*0.02*	*0.08*	*0.08*	*0.03*	0.03
																			1.00

TRANSP& SETUP:		1	2	3	4	5	EV
Setup responsibility	1	*0.57*	*0.54*	*0.74*	*0.38*	*0.38*	0.52
Transportation to site	2	*0.08*	*0.08*	*0.05*	*0.08*	*0.08*	0.07
Setup contractor	3	*0.11*	*0.23*	*0.15*	*0.38*	*0.38*	0.25
Orientation walk thro	4	*0.11*	*0.08*	*0.03*	*0.08*	*0.08*	0.08
Special walkthrough	5	*0.11*	*0.08*	*0.03*	*0.08*	*0.08*	0.08
							1.00

WARRANTIES:		1	2	3	4	EV
General	1	*0.67*	*0.75*	*0.58*	*0.58*	0.65
Structural system	2	*0.13*	*0.15*	*0.25*	*0.25*	0.20
Shingles	3	*0.10*	*0.05*	*0.08*	*0.08*	0.08
Siding	4	*0.10*	*0.05*	*0.08*	*0.08*	0.08
						1.00

Figure B6 IPIA 3 Column normalization and Vector of Priorities (EV) for Items (contd)

SUB-SYSTEMS		1	2	3	4	5	6	7	8	9	*EV*
Materials	1	*0.16*	*0.19*	*0.12*	*0.15*	*0.16*	*0.14*	*0.23*	*0.21*	*0.11*	**0.17**
Floor Assembly	2	*0.05*	*0.06*	*0.07*	*0.06*	*0.04*	*0.08*	*0.12*	*0.05*	*0.06*	**0.06**
Wall Assembly	3	*0.06*	*0.03*	*0.04*	*0.04*	*0.03*	*0.04*	*0.02*	*0.05*	*0.06*	**0.04**
Roof Assembly	4	*0.06*	*0.06*	*0.06*	*0.06*	*0.09*	*0.04*	*0.03*	*0.04*	*0.06*	**0.05**
Utilities	5	*0.11*	*0.17*	*0.15*	*0.07*	*0.12*	*0.16*	*0.23*	*0.08*	*0.12*	**0.14**
Doors and Windows	6	*0.06*	*0.04*	*0.06*	*0.08*	*0.04*	*0.05*	*0.03*	*0.05*	*0.06*	**0.05**
Cosmetics	7	*0.04*	*0.03*	*0.16*	*0.11*	*0.03*	*0.11*	*0.06*	*0.07*	*0.13*	**0.08**
Transportation and Setup	8	*0.11*	*0.17*	*0.13*	*0.19*	*0.21*	*0.16*	*0.13*	*0.15*	*0.13*	**0.15**
Warranties	9	*0.36*	*0.25*	*0.20*	*0.25*	*0.27*	*0.23*	*0.13*	*0.30*	*0.27*	**0.25**
											1.00

Figure B7 Average Column normalization and Vector of Priorities (EV) for Sub-systems

MATERIALS:		1	2	3	4	5	6	7	8	9	10	*EV*
Cabinets	1	*0.08*	*0.12*	*0.05*	*0.08*	*0.14*	*0.18*	*0.13*	*0.13*	*0.12*	*0.07*	0.11
Rollers	2	*0.02*	*0.02*	*0.02*	*0.01*	*0.02*	*0.01*	*0.02*	*0.01*	*0.01*	*0.05*	0.02
Bathtub and Shower	3	*0.16*	*0.15*	*0.09*	*0.20*	*0.21*	*0.21*	*0.21*	*0.17*	*0.17*	*0.06*	0.16
Vanity	4	*0.05*	*0.11*	*0.02*	*0.05*	*0.10*	*0.03*	*0.06*	*0.04*	*0.02*	*0.05*	0.05
Faucets	5	*0.03*	*0.05*	*0.02*	*0.02*	*0.05*	*0.08*	*0.05*	*0.09*	*0.10*	*0.06*	0.06
Ceiling Board	6	*0.02*	*0.09*	*0.02*	*0.06*	*0.03*	*0.04*	*0.10*	*0.10*	*0.03*	*0.06*	0.06
Sheetrock thickness	7	*0.03*	*0.04*	*0.02*	*0.03*	*0.04*	*0.02*	*0.04*	*0.09*	*0.06*	*0.06*	0.04
Interior door style	8	*0.02*	*0.07*	*0.02*	*0.03*	*0.02*	*0.01*	*0.01*	*0.03*	*0.02*	*0.05*	0.03
Window Frame	9	*0.03*	*0.11*	*0.03*	*0.09*	*0.02*	*0.06*	*0.03*	*0.06*	*0.05*	*0.05*	0.05
Electrical wires	10	*0.57*	*0.22*	*0.72*	*0.42*	*0.37*	*0.35*	*0.34*	*0.27*	*0.41*	*0.48*	0.42
												1.00

FLOOR ASSEMBLY:		1	2	3	4	5	6	7	8	*EV*
Axles	1	*0.04*	*0.07*	*0.03*	*0.03*	*0.06*	*0.02*	*0.03*	*0.02*	0.04
Tires	2	*0.02*	*0.03*	*0.03*	*0.04*	*0.03*	*0.02*	*0.04*	*0.04*	0.03
Joist Size	3	*0.16*	*0.15*	*0.15*	*0.19*	*0.14*	*0.20*	*0.13*	*0.07*	0.15
Joist Spacing	4	*0.19*	*0.15*	*0.15*	*0.19*	*0.32*	*0.26*	*0.18*	*0.10*	0.19
Joist System	5	*0.08*	*0.17*	*0.15*	*0.08*	*0.14*	*0.28*	*0.18*	*0.10*	0.15
Insulation R-value	6	*0.16*	*0.15*	*0.07*	*0.07*	*0.05*	*0.09*	*0.21*	*0.19*	0.12
Decking material	7	*0.21*	*0.18*	*0.21*	*0.19*	*0.14*	*0.08*	*0.18*	*0.37*	0.19
Decking Thickness	8	*0.16*	*0.08*	*0.21*	*0.19*	*0.14*	*0.05*	*0.05*	*0.10*	0.12
										1.00

WALL ASSEMBLY:		1	2	3	4	5	6	7	8	9	10	11	12	*EV*
Stud size (Interior)	1	*0.02*	*0.04*	*0.06*	*0.01*	*0.02*	*0.03*	*0.01*	*0.04*	*0.01*	*0.03*	*0.01*	*0.01*	0.02
Exterior Bottom Plate size	2	*0.01*	*0.02*	*0.02*	*0.01*	*0.01*	*0.03*	*0.01*	*0.04*	*0.01*	*0.04*	*0.03*	*0.01*	0.02
Exterior Stud spacing	3	*0.03*	*0.07*	*0.07*	*0.09*	*0.19*	*0.12*	*0.07*	*0.05*	*0.02*	*0.10*	*0.09*	*0.07*	0.08
Stud size (Exterior)	4	*0.09*	*0.11*	*0.04*	*0.05*	*0.11*	*0.07*	*0.07*	*0.05*	*0.02*	*0.10*	*0.09*	*0.01*	0.07
Insulation R-value	5	*0.09*	*0.12*	*0.03*	*0.04*	*0.08*	*0.07*	*0.24*	*0.05*	*0.25*	*0.10*	*0.09*	*0.08*	0.10
Headers above openings	6	*0.19*	*0.16*	*0.15*	*0.20*	*0.29*	*0.25*	*0.38*	*0.22*	*0.16*	*0.17*	*0.15*	*0.21*	0.21
Exterior Sheathing	7	*0.15*	*0.15*	*0.09*	*0.07*	*0.03*	*0.06*	*0.09*	*0.33*	*0.20*	*0.12*	*0.11*	*0.14*	0.13
Electrical wires pass	8	*0.05*	*0.05*	*0.14*	*0.11*	*0.16*	*0.12*	*0.03*	*0.10*	*0.22*	*0.10*	*0.11*	*0.18*	0.11
Electrical Boxes	9	*0.15*	*0.16*	*0.32*	*0.24*	*0.03*	*0.12*	*0.04*	*0.04*	*0.08*	*0.17*	*0.16*	*0.18*	0.14
Wall Sheetrock thick	10	*0.02*	*0.01*	*0.02*	*0.01*	*0.02*	*0.04*	*0.02*	*0.03*	*0.01*	*0.02*	*0.05*	*0.08*	0.03
House Wrap	11	*0.07*	*0.02*	*0.02*	*0.01*	*0.02*	*0.04*	*0.02*	*0.02*	*0.01*	*0.01*	*0.02*	*0.01*	0.02
Exterior Siding	12	*0.11*	*0.11*	*0.04*	*0.16*	*0.04*	*0.04*	*0.02*	*0.02*	*0.02*	*0.01*	*0.08*	*0.04*	0.06
														1.00

Figure B8 Average Column normalization and Vector of Priorities (EV) for Items

ROOF ASSEMBLY:		1	2	3	4	5	6	7	8	9	10	EV
Design Load	1	0.39	0.38	0.52	0.25	0.23	0.26	0.41	0.29	0.24	0.21	0.34
Roof Slope	2	0.06	0.06	0.03	0.11	0.09	0.11	0.08	0.12	0.09	0.02	0.08
Insulation R-value	3	0.11	0.27	0.14	0.20	0.21	0.12	0.19	0.18	0.15	0.07	0.18
Eave Projection	4	0.06	0.02	0.03	0.04	0.07	0.08	0.02	0.08	0.02	0.01	0.05
Eave Position	5	0.06	0.02	0.02	0.02	0.03	0.07	0.02	0.08	0.02	0.01	0.04
Roof Underlayments	6	0.06	0.02	0.05	0.02	0.02	0.04	0.03	0.02	0.02	0.02	0.03
Roof Finish	7	0.06	0.05	0.05	0.12	0.12	0.08	0.06	0.13	0.03	0.03	0.08
Roof Sheathing	8	0.06	0.02	0.03	0.02	0.02	0.07	0.02	0.04	0.06	0.06	0.04
Valley flashing	9	0.07	0.03	0.04	0.08	0.07	0.08	0.08	0.03	0.04	0.02	0.06
Roof opening waterproof	10	0.08	0.12	0.09	0.14	0.15	0.09	0.09	0.03	0.08	0.04	0.10
												1.00

UTILITIES:		1	2	3	4	5	6	7	8	9	10	EV
Water pipe	1	0.17	0.15	0.22	0.20	0.15	0.14	0.13	0.18	0.14	0.14	0.16
Pipe fittings	2	0.22	0.20	0.26	0.20	0.22	0.19	0.15	0.12	0.14	0.14	0.18
Pipefitting fastenings	3	0.12	0.12	0.15	0.18	0.28	0.23	0.17	0.17	0.10	0.14	0.17
Drainage pipe	4	0.06	0.07	0.06	0.07	0.08	0.05	0.10	0.10	0.07	0.06	0.07
HVAC System	5	0.12	0.09	0.06	0.09	0.10	0.16	0.13	0.20	0.18	0.13	0.13
HVAC Duct	6	0.08	0.07	0.05	0.09	0.04	0.07	0.05	0.10	0.10	0.06	0.07
Register Positions	7	0.05	0.05	0.03	0.02	0.03	0.05	0.04	0.02	0.07	0.08	0.04
Bathtub and Shower	8	0.08	0.14	0.07	0.06	0.04	0.06	0.19	0.08	0.17	0.14	0.10
Shutoff valves	9	0.04	0.05	0.05	0.03	0.02	0.02	0.02	0.02	0.03	0.08	0.04
20 amp GFI's	10	0.05	0.06	0.05	0.05	0.03	0.05	0.02	0.03	0.02	0.04	0.04
												1.00

DOORS / WINDOWS:		1	2	3	4	5	6	7	8	EV
Interior door width	1	0.13	0.16	0.19	0.12	0.09	0.23	0.08	0.07	0.13
Interior Door Height	2	0.04	0.05	0.06	0.13	0.09	0.03	0.04	0.06	0.06
Exterior door width	3	0.17	0.22	0.25	0.19	0.17	0.39	0.46	0.12	0.25
Number Hinges Int doors	4	0.04	0.01	0.04	0.03	0.07	0.03	0.03	0.03	0.04
Hinge type	5	0.05	0.02	0.05	0.02	0.03	0.02	0.03	0.02	0.03
Window glass	6	0.06	0.21	0.07	0.15	0.21	0.11	0.12	0.33	0.16
Extrior door Type	7	0.27	0.22	0.09	0.21	0.17	0.15	0.16	0.25	0.19
Exterior door height	8	0.24	0.11	0.25	0.15	0.16	0.04	0.08	0.12	0.14
										1.00

Figure B8 Average Column normalization and Vector of Priorities (EV) for Items (contd)

COSMETICS:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	*EV*
Carpets	1	*0.08*	*0.09*	*0.19*	*0.10*	*0.04*	*0.07*	*0.11*	*0.08*	*0.11*	*0.14*	*0.14*	*0.15*	*0.11*	*0.04*	*0.04*	*0.09*	*0.09*	0.10
Shelves	2	*0.02*	*0.02*	*0.02*	*0.03*	*0.02*	*0.02*	*0.03*	*0.01*	*0.01*	*0.01*	*0.03*	*0.01*	*0.05*	*0.01*	*0.01*	*0.01*	*0.02*	0.02
Water Heater	3	*0.07*	*0.15*	*0.17*	*0.21*	*0.27*	*0.16*	*0.18*	*0.24*	*0.18*	*0.14*	*0.07*	*0.17*	*0.14*	*0.13*	*0.15*	*0.14*	*0.10*	0.16
Sheetrock finish	4	*0.05*	*0.04*	*0.05*	*0.06*	*0.04*	*0.08*	*0.08*	*0.09*	*0.05*	*0.07*	*0.09*	*0.07*	*0.09*	*0.08*	*0.06*	*0.06*	*0.07*	0.07
Sidewall height	5	*0.38*	*0.15*	*0.12*	*0.27*	*0.19*	*0.26*	*0.20*	*0.22*	*0.19*	*0.19*	*0.15*	*0.21*	*0.16*	*0.15*	*0.15*	*0.14*	*0.11*	0.19
Ceiling paint finishes	6	*0.06*	*0.04*	*0.05*	*0.04*	*0.03*	*0.05*	*0.03*	*0.03*	*0.07*	*0.05*	*0.07*	*0.08*	*0.08*	*0.04*	*0.05*	*0.05*	*0.06*	0.05
Trim Interior doors	7	*0.03*	*0.03*	*0.03*	*0.03*	*0.03*	*0.06*	*0.04*	*0.03*	*0.05*	*0.05*	*0.06*	*0.03*	*0.03*	*0.05*	*0.03*	*0.03*	*0.03*	0.04
Trim Exterior doors	8	*0.07*	*0.09*	*0.05*	*0.04*	*0.06*	*0.10*	*0.08*	*0.06*	*0.09*	*0.10*	*0.08*	*0.08*	*0.05*	*0.06*	*0.06*	*0.07*	*0.07*	0.07
Metal mini-blinds	9	*0.02*	*0.04*	*0.02*	*0.03*	*0.03*	*0.02*	*0.02*	*0.02*	*0.03*	*0.06*	*0.04*	*0.02*	*0.06*	*0.05*	*0.02*	*0.02*	*0.04*	0.03
Refrigerator	10	*0.02*	*0.06*	*0.04*	*0.03*	*0.03*	*0.03*	*0.02*	*0.02*	*0.01*	*0.03*	*0.05*	*0.03*	*0.05*	*0.04*	*0.06*	*0.06*	*0.05*	0.04
Microwave	11	*0.01*	*0.02*	*0.05*	*0.01*	*0.03*	*0.02*	*0.01*	*0.02*	*0.01*	*0.01*	*0.02*	*0.02*	*0.05*	*0.12*	*0.01*	*0.01*	*0.02*	0.03
Dishwasher	12	*0.03*	*0.08*	*0.06*	*0.05*	*0.05*	*0.03*	*0.07*	*0.04*	*0.09*	*0.07*	*0.08*	*0.06*	*0.09*	*0.10*	*0.09*	*0.09*	*0.07*	0.07
Fireplace	13	*0.02*	*0.01*	*0.03*	*0.02*	*0.03*	*0.02*	*0.03*	*0.03*	*0.01*	*0.02*	*0.01*	*0.02*	*0.03*	*0.07*	*0.08*	*0.09*	*0.09*	0.03
Modular cabinet system	14	*0.06*	*0.04*	*0.04*	*0.02*	*0.04*	*0.04*	*0.02*	*0.03*	*0.01*	*0.02*	*0.01*	*0.02*	*0.01*	*0.03*	*0.13*	*0.10*	*0.06*	0.04
Outside water faucets	15	*0.04*	*0.06*	*0.03*	*0.02*	*0.03*	*0.02*	*0.03*	*0.02*	*0.03*	*0.01*	*0.04*	*0.02*	*0.01*	*0.01*	*0.02*	*0.02*	*0.04*	0.03
Plumbing for icemaker	16	*0.02*	*0.06*	*0.03*	*0.02*	*0.03*	*0.02*	*0.03*	*0.02*	*0.03*	*0.01*	*0.04*	*0.01*	*0.01*	*0.01*	*0.03*	*0.02*	*0.05*	0.03
Garbage Disposal	17	*0.02*	*0.00*	*0.03*	*0.02*	*0.03*	*0.02*	*0.02*	*0.02*	*0.01*	*0.01*	*0.02*	*0.02*	*0.01*	*0.01*	*0.01*	*0.01*	*0.02*	0.02
																			1.00

TRANSP& SETUP:		1	2	3	4	5	*EV*
Setup responsibility	1	*0.44*	*0.33*	*0.54*	*0.40*	*0.35*	0.41
Transportation to site	2	*0.16*	*0.12*	*0.12*	*0.05*	*0.10*	0.11
Setup contractor	3	*0.19*	*0.24*	*0.23*	*0.40*	*0.30*	0.27
Orientation walk thro	4	*0.11*	*0.22*	*0.06*	*0.10*	*0.17*	0.13
Special walkthrough	5	*0.09*	*0.09*	*0.06*	*0.04*	*0.07*	0.07
							1.00

WARRANTIES:		1	2	3	4	*EV*
General	1	*0.72*	*0.84*	*0.53*	*0.48*	0.64
Structural system	2	*0.10*	*0.12*	*0.36*	*0.37*	0.24
Shingles	3	*0.09*	*0.02*	*0.06*	*0.10*	0.07
Siding	4	*0.09*	*0.02*	*0.04*	*0.06*	0.05
						1.00

Figure B8 Average Column normalization and Vector of Priorities (EV) for Items (contd)

APPENDIX C

NUMERICAL SCORES FOR SUB-ITEMS

MATERIALS:						
Cabinets	8	Hardwood	3	Particleboard / MDF		--------
Rollers	2	Plastic	8	Metal		--------
Bathtub and Shower	9	Fiberglass	4	PVC		--------
Vanity	2	Plastic	8	Porcelain		--------
Faucets	2	Plastic	8	Metal		--------
Ceiling Board Type	2	Vinyl coated	8	Tape and Textured		--------
Wall Sheetrock type	4	Vinyl coated	8	Tape and Textured		--------
Interior door style	3	Plain Face, LUAN	7	Paneled		--------
Window Frame	8	Vinyl	6	Aluminum (metal)		--------
Electrical Devices	9	J-boxes	3	Self- Contained		--------
FLOOR SYSTEMS:						
Axles	9	New	4	Old and Certified		--------
Tires	9	New	4	Old		--------
Joist Size	6	2"X6"	7	2"X8"		--------
Joist Spacing	9	16" o/c	1	24" o/c		--------
Joist System	3	Longitudinal	7	Transverse		--------
Insulation R-value	6	R-11	8	R-21		--------
Decking material	8	Plywood / OSB	6	Novadeck		--------
Decking Thickness	7	3/4"	6	1/2"		--------
WALL SYSTEMS:						
Stud size (Interior)	4	2"X3"	6	2"X4"		--------
Exterior Bottom Plate size	3	1"X3"/ 1"X4"	8	2"X3"/ 2"X4"		--------
Exterior Stud spacing	7	16" o/c	5	24" o/c		--------
Stud size (Exterior)	8	2"X6"	6	2"X4"		--------
Insulation R-value	6	R-11	8	R-19		--------
Headers above openings	4	Single	7	Double		--------
Exterior Sheathing	8	OSB	4	Insulation Board		--------
Electrical wires pass	3	Through notch in stud	7	Through a hole in Stud		--------
Electrical Boxes	8	Fixed t Studs	2	Fixed on sheet rock		--------
Wall Sheetrock thickness	4	5/16"	6	1/2"		--------
House Wrap	5	Tyvek	2	None		--------
Exterior Siding	6	Vinyl	7	Hard board		--------
ROOF SYSTEMS:						
Design Load	4	20 Lb	6	30 Lb		--------
Roof Slope	5	3 / 12	7	4 / 12		--------
Insulation R-value	8	R-21	6	R-19		--------
Eave Projection	5	3"	7	8"		--------
Eave Position	5	Front and back	7	All around home		--------
Ceiling board thickness	6	1/2"	7	5/8"		--------
Roof Finish	5	Metal	8	Shingles		--------
Roof Sheathing	8	Plywood	2	OSB		--------
Valley flashing	6	Shingles	4	Metal		--------
Roof opening waterproofing	7	Flashing Provided	4	No Flashing		--------

Figure C1 IPIA 1-Numerical scores for Sub-items

UTILITIES:						
Water pipe	8	PVC	4	PEX		-------
Pipe fittings	6	Copper	5	Brass		-------
Pipefitting fastenings	5	Copper ring	7	Steel Ring		-------
Drainage pipe	7	PVC	6	ABS		-------
HVAC System	8	In floor	4	In attic		-------
HVAC Duct	4	Sheet metal	7	Fiber Glass		-------
Register Positions	5	Central Floor	6	Perimeter		-------
Bathtub and Shower	7	1 piece unit	4	2 piece unit		-------
Shutoff valves	8	Under every sink	4	At any one junction		-------
20 amp GFI's	7	1	5	2		-------
DOORS AND WINDOWS:						
Interior door width	6	28"	8	32"		-------
Interior Door Height	4	6.5 ft	8	7 ft		-------
Exterior door width	6	32"	8	36"		-------
Number of Hinges Int doors	6	2	8	3		-------
Hinge type	7	Full Mortise	3	Surface Mounted		-------
Window glass	4	Double pane "plain"	7	Double pane-low "E"		-------
Extrior door Type	4	Aluminum	8	Insulated Metal Core		-------
Exterior door height	4	6.5'	8	7.0'		-------
COSMETICS:						
Carpets	7	25 oz	5	18 oz		-------
Shelves	5	Non adjustable	7	Adjustable		-------
Water Heater	5	30-gallon	6	40-gallon		-------
Sheetrock finish	8	Tape and Textured	5	Vinyl sheetrock		-------
Sidewall height	5	7 ft	7	7.5 ft		-------
Ceiling paint finishes	4	Popcorn	7	Tape and textured		-------
Trim around Interior doors	5	Vinyl	7	Wood		-------
Trim around Exterior doors	4	Exposed aluminum	7	Hardi board/vinyl		-------
Mini-blinds	8	Provided in all rooms	3	Not provided in any		-------
Refrigerator	6	18 cu. ft.	7	20 cu. ft.		-------
Microwave	7	Built-in	5	Separate unit		-------
Dishwasher	7	Yes	3	No		-------
Fireplace	5	Yes	4	No		-------
Modular cabinet system	6	Yes	3	No		-------
Outside water faucets	5	1	7	2		-------
Plumbing for icemaker	7	Yes	4	No		-------
Garbage Disposal	7	Yes	4	No		-------
TRANSPORTATION & SETUP:						
Setup on site responsibility	8	manufacturer	5	retailer		-------
Transportation to site	8	Self owned	3	Contracted		-------
Setup contractor	8	fixed	1	keeps changing		-------
Orientation and walk through	9	Yes	1	No		-------
Special walkthrough	9	Yes	1	No		-------
WARRANTIES:						
General	2	1 year	6	2 years		-------
Structural system	2	1 year	8	5 years		-------
Shingles	6	25 years	8	30 years		-------
Siding	6	10 years	8	15 years		-------

Figure C1 IPIA 1-Numerical scores for Sub-items (contd)

MATERIALS:						
Cabinets	8	Hardwood	3	Particleboard / MDF		-------
Rollers	2	Plastic	8	Metal		-------
Bathtub and Shower	8	Fiberglass	3	PVC		-------
Vanity	4	Plastic	7	Porcelain		-------
Faucets	2	Plastic	8	Metal		-------
Ceiling Board Type	3	Vinyl coated	7	Tape and Textured		-------
Wall Sheetrock type	4	Vinyl coated	8	Tape and Textured		-------
Interior door style	2	Plain Face, LUAN	7	Paneled		-------
Window Frame	8	Vinyl	4	Aluminum (metal)		-------
Electrical Devices	7	J-boxes	3	Self- Contained		-------
FLOOR SYSTEMS:						
Axles	8	New	4	Old and Certified		-------
Tires	8	New	4	Old		-------
Joist Size	5	2"X6"	7	2"X8"		-------
Joist Spacing	7	16" o/c	1	24" o/c		-------
Joist System	4	Longitudinal	7	Transverse		-------
Insulation R-value	5	R-11	8	R-21		-------
Decking material	8	Plywood / OSB	5	Novadeck		-------
Decking Thickness	7	3/4"	3	1/2"		-------
WALL SYSTEMS:						
Stud size (Interior)	4	2"X3"	7	2"X4"		-------
Exterior Bottom Plate size	3	1"X3"/ 1"X4"	8	2"X3"/ 2"X4"		-------
Exterior Stud spacing	8	16" o/c	2	24" o/c		-------
Stud size (Exterior)	8	2"X6"	6	2"X4"		-------
Insulation R-value	7	R-11	8	R-19		-------
Headers above openings	3	Single	7	Double		-------
Exterior Sheathing	7	OSB	1	Insulation Board		-------
Electrical wires pass	2	Through notch in stud	7	Through a hole in Stud		-------
Electrical Boxes	8	Fixed t Studs	3	Fixed on sheet rock		-------
Wall Sheetrock thickness	5	5/16"	7	1/2"		-------
House Wrap	7	Tyvek	3	None		-------
Exterior Siding	7	Vinyl	6	Hard board		-------
ROOF SYSTEMS:						
Design Load	4	20 Lb	6	30 Lb		-------
Roof Slope	3	3 / 12	5	4 / 12		-------
Insulation R-value	6	R-21	5	R-19		-------
Eave Projection	3	3"	5	8"		-------
Eave Position	3	Front and back	7	All around home		-------
Ceiling board thickness	7	1/2"	7	5/8"		-------
Roof Finish	4	Metal	7	Shingles		-------
Roof Sheathing	7	Plywood	4	OSB		-------
Valley flashing	7	Shingles	4	Metal		-------
Roof opening waterproofing	7	Flashing Provided	3	No Flashing		-------

Figure C2 IPIA 2-Numerical scores for Sub-items

UTILITIES:						
Water pipe	8	PVC	4	PEX		-------
Pipe fittings	7	Copper	6	Brass		-------
Pipefitting fastenings	6	Copper ring	7	Steel Ring		-------
Drainage pipe	7	PVC	6	ABS		-------
HVAC System	8	In floor	3	In attic		-------
HVAC Duct	4	Sheet metal	7	Fiber Glass		-------
Register Positions	4	Central Floor	7	Perimeter		-------
Bathtub and Shower	7	1 piece unit	3	2 piece unit		-------
Shutoff valves	8	Under every sink	4	At any one junction		-------
20 amp GFI's	7	1	4	2		-------
DOORS AND WINDOWS:						
Interior door width	6	28"	8	32"		-------
Interior Door Height	4	6.5 ft	8	7 ft		-------
Exterior door width	6	32"	8	36"		-------
Number of Hinges Int doors	6	2	7	3		-------
Hinge type	7	Full Mortise	3	Surface Mounted		-------
Window glass	6	Double pane "plain"	8	Double pane-low "E"		-------
Extrior door Type	4	Aluminum	8	Insulated Metal Core		-------
Exterior door height	2	6.5'	8	7.0'		-------
COSMETICS:						
Carpets	7	25 oz	4	18 oz		-------
Shelves	2	Non adjustable	8	Adjustable		-------
Water Heater	3	30-gallon	7	40-gallon		-------
Sheetrock finish	8	Tape and Textured	5	Vinyl sheetrock		-------
Sidewall height	3	7 ft	7	7.5 ft		-------
Ceiling paint finishes	5	Popcorn	7	Tape and textured		-------
Trim around Interior doors	4	Vinyl	7	Wood		-------
Trim around Exterior doors	3	Exposed aluminum	7	Hardi board/vinyl		-------
Mini-blinds	8	Provided in all rooms	3	Not provided in any		-------
Refrigerator	6	18 cu. ft.	7	20 cu. ft.		-------
Microwave	7	Built-in	5	Separate unit		-------
Dishwasher	8	Yes	2	No		-------
Fireplace	5	Yes	4	No		-------
Modular cabinet system	7	Yes	6	No		-------
Outside water faucets	4	1	7	2		-------
Plumbing for icemaker	7	Yes	3	No		-------
Garbage Disposal	6	Yes	4	No		-------
TRANSPORTATION &						
Setup on site responsibility	8	manufacturer	5	retailer		-------
Transportation to site	8	Self owned	3	Contracted		-------
Setup contractor	8	fixed	1	keeps changing		-------
Orientation and walk	8	Yes	1	No		-------
Special walkthrough	8	Yes	1	No		-------
WARRANTIES:						
General	2	1 year	6	2 years		-------
Structural system	2	1 year	8	5 years		-------
Shingles	6	25 years	8	30 years		-------
Siding	6	10 years	8	15 years		-------

Figure C2 IPIA 2-Numerical scores for Sub-items (contd)

MATERIALS:						
Cabinets	7	Hardwood	3	Particleboard / MDF		-------
Rollers	4	Plastic	8	Metal		-------
Bathtub and Shower	8	Fiberglass	4	PVC		-------
Vanity	3	Plastic	8	Porcelain		-------
Faucets	2	Plastic	8	Metal		-------
Ceiling Board Type	1	Vinyl coated	9	Tape and Textured		-------
Wall Sheetrock type	5	Vinyl coated	7	Tape and Textured		-------
Interior door style	4	Plain Face, LUAN	7	Paneled		-------
Window Frame	7	Vinyl	4	Aluminum (metal)		-------
Electrical Devices	8	J-boxes	4	Self- Contained		-------
FLOOR SYSTEMS:						
Axles	7	New	5	Old and Certified		-------
Tires	8	New	5	Old		-------
Joist Size	5	2"X6"	8	2"X8"		-------
Joist Spacing	9	16" o/c	3	24" o/c		-------
Joist System	4	Longitudinal	7	Transverse		-------
Insulation R-value	5	R-11	8	R-21		-------
Decking material	8	Plywood / OSB	4	Novadeck		-------
Decking Thickness	7	3/4"	5	1/2"		-------
WALL SYSTEMS:						
Stud size (Interior)	5	2"X3"	7	2"X4"		-------
Exterior Bottom Plate size	5	1"X3"/ 1"X4"	7	2"X3"/ 2"X4"		-------
Exterior Stud spacing	8	16" o/c	4	24" o/c		-------
Stud size (Exterior)	7	2"X6"	5	2"X4"		-------
Insulation R-value	3	R-11	9	R-19		-------
Headers above openings	4	Single	7	Double		-------
Exterior Sheathing	7	OSB	5	Insulation Board		-------
Electrical wires pass	5	Through notch in stud	5	Through a hole in Stud		-------
Electrical Boxes	7	Fixed t Studs	5	Fixed on sheet rock		-------
Wall Sheetrock thickness	5	5/16"	8	1/2"		-------
House Wrap	8	Tyvek	1	None		-------
Exterior Siding	8	Vinyl	5	Hard board		-------
ROOF SYSTEMS:						
Design Load	5	20 Lb	8	30 Lb		-------
Roof Slope	4	3 / 12	7	4 / 12		-------
Insulation R-value	8	R-21	6	R-19		-------
Eave Projection	3	3"	7	8"		-------
Eave Position	5	Front and back	8	All around home		-------
Ceiling board thickness	5	1/2"	8	5/8"		-------
Roof Finish	4	Metal	8	Shingles		-------
Roof Sheathing	6	Plywood	8	OSB		-------
Valley flashing	8	Shingles	5	Metal		-------
Roof opening waterproofing	9	Flashing Provided	2	No Flashing		-------

Figure C3 IPIA 3-Numerical scores for Sub-items

UTILITIES:							
Water pipe	5	PVC	8	PEX		------
Pipe fittings	7	Copper	5	Brass		------
Pipefitting fastenings	7	Copper ring	5	Steel Ring		------
Drainage pipe	7	PVC	5	ABS		------
HVAC System	5	In floor	8	In attic		------
HVAC Duct	4	Sheet metal	8	Fiber Glass		------
Register Positions	4	Central Floor	8	Perimeter		------
Bathtub and Shower	7	1 piece unit	5	2 piece unit		------
Shutoff valves	8	Under every sink	4	At any one junction only		------
20 amp GFI's	3	1	8	2		------
DOORS AND WINDOWS:						
Interior door width	4	28"	8	32"		------
Interior Door Height	5	6.5 ft	7	7 ft		------
Exterior door width	4	32"	8	36"		------
Number of Hinges Int doors	4	2	7	3		------
Hinge type	7	Full Mortise	5	Surface Mounted		------
Window glass	5	Double pane "plain"	8	Double pane-low "E"		------
Extrior door Type	4	Aluminum	8	Insulated Metal Core		------
Exterior door height	3	6.5'	8	7.0'		------
COSMETICS:						
Carpets	8	25 oz	4	18 oz		------
Shelves	5	Non adjustable	7	Adjustable		------
Water Heater	5	30-gallon	8	40-gallon		------
Sheetrock finish	8	Tape and Textured	5	Vinyl sheetrock		------
Sidewall height	6	7 ft	8	7.5 ft		------
Ceiling paint finishes	5	Popcorn	8	Tape and textured		------
Trim around Interior doors	4	Vinyl	8	Wood		------
Trim around Exterior doors	5	Exposed aluminum	7	Hardi board/vinyl		------
Mini-blinds	7	Provided in all rooms	5	Not provided in any		------
Refrigerator	5	18 cu. ft.	8	20 cu. ft.		------
Microwave	6	Built-in	8	Separate unit		------
Dishwasher	8	Yes	4	No		------
Fireplace	7	Yes	5	No		------
Modular cabinet system	8	Yes	4	No		------
Outside water faucets	5	1	8	2		------
Plumbing for icemaker	8	Yes	2	No		------
Garbage Disposal	7	Yes	4	No		------
TRANSPORTATION &						
Setup on site responsibility	7	manufacturer	5	retailer		------
Transportation to site	6	Self owned	5	Contracted		------
Setup contractor	8	fixed	3	keeps changing		------
Orientation and walk through	8	Yes	2	No		------
Special walkthrough	8	Yes	2	No		------
WARRANTIES:						
General	6	1 year	8	2 years		------
Structural system	5	1 year	8	5 years		------
Shingles	6	25 years	8	30 years		------
Siding	6	10 years	8	15 years		------

Figure C3 IPIA 3-Numerical scores for Sub-items (contd)

MATERIALS:						
Cabinets	7.7	Hardwood	3.0	Particleboard / MDF		——
Rollers	2.7	Plastic	8.0	Metal		——
Bathtub and Shower	8.3	Fiberglass	3.7	PVC		——
Vanity	3.0	Plastic	7.7	Porcelain		——
Faucets	2.0	Plastic	8.0	Metal		——
Ceiling Board Type	2.0	Vinyl coated	8.0	Tape and Textured		——
Wall Sheetrock type	4.3	Vinyl coated	7.7	Tape and Textured		——
Interior door style	3.0	Plain Face, LUAN	7.0	Paneled		——
Window Frame	7.7	Vinyl	4.7	Aluminum (metal)		——
Electrical Devices	8.0	J-boxes	3.3	Self- Contained		——
FLOOR SYSTEMS:						
Axles	8.0	New	4.3	Old and Certified		——
Tires	8.3	New	4.3	Old		——
Joist Size	5.3	2"X6"	7.3	2"X8"		——
Joist Spacing	8.3	16" o/c	1.7	24" o/c		——
Joist System	3.7	Longitudinal	7.0	Transverse		——
Insulation R-value	5.3	R-11	8.0	R-21		——
Decking material	8.0	Plywood / OSB	5.0	Novadeck		——
Decking Thickness	7.0	3/4"	4.7	1/2"		——
WALL SYSTEMS:						
Stud size (Interior)	4.3	2"X3"	6.7	2"X4"		——
Exterior Bottom Plate size	3.7	1"X3"/ 1"X4"	7.7	2"X3"/ 2"X4"		——
Exterior Stud spacing	7.7	16" o/c	3.7	24" o/c		——
Stud size (Exterior)	7.7	2"X6"	5.7	2"X4"		——
Insulation R-value	5.3	R-11	8.3	R-19		——
Headers above openings	3.7	Single	7.0	Double		——
Exterior Sheathing	7.3	OSB	3.3	Insulation Board		——
Electrical wires pass	3.3	Through notch in stud	6.3	Through a hole in Stud		——
Electrical Boxes	7.7	Fixed t Studs	3.3	Fixed on sheet rock		——
Wall Sheetrock thickness	4.7	5/16"	7.0	1/2"		——
House Wrap	6.7	Tyvek	2.0	None		——
Exterior Siding	7.0	Vinyl	6.0	Hard board		——
ROOF SYSTEMS:						
Design Load	4.3	20 Lb	6.7	30 Lb		——
Roof Slope	4.0	3 / 12	6.3	4 / 12		——
Insulation R-value	7.3	R-21	5.7	R-19		——
Eave Projection	3.7	3"	6.3	8"		——
Eave Position	4.3	Front and back	7.3	All around home		——
Ceiling board thickness	6.0	1/2"	7.3	5/8"		——
Roof Finish	4.3	Metal	7.7	Shingles		——
Roof Sheathing	7.0	Plywood	4.7	OSB		——
Valley flashing	7.0	Shingles	4.3	Metal		——
Roof opening waterproofing	7.7	Flashing Provided	3.0	No Flashing		——

Figure C4 'Average'-Numerical scores for Sub-items

UTILITIES:						
Water pipe	7.0	PVC	5.3	PEX		--------
Pipe fittings	6.7	Copper	5.3	Brass		--------
Pipefitting fastenings	6.0	Copper ring	6.3	Steel Ring		--------
Drainage pipe	7.0	PVC	5.7	ABS		--------
HVAC System	7.0	In floor	5.0	In attic		--------
HVAC Duct	4.0	Sheet metal	7.3	Fiber Glass		--------
Register Positions	4.3	Central Floor	7.0	Perimeter		--------
Bathtub and Shower	7.0	1 piece unit	4.0	2 piece unit		--------
Shutoff valves	8.0	Under every sink	4.0	At any one junction		--------
20 amp GFI's	5.7	1	5.7	2		--------
DOORS AND WINDOWS:						
Interior door width	5.3	28"	8.0	32"		--------
Interior Door Height	4.3	6.5 ft	7.7	7 ft		--------
Exterior door width	5.3	32"	8.0	36"		--------
Number of Hinges Int doors	5.3	2	7.3	3		--------
Hinge type	7.0	Full Mortise	3.7	Surface Mounted		--------
Window glass	5.0	Double pane "plain"	7.7	Double pane-low "E"		--------
Extrior door Type	4.0	Aluminum	8.0	Insulated Metal Core		--------
Exterior door height	3.0	6.5'	8.0	7.0'		--------
COSMETICS:						
Carpets	7.3	25 oz	4.3	18 oz		--------
Shelves	4.0	Non adjustable	7.3	Adjustable		--------
Water Heater	4.3	30-gallon	7.0	40-gallon		--------
Sheetrock finish	8.0	Tape and Textured	5.0	Vinyl sheetrock		--------
Sidewall height	4.7	7 ft	7.3	7.5 ft		--------
Ceiling paint finishes	4.7	Popcorn	7.3	Tape and textured		--------
Trim around Interior doors	4.3	Vinyl	7.3	Wood		--------
Trim around Exterior doors	4.0	Exposed aluminum	7.0	Hardi board/vinyl		--------
Mini-blinds	7.7	Provided in all rooms	3.7	Not provided in any		--------
Refrigerator	5.7	18 cu. ft.	7.3	20 cu. ft.		--------
Microwave	6.7	Built-in	6.0	Separate unit		--------
Dishwasher	7.7	Yes	3.0	No		--------
Fireplace	5.7	Yes	4.3	No		--------
Modular cabinet system	7.0	Yes	4.3	No		--------
Outside water faucets	4.7	1	7.3	2		--------
Plumbing for icemaker	7.3	Yes	3.0	No		--------
Garbage Disposal	6.7	Yes	4.0	No		--------
TRANSPORTATION &						
Setup on site responsibility	7.7	manufacturer	5.0	retailer		--------
Transportation to site	7.3	Self owned	3.7	Contracted		--------
Setup contractor	8.0	fixed	1.7	keeps changing		--------
Orientation and walk through	8.3	Yes	1.3	No		--------
Special walkthrough	8.3	Yes	1.3	No		--------
WARRANTIES:						
General	3.3	1 year	6.7	2 years		--------
Structural system	3.0	1 year	8.0	5 years		--------
Shingles	6.0	25 years	8.0	30 years		--------
Siding	6.0	10 years	8.0	15 years		--------

Figure C4 'Average'-Numerical scores for Sub-items (contd)

APPENDIX D

CHECKLISTS FOR MANUFACTURED HOUSES (HI, H2, H3, H4, H5)

MATERIALS:

Cabinets	☐ Hardwood	■ Particleboard / MDF	☐
Rollers	■ Plastic	☐ Metal	☐
Bathtub and Shower	■ Fiberglass	☐ PVC	☐
Vanity	■ Plastic	☐ Porcelain	☐
Faucets	■ Plastic	☐ Metal	☐
Ceiling Board Type	■ Vinyl coated	☐ Tape and Textured	☐
Wall Sheetrock type	■ Vinyl coated	☐ Tape and Textured	☐
Interior door style	■ Plain Face, LUAN	☐ Paneled	☐
Window Frame	■ Vinyl	☐ Aluminum (metal)	☐
Electrical Devices	☐ J-boxes	■ Self- Contained	☐

FLOOR SYSTEMS:

Axles	☐ New	■ Old and Certified	☐
Tires	☐ New	■ Old	☐
Joist Size	■ 2"X6"	☐ 2"X8"	☐
Joist Spacing	☐ 16" o/c	☐ 24" o/c	☐
Joist System	☐ Longitudinal	■ Transverse	☐
Insulation R-value	■ R-11	☐ R-21	☐
Decking material	☐ Plywood / OSB	☐ Novadeck	☐
Decking Thickness	☐ 3/4"	☐ 1/2"	■ 5/8"

WALL SYSTEMS:

Stud size (Interior)	■ 2"X3"	☐ 2"X4"	☐
Exterior Bottom Plate size	■ 1"X3" / 1"X4"	☐ 2"X3" / 2"X4"	☐
Exterior Stud spacing	■ 16" o/c	☐ 24" o/c	☐
Stud size (Exterior)	☐ 2"X6"	■ 2"X4"	☐
Insulation R-value	■ R-11	☐ R-19	☐
Headers above openings	☐ Single	☐ Double	☐
Exterior Sheathing	■ OSB	☐ Insulation Board	☐
Electrical wires pass	■ Through notch in	☐ Through a hole in	☐
Electrical Boxes	☐ Fixed t Studs	■ Fixed on sheet rock	☐
Wall Sheetrock thickness	■ 5/16"	☐ 1/2"	☐
House Wrap	☐ Tyvek	■ None	☐
Exterior Siding	■ Vinyl	☐ Hard board	☐

ROOF SYSTEMS:

Design Load	■ 20 Lb	☐ 30 Lb	☐
Roof Slope	■ 3 / 12	☐ 4 / 12	☐
Insulation R-value	☐ R-21	☐ R-19	■ R-22
Eave Projection	☐ 3"	☐ 8"	■ 6"
Eave Position	☐ Front and back	■ All around home	☐
Ceiling board thickness	☐ 1/2"	☐ 5/8"	■ 5/16"
Roof Finish	☐ Metal	■ Shingles	☐
Roof Sheathing	☐ Plywood	■ OSB	☐
Valley flashing	■ Shingles	☐ Metal	☐
Roof opening waterproofing	■ Flashing Provided	☐ No Flashing	☐

Figure D1 Checklist for manufactured house H1

UTILITIES:

Water pipe	☐ PVC	☒ PEX	☐
Pipe fittings	☒ Copper	☐ Brass	☐
Pipefitting fastenings	☐ Copper ring	☒ Steel Ring	☐
Drainage pipe	☐ PVC	☒ ABS	☐
HVAC System	☒ In floor	☐ In attic	☐
HVAC Duct	☒ Sheet metal	☐ Fiber Glass	☐
Register Positions	☒ Central Floor	☐ Perimeter	☐
Bathtub and Shower	☐ 1 piece unit	☒ 2 piece unit	☐
Shutoff valves	☒ Under every sink	☐ At any one junction	☐
20 amp GFI's	☒ 1	☐ 2	☐

DOORS AND WINDOWS:

Interior door width	☒ 28"	☐ 32"	☐
Interior Door Height	☒ 6.5 ft	☐ 7 ft	☐
Exterior door width	☐ 32"	☒ 36"	☐
Number of Hinges Int doors	☒ 2	☐ 3	☐
Hinge type	☐ Full Mortise	☒ Surface Mounted	☐
Window glass	☐ Double pane "plain"	☐ Double pane-low "E"	☒ Single
Extrior door Type	☒ Aluminum	☐ Insulated Metal Core	☐
Exterior door height	☐ 6.5'	☒ 7.0'	☐

COSMETICS:

Carpets	☐ 25 oz	☒ 18 oz	☐
Shelves	☐ Non adjustable	☐ Adjustable	☐
Water Heater	☒ 30-gallon	☐ 40-gallon	☐
Sheetrock finish	☐ Tape and Textured	☒ Vinyl sheetrock	☐
Sidewall height	☐ 7 ft	☒ 7.5 ft	☐
Ceiling paint finishes	☐ Popcorn	☐ Tape and textured	☐
Trim around Interior doors	☒ Vinyl	☐ Wood	☐
Trim around Exterior doors	☐ Exposed aluminum	☒ Hardi board/vinyl	☐
Mini-blinds	☒ Provided in all rooms	☐ Not provided in any	☐
Refrigerator	☐ 18 cu. ft.	☒ 20 cu. ft.	☐
Microwave	☐ Built-in	☐ Separate unit	☒ none
Dishwasher	☒ Yes	☐ No	☐
Fireplace	☒ Yes	☐ No	☐
Modular cabinet system	☒ Yes	☐ No	☐
Outside water faucets	☐ 1	☐ 2	☒ none
Plumbing for icemaker	☒ Yes	☐ No	☐
Garbage Disposal	☒ Yes	☐ No	☐

TRANSPORTATION & SETUP:

Setup on site responsibility	☐ manufacturer	☒ retailer	☐
Transportation to site	☐ Self owned	☒ Contracted	☐
Setup contractor	☐ fixed	☒ keeps changing	☐
Orientation and walk through	☒ Yes	☐ No	☐
Special walkthrough programs	☐ Yes	☒ No	☐

WARRANTIES:

General	☒ 1 year	☐ 2 years	☐
Structural system	☒ 1 year	☐ 5 years	☐
Shingles	☐ 25 years	☐ 30 years	☒ 20 years
Siding	☒ 10 years	☐ 15 years	☐

Figure D1 Checklist for manufactured house H1 (contd)

MATERIALS:

Cabinets	☐ Hardwood	■ Particleboard / MDF	☐
Rollers	☐ Plastic	■ Metal	☐
Bathtub and Shower	■ Fiberglass	☐ PVC	☐
Vanity	■ Plastic	☐ Porcelain	☐
Faucets	■ Plastic	☐ Metal	☐
Ceiling Board Type	☐ Vinyl coated	■ Tape and Textured	☐
Wall Sheetrock type	☐ Vinyl coated	■ Tape and Textured	☐
Interior door style	☐ Plain Face, LUAN	■ Paneled	☐
Window Frame	☐ Vinyl	■ Aluminum (metal)	☐
Electrical Devices	■ J-boxes	☐ Self- Contained	☐

FLOOR SYSTEMS:

Axles	☐ New	■ Old and Certified	☐
Tires	☐ New	■ Old	☐
Joist Size	■ 2"X6"	☐ 2"X8"	☐
Joist Spacing	■ 16" o/c	☐ 24" o/c	☐
Joist System	☐ Longitudinal	■ Transverse	☐
Insulation R-value	■ R-11	☐ R-21	☐
Decking material	■ Plywood / OSB	☐ Novadeck	☐
Decking Thickness	☐ 3/4"	☐ 1/2"	■ 5/8"

WALL SYSTEMS:

Stud size (Interior)	■ 2"X3"	☐ 2"X4"	☐
Exterior Bottom Plate size	☐ 1"X3"/ 1"X4"	■ 2"X3"/ 2"X4"	☐
Exterior Stud spacing	■ 16" o/c	☐ 24" o/c	☐
Stud size (Exterior)	☐ 2"X6"	■ 2"X4"	☐
Insulation R-value	■ R-11	☐ R-19	☐
Headers above openings	☐ Single	■ Double	☐
Exterior Sheathing	■ OSB	☐ Insulation Board	☐
Electrical wires pass	■ Through notch in stud	☐ Through a hole in Stud	☐
Electrical Boxes	☐ Fixed t Studs	■ Fixed on sheet rock	☐
Wall Sheetrock thickness	■ 5/16"	☐ 1/2"	☐
House Wrap	■ Tyvek	☐ None	☐
Exterior Siding	☐ Vinyl	■ Hard board	☐

ROOF SYSTEMS:

Design Load	■ 20 Lb	☐ 30 Lb	☐
Roof Slope	■ 3 / 12	☐ 4 / 12	☐
Insulation R-value	■ R-21	☐ R-19	☐
Eave Projection	■ 3"	☐ 8"	☐
Eave Position	■ Front and back	☐ All around home	☐
Ceiling board thickness	■ 1/2"	☐ 5/8"	☐
Roof Finish	☐ Metal	■ Shingles	☐
Roof Sheathing	☐ Plywood	■ OSB	☐
Valley flashing	■ Shingles	☐ Metal	☐
Roof opening waterproofing	■ Flashing Provided	☐ No Flashing	☐

Figure D2 Checklist for manufactured house H2

UTILITIES:

Water pipe	☐ PVC	☒ PEX	☐
Pipe fittings	☐ Copper	☒ Brass	☐
Pipefitting fastenings	☐ Copper ring	☒ Steel Ring	☐
Drainage pipe	☐ PVC	☒ ABS	☐
HVAC System	☒ In floor	☐ In attic	☐
HVAC Duct	☐ Sheet metal	☒ Fiber Glass	☐
Register Positions	☒ Central Floor	☐ Perimeter	☐
Bathtub and Shower	☒ 1 piece unit	☐ 2 piece unit	☐
Shutoff valves	☒ Under every sink	☐ At any one junction	☐
20 amp GFI's	☐ 1	☒ 2	☐

DOORS AND WINDOWS:

Interior door width	☒ 28"	☐ 32"	☐
Interior Door Height	☒ 6.5 ft	☐ 7 ft	☐
Exterior door width	☐ 32"	☒ 36"	☐
Number of Hinges Int doors	☒ 2	☐ 3	☐
Hinge type	☐ Full Mortise	☒ Surface Mounted	☐
Window glass	☒ Double pane "plain"	☐ Double pane-low "E"	☐
Extrior door Type	☐ Aluminum	☒ Insulated Metal Core	☐
Exterior door height	☐ 6.5'	☒ 7.0'	☐

COSMETICS:

Carpets	☒ 25 oz	☐ 18 oz	☐
Shelves	☒ Non adjustable	☐ Adjustable	☐
Water Heater	☐ 30-gallon	☒ 40-gallon	☐
Sheetrock finish	☒ Tape and Textured	☐ Vinyl sheetrock	☐
Sidewall height	☐ 7 ft	☒ 7.5 ft	☐
Ceiling paint finishes	☐ Popcorn	☒ Tape and textured	☐
Trim around Interior doors	☐ Vinyl	☒ Wood	☐
Trim around Exterior doors	☐ Exposed aluminum	☒ Hardi board/vinyl	☐
Mini-blinds	☒ Provided in all rooms	☐ Not provided in any	☐
Refrigerator	☒ 18 cu. ft.	☐ 20 cu. ft.	☐
Microwave	☐ Built-in	☒ Separate unit	☐
Dishwasher	☒ Yes	☐ No	☐
Fireplace	☒ Yes	☐ No	☐
Modular cabinet system	☒ Yes	☐ No	☐
Outside water faucets	☐ 1	☒ 2	☐
Plumbing for icemaker	☒ Yes	☐ No	☐
Garbage Disposal	☒ Yes	☐ No	☐

TRANSPORTATION & SETUP:

Setup on site responsibility	☐ manufacturer	☒ retailer	☐
Transportation to site	☐ Self owned	☒ Contracted	☐
Setup contractor	☒ fixed	☐ keeps changing	☐
Orientation and walk through	☒ Yes	☐ No	☐
Special walkthrough programs	☐ Yes	☒ No	☐

WARRANTIES:

General	☒ 1 year	☐ 2 years	☐
Structural system	☐ 1 year	☒ 5 years	☐
Shingles	☐ 25 years	☐ 30 years	☒ 20 years
Siding	☐ 10 years	☒ 15 years	☐

Figure D2 Checklist for manufactured house H2 (contd)

MATERIALS:

Cabinets	☐ Hardwood	☒ Particleboard / MDF	☐
Rollers	☒ Plastic	☐ Metal	☐
Bathtub and Shower	☐ Fiberglass	☒ PVC	☐
Vanity	☒ Plastic	☐ Porcelain	☐
Faucets	☒ Plastic	☐ Metal	☐
Ceiling Board Type	☒ Vinyl coated	☐ Tape and Textured	☐
Wall Sheetrock type	☒ Vinyl coated	☐ Tape and Textured	☐
Interior door style	☐ Plain Face, LUAN	☐ Paneled	☐
Window Frame	☐ Vinyl	☒ Aluminum (metal)	☐
Electrical Devices	☐ J-boxes	☒ Self- Contained	☐

FLOOR SYSTEMS:

Axles	☐ New	☒ Old and Certified	☐
Tires	☐ New	☒ Old	☐
Joist Size	☒ 2"X6"	☐ 2"X8"	☐
Joist Spacing	☒ 16" o/c	☐ 24" o/c	☐
Joist System	☐ Longitudinal	☒ Transverse	☐
Insulation R-value	☐ R-11	☐ R-21	☐
Decking material	☐ Plywood / OSB	☒ Novadeck	☐
Decking Thickness	☐ 3/4"	☒ 1/2"	☐

WALL SYSTEMS:

Stud size (Interior)	☒ 2"X3"	☐ 2"X4"	☐
Exterior Bottom Plate size	☒ 1"X3"/ 1"X4"	☐ 2"X3"/ 2"X4"	☐
Exterior Stud spacing	☒ 16" o/c	☐ 24" o/c	☐
Stud size (Exterior)	☐ 2"X6"	☒ 2"X4"	☐
Insulation R-value	☒ R-11	☐ R-19	☐
Headers above openings	☒ Single	☐ Double	☐
Exterior Sheathing	☐ OSB	☐ Insulation Board	☒ no
Electrical wires pass	☒ Through notch in stud	☐ Through a hole in Stud	☐
Electrical Boxes	☐ Fixed t Studs	☒ Fixed on sheet rock	☐
Wall Sheetrock thickness	☒ 5/16"	☐ 1/2"	☐
House Wrap	☐ Tyvek	☒ None	☐
Exterior Siding	☐ Vinyl	☒ Hard board	☐

ROOF SYSTEMS:

Design Load	☒ 20 Lb	☐ 30 Lb	☐
Roof Slope	☒ 3 / 12	☐ 4 / 12	☐
Insulation R-value	☒ R-21	☐ R-19	☐
Eave Projection	☐ 3"	☐ 8"	☒ 6"
Eave Position	☐ Front and back	☒ All around home	☐
Ceiling board thickness	☐ 1/2"	☐ 5/8"	☒ 5/16"
Roof Finish	☐ Metal	☐ Shingles	☐
Roof Sheathing	☐ Plywood	☒ OSB	☐
Valley flashing	☒ Shingles	☐ Metal	☐
Roof opening waterproofing	☒ Flashing Provided	☐ No Flashing	☐

Figure D3 Checklist for manufactured house H3

UTILITIES:

Water pipe	☐ PVC	☒ PEX	☐
Pipe fittings	☐ Copper	☐ Brass	☐
Pipefitting fastenings	☐ Copper ring	☐ Steel Ring	☐
Drainage pipe	☐ PVC	☒ ABS	☐
HVAC System	☒ In floor	☐ In attic	☐
HVAC Duct	☒ Sheet metal	☐ Fiber Glass	☐
Register Positions	☒ Central Floor	☐ Perimeter	☐
Bathtub and Shower	☐ 1 piece unit	☒ 2 piece unit	☐
Shutoff valves	☐ Under every sink	☒ At any one junction	☐
20 amp GFI's	☒ 1	☐ 2	☐

DOORS AND WINDOWS:

Interior door width	☐ 28"	☐ 32"	☒ 30"
Interior Door Height	☒ 6.5 ft	☐ 7 ft	☐
Exterior door width	☐ 32"	☒ 36"	☐
Number of Hinges Int doors	☐ 2	☒ 3	☐
Hinge type	☐ Full Mortise	☒ Surface Mounted	☐
Window glass	☒ Double pane "plain"	☐ Double pane-low "E"	☐
Extrior door Type	☒ Aluminum	☐ Insulated Metal Core	☐
Exterior door height	☒ 6.5'	☐ 7.0'	☐

COSMETICS:

Carpets	☐ 25 oz	☒ 18 oz	☐
Shelves	☒ Non adjustable	☐ Adjustable	☐
Water Heater	☒ 30-gallon	☐ 40-gallon	☐
Sheetrock finish	☐ Tape and Textured	☒ Vinyl sheetrock	☐
Sidewall height	☐ 7 ft	☐ 7.5 ft	☐
Ceiling paint finishes	☒ Popcorn	☐ Tape and textured	☐
Trim around Interior doors	☐ Vinyl	☐ Wood	☐
Trim around Exterior doors	☒ Exposed aluminum	☐ Hardi board/vinyl	☐
Mini-blinds	☐ Provided in all rooms	☐ Not provided in any	☒
Refrigerator	☒ 18 cu. ft.	☐ 20 cu. ft.	☐
Microwave	☒ Built-in	☐ Separate unit	☐
Dishwasher	☒ Yes	☐ No	☐
Fireplace	☐ Yes	☒ No	☐
Modular cabinet system	☐ Yes	☐ No	☐
Outside water faucets	☒ 1	☐ 2	☐
Plumbing for icemaker	☐ Yes	☒ No	☐
Garbage Disposal	☐ Yes	☒ No	☐

TRANSPORTATION & SETUP:

Setup on site responsibility	☐ manufacturer	☒ retailer	☐
Transportation to site	☐ Self owned	☒ Contracted	☐
Setup contractor	☐ fixed	☒ keeps changing	☐
Orientation and walk through	☒ Yes	☐ No	☐
Special walkthrough programs	☐ Yes	☒ No	☐

WARRANTIES:

General	☒ 1 year	☐ 2 years	☐
Structural system	☒ 1 year	☐ 5 years	☐
Shingles	☐ 25 years	☐ 30 years	☒ 20 years
Siding	☒ 10 years	☐ 15 years	☐

Figure D3 Checklist for manufactured house H3 (contd)

MATERIALS:

Cabinets	☐ Hardwood	☒ Particleboard / MDF	☐
Rollers	☐ Plastic	☒ Metal	☐
Bathtub and Shower	☐ Fiberglass	☒ PVC	☐
Vanity	☒ Plastic	☐ Porcelain	☐
Faucets	☐ Plastic	☒ Metal	☐
Ceiling Board Type	☒ Vinyl coated	☐ Tape and Textured	☐
Wall Sheetrock type	☒ Vinyl coated	☐ Tape and Textured	☐
Interior door style	☒ Plain Face, LUAN	☐ Paneled	☐
Window Frame	☐ Vinyl	☒ Aluminum (metal)	☐
Electrical Devices	☐ J-boxes	☒ Self- Contained	☐

FLOOR SYSTEMS:

Axles	☐ New	☒ Old and Certified	☐
Tires	☐ New	☒ Old	☐
Joist Size	☒ 2"X6"	☐ 2"X8"	☐
Joist Spacing	☒ 16" o/c	☐ 24" o/c	☐
Joist System	☐ Longitudinal	☒ Transverse	☐
Insulation R-value	☒ R-11	☐ R-21	☐
Decking material	☒ Plywood / OSB	☐ Novadeck	☐
Decking Thickness	☒ 3/4"	☐ 1/2"	☐

WALL SYSTEMS:

Stud size (Interior)	☒ 2"X3"	☐ 2"X4"	☐
Exterior Bottom Plate size	☐ 1"X3"/ 1"X4"	☒ 2"X3"/ 2"X4"	☐
Exterior Stud spacing	☒ 16" o/c	☐ 24" o/c	☐
Stud size (Exterior)	☐ 2"X6"	☒ 2"X4"	☐
Insulation R-value	☒ R-11	☐ R-19	☐
Headers above openings	☐ Single	☒ Double	☐
Exterior Sheathing	☐ OSB	☒ Insulation Board	☐
Electrical wires pass	☒ Through notch in stud	☐ Through a hole in Stud	☐
Electrical Boxes	☒ Fixed t Studs	☐ Fixed on sheet rock	☐
Wall Sheetrock thickness	☒ 5/16"	☐ 1/2"	☐
House Wrap	☒ Tyvek	☐ None	☐
Exterior Siding	☐ Vinyl	☒ Hard board	☐

ROOF SYSTEMS:

Design Load	☒ 20 Lb	☐ 30 Lb	☐
Roof Slope	☒ 3 / 12	☐ 4 / 12	☐
Insulation R-value	☒ R-21	☐ R-19	☐
Eave Projection	☐ 3"	☒ 8"	☐
Eave Position	☐ Front and back	☒ All around home	☐
Ceiling board thickness	☐ 1/2"	☐ 5/8"	☒ 5/16"
Roof Finish	☐ Metal	☒ Shingles	☐
Roof Sheathing	☒ Plywood	☐ OSB	☐
Valley flashing	☒ Shingles	☐ Metal	☐
Roof opening waterproofing	☒ Flashing Provided	☐ No Flashing	☐

Figure D4 Checklist for manufactured house H4

UTILITIES:

Water pipe	☐	PVC	☒	PEX	☐
Pipe fittings	☐	Copper	☒	Brass	☐
Pipefitting fastenings	☐	Copper ring	☒	Steel Ring	☐
Drainage pipe	☐	PVC	☒	ABS	☐
HVAC System	☒	In floor	☐	In attic	☐
HVAC Duct	☐	Sheet metal	☒	Fiber Glass	☐
Register Positions	☒	Central Floor	☐	Perimeter	☐
Bathtub and Shower	☐	1 piece unit	☒	2 piece unit	☐
Shutoff valves	☒	Under every sink	☐	At any one junction	☐
20 amp GFI's	☒	1	☐	2	☐

DOORS AND WINDOWS:

Interior door width	☒	28"	☐	32"	☐
Interior Door Height	☒	6.5 ft	☐	7 ft	☐
Exterior door width	☐	32"	☒	36"	☐
Number of Hinges Int doors	☒	2	☐	3	☐
Hinge type	☐	Full Mortise	☒	Surface Mounted	☐
Window glass	☒	Double pane "plain"	☐	Double pane-low "E"	☐
Extrior door Type	☐	Aluminum	☒	Insulated Metal Core	☐
Exterior door height	☐	6.5'	☒	7.0'	☐

COSMETICS:

Carpets	☐	25 oz	☒	18 oz	☐
Shelves	☐	Non adjustable	☒	Adjustable	☐
Water Heater	☒	30-gallon	☐	40-gallon	☐
Sheetrock finish	☐	Tape and Textured	☒	Vinyl sheetrock	☐
Sidewall height	☐	7 ft	☒	7.5 ft	☐
Ceiling paint finishes	☐	Popcorn	☒	Tape and textured	☐
Trim around Interior doors	☒	Vinyl	☐	Wood	☐
Trim around Exterior doors	☐	Exposed aluminum	☒	Hardi board/vinyl	☐
Mini-blinds	☐	Provided in all rooms	☐	Not provided in any	☒ some
Refrigerator	☐	18 cu. ft.	☒	20 cu. ft.	☐
Microwave	☒	Built-in	☐	Separate unit	☐
Dishwasher	☒	Yes	☐	No	☐
Fireplace	☒	Yes	☐	No	☐
Modular cabinet system	☒	Yes	☐	No	☐
Outside water faucets	☐	1	☒	2	☐
Plumbing for icemaker	☐	Yes	☒	No	☐
Garbage Disposal	☒	Yes	☐	No	☐

TRANSPORTATION & SETUP:

Setup on site responsibility	☒	manufacturer	☐	retailer	☐
Transportation to site	☒	Self owned	☐	Contracted	☐
Setup contractor	☒	fixed	☐	keeps changing	☐
Orientation and walk through	☒	Yes	☐	No	☐
Special walkthrough programs	☒	Yes	☐	No	☐

WARRANTIES:

General	☒	1 year	☐	2 years	☐
Structural system	☒	1 year	☐	5 years	☐
Shingles	☒	25 years	☐	30 years	☐
Siding	☐	10 years	☒	15 years	☐

Figure D4 Checklist for manufactured house H4 (contd)

MATERIALS:

Cabinets	☐	Hardwood	☒	Particleboard / MDF	☐
Rollers	☐	Plastic	☒	Metal	☐
Bathtub and Shower	☐	Fiberglass	☒	PVC	☐
Vanity	☐	Plastic	☒	Porcelain	☐
Faucets	☐	Plastic	☒	Metal	☐
Ceiling Board Type	☐	Vinyl coated	☒	Tape and Textured	☐
Wall Sheetrock type	☒	Vinyl coated	☐	Tape and Textured	☐
Interior door style	☒	Plain Face, LUAN	☐	Paneled	☐
Window Frame	☒	Vinyl	☐	Aluminum (metal)	☐
Electrical Devices	☐	J-boxes	☒	Self- Contained	☐

FLOOR SYSTEMS:

Axles	☐	New	☒	Old and Certified	☐
Tires	☒	New	☐	Old	☐
Joist Size	☒	2"X6"	☐	2"X8"	☐
Joist Spacing	☒	16" o/c	☐	24" o/c	☐
Joist System	☐	Longitudinal	☒	Transverse	☐
Insulation R-value	☒	R-11	☐	R-21	☐
Decking material	☐	Plywood / OSB	☒	Novadeck	☐
Decking Thickness	☐	3/4"	☐	1/2"	☒ 5/8"

WALL SYSTEMS:

Stud size (Interior)	☒	2"X3"	☐	2"X4"	☐
Exterior Bottom Plate size	☒	1"X3"/ 1"X4"	☐	2"X3"/ 2"X4"	☐
Exterior Stud spacing	☒	16" o/c	☐	24" o/c	☐
Stud size (Exterior)	☐	2"X6"	☒	2"X4"	☐
Insulation R-value	☒	R-11	☐	R-19	☐
Headers above openings	☒	Single	☐	Double	☐
Exterior Sheathing	☐	OSB	☒	Insulation Board	☐
Electrical wires pass	☐	Through notch in stud	☒	Through a hole in Stud	☐
Electrical Boxes	☐	Fixed t Studs	☒	Fixed on sheet rock	☐
Wall Sheetrock thickness	☒	5/16"	☐	1/2"	☐
House Wrap	☒	Tyvek	☐	None	☐
Exterior Siding	☒	Vinyl	☐	Hard board	☐

ROOF SYSTEMS:

Design Load	☒	20 Lb	☐	30 Lb	☐
Roof Slope	☐	3 / 12	☒	4 / 12	☐
Insulation R-value	☒	R-21	☐	R-19	☐
Eave Projection	☐	3"	☐	8"	☒ 12"
Eave Position	☐	Front and back	☒	All around home	☐
Ceiling board thickness	☐	1/2"	☐	5/8"	☒ 5/8"
Roof Finish	☐	Metal	☒	Shingles	☐
Roof Sheathing	☐	Plywood	☒	OSB	☐
Valley flashing	☐	Shingles	☐	Metal	☐
Roof opening waterproofing	☒	Flashing Provided	☐	No Flashing	☐

Figure D5 Checklist for manufactured house H5

UTILITIES:

Water pipe	☐	PVC	☒	PEX	☐
Pipe fittings	☐	Copper	☒	Brass	☐
Pipefitting fastenings	☐	Copper ring	☐	Steel Ring	☐
Drainage pipe	☐	PVC	☒	ABS	☐
HVAC System	☒	In floor	☐	In attic	☐
HVAC Duct	☒	Sheet metal	☐	Fiber Glass	☐
Register Positions	☒	Central Floor	☐	Perimeter	☐
Bathtub and Shower	☐	1 piece unit	☒	2 piece unit	☐
Shutoff valves	☒	Under every sink	☐	At any one junction	☐
20 amp GFI's	☐	1	☒	2	☐

DOORS AND WINDOWS:

Interior door width	☒	28"	☐	32"	☐
Interior Door Height	☐	6.5 ft	☐	7 ft	☐
Exterior door width	☐	32"	☒	36"	☐
Number of Hinges Int doors	☐	2	☐	3	☐
Hinge type	☐	Full Mortise	☒	Surface Mounted	☐
Window glass	☒	Double pane "plain"	☐	Double pane-low "E"	☐
Extrior door Type	☐	Aluminum	☐	Insulated Metal Core	☐
Exterior door height	☐	6.5'	☒	7.0'	☐

COSMETICS:

Carpets	☐	25 oz	☒	18 oz	☐
Shelves	☐	Non adjustable	☒	Adjustable	☐
Water Heater	☐	30-gallon	☒	40-gallon	☐
Sheetrock finish	☐	Tape and Textured	☒	Vinyl sheetrock	☐
Sidewall height	☐	7 ft	☒	7.5 ft	☐
Ceiling paint finishes	☐	Popcorn	☐	Tape and textured	☐
Trim around Interior doors	☐	Vinyl	☐	Wood	☐
Trim around Exterior doors	☐	Exposed aluminum	☒	Hardi board/vinyl	☐
Mini-blinds	☒	Provided in all rooms	☐	Not provided in any	☐
Refrigerator	☐	18 cu. ft.	☒	20 cu. ft.	☐
Microwave	☒	Built-in	☐	Separate unit	☐
Dishwasher	☐	Yes	☐	No	☐
Fireplace	☒	Yes	☐	No	☐
Modular cabinet system	☒	Yes	☐	No	☐
Outside water faucets	☐	1	☒	2	☐
Plumbing for icemaker	☒	Yes	☐	No	☐
Garbage Disposal	☒	Yes	☐	No	☐

TRANSPORTATION & SETUP:

Setup on site responsibility	☒	manufacturer	☐	retailer	☐
Transportation to site	☐	Self owned	☐	Contracted	☒ fixed
Setup contractor	☒	fixed	☐	keeps changing	☐
Orientation and walk through	☒	Yes	☐	No	☐
Special walkthrough programs	☐	Yes	☒	No	☐

WARRANTIES:

General	☒	1 year	☐	2 years	☐
Structural system	☐	1 year	☒	5 years	☐
Shingles	☒	25 years	☐	30 years	☐
Siding	☐	10 years	☒	15 years	☐

Figure D5 Checklist for manufactured house H5

APPENDIX E

NORMALIZED WEIGHTED SCORES FOR SUB-SYSTEMS

SUBSYSTEMS	Vector of Priorities	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
MATERIALS:											
Cabinets	0.10	3.00	0.306	3.00	0.306	3.00	0.306	3.00	0.306	3.00	0.306
Rollers	0.02	2.00	0.040	8.00	0.159	2.00	0.040	8.00	0.159	8.00	0.159
Bathtub and Shower	0.17	9.00	1.507	9.00	1.507	4.00	0.670	4.00	0.670	4.00	0.670
Vanity	0.05	2.00	0.097	2.00	0.097	2.00	0.097	2.00	0.097	8.00	0.389
Faucets	0.03	2.00	0.059	2.00	0.059	2.00	0.059	8.00	0.237	8.00	0.237
Ceiling Board Type	0.09	2.00	0.184	8.00	0.735	2.00	0.184	2.00	0.184	8.00	0.735
Wall Sheetrock type	0.04	4.00	0.141	8.00	0.282	4.00	0.141	4.00	0.141	4.00	0.141
Interior door style	0.02	3.00	0.063	7.00	0.146	3.00	0.063	3.00	0.063	3.00	0.063
Window Frame	0.09	8.00	0.720	6.00	0.540	6.00	0.540	6.00	0.540	8.00	0.720
Electrical Devices	0.39	3.00	1.184	9.00	3.552	3.00	1.184	3.00	1.184	3.00	1.184
			0.430		0.738		0.328		0.358		0.460
FLOOR ASSEMBLY											
Axles	0.06	4.00	0.246	4.00	0.246	4.00	0.246	4.00	0.246	4.00	0.246
Tires	0.02	4.00	0.091	4.00	0.091	4.00	0.091	4.00	0.091	9.00	0.205
Joist Size	0.17	6.00	0.998	6.00	0.998	6.00	0.998	6.00	0.998	6.00	0.998
Joist Spacing	0.16	9.00	1.484	9.00	1.484	9.00	1.484	9.00	1.484	9.00	1.484
Joist System	0.15	7.00	1.045	7.00	1.045	7.00	1.045	7.00	1.045	7.00	1.045
Insulation R-value	0.07	6.00	0.394	6.00	0.394	6.00	0.394	6.00	0.394	6.00	0.394
Decking material	0.22	6.00	1.294	8.00	1.725	6.00	1.294	8.00	1.725	6.00	1.294
Decking Thickness	0.15	6.00	0.923	6.00	0.923	6.00	0.923	7.00	1.076	6.00	0.923
			0.648		0.691		0.648		0.706		0.659

Figure E1 IPIA 1-Normalized weighted scores for sub-systems

SUBSYSTEMS	Vector of Priorities	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
WALL ASSEMBLY											
Stud size (Interior)	0.02	4.00	0.093	4.00	0.093	4.00	0.093	4.00	0.093	4.00	0.093
Exterior Bottom Plate size	0.02	3.00	0.051	8.00	0.136	3.00	0.051	8.00	0.136	3.00	0.051
Exterior Stud spacing	0.06	7.00	0.399	7.00	0.399	7.00	0.399	7.00	0.399	7.00	0.399
Stud size (Exterior)	0.07	6.00	0.422	6.00	0.422	6.00	0.422	6.00	0.422	6.00	0.422
Insulation R-value	0.09	6.00	0.513	6.00	0.513	6.00	0.513	6.00	0.513	6.00	0.513
Headers above openings	0.25	4.00	1.014	7.00	1.774	4.00	1.014	7.00	1.774	4.00	1.014
Exterior Sheathing	0.16	8.00	1.273	8.00	1.273	1.00	0.159	4.00	0.636	4.00	0.636
Electrical wires pass	0.05	3.00	0.141	3.00	0.141	3.00	0.141	3.00	0.141	7.00	0.329
Electrical Boxes	0.09	2.00	0.188	2.00	0.188	2.00	0.188	8.00	0.752	2.00	0.188
Wall Sheetrock thickness	0.03	2.00	0.055	4.00	0.109	4.00	0.109	4.00	0.109	4.00	0.109
House Wrap	0.04	2.00	0.088	5.00	0.220	2.00	0.088	5.00	0.220	5.00	0.220
Exterior Siding	0.12	6.00	0.732	7.00	0.854	7.00	0.854	7.00	0.854	6.00	0.732
			0.497		0.612		0.403		0.605		0.471
ROOF ASSEMBLY											
Design Load	0.39	4.00	1.576	4.00	1.576	4.00	1.576	4.00	1.576	4.00	1.576
Roof Slope	0.02	5.00	0.081	5.00	0.081	5.00	0.081	5.00	0.081	7.00	0.113
Insulation R-value	0.11	8.00	0.851	8.00	0.851	8.00	0.851	8.00	0.851	8.00	0.851
Eave Projection	0.04	6.00	0.259	5.00	0.216	6.00	0.259	7.00	0.303	9.00	0.389
Eave Position	0.03	7.00	0.181	5.00	0.129	7.00	0.181	7.00	0.181	7.00	0.181
Ceiling board thickness	0.07	4.00	0.300	6.00	0.450	4.00	0.300	4.00	0.300	4.00	0.300
Roof Finish	0.07	8.00	0.587	8.00	0.587	8.00	0.587	8.00	0.587	8.00	0.587
Roof Sheathing	0.08	2.00	0.156	2.00	0.156	2.00	0.156	8.00	0.626	2.00	0.156
Valley flashing	0.08	6.00	0.502	6.00	0.502	6.00	0.502	6.00	0.502	6.00	0.502
Roof opening waterproofing	0.10	7.00	0.730	7.00	0.730	7.00	0.730	7.00	0.730	7.00	0.730
			0.522		0.528		0.522		0.574		0.538

Figure E1 IPIA 1-Normalized weighted scores for sub-systems (contd)

SUBSYSTEMS	Vector of Priorities	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
UTILITIES:											
Water pipe	0.04	4.00	0.173	4.00	0.173	4.00	0.173	4.00	0.173	4.00	0.173
Pipe fittings	0.07	6.00	0.393	5.00	0.328	6.00	0.393	5.00	0.328	5.00	0.328
Pipefitting fastenings	0.03	7.00	0.243	7.00	0.243	5.00	0.173	7.00	0.243	5.00	0.173
Drainage pipe	0.08	6.00	0.496	6.00	0.496	6.00	0.496	6.00	0.496	6.00	0.496
HVAC System	0.19	8.00	1.545	8.00	1.545	8.00	1.545	8.00	1.545	8.00	1.545
HVAC Duct	0.10	4.00	0.383	7.00	0.671	4.00	0.383	7.00	0.671	4.00	0.383
Register Positions	0.06	5.00	0.282	5.00	0.282	5.00	0.282	5.00	0.282	5.00	0.282
Bathtub and Shower	0.17	4.00	0.673	7.00	1.178	4.00	0.673	4.00	0.673	4.00	0.673
Shutoff valves	0.02	8.00	0.129	8.00	0.129	4.00	0.065	8.00	0.129	8.00	0.129
20 amp GFI's	0.24	7.00	1.707	5.00	1.219	7.00	1.707	7.00	1.707	5.00	1.219
			0.603		0.626		0.589		0.625		0.540
DOORS AND WINDOWS:											
Interior door width	0.05	6.00	0.303	6.00	0.303	7.00	0.354	6.00	0.303	6.00	0.303
Interior Door Height	0.06	4.00	0.232	4.00	0.232	4.00	0.232	4.00	0.232	8.00	0.464
Exterior door width	0.13	8.00	1.040	8.00	1.040	8.00	1.040	8.00	1.040	8.00	1.040
Number of Hinges Int doors	0.02	6.00	0.148	6.00	0.148	8.00	0.197	6.00	0.148	6.00	0.148
Hinge type	0.03	3.00	0.098	3.00	0.098	3.00	0.098	3.00	0.098	3.00	0.098
Window glass	0.31	2.00	0.621	4.00	1.242	4.00	1.242	4.00	1.242	4.00	1.242
Extrior door Type	0.28	4.00	1.137	8.00	2.274	4.00	1.137	8.00	2.274	8.00	2.274
Exterior door height	0.11	8.00	0.877	8.00	0.877	4.00	0.438	8.00	0.877	8.00	0.877
			0.446		0.621		0.474		0.621		0.645

Figure E1 IPIA 1-Normalized weighted scores for sub-systems (contd)

SUBSYSTEMS	Vector of Priorities	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
COSMETICS:											
Carpets	0.06	5.00	0.298	7.00	0.418	5.00	0.298	5.00	0.298	5.00	0.298
Shelves	0.01	5.00	0.072	5.00	0.072	5.00	0.072	7.00	0.100	7.00	0.100
Water Heater	0.17	5.00	0.871	6.00	1.045	5.00	0.871	5.00	0.871	6.00	1.045
Sheetrock finish	0.02	5.00	0.111	8.00	0.177	5.00	0.111	5.00	0.111	5.00	0.111
Sidewall height	0.14	7.00	1.012	7.00	1.012	5.00	0.723	7.00	1.012	7.00	1.012
Ceiling paint finishes	0.05	4.00	0.219	7.00	0.382	4.00	0.219	7.00	0.382	4.00	0.219
Trim around Interior doors	0.01	5.00	0.074	7.00	0.104	5.00	0.074	5.00	0.074	5.00	0.074
Trim around Exterior doors and windows	0.11	7.00	0.742	7.00	0.742	4.00	0.424	7.00	0.742	7.00	0.742
Mini-blinds	0.01	8.00	0.117	8.00	0.117	5.00	0.073	5.00	0.073	8.00	0.117
Refrigerator	0.04	7.00	0.256	6.00	0.219	6.00	0.219	7.00	0.256	7.00	0.256
Microwave	0.05	2.00	0.093	5.00	0.232	7.00	0.325	7.00	0.325	7.00	0.325
Dishwasher	0.04	7.00	0.290	7.00	0.290	7.00	0.290	7.00	0.290	7.00	0.290
Fireplace	0.10	5.00	0.487	5.00	0.487	4.00	0.390	5.00	0.487	5.00	0.487
Modular cabinet system	0.09	6.00	0.511	6.00	0.511	6.00	0.511	6.00	0.511	6.00	0.511
Outside water faucets	0.03	2.00	0.061	7.00	0.213	5.00	0.152	5.00	0.152	7.00	0.213
Plumbing for icemaker	0.02	7.00	0.165	7.00	0.165	4.00	0.094	7.00	0.165	7.00	0.165
Garbage Disposal	0.03	7.00	0.239	7.00	0.239	4.00	0.137	7.00	0.239	7.00	0.239
			0.562		0.642		0.498		0.609		0.620
TRANSPORTATION & SETUP:											
Setup on site responsibility	0.09	5.00	0.461	5.00	0.461	5.00	0.461	8.00	0.737	8.00	0.737
Transportation to site	0.09	3.00	0.276	3.00	0.276	3.00	0.276	8.00	0.737	6.00	0.553
Setup contractor	0.09	1.00	0.092	8.00	0.737	1.00	0.092	8.00	0.737	8.00	0.737
Orientation and walk through	0.31	9.00	2.765	9.00	2.765	9.00	2.765	9.00	2.765	9.00	2.765
Special walkthrough programs	0.42	1.00	0.416	1.00	0.416	1.00	0.416	9.00	3.747	1.00	0.416
			0.401		0.466		0.401		0.872		0.521
WARRANTIES:											
General	0.62	2.00	1.242	2.00	1.242	2.00	1.242	2.00	1.242	2.00	1.242
Structural system	0.28	2.00	0.563	8.00	2.253	2.00	0.563	2.00	0.563	8.00	2.253
Shingles	0.05	8.00	0.390	4.00	0.195	4.00	0.195	6.00	0.292	6.00	0.292
Siding	0.05	6.00	0.292	8.00	0.390	6.00	0.292	8.00	0.390	8.00	0.390
			0.249		0.408		0.229		0.249		0.418

Figure E1 IPIA 1-Normalized weighted scores for sub-systems (contd)

SUBSYSTEMS	Vector of Priorities	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
MATERIALS:											
Cabinets	0.05	3.00	0.150	3.00	0.150	3.00	0.150	3.00	0.150	3.00	0.150
Rollers	0.02	2.00	0.031	8.00	0.123	2.00	0.031	8.00	0.123	8.00	0.123
Bathtub and Shower	0.17	8.00	1.378	8.00	1.378	3.00	0.517	3.00	0.517	3.00	0.517
Vanity	0.03	4.00	0.135	4.00	0.135	4.00	0.135	4.00	0.135	7.00	0.237
Faucets	0.12	2.00	0.237	2.00	0.237	2.00	0.237	8.00	0.949	8.00	0.949
Ceiling Board Type	0.02	3.00	0.074	7.00	0.173	3.00	0.074	3.00	0.074	7.00	0.173
Wall Sheetrock type	0.06	4.00	0.231	8.00	0.462	4.00	0.231	4.00	0.231	4.00	0.231
Interior door style	0.05	2.00	0.103	7.00	0.359	2.00	0.103	2.00	0.103	2.00	0.103
Window Frame	0.08	8.00	0.664	4.00	0.332	4.00	0.332	4.00	0.332	8.00	0.664
Electrical Devices	0.39	3.00	1.179	7.00	2.752	3.00	1.179	3.00	1.179	3.00	1.179
			0.418		0.610		0.299		0.379		0.433
FLOOR ASSEMBLY											
Axles	0.02	4.00	0.076	4.00	0.076	4.00	0.076	4.00	0.076	4.00	0.076
Tires	0.02	4.00	0.076	4.00	0.076	4.00	0.076	4.00	0.076	8.00	0.151
Joist Size	0.10	5.00	0.511	5.00	0.511	5.00	0.511	5.00	0.511	5.00	0.511
Joist Spacing	0.22	7.00	1.519	7.00	1.519	7.00	1.519	7.00	1.519	7.00	1.519
Joist System	0.14	7.00	1.001	7.00	1.001	7.00	1.001	7.00	1.001	7.00	1.001
Insulation R-value	0.07	5.00	0.361	5.00	0.361	5.00	0.361	5.00	0.361	5.00	0.361
Decking material	0.27	6.00	1.601	8.00	2.135	5.00	1.335	8.00	2.135	5.00	1.335
Decking Thickness	0.16	5.00	0.804	3.00	0.483	3.00	0.483	7.00	1.126	5.00	0.804
			0.595		0.616		0.536		0.680		0.576

Figure E2 IPIA 2-Normalized weighted scores for sub-systems

SUBSYSTEMS	Vector of Priorities	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
WALL ASSEMBLY											
Stud size (Interior)	0.02	4.00	0.090	4.00	0.090	4.00	0.090	4.00	0.090	4.00	0.090
Exterior Bottom Plate size	0.02	3.00	0.068	8.00	0.181	3.00	0.068	8.00	0.181	3.00	0.068
Exterior Stud spacing	0.08	8.00	0.667	8.00	0.667	8.00	0.667	8.00	0.667	8.00	0.667
Stud size (Exterior)	0.05	6.00	0.324	6.00	0.324	6.00	0.324	6.00	0.324	6.00	0.324
Insulation R-value	0.08	7.00	0.584	7.00	0.584	7.00	0.584	7.00	0.584	7.00	0.584
Headers above openings	0.11	3.00	0.343	7.00	0.800	3.00	0.343	7.00	0.800	3.00	0.343
Exterior Sheathing	0.07	7.00	0.459	7.00	0.459	1.00	0.066	1.00	0.066	1.00	0.066
Electrical wires pass	0.24	2.00	0.477	2.00	0.477	2.00	0.477	2.00	0.477	7.00	1.668
Electrical Boxes	0.23	3.00	0.690	3.00	0.690	3.00	0.690	8.00	1.841	3.00	0.690
Wall Sheetrock thickness	0.03	5.00	0.128	5.00	0.128	5.00	0.128	5.00	0.128	5.00	0.128
House Wrap	0.02	3.00	0.049	7.00	0.115	3.00	0.049	7.00	0.115	7.00	0.115
Exterior Siding	0.04	7.00	0.305	6.00	0.262	6.00	0.262	6.00	0.262	7.00	0.305
			0.419		0.478		0.375		0.553		0.505
ROOF ASSEMBLY											
Design Load	0.23	4.00	0.912	4.00	0.912	4.00	0.912	4.00	0.912	4.00	0.912
Roof Slope	0.09	3.00	0.278	3.00	0.278	3.00	0.278	3.00	0.278	5.00	0.463
Insulation R-value	0.20	6.00	1.228	6.00	1.228	6.00	1.228	6.00	1.228	6.00	1.228
Eave Projection	0.05	4.00	0.193	3.00	0.144	4.00	0.193	5.00	0.241	8.00	0.385
Eave Position	0.05	5.00	0.241	3.00	0.144	7.00	0.337	7.00	0.337	7.00	0.337
Ceiling board thickness	0.02	7.00	0.124	7.00	0.124	4.00	0.071	4.00	0.071	4.00	0.071
Roof Finish	0.11	7.00	0.776	7.00	0.776	7.00	0.776	7.00	0.776	7.00	0.776
Roof Sheathing	0.02	4.00	0.096	4.00	0.096	4.00	0.096	7.00	0.167	4.00	0.096
Valley flashing	0.07	7.00	0.497	7.00	0.497	7.00	0.497	7.00	0.497	7.00	0.497
Roof opening waterproofing	0.15	7.00	1.085	7.00	1.085	7.00	1.085	7.00	1.085	7.00	1.085
			0.543		0.528		0.547		0.559		0.585

Figure E2 IPIA 2-Normalized weighted scores for sub-systems (contd)

SUBSYSTEMS	Vector of Priorities	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
UTILITIES:											
Water pipe	0.20	4.00	0.792	4.00	0.792	4.00	0.792	4.00	0.792	4.00	0.792
Pipe fittings	0.21	8.00	1.658	6.00	1.243	7.00	1.451	6.00	1.243	6.00	1.243
Pipefitting fastenings	0.21	7.00	1.451	7.00	1.451	6.00	1.243	7.00	1.451	6.00	1.243
Drainage pipe	0.03	6.00	0.158	6.00	0.158	6.00	0.158	6.00	0.158	6.00	0.158
HVAC System	0.10	8.00	0.773	8.00	0.773	8.00	0.773	8.00	0.773	8.00	0.773
HVAC Duct	0.04	4.00	0.167	7.00	0.292	4.00	0.167	7.00	0.292	4.00	0.167
Register Positions	0.06	4.00	0.233	4.00	0.233	4.00	0.233	4.00	0.233	4.00	0.233
Bathtub and Shower	0.12	3.00	0.354	7.00	0.827	3.00	0.354	3.00	0.354	3.00	0.354
Shutoff valves	0.03	8.00	0.259	8.00	0.259	4.00	0.129	8.00	0.259	8.00	0.259
20 amp GFI's	0.01	7.00	0.100	4.00	0.057	7.00	0.100	7.00	0.100	4.00	0.057
			0.594		0.608		0.540		0.565		0.528
DOORS AND WINDOWS:											
Interior door width	0.18	6.00	1.069	6.00	1.069	7.00	1.247	6.00	1.069	6.00	1.069
Interior Door Height	0.07	4.00	0.298	4.00	0.298	4.00	0.298	4.00	0.298	8.00	0.595
Exterior door width	0.26	8.00	2.081	8.00	2.081	8.00	2.081	8.00	2.081	8.00	2.081
Number of Hinges Int doors	0.02	6.00	0.134	6.00	0.134	7.00	0.156	6.00	0.134	6.00	0.134
Hinge type	0.02	3.00	0.072	3.00	0.072	3.00	0.072	3.00	0.072	3.00	0.072
Window glass	0.07	4.00	0.281	6.00	0.421	6.00	0.421	6.00	0.421	6.00	0.421
Extrior door Type	0.14	4.00	0.544	8.00	1.087	4.00	0.544	8.00	1.087	8.00	1.087
Exterior door height	0.23	8.00	1.878	8.00	1.878	2.00	0.469	8.00	1.878	8.00	1.878
			0.636		0.704		0.529		0.704		0.734

Figure E2 IPIA 2-Normalized weighted scores for sub-systems (contd)

SUBSYSTEMS	Vector of Priorities	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
COSMETICS:											
Carpets	0.06	4.00	0.230	7.00	0.403	4.00	0.230	4.00	0.230	4.00	0.230
Shelves	0.02	2.00	0.039	2.00	0.039	2.00	0.039	8.00	0.157	8.00	0.157
Water Heater	0.17	3.00	0.500	7.00	1.167	3.00	0.500	3.00	0.500	7.00	1.167
Sheetrock finish	0.05	5.00	0.239	8.00	0.383	5.00	0.239	5.00	0.239	5.00	0.239
Sidewall height	0.17	7.00	1.188	7.00	1.188	3.00	0.509	7.00	1.188	7.00	1.188
Ceiling paint finishes	0.02	5.00	0.121	7.00	0.169	5.00	0.121	7.00	0.169	5.00	0.121
Trim around Interior doors	0.03	4.00	0.122	7.00	0.214	4.00	0.122	4.00	0.122	4.00	0.122
Trim around Exterior doors and windows	0.06	7.00	0.415	7.00	0.415	3.00	0.178	7.00	0.415	7.00	0.415
Mini-blinds	0.06	8.00	0.487	8.00	0.487	5.00	0.305	5.00	0.305	8.00	0.487
Refrigerator	0.03	7.00	0.176	6.00	0.151	6.00	0.151	7.00	0.176	7.00	0.176
Microwave	0.02	2.00	0.039	5.00	0.099	7.00	0.138	7.00	0.138	7.00	0.138
Dishwasher	0.15	8.00	1.214	8.00	1.214	8.00	1.214	8.00	1.214	8.00	1.214
Fireplace	0.01	5.00	0.066	5.00	0.066	4.00	0.053	5.00	0.066	5.00	0.066
Modular cabinet system	0.01	7.00	0.079	7.00	0.079	7.00	0.079	7.00	0.079	7.00	0.079
Outside water faucets	0.07	1.00	0.066	7.00	0.465	4.00	0.266	7.00	0.465	7.00	0.465
Plumbing for icemaker	0.07	7.00	0.457	7.00	0.457	3.00	0.196	3.00	0.196	7.00	0.457
Garbage Disposal	0.01	6.00	0.065	6.00	0.065	4.00	0.043	6.00	0.065	6.00	0.065
			0.550		0.706		0.438		0.572		0.679
TRANSPORTATION & SETUP:											
Setup on site responsibility	0.27	5.00	1.336	5.00	1.336	5.00	1.336	8.00	2.138	8.00	2.138
Transportation to site	0.22	3.00	0.650	3.00	0.650	3.00	0.650	8.00	1.734	6.00	1.301
Setup contractor	0.35	1.00	0.354	8.00	2.830	1.00	0.354	8.00	2.830	8.00	2.830
Orientation and walk through	0.13	8.00	1.046	8.00	1.046	8.00	1.046	8.00	1.046	8.00	1.046
Special walkthrough programs	0.03	1.00	0.032	1.00	0.032	1.00	0.032	8.00	0.252	1.00	0.032
			0.342		0.589		0.342		0.800		0.735
WARRANTIES:											
General	0.66	2.00	1.329	2.00	1.329	2.00	1.329	2.00	1.329	2.00	1.329
Structural system	0.21	2.00	0.428	8.00	1.712	2.00	0.428	2.00	0.428	8.00	1.712
Shingles	0.08	4.00	0.318	4.00	0.318	4.00	0.318	6.00	0.477	6.00	0.477
Siding	0.04	6.00	0.253	8.00	0.338	6.00	0.253	8.00	0.338	8.00	0.338
			0.233		0.370		0.233		0.257		0.386

Figure E2 IPIA 2-Normalized weighted scores for sub-systems (contd)

SUBSYSTEMS	Vector of Priorities	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
MATERIALS:											
Cabinets	0.12	3	0.365	3	0.365	3	0.365	3	0.365	3	0.365
Rollers	0.02	4	0.073	8	0.146	4	0.073	8	0.146	8	0.146
Bathtub and Shower	0.12	8	0.959	8	0.959	4	0.480	4	0.480	4	0.480
Vanity	0.06	3	0.194	3	0.194	3	0.194	3	0.194	8	0.517
Faucets	0.03	2	0.069	2	0.069	2	0.069	8	0.276	8	0.276
Ceiling Board Type	0.06	1	0.056	9	0.500	1	0.056	1	0.056	9	0.500
Wall Sheetrock type	0.11	5	0.537	7	0.751	5	0.537	5	0.537	5	0.537
Interior door style	0.04	4	0.149	7	0.260	4	0.149	4	0.149	4	0.149
Window Frame	0.04	7	0.276	4	0.158	4	0.158	4	0.158	7	0.276
Electrical Devices	0.40	4	1.605	8	3.211	4	1.605	4	1.605	4	1.605
			0.428		0.661		0.369		0.397		0.485
FLOOR ASSEMBLY											
Axles	0.03	5	0.139	5	0.139	5	0.139	5	0.139	5	0.139
Tires	0.07	5	0.338	5	0.338	5	0.338	5	0.338	8	0.541
Joist Size	0.13	5	0.625	5	0.625	5	0.625	5	0.625	5	0.625
Joist Spacing	0.13	9	1.125	9	1.125	9	1.125	9	1.125	9	1.125
Joist System	0.15	7	1.032	7	1.032	7	1.032	7	1.032	7	1.032
Insulation R-value	0.28	5	1.376	5	1.376	5	1.376	5	1.376	5	1.376
Decking material	0.14	8	1.150	8	1.150	4	0.575	8	1.150	4	0.575
Decking Thickness	0.09	6	0.529	6	0.529	5	0.440	7	0.617	6	0.529
			0.631		0.631		0.565		0.640		0.594

Figure E3 IPIA 3-Normalized weighted scores for sub-systems

SUBSYSTEMS	Vector of	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
WALL ASSEMBLY											
Stud size (Interior)	0.02	5	0.076	5	0.076	5	0.076	5	0.076	5	0.076
Exterior Bottom Plate size	0.02	5	0.076	7	0.107	5	0.076	7	0.107	5	0.076
Exterior Stud spacing	0.05	8	0.374	8	0.374	8	0.374	8	0.374	8	0.374
Stud size (Exterior)	0.05	5	0.248	5	0.248	5	0.248	5	0.248	5	0.248
Insulation R-value	0.06	3	0.192	3	0.192	3	0.192	3	0.192	3	0.192
Headers above openings	0.21	4	0.824	7	1.442	4	0.824	7	1.442	4	0.824
Exterior Sheathing	0.08	7	0.535	7	0.535	1	0.076	5	0.382	5	0.382
Electrical wires pass	0.14	5	0.685	5	0.685	5	0.685	5	0.685	5	0.685
Electrical Boxes	0.19	5	0.971	5	0.971	5	0.971	7	1.360	5	0.971
Wall Sheetrock thickness	0.06	5	0.283	5	0.283	5	0.283	5	0.283	5	0.283
House Wrap	0.06	1	0.058	8	0.466	1	0.058	8	0.466	8	0.466
Exterior Siding	0.08	8	0.646	5	0.403	5	0.403	7	0.565	8	0.646
			0.497		0.578		0.427		0.618		0.522
ROOF ASSEMBLY											
Design Load	0.24	5	1.193	5	1.193	5	1.193	5	1.193	5	1.193
Roof Slope	0.11	4	0.422	4	0.422	4	0.422	4	0.422	7	0.739
Insulation R-value	0.22	8	1.724	8	1.724	8	1.724	8	1.724	8	1.724
Eave Projection	0.03	6	0.164	3	0.082	6	0.164	7	0.191	9	0.246
Eave Position	0.04	8	0.284	5	0.178	8	0.284	8	0.284	8	0.284
Ceiling board thickness	0.08	4	0.308	5	0.385	4	0.308	4	0.308	4	0.308
Roof Finish	0.06	8	0.519	8	0.519	8	0.519	8	0.519	8	0.519
Roof Sheathing	0.07	8	0.545	8	0.545	8	0.545	6	0.408	8	0.545
Valley flashing	0.07	8	0.572	8	0.572	8	0.572	8	0.572	8	0.572
Roof opening waterproofing	0.10	9	0.865	9	0.865	9	0.865	9	0.865	9	0.865
			0.660		0.648		0.660		0.649		0.699

Figure E3 IPIA 3-Normalized weighted scores for sub-systems (contd)

SUBSYSTEMS	Vector of	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
UTILITIES:											
Water pipe	0.12	8	0.971	8	0.971	8	0.971	8	0.971	8	0.971
Pipe fittings	0.11	7	0.738	5	0.527	7	0.738	5	0.527	5	0.527
Pipefitting fastenings	0.15	5	0.752	5	0.752	7	1.052	5	0.752	7	1.052
Drainage pipe	0.09	5	0.461	5	0.461	5	0.461	5	0.461	5	0.461
HVAC System	0.09	5	0.472	5	0.472	5	0.472	5	0.472	5	0.472
HVAC Duct	0.09	4	0.378	8	0.756	4	0.378	8	0.756	4	0.378
Register Positions	0.02	4	0.084	4	0.084	4	0.084	4	0.084	4	0.084
Bathtub and Shower	0.05	5	0.246	7	0.344	5	0.246	5	0.246	5	0.246
Shutoff valves	0.09	8	0.759	8	0.759	4	0.379	8	0.759	8	0.759
20 amp GFI's	0.18	3	0.530	8	1.414	3	0.530	3	0.530	8	1.414
			0.539		0.654		0.531		0.556		0.636
DOORS AND WINDOWS:											
Interior door width	0.09	4	0.379	4	0.379	6	0.568	4	0.379	4	0.379
Interior Door Height	0.04	5	0.187	5	0.187	5	0.187	5	0.187	7	0.262
Exterior door width	0.17	8	1.357	8	1.357	8	1.357	8	1.357	8	1.357
Number of Hinges Int doors	0.08	4	0.335	4	0.335	7	0.586	4	0.335	4	0.335
Hinge type	0.08	5	0.412	5	0.412	5	0.412	5	0.412	5	0.412
Window glass	0.20	2	0.391	5	0.977	5	0.977	5	0.977	5	0.977
Extrior door Type	0.21	4	0.844	8	1.687	4	0.844	8	1.687	8	1.687
Exterior door height	0.13	8	1.007	8	1.007	3	0.378	8	1.007	8	1.007
			0.491		0.634		0.531		0.634		0.642

Figure E3 IPIA 3-Normalized weighted scores for sub-systems (contd)

SUBSYSTEMS	Vector of	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
COSMETICS:											
Carpets	0.12	4	0.476	8	0.953	4	0.476	4	0.476	4	0.476
Shelves	0.01	5	0.045	5	0.045	5	0.045	7	0.063	7	0.063
Water Heater	0.07	5	0.361	8	0.578	5	0.361	5	0.361	8	0.578
Sheetrock finish	0.11	5	0.566	8	0.906	5	0.566	5	0.566	5	0.566
Sidewall height	0.18	8	1.409	8	1.409	6	1.057	8	1.409	8	1.409
Ceiling paint finishes	0.07	5	0.332	8	0.531	5	0.332	8	0.531	5	0.332
Trim around Interior doors	0.05	4	0.190	8	0.379	4	0.190	4	0.190	4	0.190
Trim around Exterior doors and windows	0.05	7	0.332	7	0.332	5	0.237	7	0.332	7	0.332
Mini-blinds	0.01	7	0.099	7	0.099	6	0.085	6	0.085	7	0.099
Refrigerator	0.05	8	0.409	5	0.256	5	0.256	8	0.409	8	0.409
Microwave	0.03	2	0.052	8	0.206	6	0.155	6	0.155	6	0.155
Dishwasher	0.04	8	0.341	8	0.341	8	0.341	8	0.341	8	0.341
Fireplace	0.07	7	0.485	7	0.485	5	0.346	7	0.485	7	0.485
Modular cabinet system	0.08	8	0.656	8	0.656	8	0.656	8	0.656	8	0.656
Outside water faucets	0.02	2	0.030	8	0.122	5	0.076	8	0.122	8	0.122
Plumbing for icemaker	0.02	8	0.127	8	0.127	2	0.032	2	0.032	8	0.127
Garbage Disposal	0.03	7	0.232	7	0.232	4	0.132	7	0.232	7	0.232
			0.614		0.766		0.534		0.644		0.657
TRANSPORTATION & SETUP:											
Setup on site responsibility	0.52	5	2.624	5	2.624	5	2.624	7	3.674	7	3.674
Transportation to site	0.07	5	0.362	5	0.362	5	0.362	6	0.435	6	0.435
Setup contractor	0.25	3	0.758	8	2.021	3	0.758	8	2.021	8	2.021
Orientation and walk through	0.08	8	0.600	8	0.600	8	0.600	8	0.600	8	0.600
Special walkthrough programs	0.08	2	0.150	2	0.150	2	0.150	8	0.600	2	0.150
			0.449		0.576		0.449		0.733		0.688
WARRANTIES:											
General	0.65	6	3.885	6	3.885	6	3.885	6	3.885	6	3.885
Structural system	0.20	5	0.981	8	1.569	5	0.981	5	0.981	8	1.569
Shingles	0.08	4	0.313	4	0.313	4	0.313	6	0.469	6	0.469
Siding	0.08	6	0.469	8	0.626	6	0.469	8	0.626	8	0.626
			0.565		0.639		0.565		0.596		0.655

Figure E3 IPIA 3-Normalized weighted scores for sub-systems (contd)

SUBSYSTEMS	Vector of	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
MATERIALS:											
Cabinets	0.11	3.00	0.328	3.00	0.328	3.00	0.328	3.00	0.328	3.00	0.328
Rollers	0.02	2.67	0.053	8.00	0.160	2.67	0.053	8.00	0.160	8.00	0.160
Bathtub and Shower	0.16	8.33	1.365	8.33	1.365	3.67	0.601	3.67	0.601	3.50	0.573
Vanity	0.05	3.00	0.162	3.00	0.162	3.00	0.162	3.00	0.162	7.50	0.405
Faucets	0.06	2.00	0.110	2.00	0.110	2.00	0.110	8.00	0.441	8.00	0.441
Ceiling Board Type	0.06	2.00	0.112	8.00	0.448	2.00	0.112	2.00	0.112	7.50	0.420
Wall Sheetrock type	0.04	4.33	0.189	7.67	0.334	4.33	0.189	4.33	0.189	4.00	0.174
Interior door style	0.03	3.00	0.088	7.00	0.205	3.00	0.088	3.00	0.088	2.50	0.073
Window Frame	0.05	7.67	0.405	4.67	0.247	4.67	0.247	4.67	0.247	8.00	0.423
Electrical Devices	0.42	3.33	1.387	8.00	3.329	3.33	1.387	3.33	1.387	3.00	1.248
			0.420		0.669		0.328		0.371		0.425
FLOOR ASSEMBLY											
Axles	0.04	4.33	0.169	4.33	0.169	4.33	0.169	4.33	0.169	4.33	0.169
Tires	0.03	4.33	0.139	4.33	0.139	4.33	0.139	4.33	0.139	8.33	0.268
Joist Size	0.15	5.33	0.796	5.33	0.796	5.33	0.796	5.33	0.796	5.33	0.796
Joist Spacing	0.19	8.33	1.616	8.33	1.616	8.33	1.616	8.33	1.616	8.33	1.616
Joist System	0.15	7.00	1.031	7.00	1.031	7.00	1.031	7.00	1.031	7.00	1.031
Insulation R-value	0.12	5.33	0.657	5.33	0.657	5.33	0.657	5.33	0.657	5.33	0.657
Decking material	0.19	6.67	1.293	8.00	1.551	5.00	0.970	8.00	1.551	5.00	0.970
Decking Thickness	0.12	5.67	0.688	5.00	0.607	4.67	0.566	7.00	0.850	5.67	0.688
			0.639		0.657		0.594		0.681		0.619

Figure E4 Average-Normalized weighted scores for sub-systems

SUBSYSTEMS	Vector of	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
WALL ASSEMBLY											
Stud size (Interior)	0.02	4.33	0.107	4.33	0.107	4.33	0.107	4.33	0.107	4.33	0.107
Exterior Bottom Plate size	0.02	3.67	0.079	7.67	0.166	3.67	0.079	7.67	0.166	3.67	0.079
Exterior Stud spacing	0.08	7.67	0.625	7.67	0.625	7.67	0.625	7.67	0.625	7.67	0.625
Stud size (Exterior)	0.07	5.67	0.391	5.67	0.391	5.67	0.391	5.67	0.391	5.67	0.391
Insulation R-value	0.10	5.33	0.554	5.33	0.554	5.33	0.554	5.33	0.554	5.33	0.554
Headers above openings	0.21	3.67	0.773	7.00	1.475	3.67	0.773	7.00	1.475	3.67	0.773
Exterior Sheathing	0.13	7.33	0.939	7.33	0.939	1.00	0.128	3.33	0.427	3.33	0.427
Electrical wires pass	0.11	3.33	0.382	3.33	0.382	3.33	0.382	3.33	0.382	6.33	0.725
Electrical Boxes	0.14	3.33	0.465	3.33	0.465	3.33	0.465	7.67	1.069	3.33	0.465
Wall Sheetrock thickness	0.03	4.00	0.105	4.67	0.122	4.67	0.122	4.67	0.122	4.67	0.122
House Wrap	0.02	2.00	0.045	6.67	0.151	2.00	0.045	6.67	0.151	6.67	0.151
Exterior Siding	0.06	7.00	0.405	6.00	0.347	6.00	0.347	6.67	0.385	7.00	0.405
		0.48	0.487	0.58	0.572	0.42	0.402	0.58	0.585	0.51	0.482
ROOF ASSEMBLY											
Design Load	0.34	4.33	1.481	4.33	1.481	4.33	1.481	4.33	1.481	4.33	1.481
Roof Slope	0.08	4.00	0.327	4.00	0.327	4.00	0.327	4.00	0.327	6.33	0.517
Insulation R-value	0.18	7.33	1.302	7.33	1.302	7.33	1.302	7.33	1.302	7.33	1.302
Eave Projection	0.05	5.33	0.264	3.67	0.182	5.33	0.264	6.33	0.314	8.67	0.430
Eave Position	0.04	6.67	0.266	4.33	0.173	7.33	0.293	7.33	0.293	7.33	0.293
Ceiling board thickness	0.03	5.00	0.167	6.00	0.200	4.00	0.134	4.00	0.134	4.00	0.134
Roof Finish	0.08	7.67	0.643	7.67	0.643	7.67	0.643	7.67	0.643	7.67	0.643
Roof Sheathing	0.04	4.67	0.167	4.67	0.167	4.67	0.167	7.00	0.251	4.67	0.167
Valley flashing	0.06	7.00	0.417	7.00	0.417	7.00	0.417	7.00	0.417	7.00	0.417
Roof opening waterproofing	0.10	7.67	0.742	7.67	0.742	7.67	0.742	7.67	0.742	7.67	0.742
			0.578		0.563		0.577		0.590		0.613

Figure E4 Average-Normalized weighted scores for sub-systems (contd)

SUBSYSTEMS	Vector of	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
UTILITIES:											
Water pipe	0.16	5.33	0.868	5.33	0.868	5.33	0.868	5.33	0.868	5.33	0.868
Pipe fittings	0.18	7.00	1.278	5.33	0.974	6.67	1.217	5.33	0.974	5.33	0.974
Pipefitting fastenings	0.17	6.33	1.060	6.33	1.060	6.00	1.004	6.33	1.060	6.00	1.004
Drainage pipe	0.07	5.67	0.395	5.67	0.395	5.67	0.395	5.67	0.395	5.67	0.395
HVAC System	0.13	7.00	0.881	7.00	0.881	7.00	0.881	7.00	0.881	7.00	0.881
HVAC Duct	0.07	4.00	0.282	7.33	0.517	4.00	0.282	7.33	0.517	4.00	0.282
Register Positions	0.04	4.33	0.183	4.33	0.183	4.33	0.183	4.33	0.183	4.33	0.183
Bathtub and Shower	0.10	4.00	0.415	7.00	0.725	4.00	0.415	4.00	0.415	4.00	0.415
Shutoff valves	0.04	8.00	0.282	8.00	0.282	4.00	0.141	8.00	0.282	8.00	0.282
20 amp GFI's	0.04	5.67	0.227	5.67	0.227	5.67	0.227	5.67	0.227	5.67	0.227
			0.587		0.611		0.561		0.580		0.551
DOORS AND WINDOWS:											
Interior door width	0.13	5.33	0.714	5.33	0.714	6.67	0.892	5.33	0.714	5.33	0.714
Interior Door Height	0.06	4.33	0.275	4.33	0.275	4.33	0.275	4.33	0.275	7.67	0.486
Exterior door width	0.25	8.00	1.963	8.00	1.963	8.00	1.963	8.00	1.963	8.00	1.963
Number of Hinges Int doors	0.04	5.33	0.187	5.33	0.187	7.33	0.257	5.33	0.187	5.33	0.187
Hinge type	0.03	3.67	0.111	3.67	0.111	3.67	0.111	3.67	0.111	3.67	0.111
Window glass	0.16	2.67	0.420	5.00	0.788	5.00	0.788	5.00	0.788	5.00	0.788
Extrior door Type	0.19	4.00	0.768	8.00	1.535	4.00	0.768	8.00	1.535	8.00	1.535
Exterior door height	0.14	8.00	1.142	8.00	1.142	3.00	0.428	8.00	1.142	8.00	1.142
			0.558		0.671		0.548		0.671		0.692

Figure E4 Average-Normalized weighted scores for sub-systems (contd)

SUBSYSTEMS	Vector of	HOUSE-1		HOUSE-2		HOUSE-3		HOUSE-4		HOUSE-5	
		M	*W*	*M*	*W*	*M*	*W*	*M*	*W*	*M*	*W*
COSMETICS:											
Carpets	0.10	4.33	0.429	7.33	0.726	4.33	0.429	4.33	0.429	4.33	0.429
Shelves	0.02	4.00	0.077	4.00	0.077	4.00	0.077	7.33	0.140	7.33	0.140
Water Heater	0.16	4.33	0.682	7.00	1.102	4.33	0.682	4.33	0.682	7.00	1.102
Sheetrock finish	0.07	5.00	0.335	8.00	0.536	5.00	0.335	5.00	0.335	5.00	0.335
Sidewall height	0.19	7.33	1.406	7.33	1.406	4.67	0.894	7.33	1.406	7.33	1.406
Ceiling paint finishes	0.05	4.67	0.232	7.33	0.365	4.67	0.232	7.33	0.365	4.67	0.232
Trim around Interior doors	0.04	4.33	0.160	7.33	0.271	4.33	0.160	4.33	0.160	4.33	0.160
Trim around Exterior doors and windows	0.07	7.00	0.501	7.00	0.501	4.00	0.287	7.00	0.501	7.00	0.501
Mini-blinds	0.03	7.67	0.235	7.67	0.235	5.33	0.163	5.33	0.163	7.67	0.235
Refrigerator	0.04	7.33	0.282	5.67	0.218	5.67	0.218	7.33	0.282	7.33	0.282
Microwave	0.03	2.00	0.052	6.00	0.157	6.67	0.174	6.67	0.174	6.67	0.174
Dishwasher	0.07	7.67	0.521	7.67	0.521	7.67	0.521	7.67	0.521	7.67	0.521
Fireplace	0.03	5.67	0.197	5.67	0.197	4.33	0.151	5.67	0.197	5.67	0.197
Modular cabinet system	0.04	7.00	0.277	7.00	0.277	7.00	0.277	7.00	0.277	7.00	0.277
Outside water faucets	0.03	1.67	0.045	7.33	0.197	4.67	0.125	6.67	0.179	7.33	0.197
Plumbing for icemaker	0.03	7.33	0.195	7.33	0.195	3.00	0.080	4.00	0.106	7.33	0.195
Garbage Disposal	0.02	6.67	0.112	6.67	0.112	4.00	0.067	6.67	0.112	6.67	0.112
			0.574		0.709		0.487		0.603		0.649
TRANSPORTATION & SETUP:											
Setup on site responsibility	0.41	5.00	2.067	5.00	2.067	5.00	2.067	7.67	3.169	7.67	3.169
Transportation to site	0.11	3.67	0.412	3.67	0.412	3.67	0.412	7.33	0.824	6.00	0.674
Setup contractor	0.27	1.67	0.454	8.00	2.181	1.67	0.454	8.00	2.181	8.00	2.181
Orientation and walk through	0.13	8.33	1.091	8.33	1.091	8.33	1.091	8.33	1.091	8.33	1.091
Special walkthrough programs	0.07	1.33	0.094	1.33	0.094	1.33	0.094	8.33	0.590	1.33	0.094
			0.412		0.585		0.412		0.785		0.721
WARRANTIES:											
General	0.64	3.33	2.148	3.33	2.148	3.33	2.148	3.33	2.148	3.33	2.148
Structural system	0.24	3.00	0.714	8.00	1.904	3.00	0.714	3.00	0.714	8.00	1.904
Shingles	0.07	5.33	0.358	4.00	0.268	4.00	0.268	6.00	0.402	6.00	0.402
Siding	0.05	6.00	0.303	8.00	0.404	6.00	0.303	8.00	0.404	8.00	0.404
			0.352		0.472		0.343		0.367		0.486

Figure E4 Average-Normalized weighted scores for sub-systems (contd)

APPENDIX F

MATRIX OF COMPARISONS AND VECTOR OF PRIORITIES FOR MANUFACTURED HOUSES

Materials

Houses	H1	H2	H3	H4	H5
score	0.43	0.74	0.33	0.36	0.46

	H1	H2	H3	H4	H5
H1	1.00	0.58	1.31	1.20	0.93
H2	1.72	1.00	2.25	2.06	1.60
H3	0.76	0.44	1.00	0.92	0.71
H4	1.72	0.48	1.09	1.00	0.78
H5	1.07	0.44	1.40	1.29	1.00
	6.27	2.96	7.05	6.47	5.03

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.160	0.197	0.186	0.186	0.186	**0.183**
H2	0.274	0.338	0.319	0.319	0.319	**0.314**
H3	0.122	0.150	0.142	0.142	0.142	**0.140**
H4	0.274	0.164	0.155	0.155	0.155	**0.180**
H5	0.171	0.150	0.199	0.199	0.199	**0.184**

Floor Assembly

Houses	H1	H2	H3	H4	H5
score	0.65	0.69	0.65	0.71	0.66

	H1	H2	H3	H4	H5
H1	1.00	0.94	1.00	0.92	0.98
H2	1.07	1.00	1.07	0.98	1.05
H3	1.00	0.94	1.00	0.92	0.98
H4	1.07	1.02	1.09	1.00	1.07
H5	1.02	0.94	1.02	0.93	1.00
	5.15	4.83	5.17	4.75	5.09

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.194	0.194	0.193	0.193	0.193	**0.194**
H2	0.207	0.207	0.206	0.206	0.206	**0.206**
H3	0.194	0.194	0.193	0.193	0.193	**0.194**
H4	0.207	0.211	0.211	0.211	0.211	**0.210**
H5	0.198	0.194	0.197	0.197	0.197	**0.196**

Figure F1 IPIA 1 Matrix of Comparisons and Vector of priorities for manufactured houses

Wall Assembly

Houses	H1	H2	H3	H4	H5
score	0.50	0.61	0.40	0.60	0.47

	H1	H2	H3	H4	H5
H1	1.00	0.81	1.23	0.82	1.06
H2	1.23	1.00	1.52	1.01	1.30
H3	0.81	0.66	1.00	0.67	0.86
H4	1.23	0.99	1.50	1.00	1.29
H5	0.95	0.66	1.17	0.78	1.00
	5.22	4.12	6.42	4.28	5.50

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.191	0.197	0.240	0.175	0.212	**0.203**
H2	0.236	0.243	0.296	0.216	0.261	**0.250**
H3	0.155	0.160	0.195	0.142	0.172	**0.165**
H4	0.236	0.240	0.292	0.214	0.258	**0.248**
H5	0.181	0.160	0.227	0.166	0.201	**0.187**

Roof Assembly

Houses	H1	H2	H3	H4	H5
score	0.52	0.53	0.52	0.57	0.54

	H1	H2	H3	H4	H5
H1	1.00	0.99	1.00	0.91	0.97
H2	1.01	1.00	1.01	0.92	0.98
H3	1.00	0.99	1.00	0.91	0.97
H4	1.01	1.09	1.10	1.00	1.07
H5	1.03	0.99	1.03	0.94	1.00
	5.05	5.06	5.14	4.68	4.99

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1979	0.1957	0.1946	0.1946	0.1946	**0.1955**
H2	0.2000	0.1978	0.1966	0.1966	0.1966	**0.1975**
H3	0.1979	0.1957	0.1946	0.1946	0.1946	**0.1955**
H4	0.2000	0.2149	0.2137	0.2137	0.2137	**0.2112**
H5	0.2041	0.1957	0.2006	0.2006	0.2006	**0.2003**

Figure F1 IPIA 1 Matrix of Comparisons and Vector of priorities for manufactured houses (contd)

Utilities

Houses	H1	H2	H3	H4	H5
score	0.60	0.63	0.59	0.62	0.54

	H1	H2	H3	H4	H5
H1	1.00	0.96	1.02	0.96	1.12
H2	1.04	1.00	1.06	1.00	1.16
H3	0.98	0.94	1.00	0.94	1.09
H4	1.04	1.00	1.06	1.00	1.16
H5	0.90	0.94	0.92	0.86	1.00
	4.95	4.84	5.06	4.77	5.52

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.2019	0.1987	0.2020	0.2020	0.2020	**0.2013**
H2	0.2099	0.2066	0.2100	0.2100	0.2100	**0.2093**
H3	0.1974	0.1943	0.1975	0.1975	0.1975	**0.1968**
H4	0.2099	0.2061	0.2094	0.2094	0.2094	**0.2088**
H5	0.1810	0.1943	0.1811	0.1811	0.1811	**0.1837**

Doors & Windows

Houses	H1	H2	H3	H4	H5
score	0.45	0.62	0.47	0.62	0.64

	H1	H2	H3	H4	H5
H1	1.00	0.72	0.94	0.72	0.69
H2	1.39	1.00	1.31	1.00	0.96
H3	1.06	0.76	1.00	0.76	0.74
H4	1.39	1.00	1.31	1.00	0.96
H5	1.45	0.76	1.36	1.04	1.00
	6.30	4.24	5.92	4.52	4.35

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1588	0.1690	0.1588	0.1588	0.1588	**0.1608**
H2	0.2214	0.2357	0.2214	0.2214	0.2214	**0.2243**
H3	0.1688	0.1798	0.1688	0.1688	0.1688	**0.1710**
H4	0.2214	0.2357	0.2214	0.2214	0.2214	**0.2243**
H5	0.2297	0.1798	0.2297	0.2297	0.2297	**0.2197**

Figure F1 IPIA 1 Matrix of Comparisons and Vector of priorities for manufactured houses (contd)

Cosmetics

Houses	H1	H2	H3	H4	H5
score	0.56	0.64	0.50	0.61	0.62

	H1	H2	H3	H4	H5
H1	1.00	0.87	1.13	0.92	0.91
H2	1.14	1.00	1.29	1.06	1.04
H3	0.89	0.78	1.00	0.82	0.80
H4	1.14	0.95	1.22	1.00	0.98
H5	1.10	0.78	1.25	1.02	1.00
	5.28	4.37	5.88	4.81	4.73

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1894	0.1999	0.1916	0.1916	0.1916	**0.1928**
H2	0.2167	0.2287	0.2192	0.2192	0.2192	**0.2206**
H3	0.1680	0.1773	0.1699	0.1699	0.1699	**0.1710**
H4	0.2167	0.2167	0.2077	0.2077	0.2077	**0.2113**
H5	0.2092	0.1773	0.2116	0.2116	0.2116	**0.2043**

Transportation & Setup

Houses	H1	H2	H3	H4	H5
score	0.40	0.47	0.40	0.87	0.52

	H1	H2	H3	H4	H5
H1	1.00	0.86	1.00	0.46	0.77
H2	1.16	1.00	1.16	0.53	0.89
H3	1.00	0.86	1.00	0.46	0.77
H4	1.16	1.87	2.18	1.00	1.67
H5	1.30	0.86	1.30	0.60	1.00
	5.62	5.46	6.63	3.05	5.11

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1779	0.1578	0.1507	0.1507	0.1507	**0.1576**
H2	0.2065	0.1832	0.1750	0.1750	0.1750	**0.1829**
H3	0.1779	0.1578	0.1507	0.1507	0.1507	**0.1576**
H4	0.2065	0.3433	0.3278	0.3278	0.3278	**0.3067**
H5	0.2311	0.1578	0.1957	0.1957	0.1957	**0.1952**

Figure F1 IPIA 1 Matrix of Comparisons and Vector of priorities for manufactured houses (contd)

Warranties

Houses	H1	H2	H3	H4	H5
score	0.25	0.41	0.23	0.25	0.42

	H1	H2	H3	H4	H5
H1	1.00	0.61	1.09	1.00	0.60
H2	1.64	1.00	1.78	1.64	0.98
H3	0.92	0.56	1.00	0.92	0.55
H4	1.64	0.61	1.09	1.00	0.60
H5	1.68	0.56	1.82	1.68	1.00
	6.88	3.34	6.77	6.24	3.72

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1453	0.1824	0.1602	0.1602	0.1602	**0.1617**
H2	0.2383	0.2991	0.2628	0.2628	0.2628	**0.2652**
H3	0.1339	0.1681	0.1477	0.1477	0.1477	**0.1490**
H4	0.2383	0.1824	0.1602	0.1602	0.1602	**0.1803**
H5	0.2440	0.1681	0.2691	0.2691	0.2691	**0.2439**

Figure F1 IPIA 1 Matrix of Comparisons and Vector of priorities for manufactured houses (contd)

Materials

Houses	H1	H2	H3	H4	H5
score	0.42	0.61	0.30	0.38	0.43

	H1	H2	H3	H4	H5
H1	1.00	0.69	1.40	1.10	0.97
H2	1.46	1.00	2.04	1.61	1.41
H3	0.71	0.49	1.00	0.79	0.69
H4	1.46	0.62	1.27	1.00	0.88
H5	1.03	0.49	1.45	1.14	1.00
	5.67	3.29	7.16	5.64	4.95

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.176	0.209	0.196	0.196	0.196	**0.194**
H2	0.257	0.304	0.285	0.285	0.285	**0.283**
H3	0.126	0.149	0.140	0.140	0.140	**0.139**
H4	0.257	0.189	0.177	0.177	0.177	**0.196**
H5	0.182	0.149	0.202	0.202	0.202	**0.188**

Floor Assembly

Houses	H1	H2	H3	H4	H5
score	0.59	0.62	0.54	0.68	0.58

	H1	H2	H3	H4	H5
H1	1.00	0.97	1.11	0.87	1.03
H2	1.04	1.00	1.15	0.91	1.07
H3	0.90	0.87	1.00	0.79	0.93
H4	1.04	1.10	1.27	1.00	1.18
H5	0.97	0.87	1.07	0.85	1.00
	4.94	4.81	5.60	4.41	5.22

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.202	0.201	0.198	0.198	0.198	**0.199**
H2	0.210	0.208	0.205	0.205	0.205	**0.207**
H3	0.182	0.181	0.178	0.178	0.178	**0.180**
H4	0.210	0.230	0.227	0.227	0.227	**0.224**
H5	0.196	0.181	0.192	0.192	0.192	**0.190**

Figure F2 IPIA 2 Matrix of Comparisons and Vector of priorities for manufactured houses

Wall Assembly

Houses	H1	H2	H3	H4	H5
score	0.42	0.48	0.37	0.55	0.50

	H1	H2	H3	H4	H5
H1	1.00	0.88	1.12	0.76	0.83
H2	1.14	1.00	1.27	0.86	0.95
H3	0.90	0.78	1.00	0.68	0.74
H4	1.14	1.16	1.48	1.00	1.10
H5	1.21	0.78	1.35	0.91	1.00
	5.38	4.60	6.21	4.21	4.61

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.186	0.190	0.221	0.153	0.176	**0.185**
H2	0.212	0.217	0.252	0.175	0.200	**0.211**
H3	0.166	0.170	0.198	0.137	0.157	**0.166**
H4	0.212	0.252	0.292	0.202	0.232	**0.238**
H5	0.224	0.170	0.267	0.185	0.212	**0.212**

Roof Assembly

Houses	H1	H2	H3	H4	H5
score	0.54	0.53	0.55	0.56	0.58

	H1	H2	H3	H4	H5
H1	1.00	1.03	0.99	0.97	0.93
H2	0.97	1.00	0.97	0.94	0.90
H3	1.01	1.04	1.00	0.98	0.94
H4	0.97	1.06	1.02	1.00	0.96
H5	1.08	1.04	1.07	1.05	1.00
	5.03	5.16	5.05	4.94	4.72

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1987	0.1992	0.1965	0.1965	0.1965	**0.1975**
H2	0.1934	0.1939	0.1913	0.1913	0.1913	**0.1922**
H3	0.2003	0.2008	0.1981	0.1981	0.1981	**0.1991**
H4	0.1934	0.2052	0.2024	0.2024	0.2024	**0.2012**
H5	0.2141	0.2008	0.2117	0.2117	0.2117	**0.2100**

Figure F2 IPIA 2 Matrix of Comparisons and Vector of priorities for manufactured houses (contd)

Utilities

Houses	H1	H2	H3	H4	H5
score	0.59	0.61	0.54	0.57	0.53

	H1	H2	H3	H4	H5
H1	1.00	0.98	1.10	1.05	1.13
H2	1.02	1.00	1.13	1.08	1.15
H3	0.91	0.89	1.00	0.95	1.02
H4	1.02	0.93	1.05	1.00	1.07
H5	0.89	0.89	0.98	0.93	1.00
	4.84	4.68	5.25	5.02	5.37

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.2064	0.2087	0.2096	0.2096	0.2096	**0.2088**
H2	0.2113	0.2136	0.2145	0.2145	0.2145	**0.2137**
H3	0.1876	0.1896	0.1904	0.1904	0.1904	**0.1897**
H4	0.2113	0.1985	0.1994	0.1994	0.1994	**0.2016**
H5	0.1834	0.1896	0.1861	0.1861	0.1861	**0.1863**

Doors & Windows

Houses	H1	H2	H3	H4	H5
score	0.64	0.70	0.53	0.70	0.73

	H1	H2	H3	H4	H5
H1	1.00	0.90	1.20	0.90	0.87
H2	1.11	1.00	1.33	1.00	0.96
H3	0.83	0.75	1.00	0.75	0.72
H4	1.11	1.00	1.33	1.00	0.96
H5	1.15	0.75	1.39	1.04	1.00
	5.20	4.41	6.25	4.70	4.51

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1922	0.2049	0.1922	0.1922	0.1922	**0.1948**
H2	0.2129	0.2270	0.2129	0.2129	0.2129	**0.2157**
H3	0.1600	0.1705	0.1600	0.1600	0.1600	**0.1621**
H4	0.2129	0.2270	0.2129	0.2129	0.2129	**0.2157**
H5	0.2219	0.1705	0.2219	0.2219	0.2219	**0.2117**

Figure F2 IPIA 2 Matrix of Comparisons and Vector of priorities for manufactured houses (contd)

Cosmetics

Houses	H1	H2	H3	H4	H5
score	0.55	0.71	0.44	0.57	0.68

	H1	H2	H3	H4	H5
H1	1.00	0.78	1.26	0.96	0.81
H2	1.28	1.00	1.61	1.23	1.04
H3	0.80	0.62	1.00	0.77	0.65
H4	1.28	0.81	1.31	1.00	0.84
H5	1.23	0.62	1.55	1.19	1.00
	5.59	3.83	6.72	5.15	4.34

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1787	0.2035	0.1869	0.1869	0.1869	**0.1886**
H2	0.2293	0.2610	0.2397	0.2397	0.2397	**0.2418**
H3	0.1423	0.1620	0.1488	0.1488	0.1488	**0.1501**
H4	0.2293	0.2116	0.1943	0.1943	0.1943	**0.2048**
H5	0.2204	0.1620	0.2304	0.2304	0.2304	**0.2147**

Transportation & Setup

Houses	H1	H2	H3	H4	H5
score	0.34	0.59	0.34	0.80	0.73

	H1	H2	H3	H4	H5
H1	1.00	0.58	1.00	0.43	0.47
H2	1.72	1.00	1.72	0.74	0.80
H3	1.00	0.58	1.00	0.43	0.47
H4	1.72	1.36	2.34	1.00	1.09
H5	2.15	0.58	2.15	0.92	1.00
	7.60	4.10	8.21	3.51	3.82

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1316	0.1415	0.1217	0.1217	0.1217	**0.1277**
H2	0.2270	0.2441	0.2099	0.2099	0.2099	**0.2202**
H3	0.1316	0.1415	0.1217	0.1217	0.1217	**0.1277**
H4	0.2270	0.3313	0.2849	0.2849	0.2849	**0.2826**
H5	0.2829	0.1415	0.2616	0.2616	0.2616	**0.2419**

Figure F2 IPIA 2 Matrix of Comparisons and Vector of priorities for manufactured houses (contd)

Warranties

Houses	H1	H2	H3	H4	H5
score	*0.23*	*0.37*	*0.23*	*0.26*	*0.39*

	H1	H2	H3	H4	H5
H1	*1.00*	*0.63*	*1.00*	*0.91*	*0.60*
H2	*1.59*	*1.00*	*1.59*	*1.44*	*0.96*
H3	*1.00*	*0.63*	*1.00*	*0.91*	*0.60*
H4	*1.59*	*0.70*	*1.10*	*1.00*	*0.67*
H5	*1.66*	*0.63*	*1.66*	*1.50*	*1.00*
	6.83	3.58	6.35	5.75	3.83

	H1	H2	H3	H4	H5	Vector of Priorities
H1	*0.1464*	*0.1757*	*0.1575*	*0.1575*	*0.1575*	***0.1589***
H2	*0.2324*	*0.2790*	*0.2501*	*0.2501*	*0.2501*	***0.2523***
H3	*0.1464*	*0.1757*	*0.1575*	*0.1575*	*0.1575*	***0.1589***
H4	*0.2324*	*0.1940*	*0.1740*	*0.1740*	*0.1740*	***0.1897***
H5	*0.2424*	*0.1757*	*0.2609*	*0.2609*	*0.2609*	***0.2401***

Figure F2 IPIA 2 Matrix of Comparisons and Vector of priorities for manufactured houses (contd)

Materials

Houses	H1	H2	H3	H4	H5
Score	0.43	0.66	0.37	0.40	0.49

	H1	H2	H3	H4	H5
H1	1.00	0.65	1.16	1.08	0.88
H2	1.54	1.00	1.79	1.67	1.36
H3	0.86	0.56	1.00	0.93	0.76
H4	1.54	0.60	1.08	1.00	0.82
H5	1.13	0.56	1.32	1.22	1.00
	6.08	3.36	6.35	5.90	4.82

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.164	0.193	0.183	0.183	0.183	**0.181**
H2	0.254	0.297	0.283	0.283	0.283	**0.280**
H3	0.141	0.166	0.157	0.157	0.157	**0.156**
H4	0.254	0.178	0.169	0.169	0.169	**0.188**
H5	0.186	0.166	0.207	0.207	0.207	**0.195**

Floor Assembly

Houses	H1	H2	H3	H4	H5
Score	0.63	0.63	0.57	0.64	0.59

	H1	H2	H3	H4	H5
H1	1.00	1.00	1.12	0.99	1.06
H2	1.00	1.00	1.12	0.99	1.06
H3	0.89	0.89	1.00	0.88	0.95
H4	1.00	1.01	1.13	1.00	1.08
H5	0.94	0.89	1.05	0.93	1.00
	4.84	4.80	5.42	4.78	5.15

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.207	0.208	0.206	0.206	0.206	**0.207**
H2	0.207	0.208	0.206	0.206	0.206	**0.207**
H3	0.185	0.186	0.185	0.185	0.185	**0.185**
H4	0.207	0.211	0.209	0.209	0.209	**0.209**
H5	0.195	0.186	0.194	0.194	0.194	**0.193**

Figure F3 IPIA 3 Matrix of Comparisons and Vector of priorities for manufactured houses

Wall Assembly

Houses	H1	H2	H3	H4	H5
Score	0.50	0.58	0.43	0.62	0.52

	H1	H2	H3	H4	H5
H1	1.00	0.86	1.16	0.80	0.95
H2	1.16	1.00	1.35	0.94	1.11
H3	0.86	0.74	1.00	0.69	0.82
H4	1.16	1.07	1.45	1.00	1.18
H5	1.05	0.74	1.22	0.85	1.00
	5.24	4.40	6.19	4.28	5.06

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.191	0.195	0.232	0.157	0.201	**0.195**
H2	0.222	0.227	0.270	0.183	0.234	**0.227**
H3	0.164	0.168	0.199	0.135	0.172	**0.168**
H4	0.222	0.243	0.288	0.196	0.250	**0.240**
H5	0.201	0.168	0.243	0.165	0.211	**0.198**

Roof Assembly

Houses	H1	H2	H3	H4	H5
Score	0.66	0.65	0.66	0.65	0.70

	H1	H2	H3	H4	H5
H1	1.00	1.02	1.00	1.02	0.94
H2	0.98	1.00	0.98	1.00	0.93
H3	1.00	1.02	1.00	1.02	0.94
H4	0.98	1.00	0.98	1.00	0.93
H5	1.06	1.02	1.06	1.08	1.00
	5.03	5.05	5.03	5.11	4.74

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1989	0.2013	0.1989	0.1989	0.1989	**0.1994**
H2	0.1956	0.1979	0.1956	0.1956	0.1956	**0.1960**
H3	0.1989	0.2013	0.1989	0.1989	0.1989	**0.1994**
H4	0.1956	0.1980	0.1956	0.1956	0.1956	**0.1961**
H5	0.2110	0.2013	0.2109	0.2109	0.2109	**0.2090**

Figure F3 IPIA 3 Matrix of Comparisons and Vector of priorities for manufactured houses (contd)

Utilities

Houses	H1	H2	H3	H4	H5
score	0.54	0.65	0.53	0.56	0.64

	H1	H2	H3	H4	H5
H1	1.00	0.82	1.01	0.97	0.85
H2	1.21	1.00	1.23	1.18	1.03
H3	0.99	0.81	1.00	0.96	0.83
H4	1.21	0.85	1.05	1.00	0.87
H5	1.18	0.81	1.20	1.15	1.00
	5.59	4.30	5.49	5.25	4.58

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1788	0.1918	0.1848	0.1848	0.1848	**0.1850**
H2	0.2169	0.2326	0.2242	0.2242	0.2242	**0.2245**
H3	0.1762	0.1890	0.1821	0.1821	0.1821	**0.1823**
H4	0.2169	0.1977	0.1906	0.1906	0.1906	**0.1973**
H5	0.2111	0.1890	0.2182	0.2182	0.2182	**0.2109**

Doors & Windows

Houses	H1	H2	H3	H4	H5
score	0.49	0.63	0.53	0.63	0.64

	H1	H2	H3	H4	H5
H1	1.00	0.77	0.93	0.77	0.77
H2	1.29	1.00	1.19	1.00	0.99
H3	1.08	0.84	1.00	0.84	0.83
H4	1.29	1.00	1.19	1.00	0.99
H5	1.31	0.84	1.21	1.01	1.00
	5.97	4.45	5.52	4.62	4.57

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1675	0.1741	0.1675	0.1675	0.1675	**0.1688**
H2	0.2163	0.2248	0.2163	0.2163	0.2163	**0.2180**
H3	0.1811	0.1882	0.1811	0.1811	0.1811	**0.1825**
H4	0.2163	0.2248	0.2163	0.2163	0.2163	**0.2180**
H5	0.2188	0.1882	0.2188	0.2188	0.2188	**0.2127**

Figure F3 IPIA 3 Matrix of Comparisons and Vector of priorities for manufactured houses (contd)

Cosmetics

Houses	H1	H2	H3	H4	H5
score	0.61	0.77	0.53	0.64	0.66

	H1	H2	H3	H4	H5
H1	1.00	0.80	1.15	0.95	0.93
H2	1.25	1.00	1.43	1.19	1.17
H3	0.87	0.70	1.00	0.83	0.81
H4	1.25	0.84	1.21	1.00	0.98
H5	1.07	0.70	1.23	1.02	1.00
	5.43	4.04	6.02	4.99	4.89

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1841	0.1986	0.1910	0.1910	0.1910	**0.1911**
H2	0.2294	0.2475	0.2381	0.2381	0.2381	**0.2383**
H3	0.1601	0.1728	0.1662	0.1662	0.1662	**0.1663**
H4	0.2294	0.2084	0.2004	0.2004	0.2004	**0.2078**
H5	0.1969	0.1728	0.2043	0.2043	0.2043	**0.1965**

Transportation & Setup

Houses	H1	H2	H3	H4	H5
score	0.45	0.58	0.45	0.73	0.69

	H1	H2	H3	H4	H5
H1	1.00	0.78	1.00	0.61	0.65
H2	1.28	1.00	1.28	0.79	0.84
H3	1.00	0.78	1.00	0.61	0.65
H4	1.28	1.27	1.63	1.00	1.07
H5	1.53	0.78	1.53	0.94	1.00
	6.09	4.61	6.44	3.95	4.21

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1641	0.1691	0.1552	0.1552	0.1552	**0.1598**
H2	0.2103	0.2167	0.1988	0.1988	0.1988	**0.2047**
H3	0.1641	0.1691	0.1552	0.1552	0.1552	**0.1598**
H4	0.2103	0.2759	0.2531	0.2531	0.2531	**0.2491**
H5	0.2512	0.1691	0.2376	0.2376	0.2376	**0.2266**

Figure F3 IPIA 3 Matrix of Comparisons and Vector of priorities for manufactured houses (contd)

Warranties

Houses	H1	H2	H3	H4	H5
score	*0.56*	*0.64*	*0.56*	*0.60*	*0.65*

	H1	H2	H3	H4	H5
H1	*1.00*	*0.88*	*1.00*	*0.95*	*0.86*
H2	*1.13*	*1.00*	*1.13*	*1.07*	*0.98*
H3	*1.00*	*0.88*	*1.00*	*0.95*	*0.86*
H4	*1.13*	*0.93*	*1.06*	*1.00*	*0.91*
H5	*1.16*	*0.88*	*1.16*	*1.10*	*1.00*
	5.42	4.58	5.35	5.07	4.61

	H1	H2	H3	H4	H5	Vector of Priorities
H1	*0.1844*	*0.1928*	*0.1870*	*0.1870*	*0.1870*	***0.1876***
H2	*0.2087*	*0.2182*	*0.2117*	*0.2117*	*0.2117*	***0.2124***
H3	*0.1844*	*0.1928*	*0.1870*	*0.1870*	*0.1870*	***0.1876***
H4	*0.2087*	*0.2035*	*0.1974*	*0.1974*	*0.1974*	***0.2009***
H5	*0.2138*	*0.1928*	*0.2169*	*0.2169*	*0.2169*	***0.2114***

Figure F3 IPIA 3 Matrix of Comparisons and Vector of priorities for manufactured houses (contd)

Materials

Homes	H1	H2	H3	H4	H5
score	0.42	0.67	0.33	0.37	0.42

	H1	H2	H3	H4	H5
H1	1.00	0.63	1.28	1.13	0.99
H2	1.59	1.00	2.04	1.80	1.57
H3	0.78	0.49	1.00	0.88	0.77
H4	1.59	0.56	1.13	1.00	0.87
H5	1.01	0.49	1.30	1.14	1.00
	5.98	3.16	6.75	5.96	5.21

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.167	0.199	0.190	0.190	0.190	**0.187**
H2	0.266	0.316	0.302	0.302	0.302	**0.298**
H3	0.131	0.155	0.148	0.148	0.148	**0.146**
H4	0.266	0.176	0.168	0.168	0.168	**0.189**
H5	0.169	0.155	0.192	0.192	0.192	**0.180**

Floor Assembly

Homes	H1	H2	H3	H4	H5
score	0.64	0.66	0.59	0.68	0.62

	H1	H2	H3	H4	H5
H1	1.00	0.97	1.07	0.94	1.03
H2	1.03	1.00	1.10	0.96	1.06
H3	0.93	0.91	1.00	0.87	0.96
H4	1.03	1.04	1.15	1.00	1.10
H5	0.97	0.91	1.04	0.91	1.00
	4.96	4.82	5.37	4.69	5.15

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.202	0.202	0.200	0.200	0.200	**0.201**
H2	0.207	0.207	0.206	0.206	0.206	**0.206**
H3	0.188	0.188	0.186	0.186	0.186	**0.187**
H4	0.207	0.215	0.213	0.213	0.213	**0.213**
H5	0.196	0.188	0.194	0.194	0.194	**0.193**

Figure F4 'Average' Matrix of Comparisons and Vector of priorities for manufactured houses

Wall Assembly

Homes	H1	H2	H3	H4	H5
score	0.49	0.57	0.40	0.59	0.48

	H1	H2	H3	H4	H5
H1	1.00	0.85	1.21	0.83	1.01
H2	1.18	1.00	1.42	0.98	1.19
H3	0.83	0.70	1.00	0.69	0.83
H4	1.18	1.02	1.46	1.00	1.21
H5	0.99	0.70	1.20	0.82	1.00
	5.17	4.28	6.29	4.32	5.24

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.194	0.199	0.239	0.168	0.212	**0.202**
H2	0.228	0.234	0.281	0.198	0.249	**0.238**
H3	0.160	0.164	0.198	0.139	0.175	**0.167**
H4	0.228	0.239	0.288	0.202	0.255	**0.242**
H5	0.192	0.164	0.237	0.167	0.210	**0.194**

Roof Assembly

Homes	H1	H2	H3	H4	H5
score	0.58	0.56	0.58	0.59	0.61

	H1	H2	H3	H4	H5
H1	1.00	1.03	1.00	0.98	0.94
H2	0.98	1.00	0.98	0.95	0.92
H3	1.00	1.02	1.00	0.98	0.94
H4	0.98	1.05	1.02	1.00	0.96
H5	1.06	1.02	1.06	1.04	1.00
	5.01	5.12	5.06	4.95	4.77

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1996	0.2002	0.1978	0.1978	0.1978	**0.1986**
H2	0.1947	0.1953	0.1929	0.1929	0.1929	**0.1937**
H3	0.1994	0.2000	0.1975	0.1975	0.1975	**0.1984**
H4	0.1947	0.2046	0.2021	0.2021	0.2021	**0.2011**
H5	0.2117	0.2000	0.2097	0.2097	0.2097	**0.2082**

Figure F4 'Average' Matrix of Comparisons and Vector of priorities for manufactured houses

(contd)

Utilities

Homes	H1	H2	H3	H4	H5
score	0.59	0.61	0.56	0.58	0.55

	H1	H2	H3	H4	H5
H1	1.00	0.96	1.05	1.01	1.07
H2	1.04	1.00	1.09	1.05	1.11
H3	0.96	0.92	1.00	0.97	1.02
H4	1.04	0.95	1.03	1.00	1.05
H5	0.94	0.92	0.98	0.95	1.00
	4.98	4.75	5.15	4.98	5.25

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.2009	0.2024	0.2031	0.2031	0.2031	**0.2025**
H2	0.2092	0.2107	0.2114	0.2114	0.2114	**0.2108**
H3	0.1921	0.1935	0.1942	0.1942	0.1942	**0.1936**
H4	0.2092	0.2000	0.2007	0.2007	0.2007	**0.2022**
H5	0.1886	0.1935	0.1906	0.1906	0.1906	**0.1908**

Doors & Windows

Homes	H1	H2	H3	H4	H5
score	0.56	0.67	0.55	0.67	0.69

	H1	H2	H3	H4	H5
H1	1.00	0.83	1.02	0.83	0.81
H2	1.20	1.00	1.22	1.00	0.97
H3	0.98	0.82	1.00	0.82	0.79
H4	1.20	1.00	1.22	1.00	0.97
H5	1.24	0.82	1.26	1.03	1.00
	5.63	4.46	5.73	4.68	4.54

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1776	0.1861	0.1776	0.1776	0.1776	**0.1793**
H2	0.2137	0.2240	0.2137	0.2137	0.2137	**0.2158**
H3	0.1745	0.1829	0.1745	0.1745	0.1745	**0.1762**
H4	0.2137	0.2240	0.2137	0.2137	0.2137	**0.2158**
H5	0.2205	0.1829	0.2205	0.2205	0.2205	**0.2129**

Figure F4 'Average' Matrix of Comparisons and Vector of priorities for manufactured houses

(contd)

Cosmetics

Homes	H1	H2	H3	H4	H5
score	0.57	0.71	0.49	0.60	0.65

	H1	H2	H3	H4	H5
H1	1.00	0.81	1.18	0.95	0.88
H2	1.24	1.00	1.46	1.18	1.09
H3	0.85	0.69	1.00	0.81	0.75
H4	1.24	0.85	1.24	1.00	0.93
H5	1.13	0.69	1.33	1.08	1.00
	5.45	4.03	6.20	5.01	4.65

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1834	0.2006	0.1898	0.1898	0.1898	**0.1907**
H2	0.2266	0.2479	0.2346	0.2346	0.2346	**0.2357**
H3	0.1557	0.1703	0.1612	0.1612	0.1612	**0.1619**
H4	0.2266	0.2108	0.1995	0.1995	0.1995	**0.2072**
H5	0.2076	0.1703	0.2149	0.2149	0.2149	**0.2045**

Transportation & Setup

Homes	H1	H2	H3	H4	H5
score	0.41	0.58	0.41	0.79	0.72

	H1	H2	H3	H4	H5
H1	1.00	0.70	1.00	0.52	0.57
H2	1.42	1.00	1.42	0.74	0.81
H3	1.00	0.70	1.00	0.52	0.57
H4	1.42	1.34	1.91	1.00	1.09
H5	1.75	0.70	1.75	0.92	1.00
	6.59	4.46	7.08	3.71	4.04

	H1	H2	H3	H4	H5	Vector of Priorities
H1	0.1518	0.1581	0.1413	0.1413	0.1413	**0.1467**
H2	0.2154	0.2243	0.2006	0.2006	0.2006	**0.2083**
H3	0.1518	0.1581	0.1413	0.1413	0.1413	**0.1467**
H4	0.2154	0.3015	0.2695	0.2695	0.2695	**0.2651**
H5	0.2657	0.1581	0.2474	0.2474	0.2474	**0.2332**

Figure F4 'Average' Matrix of Comparisons and Vector of priorities for manufactured houses

(contd)

Warranties

Homes	H1	H2	H3	H4	H5
score	*0.35*	*0.47*	*0.34*	*0.37*	*0.49*

	H1	H2	H3	H4	H5
H1	*1.00*	*0.75*	*1.03*	*0.96*	*0.73*
H2	*1.34*	*1.00*	*1.38*	*1.29*	*0.97*
H3	*0.97*	*0.73*	*1.00*	*0.94*	*0.71*
H4	*1.34*	*0.78*	*1.07*	*1.00*	*0.76*
H5	*1.38*	*0.73*	*1.42*	*1.32*	*1.00*
	6.04	3.98	5.89	5.51	4.16

	H1	H2	H3	H4	H5	Vector of Priorities
H1	*0.1657*	*0.1876*	*0.1743*	*0.1743*	*0.1743*	***0.1752***
H2	*0.2222*	*0.2515*	*0.2338*	*0.2338*	*0.2338*	***0.2350***
H3	*0.1615*	*0.1828*	*0.1699*	*0.1699*	*0.1699*	***0.1708***
H4	*0.2222*	*0.1953*	*0.1815*	*0.1815*	*0.1815*	***0.1924***
H5	*0.2285*	*0.1828*	*0.2404*	*0.2404*	*0.2404*	***0.2265***

Figure F4 'Average' Matrix of Comparisons and Vector of priorities for manufactured houses

(contd)

APPENDIX G

RANKING FOR MANUFACTURED HOUSES

MATRIX A

	Materials	Floor Assembly	Wall Asembly	Roof Assembly	Utilities	Doors& Windows	Cosmetics	Transport & Setup	Warranty
H1	*0.183*	*0.194*	*0.203*	*0.195*	*0.201*	*0.161*	*0.193*	*0.158*	*0.162*
H2	*0.314*	*0.206*	*0.250*	*0.198*	*0.209*	*0.224*	*0.221*	*0.183*	*0.265*
H3	*0.140*	*0.194*	*0.165*	*0.195*	*0.197*	*0.171*	*0.171*	*0.158*	*0.149*
H4	*0.180*	*0.210*	*0.248*	*0.211*	*0.209*	*0.224*	*0.211*	*0.307*	*0.180*
H5	*0.184*	*0.196*	*0.187*	*0.200*	*0.184*	*0.220*	*0.204*	*0.195*	*0.244*

X

MATRIX B

Eigen Values for Sub-systems
0.03
0.08
0.03
0.05
0.14
0.06
0.10
0.15
0.37

=

MATRIX C

Final Ranking

H1	175.577
H2	231.324
H3	166.331
H4	214.739
H5	213.676

Figure G1 IPIA 1 ranking for manufactured houses

MATRIX A

	Materials	Floor Assembly	Wall Asembly	Roof Assembly	Utilities	Doors& Windows	Cosmetics	Transport & Setup	Warranty
H1	*0.194*	*0.199*	*0.185*	*0.197*	*0.209*	*0.195*	*0.189*	*0.128*	*0.159*
H2	*0.283*	*0.207*	*0.211*	*0.192*	*0.214*	*0.216*	*0.242*	*0.220*	*0.252*
H3	*0.139*	*0.180*	*0.166*	*0.199*	*0.190*	*0.162*	*0.150*	*0.128*	*0.159*
H4	*0.196*	*0.224*	*0.238*	*0.201*	*0.202*	*0.216*	*0.205*	*0.283*	*0.190*
H5	*0.188*	*0.190*	*0.212*	*0.210*	*0.186*	*0.212*	*0.215*	*0.242*	*0.240*

X

MATRIX B

Eigen Values for Sub-systems
0.20
0.04
0.04
0.05
0.07
0.06
0.08
0.12
0.32

=

MATRIX C

Final Ranking

H1	175.094
H2	242.048
H3	155.869
H4	210.157
H5	217.346

Figure G2 IPIA 2 ranking for manufactured houses

MATRIX A

	Materials	Floor Assembly	Wall Asembly	Roof Assembly	Utilities	Doors& Windows	Cosmetics	Transport & Setup	Warranty
H1	*0.181*	*0.207*	*0.195*	*0.199*	*0.185*	*0.169*	*0.191*	*0.160*	*0.188*
H2	*0.280*	*0.207*	*0.227*	*0.196*	*0.224*	*0.218*	*0.238*	*0.205*	*0.212*
H3	*0.156*	*0.185*	*0.168*	*0.199*	*0.182*	*0.182*	*0.166*	*0.160*	*0.188*
H4	*0.188*	*0.209*	*0.240*	*0.196*	*0.197*	*0.218*	*0.208*	*0.249*	*0.201*
H5	*0.195*	*0.193*	*0.198*	*0.209*	*0.211*	*0.213*	*0.197*	*0.227*	*0.211*

X

MATRIX B

Eigen Values for Sub-systems
0.21
0.05
0.05
0.06
0.14
0.05
0.12
0.17
0.15

=

MATRIX C

	Final Ranking
H1	182.569
H2	229.637
H3	172.219
H4	209.785
H5	207.080

Figure G3 IPIA 3 ranking for manufactured houses

MATRIX A

	Materials	Floor Assembly	Wall Asembly	Roof Assembly	Utilities	Doors& Windows	Cosmetics	Transport & Setup	Warranty
H1	*0.187*	*0.201*	*0.202*	*0.199*	*0.203*	*0.179*	*0.191*	*0.147*	*0.175*
H2	*0.298*	*0.206*	*0.238*	*0.194*	*0.211*	*0.216*	*0.236*	*0.208*	*0.235*
H3	*0.146*	*0.187*	*0.167*	*0.198*	*0.194*	*0.176*	*0.162*	*0.147*	*0.171*
H4	*0.189*	*0.213*	*0.242*	*0.201*	*0.202*	*0.216*	*0.207*	*0.265*	*0.192*
H5	*0.180*	*0.193*	*0.194*	*0.208*	*0.191*	*0.213*	*0.205*	*0.233*	*0.227*

X

MATRIX B

Eigen Values for Sub-systems
0.17
0.06
0.04
0.05
0.14
0.05
0.08
0.15
0.25

=

MATRIX C

Final Ranking

H1	182.045
H2	233.123
H3	167.980
H4	210.688
H5	207.978

Figure G4 'Average' ranking for manufactured houses

BIBLIOGRAPHY

AARP (1999). "National Survey of Mobile Home Owners". *Technical Report,* AARP, Washington, DC.

American National Standard (1994). *Manufactured Home Installations.* National Conference of States on Building Codes and Standards, Inc.

American National Standard (1998). *Manufactured Housing Construction and Safety Standards (MHCSS).* Building Officials and Code Administrators International, Illinois.

Albern, W. (1997). Factory Constructed Housing Developments- Planning Design, and Construction. CRC Press, New York, NY.

Barshan, A., Willenbrock, J., Abdelhamid, T., Syal, M. (2003). "Manufactured Housing Construction Quality Guidelines". Michigan State University, USA.

Besterfield, D. (1994). *Quality Control.* Prentice Hall, Englewood Cliffs, NJ.

Burnside, K. (1999). *Buying a Manufactured Home.* Van der Plas Publications, San Francisco.

Caldeira, E. (1997). *Quality Management: Best Practices for Home Builders.* Home Builder Press, National Association of Home Builders, Washington, DC.

Chinyio, E., Olomolaiye, P., Corbett, P. (1998). Quantification of Construction Clients' Needs through Paired Comparisons. *Journal of Construction Engineering and Management*, January/February 1998.

Chua, D., Kog, Y., Loh, P. (1999). Critical Success Factors for Different Project Objectives. *Journal of Construction Engineering and Management*, May/June 1999.

Consumers Union, (2000). "CU urges laws to help manufactured housing affordability in Texas". Http://consumersunion.org/mh/, (site visited on: June 2002).

Consumers Union, (2001a). "An Introductory Guide to Manufactured Housing Park Cooperatives and the Services of the New Hampshire Community Loan Fund". Http://consumersunion.org/mh/, (site visited on: June 2002).

Consumers Union, (2001b). "Consumers Union, Consumers Unions Tips on Mobile Homes". Http://consumersunion.org/mh/, (site visited on: June 2002).

Consumers Union, (2001c). "Consumers beware: manufactured housing can be risky purchase". Http://consumersunion.org/mh/, (site visited on: June 2002).

Consumers Union (2001d). "Consumers Union launches Manufactured Housing Project". Http://consumersunion.org/mh/, (site visited on: June 2002).

Dozzi, S., AbouRizk, S., Schroeder, S. (1996). Utility-Theory Model for Bid Markup Decisions. *Journal of Construction Engineering and Management*, June 1996.

Eaton, R. (1997a). How to buy a manufactured Home and Save thousands of Dollars. J & R Enterprises, Moses Lake, WA.

Eaton, R. (1997b). *Manufactured Home Comparison Guide.* J & R Enterprises, Moses Lake, WA.

Farghal, S. (1996). A Methodology for Evaluation and Selection of Construction Projects with Significant Subjective Characteristics. Ph.D. Dissertation, Civil Engineering, University of Michigan, USA

Fisher, L. (1994). *Quality Improvement Methods for Home Builders*, NAHB Research Center, Maryland.

Housing and Building Technology Division (2001). *The National Manufactured Housing Construction and Safety Standards Act.* National Conference of States on Building Codes and Standards, Inc.

Hullibarger, S. (2001). *Developing with Manufactured Homes.* Manufactured Housing Institute, Arlington, VA.

Housing and Building Technology, (2000). "Guidelines for the Investigation and Reporting of Quality System Issues". U.S. Department of Housing and Urban Development.

Housing and Building Technology, (2001). "The National Manufactured Housing Construction and Safety Standards Act- Unofficial compilation of Title VI as amended by the Manufactured Housing Improvement Act of 2000". Housing and Building Technology, Herndon, Virginia.

Jewel, K. (2003). "Paper Tiger; Missing Dragon". Consumers Union South West Regional Office, Austin, Texas.

Manufactured Housing Research Alliance, (2002). *Guide to Foundation and Support Systems for Manufactured Homes.* PATH, Washington, DC.

Mason, Grobler, Willenbrock (1991). "An Analysis of Quality in Modular Housing Industry". Report No. 13, NAHB/NRC Designated Housing Research Center, Penn State.

NAHB Research Center, (2000). 'Home Builders' guide to Manufactured Housing". Repot for U.S. Department of Housing and Urban Development, Office of Policy Development and Research, PATH, Washington, DC.

NAHB Research Center, (1998). "Factory and Site-Built Housing: A Comparative Analysis". U.S. Department of Housing and Urban Development, Office of Policy Development and Research, PATH, Washington, DC.

Narasimhan, R., Talluri. S., Mendez (2001). "Supplier Evaluation and Rationalization via Data Envelopment Analysis: an Empirical Examination, *The Journal of Supply Chain Management*, Summer 2001

Norrgard, L. (1994). "Product Report, Manufactured Housing". *AARP Product Report.*

Palmer, A., Kelly, J., Male, S. (1996). Holistic Appraisal of Value Engineering in Construction in United States. *Journal of Construction Engineering and Management*, December 1996.

Porter, G. (1998). "The HUD goes to the Ground". *The Journal- the magazine for Manufactured Housing Professionals*, Manchester, GA.

Quomo, A. (1998). "Manufactured Home Consumer's Guide". The Council of State Administrative Agencies.

Rosowsky, D., Ellingwood, B. (2002). Performance-Based Engineering of Wood Frame Housing: Fragility Analysis Methodology. *Journal of Structural Engineering* January 2002.

Saaty, T. (1980). *The Analytic Hierarchy Process*. McGraw Hill, USA.

Salem, O., AbouRizk, S., Ariaratnam, S. (2003). Risk-based Life-cycle Costing of Infrastructure Rehabilitation and Construction Alternatives. *Journal of Infrastructure Systems*, March 2003

Sanders, W. (1998). "Manufactured housing: Regulation, Design Innovations, and Development Options". *Report No. 478*, Planning Advisory Service, American Planning Association.

Sarkis, J., Talluri, S. (2002). A Model for Strategic Supplier Selection. *The Journal of Supply Chain Management*, Winter 2002.

Senghore, O. (2000). *"Production and Material Flow process model for Manufactured Housing"*, Masters dissertation, Michigan State University, USA.

Stein, B. and Reynolds, J. S. (1992). *Mechanical and Electrical Equipment for Buildings.* John Wiley, New York, NY, p837-838.

Syal, M., Mehrotra, N., Senghore, O. (2001). "Manufactured Housing Trends and Regulations in Michigan, Volume 1: Industry Trends and Codes". Michigan State University, USA.

Taylor, J. (2000). "Indoor Air that Injures or Kills". *Federal Register/Vol.65, No. 62/Proposed Rule*, Manufactured Homeowners' and Homebuyers.

Taylor, J. (2000). "The Current State of Affairs in, the National Manufactured Home Construction and Safety Standards Program". Consumers Report to Congress, Manufactured Homeowners' and Homebuyers.

Torbica, Z., Stroh, R. (1999). Impact of Total Quality Management on Homebuyer Satisfaction. *Journal of Construction Engineering and Management*, May/June 1999.

Winter, S. (1999). *Manufactured Home: Installation Training Manual.* U.S. Department of Housing and Urban Development.

U.S. Department of Housing and Urban Development, (1995). *Manufactured Home Construction and Safety Standards.* HUD, Part 3280.

U.S. Department of Housing and Urban Development, (1993). *Manufactured Home procedural and Enforcement Regulations.* HUD, Part 3282.

Ziara, M., Ayyub, B. (1999). Decision Analysis for Housing-Project Development. *Journal of Urban Planning and Development*, June 1999.