



MINAMATA
CONVENTION
ON MERCURY

Distr.: General
1 September 2025
English only

**Conference of the Parties to the
Minamata Convention on Mercury
Sixth meeting**

Geneva, 3–7 November 2025

Item 4 (f) of the provisional agenda*

**Matters for consideration and action by the Conference
of the Parties: capacity-building, technical assistance and
technology transfer**

**Desk study on the overview of alternative technologies under
the Minamata Convention on Mercury****

Note by the secretariat

The annex to the present note sets out a desk study report on the overview of alternative technologies under the Minamata Convention on Mercury, including relevant case studies, undertaken pursuant to paragraph 4 of article 14 and decision MC-5/12. The document has not been formally edited.

* UNEP/MC/COP.6/1/Rev.1.

** This document has not been formally edited.

Annex

Desk study on the overview of alternative technologies under the Minamata Convention on Mercury

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I. Executive summary

1. In response to decision MC-5/12, the secretariat developed a desk study and case studies for consideration by the Conference of the Parties pursuant to article 14, paragraph 4. The desk study report provides a general overview of initiatives related to alternative technologies rather than an exhaustive analysis of all available technologies. Recognizing that a comprehensive evaluation of every alternative technology was beyond the scope of the study, the secretariat has highlighted key examples and trends. The work was carried out under a cooperation agreement with the United Nations Institute for Training and Research with funding from the contribution of Japan to the special trust fund for the Minamata Convention on Mercury in the biennium 2024–2025.

2. Analysis of national reports revealed that many parties are experiencing the following challenges in relation to alternative technologies:

- (a) Insufficient funding, reflecting the gap between the needed resources and the resources that are available and accessible;
- (b) A lack of technical capacity at the national level, including a lack of trained personnel, preventing the deployment of alternative technologies;
- (c) Insufficient institutional capacity and regulatory frameworks, hindering technology assessment and approval and creating barriers for investment in new technologies due to concerns over compliance, effectiveness and long-term sustainability;
- (d) Inadequate capacity and capability for data collection and monitoring, leading to gaps in the mercury inventories that inform decisions on policy and mitigation strategy;
- (e) Limited access to alternative technologies, both because of financial constraints and because of domestic unavailability of suitable technologies.

3. Key insights into how parties' uptake of alternative technologies could be enhanced include the following:

- (a) *Feasible alternative technologies are available for many of the major mercury source categories covered by the Convention.* Projects under the Global Environment Facility (GEF) and the Specific International Programme to Support Capacity-Building and Technical Assistance, as well as initiatives such as the Global Mercury Partnership, provide evidence of progress in transitioning from pilot projects to nationwide adoption of respective technologies, delivering measurable reductions in mercury use, emissions and releases. The case studies in the report provide several examples of this.
- (b) *National reports submitted by parties pursuant to article 21 are a key source of information for assessing challenges and progress under the Convention, including alternative technology and technical transfer issues.* Analysis of national reports submitted by parties and recent project funding trends reported by GEF highlight the fact that demand for alternative technologies exists in specific sectors, including artisanal and small-scale gold mining; mercury-added products, including in the lighting and health care (transition to mercury-free medical devices and dental amalgam) sectors; non-ferrous metals production; the cement industry; mercury waste management; and the chlor-alkali industry. In many cases information is limited, however, as parties formulate their national report responses in general terms, often noting a lack of “resources” or “capacity” without naming a specific need such as equipment, skills, funding or infrastructure.
- (c) *Effective technology transfer requires supportive policies, institutional readiness, training and monitoring of progress.* Technology transfer also requires financing and collaboration between the various stakeholders, including the donor and beneficiary parties, on mutually agreed terms. Overall, a lack of technical and institutional capacity, insufficient funding and limited access to alternative technologies are key challenges identified by parties in their national reports with respect to technology transfer under the Convention. Such barriers in turn affect parties' ability to conduct inventories, acquire alternative technologies, build the necessary infrastructure, develop regulatory frameworks and enhance their national institutional absorptive capacity. Lessons from case studies further underscore the importance of an enabling environment for technology adoption.
- (d) *Collaboration with related multilateral environmental agreements and frameworks contributes to technology transfer and thus to overall progress in achieving the objective of the Minamata Convention on Mercury.* The study highlights the advantages and importance of technical cooperation with related frameworks, such as the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade and the Stockholm Convention on Persistent Organic Pollutants, including the respective Basel and

Stockholm convention regional centres, for the implementation of the Minamata Convention. In addition, the Conference of the Parties has repeatedly recognized the importance of the technical work conducted by the Global Mercury Partnership, which produces guidance, data and pilot projects through its work in support of the overall implementation effort. There is scope to extend this type of cooperation to other multilateral environmental agreements and frameworks.

(e) *Specific needs, barriers and opportunities related to technology transfer should be further assessed to support parties in implementing the Convention.* Developing-country parties and parties with economies in transition can request the secretariat to facilitate assistance to them, as provided for in paragraph 2 (b) of article 24, including with respect to matters pertaining to technology transfer. In addition, a Convention-wide survey could be conducted to gain a better understanding of specific technology needs, barriers and opportunities. This could be part of a separate exercise that builds on the information provided in the national reports.

II. Introduction

A. Mandate

1. This desk study report is prepared in response to the obligations set forth in article 14 of the Minamata Convention on Mercury, which mandates parties to cooperate in providing technical assistance and technology transfer¹, particularly for least developed countries (LDCs), small island developing states (SIDS), and countries with economies in transition. This report relates to the further requirement, in paragraph 4 of article 14, for the Conference of the Parties (COP) to regularly assess progress, consider parties' needs for alternative technologies, identify challenges in technology transfer, and make recommendations for strengthening support mechanisms.

2. Decision MC-5/12 'Capacity-building, technical assistance and technology transfer' provided a specific mandate to examine ongoing technology transfer initiatives that facilitate the adoption of alternative technologies. Paragraphs 1 and 2 specifically requested the secretariat to develop this desk study, and case studies on (a) existing initiatives and progress made in relation to alternative technologies, including private-sector engagement; (b) the needs of parties, particularly developing-country parties, for alternative technologies; (c) any challenges experienced by parties.

3. Under the mandate provided by the COP the secretariat engaged in a cooperation agreement with the United Nations Institute for Training and Research (UNITAR) to prepare this report. The work was funded from the contribution of Japan to the Special Trust Fund of the Minamata Convention on Mercury in the biennium 2024–2025.

B. Objectives and scope

4. This desk study addresses aspects of technology transfer under the Minamata Convention on Mercury, with a view to provide insights and understanding of the transfer and diffusion of up-to-date alternative technologies at the global level. By examining the needs of developing-country parties, reviewing the progress of existing initiatives, and identifying challenges, the study provides insights to enhance the uptake of alternative technologies by parties.

5. It should be noted that this report provides a general overview of technology transfer initiatives related to mercury-free alternatives, rather than an exhaustive analysis of all available technologies. It highlights key examples and trends while recognizing that a comprehensive evaluation of every alternative technology is beyond its scope.

C. Methodology

6. This desk study's methodology is guided by decision MC-5/12.

7. First, in sections III – VI, a desk review was conducted, drawing on national reporting under the Minamata Convention on Mercury, selected Global Environment Facility project documentation, and resources from the Global Mercury Partnership, regional centers of the Basel and Stockholm Conventions, Indigenous Peoples' organizations, and other relevant stakeholders. The desk review

¹ Technology transfer is not defined in the text of the Minamata Convention. The UN's glossary of Terms for Negotiators of Multilateral Environmental Agreements defines technology transfer as 'Technology transfer means the transmission of know-how, equipment and products to governments, organizations or other stakeholders. It usually also implies adaptation for use in a specific cultural, social, economic and environmental context.' This will be used as the working definition for this report.

focused on (i) analyzing the specific needs of parties that are developing countries and parties that are countries with economies in transition, (ii) reviewing current initiatives and progress in technological alternatives, and (iii) identifying challenges in technology transfer and exploring solutions. Based on the review, key themes and trends were identified with a focus on the needs of parties that are developing countries and countries with economies in transition.

8. Second, in section VII, case studies were selected to highlight practical examples and lessons learned, with emphasis on (a) existing initiatives and progress made in relation to alternative technologies, including private-sector engagement; (b) the needs of parties, particularly developing-country parties, for alternative technologies; (c) any challenges experienced by parties. These case studies highlight how specific initiatives have tackled challenges, the impact they have achieved, and the potential for their replication or scaling-up.

9. Section VIII sets out key findings to inform the Conference of the Parties on matters related to paragraph 4 of article 14. Where deemed relevant, outreach to selected stakeholders² helped validate the findings and clarify contextual details. The contact information of the stakeholders is provided at the end of the report.

III. Existing initiatives and progress made in relation to alternative technologies, including private-sector engagement

10. A growing body of work is demonstrating that available technical alternatives to mercury now exist for major source category addressed by the Convention, albeit aspects of accessibility and economic feasibility may remain challenging. Dozens of projects captured on the Convention's public project dashboard³ show steady expansion since entry into force, ranging from industrial conversions to community-level pilots.

11. Legally binding requirements of the Minamata Convention on Mercury along with the multilateral financing can be considered key drivers of this progress. Since GEF-5 the Global Environment Facility (GEF) has allocated more than USD 500 million to mercury projects. These projects cover, inter alia, artisanal and small-scale gold mining, manufacturing processes using mercury, product phase-outs, and emission control. An online GEF mercury project dashboard provides full details and status updates of these projects. Complementing the GEF, the Specific International Programme (SIP) offers small, high-impact grants (USD 80 000 to USD 250 000 per project) that, among other things, allow parties to test alternatives. These projects include, among others, LED-lamp crushing lines⁴, laboratory upgrades for mercury analysis⁵, or mercury-free gold-processing⁶. They also aim to build the regulatory and technical capacity needed to scale these technologies up. A searchable list of Specific International Programme projects is maintained on the Convention website⁷. This is further discussed in section VI of this report.

12. The UNEP Global Mercury Partnership (GMP) plays an important role in supporting the Minamata Convention's objectives through developing technical guidance, knowledge exchange, and capacity-building initiatives. Currently, the Partnership includes close to 300 partners from governments, intergovernmental organizations, NGOs, industry, academia, and the scientific community, all committed to reducing mercury pollution and protecting health and environment. In practice, the GMP develops guidance materials, toolkits, and training modules, and facilitates information-sharing networks to disseminate best practices and technical knowledge. These resources, ranging from mercury inventory toolkits to sector-specific guidelines, help parties and stakeholders implement the Convention's provisions by informing policy development and practical measures. Through workshops, webinars, and published documents on best practices, the Partnership raises awareness and builds technical expertise in mercury management. The GMP's eight thematic work areas serve as collaborative hubs for developing and sharing specialized knowledge, assisting parties in having access to latest scientific information and tools to meet their commitments. These areas include:

² Identified in paragraph 1 of decision MC-5/12

³ <https://minamataconvention.org/en/projects/overview?utm.com>

⁴ 'Strengthening capacity to promote phasing-out of mercury-added products (lamps) in Armenia' - SIP, Round 1

⁵ 'Strengthening national laboratory for the analysis and evaluation of mercury in the environment (Cuba)' - SIP Round 1

⁶ "Reducing mercury use in artisanal and small-scale gold mining in Bolivia through improved processing technologies and formalisation" - SIP Round 2

⁷ <https://minamataconvention.org/en/projects/list>

- artisanal and small-scale gold mining,
- mercury releases from coal combustion,
- mercury-cell chlor-alkali production,
- mercury in products,
- mercury air transport and fate research,
- mercury waste management,
- mercury supply and storage, and
- mercury releases from the cement industry.

13. The GMP brings together diverse stakeholders while pooling their expertise and resources. Developed countries and industry partners within the Partnership share best available techniques (BAT) and innovative mercury-free technologies with developing country counterparts, while academia and NGOs contribute research, training, and outreach that help adapt these solutions to local needs. This multi-sector engagement helps in the transfer and diffusion of latest technologies for mercury reduction, directly supporting article 14 of the Convention. Ongoing collaboration through the Partnership, including development of guidance documents, exchange of scientific data, and technical assistance projects, ensures that new knowledge and tools are effectively communicated. By leveraging its broad network of partners, the GMP builds capacity in mercury monitoring and control, and serves as an important player for global technology transfer in mercury management. The Conference of the Parties has repeatedly recognized the importance of the technical work undertaken by the Partnership and encouraged it to continue supporting the parties through its work.

14. The successful implementation of the Minamata Convention increasingly depends on international cooperation, particularly with other conventions and institutions that address chemicals and waste issues. Over the years, cooperation between the secretariat of the Minamata Convention on Mercury and the secretariats of the Basel, Rotterdam, and Stockholm (BRS) Conventions has become especially important for areas of technical cooperation, compliance mechanisms, and scaling up technology transfer efforts. In the recent years, the Minamata Convention and BRS conventions secretariats have significantly expanded their cooperation through joint programming, shared events, coordinated trainings, and technical assistance. Under decision MC-5/19 and relevant BRS decisions BC-16/21, RC-11/8 and SC-11/20, the two secretariats are mandated to collaborate across key areas such as:

- (a) Technical assistance and capacity building, including the joint development of training materials and webinars;
- (b) Implementation and compliance coordination, particularly in preventing illegal traffic of hazardous mercury waste;
- (c) Trade control and policy alignment;
- (d) Shared use of services for conferences and knowledge management platforms, ensuring cost-efficiency and consistency.

15. An example of this cooperation is the joint webinar series on mercury waste management, organized in 2024 with support from Switzerland. These webinars brought together experts, regional centres, and parties to promote understanding of mercury waste guidelines under both the Minamata and Basel Conventions⁸. The training materials were developed in consultation with the Global Mercury Partnership, Basel Convention regional centres, as well as other global partners. The initiative is a good example which demonstrates how coordinated approaches to technical training can enhance the capacity of parties to adopt and transfer appropriate technologies.

16. The regional centres established under the Basel and Stockholm Conventions have played an important part in the implementation of the Minamata Convention on Mercury. These centres have actively supported several parties in the development of Minamata Initial Assessments (MIAs) and assisted several parties in preparing National Action Plans (NAPs). More recently, the Centres have played an active role in developing GEF projects and acting as the executing partners.

17. Going forward, parties may wish to explore with the regional centres how they could play a bigger role in supporting technology transfer, such as sharing knowledge (e.g. regional knowledge hubs), developing technical capacity (e.g. in developing/updating mercury inventories/monitoring emissions) and delivering technical training.

⁸ <https://minamataconvention.org/en/news/capacity-building-material-mercury-waste-management-available-six-un-languages>

18. The Minamata Convention secretariat is invited to and regularly participates in the annual joint meetings⁹ between the directors and coordinators of the Basel and Stockholm Conventions regional centres. This has helped build a foundation for greater collaboration, and continued collaboration could strengthen regional capacity and potentially improve technology transfer. The growing cooperation can leverage technical expertise to ensure more coherent support to parties while avoiding duplication.

19. Building on the financing and cooperation mechanisms outlined above, parties are now putting specific mercury-free technologies into practice. Within these various initiatives, a series of concrete technical alternatives are now being adopted. Mercury-free LED lighting has moved from niche to mainstream; evidence by commitment of parties to a full global phase-out of most fluorescent lamps by 2027, with manufacturers already supplying drop-in LED replacements in all major markets¹⁰. In the health sector, hospitals are replacing mercury thermometers and blood-pressure devices with digital alternatives. Dentists are also moving towards mercury free dentistry. The multi-country planetGOLD¹¹ programme supplies gravity concentration, direct-smelting and other mercury-free processing technologies to artisanal and small-scale gold mining communities, pairing the hardware with micro-credit and risk-sharing mechanisms from local financial institutions. GEF projects on chlor-alkali sector build on the private sector initiative to convert from mercury cell technology to mercury-free membrane technologies. A GEF project is also piloting sulphur-polymer stabilisation and interim-storage facilities to ensure residual mercury is managed safely and does not re-enter commerce.

20. Taken together, and demonstrated by the case studies in the report, these initiatives listed above confirm that technical alternatives are commercially available, becoming affordable and already delivering measurable reductions in mercury use and releases. The combination of multilateral finance, GMP-led knowledge exchange and tools, and active private-sector engagement is proving effective in moving them from pilot stage to national scale. Continued expansion of the GEF and Specific International Programme pipelines, deeper industry participation, and sustained capacity-building and technical assistance will be important to maintain this momentum and to ensure that all parties, particularly developing-country parties, can access and adopt mercury-free technologies according to their national priorities.

IV. Needs of parties, especially developing-country parties, for alternative technologies

21. At present, we do not have a clear picture of exact needs of developing country parties vis-à-vis alternative technologies. The information submitted by parties in their national reports (under article 21) are helpful, but they speak in general terms, often noting a lack of “resources” or “capacity” without naming the specifics e.g. equipment, skills, cost or infrastructure required. As a result, there is insufficient data on what technologies are needed, where, and by when. This information gap makes it harder to match technical support and funding with the actual demand on the ground.

22. Some information from project proposals sent to the Global Environment Facility and the Specific International Programme can provide further insight into the needs of the parties. However, these proposals show only part of the picture: some needs never reach the proposal stage, and not every project put forward is approved.

23. A way to close the information gap and narrow down the scope for further specific interventions to support parties could be to look at how the Stockholm Convention on Persistent Organic Pollutants already gathers technology-transfer data and consider whether this model is suitable for the Minamata Convention on Mercury. The online needs-assessment questionnaire is done every two to three years. The secretariat reviews the completed questionnaires and consolidates the findings into a report that tracks progress in delivering technical assistance, strengthening capacity, and transferring alternative technologies to parties.

⁹ cooperation and coordination between the secretariats of the Basel, Rotterdam and Stockholm conventions and the Minamata convention on mercury” (unep-mc-cop.5/inf/28, 2023).

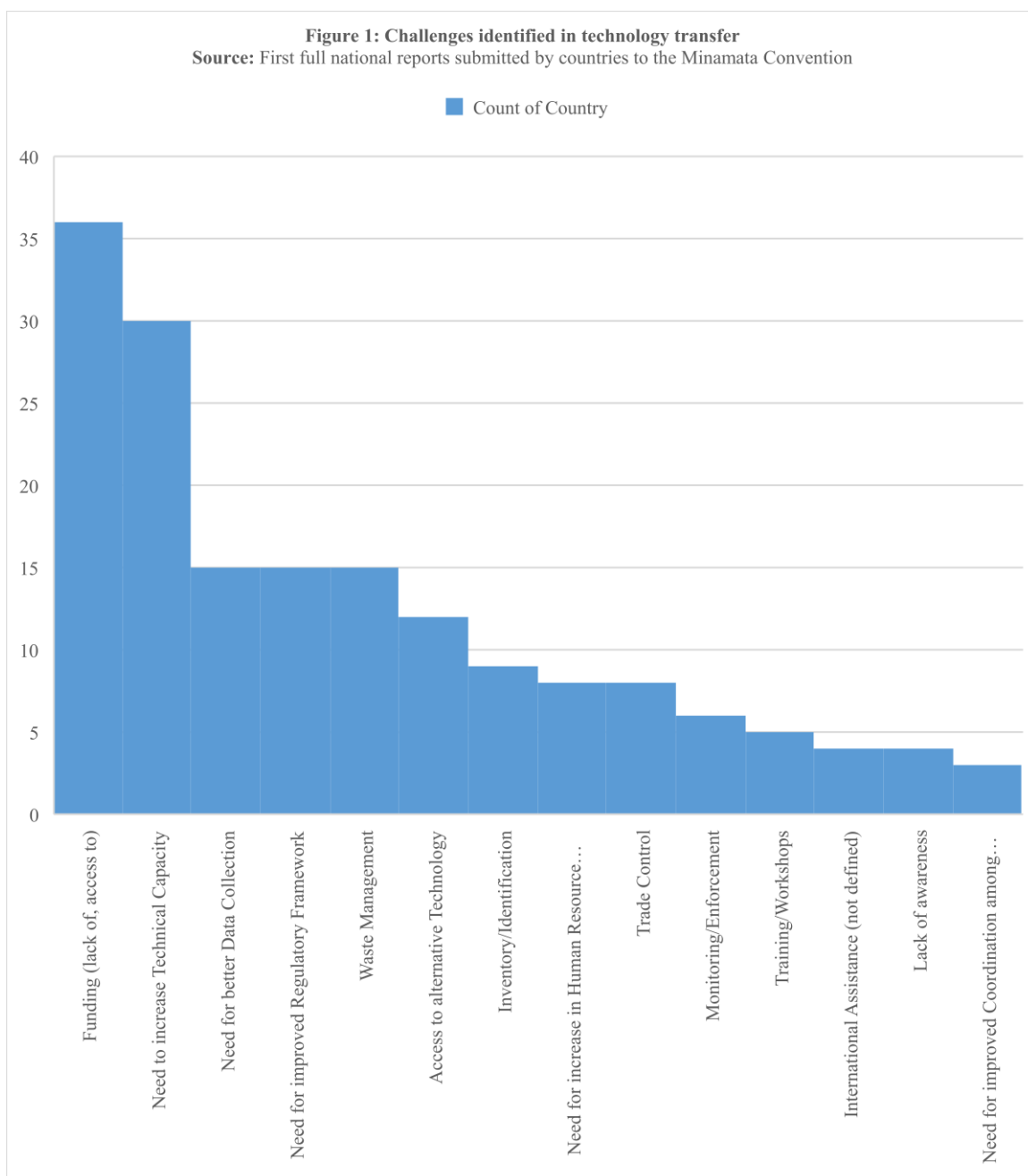
¹⁰ <https://www.clasp.ngo/campaign/clean-lighting-coalition/farewell-to-fluorecents/cop5-decision/?utm.com>

¹¹ <https://www.planetgold.org>

V. Analysis of challenges and key barriers

24. The challenges pertaining to alternative technology transfer and adoption under the Minamata Convention on Mercury are multifaceted, encompassing systemic, institutional, technical, and financial barriers. For this report, these obstacles have been identified through a review of the national reports¹² submitted by parties, which provide insights into their specific experiences in implementing the Convention. The data reflects a range of shared issues faced by parties globally. A full set of these reports, which form the foundation of this analysis in this section, is published on the website of the Minamata Convention on Mercury¹³. The focus of this section is to identify challenges parties face regarding the adoption of alternative technologies.

25. Through the examination of individual national reports, thematic categories were developed and identified. These included issues such as “lack of funding or limited access to funding”, and the “need for access to alternative technologies”. Not all reports provided specific details. Some parties indicated general “lack of resources” without clearly specifying the type of resources needed. In such cases, the context determined the appropriate categorization.



¹² Unless specified, national reports mean first and second short national reports and first full national reports submitted by parties.

¹³ <https://minamataconvention.org/en/parties/reporting>

26. Additionally, challenges identified by parties did not always relate to alternative technology transfer and adoption as national reports asked for parties to provide general challenges in the implementation of the Convention. Therefore, only the alternative technology transfer and adoption related issues were included in the analysis. Furthermore, differences exist when discussing challenges related to technology transfer; for example, challenges associated with waste management technologies differ from those related to coal combustion technologies. Nevertheless, this analysis attempts to identify overarching themes, with additional information provided in the case studies.

27. In the analysis of the first full national reports, funding emerges as the most prevalent challenge, cited by 36 parties, reflecting a gap between the necessary resources and their availability or accessibility. Technical capacity closely follows as a significant challenge, identified by 30 parties. Another key challenge is the inadequate capability for data collection and monitoring, reported by 15 parties. Similarly, regulatory frameworks and waste management infrastructures are major concerns, each highlighted by 14 countries. Further issues highlighted include limited access to alternative technologies (12 parties), indicating both financial constraints and the limited domestic availability of suitable technologies. Ten parties highlighted inventory and identification challenges, emphasizing gaps in reliable mercury use and contamination data, while nine parties stressed the importance of skilled personnel to effectively implement alternative technologies. Other challenges cited include trade control issues, training deficits, ambiguities in international assistance mechanisms, insufficient public awareness, and inadequate inter-agency coordination.

28. The above-mentioned challenges are further discussed in detail in the sections below.

A. Financial barriers

29. A consistent and prominent theme across national reports is the lack of financial resources, which remains the most significant barrier to effective technology transfer identified by parties. Parties that are developing countries and countries with economies in transition repeatedly emphasize that without adequate funding, it will be difficult to meet their obligations under the Convention. Support from the Global Environment Facility and the Specific International Programme has played an important role in helping many parties advance implementation of the Minamata Convention on Mercury. While this assistance has enabled important progress, there remains a need to strengthen and expand such funding, as current resources may be limited and competitive to access.

30. The financial challenges parties face are wide-ranging. Several parties highlighted difficulties in accessing both national and international financing for key activities such as inventories, development of action plans, acquisition of mercury-free technologies, and construction of appropriate waste management infrastructure. For example, high costs associated with the treatment and final disposal of mercury waste were noted by Argentina and Lesotho, particularly in parties lacking local facilities and needing to export hazardous waste.

31. Some parties also noted that even when funds are potentially available through international mechanisms, structural and political challenges, such as language barriers or lack of familiarity with donor procedures, can impact access.

32. The analysis of national reports also shows that financial barriers extend beyond the availability of funds. They may involve challenges related to accessing financing, aligning it with national priorities, and having the institutional capacity to effectively manage and utilize resources.

33. One of the barriers identified for technology transfer is the difficulty in accessing alternative technologies. Transitioning away from mercury use in industries, artisanal and small-scale gold mining, and consumer products often requires substantial investment in new technologies and the upfront costs are usually unaffordable. Examples highlighted include:

(a) Artisanal and small-scale gold miners continue to rely on mercury because alternative processing methods may require costly infrastructure and training.

(b) Industries that use mercury in manufacturing (chlor alkali) face high costs when replacing outdated processes with cleaner alternatives.

34. The financial burden of acquiring and maintaining alternate technology discourages widespread adoption, particularly in low-income economies. However, blended-finance models are helping parties bridge that gap. These mechanisms reduce risk for commercial lenders and bring down the effective cost of technology for end users (see case study on artisanal and small-scale gold mining).

B. Availability of alternative technologies

35. Availability of technology is improving as supply chains evolve although many developing countries do not have local industries producing mercury-free products or equipment, forcing them to import these solutions.

36. Dependence on foreign suppliers results in additional expenses related to shipping, customs duties, and compliance with international trade regulations. Moreover, some parties note that trade restrictions that limit access to environmentally friendly technologies, further complicating their efforts to implement the Minamata Convention on Mercury.

37. The absence of cost-effective and locally accessible solutions prolongs mercury reliance and slows the transition to cleaner alternatives. Furthermore, the informal and often unregulated nature of the artisanal and small-scale gold mining sector, along with a lack of comprehensive data on mining practices, further complicates the adoption and scaling up of mercury-free alternatives.

C. Institutional capacity for technology adoption

38. Even when alternative technologies are available, parties may lack the institutional capacity to adopt and implement them effectively. Government agencies responsible for environmental regulation may not have the technical expertise to evaluate, adopt, and integrate new alternative technologies into national policies. A shortage of trained professionals, including engineers, chemists, and industrial technicians, may make it difficult to install, operate, and maintain pollution control technologies. In cases where advanced equipment is imported, the lack of local expertise can result in poor implementation or even failure to utilize the technology properly.

39. Additionally, fragmented coordination among various government agencies may undermine the effective integration of new technologies, resulting in inconsistent enforcement and oversight.

40. Absence of formal mechanisms for technology assessment and approval can also be attributed to institutional weakness. Parties may not have standardized guidelines or certification processes to validate alternative technologies before they are introduced into the market. Without clear regulatory frameworks, industries may hesitate to invest in new technologies due to concerns over compliance, effectiveness, and long-term sustainability.

41. The lack of structured knowledge-sharing platforms can further hamper progress, as governments and businesses struggle to access best practices, case studies, and technical training needed for successful technology adoption.

D. Mercury waste management, interim storage and disposal

42. All parties have to manage mercury waste and technology transfer plays an important role in implementing the articles 11 and 12 on mercury waste and contaminated sites respectively.

43. While reporting in the first full national reporting cycle, at least 15 parties have identified that they lack the infrastructure necessary to handle mercury-contaminated materials in an environmentally sound manner. In several regions, hazardous waste, including mercury waste from industrial processes and consumer products, is mixed with general municipal waste due to the absence of specialized treatment facilities. This leads to uncontrolled mercury releases into the environment, contaminating soil and water sources.

44. For countries without domestic disposal facilities, an option is to export mercury waste to specialized treatment facilities in other countries. However, exporting waste across borders is expensive and must comply with international rules, including those established by the Basel Convention. The financial burden of shipping and treatment fees makes this an unfeasible solution for many governments. As a result, mercury waste often accumulates in unsafe storage conditions or is disposed of improperly, increasing long-term environmental and health risks.

45. This finding is further supported by data from the second short national reports submitted by parties to the Minamata Convention on Mercury. In response to question 11.2 "Are there facilities for final disposal of waste consisting of mercury or mercury compounds in the party's territory?" a significant number of parties, including countries in Africa, Eastern European states (EES), and Latin America and Caribbean countries (GRULAC), responded "No". As illustrated in the figure 2, only two parties in Africa answered "Yes" compared to 25 that responded "No". Similarly, all 15 responding parties from the EES region indicated they lack such facilities.

46. Another issue identified in the national reports was the inefficiency of waste management, including mercury recycling and recovery programs. Parties usually lack structured collection systems for products such as fluorescent lamps, batteries, and thermometers that contain mercury. Public awareness regarding safe disposal methods remains low, leading to widespread mismanagement of mercury waste. Without the proper infrastructure to support waste management, efforts to phase out mercury-added products remain ineffective.

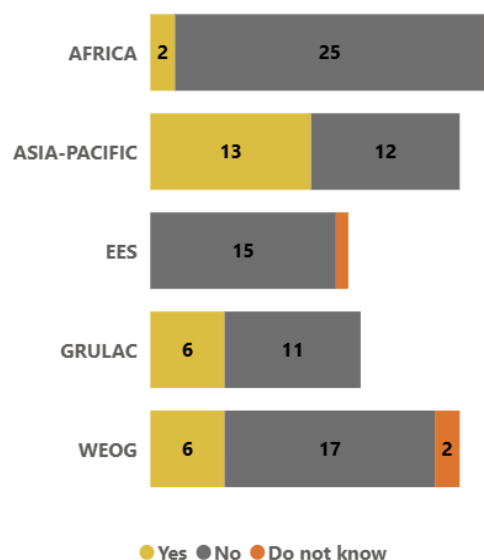
E. Gaps in monitoring and enforcement

47. Parties increasingly recognise that modern monitoring technologies are essential for enforcement and compliance. Portable mercury vapour analysers, passive air samplers, continuous-emissions monitoring systems (CEMS) and GIS-based inventory tools now feature in many GEF¹⁴ and SIP projects. For example, SIP grants to Cuba and Benin equipped national laboratories with state-of-the-art analysers, while the planetGOLD programme supplies handheld detectors for routine checks at artisanal and small-scale gold mining sites. Even so, roughly one-third of parties still report needs for better data collection, inventories or monitoring equipment in their first full national reports, signaling that uptake requires further assistance.

48. Industrial facilities, such as coal-fired power plants, cement factories, and metal smelters, require advanced filtration and scrubber technologies to control mercury emissions. However, some facilities continue to operate without these controls due to the high cost of retrofitting existing plants with modern emission-reduction technologies. In cases where countries attempt to enforce emission

Figure 2: Regional breakdown: Are there facilities for final disposal of waste consisting of mercury or mercury compounds in the Party's territory

Source: Second short national reports



¹⁴ GEF report to COP-5 – “Activities of the Global Environment Facility in the mercury area” (UNEP/MC/COP.5/INF/7, 2023).

regulations, industries may resist compliance due to financial constraints or the perceived complexity of adopting new equipment. In some cases, the lack of mandatory reporting mechanisms further weakens enforcement, allowing mercury emissions to persist unchecked.

49. Law enforcement and regulatory agencies also face difficulties in monitoring illegal mercury trade and its unregulated use. The continued availability of mercury in informal markets fuels its use in artisanal mining and other small-scale applications. Smuggling and illicit trade remain major challenges, as authorities may lack the technical tools and resources to track shipments effectively. However, technical solutions do exist: the guidance document on developing a National Action Plan to reduce and, where feasible, eliminate mercury use in artisanal and small-scale gold mining¹⁵ recommends frontline technologies such as handheld X-ray-fluorescence (XRF) analysers for rapid screening at borders, along with QR-code or blockchain-based tracking systems that record mercury movements from source to destination. Wider deployment of these tools depends on sustained procurement budgets and user training. Strengthening these frontline technologies will help parties intercept illegal flows and discourage informal markets.

50. Robust, affordable monitoring tools are important since without the data they provide, countries cannot prioritise, finance, or enforce the mercury-free alternatives identified in this study.

F. Regulatory barriers

51. Even in cases where technical solutions exist, regulatory frameworks may hinder their adoption. Some parties mentioned that they have not fully incorporated the provisions of the Minamata Convention into their national laws, creating gaps in enforcement and compliance. In some cases, outdated legislation does not provide clear guidelines on mercury phase-out timelines, technology standards, or penalties for non-compliance. The absence of well-defined regulations may lead to uncertainty among industries and businesses, slowing the transition to alternative technologies.

52. Another issue is the slow pace of policy implementation. Sometimes the process of developing and enacting environmental regulations is time-consuming and bureaucratically complex. Limited government capacity and competing policy priorities further delay the introduction of new mercury control measures. Without strong legal mandates and institutional backing, efforts to phase out mercury through technology transfer remain inconsistent and poorly enforced.

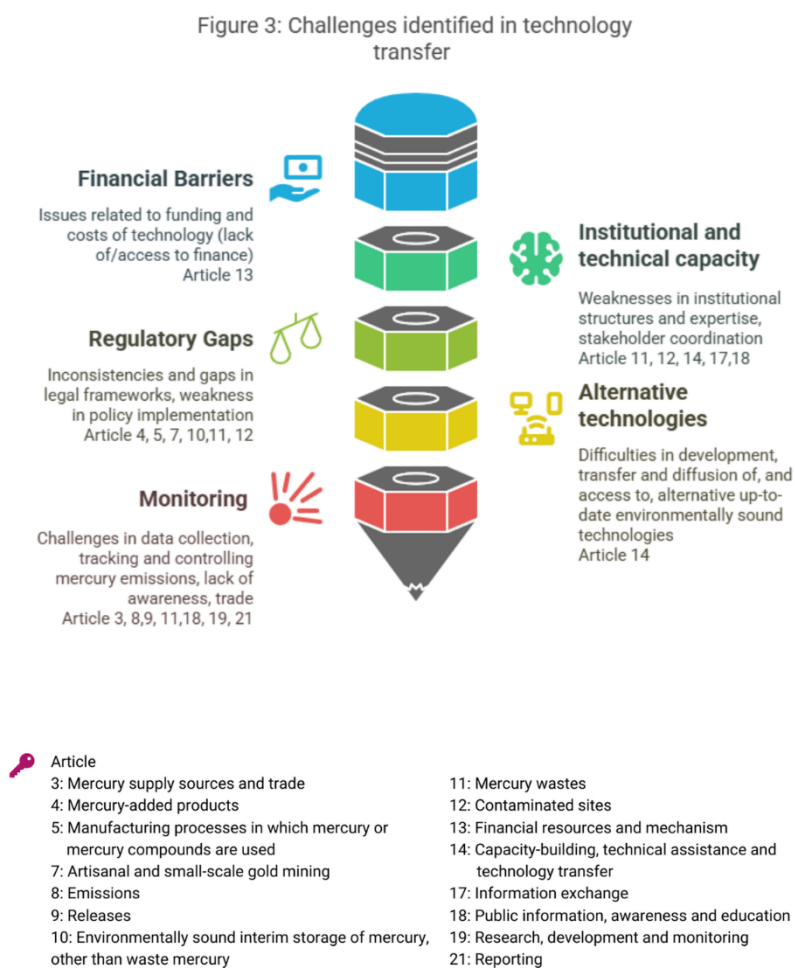
53. The fragmentation of responsibilities across multiple government agencies can also create inefficiencies in mercury management. In several cases, regulatory oversight is split between environmental, health, and trade authorities, leading to coordination challenges. The lack of an integrated approach means that technology transfer efforts are often disjointed, with various stakeholders working in isolation rather than through a comprehensive, cross-sectoral strategy.

54. Moreover, aligning national regulations with regional economic frameworks adds an additional layer of complexity, often requiring periodic renewals and creating administrative burdens that impede long-term planning.

¹⁵ https://minamataconvention.org/sites/default/files/2021-06/NAP_guidance2018_EN.pdf

G. Preliminary findings of challenges in technology transfer

55. The challenges in technology transfer, as identified through the analysis of national reports, can be, inter alia, institutional, regulatory, financial, and technical. Parties face interrelated barriers, including limited access to funding, regulatory gaps, weak institutional capacity, poor waste management infrastructure, inadequate data and monitoring systems, and restricted availability/access of alternative technologies (see figure 3). These areas are closely linked, and progress in one often depends on improvements in the others.



56. Importantly, technology transfer is not a uniform process and varies significantly across sectors. For example, replacing mercury-added products in healthcare requires different technologies, actors, and regulatory frameworks than managing emissions from coal-fired power plants or reducing mercury use in artisanal and small-scale gold mining. These sectoral differences mean that technology transfer must be context-specific, tailored to national priorities, technical realities, and institutional arrangements.

57. Moreover, the challenges identified can be mutually reinforcing, creating systemic obstacles. Financial constraints may limit the ability to invest in monitoring equipment, while the absence of trained personnel may reduce the effectiveness of imported technologies. Regulatory fragmentation and unclear mandates may make things more difficult. If not addressed in an integrated and coordinated manner, support for technology transfer risks becoming fragmented and ineffective.

58. These findings show the need for holistic approach to technology transfer, which can simultaneously look at financial, institutional, legal, and technical dimensions. Tailored support should reflect the specific needs and capacities of parties, particularly those of developing countries and countries with economies in transition.

VI. Financial mechanism and technology transfer

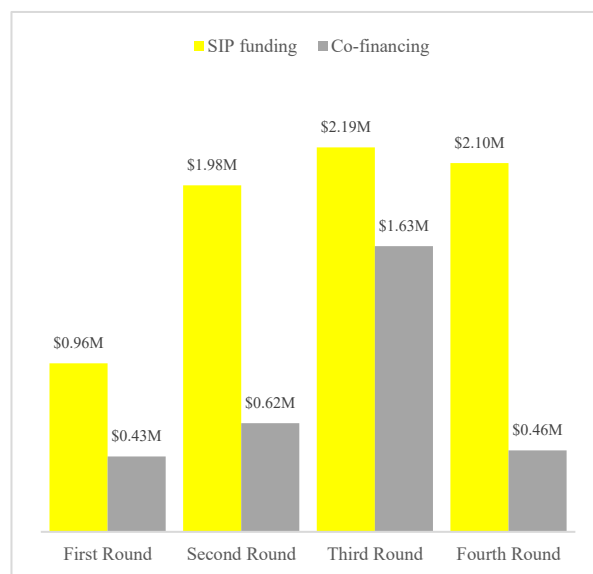
59. Article 13 of the Minamata Convention on Mercury established a financial mechanism with two main components: the Global Environment Facility (GEF) Trust Fund and a Specific International Programme. The GEF, as a trust fund, finances larger projects, many of which have technology

transfer elements (e.g. introducing mercury emission control devices in industries, developing mercury-free healthcare practices, etc.). For every COP, the GEF provides a comprehensive report of its activities and GEF's work in fulfilling their mandate under the Convention. Detailed information about the projects can be found in these reports and on GEF's website.

60. The Specific International Programme is a smaller grants programme aimed specifically at capacity-building and technical assistance on the ground. The funded projects are typically small-scale, high-impact grants that address needs which may be too small for the GEF, but important for enabling parties to implement the Convention and prepare for larger interventions. In the first three rounds of applications to the SIP, there were 63 total project applications of which 24 were approved with a total funding of 5.13 million USD. The grants by Specific International Programme have been successful in addressing some of the urgent gaps (inventories, legal drafts, targeted training) in technology transfer and helped prepare parties to seek larger GEF or bilateral funding¹⁶. However, demand continues to far exceed available resources, with 36 applications of which on 10 were approved for funding the latest fourth round of application.

61. Through four rounds of applications (2018–2024), the SIP has funded projects that contributed to adoption of technical alternatives. For example, one approved SIP project in Iran focuses on phasing out mercury-containing lamps by improving local capacity to adopt LED and other alternatives. Other SIP projects included developing laboratories for mercury monitoring and promoting mercury-free artisanal gold mining equipment. This emphasis on technology transfer directly addresses key barriers highlighted in the national reports, notably the lack of access to mercury-free alternatives and weak capacity to adopt new technologies, by equipping parties with the tools, infrastructure and know-how needed to reduce mercury use.

Figure 4: Funding in four rounds of the SIP



VII. Case studies

62. Decision MC-5/12 requested that the present desk study illustrates case studies which showcase (a) existing initiatives and progress made in relation to alternative technologies, including private-sector engagement; (b) the needs of parties, particularly developing-country parties, for alternative technologies; and (c) any challenges experienced by parties.

63. In line with this mandate, potential case studies were first mapped through the desk review and stakeholder outreach, then selected if they had direct relevance to mercury-related technology transfer with demonstrable impact on mercury reduction. Regional balance, private sector involvement and potential for scalability were additional factors considered while choosing the case studies.

64. Although no single example reflects every national circumstance, taken together these cases address some of the needs and challenges identified by parties and offer practical, replicable pathways for overcoming them.

¹⁶ UNEP/MC/COP.5/11/Add.1 “Overall report on the Specific International Programme to support capacity-building and technical assistance”

Case study 1: De-risking investment in the artisanal and small-scale gold mining sector in Colombia: creating an enabling environment for private sector participation and improving access to finance

65. In Colombia¹⁷, artisanal and small-scale gold miners have faced significant challenges in accessing formal financial services. The informal nature of their operations, coupled with a lack of legal documentation and financial records, had made it difficult for banks and microfinance institutions to assess their creditworthiness. Before the intervention of the planetGOLD¹⁸ program, financial institutions did not explicitly cater to artisanal and small-scale gold mining operators, and where miners could access financing, it was often under unrelated commercial activities such as agriculture or trade. The predominant use of cash within the sector further complicated the situation, as it left miners without formal transaction records, making it nearly impossible for them to demonstrate their profitability to lenders. The perceived high default risk and concerns over environmental, social, and governance (ESG) compliance reinforced the financial exclusion of artisanal and small-scale gold mining operators.

66. PlanetGOLD Colombia launched a targeted intervention to bridge the financial gap for small-scale miners. A key aspect of the strategy was engaging with existing financial institutions to educate them about the artisanal and small-scale gold mining sector and its potential as a viable investment opportunity. Among the steps taken was the establishment of a partnership with the Cooperative Financier of Antioquia (CFA), a microfinance institution that was more accessible to mining communities than traditional banks. To mitigate risk and encourage lending, planetGOLD Colombia provided a USD 66,000 loan guarantee, which covered up to 30% of potential losses incurred by CFA. This guarantee was instrumental in convincing CFA to develop tailored financial products for artisanal and small-scale gold mining operators, ultimately resulting in 49 loans worth USD 307,229 being granted to miners.

67. In addition to providing financial access, planetGOLD Colombia worked to increase financial literacy and capacity-building among miners. Recognizing that many artisanal and small-scale gold mining operators lacked experience in formal financial management, the program facilitated a series of financial literacy trainings, delivered both by CFA and VITAL, a local microfinance institution specializing in community-based lending. These trainings covered topics such as record-keeping, savings, and business planning, equipping miners with the necessary knowledge to manage loans responsibly. The initiative extended beyond traditional banking services, as CFA account holders were also granted life insurance, a funeral plan, and a financial lien tax exemption, making formal financial products more attractive to miners.

68. To extend financial inclusion to remote regions, planetGOLD Colombia also established peer-to-peer savings and credit groups in collaboration with VITAL. These groups provided an alternative to formal banking, allowing miners to pool resources and access credit on a community level. Over time, these efforts led to USD 55,000 in savings, with 100 members accessing loans totalling USD 25,000. The microloans, which averaged USD 100 per person, were particularly beneficial for small-scale miners especially women miners, who often faced the most significant barriers to financing.

69. A major focus of the intervention was ensuring gender inclusivity in financial access. Women miners, who were traditionally excluded from financial services due to structural barriers such as lack of collateral, received targeted support through financial education and credit mechanisms. Through the peer-to-peer loan groups, planetGOLD Colombia reached 1,193 individuals, 80% of whom were women.

70. Policy-level engagement also played an important role in ensuring the long-term sustainability of financial access for artisanal and small-scale gold mining miners. PlanetGOLD Colombia contributed to the establishment of a Financial Inclusion Roundtable, a multi-stakeholder platform led by the Ministry of Mines and Energy (MME). This initiative facilitated national dialogue on financial inclusion and resulted in the development of Colombia's Financial Inclusion Strategy for artisanal and small-scale gold mining. Additionally, in 2023, Colombia partnered with Ecuador in a benchmarking

¹⁷ The information in the case study is based on the document "Sturmes-Verbeek, D., Jumwa, C., Arias, C., and Gómez, K. (2024). *Cross-programmatic analysis and identification of best practices: ASGM financial inclusion efforts for planetGOLD phase 1 countries*. United Nations Environment Programme"

¹⁸ Additional information about the program can be found on <https://www.planetgold.org>. Furthermore, document UNEP/MC/COP.5/INF/7 provides a summary of information stemming from the experience gained to date in the first eight country projects of the planetGOLD programme.

exchange, fostering regional cooperation and knowledge sharing on financial access for small-scale miners.

71. A key success factor in the Colombian case was the role of international funding (the GEF) in de-risking investment into the artisanal and small-scale gold mining sector. Given the financial sector's perception of artisanal and small-scale gold mining as high-risk, the first-loss guarantee provided by planetGOLD Colombia played a crucial role in eliminating collateral requirements for miners seeking loans through CFA. This measure significantly lowered the barriers to entry, particularly for miners who lacked land titles or physical assets to serve as collateral.

72. The project also underscored the importance of combining financial services with non-financial benefits to make formal banking more appealing to miners. In addition to life insurance and tax exemptions, the peer-to-peer savings groups incorporated a social welfare fund to provide financial assistance to participants in case of emergencies. This holistic approach ensured that miners not only received loans but also gained access to support systems that improved their overall financial resilience.

73. Colombia's experience highlights the transformative potential of financial inclusion in the artisanal and small-scale gold mining sector when structured interventions address both demand-side barriers (such as miners' lack of financial literacy and collateral) and supply-side constraints (such as financial institutions' risk aversion and lack of sector knowledge). The country's success demonstrates that a combination of risk-sharing mechanisms, community-led savings models, financial education, and policy engagement can create a sustainable pathway for artisanal and small-scale gold mining miners to integrate into the formal financial system.

Lesson learned

74. Colombia's experience shows that improving financial access for artisanal and small-scale gold miners takes a mix of practical tools and strategic partnerships. Loan guarantees, community-based lending, and financial literacy training helped break down the barriers miners face when trying to access formal financial services. One key takeaway is that early support from institutions like the Global Environment Facility can help reduce the risk for private sector lenders. This blended finance approach, when paired with social protection benefits, continued policy dialogue and coordination among stakeholders can create sustainable access to finance for the artisanal and small-scale gold mining sector.

Case study 2: Interactive Process Optimization Guidance (iPOG) to estimate mercury emissions from coal-fired power plants and its application in Indonesia.

75. The Interactive Process Optimization Guidance (iPOG) is a software tool to estimate mercury (Hg) emissions from coal-fired power plants. It enables engineers, plant managers, and policymakers to analyze and optimize emission levels based on coal properties, combustion conditions, and gas-cleaning configurations. The iPOG was developed by the UNEP Global Mercury Partnership, Coal Partnership Area with funding from Environment Canada. It is available as a free download from the UNEP website: <https://www.unep.org/globalmercurypartnership/resources/tool/interactive-process-optimization-guidance-ipogtm>.

76. The iPOG software can provide assessments of fuel quality, gas-cleaning configurations, and external mercury control measures. It enables users to estimate mercury emissions for different gas-cleaning technologies and coal qualities, helping utilities plan for both current and future operations. By extrapolating data from limited test results, the iPOG eliminates the need for costly and time-consuming testing of every possible combination of fuel and gas-cleaning conditions.

77. The software also allows users to evaluate how system modifications impact mercury emissions. For instance, it can determine whether coal cleaning would be sufficient to meet emission targets or how fluctuations in coal properties—such as a surge in chlorine levels—might affect emissions. Additionally, the iPOG helps validate data for similar gas-cleaning configurations and identifies where mercury is oxidized and removed within the system and ultimately which in which waste stream it will leave the plant (stack emissions to air, in solid ash or gypsum, or in liquid effluent).

78. Although iPOG does not estimate the costs for the various compliance options that are analyzed, it can be used for cost effectiveness assessment of regulatory compliance options by estimating the amount of mercury can be removed for a range of control options, provided that these options are associated with cost estimates. The software also enables users to run multiple "What if?" scenarios, allowing for strategic planning across local and regional coal-fired utility facilities.

Application of iPOG in Indonesia: Identifying High-Impact Mercury Reduction Strategies

79. A significant application of iPOG was its use in the US Department of State funded project in Indonesia: “Capacity building in Southeast Asia to reduce mercury and other pollutant emissions from the coal combustion sector” where mercury emissions from the national coal-fired power fleet were analyzed. Using plant-specific data¹⁹, the iPOG facilitated the creation of a mercury inventory for the entire Indonesian coal fleet on a unit-by-unit basis. The dataset is a “living” spreadsheet which allows the operator to update the emission estimates based on fleet changes, providing an annual Tier 3 inventory under the Minamata Convention. The dataset can also be used to project future emissions based on different potential reduction strategies.

80. By integrating iPOG with estimates of mercury and Sulfur dioxide (SO₂) emissions, researchers ranked Indonesia’s coal plants based on their projected mercury contributions over their remaining operational lifetimes. The analysis revealed that just 10 power plant units accounted for over 45% of total mercury emissions from the entire fleet. This insight demonstrated that targeted interventions at a limited number of plants could significantly reduce overall mercury emissions in a cost-effective manner.

81. Initial findings from the project include:

- (a) Mercury emission rates (kg/year) do not correlate to plant size;
- (b) Mercury emission rates do not correlate to plant age;
- (c) Mercury emission intensity (gHg/GW) is important, especially for plants with high utilisation rates and long remaining lives. Increasing the utilisation rate of plants with a lower mercury emission intensity, to reduce the use of plants with a high emission intensity, could reduce the overall average emissions from the fleet on a g/GW basis; and
- (d) Plants which emit relatively high levels of both SO₂ and mercury will be prime candidates for co-benefit/multipollutant emission reduction strategies.

82. The success of this project inspired the delivery of four regional UNEP workshops²⁰ on the use of the iPOG for Tier 3 reporting to the Minamata Convention on Mercury in 2024 (Pakistan, South Africa, Vietnam and India).

Lessons learned

83. These findings highlight that a data-driven, targeted approach to mercury reduction – focusing on high-emission plants – can be more effective and cost-efficient than applying uniform emission control measures across the entire coal fleet. In this way, tools like iPOG can provide policymakers with a practical and economically viable roadmap for mercury mitigation.

Case study 3: Chlor-alkali industry transition to alternative process technologies in Mexico: Experience in aligning regulatory frameworks, financial incentives and corporate social responsibility

84. For decades, the chlor-alkali industry in Mexico relied on mercury cell technology, a method that posed significant environmental and health risks. However, obligations under the Minamata Convention on Mercury catalysed decisive action. Recognizing the urgency of phasing out mercury, the Mexican government, private industry, and international organizations forged a strategic partnership, driving a large-scale transformation effort.

85. With support from the Global Environment Facility and collaboration with the United Nations Environment Programme and the United Nations Industrial Development Organization, a project was approved in 2022 and started implementation in 2024 to eliminate mercury use and manage mercury waste in Mexico’s chlor-alkali sector²¹. With substantial funding, the initiative aimed to phase out

¹⁹ The majority of data in the current dataset represent up-to-date, plant-specific information collated by BCRC-Asia and MEMR specifically for this project. Where data were not available, estimates were produced based on extrapolation of data from similar plants and coals. The completed dataset includes over 30 input fields covering all the relevant information for each of the more than 100 coal-fired units in Indonesia. The dataset is a valuable tool which could be used by BCRC-Asia and MEMR to establish an ongoing emission inventory for the sector, as required under the Minamata Convention on Mercury.

²⁰ The workshops were organized by the Minamata Convention secretariat with funding from the European Union.

²¹ <https://www.unep.org/globalmercurypartnership/news/press-release/12-million-project-launched-stop-mercury-use-mexicos-chlor-alkali-industry>

mercury, decommission outdated facilities, and ensure the safe interim disposal of mercury waste. Key stakeholders included Mexico's environmental agencies including the Ministry of Environment and its technical area from the General Directorate for Integral Management of Materials and Hazardous Activities (DGGIMAR), the private sector—particularly CYDSA—and international regulatory bodies.

86. The private sector, particularly CYDSA, will play an important role in this transition. Industry leaders recognized the regulatory pressures stemming from the Minamata Convention on Mercury, which mandated the phase-out of mercury-based processes. Companies like CYDSA weighed the costs of inaction against the benefits of early adoption of alternative technologies. Recognizing the financial and operational advantages, CYDSA seized the opportunity to lead the sector's transition. The shift to membrane cell technology will not only ensure compliance but also bring measurable benefits. Energy efficiency is expected to improve by nearly a quarter, significantly lowering long-term operational costs. By positioning itself as a sustainability leader, CYDSA will gain a competitive edge in the global market and serve as a model for other companies in the region undergoing technological conversion.

87. The financial support, coupled with the technical expertise offered by international agencies, mitigates risks and encourage companies to commit to cleaner technologies. Beyond regulatory compliance and financial incentives, corporate social responsibility has played a role in CYDSA's decision. By participating in the project, CYDSA aligned its corporate strategy with global sustainability trends, enhancing its reputation as an environmentally responsible company.

88. The project's impact will be profound with mercury use in chlor-alkali production in two of the plants phased out. Over 100 metric tonnes of excess mercury will be safely stored in an environmentally sound manner. The transition to membrane cell technology will also increase energy efficiency, reducing costs for the private sector while benefiting the environment.²² Occupational exposure to mercury is expected to decline, leading to improved health outcomes for workers and surrounding communities.

89. The initiative provided valuable lessons on private sector engagement in sustainability transitions. Aligning economic and environmental interests is crucial, as businesses are more inclined to support initiatives that deliver financial benefits alongside regulatory compliance. Regulatory certainty and strong enforcement mechanisms encourage companies to make the transition sooner rather than later. Public-private partnerships accelerated the transformation, showing that when government incentives, international support, and private sector investment align, large-scale industrial change is possible.

Lessons learned

90. Mexico's transition to a mercury-free chlor-alkali industry illustrates how regulatory frameworks, financial incentives, and corporate responsibility can align to drive sustainable change. The involvement of the private sector was key, demonstrating that industrial sustainability is not just a regulatory requirement but also a sound business strategy. By integrating government support, private investment, and technical expertise, the project serves as a model for other nations seeking to transition to cleaner industrial practices. As industries worldwide face increasing environmental challenges, Mexico's experience provides valuable insights into how public-private collaboration can lead to meaningful and lasting environmental progress.

²² GEF project document 'eliminate mercury use and adequately manage mercury and mercury wastes in the chloralkali sector in Mexico.

Case study 4: Phasing Out Fluorescent Lighting– Lessons from the Clean Lighting Coalition (CLiC)

Overview

91. Mercury-free LED lighting offers a widely available, energy-efficient, and cost-effective alternative to fluorescent lamps (which contain mercury). Article 4 of the Minamata Convention on Mercury deals with mercury-added products including fluorescent lamps. Part I, Annex A of the Convention specifies the phase-out dates for these lamps. Replacing fluorescent lamps with LEDs provides better lighting quality, longer product life, and significant cost savings for both households and businesses. A global phase-out of fluorescents could prevent over 16,000²³ pounds (approximately 7260 kg) of mercury from entering homes and landfills by 2050 and cut more than 200 million metric tons of CO₂ emissions, the equivalent of removing four million cars from the road annually. Despite their slightly higher upfront cost, LEDs deliver quick payback periods through lower electricity bills. These environmental and economic benefits,

combined with the growing availability of drop-in LED replacements for all major fluorescent lamp types, support the case for global regulatory action.

The Clean Lighting Coalition (CLiC)

92. The Clean Lighting Coalition (CLiC), a campaign coordinated by CLASP²⁴, is a global initiative that advocates for the phase-out of mercury-based fluorescent lighting and supports the transition to clean, energy-efficient alternatives such as LED lighting. Over three years, the campaign brought together experts in lighting technology, public health, and climate, along with NGOs, government officials, and industry representatives, to push for strong action under the Minamata Convention on Mercury. By supporting the African Lighting Amendments proposed at COP-4 and COP-5, CLiC played an important role in securing agreement from 147 parties to phase out fluorescent lighting by 2027.

93. CLiC's success can be attributed to its evidence-based and strategic approach. The campaign delivered over 40 customized national analyses, demonstrating the benefits of LED adoption, including lower lifecycle costs, significant energy savings, and substantial reductions in both mercury and greenhouse gas emissions. It also equipped policymakers with tools like the MEPSY²⁵ calculator to facilitate decision-making. Through pilot retrofits in hospitals and public buildings in Brazil, the

Table 1: Comparison of common T8 LFL and LED replacements
Source: www.aceee.org/research-report/b2202

Lamp type	Residential		Commercial	
	Fluorescent	LED	Fluorescent	LED
Mercury	2.7 mg	None	2.7 mg	None
Efficacy (lumens/watt)	70–110	120–200	70–110	120–200
Color	Same	Same	Same	Same
Brightness	Same	Same	Same	Same
Typical lifetime (hours)	Up to 36,000	Up to 70,000	Up to 36,000	Up to 70,000
Price per bulb	\$4.86	\$6.59	\$4.22	\$5.19
Annual electricity cost	\$2.79	\$1.58	\$8.79	\$4.66
Life-cycle savings	—	\$11	—	\$27
Payback period (years)	—	1.0	—	0.1

²³ Amann, J. T., B. Fadie, J. Mauer, K. Swaroop, and C. Tolentino. 2022. Farewell to fluorescent lighting: how a phaseout can cut mercury pollution, protect the climate, and save money. Washington, DC: American Council for an energy-efficient economy. www.aceee.org/research-report/b2202

²⁴ Collaborative Labeling and Appliance Standards Program (CLASP), <https://www.clasp.ngo/>

²⁵ MEPSY is CLASP's digital tool to model the impacts of energy and carbon reduction policies. Pre-loaded with data from 162 countries, it supports analysis and prioritization for the most energy-intensive appliances and equipment.

Philippines and Nigeria, CLiC practically demonstrated that the transition to clean lighting is technically and economically viable. In particular, the African region has emerged as one of the leaders in regulatory efforts to transition to mercury-free lighting.

Progress in Africa

94. Across Africa²⁶, regional and national initiatives are accelerating the transition to clean lighting. Countries like Namibia and Nigeria are developing and implementing national standards for lighting efficiency, while Sudan's energy efficiency strategy sets a timeline to phase out compact and linear fluorescent lamps by 2025. At the regional level, both the Southern African Development Community (SADC) and the East African Community (EAC) have adopted harmonized standards that establish minimum energy performance requirements and effectively phase out fluorescent lamps in favor of LEDs. These coordinated efforts showcase strong political will and growing regulatory momentum for mercury-free lighting across the continent.

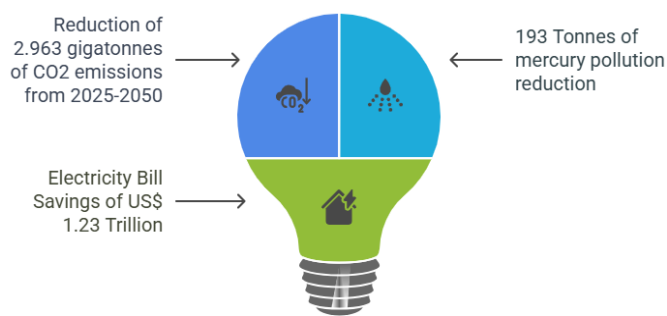
95. While source reduction as a measure to keep fluorescent lighting out of Africa's markets remains a high priority in order to cut the in-flow of mercury from lighting, concerns among the countries persist on effective management of hazardous wastes such as the end-of-life fluorescent lights. Countries like South Africa have banned the disposal of all electric lamps in landfills from 2016 onward, classifying them as hazardous waste that must be diverted from dumps²⁷. It also enacted Extended Producer Responsibility (EPR) regulations, extending producer responsibility to various sectors, including lighting equipment. South Africa also opened one of the continent's first light-bulb recycling plants in 2014 to recover mercury and other materials²⁸. Nevertheless, such facilities remain rare across Africa. Other countries have only begun addressing the challenge: Nigeria, for instance, until recently had no equipment to properly recycle fluorescent lamps, resulting in stockpiling of lamp waste. A Nigerian e-waste recycler reported "collecting and storing" over 10 tonnes of used fluorescent lamps due to lack of proper disposal technology²⁹. This long-term storage of mercury waste is a stopgap measure, reflecting the broader regional shortfall in disposal capacity.

Lessons learned

96. The CLiC initiative highlights the importance of aligning environmental action with economic and social co-benefits, and shows that even with limited resources, coordinated advocacy can drive significant technology adoption.

97. Africa's leadership, exemplified by harmonized regional standards and national regulations, underscores the power of coordinated political will. At the same time, the case also reveals an important gap in end-of-life management infrastructure for hazardous waste such as mercury-containing lamps, emphasizing the need for parallel investments in safe disposal and recycling systems to ensure that environmental gains from cleaner technologies are not offset by unmanaged hazardous waste.

Figure 5: The lighting-related decisions taken at COP-4 and COP-5 of the Minamata Convention on Mercury will result in significant benefits
Source: Farewell to fluorescents campaign



²⁶ Information obtained from <https://www.clasp.ngo/report/clean-lighting-coalition/farewell-to-fluorescents/global-policy-overview/>

²⁷ <https://ewasa.org/what-is-lighting-waste/#:~:text=the%20south%20african%20department%20of,landfills%20effective%2023%20august%202016>

²⁸ <https://www.gov.za/news/speeches/deputy-minister-barbara-thomson-opening-africa%e2%80%99s-first-light-bulb-recycling-plant-24#:~:text=today%27s%20compact%20fluorescent%20lamps%20and,still%20be%20thrown%20into%20landfill>

²⁹ <https://www.clasp.ngo/updates/clasp-collaborates-with-hinckley-to-mitigate-mercury-pollution-from-fluorescent-lamps-in-nigeria/#:~:text=%e2%80%9cfluorescents%20lamps%20are%20classified%20as,at%20our%20storage%2c%e2%80%9d%20says%20clews>

Case study 5: Tanzania’s transition to mercury-free dentistry under the Minamata Convention on Mercury: How political leadership, strong regulations, stakeholder collaboration, and international support converged to eliminate dental amalgam

98. Tanzania stands out as a leading example in Africa for successfully phasing out mercury-based dental amalgam. This transition was the result of political will, which created a clear regulatory framework. Equally important was the coordinated engagement of stakeholders, which helped raise awareness and build public support. Targeted technical training for dental professionals also played an important role in securing buy-in from the dental community, equipping them with the knowledge and confidence to adopt mercury-free alternatives.

99. The process began with the enactment of the Environmental Management (Control and Management of Mercury and Mercury Compounds) Regulations in 2020³⁰. These regulations immediately restricted the use of dental amalgam in vulnerable populations, such as children under 15 and pregnant or breastfeeding women. Complementing this, the Ministry of Health issued national guidelines³¹ that laid out a timeline for a complete phase-out. By January 2022, Tanzania implemented a full nationwide ban on dental amalgam for all patients, effectively making it the first African country to achieve mercury-free dentistry across both public and private sectors.

100. Strong alignment between environmental and health authorities enabled this transition. The Ministry of Health played a central role, not only in setting policy goals but also in mobilizing the dental sector to shift to alternative materials. The Ministry of Environment ensured compliance with treaty obligations and coordinated implementation efforts. Together, they established a strong legal and policy foundation that showed national commitment to mercury-free dentistry.

101. Tanzania emphasized collaboration with a wide range of stakeholders. The Tanzania Dental Association was actively involved, helping shape the implementation approach and encouraging its members to adopt mercury-free practices. Academic institutions contributed by updating dental education curricula, while civil society organizations led advocacy and awareness campaigns. A local NGO³², working closely with the international World Alliance for Mercury-Free Dentistry, played a key role in bringing together government officials, practitioners, educators, and consumer groups to push for ambitious national timeline and build public support.

102. At the same time, the government worked to ensure that mercury-free alternatives were accessible and affordable. Purchasing of dental amalgam was banned and supplying approved alternatives such as glass ionomer cement and composite resins started³³.

103. Tanzania’s efforts were further supported by regional and international partnerships. Participation in East African knowledge-sharing forums and collaboration with neighboring countries like Kenya and Uganda created peer learning opportunities and reinforced the feasibility of a regional shift away from amalgam. Through a regional pilot initiative supported by UNEP and WHO, Tanzanian dentists received hands-on training in mercury-free restorative techniques³⁴, while dental schools revised their teaching to reflect modern, safe alternatives. This GEF funded pilot helped in creating a new generation of dental practitioners who were both knowledgeable and confident in using alternative materials. The support of advocacy alliances such as the World Alliance for Mercury-Free Dentistry also helped elevate Tanzania’s leadership on this issue in global forums and facilitated access to resources and best practices from around the world.

Lessons learned

104. Tanzania’s successful phase-out of dental amalgam illustrates how a developing country can adopt and scale safer health technologies when political leadership, stakeholder collaboration, and targeted international support converge. By investing in training and adapting supply systems, Tanzania not only met its international commitments but also set a precedent for sustainable healthcare

³⁰ United Republic of Tanzania. (2020). “The environmental management (control and management of mercury and mercury compounds) regulations, 2020”. Dar es Salaam: Government printer.

³¹ United Republic of Tanzania, Ministry of Health. (2020). “Second guidelines for provision of oral health services”. Dar es Salaam: Ministry Of Health.

³² <https://mercuryfreedentistry.net/2022/01/12/dorah-swai-wins-first-in-africa-award/>

³³ <https://environmentalmedicine.eu/wp-content/uploads/phasing-out-on-dental-amalgam-use-tanzania.pdf?utm.com>

³⁴ UNEP and WHO, 2014: promoting the phase down of dental amalgam in developing countries.

transitions in the region. This case underscores that with the right enabling conditions, the shift to mercury-free dentistry is achievable.

105. For stakeholders interested in learning how other countries are progressing in eliminating dental amalgam, a global snapshot of mercury-free dentistry efforts can be found on the “Mercury-Free Dentistry for Planet Earth” platform: <https://environmentalmedicine.eu/mercury-free-dentistry-for-planet-earth/>.

VIII. Key findings

106. The evidence compiled in this desk study report shows that proven mercury-free alternatives are available and feasible in major source category covered by the Convention. Projects financed by the GEF and the Specific International Programme have moved several technologies, such as LED lighting, membrane-cell chlor-alkali processes and mercury-free dental materials, from pilot stage to nation-wide adoption, reducing mercury use and emissions in recent years.

107. There is also a growing coalition of partners. Cooperation among parties, industry, and civil society organizations is expanding, while the Global Mercury Partnership continues to widen the pool of expertise and resources for technology transfer. The joint BRS–Minamata initiative, together with regional centres that now serve multiple MEAs, is strengthening parties’ capacities and fostering synergies across the conventions.

108. National projects on mercury reduction show that well-targeted interventions can reduce mercury while delivering climate, energy-efficiency and public-health gains simultaneously.

109. However, transfer of alternative technologies under the Minamata Convention on Mercury has its challenges. Parties face a range of interrelated barriers, including financial constraints, limited institutional capacity, regulatory challenges, and access to alternative technologies. These challenges slow down progress toward mercury phase-out and hinder the implementation of Convention obligations.

110. While reviewing the national reports submitted by parties, it was noted that parties often describe broad constraints such as “lack of capacity” or “financial challenges” without identifying specific sectors, technologies, or institutional deficiencies. This ambiguity limits the ability of national and international partners to provide targeted and effective support. Going forward, parties may wish to be more structured, issue-specific, while identifying technology needs and capacity gaps in areas such as artisanal and small-scale gold mining, mercury-added products, and mercury emissions from industrial processes. As an example, parties, in their national reports, frequently cite the preparation of national mercury inventories as a challenge. Yet comprehensive guidance already exists, most notably the UNEP’s Toolkit for identification and quantification of mercury releases (UNEP Mercury Toolkit)³⁵, which is supported by online training modules and expert-led training. Consequently, it is important to highlight the real bottlenecks: are parties unaware of these resources, short of trained personnel to apply them, constrained by language or data-access barriers, or lacking the resources to collect and validate the necessary information?

111. Lessons from case studies further underscore the need for an enabling environment for technology adoption. The success of initiatives for technology transfer shows that multi-stakeholder engagement, including the private sector, international agencies, civil society, and affected communities is necessary.

112. The sector-specific nature of technology transfer was another key insight. Replacing mercury-based products in healthcare or lighting sectors differs significantly from emissions control in coal power plants or artisanal and small-scale gold mining formalization. Thus, solutions must be contextualized and tailored to national and sectoral realities. Furthermore, the interconnectedness of technical, legal, and financial barriers means that isolated solutions are often ineffective. For instance, importing mercury-free equipment without training technicians or developing regulatory frameworks may not be sustainable.

113. A key overarching insight is that technology transfer is not a single-step transaction, but rather a systematic process involving policy alignment, institutional strengthening, financing, and long-term capacity development. Without addressing these foundational components, technologies risk becoming underutilized or mismanaged.

³⁵ <https://www.unep.org/topics/chemicals-and-pollution-action/pollution-and-health/heavy-metals/mercury/mercury-inventory>

114. National reports can be an excellent source of information and parties may consider having a coordinated approach involving key stakeholders, to develop these reports.

115. Financial constraints are the most frequently cited barrier, according to the national reports submitted by parties. However, challenges may vary widely – from lack of access to international finance, to insufficient domestic budgeting, to weak absorptive and disbursement capacities. A national-level mapping exercise of technology needs, funding sources, and implementation priorities could help better align resources and ensure cost-effective interventions.

116. Improving data collection and monitoring systems is another priority identified by parties. They can lack reliable inventories of mercury sources and emissions due to the absence of standardized tools, equipment, and/or trained personnel. Parties may want to consider using existing knowledge hubs and websites which generate actionable data and can be better utilized to provide strategic information and support evidence-based decision-making. For example, the Global Mercury Partnership offers insights on the intersection of mercury use and environmental conservation, using the data derived from artisanal and small-scale gold mining National Action Plans (NAPs). This has led to the development of geospatial maps showing overlaps between artisanal and small-scale gold mining sites, protected areas, and regions of high biodiversity. This information can guide national planning and targeted interventions. More information is available at: <https://www.unep.org/globalmercurypartnership/insights-asgm-national-action-plans> .

117. To better understand these diverse challenges and needs of the developing countries, a dedicated global survey could be undertaken to assess parties' specific technology transfer needs, regulatory barriers, institutional readiness, and sectoral challenges. This standardized, data-driven approach could guide policy formulation and technical support at the global level. Guidance on developing the survey could be drawn from similar 'needs assessment' exercise conducted by the secretariats of the Basel, Rotterdam and Stockholm Convention. More details can be found on the BRS conventions website³⁶.

118. Finally, the Minamata Convention on Mercury implementation could benefit from synergies with other international frameworks. For example, optimizing coal plant efficiency not only reduces mercury but also cuts greenhouse gases and other air pollutants. Upgrading chlor-alkali plants from mercury-cell to membrane technology offers similar co-benefits, eliminating mercury use while boosting energy efficiency and lowering carbon footprints. Similarly, when it comes to mercury waste management, lessons can be learned from voluntary frameworks like the Extended Producer Responsibility (EPR) under the Basel Convention³⁷ which provide non-binding technical guidance, certification schemes and waste prevention strategies. Integration across conventions enhances the effectiveness and cost-efficiency of technology transfer interventions.

119. A concerted, well-coordinated global effort based on data, inclusive of diverse stakeholders, could ensure that alternative technologies are not only developed and transferred, but successfully adopted and sustained.

³⁶ <https://www.brsmeas.org/Implementation/TechnicalAssistance/Needsassessment/tabid/4898/language/en-US/Default.aspx#:~:text=You%20can%20access%20the%20needs,on%20this%20webpage%20once%20available>

³⁷ <https://www.basel.int/default.aspx?tabid=7557&utm.com>

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List of acronyms

Abbreviation	Full form
ASGM	Artisanal and Small-scale Gold Mining
BRS	Basel, Rotterdam, and Stockholm (Conventions)
CEIT	Countries with Economies in Transition
CLiC	Clean Lighting Coalition
CLASP	Collaborative Labeling and Appliance Standards Program
COP	Conference of the Parties
DGGIMAR	General Directorate for Integral Management of Materials and Hazardous Activities (Mexico)
EAC	East African Community
EES	Eastern European States
EPR	Extended Producer Responsibility
ESG	Environmental, Social, and Governance
GEF	Global Environment Facility
GIS	Geographic Information System
GRULAC	Group of Latin America and Caribbean Countries
iPOG	Interactive Process Optimization Guidance
LDCs	Least Developed Countries
LED	Light-Emitting Diode
LFL	Linear Fluorescent Lamp
MC	Minamata Convention
MEPS	Minimum Energy Performance Standards
MIA	Minamata Initial Assessment
MME	Ministry of Mines and Energy (Colombia)
NAP	National Action Plan
NGO	Non-Governmental Organization
pG	planetGOLD
SC	Stockholm Convention on Persistent Organic Pollutants
SIDS	Small Island Developing States
SO ₂	Sulfur Dioxide
T8	A type of fluorescent lamp (1 inch diameter tube)
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
WHO	World Health Organization
