Selection process # RG-T3787 – P001

TERMS OF REFERENCE

Circular Lithium: Sustainable Battery Value Chain Solutions

REGIONAL
Consultancy to review regulatory aspects for batteries waste disposals and second life.

1. Background and Justification

1.1. Established in 1959, the Inter-American Development Bank Group ("IDBG" or "Bank") is the main source of financing for economic, social and institutional development in Latin America and the Caribbean. It provides loans, grants, guarantees, policy advice and technical assistance to the public and private sectors of its borrowing countries.

1.2. Lithium batteries, or "Li-Ion", are those electrochemical energy storage devices in which energy between the cathode and the anode is transferred based on a lithium-ion flow in an electrolytic solution. The anode is usually made out of pure carbon (graphite), while the cathode is a lithium-based alloy. The most common cathodes are now the Lithium Iron Phosphate (LFP) for electric vehicles and power grid applications, and Lithium Cobalt Oxide (LCO) for wireless electronics, although many other are gaining popularity for a wide range of applications (based on alloys of Lithium and Manganese, Nickel, Titanite, etc.). 1

1.3. Li-Ion batteries are becoming a key element of the current technological developments and the efforts to electrify the economy. Their ability to store energy and deliver it in an efficient, fast, and safe manner is making possible the development of wireless digital industry, the decarbonization of the transport sector, and the integration of intermittent renewable energy technologies in power grids. Hence, in recent years, lithium has garnered strong global investor interest[2] and its demand has already overtaken the supply. Approximately 59% of the world's lithium resources are found in brines[3], 25% in minerals, and the remainder found in clays, geothermal waters and oil field brines. It is expected that by 2050 the global demand for lithium will increase by more than 950%[4] driven by a battery-based energy storage increase of thirteen times between 2018 and 2026, reaching a 158TWh market.[5]

1.4. However, despite the exponential and continued rise of Li-ion development and the commercialization of batteries, not much attention is being given to sustainable strategies at the end of the value chain of lithium, as for example the battery recycling industry. The life expectancy of a Li-ion battery is approximately 10,000 full cycles, which in many applications translate into approximately 10 years. To date, around 95%[6] of Li-ion batteries are landfilled instead of recycled upon reaching end of life. The environmental impact of Li-Ion batteries includes resource depletion, global warming, ecological toxicity, and human health impacts. It is estimated that by

[1] Others: NMC: lithium nickel manganese cobalt oxide, LMO: lithium manganese oxide, NCA: lithium nickel cobalt, LFP: lithium iron phosphate, LTO: lithium titanate. https://batteryuniversity.com/learn/article/types_of_lithium_ion
[2] IDB, 2019. Litio en la Argentina, La Cadena de Valor: Oportunidades y desafíos para el desarrollo.
[3] Kavanagh, L, et al. 2018. Global Lithium Sources – Industrial Use and Future in the Electric Vehicle Industry: A Review.
[4] The World Bank. 2017. The Growing Role of Minerals and Metals for a Low Carbon Future. Washington, DC: World Bank.
[5] Wood MacKenzie Power & Renewable Global Outlook, 2019.
[6] Heelan J. et al, 2016. Current and Prospective Li-Ion Battery Recycling and Recovery Processes

2025, there will be 11 million tons of spent Li-Ion batteries in the market[7]; hence, the question of how to recycle them and ensure circular flows of materials deserves some forethought. The USA EPA showed in 2013 that recovery of metals at end of life of Li-ion batteries can significantly reduce their life cycle impacts.[8]

1.5. There are three main recycling processes for batteries: hydrothermal recycling, pyrolysis recovery, and direct recycling of their different components. The latter allows for a higher percentage of recovered battery materials but is still in the pilot stage. Also, there are several methodologies being developed to find a second life for used batteries, furbish batteries at end of life for use in computers or other electronics, or to rejuvenate them with new electrolyte in an economically efficient manner. At this moment, the cost of recycling Li-Ion batteries is still high compare with the cost of new manufacturing, needing public support for the development of its industry[9]. Nevertheless, as more batteries come into disposal and raw material starts to become scarce (particularly cobalt), recycling will become essential. In 2017, the battery recycling market was valued at around US$10 billion, expecting an annual growth of 11% until 2026. [10]

1.6. With the projected growth of future Li-ion battery use increasing exponentially, it is critical that the recycling market also react congruently. While some actors, such as the European Union has already mandated target Li-ion battery collection and recycling rates, regardless of current economic inefficiencies[11], most countries do not have regulation that would promote recycling. Policy development, institutional frameworks, and the development of the physical infrastructure for Li-ion batteries recycling would be key for the success in the transformation to a green economy.

2. Objective and Scope of Services

2.1. The consultancy should contribute to contribute with the evaluation of the regulatory aspects that need to be reviewed regarding battery waste disposal and its logistics and batteries second life. This consultancy will also include the knowledge sharing of the results.

3. Key Activities

3.1. Develop workplan, including the schedule.

3.2. Develop an analysis of international regulatory frameworks regarding battery waste disposal and logistics and batteries second life. The consultancy should analyze at least the regulatory framework of 5 countries that have advance in the topic and clearly explain why they were chosen for the study. The consultancy should include the regulation mechanisms that were implemented, analysis of the institutional roles, identify strengths and weakness of each regulation and lessons learned during the process.

3.3. Review current regulation in the countries of the region related with battery waste disposal. In case of a lack of specific regulations on batteries, consider general waste disposal regulations.

3.4. Develop a document that includes the main recommendations regarding the regulatory changes

[7] Sanderson, H. 2017. Rise of electric cars poses battery recycling challenge. Financial Times
[8] *EPA, 2013, Application of Life Cycle Assessment to Nanoscale Technology: Lithium-ion Batteries for Electric Vehicles*
[9] https://batteryuniversity.com/learn/article/battery_recycling_as_a_business
[10] Transparency Market Research (TMR), 2017, 'Battery Recycling Market - Global Industry Analysis, Size, Share, Growth, Trends, and Forecast, 2018-2026.
[11] Hendrickson T. et al. 2015. Life-cycle implications and supply chain logistics of electric vehicle battery recycling in California. Environmental Research Letters

that will be necessary in the countries of the region regarding battery waste disposal and its logistics and batteries second life, based on the gap analysis between International bets practices and current countries regulations.

3.5. Organize a workshop to share the main findings and recommendations of the study.

4. Expected Outcome and Deliverables

4.1. Deliverable 1: Completed workplan which must include a detailed overview of key milestones as outlined in section 2.

4.2. Deliverable 2: Report on the international experience on batteries disposals and second life regulatory frameworks.

4.3. Deliverable 3: Report on main recommendations for regulatory frameworks adaptation.

4.4. Deliverable 4: Workshop on main findings of the consultancy including Deliverable 1 y 2.

5. Project Schedule and Milestones

5.1. Submit workplan 1: week from signing of contract.

5.2. Submit Deliverable 2: 45 days from signing of contract.

5.3. Submit Deliverable 3: 75 days from signing of contract.

5.4. Submit Deliverable 4: report 80 days from signing the contract.

6. Reporting Requirements

6.1. The reports should be submitted in editable versions, preferable Word format and written as a working paper, with each deliverable added as a new section. The reports should be written in English.

7. Acceptance Criteria

7.1. Report should be in Word format, with any graphs, tables, and related data in Excel format. All methodologies, assumptions, and data sources used should be clearly outlined.

8. Other Requirements

8.1. N/A

9. Supervision and Reporting

9.1. Division Leader or Coordinator: Lenin H. Balza (INE/INE) (e-mail: LENINB@IADB.ORG), with copy to Adriana Unzueta (INE/INE) (email: ADRIANAU@IADB.ORG) and Javier García (INE/INE) (email: JGARCIAF@IADB.ORG)

10. Schedule of Payments

10.1. Payment terms will be based on project milestones or deliverables. The Bank does not expect to make advance payments under consulting contracts unless a significant amount of travel is required. The Bank wishes to receive the most competitive cost proposal for the services described herein.

10.2. The IDB Official Exchange Rate indicated in the RFP will be applied for necessary conversions of local currency payments.

Payment Schedule	
Deliverable	**%**
1. Deliverable 1	10%
2. Deliverable 2	30%
3. Deliverable 3	30%
4. Deliverable 4	30%
TOTAL	100%

Selection process # RG-T3787 – P002

TERMS OF REFERENCE

Circular Lithium: Sustainable Battery Value Chain Solutions

REGIONAL

Consultancy to develop guidelines for logistics of used batteries and for the disassembly, classification, and refurbishing of battery components

1. Background and Justification

1.1. Established in 1959, the Inter-American Development Bank Group ("IDBG" or "Bank") is the main source of financing for economic, social and institutional development in Latin America and the Caribbean. It provides loans, grants, guarantees, policy advice and technical assistance to the public and private sectors of its borrowing countries.

1.2. Lithium batteries, or "Li-Ion", are those electrochemical energy storage devices in which energy between the cathode and the anode is transferred based on a lithium ion flow in an electrolytic solution. The anode is usually made out of pure carbon (graphite), while the cathode is a lithium-based alloy. The most common cathodes are now the Lithium Iron Phosphate (LFP) for electric vehicles and power grid applications, and Lithium Cobalt Oxide (LCO) for wireless electronics, although many other are gaining popularity for a wide range of applications (based on alloys of Lithium and Manganese, Nickel, Titanite, etc.). 12

1.3. Li-Ion batteries are becoming a key element of the current technological developments and the efforts to electrify the economy. Their ability to store energy and deliver it in an efficient, fast, and safe manner is making possible the development of wireless digital industry, the decarbonization of the transport sector, and the integration of intermittent renewable energy technologies in power grids. Hence, in recent years, lithium has garnered strong global investor interest[13] and its demand has already overtaken the supply. Approximately 59% of the world's lithium resources are found in brines[14], 25% in minerals, and the remainder found in clays, geothermal waters and oil field brines. It is expected that by 2050 the global demand for lithium will increase by more than 950%[15] driven by a battery-based energy storage increase of thirteen times between 2018 and 2026, reaching a 158TWh market.[16]

1.4. However, despite the exponential and continued rise of Li-ion development and the commercialization of batteries, not much attention is being given to sustainable strategies at the end of the value chain of lithium, as for example the battery recycling industry. The life expectancy of a Li-ion battery is approximately 10,000 full cycles, which in many applications translate into approximately 10 years. To date, around 95%[17] of Li-ion batteries are landfilled instead of recycled upon reaching end of life. The environmental impact of Li-Ion batteries includes resource depletion, global warming, ecological toxicity, and human health impacts. It is estimated that by 2025, there will be 11 million tons of spent Li-Ion batteries in the market[18]; hence, the question of

[12] Others: NMC: lithium nickel manganese cobalt oxide, LMO: lithium manganese oxide, NCA: lithium nickel cobalt, LFP: lithium iron phosphate, LTO: lithium titanate. https://batteryuniversity.com/learn/article/types_of_lithium_ion

[13] IDB, 2019. Litio en la Argentina, La Cadena de Valor: Oportunidades y desafíos para el desarrollo.

[14] Kavanagh, L, et al. 2018. Global Lithium Sources – Industrial Use and Future in the Electric Vehicle Industry: A Review.

[15] The World Bank. 2017. The Growing Role of Minerals and Metals for a Low Carbon Future. Washington, DC: World Bank.

[16] Wood MacKenzie Power & Renewable Global Outlook, 2019.

[17] Heelan J. et al, 2016. Current and Prospective Li-Ion Battery Recycling and Recovery Processes

[18] Sanderson, H. 2017. Rise of electric cars poses battery recycling challenge. Financial Times

how to recycle them and ensure circular flows of materials deserves some forethought. The USA EPA showed in 2013 that recovery of metals at end of life of Li-ion batteries can significantly reduce their life cycle impacts.[19]

1.5. There are three main recycling processes for batteries: hydrothermal recycling, pyrolysis recovery, and direct recycling of their different components. The latter allows for a higher percentage of recovered battery materials but is still in the pilot stage. Also, there are several methodologies being developed to find a second life for used batteries, furbish batteries at end of life for use in computers or other electronics, or to rejuvenate them with new electrolyte in an economically efficient manner. At this moment, the cost of recycling Li-Ion batteries is still high compare with the cost of new manufacturing, needing public support for the development of its industry[20]. Nevertheless, as more batteries come into disposal and raw material starts to become scarce (particularly cobalt), recycling will become essential. In 2017, the battery recycling market was valued at around US$10 billion, expecting an annual growth of 11% until 2026. [21]

1.6. With the projected growth of future Li-ion battery use increasing exponentially, it is critical that the recycling market also react congruently. While some actors, such as the European Union has already mandated target Li-ion battery collection and recycling rates, regardless of current economic inefficiencies[22], more awareness and knowledge on these aspects will be required. In this context, the IDB is looking for consultant to develop guidelines for logistics in the collection and transport of used batteries, and for the disassembly, classification, and refurbishing of battery components, including health and safety matters.

2. Objective and Scope of Services

2.1. The objective of this consultancy is to develop guidelines for logistics in the collection and transport of used batteries, and for the disassembly, classification, and refurbishing of battery components, including health and safety matters. It is expected that the guidelines will be directed and relevant to the realities of the LAC energy sector, considering the different levels of maturity and size of countries in the region.

3. Key Activities

3.1. Develop workplan, including the schedule.

3.2. Review existing literature, case studies, and peer reviewed articles on best practices on the logistics in the collection and transport of used batteries, and for the disassembly, classification, and refurbishing of battery components.

3.3. Develop guidelines on the mentioned topic using consultant experience and results from 2.2.

3.4. Consolidate feedback and inputs from the IDB team and other stakeholders with the purpose of developing a unique document, framework or system capturing all the recommendations in standard format.

3.5. Develop a general roadmap on how to implement the best practices identified.

3.6. Develop a publication such as a technical note with the guidelines, all the best practices, and a presentation of the material. The publication should follow Bank standards.

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[19] *EPA, 2013, Application of Life Cycle Assessment to Nanoscale Technology: Lithium-ion Batteries for Electric Vehicles*

[20] https://batteryuniversity.com/learn/article/battery_recycling_as_a_business

[21] Transparency Market Research (TMR), 2017, 'Battery Recycling Market - Global Industry Analysis, Size, Share, Growth, Trends, and Forecast, 2018-2026.

[22] Hendrickson T. et al. 2015. Life-cycle implications and supply chain logistics of electric vehicle battery recycling in California. Environmental Research Letters

4. Expected Outcome and Deliverables

4.1. Completed workplan.
4.2. Report on best practices
4.3. First version of the guidelines for logistics in the collection and transport of used batteries, and for the disassembly, classification, and refurbishing of battery components, including health and safety matters.
4.4. Review of the guidelines for logistics in the collection and transport of used batteries, and for the disassembly, classification, and refurbishing of battery components, including health and safety matters, considering IDB and other stakeholders' feedback.
4.5. Roadmap
4.6. Final document for publication and presentation.

5. Project Schedule and Milestones

5.1. Submit workplan 1 week from signing of contract.
5.2. Submit Report on best practices 30 days from signing of contract.
5.3. Submit First version of the guidelines for logistics in the collection and transport of used batteries, and for the disassembly, classification, and refurbishing of battery components, including health and safety matters 80 days from signing of contract.
5.4. Submit review of the guidelines for logistics in the collection and transport of used batteries, and for the disassembly, classification, and refurbishing of battery components, including health and safety matters, considering IDB and other stakeholders' feedback 95 days from signing of contract.
5.5. Submit of roadmap 110 days from signing of contract.
5.6. Submit final document for publication and presentation 130 days from signing the contract.

6. Reporting Requirements

6.1. The reports should be submitted in editable versions, preferable Word format and written as a working paper, with each deliverable added as a new section. The reports should be written in English.

7. Acceptance Criteria

7.1. Report should be in Word format, with any graphs, tables, and related data in Excel format. All methodologies, assumptions, and data sources used should be clearly outlined.

8. Other Requirements

8.1. N/A

9. Supervision and Reporting

9.1. Division Leader or Coordinator: Lenin H. Balza (INE/INE) (e-mail: LENINB@IADB.ORG), with copy to Adriana Unzueta (INE/INE) (email: ADRIANAU@IADB.ORG) and Javier García (INE/INE) (email: JGARCIAF@IADB.ORG)

10. Schedule of Payments

10.1. Payment terms will be based on project milestones or deliverables. The Bank does not expect to make advance payments under consulting contracts unless a significant amount of travel is required. The Bank wishes to receive the most competitive cost proposal for the services described herein.

10.2. The IDB Official Exchange Rate indicated in the RFP will be applied for necessary conversions of local currency payments.

Payment Schedule	
Deliverable	**%**
5. Workplan	10%
6. Report on best practices	20%
7. First version of guidelines	25%
8. Review of guidelines and roadmap	20%
9. Final document for publication and presentation	25%
TOTAL	100%

Selection process # RG-T3787 – P003

TERMS OF REFERENCE

Circular Lithium: Sustainable Battery Value Chain Solutions

REGIONAL
Open Innovation Challenge

1. Background and Justification

- Lithium batteries, or "Li-Ion", are those electrochemical energy storage devices in which energy between the cathode and the anode is transferred based on a lithium ion flow in an electrolytic solution. The anode is usually made from pure carbon (graphite), while the cathode is a lithium-based alloy. The most common cathodes are now the Lithium Iron Phosphate (LFP) for electric vehicles and power grid applications, and Lithium Cobalt Oxide (LCO) for wireless electronics, although many other are gaining popularity for a wide range of applications (based on alloys of Lithium and Manganese, Nickel, Titanite, etc.).[23]

- Li-Ion batteries are becoming a key element of the current technological developments and the efforts to electrify the economy. Their ability to store energy and deliver it in an efficient, fast, and safe manner is making possible the development of wireless digital industry, the decarbonization of the transport sector, and the integration of intermittent renewable energy technologies in power grids. Hence, in recent years, lithium has garnered strong global investor interest[24] and its demand has already overtaken the supply. Approximately 59% of the world's lithium resources are found in brines, 25% in minerals, and the remainder found in clays, geothermal waters and oil field brines.[25] It is expected that by 2050 the global demand for lithium will increase by more than 950%[26] driven by a battery-based energy storage increase of thirteen times between 2018 and 2026, reaching a 158TWh market.[27]

- However, despite the exponential and continued rise of Li-ion development and the commercialization of batteries, not much attention is being given to sustainable strategies at the end of the value chain of lithium, as for example the battery recycling industry. The life expectancy of a Li-ion battery is approximately 10,000 full cycles, which in many applications translate into approximately 10 years. To date, around 95%[28] of Li-ion batteries are landfilled instead of recycled upon reaching end of life. The environmental impact of Li-Ion batteries includes resource depletion, global warming, ecological toxicity, and human health impacts. It is estimated that by

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23 Others: NMC: lithium nickel manganese cobalt oxide, LMO: lithium manganese oxide, NCA: lithium nickel cobalt, LFP: lithium iron phosphate, LTO: lithium titanate. https://batteryuniversity.com/learn/article/types_of_lithium_ion

24 IDB, 2019. Litio en la Argentina, La Cadena de Valor: Oportunidades y desafíos para el desarrollo.

25 Kavanagh, L, et al. 2018. Global Lithium Sources – Industrial Use and Future in the Electric Vehicle Industry: A Review.

26 The World Bank. 2017. The Growing Role of Minerals and Metals for a Low Carbon Future. Washington, DC: World Bank.

27 Wood MacKenzie Power & Renewable Global Outlook, 2019.

28 Heelan J. et al, 2016. Current and Prospective Li-Ion Battery Recycling and Recovery Processes

2025, there will be 11 million tons of spent Li-Ion batteries in the market;[29] hence, the question of how to recycle them and ensure circular flows of materials deserves some forethought. The USA EPA showed in 2013 that recovery of metals at end of life of Li-ion batteries can significantly reduce their life cycle impacts.[30]

- There are three main recycling processes for batteries: hydrothermal recycling, pyrolysis recovery, and direct recycling of their different components. The latter allows for a higher percentage of recovered battery materials but is still in the pilot stage. Also, there are several methodologies being developed to find a second life for used batteries, furbish batteries at end of life for use in computers or other electronics, or to rejuvenate them with new electrolyte in an economically efficient manner. At this moment, the cost of recycling Li-Ion batteries is still high compare with the cost of new manufacturing, needing public support for the development of its industry.31 Nevertheless, as more batteries come into disposal and raw material starts to become scarce (particularly cobalt), recycling will become essential. In 2017, the battery recycling market was valued at around US$10 billion, expecting an annual growth of 11% until 2026.[32]

- With the projected growth of future Li-ion battery use increasing exponentially, it is critical that the recycling market also react congruently. While some actors, such as the European Union has already mandated target Li-ion battery collection and recycling rates, regardless of current economic inefficiencies[33], most countries do not have regulation that would promote recycling. Policy development, institutional frameworks, and the development of the physical infrastructure for Li-ion batteries recycling would be key for the success in the transformation to a green economy.

- The Inter-American Development Bank aims to accelerate the shift towards circular economies in the region and create awareness of the untapped business opportunities of circular systems. Its objective is to identify and assess sustainable business models for recycling used Li-ion batteries, both by reusing its material components or by finding a second life for the battery, focusing efforts will be focused in Bolivia, Colombia, Mexico, and Peru. The IDB is already mobilizing human and financial resources to strengthen regional strategic management capacity for the development of the lithium industry, through the project Development of lithium: Regional Platform for Sustainable Growth, which is part of the Regional Public Goods (RPG) initiative. This project mobilizes $630,000 and seeks to build a common development agenda for the countries of the Lithium Triangle (Chile, Bolivia and Argentina) and Peru, with special emphasis on overcoming the productivity and sustainability challenges that prevail throughout the lithium value chain.

29 Sanderson, H. 2017. Rise of electric cars poses battery recycling challenge. Financial Times

30 *EPA, 2013, Application of Life Cycle Assessment to Nanoscale Technology: Lithium-ion Batteries for Electric Vehicles*

31 https://batteryuniversity.com/learn/article/battery_recycling_as_a_business

32 Transparency Market Research (TMR), 2017, 'Battery Recycling Market - Global Industry Analysis, Size, Share, Growth, Trends, and Forecast, 2018-2026.

33 Hendrickson T. et al. 2015. Life-cycle implications and supply chain logistics of electric vehicle battery recycling in California. Environmental Research Letters

2. Objectives

- The objective of this contract is to design an Open Innovation Challenge that will aim to find the best solution to tackle the issue of recycling or second use of lithium batteries in Latin America and the Caribbean. The consultancy will design the challenge, define the rules and requirements, identify the judges and finally, carry out the competition.

3. Key Activities

3.1. ACTIVITY 1: Design an Open Innovation Challenge

- Define rules and requirements for the competition
- Identify the relevant judges for the challenge

3.2. ACTIVITY 2: Carry out the Open Innovation Challenge

- Coordinate all the logistical work for the challenge, including the pre-event, the event, and the post-event phases.

4. Expected Deliverables

4.1. Deliverable 1: Chronogram of activities
4.2. Deliverable 2: Competition design
4.3. Deliverable 3: Final Report

5. Reporting Requirements and Acceptance criteria

5.1. All documents and reports will be written in Spanish. Every report must be submitted in draft version to the corresponding supervisor in an electronic file. The Bank will provide feedback that must be addressed until agreeing on a final report. The report should include cover, main document, and all annexes. Zip files will not be accepted as final reports, due to Records Management Section regulations; they must be submitted in PDF, Word, Excel or Jpeg formats.

6. Supervision and Reporting

6.1. Division Leader or Coordinator: Lenin H. Balza (INE/INE) (e-mail: LENINB@IADB.ORG), with copy to Adriana Unzueta (INE/INE) (email: ADRIANAU@IADB.ORG) and Javier García (INE/INE) (email: JGARCIAF@IADB.ORG)

7. Schedule of Payments

Payment Schedule	
Deliverable	**%**
Deliverable 1: Inception report and chronogram of activities	20%
Deliverable 2: Competition design	40%
Deliverable 3: Final Report	40%
TOTAL	100%