



Enhancing Safety and Satisfaction of Electric bicycle Centralized Charging Facilities in Community: Insights from Shunyi District, Beijing

Xiu Gu*, Tongtong Jiang^a

Beijing City University, Beijing China

*xiuxiufairy@gmail.com, ^a414460417@qq.com

Abstract. With the rise of electric bicycles as a sustainable mode of urban transportation, the demand for convenient charging solutions has become increasingly critical. This paper takes Shunyi District of Beijing as an example, comprehensively investigates the current status of the utilization and management of electric bicycle centralized charging facilities in residential areas, discusses the existing problems in the construction and management of charging facilities, and proposes targeted improvement suggestions. The findings indicate that while unauthorized external wiring has been reduced, indoor battery charging persists, highlighting safety concerns. Residents express dissatisfaction with the quantity and distribution of charging facilities, pointing to the need for improved infrastructure and management. To enhance charging safety and resident satisfaction, the paper highlight the importance of strong top-level design and swift action by governments to meet residents' charging needs, thus preventing unauthorized charging practices. We delve into the necessity of multi-stakeholder cooperation, including local governments, property management, utility providers, and residents, in the construction and operational phases of charging facilities. Safety issues, particularly fire hazards associated with improper charging practices, are addressed through the lens of smart technology solutions and regulatory measures. Public awareness campaigns and the clear communication of guidelines are also discussed as crucial elements in cultivating a culture of safety and responsibility.

Keywords: Electric bicycles, Centralized charging facility, Residents' satisfaction, Charging safety

1 Introduction

As the concept of energy conservation and emission reduction gaining global traction, the use of electric vehicles (EVs) is becoming more widespread, and the two-wheeled vehicles (TWVs) have become an indispensable mode of short-distance trip because of their convenience and low cost. Popovich N et al. [1] highlighted that the unique functional characteristics of e-bikes, notably their capacity for higher speed and acceleration with minimal exertion, play a pivotal role in enhancing their utility. This includes

broadening the demographic of cycling enthusiasts, increasing the number of trips undertaken by bicycle, and significantly enhancing the overall enjoyment for users [1]. A diverse range of TWVs can be found in the market, each having different performance features and designs. Common types include e-bicycle, e-scooter and e-motorcycle [2]. For ease of expression and understanding, this paper collectively refers to them as electric bicycles.

China is a global leader in the production and sales of electric bicycles. Data indicate that by the end of 2022, the stock of electric bicycles in China had reached 350 million [3]. The extensive use of electric bicycles has facilitated convenience in people's lives, it has also introduced a series of safety issues related to charging, including increasingly occurrences of fire incidents[4].

In August 2021, the government of China issued the "Regulations on Fire Safety Management of High-rise Civil Buildings", which prohibit the parking or charging of electric bicycles inside high-rise civil buildings [5]. This imposes significant demands on the infrastructure for centralized charging facilities in communities. To grasp the challenges associated with electric bicycle charging, local authorities have adopted diverse strategies to encourage the centralized parking of these bicycles and the development of charging infrastructures[4]. Although the government attaches great importance to the construction and operation of charging infrastructure, there are still some problems in the use of electric bicycle centralized charging facilities that require in-depth investigation and research.

This paper takes Shunyi District of Beijing as an example, comprehensively investigates the current status of the utilization and management of electric bicycle centralized charging facilities in residential areas, discusses the existing problems in the construction and management of charging facilities, and proposes targeted improvement suggestions. These suggestions aim to provide a basis for the construction and management of electric bicycle centralized charging facilities in the Shunyi District, while also offering insights for urban planning and construction in other regions.

This paper also holds certain theoretical value. The existing literature on electric bicycles is predominantly focused on technical domains, such as engineering, computer science, and energy[6]. In contrast, the proportion of literature pertaining to the social sciences is significantly smaller, with empirical studies being exceedingly rare. China stands as a major user of electric bicycles. Empirical research targeting China can serve as a valuable reference for the management of electric bicycles in other countries around the world.

2 Research Objectives

2.1 The Current Status of Electric Bicycle Charging Safety in Shunyi

The study investigates whether there are instances of unauthorized charging practices within communities, such as using makeshift wiring out of building facades (known as "flying wires") and charging within residential units. It examines whether the construction of electric bicycle centralized charging facilities within communities complies with fire safety regulations and fully considers fire safety.

2.2 Resident Satisfaction with Electric Bicycle Centralized Charging Facilities in Their Residential Communities

The study assesses whether the quantity, layout, operational status of charging facilities, and the environment for storing electric bicycles in community meet the needs of the residents. It examines the convenience of using these charging facilities and investigates the overall satisfaction of residents with the electric bicycle centralized charging facilities in their residential area.

2.3 Policy Recommendations for Enhancing the Safety of Community Electric Bicycle Centralized Charging Facilities and Resident Satisfaction

The study investigates the problems that residents encounter when using charging facilities. It also identifies the issues of electric bicycle centralized charging facilities construction. Based on these findings, the study proposes recommendations accordingly for improvements in the construction of electric bicycle centralized charging facilities.

3 Survey Design and Data Collection

3.1 On-site Survey

The authors conducted field visits to 15 residential communities in the Shunyi District, covering 2 towns and all 6 street offices within the district. Through on-site observations within these communities, the authors gathered insights into the construction and operational status of electric bicycle centralized charging facilities, as well as the operation of charging apps.

3.2 Questionnaire Survey

The authors utilized both electronic and paper versions questionnaire, collecting a total of 215 valid responses, resulting in 209 collected questionnaires, of which 205 were valid.

3.3 Interview Survey

The authors conducted interview surveys targeting both electric bicycle users and community managers. At the request of the interviewees, this research report anonymizes the feedback received.

Interviews with electric bicycle users: Within the communities visited on-site, random electric bicycle users were selected for face-to-face interviews to understand their charging practices and satisfaction with the electric bicycle centralized charging facilities in the community. A total of 5 individuals agreed to be interviewed.

Interviews with community managers: The authors contacted various community property management companies, residents' committees, and street offices by phone to learn about the construction and operational maintenance of electric bicycle centralized charging facilities. Feedback was received from 4 community property managements, 2 residents' committees, and 1 street office.

4 Current Status of Electric Bicycle Centralized Charging Facilities in Shunyi District

4.1 Safety Investigation

4.1.1 Electric Bicycle Users' Awareness of Charging Safety

The issue of unauthorized wiring for charging has been effectively managed, but the problem of battery charging inside residences has not been resolved. Through on-site visits and research, it was found that in the vast majority of communities, the situation of unauthorized wiring could no longer be observed. Among the 15 communities visited by the authors, only in 2 were "flying wires" found. In interviews with residents, electric bicycle users also mentioned that due to policy requirements, they would not bring their electric bicycles into the buildings. This indicates that under the joint governance of government policies and community street supervision, the phenomenon of unauthorized wiring for electric bicycle charging has been effectively managed.

However, the survey questionnaire revealed that still 8% of respondents would remove the electric bicycle batteries to charge them at home. The main fire hazard associated with electric bicycles stems from the battery charging process, and taking the battery home for charging is equal to bringing the fire hazard home, which is no different from charging the electric bicycle inside residences. Therefore, the issue of residents charging inside buildings has not been effectively resolved.

4.1.2 Construction of Fire Safety in Electric Bicycle Centralized Charging Facilities

Management of charging areas is inadequate, and the configuration of fire safety equipment needs improvement. The main components of community electric bicycle centralized charging facilities include charging piles, charging cabinets, and battery exchange cabinets. The large-scale construction of these facilities began after the release of the "Regulations on Fire Safety Management of High-rise Civil Buildings" in 2021. As a result, many facilities were retrofitted or additionally constructed based on the original architecture and layout of the communities, with some situated inside existing enclosed bicycle sheds, some under semi-covered canopies, and others completely exposed to the open air.

The survey found that most open charging sheds in the Shunyi District are equipped with portable fire extinguishers or automatic sensing dry powder fire extinguishing balls installed on the roof of the shed. However, some charging piles and charging spots lack necessary rain protection measures. In independent enclosed sheds, the phenome-

non of equipping charging sockets is widespread, and many sheds do not have an automatic fire alarm system and automatic sprinkler system installed. At the same time, whether in enclosed sheds or outdoors, charging cabinets generally lack nearby fire extinguishing equipment, although the charging cabinets themselves come with a small automatic sensing fire extinguisher.

Management of vehicles within the charging area varies significantly between different communities. Some communities have rules for separating electric bicycles from conventional bicycles, with clear signage set up in different areas to help residents distinguish between them. In contrast, the majority of communities adopt a mixed management approach, where electric and conventional bicycles are placed together without fire breaks in between. In crowded conditions, especially within enclosed sheds, a fire can quickly spread once ignited. Moreover, residents often install highly flammable cotton windshields on electric bicycles in winter, which can exacerbate the spread and intensity of a fire, potentially causing significant damage.

4.2 Satisfaction Assessment

To investigate residents' satisfaction with the electric bicycle centralized charging facilities in their community, the authors designed two questions in the survey: "Residents' satisfaction level with the electric bicycle centralized charging facilities" and "Areas where residents feel improvements are needed in the community's electric bicycle centralized charging facilities," yielding results as shown in figure 1 and figure 2. In random interviews with residents, respondents primarily highlighted two issues. The first was a desire for increasing the charging facility quantity, especially in existing communities that already have bicycle sheds. The residences hope these common bicycle sheds could be converted into charging sheds for electric bicycles. The second was a wish for property management to strengthen vehicle management, particularly the removal of "zombie bikes (abandoned or fully charged not removed vehicles)".

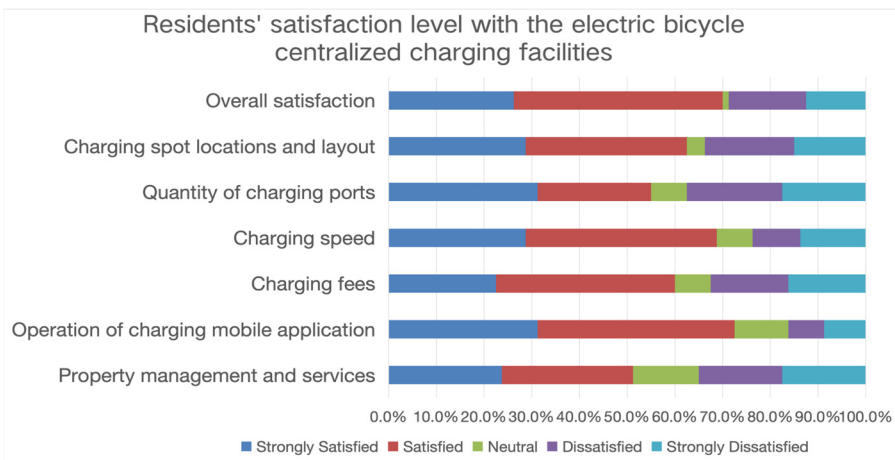


Fig. 1. Residents' satisfaction level with the electric bicycle centralized charging facilities

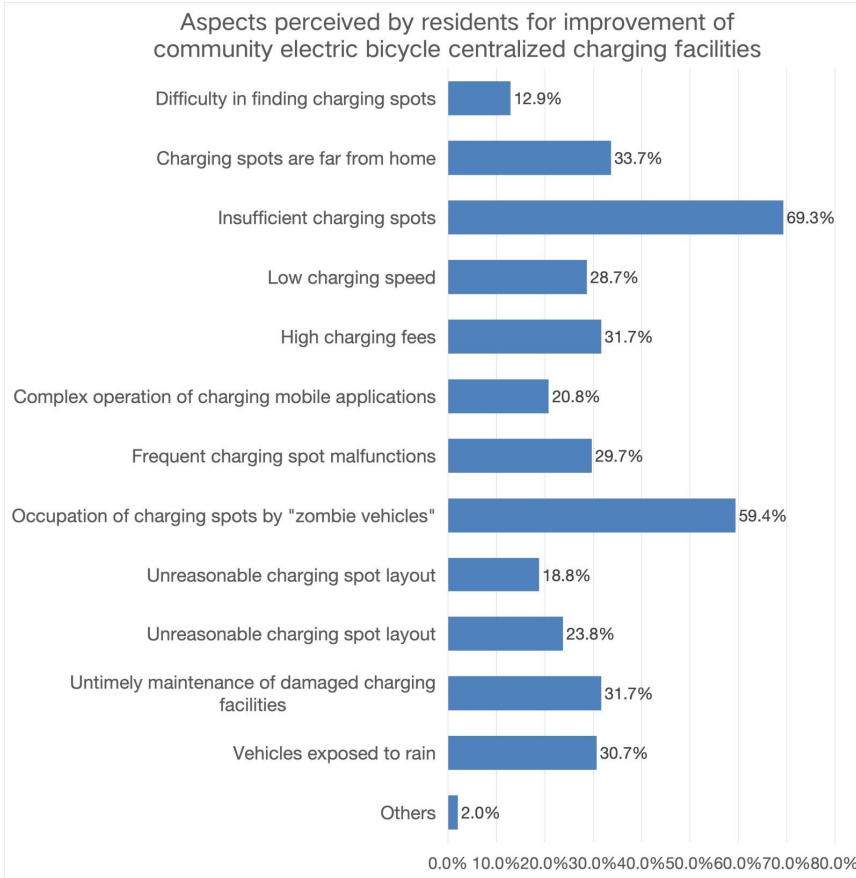


Fig. 2. Aspects perceived by residents for improvement of community electric bicycle centralized charging facilities

4.2.1 Residents' Satisfaction with the Construction of Electric Bicycle Centralized Charging Facilities

Insufficient total amount and uneven distribution of charging facilities. In questionnaire survey and interview, residents commonly expressed dissatisfaction with the number of electric bicycle centralized charging facilities within their communities, wishing for an increase in charging options. The authors' on-site investigations confirmed the issue of insufficient charging facility numbers reported by residents. For example, in the Jiahe Yiyuan community, there are 11 electric bicycle charging sheds, with each shed able to charge about 10 electric bicycles at the same time. Considering the total of more than 3,900 households, this is not enough, averaging only 0.03 charging spots per household; Lanxing Jiayuan and Cangshang communities have only one charging shed each, capable of charging fewer than 10 electric bicycles simultaneously. The insufficiency of charging facilities stems from several objective factors. For instance, to shield against rain, many communities electric bicycle centralized charging

facilities are situated within enclosed or open sheds with canopies, necessitating more space for shed construction. Interviews with property managers revealed that although there is a strong desire among residents to increase charging facilities, there is hardly spare space left in the communities for additional construction.

As shown in Figure 3, 42% of electric bicycle users need to walk 3 minutes to reach a charging facility, 25% need to walk 5 minutes, while those who walk 1 minute or 10 minutes or more account for 20% and 13% respectively, indicating a very uneven distribution of charging facilities within communities. Residents who have to walk longer distances prefer to have charging facilities closer to their homes, indicating a relative insufficiency due to uneven distribution. The layout and distribution of charging facilities significantly influence residents' willingness to use community centralized charging facilities. As shown in Figure 4, nearly 60% of residents do not use community centralized charging facilities because of the distance. Therefore, addressing the issue of uneven distribution of charging facilities could significantly reduce the phenomenon of residents charging within their homes.

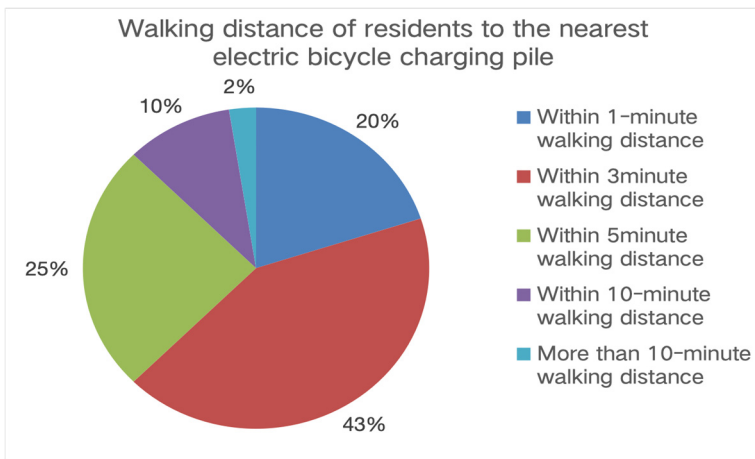


Fig. 3. Walking distance of residents to the nearest electric bicycle charging pile

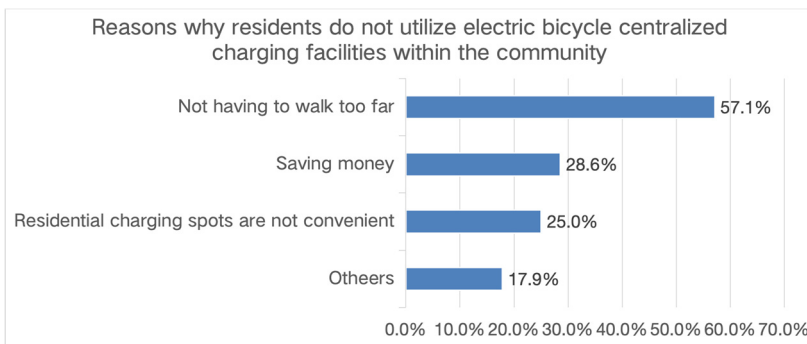


Fig. 4. Reasons why residents do not utilize electric bicycle centralized charging facilities within the community

4.2.2 Residents' Satisfaction with the Use of Electric Bicycle Centralized Charging Facilities

Charging method is simple, and the use of charging apps is convenient. Based on the authors' on-site investigation, the current charging methods for electric bicycle centralized charging facilities primarily include two options: WeChat Mini Program and card swiping, which are both straightforward. Survey results indicate that the users of these charging facilities are mostly middle-aged and young adults who are familiar with smartphone operations, resulting in high satisfaction with the charging apps. As shown in Figure 2, the survey results also reflect a high level of satisfaction among residents with the use of charging apps. Moreover, many apps come with features that allow users to find nearby charging piles and display the status of charging piles, making it convenient for users to switch locations when they cannot find an available charging spot.²

4.2.3 Residents' Satisfaction with the Management of Electric Bicycle Centralized Charging Facilities

Insufficient management of charging vehicles. "Zombie bikes" are one of the main issues reported by residents during the survey and a significant factor affecting their satisfaction with electric bicycle centralized charging facilities. The inadequate clearance of "zombie bikes" severely impacts other users' access to charging facilities and significantly reduces the residents' willingness to use centralized charging facilities. The authors' research found that the issue of "zombie bikes" has not received adequate attention from relevant management departments, nor is there appropriate supervision in place.

As shown in Figure 2, residents' satisfaction with the community property management is the lowest among all surveyed dimensions. As the facet of community management most frequently interacting with residents, property management is typically the initial point of contact for residents' issues or requests. However, feedback from the property management department suggests a lack of awareness of clear responsibility for managing community electric bicycle centralized charging facilities. Consequently, residents often express dissatisfaction when their demands are not adequately met.

5 Analysis of Safety Hazards and User Preferences

5.1 Root Causes of Safety Hazards

Inadequate Implementation of Responsibilities by Various Stakeholders in Community Centralized Charging Facilities Management. The Beijing Municipal Market Supervision Administration explicitly stipulated in the "Operational Management Service Standards for Centralized Electric bicycle centralized charging facilities" released in March 2023: Electric bicycles and conventional bicycles should be parked separately; property management, village committees, and other charging site managers should establish a routine inspection system, incorporate parking and charging order

management into daily management, and strengthen inspections of unauthorized charging behavior; centralized charging facility operators should regularly inspect and maintain equipment, ensuring that fire extinguishing and alarm devices within charging cabinets and battery exchange cabinets are functioning properly^[7]. However, the reality is that a significant number of communities mix electric bicycles with common bicycles, motorcycles, and other non-motorized vehicles; the issue of "zombie bikes" is prominent, severely affecting residents' willingness to use centralized charging facilities; property managers and other charging site managers lack awareness of their management responsibilities. The inadequate implementation of responsibilities by various managers of charging facilities can lead to "small problems" hiding "significant risks," and in the event of a fire or other emergencies, it poses a serious threat to the safety of residents' lives and property.

5.2 Reasons for Residents' Dissatisfaction of Using Centralized Charging Facilities

Community centralized charging facilities cannot fully meet residents' charging needs. According to the survey, the main forms of unauthorized charging behavior among residents in the Shunyi District are external unauthorized wiring for charging and dismantling batteries for in-home charging. The primary reason for these behaviors is that the centralized charging facilities within communities cannot fully meet the residents' charging needs. On one hand, there is an insufficient overall construction of centralized charging facilities; on the other hand, the management of existing centralized charging facilities is inadequate, with the issue of "zombie bikes" being severe. The survey found that the most significant reason residents refuse to use community centralized charging facilities is not due to the cost of charging or operational issues with the facilities but because "there are not enough charging piles" and "zombie bikes occupy charging spots," leading many residents to return home from work unable to find a charging spot. To address the root cause of residents' unauthorized charging behavior, merely increasing fire safety propaganda and the supervision of unauthorized actions is clearly not enough. Only by genuinely improving the charging environment for residents and fully meeting their charging needs can the problem be truly solved.

Insufficient overall coordination in the construction of community centralized charging facilities. The governments at all levels in Shunyi District have consistently prioritized the development of community electric bicycle centralized charging facilities. The district's People's Government outlined the necessity for additional electric bicycle centralized charging facilities in public areas of communities in the "Shunyi District 2018 Comprehensive Renovation Work Implementation Plan for Old Residential Areas"; and clear mandates regarding the quantity of electric bicycle centralized charging facilities were established in both the "Shunyi District 2021 List of Important Practical Matters for the Public" and the "Shunyi District Government Work Report 2022 List of Key Tasks"^[8-10]. Nonetheless, in the actual implementation process of construction, various challenges such as site selection and electricity access difficulties are encountered, with the renovation and construction in older communities presenting

even greater challenges. Firstly, there's a shortage of available space within older communities for additional constructions; secondly, the existing circuit layout and overall electrical capacity often cannot directly satisfy the increased demands, with some communities facing issues like self-tube electricity usage and cross-district electricity usage; additionally, some old communities lack formal property management or are under co-management with other properties, complicating the assignment of construction responsibilities^[11]. Therefore, the construction of electric bicycle centralized charging facilities necessitates coordinated planning and joint construction by local governments, the State Grid, fire departments, property management, and centralized charging facility manufacturers, rather than accomplished solely by one government department or construction entity.

Currently, the process of supplementing and adding centralized charging facilities, from residents requesting construction to the integration of the construction into community development planning and finally to completion and operation, involves multiple decision-making bodies and procedural steps, resulting in a lengthy construction period. There is an urgent need for authoritative government departments to intervene, strengthen overall planning coordination, and streamline the construction approval process.

6 Policy Recommendations for Enhanced Safety and Satisfaction

6.1 Mitigating Safety Hazards

According to the theory of accident causation, accidents typically stem from two types of hazards: "unsafe conditions of objects" and "unsafe actions of people," with fire accidents usually resulting from fire hazards. To eliminate fire accidents, it is necessary to address both "objects" and "people" to remove fire hazards^[12].

“Combining channeling and control” to implement the safety responsibilities of electric bicycle users. The primary responsibility for charging safety should lie with the owners and users of electric bicycles. Legislation and publicity should clarify that the owners and users of electric bicycles must fulfill their charging safety responsibilities to ensure charging safety^[13]. To address the issue of residents' weak awareness of charging safety and the frequent occurrence of unauthorized charging behaviors, governments at all levels should adhere to a strategy of “combining channeling and control”. On one hand, more flexible and diverse means of publicity should be employed to enhance residents' awareness of charging safety and clarify their primary responsibility in charging safety. Besides traditional posters, notices, and promotional videos, the use of social media, streaming media, and other online media can expand the reach of publicity. Introducing enterprises, schools, community organizations, and bicycle associations to conduct targeted publicity for different levels and groups can increase engagement and improve the effectiveness of the publicity. On the other hand, specific

penalties for unauthorized charging should be clarified, and the inspection and punishment of unauthorized charging should be strengthened to eliminate residents' fluke mind and prevent the occurrence of unauthorized charging behaviors.

Leveraging smart charging detection and warning platforms to eliminate in-home battery charging. Introducing an electric bicycle charging recognition system to identify in-home charging behavior of electric bicycles. For example, the AI current fingerprint algorithm detection platform established in Zhuhai District, Guangzhou, is a smart detection and warning platform for electric bicycle charging^[14]. This platform can precisely identify in-home charging behavior of electric bicycles based on hundreds of electrical data such as current, voltage, power, and higher-order harmonics in the circuit. Once unauthorized behavior is detected, the platform sends out an alarm signal, and relevant managers can promptly visit and dissuade the resident, thus eliminating the phenomenon of in-home battery charging and reducing the risk of fire incidents.

6.2 Strategies to Improve User Satisfaction

Strengthen the top-level design to accelerate the addition and supplementation of centralized charging facilities. To fundamentally solve the problem of residents' unauthorized charging, it is first necessary to address the difficulty of charging for residents. The government needs to provide clear answers to "where to charge" so that residents can properly address "how to charge". Therefore, the government should strengthen the overall coordination of top-level design and, based on actual resident needs, expedite the addition and supplementation of centralized charging facilities, ensuring that where needs to be built is built. On one hand, community electric bicycle centralized charging facilities should be included in the category of basic urban-rural public services, and the construction of these facilities should be planned and designed in sync with other public service facilities. On the other hand, the roles of government construction and management task forces at all levels should be leveraged to highlight the government's coordination and cross-sectoral coordination capabilities, balance the functions and interests of multiple parties, optimize the construction and management processes, and shorten the construction period^[15].

Joint construction and governance to implement the construction and operational management responsibilities of centralized charging facilities. Electric bicycle charging safety accidents mainly occur during the charging process, hence the fire safety management of community centralized charging facilities is of paramount importance in charging safety management. The construction of centralized charging facilities connects local governments, the State Grid, fire departments, property management, and other departments at one end and construction enterprises at the other. Both ends should cooperate closely and work together to plan, construct, govern, and share jointly. On one hand, at the early stage of construction, enterprises should fully leverage their resources at the forefront of technology to assist the government in the layout planning and product design of centralized charging facilities; the government should fully exercise its management functions, perform top-level design coordination, optimize the construction approval process, coordinate resources from various departments, improve construction efficiency, and ensure construction quality. On the other hand,

during the later stages of operation and maintenance of centralized charging facilities, construction enterprises should strictly fulfill their responsibilities of regular inspection of charging equipment, timely response to user needs, and continuous technological innovation; local governments at all levels should perform grid-based management, regularly organize safety inspections, and strictly penalize various unauthorized activities, securing a "safety lock" on electric bicycle charging.

7 Conclusion

This paper has thoroughly explored the multifaceted challenges and solutions associated with the construction and management of electric bicycle centralized charging facilities in community, with a focus on the Shunyi District's initiatives and resident feedback. The key insights gleaned from the research underscore the necessity of addressing both infrastructural and behavioral aspects to enhance the safety, efficiency, and user satisfaction of electric bicycle centralized charging facilities.

Firstly, the research highlights the critical need for strengthened top-level design and faster implementation of additional centralized charging facilities to meet the growing demand. It is evident that providing adequate and accessible charging solutions is foundational to curtailing unauthorized charging practices among residents. By integrating the development of charging infrastructure into the broader urban and rural public service framework, governments can ensure a more organized and effective rollout of these essential facilities.

Furthermore, the study underscores the importance of joint construction and governance in realizing the full potential of centralized charging facilities. The collaborative efforts between government bodies, property management, the State Grid, fire departments, and technology companies are crucial in overcoming the logistical and technical challenges faced during the construction and operational phases. Such partnerships not only facilitate the smooth execution of projects but also ensure that safety standards are strictly adhered to, thereby significantly mitigating the risk of fire accidents.

In conclusion, the successful management and expansion of electric bicycle centralized charging facilities hinge on a comprehensive strategy that encompasses robust governmental planning, collaborative governance, technological innovation, and community engagement. Addressing the dual aspects of physical infrastructure and resident behavior is paramount in creating a safe, efficient, and user-friendly charging environment. As the adoption of electric bicycles continues to rise, the insights from this research offer valuable guidance for other districts and municipalities grappling with similar challenges, paving the way for sustainable urban mobility solutions.

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