Spent batteries: a global strategy for navigating the emerging e-mobility divide

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Battery-powered transport in Bangladesh. Photo: Henrique Pacini / UNCTAD SMEP Programme.

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Contents

Key messages

- **Electric vehicle (EV) battery governance is lagging behind rapid electrification.**
- **Weak traceability enables unsafe recycling, illegal exports and "waste colonialism".**
- **Lead-acid batteries create major health risks where informal recycling dominates.**
- **Stronger extended producer responsibility (EPR), deposit-return schemes are needed.**
- **Regional recycling hubs and global coordination are key for a just battery transition.**

Keywords

Battery; lead-acid; lithium-ion; recycling; circularity; trade; electric vehicles; starter batteries

1. A changing battery landscape

The waste stream for electric vehicle (EV) batteries is one of the fastest growing and least governed at a global scale. Most existing electronic waste (e-waste) rules were designed for small electronics, not for the larger, high-voltage battery packs now entering markets through that adoption of electric mobility or e-mobility – electric vehicles of all sizes, from scooters to large trucks. This gap is especially visible in light-duty transport electrification.

In the Global South (low- and middle-income countries, as classified in the UNCTAD Data Hub), electrification is unfolding amid a broader affordability crisis. Petrol is expensive, lithium-ion battery systems remain costly and hard to recycle, and many countries lack sufficient "reverse-logistics" capacity for various types of battery technologies. As a result, low-cost lead-acid batteries continue to enter both formal and informal light-duty mobility markets, especially for smaller vehicles. While easy to recycle, lead-acid batteries are highly toxic: countries such as Bangladesh have seen rapid uptake in lead-acid battery–powered three-wheelers, with informal recycling exposing communities to dangerous levels of lead and threatening to reverse global progress made after the phase-out of leaded gasoline (Chowdhury, 2024; SMEP, 2024).

These dynamics contrast sharply with the Global North (higher income countries, as classified in the UNCTAD Data Hub), where electrification is more car-centric, supported by formal collection and recycling investments, and primarily anchored in lithium-ion technologies. Distinct North–South mobility trajectories are already generating different battery waste streams, with very different risk profiles. Research and pollution-mitigation initiatives working in low-income settings have been documenting these emerging risks.

This report examines current governance gaps and outlines coordinated North–South responses needed to ensure that electrification supports rather than undermines safety, human health, circularity and justice. We look into existing literature and news sources on the topic of e-waste and battery recycling, and we use data from the UN COMTRADE database to analyse patterns in new and scrap battery flows to identify emerging trends.

2. Tracking new and used battery flows

Global e-waste generation is rising five times faster than what countries recycle. The Global E-waste Monitor 2024 reported 62 million metric tons (tons) generated in 2022, of which only about 22% was formally collected and recycled. Current projections indicate volumes could reach around 82 million tons in 2030 (Baldé et al., 2024). Batteries used in electric mobility remain poorly captured in global trade statistics for e-waste.

In many low- and middle-income countries, battery markets further complicate the picture. Lead-acid chemistry in the transport sector usually is used in starter batteries (a global niche for lead-acid batteries) or for low-cost mobility options, such as two wheelers, due to its affordability. However, their circulation and end-of-life management are rarely monitored, despite well-documented risks from informal lead recycling. Numbers vary globally, but recycling rates for lead-acid batteries are reportedly high, for example 99% in the US (Machala et al., 2025; US EPA, 2020) and 65% in the EU (Eurostat, 2025).

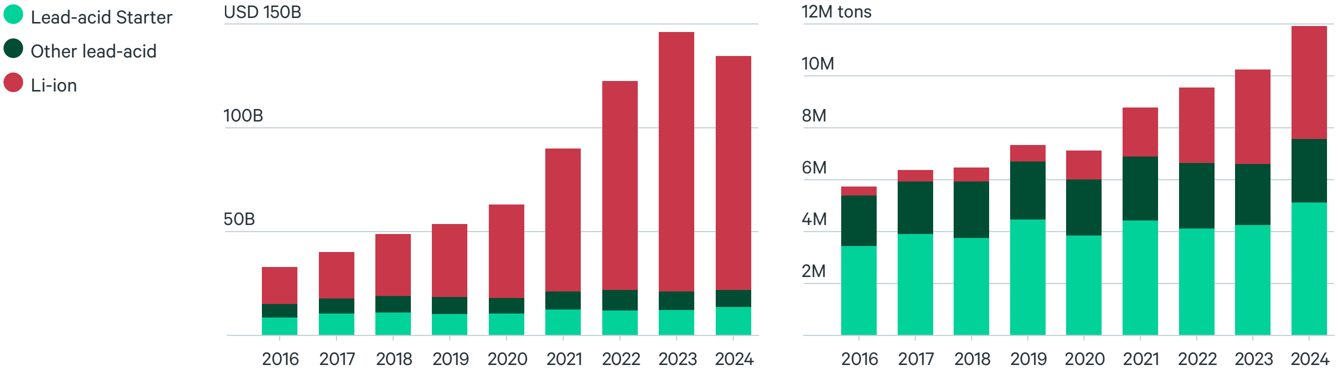
Lithium-ion systems, while more structured, often lack reverse-logistics capacity for safe collection and transport flows, during this early stage of expansion, and involve much more complex recycling processes (Chacana-Olivares et al., 2025; Rehman et al., 2025).

At the same time, informal e-mobility systems for e-bikes, e-motorcycles, tuk-tuks, or mini-EVs are expanding rapidly across many regions. Their batteries are inexpensive, frequently replaced and virtually untracked, creating a fast-growing but statistically invisible waste stream (Zaman & Ahsan, 2024). Taken together, these gaps mean that current global data significantly underestimate the scale and distribution of future battery waste, leaving countries without the data visibility needed to design regulations and fair and safe management systems. Without these data, estimates of future battery waste volumes and locations are nearly impossible to make, leaving countries to devise circularity strategies with partial or incomplete information in hand.

Figure 1 shows that global battery exports have grown roughly fivefold to USD 125 billion by 2024, driven primarily by the rapid expansion of lithium-ion batteries. This reflects the diffusion of lithium-ion technologies across multiple applications, particularly electric vehicles. At the same time, formal exports of lead-acid batteries have remained relatively stable. The data suggest that the global battery economy currently operates through two parallel systems: a rapidly expanding lithium-ion market and a smaller but mature and stable lead-acid system.

However, measured in traded weight, lead-acid batteries remain highly significant. Lead-acid batteries have lower energy densities than lithium equivalents and thus are generally heavier by a factor of 2–3. In 2024, global exports of lead-acid batteries (codes HS 850710 and HS 850720 combined) reached approximately 7.6 million tons. Asia exported around 3.5 million tons (46%), followed by Europe with 3 million tons (40%) and the Americas with about 1 million tons (13%).

Figure 1. Global exports of lead-acid starter (HS 850710), other lead-acid (HS 850720) and lithium-ion (Li-ion, HS 850760) batteries, 2016–24, by value (USD billion – left) and volume (million metric tons – right).



Source: UN COMTRADE database (United Nations, 2026).

Lithium-ion batteries (HS 850760) show a different pattern. Global export weight reached roughly 4.3 million tons in 2024, of which Asia accounted for about 3.4 million tons (79%). Europe exported 0.75 million tons (17%), while the Americas accounted for about 0.15 million tons (3%). Although Europe's absolute lithium-ion export volumes are significant, the market remains highly concentrated in Asia. This concentration is critical for future recycling dynamics: large-scale lithium-ion waste streams may emerge first and most strongly in regions where production and deployment volumes are highest.

Two implications emerge: first, despite the rapid growth of lithium-ion markets, lead-acid batteries still dominate global battery trade in terms of weight, reflecting their continued use in vehicle auxiliary systems, backup power and low-cost mobility. Second, Asia now sits at the centre of both battery systems, dominating lithium-ion production while also expanding its role in lead-acid exports.

It should be assumed that trade volumes for lithium-ion batteries will surpass lead-acid ones in the coming years; however, this does not automatically mean that lead-acid will lose its role in battery systems, particularly in the Global South, where affordability is a key driver of demand. It is important to regulate battery end-of-life for both technologies, avoiding the various risks associated with unsafe recycling practices (see Box 1).

BOX 1: STRUCTURAL ASYMMETRIES IN BATTERY END-OF-LIFE

Environmental, health and safety risks

Weak reverse logistics and informal dismantling can lead to soil and water contamination, toxic emissions and fire risks, particularly where lithium-ion handling capacity is limited and lead-acid recycling remains informal. For example, lead from discarded batteries is processed in poorly regulated smelters, where emissions of lead-laden slag, smoke and dust contaminate air, soil and nearby residential areas, exposing surrounding communities and workers to severe health risks, particularly in countries in Africa and Asia where informal setups are more common (Faradillah et al., 2025; Goodman et al., 2025; Mihai et al., 2022) (see Figure 2).

Recent investigations have found large volumes of illegally traded discarded electronics continue to flow from high- to low-income countries. The shipments are frequently processed in informal scrapyards and repair markets where electronics are refurbished, dismantled or burned for materials extraction under unsafe conditions, exposing workers and nearby communities to toxic pollution (Ghosal, 2025; Intarasuwan, 2025). These transnational e-waste flows contributed to the establishment of large, highly specialized informal waste economies in cities across the Global South, meaning that efforts towards stricter regulation and formalization must account for the livelihoods and economic dependencies tied to the sector.

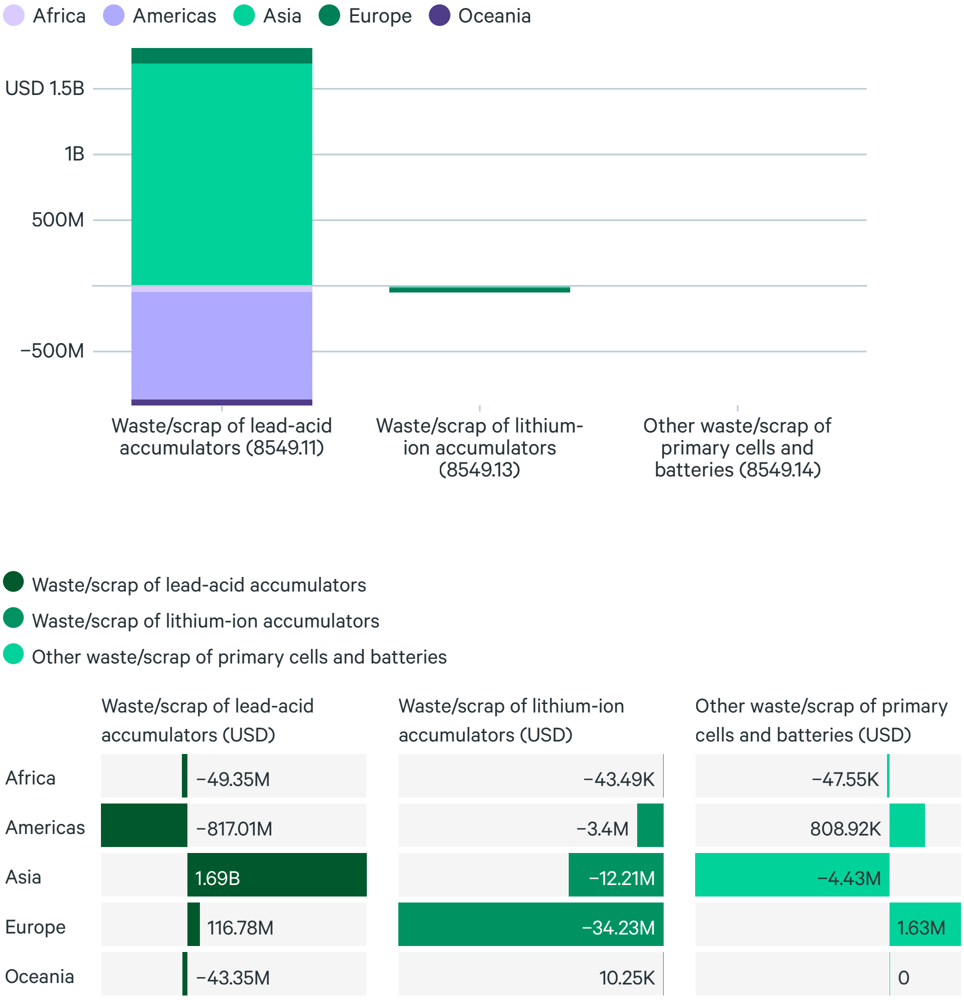
Infrastructure, economic and governance risks

Theft of battery modules and charging components can also feed unsafe informal markets and create grid and safety hazards. High compliance costs and weak enforcement can create a two-speed EV market: safer lithium systems in regulated contexts, cheaper lead-based systems elsewhere. Limited traceability and fragmented producer responsibility frameworks weaken accountability and shift end-of-life burdens to regions with lower end-of-life management capacities.

Figure 2. Lead smelting site in Dhaka, Bangladesh.

Source: © Henrique Pacini / UNCTAD SMEP Programme

Figure 3. Net import value of different types of battery scrap per region. Values reported in USD and aggregated between 2022 and 2024.



	Waste/scrap of lead-acid accumulators (USD)	Waste/scrap of lithium-ion accumulators (USD)	Other waste/scrap of primary cells and batteries (USD)
Africa	−49.35M	−43.49K	−47.55K
Americas	−817.01M	−3.4M	808.92K
Asia	1.69B	−12.21M	−4.43M
Europe	116.78M	−34.23M	1.63M
Oceania	−43.35M	10.25K	0

Source: UN COMTRADE database (United Nations, 2026).

Figure 3 presents the net import balance of battery scrap per region and waste category for the years 2022–24 (aggregated value in USD). In 2024, global used battery exports reached approximately USD 1.1 billion (aggregated HS854911, 854913, 854914). Lead-acid scrap clearly dominates this market in reported trade value, reflecting the maturity of lead recycling systems. By contrast, lithium-ion scrap trade remains extremely limited.

This discrepancy should be interpreted with caution. Lithium-ion batteries, particularly in EV and stationary storage applications, have relatively long product lifetimes: at least 15 years for stationary ones, which is double the lifetime of lead-acid batteries (Yudhistira et al., 2022). This delays the emergence of large end-of-life volumes for lithium-ion batteries. In addition, lithium-ion recycling is technologically complex and capital-intensive (Chacana-Olivares et al., 2025), which may limit the extent of international scrap trade to specialized hubs, compared to the well-established and ubiquitous global lead-acid recycling system.

Trade statistics also impose important limitations. At the HS6 level used in UN COMTRADE, “spent batteries” are not consistently disaggregated by chemistry. Although more detailed codes exist in some jurisdictions (e.g. the EU TARIC system), HS6 aggregation can group several battery types together. As a result, lithium-ion end-of-life flows may be under-represented in global trade statistics.

3. Diverging electrification pathways: why battery waste is unequally distributed

The geography of battery deployment and end-of-life management reflects a structural asymmetry between the Global North and South. In high-income markets, electrification is driven by large, high-value EVs supported by strong policy frameworks and emerging formal recycling industries. In contrast, many countries in the Global South are electrifying through smaller, lower-cost and high-turnover vehicles, e.g. e-bikes, motorcycles, rickshaws and three-wheelers, without clear incentives to formalize repair and recycling services.

Country patterns reinforce the contrast between the two chemical systems. Lead-acid scrap exports (HS 854911) are highly concentrated in the Americas (see Figure 3): the US exported roughly 0.62 million tons in 2024, accounting for more than half of global reported scrap exports. Canada and several European countries follow at smaller volumes. Asia is by far the largest net importer of lead-acid battery scrap, with a total value of imports reaching USD 1.82 billion between 2022 and 2024 (see Figure 3). Of these imports, 63% were concentrated in southern Asia.

Nevertheless, reports on transboundary e-waste movements (not just batteries) show that 65% of the total shipped volume (3.3 million tons) are uncontrolled e-waste flows from high-income countries to middle- and low-income countries, with most movements between Europe and East Asia (Baldé et al., 2024) (see also Box 1). Asian countries, despite being major producers and exporters of new lead-acid batteries are not exporting lead-acid battery scrap.

Lithium-ion scrap exports (HS 854913) remain very small and are geographically concentrated in Europe (see Figure 3), with Germany emerging as the leading exporter (31% market share in exports from 2022 to 2024). Similar to the lead-acid scrap trade, Asian countries are not major exporters. Japan (14%), China (3%) and Singapore (1%) are in the top 10 exporters of lithium-ion scrap, and together, the three countries have a market share of 18%. These relatively lower shares likely reflect domestic recycling or statistical limitations in capturing end-of-life flows rather than an absence of recycling activity.

We assume that certain scrap volumes are largely missing from official statistics due to informal recycling practices. Box 2 presents country-specific evidence of efforts to reduce such practices.

BOX 2: COUNTRY-SPECIFIC EVIDENCE

The Philippines – informal used lead-acid battery reverse logistics

The Philippines illustrates how informality can dominate used lead-acid battery flows. It is estimated that around 40% of reverse logistics for used lead-acid batteries operates informally, with higher informal purchase prices undermining formal recyclers and safe handling. Policy options under discussion include deposit-return schemes, extended producer responsibility (EPR), and stronger enforcement, aiming to shift to regulated flows (Lead-Acid Battery Recycling Initiative, 2025).

Bangladesh – trade incentives and hazardous recycling

In Bangladesh, high battery import tariffs have increased incentives for domestic informal lead recycling, while weak enforcement enables unsafe dismantling and smelting, leading to acute health hazards. Work within the UK Foreign, Commonwealth and Development Office (FCDO) and UNCTAD Sustainable Manufacturing and Environmental Pollution Programme (SMEP) highlights the need for improved reverse logistics, stronger standards, financial tools to expand access to safer lithium handling systems, and compliance mechanisms to discourage informal operators (SMEP, 2024; Zaman & Ahsan, 2024).

Eastern Africa – worker health and circular economy justice

SEI’s work in eastern Africa underscores the occupational health risks faced by informal e-waste recyclers and frames battery waste as a labour and environmental justice issue within the circular economy transition (SEI, 2025). The project will identify existing barriers to safer recycling and examines the implications of emerging EPR regulations for the sector, in order to support locally viable and equitable pathways to e-waste circularity.

4. The governance gap

The current international governance architecture was not designed for the scale and complexity of battery electrification now under way. The Basel Convention, strengthened through its plastic waste and e-waste amendments, regulates transboundary movements of hazardous waste and requires prior informed consent (PIC) for such shipments (UNEP, 2025). However, EV batteries are not sufficiently covered in the framework. Large battery packs intended for refurbishment or repurposing in second-life applications do not always fit into existing hazardous waste categories[1]. This ambiguity can delay formal recycling investments, complicate compliance and create enforcement loopholes, particularly where capacity to inspect and classify shipments is limited.

At the regional level, exploratory analysis of a potential Association of Southeast Asian Nations (ASEAN) battery recycling hub illustrates how fragmented hazardous waste definitions and uneven Basel Convention implementation can deter coordinated infrastructure development. Without harmonized classification and trade rules, investors face regulatory uncertainty, while informal or semi-formal handling can persist as the path of least resistance (TradeLab, 2025).

A further disconnect lies between EV deployment policy and e-waste governance. Electrification strategies have accelerated vehicle uptake, yet end-of-life battery management is often treated as a subcategory within broader e-waste frameworks. As EV adoption increases, this lag becomes structurally significant: upstream incentives expand battery volumes faster than downstream systems for traceability, reverse logistics and safe recovery. Global reporting already shows that electronic waste is growing faster than formal recycling capacity, signalling systemic strain (Baldé et al., 2024; Mantovani, 2024).

Data gaps further compound the challenges, as described above. The result is a governance gap: electrification is globalizing rapidly, but the rules, classifications and institutional capacity governing battery end-of-life remain fragmented and only partially aligned with this new industrial reality.

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[1] The hazardous waste categories in the Basel Convention that are relevant to this report's context are: A1160 – Waste lead-acid batteries, whole or crushed; A1170 – Unsorted waste batteries; A1180 (effective until December 2024) – Waste electrical and electronic assemblies or scrap containing components such as accumulators and other batteries, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or contaminated with constituents such as cadmium, mercury, lead, polychlorinated biphenyl; and A118123 – Electrical and electronic waste (adapted from UNEP, 2025).

5. A fair and aligned global response

The battery transition unfolds under asymmetries between battery chemistries and geographies. Lead-acid systems remain cheaper and more widely used in lower-cost mobility segments, while lithium-ion dominates high-value EV markets. At the same time, informal recycling, theft of battery and charging components, and unsafe dismantling remain economically rational in contexts where enforcement is weak and formal recycling is underdeveloped. Governance responses must therefore address not only classification gaps, but also market incentives, considering livelihood realities. Previous efforts from SMEP have already provided policy and governance directions that can address these concerns. Below we summarize them and include recommendations on how to ensure a fair and aligned response to the e-waste problem.

Prevent risk shifting through “waste colonialism” and close governance gaps

- Update Basel Convention guidelines to reflect EV battery pack and second-life module diversity, and introduce global mandatory reporting on EV battery flows to improve traceability. This should include improved battery classification, harmonized trade codes and digital traceability systems, such as battery tagging, registries and track-and-trace mechanisms linking customs, producers and recycling systems.
- Strengthen customs and border enforcement capacity to implement Basel Convention procedures effectively, including customs training, digital PIC procedures, and trusted-complier systems for certified exporters and recyclers.
- Avoid uncontrolled expansion of lead-acid battery systems in emerging light e-mobility markets without prior regulatory planning for collection, recycling and environmental standards.

Make safe recycling economically viable and socially inclusive

- Make EPR mandatory, including for exported EVs and batteries. Where EPR systems are not yet feasible, consider complementary policy instruments such as deposit–refund schemes or buyback systems to incentivize safe battery return and prevent informal recycling practices.
- Combine strong enforcement with dedicated financing facilities to scale compliant recycling sites. Introduce certification systems and performance benchmarks for environmentally responsible recyclers.
- Recognize and integrate the role of informal sectors by supporting safer livelihoods through training and education, personal protection equipment (PPE) provision, certification, microcredit, and structured collection systems.
- Complement individual support measures for informal recycling with system-level interventions that improve working conditions and eventually facilitate the inclusion of informal workers in formal recycling systems, such as recycling cooperatives, scrapyard infrastructure upgrades, producer-funded inclusion schemes; free health monitoring and facilitated healthcare access; and greater worker participation in decision making.
- Address unsafe informal battery economies by tackling electricity theft and unsafe charging practices through improved metering, monitoring and enforcement.

Synchronize trade, mobility and development policy

- In the Global North, extend producer responsibility to exports, support harmonized UN COMTRADE HS codes refinement and battery traceability, and guide development assistance toward expanding formal recycling capacity for lithium-ion systems.
- In the Global South, strengthen import oversight for used EVs and batteries, regulate second-hand flows, and develop regional recycling hubs to achieve economies of scale.
- At the multilateral level, improve global battery classification guidelines, promote uptake of UN consumer protection standards (including reliable performance labelling and end-of-life information), and facilitate South–South knowledge exchange and applied research on pollution and informal recycling.
- Support the development of structured collection systems, market data and pollution-hotspot mapping to better understand battery flows and guide enforcement and investment priorities.
- Promote regional cooperation platforms and development finance initiatives, e.g. through ASEAN, the Asia-Pacific Economic Cooperation (APEC), the Regional Comprehensive Economic Partnership (RCEP), and regional development banks, to support investment in battery recycling infrastructure and regional recycling hubs.

Electrification of mobility does not automatically create a clean system. Without coordinated global action, informal recycling, illicit business models and chemistry-driven inequalities may expand alongside clean mobility markets. Aligning trade, mobility and waste governance, while ensuring viable economic incentives for safe recycling, will be central to delivering a battery transition that is low-carbon, safe and globally just.

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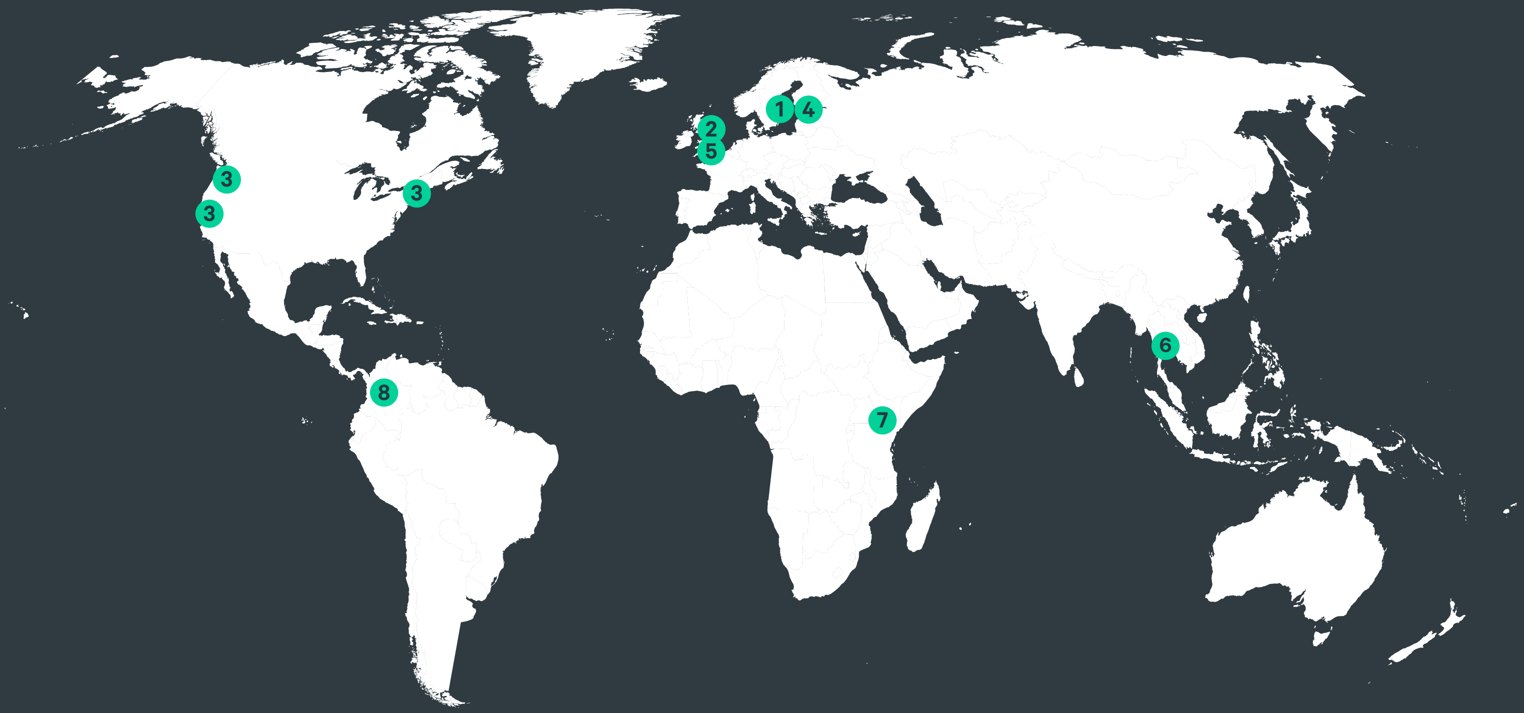

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