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**Re:** **Submission for Special Rapporteur’s thematic report on detoxification/decarbonization**

Dear Dr. Orellana:

Thank you for inviting the public to provide comments and information on the toxic pollution and human rights implications of certain technological solutions to climate change for your upcoming report to the UN Human Rights Council in September. Earthjustice[[1]](#footnote-2) is writing to provide feedback on 1) minimizing toxic impacts from the transition to energy systems dominated by renewables, energy storage, and electromobility; 2) reducing harms from substitution of hydrogen fuel for fossil fuels; and 3) the dangers of using carbon, capture, and storage.

Earthjustice strongly supports technological solutions to mitigate climate change through a shift away from fossil fuels, including the use of renewable energy and the limited use of green hydrogen. However, our growing demand for energy in a carbon-constrained world generates new risks, harms, and tradeoffs, with some technologies bringing toxins to communities that may not have been affected under the fossil fuel paradigm, while others focused myopically on greenhouse gas reductions prolong toxic exposures among communities long suffering from poor air quality.

There is much that can be done to reduce these new toxic burdens. Governments must urgently take regulatory action to minimize toxic pollution from these processes by committing to both the principles and practices of circularity in a groundbreaking way, and halting and preventing the human rights violations that toxic hard rock mining and the rest of the renewable energy and battery supply chains generate. Finally, governments must stop subsidizing the false solutions of the incumbent fossil fuel industry, which touts products that purport to address climate change while perpetuating society’s dependence on their toxic products.

# Toxic implications of renewable energy, battery storage, and electromobility

Shifting away from fossil fuels is essential to prevent climate change and will reduce toxic burdens in communities around the world who have been suffering the health consequences of air and water pollution from the production, processing, transport, and combustion of these fuels for decades. While estimates vary, the continued use of renewable energy, battery storage, and electromobility will require multiplying the production of the minerals that are used to develop these technologies several times over through the coming decades.[[2]](#footnote-3)

The toxicity of the metals in these technologies and the byproducts of the processes used to create and recycle them also creates toxic pollution. Renewables and batteries are dependent on a range of mined minerals, including ones harmful to human health such as cobalt, nickel, some rare earths, and silver. [[3]](#footnote-4) The processing of these materials, including in smelters, exacts a health toll on surrounding communities through their air and water emissions, the release of large quantities of harmful criteria air pollutants like sulfur dioxide, the dumping of toxic slag, and their common dependence on dirty coal-fired power.[[4]](#footnote-5) Manufacturing of these technologies also have toxic byproducts.[[5]](#footnote-6) For example, the use of lithium-ion batteries in vehicles and for energy storage carries risks of toxic fires.[[6]](#footnote-7) The landfilling or dumping of these technologies at the end of their useful lives leads to leaching of toxic compounds into local soils and waterways, and risks more battery fires.[[7]](#footnote-8) Recycling these materials is critical to reducing demand for new mines, but also must be properly regulated to avoid harmful air and water emissions.[[8]](#footnote-9) Below, we focus further on two links in this chain of toxic impacts, mining and end-of life, and present ways to reduce these impacts.

## Mining

The toxic legacies of mines around the world are well-known. The mining of minerals for the energy transition today can also be harmful. For example, researchers have carefully documented the toxic legacy of cobalt mining in the border regions between the Democratic Republic of Congo and Zambia.[[9]](#footnote-10) Communities there are affected by open pit mines developed by state-owned and multinational corporations, small-scale mining, and smelters, with researchers finding significantly elevated levels of arsenic, cobalt, cadmium, lead, and uranium in urine samples of communities living near mines and smelters in Katanga.[[10]](#footnote-11) These elevated levels result from exposure to waters contaminated by effluents, consumption of crops grown in contaminated soils, and ingestion of dust laden with heavy metals.[[11]](#footnote-12)

Some electric vehicle manufacturers have shifted to using more nickel in battery cathodes, resulting in an explosion of nickel production in several parts of the world. Indonesia has been particularly hard hit[[12]](#footnote-13): toxic tailings have been dumped in the ocean and other waterways, killing fish and contaminating those that survive, and smelters releasing toxic emissions have required the construction of massive new coal-fired power plants, which have caused further pollution.[[13]](#footnote-14)

Remining, which involves using minerals already removed from the earth but never fully extracted and processed, including waste rock and tailings, offers an opportunity to reduce the extent of and impacts of primary mining. While these materials may have previously been considered wastes, shifting economics and a truer accounting of their harmful impacts makes the re-use of them more appealing.[[14]](#footnote-15) If done well, remining can lead to the cleanup of long-abandoned toxic waste sites still causing harm.[[15]](#footnote-16) However, if done poorly, remining can remobilize inert toxic materials, destabilize tailings dams, or introduce new toxins into the environment.[[16]](#footnote-17) Where new wastes are created from the further processing of these ores, these must be properly handled, avoiding reinjuring communities and ecosystems still recovering from past injuries. Clear regulations should be enacted to regulate remining and to revise liability rules around mine cleanups.[[17]](#footnote-18) Communities that would be affected must give their consent prior to remining projects proceeding, and environmental impact studies for remining must be undertaken just as with new mining projects.

## End of life

When renewable energy technologies reach the end of their useful lives, they present both risks and great opportunities. If left on roadsides or in landfills, the heavy metals in solar panels (silver, cadmium, chromium, manganese, lead, indium, tellurium, and zinc)[[18]](#footnote-19) and batteries (lithium, cobalt, nickel, manganese, iron, chromium and copper)[[19]](#footnote-20) can leach out into soils and waterways, leading to heavy metal contamination of workers and surrounding communities, particularly children.[[20]](#footnote-21) Incineration of these materials release dioxins and heavy metals that are harmful to local populations, and have been associated with higher cancer burdens in surrounding communities.[[21]](#footnote-22) Inappropriate handling and landfilling of lithium-ion batteries is also a common cause of toxic fires.

Creating a more circular economy for these technologies is one of the primary means proposed to reduce the impacts of the energy transition. Proper recycling of renewable energy technologies and their reinjection into production streams reduces these harms and risks at the end of these technologies’ lifecycles and minimizes the need for new mining. Various scenarios show that the need for new raw materials for these technologies can be reduced significantly, by 50% or more for some metals by 2050, with strong recycling measures in place around the world.[[22]](#footnote-23) In most places, recycling falls far short of this potential - in the US, for example, only 10% of solar panels are recycled.[[23]](#footnote-24)

Some leading governments, with the EU in front, have begun to put requirements in place for recycling these technologies.[[24]](#footnote-25) It is crucial that these mandates be accompanied by bans or strict and enforced regulations on exports of these technologies to be recycled abroad, and mandates of best practices for the recycling of these materials.

*Bans or limits on exports*

Bans or strict regulation on exports from the Global North of end of life energy transition technologies are important because this type of waste could easily follow the same path as e-waste has globally: years of exports of e-waste from high income countries to low- and middle-income countries (LMICs) have left toxic legacies in recipient countries.[[25]](#footnote-26) It is estimated that about 80% of e-waste from developed countries is illegally exported to these LMICs including China, India, Nigeria, Brazil, Ghana, and Pakistan.[[26]](#footnote-27) Much of the work of recycling in these countries is carried out by informal workers without protective equipment that comb e-waste and process waste at their homes, and rely on a variety of hazardous methods, including open burning, heating and melting, manual dismantling, acid leaching, cyanide salt leaching, and mercury amalgamation to maximize the value of these wastes.[[27]](#footnote-28) Pollutants from these processes then contaminate groundwater, air, and food sources.[[28]](#footnote-29) This unregulated recycling exposes these workers and the communities surrounding e-waste dumps to a range of endocrine disrupters and neuro- and immune-toxins, and other health impacts.[[29]](#footnote-30) Waste from renewable energy and battery technologies cannot be permitted to continue this pattern. Clear guidelines should also inform the donation of used solar panels and electric vehicles that have some life left to middle- and low-income countries, to ensure they do not simply end up contaminating roadsides within a few years.[[30]](#footnote-31) New export rules, such as those proposed by the [Öko-Institut](https://www.oeko.de/en/press/archive-press-releases/press-detail/2022/donating-used-lithium-ion-batteries-to-africa-clear-rules-urgently-needed), must be implemented to prevent the same waste disaster that resulted in the toxic harms we have seen in these places, and all countries must be prepared to reuse and recycle their own energy transition technologies. [[31]](#footnote-32)

*Best practice mandates to reduce toxic impacts of recycling facilities*

Low- and middle-income countries must also invest in properly regulating the management of recycling these new waste streams. Even with bans of e-waste exports from high-income countries, these countries will face a high waste burden to manage from these technologies: in 2020, for example, an estimated 12,000 tonnes of off-grid solar waste was generated across sub-Saharan Africa, a 545% increase from 2016.[[32]](#footnote-33) Among these mandates must be rules governing formal recycling facilities – those facilities that are regulated and have workers trained in safety protocols and controls on pollutants such as stack scrubbers. Most of these facilities use one of two kinds of recycling: pyrometallurgical recycling, in which heat is used to breakdown materials, or hydrometallurgical recycling, in which chemicals are used to leach valuable materials out of electronics.[[33]](#footnote-34) While well-maintained scrubbers and wastewater treatment plants can reduce emissions from these processes, pyrometallurgical recycling processes still generate and emit a range of toxic air emissions, not dissimilar to those emitted by incinerators, while hydrometallurgical recycling can generate toxic liquid waste streams that are often inadequately treated before being released into the environment.[[34]](#footnote-35)

Governments should also incentivize a greater proportion of recycling to be done via physical or direct recycling, which has lower environmental impacts. Physical recycling, the physical dismantling or breaking apart of the original components of the technologies, is generally required prior to any other treatments. The more comprehensive this physical recycling can be, the more effective the whole process will be at recovering materials. Some recycling companies today are investing in developing sophisticated robots to improve this breakdown process.[[35]](#footnote-36) The least harmful kind of recycling, direct recycling, would recover whole parts of technologies, such as cathodes that can then go directly into new batteries, without having to break these down into their component metals. This direct recycling is much less energy intensive and produces fewer byproducts.[[36]](#footnote-37)

Several practices can improve and enable more comprehensive physical recycling and more direct recycling. The first is regulation that standardizes technologies to allow recyclers to know just what they are getting, much like regulations requiring the standard-form lead acid battery for cars to minimize risks from lead recycling. This is generally disliked by companies, however, because it is seen as stifling innovation.[[37]](#footnote-38) Product labeling requirements are a second-best option, so that recyclers are aware of what materials are in a particular technology, although some companies even oppose this out of concerns about intellectual property rights. Other regulations include requirements for technologies to be more recyclable and interchangeable,[[38]](#footnote-39) and regulations requiring that clean energy technology companies take back and recycle their own products or work closely with other companies, including transportation companies (extended producer responsibility mandates).[[39]](#footnote-40) Banning landfilling of these products while adding strict controls on emissions from recycling facilities could also incentivize technologies that are easier to disassemble and encourage a greater role for physical and direct recycling.

Finally, minimizing throughput of all materials by reducing demand always comes first in the circular economy hierarchy. This will require improvements in land use planning, public transportation, and infrastructure to reduce dependence on personal use electric vehicles, and higher efficiency buildings and appliances to reduce energy demand. Increases in the efficiency and durability of solar panels, wind turbines, and batteries are also an important part of reducing throughput. Reuse of these technologies will also be critical to maximize their use, such as using second-life EV batteries (which generally still retain a charge of at least 70% when owners decide their range is no longer sufficient) for stationary storage.[[40]](#footnote-41) Finally, technological substitution can be an important part of the solution set, though it is important that this substitution be toward *less* toxic and more abundant materials, rather than simply swapping one toxic product for another. For example, sodium-ion or solid-state batteries might be able to overtake lithium-ion batteries in EVs in the long term, while compressed air, iron-air flow batteries,[[41]](#footnote-42) or any number of other up-and-coming technologies might have a chance in the stationary storage space.[[42]](#footnote-43)

# Hydrogen

## Hydrogen is being discussed globally as a key to decarbonization because of its potential replacement of fossil fuels as fuel and feedstock in various activities. However, hydrogen can be produced in many ways, all of which present risks and inefficiencies, and all of which have harmful impacts. Hydrogen production from fossil fuels, including methane and coal, produce many toxic byproducts.[[43]](#footnote-44) Carbon capture and storage (CCS) (discussed further below) technologies proposed to clean up the carbon emissions do not reduce these other toxic byproducts.

Hydrogen produced via electrolysis that runs on renewable energy, commonly known as “green” hydrogen, has many benefits over fossil fuel-based versions, particularly in its lack of emissions at the site of the hydrogen production. However, producing appreciable amounts of hydrogen requires significant quantities of renewable energy, which have their own toxic burden and which is highly inefficient. Electrolysis is very energy intensive, and much energy is lost in the conversion of water, to hydrogen, back to energy, including during storage and transportation.[[44]](#footnote-45) Electrolysers and fuel cells also contain minerals that must be mined and properly handled at the end of their useful lives, including platinums and toxic rare earth elements.[[45]](#footnote-46) Renewables should be invested primarily to give access to electricity and clean air to those who lack them today, rather than being used for inefficient hydrogen production. Green hydrogen instead should be dedicated to hard-to-abate industrial and transport sectors, and its production should not take away from renewable energy needed to power grids. Because it is impossible to distinguish hydrogen produced from gas from green hydrogen once it leaves the production facility, there is a risk of fraudulent labeling which allows for the laundering of dirty hydrogen to pass as green. Therefore, proper certification, audit and traceability processes are also critical to ensure hydrogen labeled as “green” is authentic.[[46]](#footnote-47)

# Carbon Capture and Storage

# CCS is attracting increasing public and private investment as a means of dealing with the CO2 emissions at a wide range of power and industrial facilities. While a lofty goal, CCS enables increased toxic burdens in communities commonly already overburdened by toxic air in three ways.[[47]](#footnote-48)

First, CCS is increasingly being used to justify the perpetuation of fossil fuel-based industries, but does nothing to address the toxins emitted either from these industries into surrounding communities, or the upstream supply chain of gas, oil, and coal production and transport.[[48]](#footnote-49) In the United States, petrochemical facilities have historically had devastating impacts on disproportionately poor Black and Latino populations, and new petrochemical facilities touting CCS as a means of addressing their pollution are being proposed for these same communities.[[49]](#footnote-50)

Second, as noted above, the additional fuel necessary to power the carbon capture and storage equipment – some 13-44% more than the plant would normally use - leads to higher air pollution burdens in communities around the point of combustion, as well as around the upstream production, processing, and transport of the fuel to power the CCS.[[50]](#footnote-51)

Finally, amine-based chemicals used to scrub the carbon dioxide out of the flue gas in some CCS technologies themselves emit volatile amines that breakdown into other harmful products like ammonia and ethylamine.[[51]](#footnote-52) Without better controls on the cancer-causing pollutants and respiratory and cardiovascular irritants these facilities produce, CCS continues to harm communities.

1. Earthjustice is a non-profit public interest law organization dedicated to using the power of law and the strength of partnership to protect people’s health; to preserve magnificent places and wildlife; to advance clean energy; and to combat climate change. [↑](#footnote-ref-2)
2. *E.g.* IEA, *The Role of Critical Minerals in Clean Energy Transitions*, 287 (2021), <https://iea.blob.core.windows.net/assets/24d5dfbb-a77a-4647-abcc-667867207f74/TheRoleofCriticalMineralsinCleanEnergyTransitions.pdf>; Kirsten Hund *et al.*, *Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition* (2020), <https://www.worldbank.org/en/topic/extractiveindustries/brief/climate-smart-mining-minerals-for-climate-action>; [↑](#footnote-ref-3)
3. Elsa Dominish, Sven Teske & Nick Florin, *Responsible minerals sourcing for renewable energy* (2019), <https://earthworks.org/cms/assets/uploads/2019/04/MCEC_UTS_Report_lowres-1.pdf>. [↑](#footnote-ref-4)
4. *E.g.* Xiaoyun Shen, Yongkuan Chi & Kangning Xiong, *The effect of heavy metal contamination on humans and animals in the vicinity of a zinc smelting facility*, 14, PLOS ONE, e0207423 (2019), <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0207423>; Yuanmei Hu *et al.*, *Health risks to local residents from the exposure of heavy metals around the largest copper smelter in China*, 171, Ecotoxicology and Environmental Safety, 329–336 (2019), <https://www.sciencedirect.com/science/article/pii/S014765131831371X>; Dunn, J.B. et al., *The significance of Li-ion batteries in electric vehicle life-cycle energy and emissions and recycling’s role in its reduction*. Energy Environ. Sci., (2015), http://dx.doi.org/10.1039/C4EE03029J%5Cnhttp://xlink.rsc.org/?DOI=C4EE03029J. [↑](#footnote-ref-5)
5. In the production of lithium-ion batteries, for example, electrolyte chemicals and binders are acutely toxic, and the batteries use fluoropolymers that generate persistent bioaccumulative and toxic substances in their production (Mats Zackrisson & Steffen Schellenberger, *Toxicity of lithium ion battery chemicals -overview with focus on recycling* (2020), <https://www.ri.se/sites/default/files/2020-10/Toxicity%20risk%20report_18%20June%202020_0.pdf>). There is promising research into changing chemistries to reduce these hazards, e.g. Rachid Essehli *et al.*, *Hydrothermal synthesis of Co-free NMA cathodes for high performance Li-ion batteries*, 545, Journal of Power Sources, 231938 (2022), <https://www.sciencedirect.com/science/article/pii/S0378775322009211>, and Jianlin Li *et al.*, *Water-Based Electrode Manufacturing and Direct Recycling of Lithium-Ion Battery Electrodes—A Green and Sustainable Manufacturing System*, 23, iScience (2020), [https://www.cell.com/iscience/abstract/S2589-0042(20)30266-2](https://www.cell.com/iscience/abstract/S2589-0042%2820%2930266-2). [↑](#footnote-ref-6)
6. Yang Peng *et al.*, *A comprehensive investigation on the thermal and toxic hazards of large format lithium-ion batteries with LiFePO4 cathode*, 381, Journal of Hazardous Materials, 120916 (2020), <https://www.sciencedirect.com/science/article/pii/S0304389419308696>; Fredrik Larsson *et al.*, *Toxic fluoride gas emissions from lithium-ion battery fires*, 7, Sci Rep, 10018 (2017), <https://www.nature.com/articles/s41598-017-09784-z>; Teresa L. Barone *et al.*, *Lithium-ion battery explosion aerosols: Morphology and elemental composition*, 55, Aerosol Science and Technology, 1183–1201 (2021), <https://www.tandfonline.com/doi/full/10.1080/02786826.2021.1938966>. [↑](#footnote-ref-7)
7. Daniel Hsing Po Kang, Mengjun Chen & Oladele A. Ogunseitan, *Potential Environmental and Human Health Impacts of Rechargeable Lithium Batteries in Electronic Waste*, 47, Environ Sci Technol, 5495–5503 (2013), <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5920515/>; Weiguang Lv *et al.*, *A Critical Review and Analysis on the Recycling of Spent Lithium-Ion Batteries*, 6, ACS Sustainable Chem. Eng., 1504–1521 (2018), <https://pubs.acs.org/doi/10.1021/acssuschemeng.7b03811>; and Phoebe O’Connor & Patrick Wise, *An Analysis of Lithium-ion Battery Fires in Waste Management and Recycling,* U.S. EPA, (2021), <https://www.epa.gov/system/files/documents/2021-08/lithium-ion-battery-report-update-7.01_508.pdf>. [↑](#footnote-ref-8)
8. François Larouche *et al.*, *Progress and Status of Hydrometallurgical and Direct Recycling of Li-Ion Batteries and Beyond*, 13, Materials, 801 (2020), <https://www.mdpi.com/1996-1944/13/3/801>. [↑](#footnote-ref-9)
9. Emmanuel K. Atibu *et al.*, *High contamination in the areas surrounding abandoned mines and mining activities: An impact assessment of the Dilala, Luilu and Mpingiri Rivers, Democratic Republic of the Congo*, 191, Chemosphere, 1008–1020 (2018), <http://www.sciencedirect.com/science/article/pii/S0045653517316326>. [↑](#footnote-ref-10)
10. Célestin Lubaba Nkulu Banza *et al.*, *High human exposure to cobalt and other metals in Katanga, a mining area of the Democratic Republic of Congo*, 109, Environmental Research, 745–752 (2009), <https://www.sciencedirect.com/science/article/pii/S0013935109000814>. [↑](#footnote-ref-11)
11. Emmanuel K. Atibu *et al.*, *Concentration of metals in surface water and sediment of Luilu and Musonoie Rivers, Kolwezi-Katanga, Democratic Republic of Congo*, 39, Applied Geochemistry, 26–32 (2013), <https://www.sciencedirect.com/science/article/pii/S0883292713002436>. [↑](#footnote-ref-12)
12. Kadek Nando Setiawan *et al.*, *Simulation of Contaminants Transport in Groundwater From Nickel Mining Waste Dump Southeast Sulawesi* (2022), <https://www.researchsquare.com/article/rs-1122818/v1>; Eko Rusdianto, *Sulawesi nickel plant coats nearby homes in toxic dust*, Mongabay Environmental News, 2022, <https://news.mongabay.com/2022/11/sulawesi-nickel-plant-coats-nearby-homes-in-toxic-dust/>; Eko Rusdianto, *FOIA lawsuit suggests Indonesian nickel miners lack environmental licenses*, Mongabay Environmental News, 2023, <https://news.mongabay.com/2023/01/indonesia-nickel-mining-batteries-ev-environmental-license-foia/>. [↑](#footnote-ref-13)
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17. See, for instance, Martin [D-NM Sen. Heinrich, *Text - S.3571 - 117th Congress (2021-2022): Good Samaritan Remediation of Abandoned Hardrock Mines Act of 2022* (2022), <http://www.congress.gov/>. [↑](#footnote-ref-18)
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19. Wojciech Mrozik *et al.*, *Environmental impacts, pollution sources and pathways of spent lithium-ion batteries*, 14, Energy Environ. Sci., 6099–6121 (2021), <http://xlink.rsc.org/?DOI=D1EE00691F>. [↑](#footnote-ref-20)
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21. Javier García-Pérez *et al.*, *Cancer mortality in towns in the vicinity of incinerators and installations for the recovery or disposal of hazardous waste*, 51, Environment International, 31–44 (2013), <https://www.sciencedirect.com/science/article/pii/S0160412012002279>. [↑](#footnote-ref-22)
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23. Casey Crownhart, *Solar panels are a pain to recycle. These companies are trying to fix that.*, MIT Technology Review, 2021, <https://www.technologyreview.com/2021/08/19/1032215/solar-panels-recycling/>. [↑](#footnote-ref-24)
24. The EU has led jurisdictions around the world with the most ambitious rules, requiring 85% collection and 80% recycling of PV panel materials under the [WEEE Directive](https://environment.ec.europa.eu/topics/waste-and-recycling/waste-electrical-and-electronic-equipment-weee_en), and requiring under its new [Battery Regulation](https://www.europarl.europa.eu/RegData/docs_autres_institutions/commission_europeenne/com/2020/0798/COM_COM%282020%290798_EN.pdf) that 90% of cobalt, nickel, and copper and 50% lithium be recovered from batteries by 2025, increasing to 95% and 80% respectively by 2030. New batteries must also contain recycled materials: 16% cobalt, 6% lithium, and 6% nickel in 2030, increasing to 26%, 12%, and 15% respectively in 2035.  [↑](#footnote-ref-25)
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27. Sarker M. Parvez *et al.*, *Health consequences of exposure to e-waste: an updated systematic review*, 5, The Lancet Planetary Health, e905–e920 (2021), [https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(21)00263-1/fulltext](https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196%2821%2900263-1/fulltext). [↑](#footnote-ref-28)
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