

# *Investigation on the Energy Savingbehavior of Urban Residents' Existing Residential Buildings*

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**Abstract:** The willingness and attitude of urban residents towards green transformation of residential properties depend on their own conditions (gender, age, marital status, education level, occupation, monthly family income, family consumption habits, etc.) and the balance of housing needs. This study takes the perspective of residents' needs and refers to grounded theory to develop a survey questionnaire on the willingness of existing residential green renovation. The questionnaire mainly consists of closed ended questions on "sociodemographic variables" and "living status variables", as well as "green transformation motivation variables", "green transformation ability variables", "green transformation behavior variables", and "situational environment variables". The survey found that factors such as monthly family income, and household consumption habits affect the willingness and behavior of urban residents towards green renovation of existing residential buildings.

## 1. Introduction

The development of urban construction promotes the improvement of residents' living environment and community public space. People not only pay attention to the improvement of living environment and activity space during the process of community public space and existing residential renovation, but also care about whether energy consumption can be reduced and the impact on the environment can be decreased.<sup>[1]</sup> This study investigates the willingness of residents to carry out energy-saving behaviors in the green renovation of existing residences, analyzes the reasons, and seeks solutions.<sup>[2]</sup>

### 2.1 Research Instrument

This survey research utilized a self-developed "Questionnaire on the Willingness of Green Renovation of Existing Residences", which covered several dimensions including living conditions, renovation motivation, renovation behavior, renovation capacity, and situational environment. The questionnaire also included demographic and statistical variables such as gender, age, marital status, educational attainment, occupation, monthly household income, and household consumption habits. People's attitudes towards things can predict their possible behaviors, and there is a strong

correlation between attitudes and behaviors.<sup>[3]</sup> Questionnaires can help understand people's attitudes. Unlike length or distance, attitudes cannot be directly measured to obtain an accurate data; they can only be inferred through comparative analysis of individual responses to understand their intentions and behaviors.

## 2.2 Respondents

This survey targeted residents from various cities within the northern Beijing-Tianjin-Hebei region as research subjects. A sampling survey was conducted through a questionnaire to thoroughly investigate urban residents' willingness to engage in green and energy-saving renovation projects. Statistical data were employed for empirical analysis. Family consumption habits are shaped by a combination of individual backgrounds, family structures, and monthly household income.

## 2.3 Distribution and collection of questionnaires

The questionnaire ultimately selected three cities for investigation, namely Beijing, Tianjin, and Shijiazhuang, all of which are located within the capital economic circle of the Beijing Tianjin Hebei region. The questionnaire was distributed both online and offline. Most questionnaires are distributed through mobile apps and web pages, while a small portion are conducted through physical (face-to-face distribution, face-to-face answering) questionnaires. 750 questionnaires were distributed, and 601 were actually collected, 601 questionnaires were valid, with an effective response rate of 80.13%.

## 2. Analysis of Residents' Behavior for Green and Energy saving Renovation of Existing Residential Buildings

### 3.1 Validity testing of formal questionnaire

Table 1: Validity test

| Variable group name | Kaiser-Meyer-Olkin measure of sampling adequacy(KMO) | Bartlett's Test of Sphericity |     |      |
|---------------------|------------------------------------------------------|-------------------------------|-----|------|
|                     |                                                      | Approx. Chi-square            | df  | Sig. |
| Behavior            | 0.846                                                | 11177.351                     | 21  | .000 |
| Motivation          | 0.791                                                | 1227.199                      | 55  | .000 |
| Capacity            | 0.882                                                | 1698.948                      | 36  | .000 |
| Contextual          | 0.816                                                | 2076.389                      | 136 | .000 |

From Table 1, it can be seen that variable behavior, motivation, capability and contextual, these four group of variable's KMO value is 0.846, 0.791, 0.882, 0.816, which all larger than 0.7. That means they are good to do exploratory analysis. Bartlett's test all shows that sig. value is .000, which means variables have relationship with each other, it is foundation for extract factors.

### 3.2 Descriptive Analysis

Through statistical analysis, we can have a comprehensive understanding of residents' concepts and transformation behaviors. Statistical analysis provides detailed information, including total sum, mean, standard deviation, and frequency and percentage of each item. The distribution characteristics of the questionnaire are shown in Table 2. The distribution of the variables' social demographic background (Backend) and living conditions (Living situation) is basically normal, without many extreme values, which is basically reasonable.

Table 2: Descriptive statistical analysis of variable sociodemographic background and living situation characteristic

| variables                                   | Number                                          | Frequency | Percent% | variables                        | number                       | Frequency | Percent% |
|---------------------------------------------|-------------------------------------------------|-----------|----------|----------------------------------|------------------------------|-----------|----------|
| gender                                      | Male                                            | 270       | 44.9     | Residence population             | 1                            | 24        | 4.0      |
|                                             | Female                                          | 331       | 55.1     |                                  | 2                            | 71        | 11.8     |
| Age                                         | Under 18                                        | 10        | 1.7      |                                  | 3                            | 270       | 44.9     |
|                                             | 18-25                                           | 91        | 15.1     |                                  | 4                            | 115       | 19.1     |
|                                             | 26-30                                           | 141       | 23.5     |                                  | 5                            | 95        | 15.8     |
|                                             | 31-40                                           | 215       | 35.8     | Number of older people           | 6                            | 26        | 4.3      |
|                                             | 41-50                                           | 109       | 18.1     |                                  | 0                            | 332       | 55.2     |
|                                             | 51-60                                           | 31        | 5.2      |                                  | 1                            | 114       | 19.0     |
|                                             | Mroe than 60                                    | 4         | 0.7      |                                  | 2                            | 150       | 25.      |
| Marital status                              | single                                          | 193       | 32.1     |                                  | 3                            | 5         | 0.8      |
|                                             | Marriage                                        | 408       | 67.9     | Number of child live in a family | 0                            | 304       | 50.6     |
| occupation                                  | Worker, server, consultant, construction worker | 93        | 15.5     |                                  | 1                            | 244       | 40.6     |
|                                             | Government related staff                        | 162       | 27.0     | Time of construction             | 2                            | 51        | 8.5      |
|                                             | Teacher                                         | 74        | 12.3     |                                  | 3                            | 2         | 0.3      |
|                                             | Private enterprise                              | 167       | 27.8     |                                  | Before 1980                  | 31        | 5.2      |
|                                             | unemployed                                      | 31        | 5.2      |                                  | 1981- 1990                   | 59        | 9.8      |
|                                             | student                                         | 74        | 12.3     |                                  | 1991- 2000                   | 125       | 20.8     |
| Education background                        | Senior high school or equivalency               | 119       | 19.8     | Total area                       | 2001- 2010                   | 240       | 39.9     |
|                                             | Bachelor degree or equivalency                  | 333       | 55.4     |                                  | After 2011                   | 146       | 24.3     |
|                                             | Master degree                                   | 120       | 20.0     |                                  | Less than 40 m <sup>2</sup>  | 26        | 4.3      |
|                                             | PhD                                             | 29        | 4.8      |                                  | 40-80 m <sup>2</sup>         | 138       | 23.0     |
| Family total Monthly income                 | Under 4000 RMB                                  | 122       | 20.3     |                                  | 80-120 m <sup>2</sup>        | 263       | 43.8     |
|                                             | 4000-10000 ¥                                    | 301       | 50.1     | Property type                    | 121-150 m <sup>2</sup>       | 119       | 19.8     |
|                                             | 10000-20000¥                                    | 125       | 20.8     |                                  | 151-200 m <sup>2</sup>       | 38        | 6.3      |
|                                             | More than 20000 RMB                             | 53        | 8.8      |                                  | More than 200 m <sup>2</sup> | 17        | 2.8      |
| Self evaluation of family total consumption | Family totally income could afford spend        | 435       | 72.4     |                                  | Rent                         | 49        | 8.2      |
|                                             | Family totally income hardly afford spend       | 149       | 24.8     |                                  | Have ownership               | 511       | 85.0     |
|                                             | Family totally income cannot afford spend       | 17        | 2.8      |                                  | Public house                 | 41        | 6.8      |
|                                             |                                                 |           |          | Living floor                     | Ground floor                 | 96        | 16.0     |
|                                             |                                                 |           |          |                                  | Top floor                    | 91        | 15.1     |
|                                             |                                                 |           |          | dwellingduration                 | Other floor                  | 414       | 68.9     |
|                                             |                                                 |           |          |                                  | Less than 1 year             | 49        | 8.2      |
|                                             |                                                 |           |          |                                  | 1-3 year                     | 126       | 21.0     |
|                                             |                                                 |           |          |                                  | 3-5 year                     | 123       | 20.5     |
|                                             |                                                 |           |          |                                  | 5-10 year                    | 119       | 19.8     |
|                                             |                                                 |           |          |                                  | More than 10 years           | 184       | 30.6     |

The variables of "Motivation" and "CAPABILITY" simultaneously affect residents' renovation behavior. The average value reflects the respondents' opinions, with 3 indicating a neutral stance towards the question, 1-3 representing negative feedback, and 3-5 representing positive feedback. Further research shows that the majority of the respondents believe they are familiar with relevant renovation knowledge or have access to such knowledge, with most average values being greater

than 3. Among these methods, majority people think professional energy consultant could help a lot (mean=4.04). Compare with professional knowledge, the situation of construction ability is slightly negative. Most of residence think they do not have abundant ability to DIY and do not have confident to fulfil retrofit ideas (mean is 2.84 and 2.97). For other question about construction ability, respondent most stay on neutral attitude. For motivation variable, respondent largely have positive reflection on dimension of personal preference and environment responsibility. The majority of the respondents agree that the needs of the elderly and children should be prioritized (average value = 4.39), and they also think it is important to use environmentally friendly decoration materials (average value = 3.93), and strongly agree to improve the quality of life and pay attention to living standards (average value = 4.06). Large number of residences have strong responsibility towards environment (mean=4.39) and they pay close attention to air pollution and could use ways to protect themselves from pollution. Regarding environment problem, Most of people could sacrifice their own interested (mean=3.91). Large group of people do rely on government's leading (mean=3.70), cost effective is important (mean=3.95), but not the only criterion. The majority of residence do have higher requirement about living space, they disagree with make do with living environment (mean=2.74)

### 3.3 Self-evaluation of family total consumption

Table 3 ANOVA of self-evaluation of family total consumption

|                               |                | Sum of Squares | df  | Mean Square | F     | Sig. |
|-------------------------------|----------------|----------------|-----|-------------|-------|------|
| Indirect Participate Behavior | Between Groups | 10.457         | 2   | 5.228       | 5.303 | .005 |
|                               | Within Groups  | 589.543        | 598 | .986        |       |      |
|                               | Total          | 600.000        | 600 |             |       |      |
| Direct Retrofit Behavior      | Between Groups | 15.188         | 2   | 7.594       | 7.765 | .000 |
|                               | Within Groups  | 584.812        | 598 | .978        |       |      |
|                               | Total          | 600.000        | 600 |             |       |      |

Table 4 Test of Homogeneity of Variance

|                               | Levene Statistic | df1 | df2 | Sig. |
|-------------------------------|------------------|-----|-----|------|
| Indirect Participate Behavior | 3.332            | 2   | 598 | .036 |
| Direct Retrofit Behavior      | 2.172            | 2   | 598 | .115 |

Table 5 Multiple Comparisons

| Dependent Variable       | (I) Self evaluation of family total consumption | (J) Self evaluation of family total consumption | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval |             |
|--------------------------|-------------------------------------------------|-------------------------------------------------|-----------------------|------------|------|-------------------------|-------------|
|                          |                                                 |                                                 |                       |            |      | Lower Bound             | Upper Bound |
| Direct Retrofit Behavior | could afford spend                              | hardly afford spend                             | .212                  | .094       | .078 | -.018                   | .443        |
|                          |                                                 | cannot afford spend                             | .839*                 | .244       | .003 | .239                    | 1.439       |
|                          | hardly afford spend                             | could afford spend                              | -.212                 | .094       | .078 | -.443                   | .018        |
|                          |                                                 | cannot afford spend                             | .627*                 | .253       | .047 | .006                    | 1.248       |

\*The mean difference is significant at the 0.05 level

Table 3 shows, ANOVA analysis shows that different self-evaluation have significant effect on both indirect participate behavior (F=5.303, P=.005) and direct retrofit behavior (F=7.765, P=.000). However, after Multiple Comparisons, indirect participate behavior's result conflict with ANOVA analysis. Hence, we only keep direct retrofit behavior's result. Tables 4 and 5 indicate, through the Scheffe method, that families who cannot afford daily expenses are significantly more hesitant to undertake direct retrofitting compared to those who can afford daily costs and those who

find it moderately difficult to do so. The respective mean differences are 0.839 and 0.627.

### 3. Conclusions

Through descriptive statistical analysis of the questionnaire and research on the retrofit behavior of households with different consumption levels. It was found that householders with different consumption levels have a significant impact on both participatory and direct retrofit behaviors.

Families who can afford daily expenses are more willing to undergo direct renovation. Married individuals, teachers, researchers, and residents who have lived in a community for a long time are more likely to engage in participatory retrofit behavior. Compared with direct retrofit behavior, participatory retrofit behavior is more likely to occur in a specific group, and the conditions for participatory transformation are easier to predict and intervene.

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