Introduction of Extended Producer Responsibility in China

Li Yang (Zhongnan University of Economics and Law)
Fujikawa Kiyoshi (Aichi Gakuin University)

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Li Yang† and Fujikawa Kiyoshi‡

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† Associate Professor, Zhongnan University of Economics and Law, Hubei, China
Email: z0004698@zuel.edu.cn
‡ Professor, Aichi Gakuin University, Nagoya, Japan.
Email: fujikawa@dpc.agu.ac.jp

Abstract

There is an urgent need to establish an effective disposal and recycling system in China since the number of end-of-life vehicles is rapidly increasing due to the growth of motorization. China is increasingly applying Extended Producer Responsibility (EPR) principles to its automotive industry based on the experience of more developed countries. However, EPR-related institutional design is complex, and there are many difficulties involved in establishing a system as corporate recycling technology and public environmental awareness are not on par with the developed world. We believe that China should introduce an EPR system to its automobile industry and promote recycling to realize a more recycling-oriented society. This paper will introduce the current status of China's automotive recycling system and the current challenges of applying EPR to its automotive industry with focus on electric vehicles (EV).

The establishment of EV battery recovery systems and recovery technologies are still being explored in China. Regulatory methods and economic methods have been proposed for the proper collection and disposal of storage batteries in China. However, the challenges related to the recovery of EV used batteries can be summarized in the following three points: 1) standardization and normative design and manufacturing for the reuse of used batteries; 2) development of laws for the storage and transportation of used batteries; and 3) standardization of the treatment process and recycling method of used batteries as well as the improvement of treatment technology.

Key words

end-of-life vehicles, extended producer responsibility, electric vehicle

Abbreviations

ASR	automobile shredder residue
BEV	battery electric vehicles
ELV	End-of-Life Vehicles
EPR	Extended Producer Responsibility
METI	Ministry of Economy, Trade and Industry
MoE	Ministry of Environment
MOTAS	Motor-car Total information Advanced System
OECD	Manual of Organisation for Economic Co-operation and Development
PHEV	plug-in hybrid electric vehicles

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1. Introduction

In line with China’s economic growth, the country’s automotive industry has expanded, reaching record highs in both production and sales in 2021 and remaining the largest in the world for the thirteenth consecutive year. However, the number of end-of-life vehicles is rapidly increasing due to the growth of motorization, and there is an urgent need to establish an effective disposal and recycling system. In developed countries, recycling systems based on Extended Producer Responsibility (EPR) have been in place in a number of industries since the 1990s, and the governments of developing countries have recently been following the lead of developed countries in establishing legislation related to recycling. China is increasingly applying EPR principles to its automotive industry based on the experience of more developed countries. However, EPR-related institutional design is complex, and there are many difficulties involved in establishing a system as corporate recycling technology and public environmental awareness are not on par with the developed world. We believe that China should introduce an EPR system to its automobile industry and promote recycling to realize a more recycling-oriented society. This paper will introduce the current status of China's automotive recycling system and the current challenges of applying EPR to its automotive industry.

There have been many previous studies on China's automobile recycling systems. For example, Hiraiwa (2013) described the evolution of China's automobile recycling policy. Wang et al. (2007) and Choi (2008) identified and clarified issues in the Chinese automobile recycling business based on comparisons between Japan and China.

The Guidance Manual of Organisation for Economic Co-operation and Development (OECD) defines EPR as “an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle.” (OECD, 2001). The Manual explains the need for the application of EPR: “The important implications and changes associated with EPR stem from both the product treatment at the post-consumer phase, addressing the upstream activities in the selection of materials and the design of the product. It is believed that, under these conditions, appropriate signals can be sent to the producer to internalize a substantial portion of the environmental externalities from the final disposal of the product.” When the producer and recycler are separate economic entities, “ease-of-recycling” is not at the forefront of the producer's mind. However, this problem can be eliminated when the producer and recycler are the same entity.

This paper first discusses how the number of end-of-life vehicles is increasing due

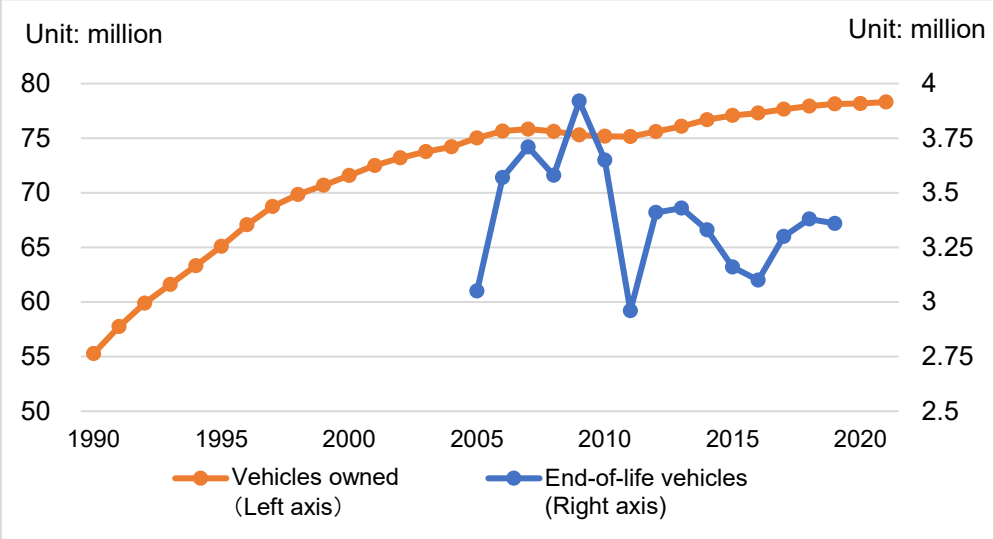
to growing motorization in China, and how the problem of automobile recycling is becoming more apparent. Then, by comparing the automobile recycling systems of Japan and China we point out the problems found in China's systems. Finally, we examine the application of EPR to the Chinese automobile industry.

2. The Development of Motorization and the Emergence of ELV in China

2.1 Trends of End-of-Life Vehicles (ELV) in Japan

Full-scale motorization in Japan began in the late 1960s. The expansion of both the domestic market and exports due to economic growth led to a dramatic increase in the automobile industry's production capacity, which reached 13 million units per year in 1990. However, domestic automobile production has been on a downward trend since 1990, as the domestic market is approaching saturation and overseas production is increasing. Figure 1 shows the number of automobiles owned and used in Japan. Although the number of owned vehicles continues to increase, the rate of growth has slowed since 1997, when it exceeded 70 million units. The number of automobiles per 1,000 people grew from 14 in 1960 to 168 in 1970, 467 in 1990 and 572 in 2000, but there has been little change since the turn of the millennium[1].

Figure 1 The numbers of vehicles owned and end-of-life vehicles in Japan



Source: Created by the authors based on data from the Automobile Inspection and Registration Information Association and METI and MoE (2020).

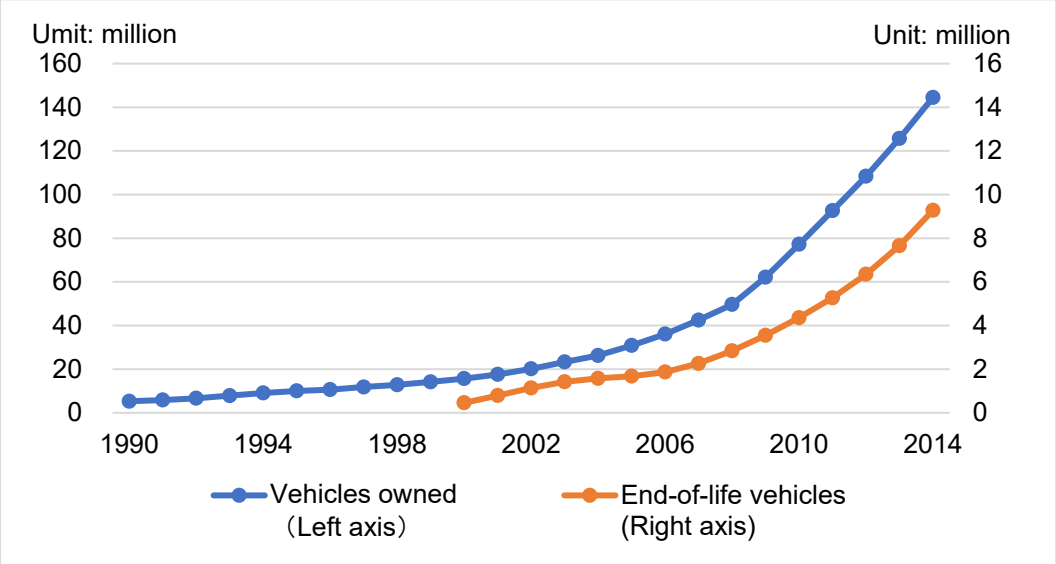
[1] The number of vehicles per 1,000 people in Japan was calculated by the author based on data for the number of owned vehicles (Japan Automobile Manufacturers Association, 2016) and the size of the population (Statistics Bureau, Ministry of Internal Affairs and Communications).

Conversely, while the number of end-of-life vehicles can fluctuate widely, it remains at approximately 3 to 4 million vehicles per year. However, about 1.5 million of these vehicles are exported overseas to be sold second-hand. It is estimated that approximately 1.5 to 2 million end-of-life vehicles appear annually in Japan[2].

2.2 End-of-Life Vehicle Trends in China

Prior to the adoption of the reform and open-door policy in 1978, China produced only about 150,000 automobiles per year, with the majority being trucks. Subsequently, the Chinese government launched a series of measures to promote the automobile industry and shifted the emphasis of automobile production from trucks to passenger cars. China's accession to the WTO in the early 2000s accelerated the growth of the Chinese economy. This increased demand for passenger cars, especially in large coastal cities, ushering in an era of full-fledged motorization. To mitigate the impact of the 2008 Lehman Brothers collapse, the Chinese government adopted “Ten Major Measures to Promote Domestic Demand and Economic Growth.” In the following year, 2009, the “Automobile Industry Readjustment and Promotion Plan” was announced to stimulate automobile purchasing, and motorization expanded to inland and rural areas. In 2009, production and sales exceeded 13 million units, making it the largest automobile market in the world.

Figure 2 The numbers of vehicles owned and end-of-life vehicles in China



Source: Created by the authors based on China Statistical Yearbook (2021) and Li and Fujikawa (2017)

Figure 2 shows the number of automobiles owned and operated in China. The number of owned vehicles grew from 5.31 million in 1990 to 77.22 million in 2010, surpassing

[2] Ministry of Economy, Trade and Industry and Ministry of the Environment (2000) "Current Status of Automobile Recycling."

Japan's 75.36 million and ranking second-highest in the world after the U.S., which has 248.23 million. By 2014, the number of vehicles owned in China had exceeded 144.52 million and is expected to continue to increase (Japan Automobile Manufacturers Association, 2017: 105–106). The number of cars owned per 1,000 people in China has increased rapidly from 5 in 1990 to 58 in 2010 and 107 in 2014[3], in line with Japan's earlier experience of growth from 64 in 1965 to 168 in 1970[4]. China is in the early stages of motorization, which is similar to this period in Japan. In 2040, the number of automobiles owned in China is expected to reach 450 million. With a population of 1.5 billion, the number of automobiles owned per 1,000 people is expected to be around 300, approximately half the current number in Japan (China Automobile Dealers Association 2015: 322).

However, the number of end-of-life vehicles generated in China was only 460,000 in 2000 but surpassed 4 million after ten years, that is, 2010. The number of end-of-life automobiles in China is expected to continue to grow and is estimated to exceed 20 million vehicles by 2020 (Li & Fujikawa 2017, China Investment Consulting Network 2016).

3. Comparison of the Recycling Systems of Japan and China

3.1 The Japanese Legal Framework for Automotive Recycling

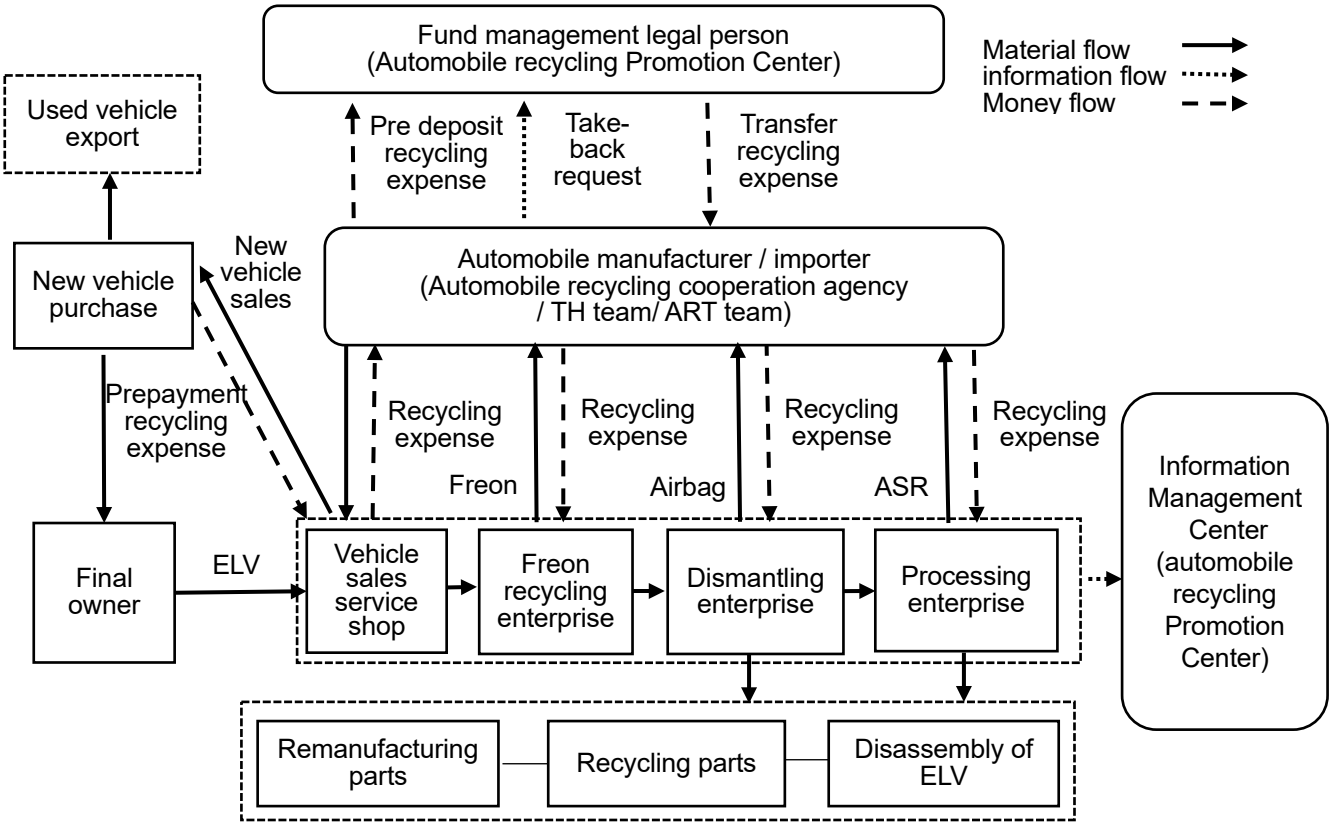
In Japan, the End-of-Life Vehicles Recycling Law, based on EPR concepts, came into effect in January 2005. The direct cause for the enactment of this law was the collapse of the existing end-of-life vehicle recycling system due to reversed charging for end-of-life vehicle disposal (Asaki 2004). Japan's automobile recycling flow is shown in Figure 3. The final owner delivers the used vehicle to a salvage company (e.g., automobile dealers), and the salvage company delivers the used vehicle to a fluorocarbon recovery company. The recovery company recovers the fluorocarbon contained in the air conditioners of automobiles and then returns the end-of-life vehicles to their manufacturers. Under the End-of-Life Vehicles Recycling Law, automobile manufacturers are responsible for the disposal of airbags and automobile shredder residue (ASR). The automobile manufacturer delivers the used automobile to a wrecker once the fluorocarbons have been recovered. The wrecker removes the airbags, engine, doors, and other useful parts, and then delivers the dismantled vehicle to a shredder. For the recycling of airbags, automobile manufacturers have jointly established the Japan Automobile Recycling Cooperation Organization (a general incorporated

[3]The number of cars per 1,000 people in China was calculated by the author based on data on the number of cars owned (Japan Automobile Manufacturers Association2016) and China's population (National Bureau of Statistics of the People's Republic of China 2015).

[4] As of 2014, global average for cars owned per 1,000 people was 167, while the U.S. average was 809. See Japan Automobile Manufacturers Association (2016: 64).

association). The processing is outsourced. Shredders shred dismantled vehicles and recover useful metals. The ASR is sorted, collected, and delivered to the automaker. ASR processing is divided into two teams (the ART team and the TH team) according to the vehicle's manufacturer, and the recycling is performed by contractors from each team[5].

Figure 3 Illustration of Japan's recycling system



Source: Created by the authors based on METI and MoF (2002)

Under the Japanese system, the roles of each party are clearly defined to ensure that end-of-life vehicles are disposed of properly. In the case of new cars, the buyer of a new car "prepays" the recycling fee[6] to the dealer. The fee is set by each automaker, resulting in competition among the manufacturers. The Automotive Recycling Promotion Center manages the recycling fees in case an automaker goes bankrupt. When end-of-life vehicles are exported to foreign countries to be sold second-hand, a surplus is generated. This surplus is utilized for countermeasures against illegal dumping, to

[5] The ART team (Automobile Recycling Promotion Team) was formed of 13 corporations including Nissan, Isuzu, Fuji Heavy Industries, Mazda, Mitsubishi Motors, etc. The TH team (Toyota-Honda Team) was formed of 8 corporations including Toyota, Honda, Daihatsu, Hino, and others.

[6] In addition to the recycling fees for the three items (CFCs, airbags, and ASR), the charges also cover the operating costs of the Information Management Center and the Automotive Recycling Promotion Center.

subsidize remote islands, and to reduce the financial burden on vehicle owners. (Ministry of Economy, Trade and Industry and Ministry of the Environment 2002).

Japan's End-of-Life Vehicles Recycling Law has introduced an electronic manifest system. This system is a world-first in that recycling information at each stage of the process can be checked by an information management system (Japan Automobile Manufacturers Association, 2015:34). The electronic data processing system (Motor-car Total information Advanced System, MOTAS) for vehicle registration and inspection operations in Japan centrally manages registration and inspection data for vehicles owned throughout the country. A monitoring system for end-of-life vehicles tied to MOTAS has been established, and the status of vehicle recycling can be checked on the Automobile Recycling System's website[7].

The End-of-Life Vehicles Recycling Law has promoted the reorganization of the end-of-life vehicle treatment and recycling industry. The overall recycling rate of end-of-life vehicles has increased from 83%, which was before the law came into effect, to 99% (Ministry of the Environment2015). In addition, it is also recognized as having achieved "clarification of distribution routes for end-of-life vehicles, progress in recycling by vehicle manufacturers, and a decrease in illegal dumping and improper storage"(Ueda 2010:82). At the same time, unlike the EU End-of-Life Vehicle Directive, which places physical and economic responsibility on the manufacturer, Japan's "Automobile Recycling Law" makes the automaker responsible for the disposal of fluorocarbons, airbags, and ASR through the utilization of existing infrastructure (wreckers and shredders). This method is called "Japanese EPR" and is regarded as "an efficient method tailored to Japan's social conditions"(Asaki 2004:81–82, Otsuka 2002:195, Lee 2007:324, Wang 2014:1299).

3.2The Legal and Regulatory Framework for Automobile Recycling in China

Legislation related to automobile recycling in China was initiated in the 1980s. The "Truck Recovery Law" (trialed), which came into effect in 1980, stipulated procedures for the recovery of trucks and clearly stated that end-of-life vehicles were to be recovered, dismantled, and disposed off as scrap steel. The "Regulations to Accelerate the Disposal of Older Vehicles" (provisional), which came into effect in 1986, set standards for scrapping vehicles and maximum mileage limits for each vehicle type. In the 1990s, policies were implemented to strengthen the monitoring systems within the automobile industry and the market and to foster incentives to replace automobiles. The Waste Motor Vehicle Recovery Law, which came into effect in 1990, stipulates the obligations of management departments and business entities for the recovery and

[7] Automotive Recycling System <http://www.jars.gr.jp/>. Funazaki (2009) mentioned this system as "an advanced system that is unique to Japan."

disassembly of end-of-life vehicles, the issuance of end-of-life vehicle recovery certificates, the acceptable fluctuation range for end-of-life vehicle purchase prices, and the prohibition of reuse of the five major components of end-of-life vehicles (engines, steering, transmission, axle shafts, and frames). The “Law on Qualification and Certification of Recovery (Dismantling) Enterprises of End-of-Life Vehicles” (provisional), which came into effect in 1997, introduced a qualification system for enterprises that recover and dismantle end-of-life vehicles. A subsidy system has also been introduced to provide incentives for purchasing new vehicles. The “Law on Fixed Subsidy for Renewal of Older Vehicles” (provisional), which came into effect in 1995, defined the scope and criteria for providing subsidies for vehicle disposal.

Table 1 lists the efficiencies of the automotive recycling-related regulations enacted since 2000. The “Measures for the Management of Recovery of Scrapped Vehicles” (hereinafter referred to as Decree 307), which came into effect in June 2001, will be the central law of China's automobile recycling system until the law was revised in 2019. Decree 307 stipulates the supervision and management methods for the collection and dismantling of end-of-life vehicles, the conditions for establishing a dismantling company and system for their certification, the obligations of certified companies, the procedures and purchase price of end-of-life vehicles, and penalties for related illegal acts.

Table 1 Main Regulations Related to Automobile Recycling in China Since 2000

施行日	法令･規程･基準
2001/06/16	Measures for the administration of the recycling of end-of-life vehicles
2004/05/01	Road Traffic Safety Law
2004/05/01	Motor Vehicle Registration Regulations
2006/02/06	Technical policy of automobile product recycling
2008/03/02	Administrative measures for Pilot Remanufacturing of auto parts
2009/07/13	Implementation measures for replacing old vehicles with new ones
2013/05/01	Regulations on compulsory scrapping standards of motor vehicles
2013/07/04	Pilot implementation plan of "trade in" for remanufactured products
2014/09/01	Opinions on strengthening and improving motor vehicle inspection
2015/06/01	Management requirements for hazardous substances and recyclability of automobiles
2016/01/05	Technical policy for recycling of electric vehicle power battery (2015 Edition)
2017/01/04	Notice on strengthening the supervision of environmental protection compliance of second-hand vehicles
2019/06/01	Measures for the administration of recycling of end-of-life motor vehicles
2019/12/17	Technical specification for scrapped motor vehicle recycling and dismantling Enterprises
2020/09/01	Detailed rules for the implementation of the administrative measures for the recovery of end-of-life motor vehicles

Source: Created by the authors based on the official websites of relevant departments of the Chinese government.

The Chinese government implemented the “Road Traffic Safety Law,” and the “Motor Vehicle Registration Regulations” on May 1, 2004. These regulated the vehicle registration and cancellation system, the vehicle inspection system, and the compulsory vehicle scrapping system[8]. The compulsory vehicle scrapping system was amended in 2013, as shown in Table 2. The new disposal regulations alter the age limits for the disposal of some vehicles. The limitation on the number of years of use for small non-operational vehicles was abolished. Medium-sized taxis were extended from 8 to 10 years; whereas buses were shortened from 15 to 13 years.

Table 2 Conditions to be end-of-life vehicles by vehicle type in China

Vehicle type and usage				Expiration date (years)	Mileage (10,000km)
passenger car	Commercial	Taxi	Small	8	60
			Middle	10	50
			Large	12	60
		Bus		13	40
	Non Commercial	Small		--	60
		Middle		20	50
		Large		20	60
Truck	Light truck			12	50
	Small, middle and large truck			15	60
	dangerous goods transport vehicle			10	40

Source: Created by authors based on the site of Ministry of Commerce of China <http://www.mofcom.gov.cn>

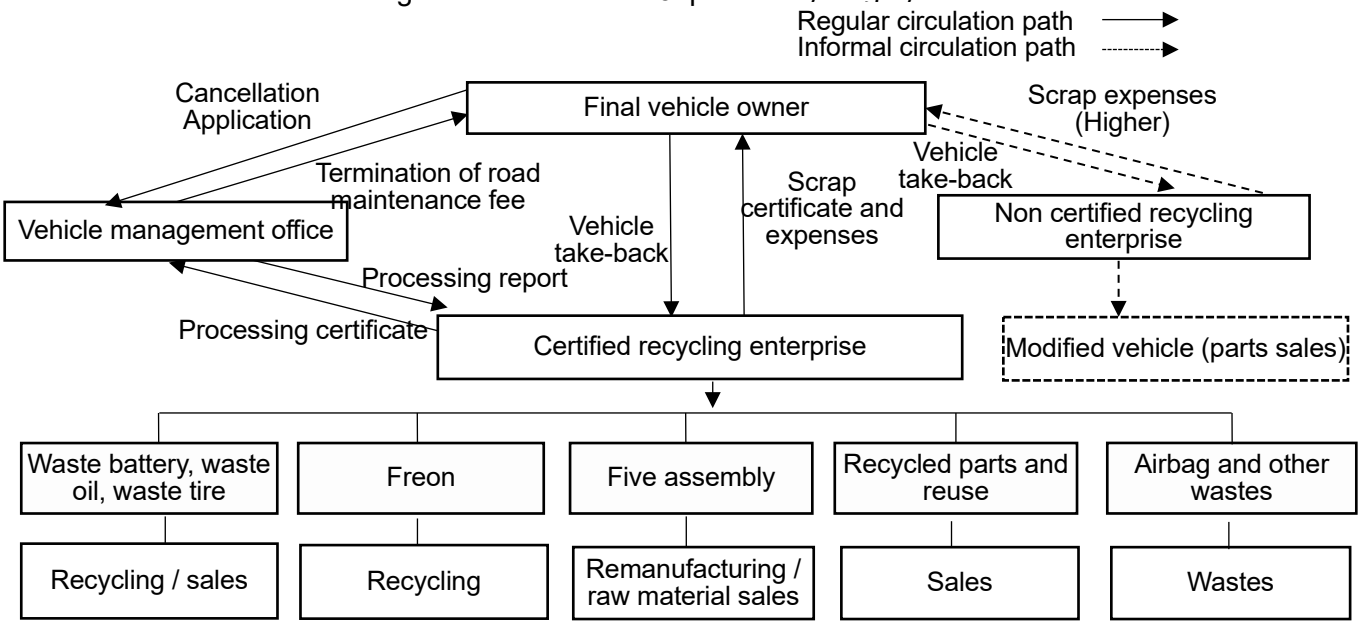
Various subsidy programs have been established to promote the replacement and recycling of automobiles. The Automobile Recycling Implementation Law enacted in 2009 specified a policy of providing subsidies for light-duty trucks and medium-duty buses in use for less than eight years, medium and light-duty trucks in use for less than 12 years, medium-duty buses other than taxis, and “yellow-marked vehicles[9]” that are disposed of while still in use. The 2013 “Model Implementation Plan for Promoting Used Product Recycling” specifies the implementation of a recycling promotion policy that provides a subsidy of up to 2,000 yuan (¥31,584)[10] to purchasers of recycled parts.
The revised Waste Motor Vehicle Recovery and Management Act (hereinafter, Decree 715) went into effect in June 2019. Decree 715 authorized the sale of the five major discarded vehicle components to remanufacturing companies under the premise of ensuring safety to adapt to the demands of the development of a circular economy. Allowing the recycling of the five major components is expected to increase the value

[8] Vehicle registration is divided into new registration, amended registration, transfer registration, suspension of registration, and cancellation of registration. (Yano Research Institute 2008:12–14).
[9] The term "yellow-marked vehicle" refers to gasoline vehicles that do not meet China I and diesel vehicles that do not meet China III emission standards.
[10] The exchange rate used is the average for 2013 (China National Statistics Bureau 2015). The same applies to yen conversions below.

of recovered vehicles, thereby increasing the profits of dismantling companies and at the same time discouraging illegal vehicle disposal.

China's automobile recycling flow is shown in Figure 4. End-of-life vehicles received by licensed dismantling companies (solid line) are disassembled, and fluorocarbons are recovered and airbags are disposed of as waste. This is similar to in Japan, but parts such as batteries, engines, steering wheels, transmissions, axle shafts, and frames are sold to other companies as resources. The Chinese government has enacted various laws, policies, and standards related to automobile recycling. However, its automobile recycling system does not always operate smoothly.

Figure 4 Illustration of Japan's recycling system



Source: Created by the authors based on China Automobile Distribution Association (2011:196, 2014:203)

4. The Introduction of EPR in the Chinese Automotive Sector

The Chinese government is currently promoting the introduction of EPR. The “Automotive Product Recovery and Utilization Technology Policy” enacted in 2006 set forth the goals shown in Table 3 aimed at strengthening producer responsibility for automobile manufacturers and importer distributors with regard to automobile recycling. The Circular Economy Promotion Law of the People's Republic of China, enacted in 2008, was the first formal EPR legislation in China and clearly states that producers are responsible for recycling products or packaging that are on the mandatory collection list. In addition, the “Law of the People's Republic of China on the Promotion of Clean Production” revised in 2012 contains provisions on producer responsibility at the product design stage. It is said to be the “law that sets the foundation” for EPR (Wang 2015:172–173). The “Automotive Hazardous Substances and Recoverability Management

Requirements" introduced in 2015 require automobile manufacturers to design vehicles to be easily recyclable and to use low-toxicity materials with a low environmental impact. This prohibited the use of six hazardous substances [11] in M1 class vehicles [12] manufactured after January 1, 2016. In addition, guidelines on the use of hazardous substances and possible recovery utilization rates are provided in the "Vehicle Production Companies and Product Public Notice," and the "Vehicle Dismantling Guidebook" is provided to recovery and dismantling companies. Furthermore, to standardize the recovery and utilization systems for electric vehicle storage batteries and also to promote the EPR system, the "Technical Policy on the Recovery and Utilization of Electric Vehicle Storage Batteries" was issued by the State Development and Reform Commission, Ministry of Industry, Ministry of Environmental Protection, Ministry of Commerce, and General Administration of Quality Inspection on January 5, 2016. It clarified that electric vehicle and storage battery production companies are the responsible entities for the recovery and utilization of storage batteries.

Table 3 Three-stage target of automobile recovery / utilization technology policy

Target year	Objective	Recycle rate	Recycled material usage rate
2010	M2, M3, N2, N3 vehicle	85%	over 80%
	M1, N1 vehicle	80%	over 75%
2012	All domestic and imported vehicle	90%	over 80%
2017	All domestic and imported vehicle	95%	over 85%

Source: Created by the authors based on the official website of the government of China.
Note: M1 is a passenger car with a passenger capacity of 9 or less, M2 is a passenger car with a passenger capacity of 10 or more and weighs 5 tons or less, M3 is a passenger car with a passenger capacity of 10 or more and weighs 5 tons or more, and N1 is a truck of 3.5 tons or less, N2 is a truck over 3.5 tons, and N3 is a truck over 12 tons.

5. Establishing an EV Storage Battery Recycling System

5.1 The Background of EV Introduction in China

Energy consumption in China has increased dramatically in tandem with the country's rapid economic growth. Most of the energy consumed consists of fossil fuels such as coal, petroleum, and natural gas. China notably accounts for about half of the world's coal consumption. In addition to fossil fuel consumption being a contributor to global warming, industrialization and motorization are also causing serious air pollution in urban areas. The Chinese government recognizes that future economic growth is not sustainable unless it rethinks its traditional approach. Accordingly, the introduction of renewable energy is being promoted as a means of reducing dependence on fossil fuels,

[11] The EU and Japanese automobile recycling laws regulate only four substances (lead, mercury, hexavalent chromium, and cadmium), but in China, six substances are regulated, including the flame retardants PBB and PBDE.
[12] From January 1, 2018, the use of hazardous substances has also been restricted for vehicles in continuous production.

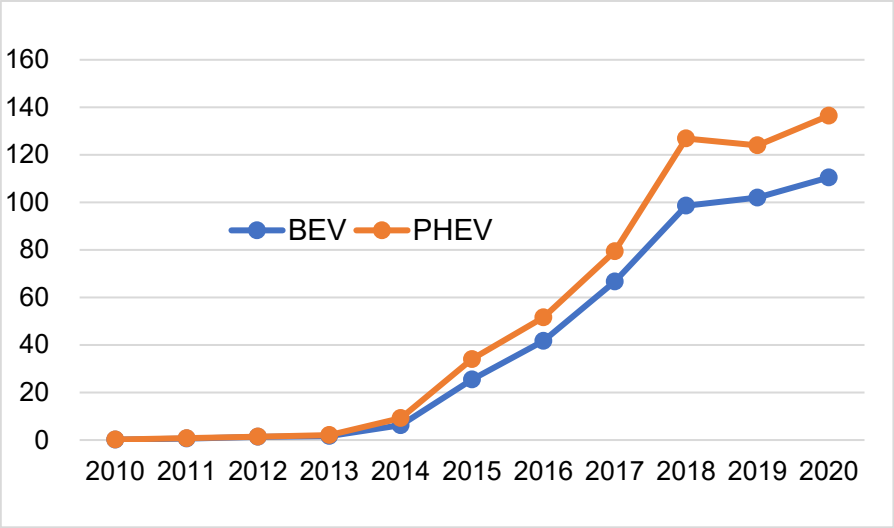
restructuring energy systems, and introducing energy-efficient equipment. In the automotive field, the manufacturing and proliferation of EVs are rapidly expanding. EVs in China include battery electric vehicles (BEVs), hybrid electric vehicles, and fuel cell electric vehicles. While ordinary gasoline-powered vehicles run by burning gasoline in their engines and emit exhaust gases such as CO_2 and NO_x, EVs do not emit exhaust gases while running because the motor is powered by electricity stored in the battery. By using a motor instead of an engine, about 80% of the electric energy can be utilized for driving. In addition, the use of electricity generated from renewable energy sources such as solar and wind power can also reduce CO_2 emissions resulting from power generation.

5.2 EV Adoption in China

Figure 5 shows the trends in EV production in China over the period 2010–2020. EV production declined slightly in 2019 from 1,269,000 units in 2018 (BEVs: 986,000, PHEVs: 283,000), with the total number of EVs being 29,000 units less than the previous year. Meanwhile, BEV production increased to 1,020,000 units and PHEV production declined to 220,000 units. The number of BEVs and PHEVs has continued to increase since 2020, with BEVs and PHEVs up 85,000 and 125,000 units, respectively, from the previous year, making China an electromagnetic vehicle powerhouse that has surpassed the United States as the producer of one-third of the world's EVs[13].

[13] Prepared by the author using data from the China Automotive Technology Research Center and the China Association of Automobile Manufacturers (2021).

Figure 5 trends in EV production in China



Source: Created by the author based on China Automotive Technology Research Center, China Automotive Industry Association (2021).

5.3 Recovery of EV Storage Batteries in China

The rapid development of EVs has brought to light the problem of recovery and utilization of storage batteries, and there is an urgent need to establish a system for their collection and recycling (Li et al.; 2022). Batteries for EVs include lead-acid batteries, nickel-metal hydride batteries, lithium-ion batteries, and iron phosphate ion batteries, which differ significantly from conventional batteries for electronic devices. Compared to those used in other electronic equipment, storage batteries for automobiles have a complex structure with a large weight and volume and carry a high voltage (which is itself a major safety hazard). These characteristics make reuse difficult (Winslow et al.;2017). The history of EV usage worldwide is still short, and many countries, including China, are exploring the production of EV battery recovery systems and technologies for reusing EV batteries (Chen et al.; 2019). Current decommissioning companies in China lack experience in processing storage batteries due to insufficient cooperation with producers.

Currently, the manufacturer's warranty period for EV storage batteries in China is ten years. However, battery degradation leads to a reduction in cruising range, even during the warranty period. If the remaining capacity of the battery falls below 80%, the battery cannot be used. Generally speaking, the service life of EV storage batteries is five to ten years, so the reuse value of power storage batteries is high. Therefore, this paper examines the construction of a system for the collection and treatment of used storage batteries, primarily by EV and power battery manufacturers from the viewpoint of EPR.

Currently, production and sales in China are centered on BEVs and PHEVs, with FCVs having very low production and sales volumes. With the rapid expansion of EV

manufacturing and adoption, China urgently needs to establish a system to collect and recycle used batteries. Policies such as “Technical Policy for Recovery and Utilization of Automobile Products” (Article 15) and “Technical Policy for Recovery and Utilization of EV Power Storage Batteries (2015)” promote the establishment of recycling systems for EV power storage batteries from an EPR perspective. When designing a system from the perspective of EPR, it is necessary to clarify the roles of each party involved in the recovery of EV-powered storage batteries (Hosoda 2008). The roles of key stakeholders in the recovery of EV-powered storage batteries can be summarized as follows.

1) EV manufacturers and storage battery manufacturers

EV manufacturers and storage battery manufacturers are responsible for collecting, recycling, and disposing of the powered storage batteries they manufacture. EV manufacturers design their EVs with the easy disassembly of the powered storage batteries in mind. The manufacturers of EVs and storage batteries collect information on the type, model, quantity, weight, distribution, etc. of their used storage batteries and report it to the regulatory authorities.

2) Final owners

The final vehicle owner is obligated to hand over the used storage batteries to an authorized retrieval agent. If the EV is to be used continuously, the spent batteries must also be replaced with new ones.

3) Retrieval agents

The role of the battery collection company is important because it serves as the point of contact between the final owner of the batteries and the battery disposal company. The retrieval agent collects information on the type, quantity, weight, distribution, etc., of used power storage batteries.

4) Battery disassembly processors

The role of a battery disassembly processor is to properly dismantle and recycle used batteries. The steel parts are sold to steel companies as steel raw materials, and the plastic parts are reused by waste plastic companies as recycled materials. Usable parts are reused by battery manufacturers.

5) Government

To promote the cascading use of storage batteries, the standardization of storage battery design and the establishment of a product code system and traceability system for storage batteries must be promoted. The government assists storage battery producers in promoting the cascading use of used storage batteries.

Based on the above, we will discuss the construction of a recovery and processing system for used power storage batteries based on current Chinese policies and the recovery systems of developed countries such as Japan from the viewpoint of EPR. The assumption for the construction of this system is that the entities responsible for the collection of EV storage batteries in China will be the EV manufacturers, the storage battery producers, and the battery cascade users. Under this assumption, a product code and traceability system for storage batteries will be established, and parties involved at each stage will register battery production, distribution, and collection and disassembly information in the “National Information Management System for Disposal and Renewal of Older Vehicles.”

The issues related to the recovery of used EV batteries can be summarized in the following three points.

1) Normalization and standardization of design and manufacture for reuse

Storage batteries have not yet been properly codified and standardized. Although this is a difficult task for automobile manufacturers and battery producers, reusing storage batteries will be difficult without some improvement in standardization and generalization, and it is unlikely that the price of storage batteries will decrease without this.

2) Establish laws regarding the storage and transportation of used batteries

Due to the hazardous nature of used batteries during storage and transportation, specialized collectors and transporters are needed. It will also be important to establish laws regarding the storage and transportation of storage batteries in the future.

3) Standardization of treatment processes and recycling methods and improvement of treatment technologies

The recycling of EV storage batteries, especially the treatment process and mechanism, needs to be standardized. Proper quality assurance is difficult to achieve if the batteries are handled by small auto repair shops, as the recycling of storage batteries is a labor-intensive process. Disassembly work must be centralized through the appointment of companies that have the necessary human resources and skills to carry out the work.

6. Conclusion

China's automotive industry will reach a record high in terms of both production and sales in 2021, and has been ranked first in the world for the past 13 consecutive years. However, the number of end-of-life vehicles is increasing rapidly, and there are concerns about resources wasted due to improper disposal. Therefore, there is an urgent need to establish appropriate disposal and recycling systems.

This paper reviews the changes in laws and regulations since the 1980s, and summarizes the current systems such as the eligibility certification system, vehicle deregistration system, and subsidy system. It then compares the status of the introduction of EPR in automobile industries of Japan and China. In the future, it will be necessary to examine technical issues such as the improvement of disassembly treatment technology and resource recycling technology. It will also be necessary to look at issues of awareness such as strengthening incentives for recycling-oriented design and improving the legal compliance and environmental awareness of market participants, and promoting the EPR philosophy in consideration of the social circumstances in each country. In addition, Japan was the first Asian country to introduce an EPR system, and has a better track record and technology in waste treatment and recycling than other countries in Asia. Cooperation between China and Japan in the field of recycling is an important issue that cannot be ignored, and further consideration should be given to strengthening the cooperative relationship, including the technical aspects from the Japanese side.

As an example of the application of EPR to the automotive industry, this paper examines the construction of a recycling system for storage batteries used in EVs, which have been rapidly increasing in recent years. China now faces the same environmental pollution issues due to illegal dumping and improper disposal of conventional end-of-life vehicles, just as developed countries such as Japan have experienced in the past. At the same time, it faces the problem of EV storage battery recycling, which has become an emerging issue throughout the world. In China, the introduction of EVs has been considered a key to solving environmental problems such as air pollution and CO_2 emissions caused by conventional vehicles, and the manufacturing and adoption of EVs is rapidly expanding. In China, the number of used batteries has begun to increase as EVs become more popular, and there is an urgent need to establish a collection and recycling system for these batteries.

The history of EV usage is short, and the establishment of EV battery recovery systems and recovery technologies are still being explored in China as well as in more developed countries. In China, regulatory methods such as the establishment of a product code and traceability system, and economic methods such as taxes and subsidies, have been proposed for the proper collection and disposal of storage batteries. However, the issues related to the recovery of EV used batteries can be summarized in the following three points: 1) standardization and normative design and manufacturing for the reuse of used batteries; 2) development of laws for the storage and transportation of used batteries; and 3) standardization of the treatment process and recycling method of used batteries as well as the improvement of treatment technology.

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