

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

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Abstract

This paper combs the development history and current situation of Design for Sustainability (DFS), and discusses the role of DFS in social transformation. The author studies the methods and tools of DFS and their achievements in different fields. The research shows that DFS can provide effective solutions in different fields. In the article, the author finds that the DFS policy will be different in different contexts, so the author puts forward the DFS method in the Chinese social context. Under the severe theme of climate change, the research is focused on the issue of carbon emissions. Using the DFS method in the context of Chinese society, the author takes the design of sustainable service system for kitchen waste recycling as a case, and tries to introduce the DFS method into the problem of reducing carbon emissions.

Keywords: Design for Sustainability (DFS), Carbon Emission, Sustainable Social, Kitchen Waste Recycling

Design for Sustainability (DFS) guidance under social transformation

With the development of social economy, the ecological problems of the earth are facing more and more severe challenges. UN Secretary General Guterres said at the UN high level political forum on sustainable development in 2021: under the influence of COVID-19, the structural challenges of climate crisis and inequality to sustainable development are becoming serious (Arora, N. K., & Mishra, I.,2019). In recent years, with the social development, the adjustment of economic structure and the

deterioration of ecological environment, the process of sustainable development goals has been hindered. On the one hand, in contemporary, mankind is facing the current situation of ecological overload. On the other hand, it is facing the phenomenon of insufficient social foundation. Against this background, the design field has gradually developed the concept of Design for Sustainability (DFS). Designers begin to think about social, economic and environmental issues besides users in the DFS. GH Bruntland, chairman of the United Nations Environment Committee, firstly proposed the concept of DFS in the 1980s, and the word "Sustainable" began to enter the field of design. In the thinking of DFS, designers have developed from the design of product life cycle to the sharing design for the purpose of use, and from the user centered to the society centered, constantly expanding their development boundary in the sustainable field.

In the process of transition to a sustainable society, contemporary society is facing not only technical challenges, but also the joint role of society, economy and environment. DFS plays an intermediary role in linking the government, enterprises, communities and individuals in this process. In recent years, many scholars have carried out research around DFS, and summarized the design methodology of DFS in different fields in the process of social practice.

In the field of social innovation, Professor Ezio Manzini established the DESIS network alliance and carried out many related DFS studies in Universities in Europe, China, India and Brazil (Manzini, E.2009).

In the Product Service System Design (PSSD), Professor Earo Vezzoli put forward the concern about the product life cycle and ecological benefits, and emphasized the wellbeing of future generations, especially the irreplaceable natural resources (Vezzoli, C., et al..2017).

In the field of design methodology, Claire K. Wan and Shih Yu Lin proposed a dialectical thinking model in DFS from three aspects: conception, imagination and realization. This model integrates social value, practice and development space. By integrating dialectical thinking, designers are encouraged to continuously adjust design schemes and solve design challenges in the process of time and space development. It provides designers with a thinking framework for sustainable development, so as to strengthen the role of designers in promoting sustainable design transformation (Wan, C. K., & Lin, S. Y.2022).

With the continuous efforts of designers and scholars, the concept and tools of DFS are constantly improving, and they try to intervene in DFS in different fields to enrich the content and experience of their design practice.



Chang Xiong, Sang Guangliang

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

Linköping University Electronic Press

Research Value of Design for Sustainability (DFS) Development in Carbon Emission

Design Efforts in the Field of Carbon Emission Reduction

With the intensification of global warming, climate change has caused a considerable malignant impact on the survival and development of human society. Therefore, climate change has become a global problem. In 2015, in order to cope with climate change, various countries held the United Nations Climate Change Conference in Paris, France. The conference stated that the goal of zero global greenhouse gas emissions would be achieved by the middle of this century (S Stocker, T. (Ed.) 2014). DFS is trying to intervene in human activities and carbon emissions as a bridge.

As an activity of planning human behavior, design has an irreplaceable role and position in human society while it is committed to improving human life. When the environmental problems become more and more serious, in the 1990s, the society developed a design trend: Ecological Design. In the field of ecological sustainability, design has made many excellent achievements. However, when only talking about ecological sustainability, it is easy to overlook the other two important pillars of sustainable development: economy and society. To some extent, this process needs to sacrifice part of the interests of the enterprise to exchange for ecological benefits, or produce some negative social effects, so it will be hindered in the development process.

Research Value of Design for Sustainability (DFS) Development

DFS emerges as the times require. As a design activity aiming at human sustainable development, it involves all aspects of human life. Its research content not only includes ecological sustainability but also involves social, economic, technological and cultural aspects, and realizes human sustainable development from the perspective of the whole society.

Liu Xiang, et al, took the works in the first China (Huaihua) Rural Revitalization Design Innovation Competition as examples. The author studied and analyzed the green sustainable characteristics and methods of its agricultural products, refined the development path of its green sustainable design, and solved the problem of resource waste and consumption of agricultural products in modern society (Liu Xiang, et al..2021).

Professor Carla Cipolla and Professor Ezio Manzini, based on the research background of the social ecosystem in the peaceful slums of Rio de Janeiro, took the establishment of new energy relations between local commercial companies and slum



Chang Xiong, Sang Guangliang

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

Linköping University Electronic Press

residents as a case. They used DFS methods and tools to participate in local social innovation, explore the coordination framework of material and social resources in the process of transformation and change of informal settlements, and promote the establishment of more open, flexible and transparent social networks in local society (Cipolla, C., et al..2015).

Claire K. Wan and Shih Yu Lin, under the background of DFS, discussed and studied negotiated sustainable product design from three aspects: social value, time dimension and development space, and elaborated a set of different comprehensive design strategies that can help designers to adopt when facing complex problems (Wan, C. K., & Lin, S. Y. 2022).

It can be seen that throughout the world, DFS is being integrated into all walks of life in a comprehensive, targeted and applicable way, and its relevant knowledge and tools can effectively help the society to transform to sustainable development.

Consideration on Carbon Emission under Design for Sustainability (DFS) Development

DFS Method of Carbon Emission under Traffic Background

The transformation of low-carbon cities has become the goal pursued by various countries, and has made certain achievements to varying degrees. With the growth of urban traffic demand, it is important part of low-carbon links. Some researchers have established sustainable linear regression models based on the characteristics of different urban communities through the analysis of population data. Low carbon travel can achieve the goal of reducing carbon emissions by promoting the combination of different sustainable transport modes. Conticelli e, Gobbi and Rosas PIs have developed a Decision Support System (DSS), which used big data and the results of users' judgment on the quality of key factors (KFS) to evaluate and visualize the nodes in each trip, so that the DSS can assist users in making decisions and provide effective solutions (Conticelli, E., et al..2021).

DFS Method of Carbon Emission under Product Background

Straw furniture can reduce the pollution caused by straw burning, and can reuse straw resources to reduce carbon emissions and promote the development of green economy. Gu Yi and Chen Jian put the method of DFS into the carbon footprint of straw furniture, established the carbon footprint certification system of straw furniture, and optimized and improved the technology level of the whole straw furniture industry



Chang Xiong, Sang Guangliang

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

Linköping University Electronic Press

by quantifying the carbon footprint of the whole life cycle of straw furniture products. Researchers analyze the carbon footprint based on the life cycle assessment method, a tool for DFS (Gu Yi & Chen Jian 2015).

DFS method of Carbon Emission under Building Background

Carbon emissions in the construction industry account for a very high proportion of the total global carbon emissions. Carbon emissions will occur in all stages of the building life cycle, but the impact is different in each stage. In order to meet the challenges in the process of sustainable development in the field of architecture, Xi C and Cao s j proposed the "Standard Calculation Prediction Optimization" (SCPO) path for future architectural design. It takes the standard system as the framework, the carbon calculation method as the basis, the prediction model as the theory, and the low-carbon building as the goal (Xi, C., & Cao, S. J.2022).

To sum up, in different scenarios of carbon emissions, DFS has a positive impact on reducing carbon emissions in transportation, products and buildings by changing the interaction mode between stakeholders, and involving users' behavior lines, product structure and planning layout, effectively reducing the impact of carbon pollution. Thus, DFS plays an irreplaceable role in the social goal of reducing carbon emissions. Under the guidance of these DFS methods and tools, the author hopes to explore a bottomup sustainable development path and policy linking the government, enterprises, communities and citizens in the context of Chinese society.

Design for Sustainability (DFS) Method of Carbon Emission in Chinese Social Context

In 2020, China promised to achieve carbon peak by 2030 and carbon neutrality by 2060. On the basis that most developed countries took 40 to 80 years to achieve this goal, China is facing a situation of tight time and urgent tasks (Zhang Haonan, et al..2022). Due to China's national nature, a social structure has been formed in which the government is the main body, enterprises are the fulcrum of economic development, communities are the main means of management, and citizens are the smallest implementing units. Under these rules, the generation and operation of DFS need to adapt to its framework, which determines the legitimacy of products and services. In order to achieve this goal, policy will become the primary consideration in the sustainable design process. As the fulcrum of social and economic development, enterprises also play an extremely important role in DFS. Therefore, it is necessary to make full use of and cooperate with relevant enterprises to make efforts for the



Chang Xiong, Sang Guangliang

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

Linköping University Electronic Press

transformation of a sustainable society. As a social innovation activity, DFS needs to be supported and managed by the smallest social organization. In China, as the smallest organizational unit in society, the community has become an important link in the management of citizens and can play a positive role in social innovation. Hence, the role of community elements in sustainable design needs to be fully considered. As an activity to change human behavior, residents are the smallest executive unit, which bears the burden of social transformation. So, the rights and obligations of citizens should be respected and valued by researchers and designers.

Design Focus

As a design methodology of social innovation, DFS has a wide range of applications. In the initial stage of design, we focus on the design scene from the macro, meso and micro perspectives by observing certain social phenomena. At the macro level, understand the social background of DFS from the perspective of policy, so that its design means can be supported by policy, and lay a good foundation for its later design practice. At the meso level, the technology and capital of enterprises and the human resources of communities develop around the most important issues in the people's livelihood. Enterprises and communities play the role of realizing macro policies and organizing the realization of products and services in DFS. Therefore, in the process of focusing on DFS, we need to focus on the basic platforms and infrastructure of enterprises and communities. At the micro level, DFS needs to create the needs and motivation of citizens in a certain goal, and achieve the DFS goal by simplifying the process, cultivating habits and establishing a sense of achievement.

Investigation and Analysis

After determining the design scenario through design focus, researchers and designers need to clarify the international existing technology and development status through investigation and analysis. In this context, it is necessary to sort out and analyze different requirements of the same scenario and different solutions under the same requirement. Compare the advantages and disadvantages of existing solutions horizontally and vertically, and envision possible solutions in the process. What is important is that researchers and designers need to visit and investigate the stakeholders, and fully understand the allocation of existing roles, resources and environment in this process. At the same time, the contents focused on the design are refined and analyzed to ensure the feasibility of the project.



Chang Xiong, Sang Guangliang

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

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Demand Sorting

On the basis of the previous research, the demand is analyzed with the tools of DFS. The priority of requirements is classified according to user, requirement, function, value and other dimensions through design positioning. Analyze and extract the needs and pain points of each stakeholder through design tools such as motivation matrix. After determining the relationship and needs of various stakeholders, all resources and funds are combined through the system diagram to understand the objects provided and accepted by material and non-material in the whole system. Through the service blueprint, the service process and the relationship between the front and back of the whole service are designed, the service provider, service object, service design and service process are confirmed to be presented in a visual form. Based on the above requirements, preliminary solutions and ideas are formed for the design output.

Design Output

As a systematic design method, DFS takes place in the dynamic dimension of time and space. Therefore, the final scheme often results in the systematic output of a service + product. In this stage, researchers and designers need to comprehensively consider the contact points of human interaction, human-machine interaction and machine-machine interaction in the system from the perspective of the system. At the same time, the product design existing in the system can more meet the needs of the current system. Then, researchers and designers need to carry out life cycle assessment on the sustainable design scheme, and test the corresponding model of the final design structure in the three dimensions of economy, environment and society to ensure its rationality and feasibility.

In a complex social system, the tools and methods of DFS can help researchers and designers clarify their ideas and pay attention to every element that needs to be considered in every stage of design innovation. Of course, in different social environments, we need to adjust the design elements and plan the design methods according to the social structure. In the case of social innovation that promotes social transformation, DFS needs to comprehensively consider the roles and tasks undertaken by the government, enterprises, communities and citizens at all stages of design. In this design method, try to propose other possible alternatives, and select the system design results that conform to the concept of sustainable triangle.



Chang Xiong, Sang Guangliang

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

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Design Practice - Design of Sustainability (DFS) service system for Kitchen Waste Recycling

Design Focus

According to the report of the United Nations Environment Programme (UNEP), the world wasted 1.3 billion tons of food in 2019, while China wasted 117 million tons of food (Zhong Ming, Z., et al., 2021). In China, more than 44.78 million tons of kitchen waste are wasted every year. Traditional kitchen waste is combustible waste during incineration. During the storage and transportation of food waste, a large number of harmful gases such as formaldehyde will also be produced. At present, under the background of the policy of "Carbon neutral · Carbon peak Target" formulated by the Chinese government, all sectors of the society have begun to study the issue of carbon emissions. In this context, the author's design practice objective focuses on how to reasonably recycle and treat food waste to reduce carbon emissions.

Due to the special dietary structure and characteristics of the Chinese, the main components of kitchen waste are food residues containing rice and flour, vegetables, meat and bones, animal and vegetable oils and soup. It is rich in nitrogen, scale, potassium, calcium and various trace elements. According to statistics, all the food waste produced in China in a year can be utilized, which is equivalent to saving 2 million hectares of corn energy output and 6 million tons of biodiesel, with obvious resource characteristics.

In China, the traditional treatment methods of kitchen waste are mainly landfill and incineration. The landfill gas and leachate produced by the fermentation of landfill will cause secondary pollution to the environment. The incineration method has the most sufficient incineration efficiency of only 90%, and the annual emission of carbon dioxide and sulfur dioxide can reach 86000 tons and 295 tons respectively. The existing resource-based treatment technologies include biological fermentation to make fertilizer (residue), biodiesel (oil) and biological humic acid soil conditioner, which can reduce the carbon dioxide emissions of about 3 million tons per year.

Investigation and Analysis

At this stage, the author divided the kitchen waste into catering waste and home kitchen waste for desktop research and field research. In the desktop research, the author focuses on the current situation and policies of the Chinese government on catering waste, the treatment methods of various countries in the world, the amount of catering waste, the current situation of Chinese's understanding of kitchen waste, the amount of kitchen waste, the existing main treatment methods of Chinese and the



Chang Xiong, Sang Guangliang

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

Linköping University Electronic Press

product technology research. In the field research, Wuhan University of technology was mainly taken as the key research object. The author interviewed the stakeholders to understand the current collection scope, treatment destination and the process from the dining table to the waste treatment plant.

It could be seen from the survey results that the Chinese government has actively promoted the recycling of food waste in recent years, and is strengthening the construction of the collection, transportation and disposal system of kitchen waste. The development direction is expanding from urban to rural areas and strengthening the construction of infrastructure. In the United States, the United Kingdom, South Korea, the United Kingdom and Switzerland, it is found that the main treatment method is unified collection and treatment by the government or enterprises. Some households in the United States have purchased kitchen waste processors to discharge the separated garbage into the sewer, and the grease is sent to relevant factories for utilization. The existing recycling process in China mainly concentrates the collected garbage, and the final output is divided into swill, animal feed and gutter oil.

In the questionnaire survey, the author selected the young people living in cities. This group has a strong environmental awareness and a high acceptance of new things. In the design of the questionnaire, the author prepared seven narrative questions, three exploratory questions, three hypothetical questions and four interactive questions. 220 questionnaires were distributed with the electronic questionnaire as the carrier, and 97 valid questionnaires were collected. The current problems are sorted out from the results: 1. Kitchen waste is easy to accumulate in the family, and most of them are not separately pre classified. 2. Most of the residents understand the benefits of classifying kitchen waste, which can be practically implemented. They have very low experience in the use of personal related products or collective participation. 3. The residents' awareness of waste classification has been improved under the publicity of the government, but there is a slight lack of understanding and thinking on corresponding treatment. 4. The contemporary residents need to be correctly guided to treat the new disposal methods, and the overall attitude of positive response is obviously good.



Chang Xiong, Sang Guangliang

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

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Research Objective : to understand the situation of urban residents on kitchen waste and its treatment, so as to formulate and provide corresponding services in a reasonable manner

Target Population: Urban Youth

Narrative questions:

01. How many are your family members? 1-2, 3-5, 6 or more
02. Do you have garbage classification in your home? Never, occasionally, always
03. What is the situation of kitchen waste in your home? Less, average, more
04. Do you know that kitchen waste can be recycled? I don't understand. I understand this very well
05. Do you know that kitchen waste can be turned into compost? I don't understand. I understand this very well
06. Do you know about kitchen waste separator? I don't understand. I understand this very well
07. Do you know the classification of kitchen waste in your community? I don't understand. I understand this very well

Exploratory questions:

01. Do you think it is necessary for each household to implement garbage classification? It's unnecessary. I'm willing to look forward to it
02. Have you thought that kitchen waste can be used for family planting? I never thought about it. I have an idea. I'm looking forward to it
03. Have you considered turning kitchen waste into fertilizer through your own efforts? I didn't think about it. I've thought about it. I'm looking forward to it

Hypothetical question:

01. If there is an existing technology that can centrally treat kitchen waste in your home, are you willing to? I don't care if I don't want to
02. If you provide a way to solve the problem of garbage classification and make the city better, are you willing to participate? I don't care if I don't want to
03. If you provide an opportunity to try household planting with kitchen waste, are you willing to try? I don't care if I don't want to

Interactive questions:

01. Are you troubled by kitchen waste? If so, is it convenient to write?
02. Do you know the way to deal with kitchen waste now? If so, is it convenient to write?
03. After completing the above questions, how do you expect to deal with kitchen waste?
04. After completing the above problems, how much effort are you willing to make for the disposal of kitchen waste? It has nothing to do with me. Try your best and respond positively

Figure 1. Questionnaire: Self drawn by the author

In the user interview, the three contents of the recycling process, transportation process and waste destination of the kitchen waste were mainly taken as the search points, and detailed interviews were conducted with the canteen recycling personnel, canteen management personnel and waste transporters. The author sorts out and classifies the interview results according to the user definition, work task and garbage destination, and sorts out the following opportunities: 1. The kitchen garbage needs to be treated in time to prevent the environment from being affected by decay and odor, and it is expected to reduce the work burden and improve the work efficiency; 2. Master the direction of garbage and transportation scheduling in real time; 3. Conduct oil-water separation for the pretreatment of kitchen waste to reduce ineffective transportation.



Chang Xiong, Sang Guangliang

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

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Figure 2. Interview Questions: Self drawn by the author

There are three commonly used methods for treating kitchen waste in China: 1. Crushing and direct discharge; 2. Aerobic composting method; 3. Community centralized collection. The author compares the advantages and disadvantages of the three methods and finds that the three methods are not effective. First of all, because the Chinese food contains a large amount of oil, the smashing method may lead to blockage of the sewer. Secondly, the water content of Chinese food waste is high, which is not within the range of the optimal water content for composting. It is difficult for the microbial composting environment to reach the appropriate conditions. Therefore, the aerobic composting needs equipment to assist. Finally, the way of centralized collection in the community is complex, and secondary pollution is easy to occur in the treatment process.

In the sorting out of the survey results, the author sorted out catering waste and household kitchen waste, and sorted out 8 and 6 opportunity points respectively. The demands for sorting out catering waste are as follows: 1. Reasonable recycling to avoid secondary pollution in the recycling process; 2. Popularize the process and recycling awareness of recycling personnel of catering enterprises; 3. Reduce the work burden of all stakeholders in the recycling process and improve work efficiency; 4. Master the direction of catering waste and transportation scheduling in real time; 5. Pay attention to the impact on the surrounding environment at the centralized recovery point, and increase the odor removal device; 6. Conduct pretreatment and oil-water separation of catering waste before transportation to reduce ineffective transportation; 7. Make the disposal of catering waste transparent to avoid violations; 8. Find a more environmentally friendly, sustainable and resource-based treatment method for food waste.



Chang Xiong, Sang Guangliang

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

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The demands for the disposal of household kitchen waste are as follows: 1. Residents are troubled by the disposal of kitchen waste and hope to solve it in a reasonable way; 2. Residents are willing to participate in activities related to improving the earth's environment and reducing carbon emissions; 3. Take relevant measures to let residents understand the importance of reasonable disposal of household kitchen waste to environmental protection; 4. To take a series of measures to let residents understand the benefits of classifying household kitchen waste and improve their participation. 5. To take community centralized recycling or household as a unit of processing equipment for processing; 6. Residents have the habit of using household kitchen waste for composting and planting.



Figure 3. Arrangement of Opportunity Points: Self drawn by the author

To sum up, in the current solution, there is no systematic treatment method for food waste, and stakeholders in most processes and links are not involved.

Demand Sorting

In the stage of demand arrangement, the author positions the opportunity point according to the user, demand, function and value.

In terms of user, the positioning is as follow: 1. Urban residents prefer planting; 2. Small and medium-sized catering enterprises - shortage of operating costs; 3. Large catering enterprises and organizations - leading the trend of green and environmental protection and improving the brand and social value.

The demand orientation is as follows: 1. Solve the problem of household kitchen waste which is difficult to handle, and meet the specific population who prefer planting. 2. It is difficult for small and medium-sized catering merchants to purchase food materials, the supply channel is complex and the cost is too high, and it is difficult to dispose the food waste in time. 3. Seek new scientific solutions that can drive the influence of brands and organizations on regional or world industries and fields.



Chang Xiong, Sang Guangliang

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

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In terms of function, it is positioned as follows: home composting, home planting, centralized waste recycling, incentive feedback from supermarkets and fruit and vegetable markets; odorless kitchen waste treatment, timeliness recycling service, standardized kitchen waste recycling enterprise incentive mechanism; vertical farming waste treatment technology compost application, vertical farming planting supervision system, vertical farming planting resource mobilization system.

The value orientation is as follows: 1. Social value: with the participation of all parties, the individuals or organizational units that generate carbon emissions actively participate in and eliminate their own carbon emission levels through design means to realize the social significance of individuals and organizations; 2. Environmental value: through the brand-new design scheme, it can effectively solve the current high carbon emissions and even energy problems, and achieve real healthy / sustainable development; 3. Economic value: promote the development of new economy under green wisdom, green manufacturing and green life, optimize the economic interest relations of all parties, and let garbage recycling generate economic benefits to serve all beneficiaries; 4. Design value: based on the comprehensive consideration of the service system in the DFS, the design will be better and truly focused on the sustainable field, to achieve carbon neutral and carbon peak power design.

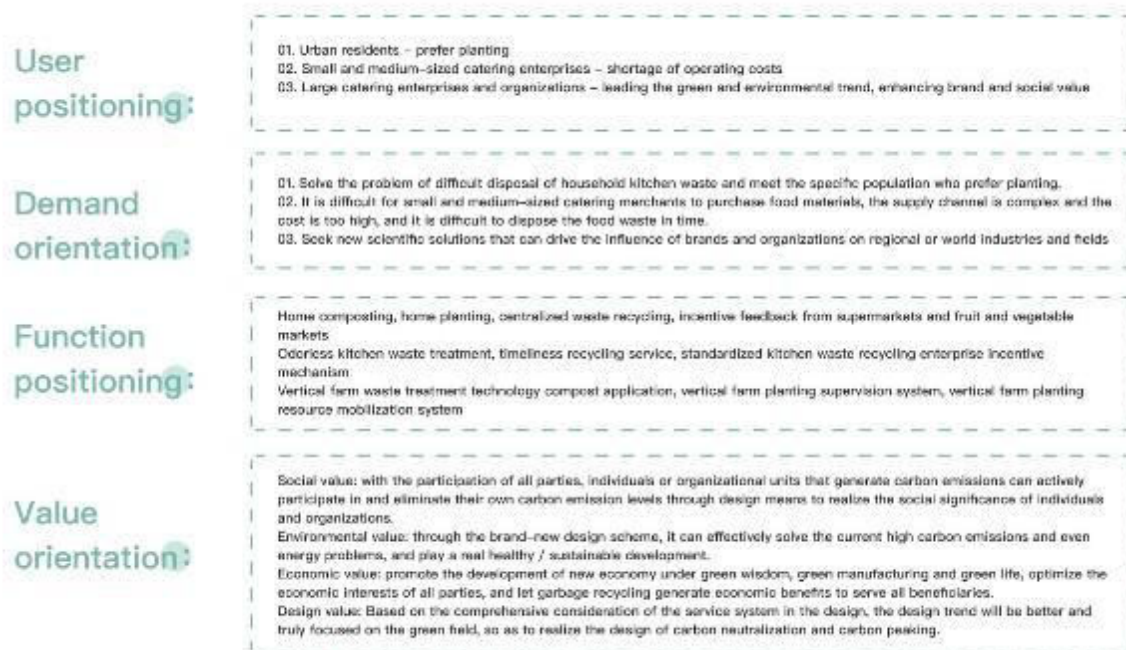


Figure 4. Design Positioning: Self drawn by the author



Chang Xiong, Sang Guangliang

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

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After defining the design orientation, the author combs out the needs and mutual relations of stakeholders from their own perspective through the motivation matrix. The following contents are sorted out: 1. Participate in kitchen waste recycling and maintain the earth's environment; 2. Jointly create a beautiful public catering environment; 3. Create new recycling methods to facilitate garbage recycling; 4. Collect and treat kitchen waste to provide raw materials for vertical rural areas; 5. Create a healthy public catering environment; 6. Create a healthy public catering environment; 7. Timely delivery; 8. Use points to exchange for food materials and additional food materials sales activities; 9. Publicize and promote kitchen waste recycling.

Give To	Resident	Public Catering	Commercial Super Market	Enterprise/Traders Or Retailer Waste	Vertical Plant Waste	State/County/Province Government	Recycling Personnel	Household Kitchen Waste	Government Departments
Resident	Participate in Kitchen Waste Recycling	High-Tech Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling
Public Catering	Provide Kitchen Waste Recycling	High-Tech Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling
Commercial Super Market	Provide Kitchen Waste Recycling	High-Tech Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling
Enterprise/Traders Or Retailer Waste	Provide Kitchen Waste Recycling	High-Tech Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling
Vertical Plant Waste	Provide Kitchen Waste Recycling	High-Tech Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling
State/County/Province Government	Provide Kitchen Waste Recycling	High-Tech Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling
Recycling Personnel	Provide Kitchen Waste Recycling	High-Tech Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling
Household Kitchen Waste	Provide Kitchen Waste Recycling	High-Tech Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling
Government Departments	Provide Kitchen Waste Recycling	High-Tech Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling
Government Policy Support	Provide Kitchen Waste Recycling	High-Tech Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling	Provide Kitchen Waste Recycling

Figure 5. Motivation Matrix: Self drawn by the author

Design Output

On the basis of motivation matrix, the author combines all resources and funds through system diagram to understand the objects provided and accepted by material and nonmaterial in the whole system. The main bodies of stakeholders are determined as kitchen waste recycling system, vertical planting system, household kitchen waste, household planting equipment, government departments, public kitchen waste, commercial supermarket market, background technicians and recycling personnel. The energy transformed by the kitchen waste recycling system is input into the vertical planting system, and the service system composed of it provides food materials for the supermarket market, and the supermarket becomes the publicity channel of the service system. At the same time, the service system provides processing paths for recycling personnel, and recycling personnel and public kitchen waste provide resources for the service system. Government departments provide policy support for the operation of the whole service system, and the service system creates social benefits for the



government. The family kitchen waste system organized by the community provides economic benefits for the supermarket, and the market provides food incentives for family kitchen waste. The above forms a complete service system relationship between the government, enterprises, communities and individuals.

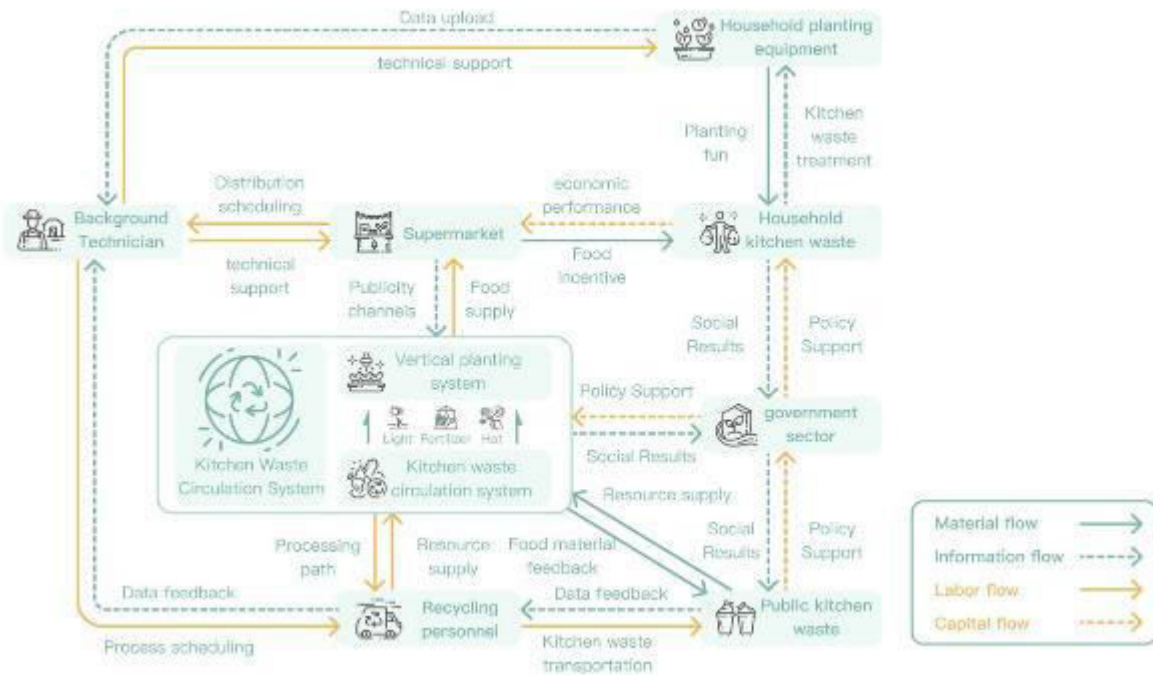


Figure 6. System Diagram: Self drawn by the author

After clarifying the relationship between the four system subjects, the author presents the detailed service process in the form of service blueprint. Through the service blueprint, the front and back stage behaviors and contact nodes in the service process are sorted out, and the residents' behaviors, managers' behaviors and interactive tangible objects are listed one by one. In this process, it explains how the Design of Sustainability (DFS) system can help the government, enterprises, communities and citizens to achieve the goal of reducing carbon emissions in the kitchen waste treatment scenario.



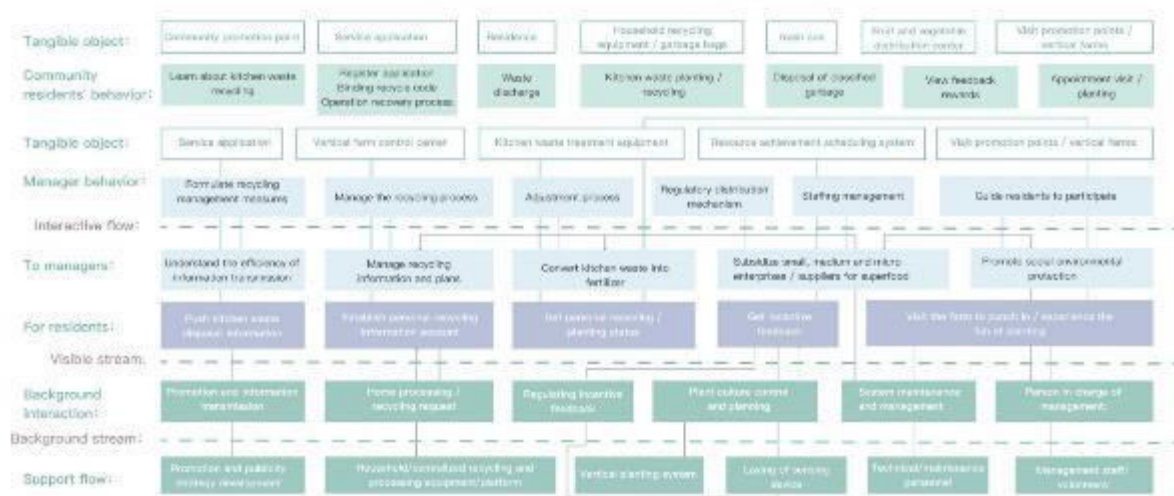


Figure 7. Service Blueprint: Self drawn by the author

In the service scenario construction, the author presents the system through visualization. First of all, in the kitchen waste recycling scenario, catering enterprises collect kitchen waste in a centralized manner, conduct oil-water separation pretreatment at the recycling point, and discharge waste water, thus improving the efficiency of storage and transportation at the recycling point. At the same time, the odor removal device is added at the recovery point to minimize the impact on the surrounding environment. When the recovery device reaches a certain capacity, the recovery personnel will be notified to handle it. Meanwhile, the transportation route will be intelligently planned in the background of the system to improve personnel efficiency. In the household kitchen waste composting scene, the author designed a household kitchen waste planting machine, which directly converts kitchen waste into soil fertilizer to provide nutrition for vegetables.

In the meantime, it is equipped with a mobile app to let users know the maturity of vegetables and the reduced carbon emissions on their phones. At the same time of planting, the reduced carbon emissions will be stored in the form of credits, so that users can exchange seeds and food materials at nearby supermarkets. On the one hand, the kitchen waste generated by communities and enterprises is directly transported to the vertical planting farm, which converts the recycled waste into energy and feeds back to the corresponding agricultural and sideline products of the supermarket in the process. On the other hand, as a feedback transfer station, supermarkets provide enterprises and communities with corresponding vegetable rewards.



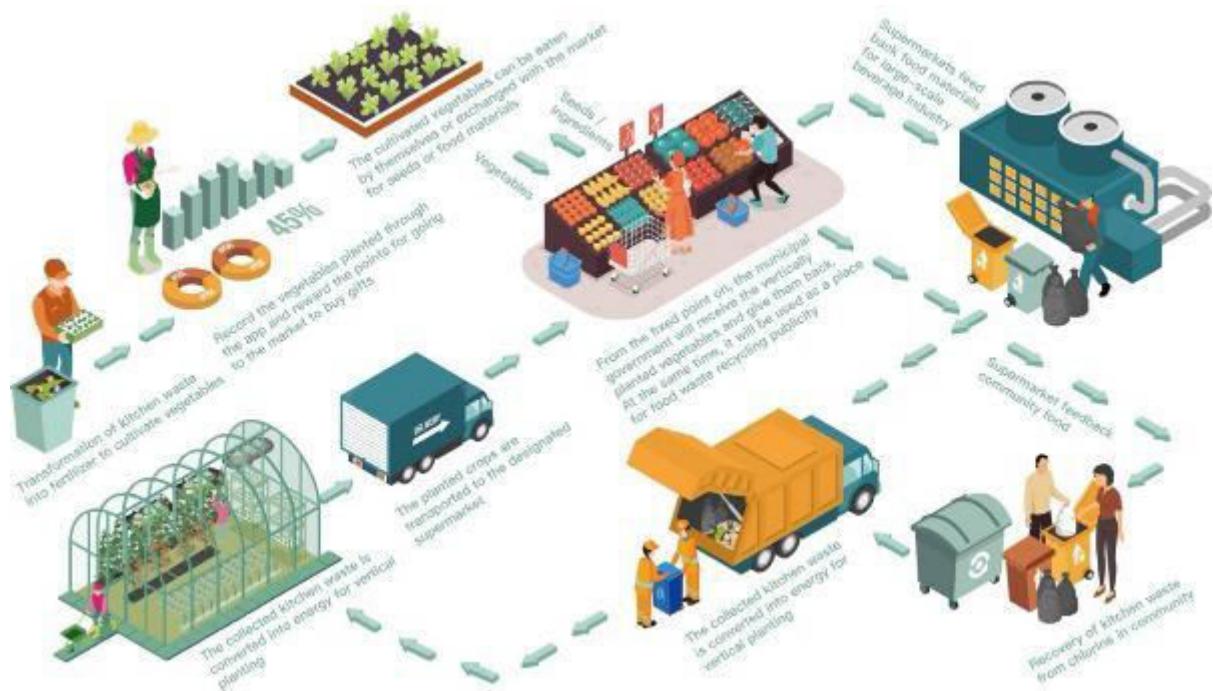


Figure 8. General Service Scenario: Self drawn by the author

In the final design results, the author builds the framework of the whole DFS service system and interprets the design results from the perspective of national policies and social background. In the design of sustainable service system for food waste recycling, enterprises and families are taken as resource providers, vertical planting industry is taken as resource recipients, and the Chinese government is taken as a bridge to promote the exchange of resources between the two sides. In this process, through the efficient reuse of resources, the design of the interaction between stakeholders and the support of national policies, the social, economic and environmental benefits produced by the project conform to the goal of DFS.



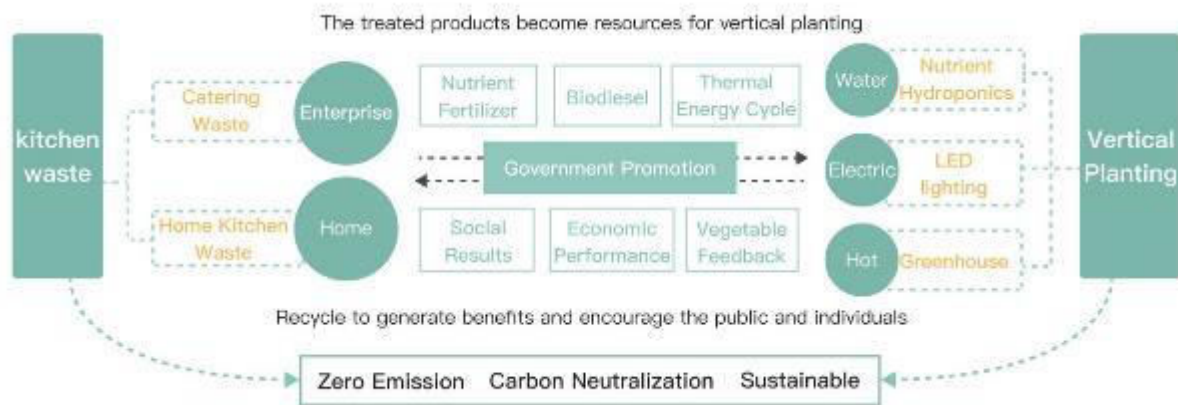


Figure 9. System Framework: Self drawn by the author

Case study

Ltd. in China relies on information technology to intelligently manage all aspects of waste separation, greatly simplifying the process of household food waste collection, tracking the user's waste through the system and offering regular environmental rewards to increase the residents' motivation to participate. The CFCCTJA1 Food Waste Disposal Machine can verify the user's identity through face recognition or two-dimensional code identification, and upon receipt of the food waste, the food waste will be processed by the processing equipment inside the product in the first instance, which will eventually convert the food waste into organic fertiliser, thus effectively avoiding problems such as food waste decay and mosquito breeding. The service process constructed in this paper can be used for medium-sized food waste recycling sites such as community or school canteens. In the process of implementing such products, the guidance of government and community service personnel is required to a large extent, while the cooperation of waste recycling personnel is required in a series of postcomposting usage services. With the cooperation of multiple stakeholders, the service process mentioned in this paper can maximize the solution to the problem of food waste reuse under the theme of carbon neutrality.



Chang Xiong, Sang Guangliang

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

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Figure 10. System Framework: Jiangsu Wandeford Public Facility Technology Co.

Conclusion and Prospect

This paper briefly combs the development process and development value of DFS, and analyzes the application and achievements of DFS in the process of social transformation. Based on the sustainable triangle, DFS studies how to make the contemporary society turn to sustainable society by designing human behavior under the premise of balancing economy, society and environment. Researchers and scholars have enriched the methodology and application fields of DFS in their respective fields and made great achievements in the world. The author shows the research contents and achievements of DFS in social innovation, architecture and design methodology, and reveals the effectiveness of DFS in solving problems. Under the current severe climate problem, the author focuses on the value of DFS in reducing carbon emissions. In this study, the author first discusses its achievements and contributions in the perspective of transportation, products and construction. The relevant DFS processes are described from a relatively macro perspective. The research finds that DFS can effectively provide solutions for carbon emission scenarios. Meantime, this paper emphasizes the difference of design methods of DFS in different contexts, and puts forward the design methods of DFS in reducing carbon emissions in the context of Chinese society. The author uses the output design method in the kitchen waste scene, conducts a small-scale design practice, and outputs a set of



Chang Xiong, Sang Guangliang

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

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sustainable service design system for kitchen waste recycling that integrates the government, enterprises, society and citizens.

However, due to the limited time, the author failed to test and verify the sustainability of the design results at the end. There is still more room to improve and practice the methods proposed in this paper in the future.



Chang Xiong, Sang Guangliang

A study of Chinese residents participating in design for sustainability in the context of carbon neutrality

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Chang Xiong, Sang Guangliang

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