Supported by:

Federal Ministry for Economic Affairs and Climate Action

INTERNATIONAL CLIMATE INITIATIVE

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

on the basis of a decision by the German Bundestag

Capacity Development for Climate Policy in the countries of Southeast, Eastern Europe, the South Caucasus and Central Asia, Phase III

SITUATION REPORT: **MANAGEMENT OF BATTERIES FROM END-OF-LIFE HYBRID VEHICLES IN MONGOLIA**

2022

Wherever you go in Mongolia, you will always find a Toyota Prius. In 2020 they made up 28% of the vehicles market. But why are there so many of these hybrid electric vehicles (HEVs), and can something be done with the batteries once these cars finally reach the end of their lives? In 2020, the GIZ Project Capacity Development for Climate Policy (CDCPIII) commissioned a small fact-finding mission into this topic with some local consultants and supplemented this through discussions with other local stakeholders and donors. This briefing summarises the current situation relating to used or waste batteries from hybrid vehicles in Mongolia and outlines potential pathways to manage these in a sustainable manner.

1. HYBRID VEHICLES IN MONGOLIA

In recent years, the number of HEVs in use in Mongolia has increased dramatically, reaching 184,175 in October 2020, making up 29,9% of all state-inspected vehicles. HEVs have overtaken diesel vehicles (28.9%) and come second only to petrol vehicles (41.2%). The vast majority of these HEVs are imported second-hand Toyota Priuses.
In the seven years leading up to October 2020, 308,390 passenger cars were imported to the country. 48% of these were HEVs, with the vast majority (137,315 or 93%) being Toyota Prius models. Although there are over a million registered vehicles (including motorized and non-motorized such as trailers), only those that have gone through state inspection are permitted by law to be driven.

Why is there such high demand for used Toyota Priuses? The exemption of HEVs from excise duty and air pollution controls led to a switch to HEVs, bringing Toyota Prius to the top spot. Import duties would be around $3,500 for a similarly aged internal combustion engine (ICE) vehicle. Once users started to use the Prius, the car gained a reputation for being reliable and the large nickel-metal hydride (NiMH) battery even functions dependably in the extremely cold temperatures of down to -40 degrees Celsius in the Mongolian winter. The local Toyota dealer hypothesizes that a positive reinforcement cycle occurred: as more used Toyota Priuses came onto the market, more repair shops started to cater to this market and import spare parts, leading to more used Priuses being imported as they can be repaired locally. There are currently no age restrictions on used car imports, although for ICE vehicles the import duties increase with age. Most of these vehicles are imported from Japan, with trade export statistics from Japan showing that 23-24% of used HEVs

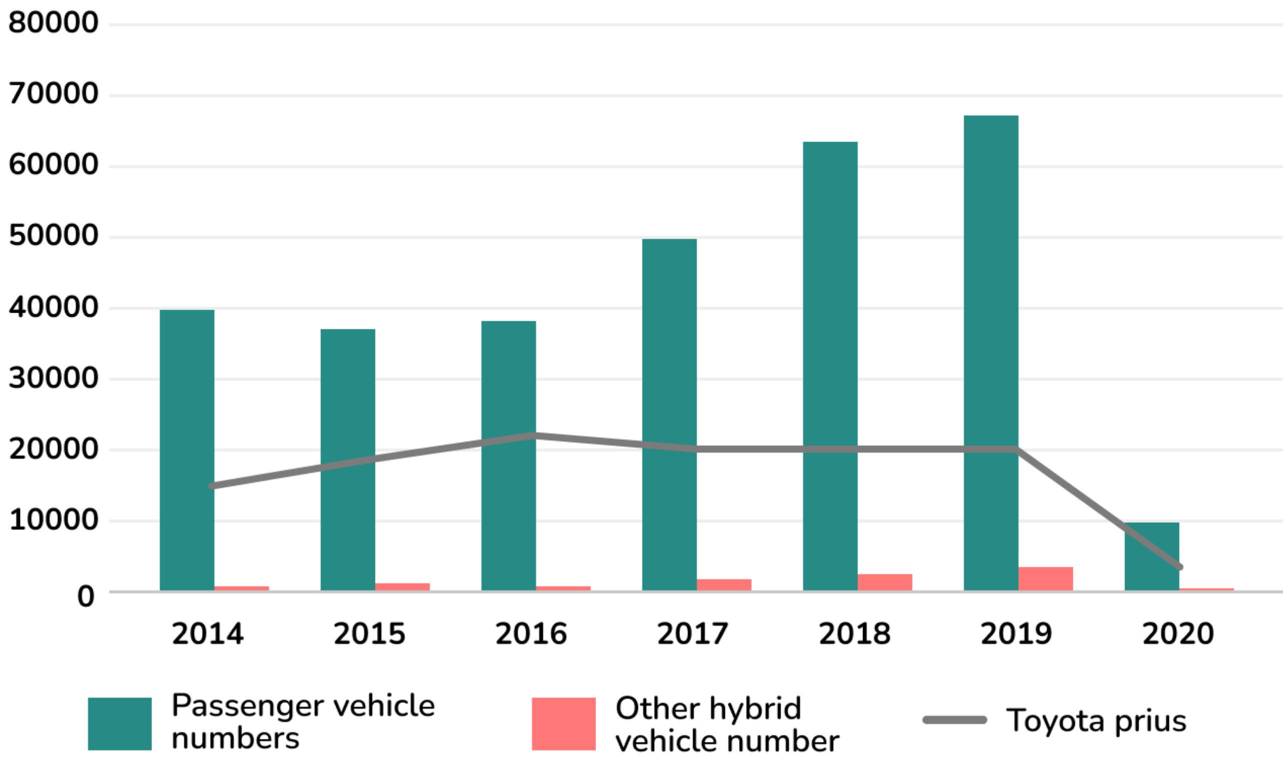

Figure 1. Imported passenger vehicle numbers in the last 7 years, Mongolia

exports went to Mongolia in 2017-18.[1] Since over 78.2% of total vehicles in Mongolia are aged 10+ years, it can be assumed that most of the Priuses are of a similar age. Of the state inspected vehicles in 2019, 13.2% of vehicles are aged between 7-9 years, leaving only 14% aged less than 6 years.

2. WHAT KIND OF BATTERIES ARE USED IN HEVS?

Almost all cars have a 12V starter/systems lead acid battery used to power all the other conventional components. In HEVs there is an additional high-voltage battery system used to power the electric motor, with high voltage batteries ranging from 206V – 300V depending on their application. Three main types of battery are used in vehicles:

Lead Acid starter/systems battery (most vehicles)

While some deep-cycle lead acid batteries were used to power some of the first EVs, the low energy density means that their weight is prohibitive for powering HEVs and EVs. Lead acid batteries are,

[1] Scenario Analysis on the Generation of End-of-Life Hybrid Vehicle in Developing Countries—Focusing on the Exported Secondhand Hybrid Vehicle from Japan to Mongolia

however, low-cost and widely used as 12V starter batteries in almost all motorized vehicles using conventional fuels, as well as most electric and hybrid vehicles. Lead is highly toxic, and it is important that such batteries undergo environmentally sound management at end-of-life (EoL). Many low- and middle-income countries suffer from major environmental and health impacts caused by unregulated local lead smelters. EoL management of these batteries is beyond the scope of this briefing - for an overview on treatment practice in this context, see standard operating procedures developed by Sustainable Recycling Industries.[2]

Lithium-Ion (Li-Ion) Batteries (electric vehicles)

This type of battery is currently used for plug-in hybrid vehicles (PHEVs) and EVs, as well as portable consumer products such as mobile phones and laptops, due to its high energy density, power-to-weight ratio, good high-temperature performance, and low self-discharge. While not as toxic as lead, recycling is normally associated with costs until technologies are improved further. If not transported, stored and disposed of correctly, these batteries can cause fires or explosions due to their residual charge. Recycling processes are currently still being developed and improved by various actors, mainly in North America, China, Singapore and Europe. Even though there are reuse and refurbishment activities ongoing, there are almost no official recycling facilities in low- and middle-income countries. For an overview of recycling feasibility considerations of lithium-ion batteries in this context, see the study by the PREVENT Waste Alliance in Nigeria.[3]

Nickel-Metal Hydride (NiMH) Batteries (hybrid vehicles)

These batteries are widely used in HEVs (especially in older models) because of their long-life cycles (longer than lead-acid batteries), abuse tolerance, and safety. While less toxic than lead, nickel also poses health and environmental risks. NiMH batteries may be classified as hazardous waste, depending on local legislation. Recycling processes can either be pyrometallurgical (thermal process) or hydrometallurgical (mechanical separation).

[2] Standard Operating Procedures Lead Acid Batteries (SRI): https://bit.ly/3OL6ocx
[3] Management of End-of-life Li-ion Batteries through E-waste Compensation in Nigeria: https://bit.ly/3ESQl2t

Several studies from both Japan and China have indicated that many HEVs and EVs are exported as used cars and will reach their EoL in less developed countries, where recycling infrastructure is limited.[4] In 2019, only 276 fully electric cars were registered on the market, so most of the waste lithium-ion batteries currently in Mongolia are likely to be from consumer electronics. Given the domination of the HEV market by used Toyota Priuses, this briefing therefore focuses on what can be done at end-of-life of the NiMH batteries resulting from used Toyota Priuses in Mongolia. The first Prius generation (XW10) manufactured from 1997 to 2000 and models since have used NiMH batteries. Toyota warranties the longevity of batteries for 8 years / 160,000 km (in some instances also 10 years). Although Toyota started to offer lithium-ion batteries in some Prius models from 2012, they continue to offer models with NiMH to enable diversity of supply and reliable performance in extreme temperatures where necessary.

3. END-OF-LIFE MANAGEMENT PATHWAYS FOR NIMH BATTERIES

While the use of HEVs is generally seen as positive for the environment, it can be harmful to the environment without an EoL strategy for the batteries, due to the hazardous chemical components they contain. Improperly disassembled and disposed batteries can create soil and water pollution with serious risks to the well-being of humans and biodiversity. Proper disposing of batteries requires a comprehensive recycling and/or waste management system. Following the circular economy and the waste hierarchy, the priority is first to extend the lifetime of batteries to reduce waste through repair and re-purposing in alternative applications. Following this, adequate waste management and recycling should be applied.

[4] Wang S, Yu J, Okubo K. Estimation of End-of-Life Hybrid Vehicle number in Japan considering secondhand vehicle exportation. Waste Management. 2020 Mar 1; 104:198-206.

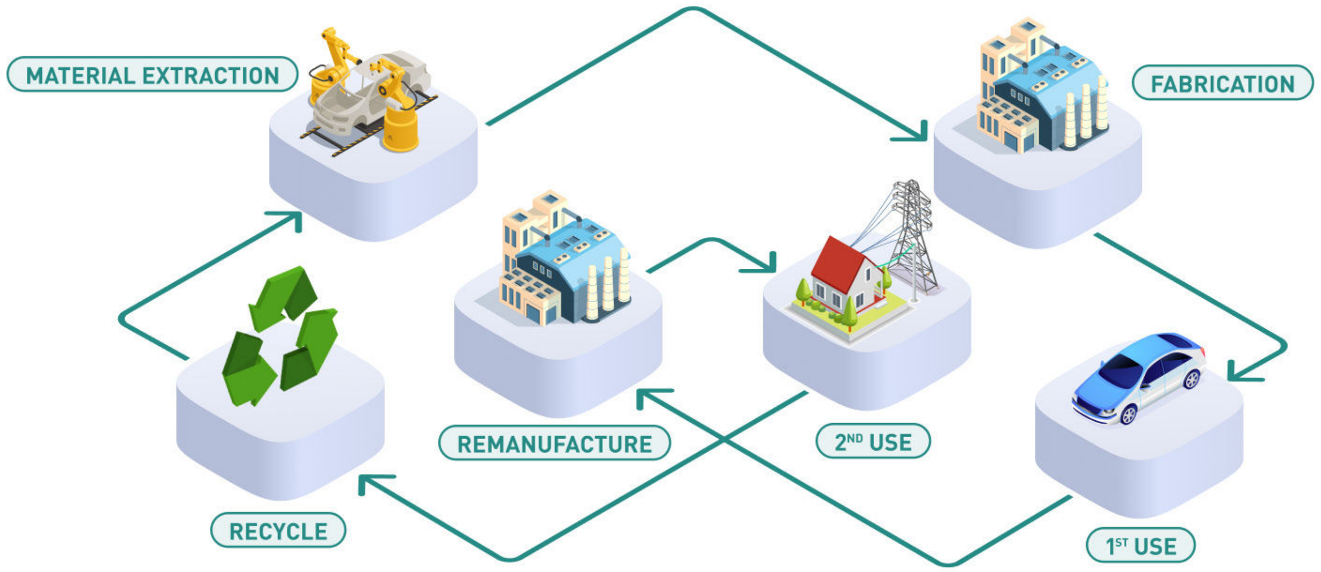

Figure 2: *Lluc Canals Casals, B. Amante García, Camille Canal, Second life batteries lifespan: Rest of useful life and environmental analysis, Journal of Environmental Management, Volume 232, 2019*

Repair and remanufacturing

Extending the lifetime of batteries can reduce the number of batteries reaching their end of life. Prius battery packs are made up of 28 modules (depending on generation), each containing six 1.2 V cells. When a module reaches low capacity, it will cause a voltage spike in the battery pack and a trouble code may appear. At this point the module can be exchanged for a new module; however, it is important to rebalance the capacities across the battery pack, as otherwise this will lead to faster degradation and failure of the other modules. Apps and YouTube instruction videos are available which assist repairers in finding the weak links in the battery pack.

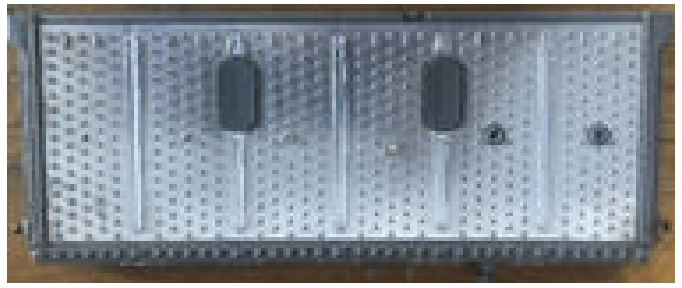

Figure 3: *Module of nickel metal hydride battery (left) and battery pack of a Toyota Prius generation 2 (right)*

Many repair shops across Mongolia replace modules for an average market price of MNT 30,000 (approx. 11 Euros) per module; however, rebalancing the battery pack may be less of a priority. Two companies (Munkhhada LLC and Tavan Bogd LLC) import entire replacement high voltage battery packs for a price of between 900,000-1200,000 MNT (ca. 330 – 435 Euros), depending on the number of modules. They only import second-hand recharged batteries in good condition as the price of a new pack is 5 to 7 times higher (1200 Euros - 3500 Euros inclusive service fee).

Research by Wang et al. advocates for policies which support the re-use of modules from spent battery packs to make remanufactured battery packs. Where repairers are replacing modules, it is possible that this is already practised in Mongolia.

Re-purposing in Solar Storage Applications

As the least densely populated country in the world, Mongolia's nomadic culture and livestock husbandry have placed herder households across the vast steppe where infrastructures are limited. 151,219 households in Mongolia use renewable energy in rural areas outside Ulaanbaatar (National Statistics Office, 2019). Manufacturers recommend that end-of-life of an EV battery for electric vehicles is when the remaining capacity reaches 80%. However, the battery can continue to be used in other applications that require less demanding performance such as stationary storage in solar applications. With Toyota's battery warranty of 8 years / 160,000 km from the date of first use, it could be promising to look at whether used batteries could be re-purposed and used in stationary storage applications with solar panels by herders. Re-purposed NiMH battery packs could potentially have significant positive environmental impacts and offer a reasonably priced alternative to such households.
Households usually use lead acid or lithium-ion batteries in their solar systems, with most households opting for the cheaper lead acid batteries even though only car starter batteries are available on the market. The most commonly used 12V lead-acid batteries in cars have a capacity of 40AH – 200AH and the price ranges from MNT 130,000 to MNT 550,000 (ca. 50 – 200 Euros). This price is 1.5 times cheaper if it is from a Chinese manufacturer. Using low-cost car batteries instead of batteries designed for use in solar systems leads to rapid failure of the batteries and additional waste, as they are not de-

signed for deep discharge cycles associated with solar applications.[5] Re-purposing NiMH battery modules for solar applications is not trivial, as each module has a nominal voltage of 7.2 V, requiring connection in series and parallel to reach nominal voltages of common household/solar applications (12 V, 48 V, 220 V). A battery management system would be required as unequally charged modules pose a risk of disfunction, heat, and explosion, also making a protective case necessary for safety reasons. Even if technically feasible, it seems that the residual charge of batteries entering the replacement/waste stream in Mongolia is the major barrier here. The condition of imported HEV batteries is not inspected nor registered officially at the border, meaning that some vehicles could come in with remaining capacity, while others come in with dead batteries. As these cars have often already been used for 10-15 years or more (possibly even at the time of import), they are very likely to have only a limited battery life remaining. Users are likely to use these batteries until failure.
In interviews with local stakeholders, it was stated that one local company looked at re-manufacturing batteries; however, they found that most batteries had very limited residual life and the project was discontinued. Nevertheless, this topic is being researched in several contexts, though a lot depends on the battery type in question, with lithium-Ion batteries being potentially more suitable for second life repurposing.

Recycling

Due to the lack of a legal framework and the necessary resources and technology to recycle batteries, there is no unified system or facilitation for collecting, reusing and recycling EoL batteries in Mongolia. Although there is no recycling plant in place, the government of Mongolia understands the importance of such facilities and has made some efforts to facilitate such technologies. The Mongolian National Waste Association (MNWA) and Recycle Park LLC are jointly conducting a feasibility study for a recycling plant for EoL vehicles. The MNWA is also working on higher-level production such as recycling batteries and extracting raw materials, with the goal of recycling lead acid batteries and high-voltage hybrid car batteries.
Vehicles at the end of their life span generate various types of solid wastes. According to a study completed by Sica LLC in 2018, 57,372 tons of solid waste from cars were generated in 2018 in Mongolia, of which 57.5% was from Ulaanbaatar and the remaining 42.5% from rural Mongolia. The authors estimated that a total of 38.43 tons of this volume was from high voltage HEV batteries. 38.43 tons does not represent more than a few containers that need to be treated per year, which would not justify setting up a recycling facility. However, the volume of batteries reaching the waste stream is set to grow substantially, depending on the lifetime of the vehicles/batteries entering Mongolia.[6] Considering the 184,175 Priuses registered in 2020 and the weight of the battery pack of the Toyota Prius Gen 2 (53.3 kg), it can be estimated that eventually 9,816 tons of NiMH batteries will enter the waste stream.
In the absence of local subsidies for recycling, recycling depends on the materials that can be recovered from the batteries and their value. The main metals by concentration in NiMH batteries are shown in the table below:

CHEMICAL NAME	ELEMENTS	CONCENTRATION, %
Hydrogen Absorbing Alloy	Ni, Co, Mn, Al	20-40
Nickel-Cobalt-Zinc oxide	Ni, Co, Zn	15-25
Nickel	Ni	5-15
Iron	Fe	20-40

Table 1: *Composition percentage of chemical elements in a NiMH battery*
Source: Separation Technology, Inc., 2015

15% nickel content could potentially be attractive to recyclers – in particular with recent rises in nickel value. However, setting up local treatment facilities requires capital investments that can recover their value over time and a supporting collection infrastructure and legal framework (see next section). At the present time it is assumed that batteries are either stored at repair shops, enter some local, possibly unregulated recycling processes or go to landfill. It may also be that a number of batteries make their way to China for recycling. Some countries are investigating local pre-processing steps for recycling batteries and then exporting to Japan's HEV recycling infrastructure.[7] This could also be an option for Mongolia; alternatively, Japan (or oth-

[5] For example see this fact finding study of the lead acid battery market in Myanmar (p18): https://www.oeko.de/fileadmin/oekodoc/Batteries-from-SHS-Myanmar.pdf

[6] Scenario Analysis on the Generation of End-of-Life Hybrid Vehicle in Developing Countries—Focusing on the Exported Secondhand Hybrid Vehicle from Japan to Mongolia: https://bit.ly/3F7TAJO

[7] See research carried out by Toyota Thailand on pre-processing/repurposing and sending batteries to Japan for end-processing: Toward the Creation of the Asian xEV Battery Recycling Zone - https://bit.ly/3GUeXjc

er countries) could provide technical assistance to support the setup of HEV recycling infrastructure in Mongolia. Given a viable business case and accurate data on the generation of waste NiMH or Li-Ion batteries, private companies may be interested in taking the first step here. However, current volumes remain moderate, so finding a possible thermal recycling process which allows treatment/recycling of various materials (e. g. from the local mining sector) according to international standards may be the optimal solution.

Exporting

Exporting battery wastes is currently difficult, as both Mongolia and China are parties to the Basel Convention which controls the export of hazardous wastes. Under the Basel Convention, exporters wishing to ship wastes classified as hazardous must apply the Prior Informed Consent Procedure, requesting permission from all involved authorities. This tends to be a costly and time-consuming process for exporters.[8] Under the Basel Agreement, Mongolia agreed not to transport end-of-life batteries through its neighboring countries China and Russia because of the hazards of oxidizing, heating up and burning. Non-reusable batteries can only be exported as raw materials or products after recycling. While it is highly likely that suitable recycling facilities for the batteries can be found in neighbouring China, current rules against imports of recycled metals and wastes are very strict. Japan could potentially also show an interest in receiving batteries in their facilities, but this would most likely require transit approvals from the neighbouring countries under the Basel Convention. Without changes to the exporting agreements, Mongolia won't be allowed to export batteries which consequently means that developing national recycling mechanisms for high-voltage batteries would be required.

4. INSTITUTIONAL AND LEGAL BACKGROUND

Taking account of waste from vehicles, Mongolia has laws and regulations in place on air, water, soil, environment, road transport, waste, and hazardous chemicals (see Annex 6 for full list). However, there is a lack of law and regulation, in particular, for waste from vehicles and battery waste with the exception of a standard adopted for the transport of lead-acid batteries for recycling purposes only (MNS 6783: 2019). This national standard is aimed at regulating the collection, storage and transport of 12V lead-acid batteries until a recycling facility is in place. There is no clause related to decommissioned vehicles and batteries in the Law on Road Transport, nor are batteries mentioned in the standard on recycling of EoL vehicles (MNS 6594: 2016). Hence, HEV battery waste is regulated under the Law on Waste, the Law on Hazardous and Toxic Chemicals, and regulations on transport and storage of hazardous waste according to their chemical components and classification as explosive waste.

№	Title of the Law	Date of Approval	Purpose of the Law	Chapter, articles	Articles and provisions related to road transport sector waste
1	Law on Waste	12 May 2017 /amended/	The purpose of this law shall be to govern relationships related to collection, transportation, storage, and landfill of household and industrial waste and reusing of waste as a source of raw materials to prevent and eliminate hazardous impacts of household and industrial wastes on public health and the environment.	Chapter 8 Article 43	The law regulates the treatment, collection, recycling, reuse, burial and disposal of ordinary and hazardous waste.
2	Law on Road Transport	04 June 1999	Regulates freight and passenger transport activities, use of motorized vehicles, and sets technical specifications for motorized vehicles.	Chapter 6 Article 23	There is no regulation on waste
3	Law on Environmental Protection	30 March 1995	Ensuring the right to live in a healthy and safe environment, harmonizing social and economic development with the environment, protecting the environment in the interests of present and future generations, rational use of its resources and restoration of its natural potential to regulate the relations arising between the state, citizens, business entities and organizations.	Chapter 9 Article 59	Article 21 of Chapter 4 of this law stipulates burial and disposal of toxic and hazardous substances and waste in designated areas.
4	Law on Toxic and Hazardous Chemicals	30 March 2006	Regulations related to export, import, transportation and production, storage, sale, transportation, use, destruction and control of toxic and hazardous chemicals across the border of Mongolia.	Chapter 3 Article 20	Chapter 2 of this law sets out the requirements for regulating activities related to toxic and hazardous chemicals and how to regulate hazardous waste from vehicles.

__Table 2:__ Composition percentage of chemical elements in a NiMH battery

[8] Discussion Paper. Practical Experiences with the Basel Convention: https://bit.ly/3u2HH1s

Institutional roles

Currently, there is no regulatory body governing the management of batteries removed from vehicles. There is a significant need for the establishment of such an authority. This can be achieved by a public-private partnership where the government sets out the policy, procedure and certification, while entities run businesses under such regulations. The entities need to be licensed to run such activities by meeting technical specifications set by the government authority and their operations for recycling used batteries monitored on regular basis. Subsequently, entities can sell recycled products and batteries in foreign markets. The following table outlines some roles that could be played by different institutions in supporting the set-up of a recycling framework.

Institution	Roles
Government	• Monitor business activities in the battery recycling area, ensuring they meet the safety and environmental regulations through the certification authority • Take legal action against businesses that breach relevant regulations
Certification Authority	• This authorized organization could be set up solely by the government or in partnership with a business or NGO in order to regulate the recycling business. • Develop safety and environmental regulations for battery recycling • Draw up minimum requirements and standards to be met for business in order to run recycling activities • Accept open proposals from businesses to run activities in the field • Select and certify businesses meeting all standards and regulations • Monitor and audit business activities, ensuring they are abiding by relevant laws and regulations • Take disciplinary action; further, revoke certification in the event of regulation breaches • Collaborate and partner with an international organization and business on the recycling, exporting, and importing raw materials from end-of-life batteries • The authority could be self-funded through an annual certification fee or can be funded through hazardous waste tax
Private Entities	• Obtain a license to run recycling activities from the authority by meeting safety and environmental standards and regulations and paying a license fee annually • Collect, store, recycle and repair HEV end-of-life batteries • Disassemble and extract valuable raw materials from batteries and sell them on the local and international market

Table 3: fact-finding study carried out by Bazarragchaa Ichinnorov, Professor, Mongolian University Science and Technology

5. INITIATIVES ON RECYCLING BATTERIES FROM VEHICLES IN MONGOLIA

Recycling Park LLC is a Korean company working towards establishing a recycling park in Nalaikh, a remote district of Ulaanbaatar. The recycling park plans to collect, disassemble and sort vehicles after the end of their life span. After sorting, the parts will be sold or sent to other recycling companies. Recycling Park LLC planned to disassemble 12V and high voltage batteries from hybrid cars and send them to factories for the next stage purpose, but they will not purchase and recycle batteries. The construction work was supposed to start in 2020. However, it has been delayed.

Recycling parks were planned to be built on two dumpsites, Narangi-in Enger and Tsagaan Davaa between 2017 and 2032. However, due to unknown reasons, project planning has been stopped.

The Japanese government has conducted several studies on recalling and recycling HEV batteries exported to Mongolia. Japan's Ministry of Foreign Division sent researchers to determine the possibility of transporting high voltage batteries from Mongolia to Japan. The research was conducted jointly by the Ministry of Economy and Industry and Nippon Steel & Sumikin Research Institute Corporation in 2015. After meeting with key stakeholders and organizing a training event at the National University of Science and Technology, the research results suggested that Mongolia should collect HEV battery waste until Japan can import and recycle it.

The Mongolian government has approached the Japanese government on the negotiation of accumulated taxes for exported cars in Mongolia. In Japan, a vehicle recycling tax of $100 is reflected in the market price of the car. When an individual buys a new car, he/she pays this tax. Then again when the individual sells this car after usage, the price reflects the tax amount. Because of this system, when a car is imported to Mongolia, the Mongolian buyer is paying the recycling tax in Japan. The Japanese government is currently accumulating those taxes collected from exported cars. There have been a few discussions between the Mongolian government and the Japanese government about moving this fund accumulated from cars exported to Mongolia. However, the two parties have not yet reached an agreement.

Conclusions and next steps

There are a large number of HEV batteries in Mongolia and this number is increasing year on year as the import of HEVs continues to grow. Since Mongolia usually imports second-hand Toyota Prius vehicles from Japan, most HEVs in Mongolia use NiMH batteries. There is a lack of regulations in Mongolia for both repurposing and recycling of such batteries, with the legal framework not clear for businesses that run activities in this field. Due to a lack of regulations, there are safety and environmental risks that come with illegal recycling activities.
Three main treatment pathways are conceivable, but each face challenges that must first be overcome:

- **Extend battery lifetime through re-purposing and re-use:** initial indications show that the expected low residual charge in Toyota Prius batteries and voltage adaptation requirements make re-use and repurposing at EoL in the Mongolian context unattractive.
- **Treatment in local recycling facilities:** there is no recycling facility in the country, either for the currently prevalent NiMH or for Li-Ion batteries. Such a facility requires capital investment and a guarantee of receiving a minimum volume for recycling. Instead of a dedicated facility for these batteries, economies of scale could possibly be met through combining with treatment/recycling in facilities/processes in the mining industry.
- **Export to other countries for recycling:** there is currently no way to export the battery "waste" legally due to the Basel Convention and other laws in neighbouring countries. Instead, end-of-life batteries are either exported illegally, stored (mostly in inappropriate facilities) or dumped on landfills or in nature with grave environmental impacts.

The following actions could support the move towards sustainable EoL management of these batteries:

1. Conduct stakeholder dialogue between the government and private sector to understand how to address needs on battery recycling from a legal and technical perspective. Additionally, an international exchange with parties from China, Russia and Japan could support finding solutions to export issues but also provide context on nearby recycling systems and options. Moreover, the idea of creating an Asian battery recycling zone could be further elaborated.[9]
2. Establish an extended producer responsibility (EPR) system with associated legal clarity for collecting, sorting, storing, reusing, and recycling batteries, and estimate the costs associated with selling and recycling batteries. This system could be supported through a fund that can be accumulated from the vehicle import tax. A certain percentage of this tax could be allocated for the purpose of dealing with hazardous waste from vehicles, especially battery recycling and reuse.
3. Establish a self-funded organization in charge of battery recycling within a public-private partnership framework. This organization would need to identify and enforce the responsibilities of importers.
4. Establish an authority to develop and enforce rules, regulations, and standards related to the collection, sorting, storage, reuse, and recycling of high voltage batteries for hybrid vehicles.
5. Introduce a system where the consumer brings an old battery to the site when purchasing a new one which will be registered in a unified system which helps to keep track of battery waste.
6. Certify qualified entities, based on clear guidance, to collect and manage batteries (possibly including repair, re-use, recycling and/or export). Aspects around recycling will require involving experienced private entities with these processes and an understanding of the technical feasibility given the current volumes – here feasibility studies may support decisions.
7. Train professionals and develop expertise in the field of various types of battery recycling.

[9] See research carried out by Toyota Thailand on pre-processing/repurposing and sending batteries to Japan for end-processing: https://bit.ly/3ioCKh0

This briefing is based on an initial fact-finding study carried out by **Bazarragchaa Ichinnorov,** Professor, Mongolian University Science and Technology

Supported by **Udval Oyunsaikhan**, MSc, Sustainability in Transport, University of Leeds

Briefing compiled by: **Daniel Hinchliffe** and **Thorge Ketelhodt**.