Conciencia Digital

ISSN: 2600-5859
Vol. 7 No. 2, pp. 141 – 155, April - June 2024

www.concienciadigital.org

Estado del arte de la prospectiva del uso de baterías de iones de litio en autos híbridos: evaluaciones ambientales y desarrollo industrial sostenible en Latinoamérica

State of the art of the prospective use of lithium-ion batteries in hybrid cars: environmental evaluations and sustainable industrial development in Latin America

[1] Carmen del Rocio Moyon Moyon https://orcid.org/0000-0001-8798-7060
Postgraduate Studies Department, National University of Chimborazo, Riobamba, Ecuador.
carmy_111@hotmail.com

[2] Lizeth Alejandra Gavilanes Yunga https://orcid.org/0009-0008-2873-6323
Industrial Engineering, Faculty of Engineering, National University of Chimborazo, Riobamba, Ecuador.
lizeth.gavilanes@unach.edu.ec

[3] Luis Angel Huilca Modumba https://orcid.org/0009-0006-5079-0954
Industrial Engineering, Faculty of Engineering, National University of Chimborazo, Riobamba, Ecuador.
luisa.huilca@unach.edu.ec

[4] Juan Diego Lema Rodriguez https://orcid.org/0009-0001-5437-0379
Industrial Engineering, Faculty of Engineering, National University of Chimborazo, Riobamba, Ecuador.
diego.lema@unach.edu.ec

Scientific and Technological Research Article
Sent: 12/19/2023
Revised: 01/22/2024
Accepted: 02/09/2024
Published: 04/15/2024
DOI:https://doi.org/10.33262/concienciadigital.v7i2.2994

Please quote: Moyón Moyón, C. del R., Gavilanes Yunga, L.A., Huilca Modumba, L. Ángel, & Lema Rodríguez, J.D. (2024). State of the art of the prospective use of lithium-ion batteries in hybrid cars: environmental assessments and sustainable industrial development in Latin America. ConcienciaDigital, 7(2), 141-155.https://doi.org/10.33262/concienciadigital.v7i2.2994

DIGITAL CONSCIOUSNESS,*and*It is a multidisciplinary, quarterly journal, which will be published electronically. Its mission is to contribute to the training of competent professionals with a humanistic and critical vision who are capable of presenting their research and scientific results to the same extent that their intervention promotes positive changes in society.https://concienciadigital.org
The journal is published by Editorial Ciencia Digital (a prestigious publisher registered with the Ecuadorian Book Chamber with membership number 663).www.celibro.org.ec

Conciencia Digital

ISSN: 2600-5859
Vol. 7 No. 2, pp. 141 – 155, April - June 2024

www.concienciadigital.org

*This journal is licensed under a Creative Commons AttributionNonCommercialNoDerivatives 4.0 International License. Copy of the license:*http://creativecommons.org/licenses/by-nc-nd/4.0/

Palabras claves:
Baterías, ion, Litio, ambiente, desarrollo, industrial, sostenible, híbridos.

Resumen

Introducción: En la actualidad el almacenamiento de energía mediante el uso de baterías de iones de Litio se ha vuelto más popular, fundamentalmente por características como el enorme potencial de almacenamiento, la integración de energías renovables para su carga y por supuesto la aplicabilidad de movilidad eléctrica. El rendimiento de las baterías de iones de Litio se ha visto afectado debido a la degradación acelerada, así como las diferentes condiciones ambientales agresivas de ciertas ciudades. El sector industrial del triángulo de Litio que integran Chile, Argentina y Bolivia se ha visto beneficiado con el uso de baterías de ion-Litio, sin embargo, el desarrollo industrial sostenible anclado a la protección del medio ambiente es una de las falencias que no contempla un escenario positivo para Sudamérica. **Objetivo:** Analizar la prospectiva sobre el uso de baterías de iones de Litio en autos híbridos tomando como referente las evaluaciones ambientales y desarrollo industrial sostenible en Latinoamérica. Metodología. Uso del diseño no experimental, nivel descriptivo de corte cualitativo basado en la revisión bibliográfica de artículos, tesis y libros. **Resultados:** A nivel de la región es incipiente el manejo de leyes en manejo responsable del Litio, lo que deviene en conflictos sociales por el uso del agua, un recurso indispensable para las comunidades. Además, en la industria de vehículos híbridos no se maneja un desarrollo industrial sostenible, pese a que el volumen de venta aun no es significativo. **Conclusión:** Se concluyó que la prospectiva del uso de baterías ion-Litio anclado al desarrollo industrial sostenible y cuidado del medio ambiente avizora en la región políticas débiles en la gestión del Litio y manejo responsable del agua, donde alternativas como economía circular, reutilización de baterías y asesoramiento a poblaciones se convierten en alternativas de solución en los países de la región.

Keywords:
batteries, ion, lithium, environment, development, industrial,

Abstract

Introduction: Currently, energy storage using lithium-ion batteries has become more popular, due to characteristics such as the enormous storage potential, the integration of renewable energies for charging and of course the applicability of electric mobility. The performance of lithium-ion batteries has been affected due to

sustainable, hybrids.

accelerated degradation as well as different aggressive environmental conditions in certain cities. The industrial sector of the lithium triangle made up of Chile, Argentina and Bolivia has benefited from the use of lithium-ion batteries, however, sustainable industrial development anchored to environmental protection is one of the shortcomings that it does not contemplate. a positive scenario for South America. Objective: Analyze the prospects for the use of lithium-ion batteries in hybrid cars taking as a reference environmental evaluations and sustainable industrial development in Latin America. Methodology: Use of non-experimental design, qualitative descriptive level based on bibliographic review of articles, theses, and books. Results: At the regional level, the implementation of laws on the responsible management of lithium is incipient, which results in social conflicts over the use of water, an indispensable resource for communities. Furthermore, sustainable industrial development is not managed in the hybrid vehicle industry, even though the sales volume is not yet significant. Conclusion: It was concluded that the prospective use of lithium-ion batteries anchored to sustainable industrial development and care for the environment envisions weak policies in the region in lithium management and responsible water management, where alternatives such as circular economy, battery reuse and advice populations become alternative solutions in the countries of the region.

Introduction

Currently, the charging process of an electric vehicle requires connecting to the electricity grid of the country in which the consumer is located, so the cleaner the energy sources of the countries, the greater the environmental advantages of using a hybrid electric vehicle compared to one with an internal combustion engine. However, it should be noted that "The reality is that we are still nowhere near the number of electric vehicles we need to achieve the Paris climate goals or any significant alleviation of climate change" (Natural Resource Governance Institute, 2021).

In order to carry out an analysis process on problems associated with development, the United Nations Conference on Environment and Development was held in Rio de Janeiro, Brazil, in June 1992. In the round of world conferences known as the new social cycle, important issues related to environmental awareness and anchored to sustainable

development were addressed, which until then had been scarce or even non-existent (Economic Commission for Latin America and the Caribbean [ECLAC], 2002).

However, progress was still not evident as principles of environmental protection and sustainable development were still seen as restrictive to social and economic development, which led to limiting the capacity of governments to stop environmental deterioration and control pollution, thus generating institutional fragility in the field (Economic Commission for Latin America and the Caribbean [ECLAC], 2002).

Márquez (2019) comments that despite this, the conference was one of the most important events on the environment, which for ECLAC (2002) determined a solid global vision that inclined to formulate government policies on sustainability and that also covered other areas such as culture and education, where the social approach becomes indispensable for environmental protection.

Prior to this world event, other international events were also held, such as the Stockholm Earth Summit in 1972, revealing the importance of human beings as creators of innovations towards the transformation of resources in a positive way for economic and social development. Likewise, the Rome Report of 1987, which proposed new forms of cooperation and governmental, social and institutional commitment, and the 2012 Summit held in Johannesburg, whose commitment was to forge sustainable development towards the construction of more humane, respectful and supportive societies with the environment and human dignity (Márquez, 2019).

As can be seen, the effort to link the environmental issue to sustainable development has been a source of global interest due to the irreversible effects caused by processes such as industrialization, which in areas such as the automotive industry has generated pollution. In this regard, Pérez-Sepa et al. (2022) point out that, faced with the problem of the impact on the environment of fossil fuel vehicles, both the private and public sectors have invested time and money in research that will lead to increasing the efficiency of internal combustion engines towards the electrification of the power train and, with it, to obtaining hybrid vehicles.

In this regard, the study by Romero-Carrión et al. (2023), related to the use of vehicles with lithium-ion batteries and sustainable development in South America, indicates that the extraction of lithium for use in electric vehicle batteries has generated a positive impact, since it has not only contributed to reducing greenhouse gas emissions and, therefore, improving air quality; but it also generates the possibility of increasing the volume of lithium-ion battery consumption, which benefits the so-called lithium quadrilateral made up of Peru, Chile, Argentina and Bolivia, whose mineral resources find large reserves at the level of these geographical areas.

Romero-Carrión et al. (2023) argue that lithium-ion batteries will represent a major challenge in the future in terms of waste management, which makes it imperative to recycle and reuse them in order to promote balance in the global demand for the chemical element related to sustainable environmental and social extraction in accordance with the objectives set out in sustainable development. In the field of production, the trend is to ensure investments in industry and infrastructure, but in a sustainable way (Brito-Carvajal, 2021).

On the specific topic of hybrid vehicles, Pérez-Sepa et al. (2022) point out that among the characteristics that stand out in them are the combination of chemical energy that comes from fossil fuel with the electrical energy stored in the battery. In addition, the operating principle allows obtaining a storage system with high capacity, fast recharging and autonomy in the process.

The above determines that, unlike electric vehicles, these are assisted by a gasoline engine and an electric motor, but they constitute a valid alternative to control gas emissions. However, according to the research developed by Carrera (2021), pollution is significant in the manufacturing process, use and disposal of batteries, which is why he agrees with Romero-Carrión et al. (2023), in pointing out that recycling becomes a valid alternative, where lithium-ion batteries are 90-95% recyclable, thus promoting sustainability.

As an interesting fact, the study by Zagorodny (2023) determined that the reuse of batteries in their second life is a more viable option than recycling, but that involves the use of technology with artificial intelligence techniques in order to obtain the highest purity and quality of the materials that are recovered, but anchored to energy efficiency and, as far as possible, to reduce environmental impacts.

He points out that the European Union has studied in depth the perspective of the circular economy of disused batteries, seeking common objectives with any type of electromobile economy. This means that, contrary to the linear economy of production-consumption-disposal, this type of economy promotes the preservation of the value of materials and products for as long as possible, reusing them or finally recycling them to reduce waste production as much as possible. The idea is to promote an efficient and sustainable economy at a global level by 2050 (Zagorodny, 2023).

As can be seen, from the research described, there is interest in promoting environmental awareness based on the efficiency of lithium-ion batteries in hybrid vehicles, but anchored to the sustainable industrial development of the countries, that at the regional level the chemical element has been increasing its production volume in hybrid vehicle batteries as indicated by Zagorodny's research (2023).

The above determines that by pointing out that Lithium together with oil will become the new strategic factor in global politics and economy, due to the significant demand in recent times at a global level in fields such as the automotive industry, for Azamar et al. (2022), its exploitation will lead to causing great crises in the regions where it is used as environmental damage and affect people's health, while its exploitation requires large quantities of water, although for Latin American countries such as Chile, Argentina, Bolivia and Peru it represents an important item for their local and national economy.

Based on the above, the relevance of the study is determined taking as a reference the scientific problem of the research that refers to what is the perspective on theuse of lithium-ion batteries in hybrid cars taking as a reference environmental assessments and sustainable industrial development in Latin America?

The intention is to expand a deeper vision on the benefits and disadvantages of using lithium-ion batteries for hybrid cars in Latin America, taking into account two central factors: care for the environment and sustainable industrial development, the latter point that at the Ecuadorian level encompasses the use of strategies that promote the greenest technology in accordance with the 2021-2025 Opportunity Creation Plan, Ecological Transition axis, within objective 11 related to the conservation, protection and sustainable use of natural resources and objective 12 with a focus on promoting sustainable development models by applying measures to mitigate climate change (National Planning Secretariat, 2021).

From the above, the present research is based on the main objective that refers to analyzing theprospective on theuse of lithium-ion batteries in hybrid cars taking as a reference environmental assessments and sustainable industrial development in Latin America, since as has been evident, the environmental impact goes hand in hand with sustainable industrial development and an environmental protection culture.

Methodology

The study is framed in the non-experimental design, qualitative approach and descriptive level taking as a reference that within this type of design the phenomenon is analyzed without manipulating its variables (Arispe et al., 2020), and that it contributes to collecting information based on events that have already occurred. According toGuevara et al. (2020), the descriptive level is used when you want to describe a reality from all its main components, which in the present study describes the use of lithium-ion batteries in hybrid cars from environmental assessments and sustainable industrial development in Latin America.

ISSN: 2600-5859
Vol. 7 No. 2, pp. 141 – 155, April - June 2024

For this purpose, content analysis is used as a technique, based on a bibliographic review ofscientific articles, third and fourth level theses within the reality of Latin American countries.

HeThe analysis includes three phases. The first is related to identifying the dynamics of the environment and sustainable development category according to 4 Latin American countries; the second part investigates the relationship between the environment, sustainable development and the use of lithium-ion batteries from the position of 3 authors; and finally, analyzes the situation of the automotive industry in relation to the use of lithium-ion batteries in hybrid vehicles, in countries such as Chile, Ecuador and at the level of the region in general.

The inclusion criteria include academic production from virtual repositories of academic significance such as Scopus, Redalyc and Scielo, as well as third and fourth level theses and books that cover categories related to the environment, sustainable industrial development and the use of lithium-ion batteries in hybrid and electric vehicles. In addition, publications in Spanish, without excluding texts in English and Portuguese, if applicable.

Regarding the exclusion criteria, academic productions published in the last 5 years that are not related to sustainable industrial development and the environment and that do not refer to the automotive industry are not taken into account.

Since this is a bibliographic review study, authorization from institutions, scientific councils, ethics committees or informed consent is not required, but ethical aspects of the research are mentioned, addressing the fidelity of the studies included in the research without manipulating the data at will, and the use of transparency in the analysis, in order to obtain results that adhere to objectivity criteria.

Results

This section describes the results obtained in the study, as well as its discussion, linking the findings with the contributions of other research. It is explained in detail.

Table 1 shows the results obtained based on three categories: the relationship between the environment and sustainable development and the extractive activity of lithium in countries such as Argentina, Bolivia, Chile and Peru.

ISSN: 2600-5859
Vol. 7 No. 2, pp. 141 – 155, April - June 2024

Table 1

Analysis of the categories of environment-sustainable development and lithium in countries in the region

Country	Main ideas
Argentina	Romero-Carrión et al.(2023): • There is no specific regulatory framework for lithium. Each province has the right to dictate regulations governing extractive activity. Diaz(2020) • It is a country with the potential to become a major global producer of lithium, but the role of the state is essential in establishing rules in the production phase and value chain to ensure sustainable development without violating the rights of local communities. • There is fear in the communities regarding lithium extraction. They believe it will affect their way of life, which leads to their opposition to the exploitation of the mineral. Fernandez(2021) • Salt flats maintain fragile ecosystems, in which water is the most important resource for the communities in the area dedicated to farming and grazing activities. • There is an asymmetry between lithium companies and local communities. This is largely due to the low educational level of the population and the reduced budget for generating improvement projects in local areas and increasing their participation in engineering and consulting services.
Bolivia	Romero-Carrión et al.(2023): • Mining regulations maintain a hierarchical level whose control is the responsibility of the central State. There is a law that provides for the processing of waste. Diaz(2020) • Regarding lithium mining, indigenous peoples have not been consulted, since there is no special law on the matter. • There is a conflict of interest generated by the different actors, the lithium mining company, farmers, and the tourism sector, generating negative consequences in the socioeconomic sectors. Obaya & Cespedes(2021) • There are no conclusive studies on the impact of extractive activity, nor are the affected communities actively involved in decision-making, despite the fact that the activity is carried out in their jurisdiction.
Chili	Romero-Carrión et al.(2023): • There is a recycling law focused on promoting reuse, but it does not consider potential opportunities for recycling lithium-ion batteries. Obaya & Cespedes(2021) • It is necessary to create institutions that give way to innovation and commercial scaling of entrepreneurship and companies aimed at the circular economy.
Peru	Romero-Carrión et al.(2023):

ISSN: 2600-5859
Vol. 7 No. 2, pp. 141 – 155, April - June 2024

- In 2021, a law on the exploration, exploitation and industrialization of Lithium and its derivatives was approved at the national level to guarantee sustainable development.

Fountain: Romero-Carrion et al. (2023), Diaz (2020), Fernandez (2021), Obaya & Cespedes (2021)

The dynamics of the exercise of environmental care anchored to the sustainable development of communities affected by lithium extraction have as their central point the lack of clear policies to positively articulate the exposed categories, where the mineral has generated conflicts of interest, rejection of extraction especially in Argentina and Bolivia, two of the countries that include the Lithium triangle, those that have the largest number of deposits.

This is an issue that for ECLAC(2023)Since lithium is a potential strategic resource for the countries in question and Chile contributes to economic development, it considers that poor management will affect the sustainability of ecosystems, but considers intraregional cooperation and coordination viable with a view to environmental and social sustainability.

Regarding recycling initiatives, Bolivia and Chile have laws that promote waste processing, but in the case of the latter country they do not include initiatives related to recycling lithium-ion batteries, which indicates that the regulations are very general in their application. Of the countries exposed, Peru is the only country that explicitly establishes a law that relates lithium extraction to sustainable development, although it does not belong to the lithium triangle like Chile, Argentina and Bolivia.

In light of the above, Diaz(2020)It mentions the need to generate modifications in the current legislation regarding the participation of States, where in countries such as Argentina a national Lithium policy should be promoted tending to consider the mineral as of public interest with its respective benefits for society.

Finally, the researchers propose alternative solutions such as the active involvement of affected communities by carrying out educational programs, engineering services and consultation in Argentina. In addition, in Chile, the proposal is to strengthen a circular economy with innovation and entrepreneurship as its central axes.

Table 2 describes the relationship between the environment, sustainable development and the use of lithium-ion batteries from the perspective of three researchers.

ISSN: 2600-5859
Vol. 7 No. 2, pp. 141 – 155, April - June 2024

Table 2

Analysis of the category of environment, sustainable development and use of lithium-ion batteries

Author/year of publication/link	Main ideas
Romero-Carrión et al.(2023) Link: https://n9.cl/958n9	• There is a balance in the sale of lithium-ion batteries in electric vehicles (pure and hybrid) with an opportunity for economic development especially in Argentina, Bolivia and Chile, with the largest lithium deposits. • There is no clarity between the socio-environmental category and sustainable development, due to the negative environmental effects of extraction and social conflicts associated with the use of water. • Recycling of lithium-ion batteries is still in its infancy in the region. • Increased consumption of lithium-ion batteries will become a major challenge for waste management.
Solano & Titуaña(2022) Link: https://n9.cl/704ezx	• Given the exponential increase in electric vehicles, recycling and reuse are an alternative to solve the availability of the resource in the medium and long term. • Sales are higher for hybrid vehicles than for electric ones.
Diaz(2020) Link: https://n9.cl/g7mr2w	• Lithium has become an indispensable element of modern societies that are becoming more electronic and digital, transcending its importance for the current economy.

Fountain: Romero-Carrión et al. (2023), Solano & Titуaña (2022), Diaz (2020)

Within the research process carried out, the term electric vehicles refers to those of pure and hybrid denomination, that is, those that run on 100% electricity and those that combine with fossil material. Thus, Romero-Carrión et al. (2023) warn that factors such as the negative effects generated by the extraction of Lithium due to the excessive use of water and the conflicts associated with the poor management of the issue in the communities involved are indicators that there is no management in terms of the environment anchored to sustainable development, which determines that there are no programs with a vision for the future on the effects due to the lack of waste management resulting from Lithium-ion batteries.

At this point, ECLAC(2021)Although the level of investment in waste management and recycling varies from one country to another in the region and the Caribbean, in general terms it is very limited, which requires support from private participation and incentives to promote a circular economy.

Solano & Titуaña (2022) state that, since statistics show that the global sale of hybrid vehicles is greater than that of electric vehicles, there is a need to generate programs with

ISSN: 2600-5859
Vol. 7 No. 2, pp. 141 – 155, April - June 2024

a tendency towards recycling. Here, the term reuse appears for the first time, where the author proposes it as an alternative to promote sustainable industrial development.

Finally, Diaz(2020)suggests that given the increased use of lithium in modern societies, which are particularly electronic and digitalized, there is a need to review the responsible extraction of the mineral, taking as its axis the dynamics of a more inclusive economy.

Table 3 analyzes the situation of the automotive industry in relation to the use of lithium-ion batteries in hybrid vehicles, in countries such as Chile, Ecuador and at the regional level in general.

Table 3

Analysis of automotive industry categories, use of lithium-ion batteries and hybrid vehicles

Country	Main ideas
Chili	Valenzuela et al.(2017) • In the automotive industry, plug-in hybrid and electric cars have been sold in the country for 2019, but the volume is still incipient. In the next decade, it will increase, which will make Lithium key to promoting the industry with a possible new economic super-cycle for the country.
Ecuador	Solano & Tituaña(2022) • Ecuadorian environmental legislation contemplates the correct and comprehensive use of batteries, especially those made from mercury, followed by lithium and nickel. • Lithium-ion batteries are the most widely used in the automotive sector, with sales in Ecuador increasing by 200% between 2020 and 2021 due to being more economical and environmentally friendly, but sales are still incipient at the national level.
At the regional level	Zagorodny(2023) • Electromobility is still in its infancy in Latin America, where Chile, Colombia, Peru, Brazil and Uruguay have seen some progress, especially in the public transport fleet. • In the region, regulations regarding the management of electric mobility batteries are still in the early stages of discussion, given the incipient state of electric mobility. • Reusing batteries is a preferable option to recycling as it saves resources and environmental impacts. • It is necessary to apply a circular economy, which considers that waste is not waste but resources, an important element for a sustainable economy. • To generate sustainable ventures, hydrogeological studies are required to ensure adequate recharge of reservoirs. • Appropriate comprehensive environmental management is required for batteries no longer in use and those removed from electric mobility. It is a symptom of a modern state concerned with a healthy environment and a sustainable economy.

Fountain: Valenzuela et al.(2017), Solano & Tituaña(2022)and Zagorodny(2023)

Regarding the sale of hybrid vehicles within the automotive industry, it is noted that although the volume is still incipient in countries in the region such as Chile and Ecuador, such as the promotion of programs related to electro mobility and regulations aimed at managing electric mobility batteries, this does not mean that measures and programs that promote sustainable industrial development should not be included, although none of the research presented explicitly sets forth the term sustainable industrial development.

As alternative solutions to overcome the challenges related to lithium extraction and the medium-term effects that its disuse will generate, the so-called circular economy, where waste is treated as a resource anchored to a sustainable economy, is once again considered as a transcendent category. In addition, at this point it is noted that reuse is the most viable alternative to recycling, the latter point which has already been contemplated in the laws of the region, but in a generalized manner.

As a transcendental point, the need to carry out hydrogeological studies as a way to guarantee the maintenance of water resources in the areas affected, and to anchor the drive for a sustainable economy related to categories such as sustainable enterprises, a healthy environment and comprehensive environmental management.

Conclusions

- It can be concluded that the responsible use of lithium is closely linked to environmental protection and sustainable industrial development, which determines the need to strengthen policies focused on adequate recycling management, which is mentioned in the law in the countries analyzed, but in a generalized manner. However, considering that reuse is a more viable measure than recycling, due to the less negative impacts on the environment, it is of interest to focus on this aspect, with clearer and more conclusive measures and regulations. This is despite the fact that at the regional level the sales volume of products such as hybrid vehicles containing lithium-ion batteries, among others, is still incipient.
- It was established that there is a primary need for the industrial sector to implement more specific action measures in practice in order not to affect the extraction, use and recycling of Lithium, based on the fact that these processes require large amounts of water resources for their processing, anchored to a more active participation of the affected community with educational and advisory programs and with a focus on a circular economy and awareness based on environmental protection.
- It was concluded that the countries that comprise the so-called Lithium Triangle have significant potential for economic development with the extensive deposits

of this mineral in the areas. There is a gap between sustainable development and the environment, where in the industrial sector there are no specific actions in this area either, although so-called electromobility is still in its infancy in the region.

Conflict of interest

The author declares that there is no conflict of interest in relation to the submitted article.

Bibliographic References

Arispe, C., Yangalí, J., Guerrero, M., Lozada, O., Acuña, L., & Arellano, C. (2020). Scientific research. International University of Ecuador.

Azamar, A., Slipak, A., Fornillo, B., & Campanini, J. (2022). Lithium in Latin America. Global demand against socio-environmental damage. Autonomous Metropolitan University.

Brito-Carvajal, J. (2021). Industrial production system: sustainability and productivity. Knowledge Pole, 6(9), 2521-2531. https://acortar.link/6sU8Tv

Carrera, J. (2021). Recycling of hybrid vehicle batteries for implementation in the propulsion system. ESPE.

Economic Commission for Latin America and the Caribbean [ECLAC]. (2002). The sustainability of development in Latin America and the Caribbean: Challenges and opportunities. United Nations.

Díaz, F. (2020). Lithium in Argentina. Multidisciplinary visions and contributions from UNLP. UNLP.

Fernández, E. (2021). On the road to sustainability? Socio-environmental impacts of lithium extraction linked to the transition towards electromobility. Universidad Andina Simón Bolívar.

Guevara, G., Verdesoto, A., & Castro, N. (2020). Educational research methodologies (descriptive, experimental, participatory, and action research). Recimundo, 163-173.

Márquez, F. (2019). Sustainable development and environment. Ecotec University.

Natural Resource Governance Institute. (2021). Global supply chain for electric vehicle batteries: governance implications. In Strategic minerals, supply chains, and governance in the Andes: Towards a civil society advocacy agenda (pp. 58–72). http://www.jstor.org/stable/resrep42307.7g

ISSN: 2600-5859
Vol. 7 No. 2, pp. 141 – 155, April - June 2024

Obaya, M., & Céspedes, M. (2021). Analysis of global lithium-ion battery production networks. ECLAC.

Pérez-Sepa, M., Guasumba, J., Angueta, A., & Calero, D. (2022). Estimation of the useful life of hybrid vehicle batteries: causes and consequences. Scientific Journal of the Sciences Domain, 7(2), 770-781. http://dx.doi.org/10.23857/dc.v8i2.2674

Romero-Carrión, V., Casani-Allende, J., Rivadeneyra, C., & Altamirano, J. (2023). Prospects for the use of lithium-ion battery vehicles and sustainable development in South America. Kawsaypacha Journal (11). https://acortar.link/PgEpjS

National Planning Secretariat. (2021). Opportunity Creation Plan 2021-2025. https://acortar.link/1unBK7

Solano, E., & Tituaña, K. (2022). Comparative analysis of the impact caused by recycling alternatives for high-voltage batteries in hybrid-electric vehicles after their useful life. Universidad Técnica del Norte.

Valenzuela, M., Rojas, R., Segovia, M., & Quintana, S. (2017). Lithium battery recycling: an opportunity for Chile's sustainability. Autonomous University of Chile.

Zagorodny, J. (2023). Integrated management of end-of-life batteries from electric vehicles within the framework of a circular economy strategy. United Nations.

Conciencia Digital

ISSN: 2600-5859
Vol. 7 No. 2, pp. 141 – 155, April - June 2024

www.concienciadigital.org

The article published is the sole responsibility of the authors and does not necessarily reflect the thinking of the Revista Conciencia Digital.

The article remains the property of the journal and, therefore, its partial and/or total publication in another medium must be authorized by the director of the Conciencia Digital Journal.