Reexamine the relationship between new environmental paradigm and low-carbon consumption behavior

Xue-Min Xu\textsuperscript{1,2,a}, Sheng-Jung Ou\textsuperscript{3,b*}, Cheng Huang\textsuperscript{1,c*}

\textsuperscript{1}Department of Environmental Art and Design, Shanghai Art and Design Academy, China
\textsuperscript{2}PhD program in Architecture and Urban design, Department of Architecture, Chaoyang University of Technology, Taiwan
\textsuperscript{3}Department of Landscape and Urban Design, Chaoyang University of Technology, Taiwan

E-mail: \textsuperscript{a}452780491@qq.com; \textsuperscript{b}sjou@cyut.edu.tw; \textsuperscript{c}316842182@qq.com

Abstract. Carbon emission is an important cause of ecological imbalance and environmental pollution. Environmental issues such as energy consumption and carbon emissions caused by rapid economic development are important content that must be controlled at present. Reducing energy consumption in daily life is one of the most important energy-saving measures in densely populated cities. This study analyzed the environmental attitude of Shanghai citizens and the life energy-saving strategies promoted by the local government and found that the fulfillment of energy-saving behavior in daily life depends on people's awareness of ecological balance and the degree of energy crisis. At the same time, the study found that energy-saving through building energy conservation, public resources and control of living consumption to promote the balanced development of ecology. The implementation of building energy conservation, electricity conservation, control of living consumption and other energy conservation behavior are also important ways to save energy.

1. Introduction
The Shanghai Municipal Government has made effort to deal with energy consumption and carbon emissions caused by urban development in recent years. In 2014, the State Council issued the “Energy-saving and Emission reduction Action Plan for 2014-2015”, which mainly controls energy consumption and carbon emissions from the aspects such as industrial production of the adjusting industrial structure, speeding up the construction of energy saving and emission reduction projects, focusing on energy consumption industries to save energy and reduce carbon emission, strengthening the promotion of technology innovation and new technologies, and tax policies to save energy and reduce emissions [1]. The total energy consumption of Shanghai has increased with a stable population after 2015. In view of the terminal consumption of industrial energy in Shanghai, the ratio of industrial energy consumption to total energy consumption has decreased year by year since 2015. Although the energy consumption of industrial production is controlled, the energy consumption of living consumption, other third industries and transportation increases year by year.

Public participation in life energy-saving activities has been advocated through various media. There are many ways to promote the living environment, such as the theme activities of the conservation day, the low carbon day, TV program of the life energy-saving methods, the
environmental protection activities and education in campus. Based on the previous investigation of the environmental attitude and energy-saving behavior of Shanghai residents, it is concluded that a good environmental attitude is an important prerequisite for the performance of energy-saving environmental protection behavior through typical correlation analysis. Participation in energy-saving behavior can also contribute to the development of good environmental attitude [2]. As for many energy-saving strategies in daily life, which ones are widely recognized by the public and can be actively implemented, and which ones reflect the public's environmental attitude and play an important role in environmental protection, are expected to be understood in this study.

2. Research method
This study is based on the questionnaire with environmental attitude and energy-saving behavior of Shanghai citizens. The environmental attitude survey adopts the new environmental paradigm (NEP) scale [3], which is used as the measurement part of environmental attitude. The life energy-saving behavior survey is combined with the various energy-saving strategies implemented by the Shanghai government based on the current status of the urban environment, and summarizes the issues involving clothing, food, housing, and transportation from the people’s daily life. A total of 30 items of urban energy-saving and low-carbon living behaviors were prepared as a measurement part of energy-saving behaviors. According to the agreement of environmental attitude and willingness of energy-saving behavior, the whole questionnaire was compiled by Likert 5 point scale from high (5) to low (1). The questionnaire which containing a total of 42 questions composed of two parts of the scale, environmental attitude and daily energy-saving behaviors restricted to be distributed within the Shanghai area through the form of online survey. A total of 219 valid questionnaires of long-term residence subjects were obtained. Men accounted for 30.6% and women 69.4% of the sample. The group aged under 30 accounted for 16.4% of the total population, 42.5% of the group aged 31-40, 13.2% of the group aged 41-50, and 11.4% of the group aged over 50. The subjects with high school education or less accounted for 11.9% of the total, those with college education account for 62.1%, and graduate school education or above of the subjects accounted for 26%.

3. The results
The environmental attitude scale section carries on the reliability analysis according to the new environmental paradigm (NEP) scale including “Limits to growth”, “Anti-anthropocentrism” and “Balance of nature” these three aspects [4]. In the “Anti-anthropocentrism” part which contains 4 items, the reliability test found that after deleting the question NO. 9 (It is human right to adapt the natural environment to suit our life), the Cronbach’s α of this part increased to 0.861. The reliability test of the environmental attitude questionnaire found that excluding question NO.9, the overall Cronbach’s α could be increased from 0.642 to 0.682. The statistical analysis of the environmental attitude part included a total of 11 questions except question NO.9, which was invalid in the reliability test. According to the three aspects of environmental attitudes questionnaire named "Balance of nature" (Y₁), "Limits to growth" (Y₂), and "Anti-anthropocentrism" (Y₃), three new variables were obtained with the mean value of the items in each aspect respectively for the establishment of the regression model.

Since there are many items in the energy-saving behavior part of the survey, in order to facilitate the later regression analysis, this study used the analysis results extracted by energy-saving behavioral factors of the previous study. The p value of the Bartlett's spherical results is 0.000 and the KMO value is 0.931. The five oriented factors were “Economize on living goods”, “Economize public resources”, “Energy-efficient buildings”, “Electricity saving” and “Low-carbon transportation”. The total explanatory variance is 62.968% [2].

Multiple regression analysis was used to establish regression models respectively. The three main factors of environmental attitude are “Balance of nature” (Y₁), “Limits to growth” (Y₂), and “Anti-anthropocentrism”(Y₃). Five factors of energy-saving behavior are “Economize on living
goods”(X₁), “Economize public resources”(X₂), “Energy-efficient buildings”(X₃), “Electricity saving”(X₄), and “Low-carbon transportation”(X₅).

Stepwise regression method was used to establish the model by the environmental attitude “Balance of nature” (Y₁) and the five factors of energy-saving behavior. It is found that the five factors of energy-saving behavior finally enter the fifth model, the R value is 0.679, and the model determination coefficient R² is 0.461. All the test coefficients of the fifth model are higher than other models, and the fitting degree of the equation is better. The P values of the five models indicated that there is a significant linear relationship between energy-saving behavior and the environmental attitude “balance of nature” (p<0.05), the regression model is established successfully and the fifth model is the optimal model. According to the Table 1, the multiple regression model by the environmental attitude “Balance of nature” and the energy-saving behavior can be obtained as following:

\[ Y₁=1.559 + 0.197 X₁ + 0.196 X₂ + 0.184 X₃ + 0.109 X₅ + 0.076 X₄ \]

According to the regression model of environmental attitude “Balance of nature” and energy-saving behavior, “Balance of nature” is positively correlated with all life energy-saving behavior. People believe that “Energy-efficient buildings”, “Economize public resources” and “Economize on living goods” play important roles in promoting ecological balance. “Low-carbon transportation” also contributes to the balanced development of ecology. However, “Electricity saving” is a relatively minor impact factor.

Table 1. Statistics of the Stepwise Regression of Environmental Attitude “Balance of Nature” and Energy-saving Behavior

| Energy-saving Behavior                  | Non-standardized coefficient | Standardized coefficient | t     | Sig. |
|----------------------------------------|------------------------------|--------------------------|-------|------|
| Model                                  | B                            | SE                       | Beta  |      |
| (const)                                | 1.559                        | 0.026                    | 58.876| 0.000***|
| Energy-efficient buildings              | 0.197                        | 0.027                    | 0.373 | 7.419| 0.000***|
| Economize public resources              | 0.196                        | 0.027                    | 0.371 | 7.373| 0.000***|
| Economize on living goods               | 0.184                        | 0.027                    | 0.348 | 6.920| 0.000***|
| Low-carbon transportation               | 0.109                        | 0.027                    | 0.206 | 4.097| 0.000***|
| Electricity saving                      | 0.076                        | 0.027                    | 0.144 | 2.867| 0.005** |

* Dependent variable: Balance of nature
b p<0.05*,  p<0.01**,  p<0.001***

With stepwise regression model established by environmental attitude “Limits to growth” (Y₂) and energy-saving behavior, it is found that the five factors of energy-saving behavior finally enter the fifth model, the R value is 0.656, and the model determination coefficient R² is 0.431. Each test coefficient of the fifth model is higher than other four, and the fitting degree of the equation is better. The P values of the five models indicated that there is a significant linear relationship between energy-saving behavior and the environmental attitude “Limits to growth” (p<0.05), the regression model is established successfully and the fifth model is the optimal model. According to the Table 2, the multiple regression model by the environmental attitude “Limits to growth” and the energy-saving behavior can be obtained as following:

\[ Y₂=1.918 + 0.232 X₂ + 0.207 X₃ + 0.193 X₅ + 0.189 X₅ + 0.034 X₃ \]

From the stepwise regression model of environmental attitude “Limits to growth” and energy-saving behavior, “Limits to growth” is positively correlated with all five energy-saving behavior factors. The public has shown a high degree of recognition of the limitation of natural resources in energy-saving behavior with “Energy-efficient buildings”, “Electricity saving”, “Economize on living goods” and “low-carbon transportation”. “Economize public resources” is considered to have less impact on natural resource consumption than others.
Table 2. Statistics of the Stepwise Regression of Environmental Attitude “Limits to Growth” and Energy-saving Behavior

| model                                | Non-standardized coefficient | Standardized coefficient | t     | Sig.  |
|-------------------------------------|------------------------------|--------------------------|-------|-------|
|                                     | B               | SE  | Beta |       |       |       |       |       |       |
| (const)                             | 1.918           | 0.034 |      | 55.997 | 0.000*** |       |       |       |       |
| Energy-efficient buildings           | 0.232           | 0.034 | 0.350 | 6.764 | 0.000*** |       |       |       |       |
| Electricity saving                  | 0.207           | 0.034 | 0.312 | 6.027 | 0.000*** |       |       |       |       |
| Economize on living goods           | 0.193           | 0.034 | 0.291 | 5.637 | 0.000*** |       |       |       |       |
| Low-carbon transportation            | 0.189           | 0.034 | 0.284 | 5.492 | 0.000*** |       |       |       |       |
| Economize public resources          | 0.143           | 0.034 | 0.215 | 4.156 | 0.000*** |       |       |       |       |

a Dependent variable: Limits to growth
b \( p < 0.05 \), \( p < 0.01 \), \( p < 0.001 \)

The same regression method was also used to establish model for environmental attitude “Anti-anthropocentrism”\((Y_3)\) and energy-saving behaviors. Only “low-carbon transportation” and “Electricity saving” the two energy-saving behavior factors finally entered into the model, the \( R \) value is 0.236, and the R-square was 0.056 which is far less than 0.3. It was failed to establish the regression model between the environmental attitude “Anti-anthropocentrism” and energy-saving behaviors.

4. Discussion

According to the results of above regression analyses, people believe that Energy-efficient buildings are the primary energy-saving behavior for ecological balance and protection of natural resources. Architectural space is the indoor environment in which people engage in various activities daily. 90% of a person’s life is spent indoors. The metropolis has a large population and high building density. The implementation of building low-carbon behavior is of great significance to energy conservation. Low-carbon building energy-saving strategies are divided into two aspects: low-carbon construction and low-carbon use. Environmental protection of building construction is one of the important strategies for low-carbon buildings. Reducing construction energy consumption mainly refers to the use of environmental protection materials to reduce pollution levels, while the renewable construction materials can reduce the damage to the ecological environment. Low-carbon buildings using green materials can generally be recognized and valued by the public. In addition to their benefits for ecological balance, more importantly, their lower release of harmful substances contributes to the health of the people. This also exposes the social problem that green materials have not popular in the building materials market currently, the traditional building materials are still dominated on the market. In addition, because of the advanced technology of green materials, their prices are much higher than traditional materials. In the strategy of low-carbon construction, it is necessary to continuously popularize green building materials through technological innovation, and improve the cost-effectiveness of green materials, so as to promote the green consumption of environmentally friendly materials and reduce the damage to the ecological balance. Regarding the low-carbon use of buildings, commercial building facilities can be reasonably regulated according to actual usage. On the other hand, the time-sharing price strategy for water, heating, natural gas and other energy can be further implemented based on the time-sharing electricity price strategy that has been implemented to promote the popularization of people’s building energy-saving behavior.

People believe that low-carbon consumption and low-carbon transportation contribute to ecological balance and conservation of natural resources. In the aspect of living consumption and energy consumption, the consumption of residents in the retail chain of Chinese social consumption accounts for a great proportion. In recent years, Shanghai has ranked first in luxury goods consumption, online shopping [5], catering consumption [6] and social consumer retail sales in the country [7]. In addition to consumer behavior that meets basic living conditions, low-carbon consumer behavior is mainly targeted at non-essential consumption for life convenience such as advocating to reduce the consumption of disposable products like paper towels, chopsticks, lunch boxes, plastic bags and other...
non-essential consumption of animal fur and other treasured animal products is of great significance to ecological balance and environmental protection. In addition, the energy consumption of transportation increases rapidly, and the total number of people traveling in Shanghai increases year by year [8]. Since 1997, Shanghai issued the “Shanghai Road Traffic Management Ordinance” [9]. Due to the increasing pressure of traffic congestion, the detailed rules of time-divided traffic limit for vehicles have been revised for several times. Low-carbon transportation is also considered to be one of the factors to maintain ecological balance. Traffic carbon emissions leads to seriously air pollution which causes the health of organisms to be threatened.

The “Economize public resources” is considered to promote ecological balance more than the conservation of natural resources. The energy-saving behaviors of public resources mainly include participating in greening activities, the management of common bicycle use, saving public water, electricity and so on. It is obvious that participating in urban greening and saving water resources can promote ecological balance. A good management of using shared bicycles can help to reduce carbon emission to a certain extent and protect the ecological balance. It is also an objective fact that the energy-saving behavior of electricity saving energy is considered to be more beneficial to the protection of natural resources than to the ecological balance.

5. Conclusions
This study established regression models of Shanghai residents’ environmental attitudes and energy-saving behaviors. It was found that building energy-efficient is regarded as the primary energy-saving behavior aspect of ecological environment and natural resource protection. First, it is important to promote energy-saving behavior of building spaces through policies such as popularization of green building materials, humanized management of buildings and the construction of buildings. Policies such as time-sharing and tiered pricing for resources have tried to promote low-carbon and energy-saving behavior in building spaces. Second, low carbon consumption and low-carbon transport both have quite a few oriented energy-saving policies are also believed to contribute to development of the ecological balance and the protection of natural resources. In order to implement the energy-saving behavior strategy more widely and deeply, it is particularly important to improve people's attention to the ecological environment and natural resources and their sense of responsibility. The publicity of energy-saving strategy for maintaining public resources should focus on the importance of ecological balance, while the publicity of electricity-saving strategy can start from the perspective of natural resources crisis, so as to gain the public's understanding on the knowledge level and the recognition of the implementation of energy-saving behavior.

Acknowledgments
Author Contributions: Conceptualization, X.-M.X. and S.-J.O.; methodology, X.-M.X. and S.-J.O.; software, X.-M.X.; S.-J.O. and C.H.; validation, X.-M.X.; S.-J.O. and C.H.; formal analysis, X.-M.X.; S.-J.O. and C.H.; investigation, X.-M.X and C.H.; resources, X.-M.X and C.H.; data curation, X.-M.X and C.H; writing—original draft preparation, X.-M.X. and S.-J.O.; writing—review and editing, X.-M.X.; S.-J.O. and C.H.; supervision, S.-J.O.; project administration, X.-M.X and C.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding

Conflicts of Interest: The authors declare no conflict of interest

References
[1]. General Office of the State Council of the People’s Republic of China. (2014). 2014-2015 Energy Conservation and Emission Reduction Low Carbon Development Plan. Available online: http://www.gov.cn/zhengce/content/2014-05/26/content_8824.htm (accessed on 20 Jan 2020)
[2]. Xu, X. M. & Ou, S. J. (2020). The Influence of Public Environmental Attitude on the Implementation Intention of Energy-saving Strategies. Journal of Design and Environment. 21: 69-86
[3]. Zhang, Z. C. (1995). Analysis on the attitude of environmental protection teachers with the New Environmental Paradigm. *Environmental Education Quarterly*. 26: 37-45

[4]. Guagnano G. A., Stern P. C., Dietz T. (1995). Influences on attitude-behavior relationships: a natural experiment with curbside recycling. *Environment and Behavior*. 27: 699-718

[5]. China Commerce Think Tank, Inc. China Urban Consumption Upgrade Report 2018. Available online: http://www.cctpress.com/NewsView.asp?ID=167&SortID=14 (accessed on 20 Jan 2021)

[6]. CBNdata & Koubei, Inc. China Catering Consumption Report of 2017. Available online: https://www.cbndata.com/report/392/detail?isReading=report&page=1 (accessed on 20 Jan 2021)

[7]. National Bureau of Statistics of China. (2019). Available online: http://data.stats.gov.cn/easyquery.htm?cn=E0105 (accessed on 20 Jan 2020)

[8]. Shanghai Urban and Rural Construction and Transportation Development Research Institute. Shanghai Traffic Annual Report of 2019. Available online: http://tjj.sh.gov.cn/tjjn/20200427/4aa08fba106d45fda6cb39817d961c98.html (accessed on 12 Jun 2020)

[9]. Shanghai Public Security Bureau. Shanghai Vehicle Restriction Regulations. 2016. Available online: http://sh.bendibao.com/traffic/201649/159141.shtml (accessed on 12 Jun 2020)