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Study on Policy Tasks for Promoting a Business Using Spent Electric Vehicle Batteries

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Abstract: With the rising demand for electric vehicles (EVs), it is also becoming increasingly important for policymakers to devise measures on how best to handle spent EV batteries. Policymakers need to devise a system that ensures the economic efficiency of recycling used EV batteries, and support the effective operation of such a system with legal and policy measures. This study aims to present, in a systematic manner, the policy measures needed to foster an environment that actively makes use of spent EV batteries, based on a review of Korean practices and experiences. Based on in-depth interviews with experts, this study explains why the policy measures it recommends are essential, what obstacles stand in the way of implementing those measures and how we may overcome them, as well as other factors we should consider when implementing these measures. As a result, we identified top-priority policy tasks, such as defining regulatory provisions that apply to each stage using spent batteries, as well as clarifying the cost- and profit-sharing structure. We also explored potential and major obstacles and factors that may stand in the way of the implementation of recommended policy measures.

Keywords: electric vehicle; spent battery; top-priority policy task; in-depth interview

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1. Introduction

The demand for electric vehicles (EVs) is rising worldwide as governments and citizens seek ways to combat climate change by opting for more eco-friendly modes of transportation. According to Bloomberg New Energy Finance [1], the cumulative number of EVs sold worldwide soared from 8000 in the first quarter of 2011 to 6.88 million by the last quarter of 2019. The demand for such vehicles is expected to only grow in the coming years. The International Energy Agency (IEA)'s New Policies Scenario [2] projects that 23 million EVs will be sold around the world by 2030. The South Korean government, too, is determined to fuel the demand for EVs by implementing current policy incentives. The Third Energy Master Plan, announced in 2019, envisions increasing the number of EVs sold in Korea from 55,000 to 8.3 million by 2040 [3]. Should this plan be implemented as it is, EVs would come to make up nearly 40% of all vehicles sold and registered in Korea.

With the demand for EVs on the rise, it is also becoming increasingly important for policymakers to devise measures on how best to handle used EVs. Similar to vehicles with conventional internal combustion engines (ICEs), EVs are also scrapped and their parts are appropriately recycled at the end of their lifespan. It is thus crucial for governments to find the most economical ways of recycling used EV batteries to ensure the eco-friendliness and economic value of EVs [4]. Policymakers thus need to devise a system that provides the economic efficiency of recycling used EV batteries and support the effective operation of such a system with legal and policy measures.

Batteries that are removed and collected from used EVs can be handled differently depending on their remaining lifespans or state of health. The lithium, nickel, manganese, cobalt, and other such elements found in batteries may be separated and recycled. The

batteries may also be reused in other EVs or put to good use in other devices. In this respect, terminology can shape our view of how second-hand EV batteries can be used. Whereas the term "waste battery" calls to mind ultimate disposal or simple recycling, that of "spent battery" reminds us of the potential these used batteries have for more diverse use.

There is a growing volume of research worldwide on the technical and economic feasibility of business operations involving the use of spent EV batteries [4–16]. There is, however, a relative dearth of research on the policy measures needed to boost and support these businesses. With the number of EVs in actual operation still limited, studies reviewing the technical and economic feasibility of recycling, reusing, and second-using spent EV batteries have been prioritized thus far. The limited number of policy studies that have been conducted emphasize the need for a legal basis for defining and imposing "extended producer responsibility (EPR)" to extend the service life of rechargeable batteries [17]; explore policy measures necessary to establish and foster a system for collecting and recycling returned batteries [18,19]; or focus on the importance of battery ownership [18,19], the partnership between industries [4], and policy support such as subsidies or incentives [4,5,20] for the secondary use of batteries. While these studies discuss, to some extent, the policy measures necessary to promote the further use of spent EV batteries, they fall short of providing a comprehensive and detailed picture. For policy research to have a substantial effect, it is crucial for authors to not only emphasize necessary and important policy tasks to be done, but also analyze the actual and potential obstacles to the policy measures, and how such barriers could be removed. The existing policy studies, however, explore policy implications of spent EV batteries only as a part of analyzing the overall business prospects or feasibility of applying these batteries to business.

The objective of this study is to present, in a systematic manner, the policy measures that are needed to foster an environment that actively makes use of spent EV batteries, based on a review of Korean practices and experiences. Based on in-depth interviews with experts, this study explains why the policy measures it recommends are essential, what obstacles stand in the way of implementing those measures and how they may be overcome, and what other factors should be considered in implementing these measures. The main emphasis of this study is to prompt ongoing research beyond only listing policy measures necessary to encourage the effective use of spent EV batteries by calling researchers' attention to detailed alternatives. The goal is to provide a framework to guide future policy research on the use of spent EV batteries.

This study is structured as follows. The second section provides a survey of the existing literature on major policy tasks involved. The third section describes the method taken by this study to explore the policy implications of using spent EV batteries. The fourth section presents the results of in-depth interviews with experts. The fifth section discusses the findings, suggests policy implications, and summarizes the conclusions of this study.

2. Literature Review

A review of the literature on the use of spent EV batteries reveals that there are three main policy emphases commonly found in the studies: developing and fine-tuning the system for managing spent batteries, fostering an environment conducive to the use of spent batteries, and developing a market that enhances the value of spent batteries.

As for developing and fine-tuning the system for managing spent batteries, researchers first stress the need to clarify the roles and functions of different stakeholders [17–19,21]. The exact scope of the obligations and duties of different stakeholders, including owners, local governments, and manufacturers, should also be defined [22,23]. Second, legal provisions should be enacted to define the legitimate grounds, roles, and functions of the facilities that are needed to handle EV batteries at different stages of their lifecycle, which is in tandem with the clarification of stakeholders' roles and functions. Specifically, statutes defining the legal grounds, roles, and functions of facilities or agencies for handling the return and collection, performance evaluation, recycling, and reuse of used EV batteries

should be introduced, while promoting in-depth discussions on the safety measures and procedures for the recycling, reuse, and second-use needed [4]. Specific instructions on how spent batteries are to be dismounted, transported, and stored should be provided concerning the return and collection of batteries. As for performance evaluation, legal provisions should be established for the creation of a testing institution, as well as the definition of its roles and functions. Statutes for the creation of agencies that support the testing institution should also be introduced. Regarding the use of spent batteries, regulatory standards on how the tasks involved are to be handled should be established, along with legal provisions supporting the creation and function of the required facilities. Specific rules are also needed on the types and eligibility of facilities that handle spent batteries, as well as on the safe handling and disassembly thereof [18,19,23–25]. Third, the structure of cost- and profit-sharing should also be established. Legal provisions are needed to define who should bear the cost of dismounting and transporting spent batteries. Regulatory standards are also required on how the costs of performing tests on spent batteries and issuing certificates, as well as the profits of the use of spent batteries, should be allocated [19].

Toward fostering an environment that is conducive to projects related to the use of spent EV batteries, researchers also emphasize the need for policy support for experimental projects and the sharing of information among stakeholders, Jiao and Evans [4] stress the need for policy finance for technology testing projects, as well as new models of partnership between governments and energy corporations. Furthermore, the researchers call for the creation of platforms for data exchange among stakeholders and minimization of the asymmetry of information between battery suppliers and backstream stakeholders.

As for enhancing the value of used EV batteries and fostering markets, the literature recommends establishing a policy basis to that effect first and foremost. Policy incentives are particularly needed to encourage consumers to maintain the quality of their EV batteries [4]. A mechanism may be required to provide greater rewards for consumers who return quality EV batteries than for those who return batteries of poor quality. A system of regular maintenance services should also be established to ensure the quality of spent batteries [19]. Furthermore, researchers propose improving policy measures for the electricity market to foster the demand for electricity storage systems (ESS) [4,26]. This requires fostering markets for power system support services (frequency readjustment, reserve power, voltage readjustment, etc.) by guaranteeing sufficient rewards. It also requires encouraging energy "prosumers," who form a significant source of ESS demand.

3. Methodology

To identify policy measures that can substantially promote the use of spent EV batteries, we conducted in-depth interviews, in September and October of 2018, with experts involved in research or business in relevant areas. The interviews took place in written form using a questionnaire containing open-ended questions. The questions were worded to identify high-priority policy measures necessary to foster the use of spent EV batteries, based on the results of literature review presented above. The items were also placed so that they would induce spontaneous conversation, encouraging interviewees to form their responses by ruminating upon specific policy measures and goals, not limited to the results of literature review.

The method of this study corresponds to a semi-structured interview. Semi-structured interviews are one of the most widely used methods in qualitative research [27,28]. This method allows researchers to deeply explore the ideas and thoughts of interviewees through a pre-determined open-ended question format. In order to use this method effectively, it is necessary to target experts who have sufficient knowledge about the related content, and questions must be systematically designed in a direction that achieves the research purpose.

This study introduces a questionnaire design to effectively identify the priorities of policy tasks for specific issues and to comprehensively analyze related obstacles, specific

solutions, and precautions. The questionnaire (Table 1), designed for top-priority policy task identification (TPTI), asked the interviewees to identify three of the most pressing tasks they could think of and explain why they thought that those tasks were so urgent. The questionnaire then asked the interviewees what major obstacles they expected to be standing in the way of undertaking those tasks, and also to identify specific measures or actions needed to remove those obstacles. Finally, the questionnaire asked the interviewees to identify other factors, including possible side effects, that should be considered before undertaking the policy tasks they had proposed.

Table 1. Top-priority policy task identification (TPTI) questionnaire.

Top-Priority Policy Tasks and Reasons:
1. What policy tasks do you think should be implemented ahead of others toward fostering an active market for spent electric vehicle (EV) batteries? 2. In your opinion, what are the reasons for those tasks so important?
Significant Obstacles and Solutions: 3. What major obstacles do you anticipate in undertaking the policy tasks you proposed? 4. What specific measures or actions are needed to overcome such barriers?
Factors to Consider: 5. What are the possible side effects and other such factors that should be considered in undertaking the policy tasks you propose?

Expert interviews in the existing literature on policy measures are mostly geared toward identifying major obstacles and possible solutions. This study, however, departs from that conventional approach by leading interviewees to identify not only policy tasks but also the reasons behind those tasks. This enables us to understand different reasons in support of the same tasks picked by experts. Moreover, by leading interviewees to identify possible side effects and other such factors that should be considered before undertaking the proposed policy tasks, this study invites us to review the full range of potential impacts that the proposed policy measures could exert.

A total of 18 experts were interviewed for this study, each with at least ten years of experience in his or her respective field. Specifically, seven of the experts were academics and researchers; five were industry insiders; four were consultants; and two were civil servants working in local governments. Some of the industry insiders were also academics/researchers (numbers 8 and 9). Researchers affiliated with private corporations or businesses were categorized as industry insiders (Table 2).

Table 2. An overview of the interviewed experts.

No. [1]	Academics/Researchers	Industry Insiders	Consultants	Civil Servants	Area of Expertise	Position Title
#1	√				Smart city/transportation	Research Fellow
#2	√				Automobiles	Senior Research Fellow
#3	√				Automobiles	Professor
#4	√				Environmental policy	Research Fellow
#5	√				Environmental policy	Research Fellow
#6	√				Energy policy	Research Fellow
#7	√				Energy storage	Professor
#8	(√)	√			Automobiles	Senior Research Fellow
#9	(√)	√			Energy storage	Senior Research Fellow
#10		√			Battery recycling/reuse	Chief Executive Officer (CEO)
#11		√			Battery recycling/reuse	Executive Director
#12		√			Battery recycling/reuse	Vice chairman
#13			√		Strategy/planning	Director

Table 2. *Cont.*

No. [1]	Academics/Researchers	Industry Insiders	Consultants	Civil Servants	Area of Expertise	Position Title
#14			√		Clean transportation	Secretary General
#15			√		Environment business	CEO
#16			√		Resource planning	Senior Expert
#17				√	Environmental planning	Research Fellow
#18				√	Innovation	Team Leader
Total	7	5	4	2	-	-

[1] To ensure the anonymity of experts, they are identified by numbers rather than real names.

4. Results

The top-priority policy tasks identified by the experts can be divided into five categories: development and clarification of regulations, description of market actors' roles, fostering of a business environment, policy reforms and market formation, and infrastructure development. A total of 18 policy tasks were identified as top-priority by the experts (Table 3).

Table 3. Top-priority policy tasks.

Category	Subcategory	Task No.	Task	Experts
Development and clarification of regulations	Different stages of lifecycle	1	Return/collection	#1, #4, #5, #7, #9, #12, #15
		2	Performance evaluation	#2, #4, #6, #7, #8, #9, #10, #13
		3	Recycling/reuse/second-use	#4, #7, #9, #15, #12,
	Other	4	Cost/profit-sharing structure	#5, #15, #18
Clarification of market actors' roles		5	Definition of roles and functions of stakeholders	#3, #5, #8, #9, #10, #14, #15, #18
		6	Introduction of the extended producer responsibility (EPR) rule	#1, #12, #17
		7	Designation of performance testing agencies (automakers/battery manufacturers)	#8
		8	Designation of the spent battery use as an area of business for small and medium enterprises (SMEs)	#10
Fostering of business environment	Research and development (R&D) support	9	Development of design techniques, maintenance techniques, and simplified assessment tools for repair/scrapping	#7, #11, #14
	Testing support	10	Provision of support for testing projects and sharing information	#1, #3, #9
	Realistic rewards	11	Enhancement of businesses' profits by enhancing the value of spent batteries	#8
	Standardization	12	Standardization of battery management support (BMS)	#4, #10

Table 3. *Cont.*

Category	Subcategory	Task No.	Task	Experts
Policy reforms and market formation		13	Policy reforms to foster the electricity storage systems (ESS) market	#3, #6, #18
		14	Introduction/increase of financial incentives for returning batteries	#13
		15	Fostering of demand for spent batteries	#13, #14, #18
Infrastructure development		16	Establishment of local recycling/reuse centers	#2, #17
		17	Introduction of auto shops specializing in EVs	#2
		18	Development of EV battery lifecycle statistics	#5, #6, #7, #11

We list the top-priority policy tasks proposed by the experts and the background in which the tasks have been selected. Overall, defining regulatory provisions applying to each stage of using spent batteries was the area that most experts identified as a top priority. A significant number of experts also expressed the need to clarify the roles of market actors. We also explore potential and major obstacles and factors that may stand in the way of the implementation of recommended policy measures for fostering the use of spent EV batteries (also in Appendix A).

4.1. Legal Provisions Mandating the Return of EV Batteries

4.1.1. Background

The lack of an explicit statutory provision of the system for collecting spent EV batteries leaves room for potential safety hazards and accidents (#4). Although the law requires EV owners to return spent batteries to local governments, the absence of an effective system for managing the returned batteries has led to the accumulation of such batteries in junkyards. Policymakers need to clarify whether the public sector (local or national government agencies) should collect and store batteries, or whether the private sector (battery or EV manufacturers) should do so (in partnership with the public sector) (#s 5 and 15).

4.1.2. Obstacles and Factors to Consider

Although physical spaces are needed to boost the economies of scale and profitability of the commercial use of spent EV batteries, some communities may resist the creation of such facilities in their midst due to the environmental harms, safety issues, and other such factors involved. Governmental actors should, therefore, appoint teams of professional personnel to ensure the safe and non-hazardous management of such facilities, disclose the details of the process transparently to the public, and advertise the economic benefits that such facilities can bring to communities, including the creation of more skilled jobs. The roles and responsibilities of the stakeholders involved in different stages of operating such facilities, however, should be defined based on practical feedback from working-level participants rather than a theoretically coherent plan (#9).

The legal provisions on when and how governmental actors may reclaim the subsidies they have provided for EV owners lack specificity, particularly concerning EV drivers liable for repaying subsidies, actors in charge of collecting them, periods of collection, and rates of the collection (#15). The lack of explicit provisions on not only how EV batteries are to be returned but also on how they are to be reused or scrapped is also problematic (#s 5 and 12).

4.2. Legal Provisions on Performance Testing and Evaluation

4.2.1. Background

Testing and evaluating the residual service life of used EV batteries is crucial to determine the price of used EVs and decide whether the batteries are to be recycled or reused (#s 4 and 13). The lack of clear standards, rules, and certifying agencies for spent EV battery performance testing means that there are no mechanisms to ensure the quality of those batteries (#13). The government should thus introduce detailed criteria for certifying the residual service life or value of used EV batteries (#s 2, 6, 7, 8, 9, and 10).

4.2.2. Obstacles and Factors to Consider

It is impossible to develop appropriate and objective techniques/standards for testing the performance of spent EV batteries overnight. The government should thus consider establishing an official certification agency tasked with evaluating the residual service life of batteries (#13). Developing and introducing specific criteria for such evaluation, however, would take years. Provisional policy measures are therefore needed to ensure the efficient collection and handling of batteries in the meantime (#2).

Some have also criticized the lack of consistent standards applicable to the performance evaluation of batteries of different types, including those using cathode materials. Global standards are needed in this regard, but some confusion may arise regarding the exact specifications and detailed testing criteria (#4).

4.3. Legal Provisions on the Use of Spent EV Batteries

4.3.1. Background

There are no explicit legal or policy provisions that lay out the process, method, facilities, or licensing for the recycling or reuse of spent EV batteries in storage (#15). Detailed standards and rules should be established to outline how spent batteries are to be used, how their materials are to be handled and disposed of, the facilities in charge of handling such materials, and relevant safety measures (#s 4, 7, 9, 12, and 15).

4.3.2. Obstacles and Factors to Consider

Specifying the criteria for certificates of the use of spent EV batteries will necessarily multiply the number and types of tests required, thereby raising the overall cost. It is, therefore, crucial to optimize and simplify the testing process (#8). The lack of clear criteria for defining the scope of products to be certified has been a significant obstacle so far. Core stakeholders should thus engage in active discussions to illustrate the range based on consultation (#7).

The diversity of the institutional actors involved, including the Ministry of Environment (MOE) and Ministry of Trade, Industry, and Energy (MOTIE), has also been delaying effective communication and coordination. The MOE, as Korea's highest authority on recycling, should take the lead in establishing a system for the collection, storage, recycling, and processing of spent batteries. The MOTIE, with its authority on the development and enforcement of product standards, should introduce performance criteria for batteries to be reused or recycled to promote demand and also prevent possible consumer losses (#12).

4.4. Clarification of the Cost- and Profit-Sharing Structure

4.4.1. Background

Detailed discussions are needed on how the costs of collecting, storing, and evaluating the performance of used EV batteries are to be shared, as well as how the profits generated from the use of used EV batteries are to be shared (#5). Although governmental actors in Korea provide subsidies for EV purchases on the condition that the owners return spent batteries later, they have failed to foster demand for the diverse uses of the returned batteries. By determining and clarifying how the costs and profits are to be shared, they may be able to energize relevant industries and create jobs (#18).

4.4.2. Obstacles and Factors to Consider

Although businesses have launched their research on this subject, the absence of official guidelines on how the costs and profits of used EV batteries are to be shared continues to generate confusion, leading to delays in an analysis by even businesses favorably inclined toward the idea. On the other hand, presenting official guidelines may encounter resistance from existing market actors. Therefore, a council is needed to coordinate discussions among operating and interested businesses. At present, determining rigid rules of cost- and profit-sharing, without complete and thorough feasibility analyses, may backfire and negatively affect industries (#18).

4.5. Definition of the Roles and Functions of Stakeholders

4.5.1. Background

It is critical to define, with specificity and clarity, the respective roles and functions of different stakeholders throughout the entire process, from the return and collection of batteries to performance evaluation, reuse, and recycling (#s 3, 5, 8, 9, 10, 14, 15, and 18). Debates should thus continue how to define and extend the scope of the respective roles and responsibilities of institutional actors. New rules and policy reforms ought to reflect a systematic division of labor among stakeholders.

4.5.2. Obstacles and Factors to Consider

Although defining the respective roles of diverse stakeholders is among the necessary steps for implementing new policy measures, conflicts often arise over the specific definitions of different stakeholders' responsibilities (#s 14 and 3). The applicable laws and institutions should first be revisited, and legal consultations should be held to determine who should pay the costs, with the results being communicated to the diverse stakeholders before enforcement (#s 14 and 5). Actors with recycling obligations, such as EV owners, local governments, and automakers, may request additional incentives to help them fulfill their duty (#14).

Interdepartmental cooperation is key to this process, particularly between the MOE and MOTIE in Korea, in terms of which ministry should oversee certification and to what extent (#s 14 and 15).

4.6. Introduction of the EPR Rule

4.6.1. Background

It is crucial to impose new legal obligations on producers, who have the final say on the design, performance, and other characteristics of EV batteries, concerning the recycling and reuse of spent batteries, ensuring that they can play a central role in the recycling system (#s 1 and 12). Applying the EPR rule would encourage producers to be mindful of the need for the use of spent batteries in the design process, thereby inducing improvements in the economic value and safety of spent EV batteries.

4.6.2. Obstacles and Factors to Consider

There is still controversy over who should be charged with the EPR—battery manufacturers or automakers/importers. So far, there has been more support for charging manufacturers and importers of EVs with the EPR, but some fear that EV makers and importers would simply transfer the cost to consumers. The scope of batteries amenable to recycling may also turn out to be a controversial topic (#s 1 and 17).

Conflicts may also arise between vehicle scrapping and recycling businesses, on the one hand, and EV manufacturers, on the other, as each side tries to stake a higher claim on the profits generated by spent EV batteries. As lawmakers are currently reviewing the possible application of the EPR rule to automakers, consideration should also be given to protecting the interests of existing recycling operators until they are ready to accept the transition. A long-term and thorough review of how battery manufacturers and original

equipment manufacturers (OEMs) should divide their roles and responsibilities is also needed to ensure the successful implementation of the EPR rule (#16).

4.7. Designation of EV and Battery Manufacturers as Performance Testing Agents

4.7.1. Background

EV batteries are hazardous materials with high energy densities that require particular care and caution in handling. Improper management and use of used EV batteries can lead to significant financial and human losses. Battery and EV manufacturers possess extensive amounts of data about the development of the products they produce, and may, therefore, be the candidates most suited to serve as agents responsible for testing and evaluating the performance of spent batteries (#8).

4.7.2. Obstacles and Factors to Consider

Currently, specialized testing agencies face no requirements for mandatory participation, while the testing process itself is costly. Financial incentives are thus needed to increase engagement. Yet consideration should also be given to the possible pressure that such incentives may exert upon raising government subsidies for EVs and the prices of spent EV batteries (#8).

4.8. Designation of the Spent Battery Use as an Area of Business for SMEs

4.8.1. Background

Each local government can facilitate the management and use of spent EV batteries by designating and managing private-sector third parties to handle those batteries. Limiting the eligibility to become such designated agents to small and medium enterprises (SMEs) would enable SMEs to participate more actively in the spent EV battery market and thereby contribute more to local economies (#10).

4.8.2. Obstacles and Factors to Consider

One problem is that little discussion has been held so far on the need to limit the use of spent EV batteries to SMEs only. Local governments should be able to commission local private-sector operators to dismount, store, and handle spent EV batteries. In contrast, the central government should share information with local governments on the proper handling of those batteries. The value of used EV batteries should also be appraised in light of the costs of recycling and reusing them. Too high a cost, for private-sector operators commissioned by local governments, for the collection of spent EV batteries will likely deter active investment in the spent battery use industry (#10).

4.9. R&D Support

4.9.1. Background

Research and development (R&D) of appropriate technologies is crucial to foster the demand for spent EV batteries (#14). Particularly noteworthy is consistency in the quality of battery modules and cells that are directly or parallelly connected to make up the battery. However, there are few proven techniques for adequately evaluating the quality of the modules and cells of spent batteries. It is, therefore, essential to develop methods for assessing the design and forecasting the quality of EV batteries to be reused/recycled later (#7). There is also no effective system for inspecting and evaluating the quality of EVs regularly. Yet EVs may need to be inspected and tested before the proper use of their spent EV batteries can be determined. Auto shops and junkyards should be given simple tools with which they can check the state of spent EV batteries. However, no applications to help these actors inspect and dismount EV batteries have yet been developed (#11). More significant support is thus needed for the R&D of equipment for testing and certifying the performance of spent batteries, as well as for reducing the cost of quality certification (#2).

4.9.2. Obstacles and Factors to Consider

The shortage of spent EV batteries in Korea today is a significant factor limiting the growth prospects of the industry, despite its future potential. It also serves to deter active investment in the development of more efficient recycling techniques. A wide range of incentives, direct and indirect, is thus needed to support R&D on recycling, reuse, and second-use technologies as well as to foster and stabilize the market. However, policymakers should be aware of the possibility that techniques developed with such incentives may lead to an effective monopoly that interferes with the growth of the industry in the long run (#14).

The lack of effective collaboration among ministries has also been faulted. Different departments should discuss and coordinate the roles they are to perform respectively in supporting R&D, mainly to avoid redundancy with the existing regular inspection system (#11).

The existing institutional actors also lack a proper understanding of how high-voltage equipment and technologies work. Training and written manuals are thus needed for these institutions but should be delivered in ways that minimize resistance from the institutions already involved in the handling of EV batteries (#11).

4.10. Support for Testing Projects and Information-Sharing

4.10.1. Background

The public sector needs to make an active investment in projects that experiment with and test technologies for evaluating and reusing spent EV batteries, as such projects can lead to the birth of new industries and boost the commercial success thereof (#s 1 and 3). A wide range of testing projects backed by the public sector is needed to develop and test business models that cater to each country's unique business conditions (#9).

4.10.2. Obstacles and Factors to Consider

Businesses may be tempted to undertake testing projects for the sake of meeting formal criteria for more policy support rather than producing substantial and actual results. It is, therefore, essential for the government to establish and enforce rigorous rules for assessing such projects, requiring participants to develop and renew their evaluation goals and plans regularly and ensuring that participants who fail to meet the targets are expelled. Due to the problems of tempting businesses to focus on outward aspects only, policymakers should design testing projects based on extensive participation and thorough planning by all participants in the value chain, including battery producers and distributors, equipment manufacturers, and energy companies (#9).

Defining the respective roles of different participants in R&D and testing projects could be a potential source of conflict. Local governments, which currently have claims to spent EV batteries, should be allowed to play a role in testing projects. The projects should also be designed to enable the participation of ESS manufacturers and car-scrapping businesses. Equally important is to determine the extent to which the public sector is to support testing projects, and any limitations thereof (#1).

4.11. Rational Reward Structure to Enhance the Profitmaking Prospects of Businesses

4.11.1. Background

Businesses may be reluctant to participate in the spent EV battery market in their early stage due to the limited possibilities for profitmaking. To overcome this, governmental actors need to provide rational incentives and rewards until early-stage participants gain stability in the market, thereby helping them enhance their profitmaking prospects (#8).

4.11.2. Obstacles and Factors to Consider

At present, there is no official guideline on appropriate rewards and incentives, while providing such incentives also generates additional costs. The government should establish

a rational incentive plan to improve the profitability of spent EV batteries. It should also consider the suitability in selecting appropriate businesses and agencies (#8).

4.12. Standardization of Battery Management System (BMS)

4.12.1. Background

The absence of a standard for evaluating the performance retention of used EV batteries can be a significant obstacle to fostering demand. A clear guideline is needed on whether used EV batteries are to be scrapped or reused/recycled (#4), along with a standard system for evaluating the remaining value of battery packs and modules (#10).

4.12.2. Obstacles and Factors to Consider

There is currently no law mandating the standardization of processes for testing and evaluating used EV batteries. It is thus critical for the government to establish standards for testing and to evaluate spent battery packs and modules (in terms of performance, capacity, etc.) to aid in their recycling, reuse, second-use. The process for certifying the recyclability/reusability of batteries should also be determined (#10).

Some tests can be conducted only with the cooperation of battery manufacturers. Policymakers should consider requiring battery manufacturers to disclose at least part of their BMS protocol sources about used batteries, under official standards on the eco-friendly recycling of resources, and share those sources with institutions and businesses that use spent batteries. Sharing sources of data on BMS protocols should also be based on consultation with EV manufacturers (#10).

4.13. Policy Reforms to Foster the ESS Market

4.13.1. Background

The ESS may harbor the highest potential demand for the use of spent EV batteries. Still, the ESS market in Korea remains underdeveloped, casting considerable uncertainty on the future demand for spent EV batteries as well (#s 3 and 18). It is crucial to reform the policy and institutions surrounding the ESS market so that these storage systems can serve their intended roles in response to the growing demand for intermittent renewable energy (#6).

4.13.2. Obstacles and Factors to Consider

Fostering the ESS market requires overhauling the entire power market system in Korea inevitably, which is a task of herculean complexity. Fostering the demand for ESSs should, therefore, be aligned with other policy measures promoting energy transition. With new and renewable energy's share of the Korean power market expected to increase rapidly in the coming years, the Korean government should lead reforms of the power market in ways that respond to real-time fluctuations in the supply of renewable energy from ESSs and allow for adequate compensation for the additional reserved power that ESSs contribute. Nevertheless, the overarching goal should be not fostering the demand for ESSs, but rather achieving a balanced energy transition toward enhancing the eco-friendliness, financial feasibility, and security of energy systems nationwide. Over-compensating ESSs to foster only demand might compromise the efficiency of the overall energy systems (#6).

4.14. Introduction of Incentives for the Return of Batteries

4.14.1. Background

The residual service life of batteries can vary greatly depending on the conditions under which they have been used. The current practice of requiring EV owners to return batteries without the expectation of any financial incentives or rewards fails to induce EV owners to drive their vehicles in ways that maximize the service life of EV batteries. The result of this is EV owners' reluctance to return batteries and also the excessive amounts of time and costs involved in returning, collecting, reusing, and processing spent batteries (#13).

4.14.2. Obstacles and Factors to Consider

The statutory provisions requiring the return of objects subject to government subsidies need revision. The lack of a clear definition of who should return such objects stands in the way of the efficient collection of subsidized goods. Incentives should be paid in proportion to the residual service life of returned batteries. In contrast, those responsible for collecting the returned batteries (governmental actors, private businesses, etc.) should also be clarified. However, policymakers should be aware that abolishing the current, unpaid requirement for the return of EV batteries may lead to the arbitrary disposal of returned batteries or their disassembly and handling by unauthorized businesses.

4.15. Fostering the Spent EV Battery Market

4.15.1. Background

The demand must exist to encourage the commercial use of spent EV batteries (#13). The absence of apparent and firm demand for spent EV batteries is delaying the growth of the market for the commercial recycling, reuse, and second-use of such batteries (#s 13 and 18).

4.15.2. Obstacles and Factors to Consider

While innovation in new battery technologies continues and prices keep falling, the sources of demand for spent EV batteries remain scattered and limited. The public sector should thus take leadership in terms of generating demand. However, enforcing quotas for used batteries may lead to the use of batteries that are low in quality and costly (#13). Official criteria for the trade and management of used batteries should be established and updated (#13), while demand for not only ESSs but also rare earth materials should also be fostered (#14).

The lack of public confidence in spent batteries is yet another obstacle. To address this issue, lawmakers should enact statutes that require battery manufacturers to design, produce, and guarantee their batteries with recycling in mind. However, imposing excessive regulatory requirements, including warranties, may adversely affect the competitiveness of the battery industry (#18).

4.16. Creation of Local Centers for the Spent Battery Use

4.16.1. Background

EV batteries are lithium-ion batteries. Storage of these batteries requires that the surrounding temperature and humidity levels be kept constant. It also requires physical facilities capable of withstanding fires and other such disasters. The only way to extinguish a lithium-ion battery fire is to completely cut off the oxygen supply to the location of the fire. Storage of these batteries therefore requires exclusive disaster prevention measures and devices. An EV battery also typically weighs upwards of 200 kg. Specialized hardware, equipped with all electrical safety features, is therefore needed to lift and handle these heavy, highly charged batteries (#2).

The government should introduce guidelines on the creation and operation of local centers specifically for spent EV batteries, as such batteries are distinct from other recyclable objects. Local governments should be entrusted with the management of such facilities toward establishing a systemic and professional nationwide system of spent EV battery management (#s 2 and 17).

4.16.2. Obstacles and Factors to Consider

Although centers dedicated exclusively to the use of spent EV batteries, distinct from other recyclable goods, are needed, little planning has been done to that end so far. Policymakers should thus consider establishing at least one or two spent EV battery centers for each metropolitan city or province. EV manufacturers or experienced recycling organizations may be screened and designated to manage these centers. Performance testing and certification centers are also needed and may be either added to existing

automobile inspection stations or newly created. As the number of spent EV batteries returned varies widely among local governments, specific guidelines should be introduced on designing appropriate facilities for storing and managing returned batteries efficiently and safely (#s 2 and 17).

In the meantime, the roles and functions of the centers remain ambiguous. To foster private-sector demand for recycled and reused goods, the centers should focus on researching and testing recycling, reuse, and second-use standards and handling the objects rejected by the market due to slim profit margins. Establishing too broad a scope of roles for recycling centers could dampen market demand in the long term (#16).

4.17. Introduction of Specialized auto Shops Capable of Handling EV Batteries

4.17.1. Background

Not long after the first commercial EV models were launched in the Korean market, accidents involving these vehicles began to occur (two on Jeju Island in 2016 and one in Seoul in 2017). In most cases, the damaged cars were scrapped. There are, however, very few auto shops capable of handling EVs and EV batteries. The risks of electrocution from the high-voltage, high-current EV batteries prevent mechanics nationwide from attempting to repair EVs that have been damaged in accidents. The three initial accidents that occurred on Jeju Island and in Seoul led to the scrapping of the EV batteries, even though the batteries themselves remained intact after the disasters (#2).

Licenses for professional mechanics are exclusively focused on conventional ICE vehicles. It is crucial to increase the number of machines capable of handling these vehicles nationwide to foster the demand for EVs and enhance EV drivers' convenience. Policy measures are thus needed to introduce specialized licenses for EV mechanics (#2).

4.17.2. Obstacles and Factors to Consider

There is still confusion over the respective roles of different departments. MOLIT is responsible for issuing licenses for mechanics, but it is MOTIE that oversees the standard techniques and skills of mechanics. Meanwhile, the MOE handles the collection and management of batteries. An interdepartmental committee is needed to ensure prompt decision-making and the introduction of new licenses. Preferably, this committee should be installed as part of the Prime Minister's Office rather than anyone ministry, and the departments involved should do their best to collaborate with it (#2).

4.18. Development of Battery Lifecycle Statistics

4.18.1. Background

New codes for wastes and resources related to EVs should be introduced to facilitate the digitalization and management of data on the use and movement of spent EV batteries (#5). Furthermore, a centralized system is needed to trace data on the use of spent EV batteries to support the evaluation of the consistency of the battery module and cell quality (#7). The inspections required before EV batteries can be reused tend to be highly costly, and a centralized system that stores and manages data on these batteries can help reduce the time and costs involved in such inspections. A system is thus needed to manage big data on the entire lifespan of EV batteries, from production to testing, inspection, disassembly, reuse, and recycling (#s 6 and 11).

4.18.2. Obstacles and Factors to Consider

The lack of a transparent system, interdepartmental coordination, and measures to ensure security and privacy presents a potential source of issues. A system should be designed and established to support the analysis of data that can be collected at each stage and protect security and privacy to avoid such issues. In the process, the specifics of the infrastructure and the parties involved should also be clarified (#11).

Policymakers seem to be unaware of the importance of the technology involved in handling spent EV batteries. Government employees and institutions in charge of public

R&D budgets should be made aware of the importance of techniques for testing the quality of battery modules and cells and designing recyclable and reusable EV batteries (#7).

There is also a wide variety of data protocols on tracing the use of batteries. The protocols on data gathering should be standardized and incorporated into requirements about EVs. Forcing EV manufacturers and owners to abide by such data standard could encounter some resistance, and thus appropriate incentives should be devised (#7).

5. Conclusions and Policy Implications

Based on the literature review and interviews with researchers, entrepreneurs, consultants, and local government officials with expertise in EVs, batteries, transportation, the environment, and energy, this study identifies policy measures necessary to promote the use of spent EV batteries as well as the obstacles, possible solutions, and other factors of caution that need to be considered alongside such measures. The findings of these in-depth interviews provide a more comprehensive and specific list of policy measures that reflect Korea's particular circumstances and conditions than the survey of the existing literature.

It is essential to undertake at least some of the policy tasks emphasized by experts to promote and facilitate the use of spent EV batteries. Figure 1 below summarizes the weights for each policy task based on the results of Table 3. In this study, experts presented three priority policy tasks, and the weights of those tasks were calculated based on the number of experts who judged that the importance of each policy task was high. Experts call for the establishment of specific rules on the legal bases, roles, and functions of facilities involved in the handling, performance evaluation, and recycling and reuse of used EV batteries. Detailed rules are particularly needed to define the locations, timeline, and processes of collecting returned batteries safely and efficiently. Specific rules are also required concerning the collection of subsidies from EV owners, the setting of eligibility criteria, agencies responsible for collecting spent batteries, timeline, and percentages of support to be returned. The experts interviewed for this study also strongly emphasized the need for clear rules on battery performance evaluation, particularly in the form of valid and reliable criteria for the certification of performance evaluation results necessary for determining whether and how used EV batteries are to be used. Specific rules are also needed for the facilities, compliance, and safety instructions regarding the reuse, recycling, and disposal of used EV batteries.

Experts also emphasize the importance of supporting testing projects and sharing information. Testing spent EV batteries requires verification through diverse methods. It is, therefore, crucial to promote cooperation among businesses and increase technological compatibility. Testing projects conducted for perfunctory purposes only, however, would lead to the inefficient use of fiscal resources. The evaluation criteria should be made more rigorous, and all parties participating in the value chain, including battery-owning companies, equipment makers, and energy companies, should be required to plan and design their testing projects thoroughly in advance.

Enhancing the value of used EV batteries has also been emphasized by many. Incentives and regular maintenance programs should thus be introduced to enable users to keep their EV batteries in good condition before returning them. As ESSs are currently a significant source of demand for spent EV batteries, policy support is needed to foster the growth of the ESS market. This, in turn, should be aligned with other policy measures promoting energy transition and the expansion of renewable energy. However, policymakers should strive to achieve a balance among the eco-friendliness, financial feasibility, and security of all energy systems through energy transition instead of focusing solely on fostering the demand for ESSs, as introducing excessive incentives or rewards for encouraging the ESS market would compromise the economic feasibility of the overall energy system.

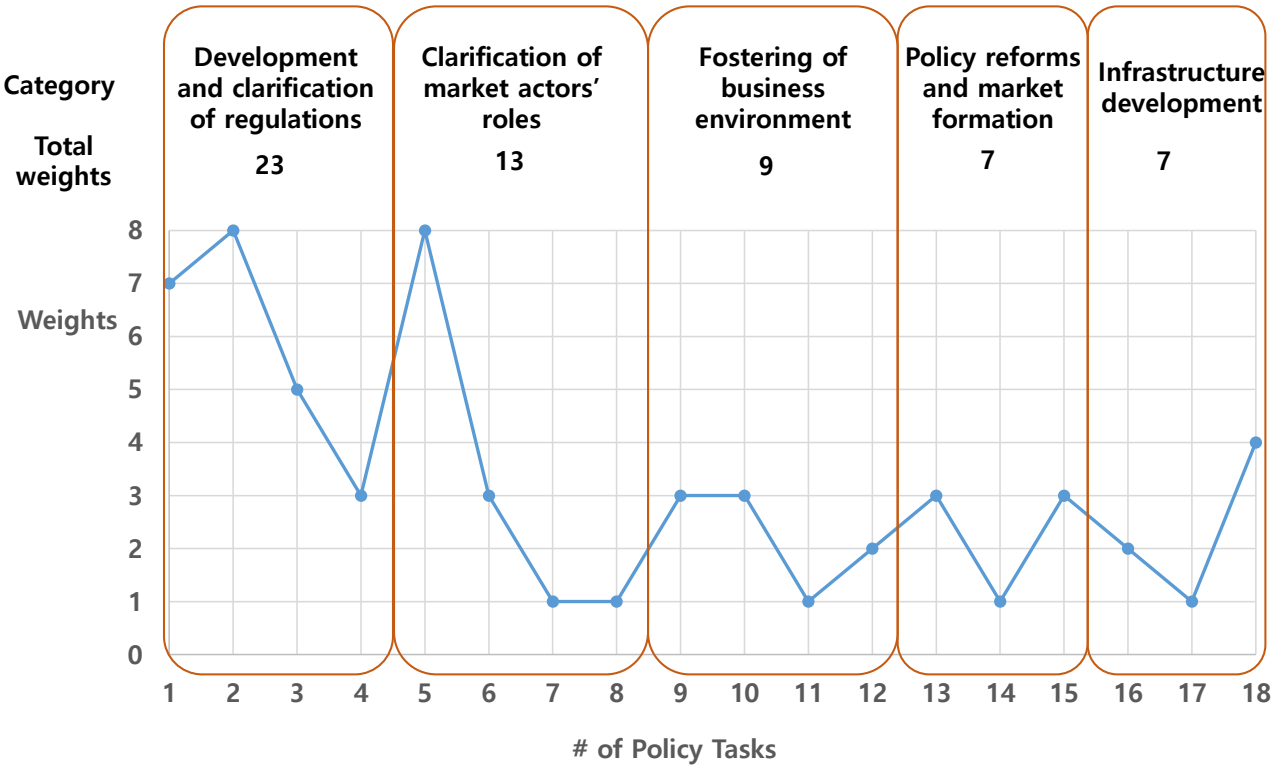

Figure 1. Policy tasks and their weights.

Policymakers should also consider, in a comprehensive manner, the obstacles, possible solutions, and other factors of caution implicated in those tasks. As for the return and collection of spent batteries, setting up facilities to handle those tasks may encounter resistance from local communities due to the potential safety issues. One possible way of minimizing such resistance is to provide transparent and specific information on the actual likelihood of such risks and possible solutions, all while maintaining the necessity of the proposed facilities. Regarding performance evaluation, policymakers would find it impossible to introduce reliable and objective criteria and methods of assessment in the short run, as it would take years to develop valid criteria for evaluating and certifying the residual service life of batteries. Policymakers should, therefore, provide measures that can ensure the efficient collection and handling of used EV batteries in the meantime. Refining certification criteria for the recycling and reuse of batteries has the benefit of increasing the safety of the batteries used. Still, it also threatens to increase the complexity and costs of the tests required for certification. Policymakers should, therefore, seek to strike a balance that allows them to enhance the safety of recycled/reused batteries while also maximizing the cost-effectiveness of certification.

While authors of the existing literature and interviewed experts agree on many of the policy tasks that should be carried out, they also differed on other policy tasks. This divergence of opinion was more apparent in the interviews with experts, mainly because the experts held competing interests in spent EV batteries and, accordingly, differed in their preferences for policy measures. Experts, for example, agree that it is paramount to clarify the roles of stakeholders, but they disagreed on the exact definitions or scopes of those roles. If our primary goal were to enhance the safety and reliability of spent EV batteries, introducing the EPR rule and limiting the authorization to evaluate battery performance to only EV and battery manufacturers would be the best policy alternatives. However, if we want to maximize the number of competing businesses in the spent battery market, to find more diverse applications for those batteries, we should apply policy measures that encourage EV and battery manufacturers to share their information with other market

actors. We would also need to standardize relevant technologies and leave more significant room for the participation of SMEs.

Another major policy concern is, therefore, finding the right balance between a manufacturer-centered approach to the spent EV battery market, on the one hand, and an open and participatory approach, on the other. Policymakers should thus review not only the primary policy measures needed to foster that market but also the different and competing interests among existing and potential market actors, and how best to coordinate those interests while not losing sight of the need to grow the market. The importance of interdepartmental and government-wide cooperation in this process cannot be overemphasized. At present, however, both the MOE and MOTIE, in the case of Korea, are considering plans to create their own respective battery collection centers. Moreover, no clear rules are defining the respective roles of different departments in setting up auto shops catering specifically to EVs. Various departments should also work together to minimize the redundancies of the R&D projects they support and maximize the synergy thereof. Interdepartmental cooperation is much needed, and a new interdepartmental committee may be set up, reporting to the Prime Minister.

Policymakers should also strive to maximize the effectiveness of the measures they introduce by gaining a clear understanding of the correlations among diverse policy tasks. Although people have different policy preferences, there is a hierarchy (or an order of different priorities) among policy tasks. Figure 2 below visualizes the correlations among the policy tasks identified and listed in this study. Establishing and clarifying the rules concerning spent EV batteries at different stages of their lifecycle is placed at the center, as that task is to catalyze the other tasks. Establishing clear standards on the return, collection, performance evaluation, reuse, recycling, and profit- and cost-sharing of used EV batteries also facilitates the clarification of stakeholders' rules and promotion of the demand and supply of spent batteries. Introducing legal grounds for infrastructure expansion will also catalyze the development of infrastructure, including local centers, auto shops specializing in EVs, and a battery lifecycle statistics system.

Stakeholders' roles can be clarified not only with rules and statutes but also through communication and consultation. Defining which parties are responsible for each stage of the handling of spent EV batteries and clarifying the roles of the different institutions and government agencies involved can contribute much to coordinating the diverse and competing interests surrounding those batteries. In turn, mitigation of such competing interests will catalyze the expansion of infrastructure. Facilities, statistics, and other such features of infrastructure will promote the supply and demand of spent batteries, helping foster the market further.

Interdepartmental cooperation is again key to establishing clear rules and also clarifying stakeholders' roles. Competing interests should be managed and resolved in order to develop and expand infrastructure, thereby increasing the potential for fostering the market. When spent EV batteries gain adequate market appeal, thus allowing them to compete with new batteries in terms of eco-friendliness, economic value, and other factors, the market will naturally develop and thrive.

The market for spent EV batteries is still in a very early stage in Korea, with almost no supply. It is, therefore, not advisable for Korean policymakers start by focusing on fostering supply and demand. Instead, they should prioritize determining and clarifying rules and roles, and proceed with expanding infrastructure accordingly. Policy support for R&D and testing projects should be provided while resources are invested in developing infrastructure. The emphasis on understanding correlations or the order of policy tasks highlights the importance of understanding how the completion of one set of tasks affects the conclusion of the other, thus enhancing the effectiveness of policy decisions made and implemented.

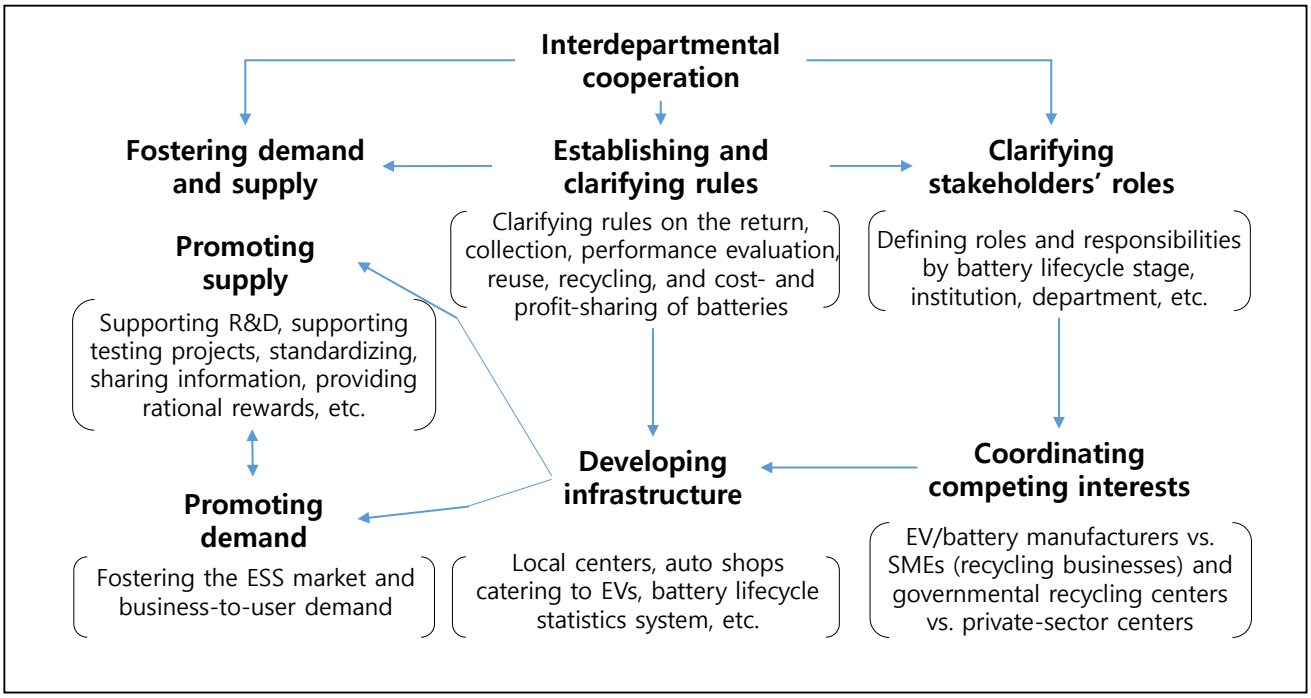

Figure 2. Correlations among policy tasks.

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Appendix A

Table A1. Obstacles and factors to consider.

Task	Obstacle	Solution	Factor to Consider
1	Local communities' resistance to battery-handling facilities	Transparent disclosure of facilities' management details and continued advertising of benefits	Realistic opinions from working-level officials
	Lack of clear rules on the return, reuse, and disposal of batteries	Addition of new provisions in the CACA, Act on the Resource Circulation of Electrical and Electronic Equipment and Vehicles, etc.	n/a
	Lack of interdepartmental coordination	Clarification of roles through communication among government departments, battery manufacturers, private sector, etc.	n/a
	Lack of specific rules on how EV subsidies are to be returned	Specific rules on who should repay subsidies, who should collect them, timeline, percentages of subsidies to be repaid, etc.	n/a

Table A1. *Cont.*

Task	Obstacle	Solution	Factor to Consider
2	Difficulty of securing reliable evaluation technologies and objective certification criteria in the short term	Appointment of competent organizations to handle the evaluation of the residual service life of batteries	Measures for the efficient collection and handling of batteries are needed until official performance evaluation and certification criteria are introduced
	Lack of performance evaluation equipment	Provision of support for R&D on technologies and equipment using highly reliable output and alternating impedance	n/a
	Lack of consistent performance standards for different types of batteries (e.g., cathode materials)	Global standardization of testing and evaluation procedures	Possible confusion over test specifications/ categories, etc.
3	Refinement of certification criteria leading to complexity and higher costs of certification tests	Optimization and simplification of testing processes	n/a
	Ambiguity of products to be certified	Sufficient communication among core stakeholders	n/a
	Diversity of government departments involved	Creation of system for using batteries established by the MOE, and product-specific criteria for using spent batteries established by MOTIE, to promote secondary use and prevent consumer losses	n/a
4	Resistance of existing businesses to new research and standards	Formation of a council for discussions among existing businesses, etc.	Deciding how profits are to be shared may adversely affect the entire industry if a financial feasibility analysis remains incomplete
5	Different opinions on roles of stakeholders	Reform of legal and policy grounds, communication among stakeholders, and clarification of roles among government departments	Parties obliged to recycle (EV owners, local governments, EV manufacturers, etc.) may require additional incentives
6	Lack of provisions in the laws such as WCA, APSRR, etc.	Addition of new provisions in said statutes on the management, recycling, and reuse of spent batteries	Timing of the effectuation and obligations should be decided in consideration of existing EV subsidy programs
	Dispute over who should bear the EPR (battery manufacturers vs. EV manufacturers or importers)	Imposition of the EPR on EV manufacturers and/or importers	EV manufacturers or importers may transfer the cost of recycling to consumers, and disputes may also arise over the scope of products to be recycled
	Possible conflicts between existing car scrap/recycling services and EV manufacturers	As the EPR is to be imposed on EV manufacturers, existing recycling businesses should be given support and protection to complete their transition for a certain period of time	Roles and responsibilities of battery manufacturers, OEMs, etc. should be reviewed thoroughly to ensure the successful implementation of the EPR
7	No rule requiring specialized agencies to participate and general cost involved in performing duties	Establishment of appropriate rewards/benefits for the costs involved	Upward pressure on EV subsidies and battery prices
8	Lack of discussions	Designation of private-sector businesses to handle batteries on local governments' behalf and value of batteries collected to reflect cost invested in reusing/recycling them	Excessive costs of reusing/recycling batteries may deter further investment in the future

Table A1. *Cont.*

Task	Obstacle	Solution	Factor to Consider
9	Interdepartmental confusion (MOLIT issuing mechanics' licenses; MOTIE overseeing EV-related technologies; MOE overseeing battery collection and handling)	Formation of an interdepartmental committee to coordinate discussions, accelerate decision-making, and facilitate rapid introduction of licenses	Mutual consultation and understanding is needed (and possibly a committee reporting directly to the Prime Minister)
10	Lack of system and interdepartmental communication at each stage, leading to security and privacy risks	Design and development of programs capable of collecting available data at each stage, while taking into consideration security and privacy concerns	Infrastructure development and clarification of stakeholders' roles are needed
	Failure to recognize importance of spent battery technologies	Convincing of R&D officials and institutions of the importance of developing technologies for assessing the quality of battery modules and cells (direct or alternating) and recyclable battery designs	n/a
	Diversity of usage-tracing data protocols	Standardization of necessary data to be incorporated into EV requirements	Requiring EV companies and owners to comply with data standards may encounter some resistance, requiring incentives
	Lack of codes for handling EV battery-related waste	New codes to be added to EcoAS to enable the program to collect EV-related data	n/a
11	Shortage of spent batteries limiting growth of industry and deterring investment necessary for developing more effective recycling technologies	Provision of policy support for R&D on battery recycling/reuse technologies and direct and indirect policy incentives to foster market	Limits on applying new technologies may give rise to monopolies/fail to grow market significantly
	Lack of interdepartmental communication (among MOLIT, MOE, and MOTIE)	Definition of roles and responsibilities by each department and interdepartmental consultation	Redundancy with existing interdepartmental inspection system
	Existing institutions' failure to understand high-voltage equipment and technologies	Provision of training and manuals	Possible resistance from existing institutions
	Lack of information sharing among vehicle businesses preventing discovery of more affordable options	Holding of pre-negotiations with EV and battery manufacturers and definition of rules on the scope of and obligations related to the data to be shared on subsidized vehicles	A process for certifying safety and accuracy should be established
12	Temptation for businesses to conduct testing projects for perfunctory reasons only	Imposition of requirement on businesses to articulate clear goals for each stage and establish evaluation plans and development of rigorous criteria	All value chain participants need to plan their testing projects thoroughly
	Possible disputes with parties undertaking R&D and testing over definition of roles	Local governments with claims to spent batteries and that can potentially foster demand for those batteries should participate in testing projects	The scope of testing projects and their limits should be defined before public sector participation begins
13	Complexity of power market reform	Connection of battery policy measures to policy tasks for energy transition	ESSs to be supported to the extent compatible with higher values (economic value, eco-friendliness, security, etc.)

Table A1. *Cont.*

Task	Obstacle	Solution	Factor to Consider
14	Reform of rules on collecting EV subsidies from EV owners (lack of specificity delaying efficient return of batteries)	Provision of incentives for returned batteries proportional to their residual service life (to be paid by local governments or businesses commissioned to handle batteries)	Extra measures needed to prevent the arbitrary disposal or handling of batteries by unauthorized parties after the battery return duty is lifted
15	Technological innovation and price reduction vs. insufficient demand	Fostering of public-sector demand for spent batteries	Mandating the use of spent batteries may lead to the use of low-quality and high-cost batteries
		Establishment of standard on battery trade and reform of regulatory system	n/a
		Provision of support for R&D on technologies and markets for recycling rare earth materials	n/a
	Lack of consumer confidence in recycled batteries	Imposition of legal requirement on battery manufacturers to design, produce, and provide warranty for batteries and their recycling	This kind of regulatory burden may compromise the battery industry's competitiveness
16	Lack of plans for recycling/reuse centers for spent EV batteries, distinct from other recycling centers	One or two EV battery recycling centers should be set up per metropolitan city/province, operated either directly by EV manufacturers or existing recycling centers designated by local governments in order to meet certain criteria	As the quantities of returned batteries vary widely by region, specific rules are needed to ensure the design, technology, and safety of appropriate facilities for managing and storing these batteries efficiently.
	Confusion over departments in charge of setting up battery recycling/reuse centers	Centralization of departments	Effective communication is needed to avoid disputes (an interdepartmental committee reporting to the Prime Minister may be needed)
	Lack of clarity over the roles and functions of recycling centers	Focus on testing, research and other tasks necessary to develop effective recycling/reuse standards, but shunned by the market for being unprofitable	Expanding the scope of recycling centers' roles may interfere with market growth
17	Lack of appropriate reward standards and high cost of rewards	Establishment of rational standards for rewards and plans for enhancing profitability	Lack of appropriate rewards deters businesses from participating
18	No legal requirement to standardize testing and evaluation processes	Introduction of (performance/capacity) standards for evaluating/testing spent battery packs/modules	Clarification of rules for certifying recyclability/ reusability
	Cooperation of battery manufacturers necessary for some tests	Partial disclosure of BMS protocol sources used in batteries to institutions/businesses handling spent batteries	EV manufacturers should be consulted on sharing data sources for part of their BMS protocols

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