# The Impact of Affordable Sustainable Housing Neighborhoods on Housing Cost Efficiency

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## **Abstract**

The effect of global economic crises has greatly impacted housing market, in particularly affordable housing which suffered dramatically. Poor environmental quality, higher resident's health complications, and larger maintenance and operation bill have all been noticed as major common outcomes of such an impact. As a result, the idea of Affordable Sustainable Housing Neighborhoods (ASHN) was reformed to consider healthier lifestyle, better environmental surrounding, and higher cost efficiency. In this work research, an assessment of cost efficiency will be performed on these neighborhoods, in terms of shelter, utility, and transportation for better understanding and recommendations. This study will be based on both supply-side stakeholders and demand-side feedbacks. As a result of this study work, a salient discrepancy was found between supply-side and demand-side stakeholders in term of ASHN's efficiency. That is, ASHN's efficiency did not meet resident's expectations and therefore, a comprehensive assessment methodology is necessary to involve third party for cross validation purposes and facilitate interpretation of research results.

**Keywords:** affordable housing, sustainable neighborhood, housing cost assessment, Leadership in Energy and Environmental Design for Neighborhood (LEED ND)

## 1. Introduction

A growing interest in sustainable neighborhoods development has been evolved in the last few years. With an emphasis on improving community life style, providing healthier living environment, and more efficient residence in terms of housing cost (Nelson et al., 2004; Myerson, 2007; Morris & Langdon, 2007), this work study has focus on green building as a solution. Green building technology stated "Of the total expenditures an owner will make over the span of a building's service lifetime, design and construction expenditures, the so-called 'first costs' of a facility, account for just 5-10 percent. In contrast, operations and maintenance costs accounts for 60-80 percent of the total life-cycle costs" (U.S. Green Building Council, 2002, p.17). Green home is more efficient than conventional over the lifetime period, however, such a fact can be miss leaded. Therefore, a serious need to investigate initial cost and long-term benefit is required to appreciate how ASHN meets essential criteria of housing affordability. This investigation can be accomplished through a comprehensive vision that discusses the following:

- 1) Users is ASHN designed to suit wide spectrum of income range, from high to low?
- 2) Standards does ASHN provide better environmental and living quality?
- 3) Return of investment does ASHN guarantee low cost of operation and maintenance over lifetime (Myerson, 2007; Stone, 2006)?

Unfortunately, the promised savings of sustainability are based on theoretical calculations, or computerized models, not on a real life scenarios for affordable housing units (Langdon et al., 2004). In addition, the majority

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of researches discuss the effect of sustainable strategies in generic way, such as increasing/decreasing housing cost (Downs, 2005; Steinacker, 2003; Edward & Hains, 2007; Voith & Crawford, 2004). As a result, there is a serious need to assess a real life, occupied housing units in sustainable neighborhoods, to provide a valuable data on ASHN efficiency. This will link real-time data to computerized models and information to empower ASHN application.

This research directly addresses the efficiency of sustainable housing units, in terms of "total" housing cost, based on the feedback from both supply-side stakeholders (planners, architects, and developers) and demand-side (residents), to help providing evidence that supports affordable sustainable housing neighborhood. For the purpose of this research, "total" housing cost is defined through three components: 1) shelter cost, measured by the percentage of annual net income spent for a mortgage or rent; 2) utility cost, measured by the percentage of annual net income spent for utility bills; and 3) transportation cost, measured by the percentage of annual net income spent on vehicle purchase, fuel, maintenance, insurance, public transportation fees, and other related expenses. This assessment should help to identify the opportunities and challenges, and bridge the gap to promote higher levels of satisfaction among residents living in ASHN, as well as motivating and encouraging low and middle income households to embrace sustainability.

#### 2. Relevant Literatures

Now a day, there is a crisis in affordable housing where prices have risen steadily and construction does not meet standards that guarantee good quality over the life of a project. In Retsinas' (2005), more than 14 million American households spend more than half of their income on housing with majority of those households considered low-income, and 6.3 million households receive rental subsidies. Even with subsidies, about three million still spend more than 30 percent of their income on housing! As a result, access to affordable housing is a challenge for most working American families, who are burdened with housing cost, living situations (crowded shelter), and unacceptable conditions (Hardiman, 2010).

Lack of affordability is connected with shelter poverty, which is related to household's inability to meet non-housing needs (such as food, clothing, medical care, and transportation, ...etc) at a minimum level after housing payment (Stone, 2006). Paying too much of households income on housing will reduce affordability and affect negatively on families to meet basic needs (Schwartz, 2009). This negatively affects family's financial stability and may force frequent moves. For example, a study in Ohio showed that 42 percent of families who spent more than half of their income on housing, moved within six-month period. As a result, these frequent moves may interrupt work schedules, jeopardize employment, and will negatively impact children to reduce development of basic skills, and increase school drop outs. Inadequate housing also has been linked to family's health complications through increasing rates of asthma, respiratory disease, lead poisoning, and poor nutrition, which can retard a child's physical and intellectual development (Sard & Waller, 2002). Therefore, providing good quality housing units should promote more equal social, educational, and economic opportunities and help create more equitable environment for all.

By this discussion, the need to incorporate sustainability with affordable housing neighborhoods is a must since it aims to achieve healthier environment and more efficient residences in terms of housing cost. This can be clearly apprehended through several strategies adopted by Leadership in Energy and Environmental Design for Neighborhood (LEED ND) that takes the approach of smart growth and new urbanism further. This represented by revitalizing existing urban areas, reducing land consumption, reducing automobile dependence, promoting pedestrian activity, improving air quality, decreasing polluted storm water runoff, and building more livable communities for people of different income levels (USGBC, 2009). These techniques emphasize the following: 1) Location efficiency by encouraging new development in places has accessible services and amenities such as transit, walkable commercial development, and existing municipal services. Also, re-development of Brownfield and infill sites; 2) Environmental preservation by protecting water courses, wildlife habitat, endangered species, and sensitive or valuable agricultural lands; and 3) Resource efficiency that utilize technology and design skills at different fields (construction materials, electricity, water treatment, and waste management) to promote efficiency (Tsenkova & Syal, 2009).

In spite of sustainable strategies positive effect in affordable housing field, there are some challenges which could eliminate its efficiency. These challenges can be summarized as follows: 1) Smart growth and compact development that may shift the future development inward and will constrain the supply of land for housing, thus potentially causing housing prices to increase (Voith & Crawford, 2004). 2) Environmental Impact Statement (EIS), which is required due to the contamination of the Brownfield developments, or buildings reuse will require intensive work to clean it up which may delay the construction as well as increase housing cost and make

it less affordable (Edwards & Haines, 2007). 3) Design challenges and limitations refer to dealing with new technology, green materials, skilled labor, and building codes that may increase the development cost and, hence, the price of housing (Downs, 2005).

Sustainability has a great potential achieving affordable housing efficiency, however, there are many challenges may constrain the implementation and increase the cost. Therefore, there is a serious need to assess the cost efficiency of ASHN based on the feedback analysis from supply-side stakeholders (architects, planners, and developers) and demand-side (families who are living in ASHN). This was achieved through the following research questions:

- Q1: Based on supply-side stakeholders' feedback, do ASHNs provide an efficient life (total cost of shelter, utility, and transportation)?
- Q2: Is there a significant difference among supply-side stakeholders, and between demand-side and supply-side stakeholders in their views of housing costs efficiency in terms of shelter, utility, and transportation costs?

#### 3. Method

In this research, cost efficiency assessment for ASHN has been the focus through studying affordable housing projects registered in LEED ND developments (U.S.Green Building Council, 2010). Out of 205 registered LEED ND developments in the US, only 114 projects have housing units. After evaluating the entire bulk of projects, only 56 developments, distributed over 24 states were included in the final research sample. These developments contain affordable units for working families; units priced below market rate; and mixed income units suitable for low and middle income families. Those 56 projects were used as a resource for the research sample to extract contacts of supply-side stakeholder participants and select occupied neighborhood for residents data collection. Cost efficiency assessment was investigated through exploring:

- a) Beliefs about cost efficiency of ASHN; and
- b) Cost comparison between ASHN and conventional residential units.

This was achieved by conducting a survey from:

- 1) Supply-side stakeholders (planners, architects, and developers) of the 56 developments. Data were collected through on-line survey (Questionnaire pro.com) that consisted of nine closed ended questions. About 70 percent response rate (141 out of 200) was achieved within ten weeks (Jun. 22<sup>nd</sup> Aug. 26<sup>th</sup>, 2011), 126 responses (40 planners, 42 architects, and 44 developers) were considered for data analysis.
- 2) Demand side (residents) of ASHN occupancies (Mueller Central, Austin-Texas-USA). This development was selected due to the higher occupancy level since most of the developments were either still under construction or had low occupancy rate by September, 2011. Face-to-Face interviews with residents of Mueller Central, Austin-Texas were administered on October 1<sup>st</sup>, 2011 by the researcher using a structured questionnaire consisted of nine closed ended questions. 51 responses were collected from the neighborhood through random selection.

## 4. Results

Analysis of Variance (ANOVA) and Chi-Square analysis were used to analyze the collected data. It was applied to test the differences among supply-side stakeholder's feedback, and between supply-side stakeholder's and resident's feedback (demand side). Doing so, provided assessment of ASHN cost efficiency in terms of shelter, utility, and transportation costs through:

- 1) Beliefs about cost efficiency of ASHN; and
- 2) Cost comparison between ASHN and conventional residential units.
- 4.1 Beliefs about Cost Efficiency of ASHN

The beliefs about cost efficiency of housing unit in affordable sustainable neighborhoods were observed by examining the differences among supply-side stakeholders, and between supply-side stakeholders and demand-side (residents of Mueller Central). The examination was based on the efficiency of ASHN in terms of shelter, utility, and transportation. Collected data was scrutinized using analysis of variance (ANOVA) with an alpha level of 0.05. which shows a significant difference between supply-side stakeholders and demand-side regarding ASHN efficiency in terms of shelter, where (F (1,176) = 20.94, P = 0.0), as shown in Table 1. Results have showen there is no significant difference among supply-side stakeholders as a group. Results can be easily interpolated through the frequency analysis (Table 2), where about 60 percent of supply-side stakeholders generally agreed or strongly agreed about the cost efficiency of ASHN in terms of shelter. While one third of the

residents were undecided, almost one sixth disagreed. As a result, it can be determined that residents of Mueller Central disagreed with supply-side stakeholders of ASHN regarding shelter efficiency.

Table 1. ANOVA results for beliefs about housing cost efficiency of ASHN

Beliefs about the cost efficiency of ASHN	Com		among holders	supply views	-side	Comparison between supply-side stakeholders and demand-side views					
	SS	df	MS	F	Sig.*	SS	df	MS	F	Sig.*	
Shelter cost											
Between Groups	1.266	2	0.63	0.74	0.48	18.20	1	18.2	20.94	0.00	
Within Groups	104.9	123	0.85			161.7	175	.87			
Total	106.2	125				179.9	176				
Utility cost											
Between Groups	2.722	2	0.91	1.36	0.26	155.6	1	38.9	26.97	0.004	
Within Groups	81.15	123	0.67			248.1	175	1.44			
Total	83.87	125				403.7	176				
Transportation											
Between Groups	5.827	2	2.91	4.47	0.13	23.64	1	23.6	29.47	0.001	
Within Groups	80.21	123	0.65			149.2	175	.802			
Total	86.04	125				172.9	176				

SS: Sum of Squares

df: Degree freedom

MS: Means Square

Description: Significant differences between supply-side stakeholders and demand-side views regarding the beliefs of ASHN's cost efficiency.

Table 2. Frequency analysis for ASHN Efficiency in terms of shelter cost

ASHN is	Planner		Architect		Developer		Resident		Total	
efficient in terms of shelter cost	N	%	N	%	N	%	N	%	N	%
Strongly agree	13	7.3	10	5.6	8	4.5	5	2.8	36	20.3
Agree	16	9	18	10.2	20	11.3	13	7.3	67	37.8
Neutral	7	4	11	6.2	12	6.8	17	9.6	47	26.6
Disagree	4	2.3	3	1.7	3	1.7	16	9	26	14.7
Strongly disagree	0	0	0	0	1	0.6	0	0	1	0.6
Total	40	22.5	42	23.8	44	24.9	51	28.8	177	100

N: Count of responses

Description: Differences between supply-side and demand-side beliefs regarding shelter cost efficiency of ASHN.

In terms of utility cost, the data (Tables 1, and 3) revealed similar results regarding ASHN efficiency. ANOVA shows a significant difference between supply-side stakeholders and demand-side, where (F (1,176) = 26.97, P = 0.004) as shown in Table 1. This can be explained by the frequency analysis of their beliefs about utility efficiency (Table 3), where more than 90 percent of supply-side stakeholders strongly agreed or agreed on

<sup>\*</sup> Significant at 0.05 probability level

ASHN efficiency in terms of utility; while 45 percent of residents were undecided regarding utility efficiency and about 20 percent of them disagreed.

Table 3. Frequency analysis for ASHN Efficiency in terms of utility cost

ASHN is efficient in terms of utility cost	Pla	Planner		Architect		Developer		ident	Total	
	N	%	N	%	N	%	N	%	N	%
Strongly agree	26	14.7	28	15.8	28	15.8	5	2.8	87	49.2
Agree	12	6.8	14	7.9	12	6.8	13	7.3	51	28.8
Neutral	1	0.6	0	0	4	2.3	23	13	28	15.8
Disagree	1	0.6	0	0	0	0	9	5.1	10	5.6
Strongly disagree	0	0	0	0	0	0	1	0.6	1	0.6
Total	40	22.5	42	23.8	44	24.9	51	28.8	177	100

N: Count of responses

Description: Differences between supply-side and demand-side beliefs regarding utility cost efficiency of ASHN.

In terms of transportation cost, ANOVA shows a significant difference between supply-side stakeholders and demand-side in the scores of their feedback about ASHN efficiency, where (F (1,176) = 29.47, P = 0.001), as shown in Table 1, last section. On the other hand, there is no significant difference within supply-side stakeholders. This is visible through the frequency analysis in Table 4, where about 80 percent of supply-side stakeholders agreed and strongly agreed on ASHN efficiency in terms of transportation. However, about 40 percent of the residents were undecided and about 20 percent disagreed on transportation efficiency.

Table 4. Frequency analysis for ASHN Efficiency in terms of transportation cost

ASHN is efficient In terms of transportation cost	Planners		Architects		Developers		Residents		Total	
	N	%	N	%	N	%	N	%	N	%
Strongly agree	21	11.9	21	11.9	12	6.8	8	4.5	62	35
Agree	14	7.9	16	9	16	9	13	7.3	59	33.3
Neutral	5	2.8	3	1.7	16	9	20	11.3	44	24.9
Disagree	0	0	1	0.6	0	0	8	4.5	9	5.1
Strongly disagree	0	0	1	0.6	0	0	2	1.3	3	1.7
Total	40	22.5	42	23.8	44	24.9	51	28.8	177	100

N: Count of responses

Description: Differences between supply-side and demand-side beliefs regarding cost efficiency of ASHN in terms of transportation.

In summary, all supply-side stakeholders agreed on the cost efficiency of ASHN in terms of shelter, utility, and transportation, and there is no a significant difference within them as a group based on analysis of the variance test with an alpha level of 0.05. However, as shown in Tables 1, 2, 3 and 4, a significant difference exists between residents of Mueller Central (ASHN project) and the supply-side stakeholders with regard to the cost efficiency of ASHN.

# 4.2 Cost comparison Between ASHN and Conventional Residential Units

This section compares housing costs (shelter, utility, and transportation) in affordable sustainable housing units and conventional neighborhoods. This comparison was conducted by using the Chi-square test with an alpha level of 0.05 to examine if there is a significant difference between supply-side stakeholders and demand-side (residents of Mueller Central) as shown in Table 5.

Table 5. Chi-square results for comparison of differences

Cost comparison Between ASHN and conventional unit	Con	nparison a stakeho	mong supply lders views	-side	Comparison between supply-side and demand-side views					
	$X^2$	df	P*	N	$X^2$	Df	P*	N		
mortgage / rent	17.232	12	0.141	126	10.264	2	0.006	177		
Utility	17.253	15	0.304	126	75.063	2	0.01	177		
Transportation	31.51	18	0.052	126	14.014	2	0.001	177		

X<sup>2</sup>: Chi-Square

df: Degree of freedom

N: Count of responses

\* Significant at 0.05 probability level

Description: Significant differences between supply-side stakeholders and demand-side views regarding the housing cost comparison between ASHN and conventional housing neighborhood.

The Chi-square test shows a significant difference between supply-side stakeholders and demand-side (residents) on their feedback about housing cost comparisons in terms of shelter, where  $(X^2 (2, 177) = 10.264, P = 0.006)$  as shown in Table 5. This is visible on the frequency analysis in Table 6, where about 50 percent of supply-side stakeholders stated that residents of ASHN pay the same for the shelter (mortgage / rent) as those in conventional residential units. But, about 40 percent of residents disagreed and asserted that they pay more for the shelter.

Table 6. Frequency analysis for cost comparison in terms of shelter

Cost comparison in terms of shelter	Pla	nner	Arc	hitect	Deve	eloper	Res	ident	Total		
	N	%	N	%	N	%	N	%	N	%	
Less cost	2	1.3	3	1.7	6	3.4	9	5.1	20	11.3	
Same cost	26	14.7	23	13	23	13	17	9.6	89	50.3	
More cost	12	6.8	16	9	15	8.5	25	14.1	68	38.4	
Total	40	22.5	42	23.8	44	24.9	51	28.8	177	100	

N: Count of responses

Description: Differences between supply-side and demand-side beliefs regarding shelter cost comparison.

Data revealed similar results regarding cost comparisons for utility payments. The Chi-square test shows a significant difference between supply-side stakeholders and demand-side based on their feedback, where  $(X^2 (2, 177) = 75.063, P = 0.01)$ , as shown in Table 5. However, there is no significant difference among supply-side stakeholders. This can be explained by the frequency analysis in Table 7, where more than 90 percent of supply-side stakeholders believe that utility cost of ASHN is less than conventional housing, while about 40 percent of residents state that they pay the same as conventional units and 25 percent of them assert that they pay more.

Table 7. Frequency analysis for cost comparison in terms of utility

Cost comparison in terms of utility	Planner		Architect		Developer		Resident		Total	
	N	%	N	%	N	%	N	%	N	%
Less cost	37	20.90	40	22.6	41	23.2	17	9.6	135	76.3
Same cost	3	1.7	1	0.6	3	1.7	21	11.9	28	15.8
More cost	0	0	1	0.6	0	0	13	7.3	14	7.9
Total	40	22.5	42	23.8	44	24.9	51	28.8	177	100

N: Count of responses

Description: Differences between supply-side and demand-side beliefs regarding utility cost comparison.

Moreover, the Chi-square test shows a significant difference between supply-side stakeholders and demand-side based on the scores of their feedback about cost comparison in terms of transportation, where  $(X^2 \ (2, 177) = 14.014, P = 0.001))$  (see Table 5). This is also visible in Table 8, where more than 70 percent of supply-side stakeholders believe that transportation cost of ASHN is less than conventional housing, while about 50 percent of residents stated they pay same as those in conventional units.

Table 8. Frequency analysis for cost comparison in terms of transportation cost

Cost comparison in terms of transportation	Planner		Architect		Developer		Resident		Total	
	N	%	N	%	N	%	N	%	N	%
Less cost	32	18.1	30	16.9	23	13	19	10.7	146	82.5
Same cost	7	4	11	6.2	21	11.9	27	15.3	22	12.4
More cost	1	0.6	1	0.6	0	0	5	2.8	9	4.8
Total	40	22.5	42	23.8	44	24.9	51	28.8	177	10

N: Count of responses

Description: Differences between supply-side and demand-side beliefs regarding transportation cost comparison.

Consequently, there is no a significant difference within supply-side stakeholders as a group based on Chi-square tests with an alpha level of 0.05, where most of them believe that shelter cost of affordable housing unit in sustainable neighborhood is the same as conventional housing units. Also, it was believed that utilities and transportation in ASHN cost were less than conventional units. On the other hand, there is a significant difference between residents of Mueller Central, an ASHN development, and the supply-side stakeholders regarding cost comparison between ASHN and conventional housing units (Tables 5, 6, 7 and 8).

### 5. Discussion

Based on the supply-side stakeholder's feedback, it appears that sustainable strategies have a promising future in affordable housing field due to its lower operating cost. However, residents of examined neighborhood (Mueller Central – Austin) claimed that cost of shelter (mortgage/rent), utility, and transportation have remained the same as conventional housing unit. This discrepancy can be related to either overestimate the savings by supply-side stakeholders, or improper operation and maintenance for the system by the demand-side (Frank, 2012). Based on that, the U. S. Green Building Council - Office of Sustainability and the Public Policy Center (2010) required a third party (consultant) to evaluate the sustainable design and collect real-life data after occupancy with consideration for design parameters. For example, Knox Housing Partnership monitored actual energy usage for an experimental housing unit. Results from the investigations indicated a 39 percent annual energy savings per unit. Despite this savings, it appears that residents' satisfaction is low (Block, 2010). This indicates that there is a need to observe and measure resident's actual savings in total costs with green building performance and compare it with their expectation (Bourland, 2009), which could positively influence their satisfaction, and increase the demand for green buildings to move towards the production stage. This then could help to reduce the cost of green material and labor and increase affordability of sustainable neighborhoods.

While this research points out potential for the "Green Building" concept, the overall assessment of this idea is mired in controversy due to several factors: limited "green projects" have been built to date and not occupied for a long enough time for a more longer term assessment (5-10 years); recent commercial "green" buildings, have provided mixed reviews and sometimes obvious areas of failures. "Green Schools" have become an area where building renovation / construction have been used to push for the perceived operating cost savings but showing mixed results or little or no net benefit (Frank, 2012).

Final recommendation by the researchers may be one of cautious progress with more rigorous assessment method to enhance a more robust evaluation, followed by a decision making process with clear goals and objectives to enable better decisions to implement in the public realm, in an era of limited public funds, and a need for better accountability. The idea of "Green Building-Projects" is tantalizing but remain a mirage in terms of "cost savings" promised by the designers/architects, planners, and developers.

The following steps may be viewed as a starting point for decisions on "green buildings", and improving ASHN efficiency, supported through green life practice by residents:

- Public education and awareness of residents to adjust their habits such as reworking daily activities based on
  the public transportation schedule to reduce transportation costs, and amending routines to control their
  activities within utility conservation parameters such as using dishwasher once per a day or less, closing all
  windows and keeping thermometer around 75F in the summer, etc (Wheeler, 2000; Priemus & Heuvelhof,
  2005).
- Sustainable demonstrations and trainings to educate residents how to maintain and operate the green building. These demonstrations should provide information about a building's systems to enhance management and cost efficiency (Office of Sustainability and the Public Policy Center, 2010).
- Involve community residents during the construction stage to reduce construction costs and could be considered as training for building operation and maintenance (Myerson, 2007; Morris & Langdon, 2007).
- Post occupancy evaluations for affordable green communities to help to realize the strengths and weaknesses of used strategies, and a base for future development. This helps professionals to be more creative than experimental (Salama & Alshuwaikhat, 2006; Nothstine, 2006).
- Provide incentives to residents through property tax credits and grants for green technology to help absorbing higher initial costs of green buildings and reduce shelter (mortgage/rent) cost (Retzlaff, 2009; Office of Sustainability and the Public Policy Center, 2010).
- Improve design flexibility by providing various investment options such as live/work units and urban yards. This will increase residents' income and have a positively effect on housing affordability as well as enhance residents' satisfaction (Barnes et al., 2009; Nothstine, 2006; Pyatok, 2005).

## 6. Conclusion

Achieving successful ASHN requires incremental implementation of sustainable strategies along with continuous evaluation to ensure its effectiveness. Also, deploying technologies with the shortest economic payback then moving towards solutions with longer-term return is highly recommended. These kinds of actions require collaboration between all professionals who design, plan, develop, build, assess, and live in this type of communities to be better in the near future through creative solutions as being supported by Retsinas (2005), Pyatok (2005), and Boyd (2001) who insured the importance of the collaboration among all stakeholders through highlighting the role of different players as the follow:

- a) Governments role represented by providing different programs that help to acquire, produce, or rehabilitate housing units and then improve it to be green;
- b) Planner roles represented by understanding new trends in planning that could improve the status of housing affordability;
- c) Architects who could design better communities with affordable efficient use of space to save materials; higher density could lower property land cost per unit, and technical innovations could conserve energy;
- d) Developers who considered as driving forces in breaking down old models and creating a new generation of housing that blends affordability with green technology; and
- e) Community residents who should participate in the decision making from the beginning of the design process.
- 6.1 Research Limitation and Recommendation

Since the data of this research was based mainly on supply-side stakeholders of ASHN and a small sample of residents of Mueller Central neighborhood, there is a need to improve the validity and reliability of the data by:

- a) Collect data from several neighbourhoods and increase research population.
- b) Collect data from different primary and secondary resources, such as utility record from utility companies, monthly mortgage/rental payment for housing unit, and transportation models for calculating trips cost. Moreover, most of the demand-side (residents) responses were collected after a short time of occupancy (about six months) by them. While the efficiency of sustainable design can be recognized over time (about ten years), longitudinal study is essential for this kind of neighbourhoods to validate the data.

Therefore, more comprehensive assessment method is highly recommended through the following steps:

• More reliable methodology of ASHN assessment can be proposed by selecting at least one neighborhood in each region of USA, to allow for a more representative sample.

- Create interview instrument with input from developers, planners, and architect teams in the selected neighborhoods discussing their visions and expectations regarding cost efficiency of housing units.
- Collect feedback from residents who have lived in such housing units for at least 6 months. The feedback should be collected over time (1 year, 3 years, 5 years, and 10 years), and collected via mail survey or by trained personnel for better response rate.

Since data collected from supply-side stakeholders could represent their expectations or estimations, while data collected from demand-side may mainly represent satisfaction levels more than actual saving, it will be appreciated to collect data from a third party and then increase research validity. This data should include utility usage (over 12 months) through monitoring devices or meters. Likewise real estate analysis for mortgage / rent cost may facilitate realizing the shelter cost, and accessibility study for shopping and entertainment activities for each community may help to realize the transportation cost. The diversity of data sources may also serve as assessment techniques for cross validation strategy and improve the generalization.

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