MONTHLY RESEARCH DIGEST

An Executive Briefing on New & Notable Sustainability Research

In This Issue – **March 2026**

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ENERGY TRANSITION

The State of Energy Innovation 2026

By International Energy Agency

View the full report here

Notable Highlights

- **155 significant global energy innovations** ("innovation highlights") **were identified in 2025.** Detailed highlights are available HERE.
- **Corporate energy R&D grew by 1%** in 2024 to $160 billion, the lowest rate since 2015.
- **Venture capital investment in energy technology start-ups fell** for the third consecutive year to $27 billion in 2025, the lowest level since 2020.
- Investing in energy **innovation to enhance the competitiveness of facilities can enable companies to** achieve higher sales revenue, increase factory investment, lower energy bills and import costs, and avoid environmental remediation, energy supply shocks, and the impacts of outages.
- **Energy storage has become a main focus of energy innovation,** with batteries accounting for 40% of all energy patents in 2023 (preliminary data suggest even larger percentages in 2024 and 2025).

Objective

- To explore developments in global energy innovation in 2025, including spending trends, patenting, technology competitiveness, policy progress, electricity grid resilience, and fusion energy.

Background

- The data in this second edition of the report is based on 155 global energy innovation developments ("innovation highlights"), a survey of over 270 energy technology practitioners across over 40 countries and 12 energy technology domains, and peer review (methodology on pg. 1-4, 19, 261-267).
- The 155 innovation highlights were selected from the 640 technologies in the IEA ETP Energy Technology Guide, which classifies technologies by their global Technology Readiness Level (TRL) (pg. 29):
    - TRL 1-3: initial idea and concept development

   - TRL 4-6: prototyping
   - TRL 7-8: demonstration
   - TRL 9+: early adoption and commercial operation through to maturity)
- Data on corporate R&D were from the annual financial statements of over 3,000 energy-sector companies, primarily those listed on stock exchanges worldwide.
- Crunchbase and the Cleantech Group provided commercial datasets covering over 12,000 energy-related startups and the associated deals involving over 27,000 investors.
- The European Patent Office (EPO) provided patent data.

Report Findings

Recent developments in global energy innovation (pg. 27-57):

▷ **Subchapters:** notable upgrades in technology readiness (pg. 29), see page #s below for additional subchapters

- **The chapter includes a snapshot of promising energy innovations worldwide in five key categories (out of 155 significant innovations identified):**
   - **Prominent advances in research and prototyping (pg. 32)** (e.g., lithium-iron batteries with high performance and lower critical mineral content)
   - **First-of-a-kind pilot and demo achievements (pg. 35)** (e.g., successful testing of geological hydrogen storage demonstration)
   - **Announced commitments** from companies or investors to increase technology readiness (pg. 39) (e.g., synthetic fuel plants)
   - **New products and processes reaching the market (pg. 42)** (e.g., commercial deployment of sodium-ion batteries)
   - **Enhancements to R&D facilities, test sites, and innovation support** (pg. 44) (e.g., announcement of a new AI platform for energy research)

Energy innovation spending trends (pg. 58-85):

▷ **Subchapters:** public R&D spending (pg. 61), corporate R&D spending (66), venture capital R&D spending (71)

- **Roughly 9% of all public and private R&D spending worldwide was dedicated to energy in 2024.**
- Spending on energy innovation is rising faster than total R&D across all sectors.

Corporate R&D spending:

- The total annual corporate R&D spending in the automotive, aviation, shipping, rail, heavy industry, industrial electronics, and buildings sectors increased by around $10 billion to **$350 billion in 2024.**
- **Chinese companies accounted for 60%** of global corporate R&D for the energy supply and infrastructure sectors in 2024.

Venture capital R&D spending:

- **VC funding for energy-related start-ups fell** for the third year in a row in 2025 to $27 billion. **AI deals accounted for one-third of total VC funding** in 2025 and represented the largest share of deal value.
- **VC growth areas** include carbon removal, critical minerals, low-emissions industrial production, next-generation geothermal, aerospace, nuclear fission, and fusion energy. These technologies together accounted for **one-third of energy VC funding in 2025, up from less than 5%** from 2015 to 2019.

Public R&D spending:

- **Global public energy R&D expenditure was $55 billion** in 2024, a 70% increase in real terms from 2015 but a decrease from the previous year.
- An estimated **78%** of 2024 funding **went to low-emission technologies.**

Energy innovation patents (pg. 86-103):

▷ **Subchapters:** trends in energy technology patenting (pg. 86), national specializations in energy technologies (92), trends in selected technology areas (95)

- **Patents for low-emissions energy technologies increased by about 79%** from 2010 to 2023 (the latest year for which data are available). These represent 97% of all energy technology patents in China in 2023, 80% in the U.S., and 68% in Europe.
- **Energy storage technologies accounted for over 40%** of global energy patents in 2023 (up from 15% in 2015), largely driven by advances in battery technology.
- Patenting for **critical minerals production** reached around 33,000 international patent families in 2023, up from around 13,000 in 2010.
- China represented nearly two-fifths of all energy patenting in 2023.

Energy innovation for competitiveness (pg. 139-173):

- **Subchapters:** economic payoffs from public spending on energy innovation (pg. 140), innovation opportunities in key technology areas (pg. 163), key priorities to enhance competitiveness (169)

- Companies investing in energy-efficiency innovation have seen **labor productivity 15-18% higher.**
- Pages 163-169 include **examples of innovations** that can boost competitiveness by lowering manufacturing costs, new technologies with better performance, and new technologies that offer lower costs and better performance.

Technology innovation for electricity grid resilience (pg. 174-215):

- **Subchapters:** grid challenges (pg. 175), the case for strengthening grid innovation (179), ensuring real-time stability and power quality (183), system adequacy and flexibility (192), physical grid resilience (202), grid governance, interoperability, and cybersecurity (204), priorities for accelerating grid innovation (212)

- **Future grid resilience is constrained less by the availability of technology than by the pace of technology integration.** Many technologies are at high readiness levels. However, additional planning, regulatory incentives, market design, and accountability are needed to further deploy them and reduce costs.
- **Technical challenges to electricity grid resilience** include ensuring real-time stability and power quality; physical grid resilience; system adequacy and flexibility; and effective grid governance, interoperability, and cybersecurity (detailed challenges on pg. 183).
- Pages 183-210 provide an **overview of technologies** for addressing these challenges.
- Pages 212-215 include **priorities for grid service providers** to accelerate innovation.

Technology innovation for grid-connected fusion energy (pg. 216-254):

- **Subchapters:** the case for strengthening fusion energy innovation (pg. 216), fusion energy technology landscapes (225), priorities for accelerating fusion energy innovation (252)

- In 2025, Google and Microsoft became the **first companies to enter into power purchase agreements for** future fusion power plants.
- In 2025, **several governments announced commitments** to commercialize fusion energy. The U.S. published a fusion energy roadmap, and the U.K. announced $3.2 billion in funding for a prototype fusion power plant by 2040.

Energy policy progress (pg. 104-138):

▷ **Subchapters:** overarching energy innovation strategies (pg. 106), direct financial support (109), tax incentives (121), demand-creation measures (125), access to research infrastructure (129), policy gaps and priorities (136)

- **More than 80 new energy innovation policies were introduced in 2025,** along with over 60 initiatives issued under existing policies. **Key themes** include the use of AI to accelerate energy technology innovation, industrial competitiveness, supply chain resilience, electricity security, and the development of commercial fusion energy.
- Pages 108-109 and 111 provide an overview of **recent shifts in US energy innovation policies** during the Trump administration, including grant programs.

VOLUNTARY CARBON MARKET

2026 State of the Voluntary Carbon Market

By Carbon Direct

View the full report here

Notable Highlights

- **Carbon credit retirements in the voluntary carbon market (VCM) decreased by 7% from 2024 to 2025** to 157 million metric tons (Mt), while **credit issuances increased by 3%** to 288 Mt.
- **Carbon dioxide removal (CDR) credits accounted for 5% of 2025 retirements** and 6% of issuances, with 95% of the issuances originating from nature-based pathways.
- **Forward offtake agreements are increasing.** The volume of high-durability CDR credits (e.g., direct air capture) to be delivered in the future is 70x the volume retired in 2025 (29 Mt of CO2 equivalent vs. 0.42, respectively).
- Corporate targets suggest CDR demand could reach 46-110 Mt by 2030. However, **current corporate action suggests demand may only reach 28 Mt** by that time**.** Supply is **estimated at 62 Mt by 2030**.
- An estimated **80%+ of the 2030 pipeline for high-durability CDR is at risk** due to insufficient project offtake and financing agreements.
- **Nature-based CDR requires a 30–220% increase in finance** to support current corporate targets and increase supply.
- The following Report Findings include **actions for CDR buyers and investors to help scale the VCM.**

Objective

- To assess the state of the voluntary carbon market (VCM) in 2025, including trends, carbon dioxide removal (CDR) market trends, and CDR supply and demand.

Background

- The report data is based on (methodology on pg. 32-33):
  - A review of the commitments of “top active buyers” in the CDR market.

- Data from Carbon Direct's proprietary database, the CarbonPlan OffsetsDB, the CDR.fyi database, the MSCI Corporate Data module, the Puro.earth registry, and the Voluntary Registry Offsets Database.
- An analysis of publicly committed capital allocations to nature-based credits and data on carbon capture, utilization, and storage (CCUS) projects.

- "Nature-based CDR" refers to carbon removal approaches that rely on ecosystem processes (e.g., reforestation). "High-durability CDR" pathways store CO2 for centuries to millennia (e.g., direct air capture with geologic storage).

Notable Findings

Voluntary carbon market (VCM) trends (pg. 9-12):

- **Issuances exceeded retirements by roughly 80% in 2025,** adding to a surplus of more than 1 billion credits.
- **Renewable energy, REDD+, and non-CO2 gas projects continued to represent the bulk of VCM credits in 2025.**
  - **Renewable energy** accounted for around **30% of retirements** in 2025.
  - **REDD+ issuances decreased by over 40%** from 2023 levels due to projects transitioning to updated methodologies to address over-crediting concerns.
  - **Super-pollutant** (e.g., methane) **credits accounted for about 20% of issuances.** From 2020 to 2025, issuances increased by about 180%, and **retirements grew by about 150%.**
  - Afforestation, reforestation, and revegetation (ARR) credits increased in 2025 after facing supply constraints from 2022 to 2024.
  - Page 11 breaks down **supply-and-demand balances** across major credit types from 2022 to 2025.

CDR market trends (pg. 14-16):

- **95% of CDR issuances in 2025 originated from nature-based pathways.**
  - Improved Forest Management **credit retirements increased by 2.5x** from 2023, driven by shorter project timelines and a more consistent supply flow.
  - ARR credit issuances and retirements have a roughly 1:1 ratio.
- **5% of CDR issuances in 2025 originated from high-durability CDR pathways**.
  - High-durability CDR credit **retirements grew fivefold** from 2023 to 2025.

    - From 2021 to 2025, roughly 80% of high-durability CDR issuances and retirements came from biochar and geologic storage.
- **Forward offtake agreements are increasing.**
    - Microsoft accounts for 70% of CDR offtakes announced to date.
    - Payment certainty, commitments from multiple buyers, multi-year offtake timelines, and sunset clauses are essential for reaching a Final Investment Decision.
    - Large high-durability CDR offtakes should span 10-15 years to address any financing issues and provide long-term revenue certainty.

CDR market demand (pg. 18-23):

- **Companies are increasingly purchasing carbon credits but not publicly disclosing transactions:** 55% of tons retired on the spot market over the past three years were anonymous, possibly to avoid scrutiny or reputational risk.
- **Buyers who remain reluctant to engage** in the absence of clear regulatory and standards guidance **risk falling behind competitors** when policies eventually come into force and access to high-quality CDR tightens.
- Page 23 breaks down policies and standards that could increase demand.

CDR market supply (pg. 25-29):

- **$18 billion in publicly committed funds for nature-based CDR were announced from 2018 to 2025**.
    - Deploying the funds immediately to generate high-quality CDR could translate to up to 32 Mt of annual nature-based CDR supply by 2030 and 290 Mt of cumulative supply by 2040.
    - Improved Forest Management projects can scale quickly to meet demand but require continual investment to provide a consistent supply.
    - The cost of capital significantly influences credit prices: Project finance relies primarily on private capital providers with high return-on-investment expectations.
- **Most planned high-durability CDR will not commence operation without additional offtake.** If the pipeline for commercial-scale facilities fails, the CDR industry risks a “valley of death” scenario in which resources are exhausted and cannot reach maturity.
- **Key challenges to delivering CDR projects** include insufficient regulatory support and CDR guidance, unclear forward demand signals, high capital costs, and the lag between

project development and credit generation, which reduces supplier liquidity and exposes suppliers to risks from unanticipated market changes.

Actions for CDR buyers and investors to help scale the VCM (pg. 30):

- **Balance purchases** that validate new CDR pathways with offtake that brings commercial-scale CDR facilities online.
- **Conduct due diligence** to evaluate project strengths, weaknesses, opportunities, costs, and risks. Rapid evaluations are better suited to triaging project pipelines, while large, multi-year projects may require deep, iterative investigations.
- **Make offtake contracts bankable** to increase the likelihood of project delivery. Structure long-term contracts to reduce project risk, improve supplier liquidity (e.g., through upfront deposits), and unlock lower-cost capital.
- **Strengthen market signals through transparency.**
    - Publicly disclose retirements and purchasing intent.
    - Develop shared definitions of project quality to reduce uncertainty among suppliers and investors.
- **Obtain project assurance.**
    - For major projects, consider independent, milestone-based assurance to identify technical, commercial, governance, and delivery risks early.
    - Leverage milestone- and risk-based payment triggers to tie project finance to execution, thereby increasing the likelihood of successful commissioning.

SUSTAINABLE PACKAGING

Paper-Based Flexible Packaging

By Ellen MacArthur Foundation

View the full report here

Notable Highlights

- **Responsibly designed paper-based flexible packaging can help address plastic pollution in markets with high leakage rates** when reducing reliance on small-format flexible packaging is not immediately feasible.
- **Responsibly designed small-format, paper-based flexible packaging** avoids forest degradation; minimizes environmental impacts during production; meets technical, economic, and consumer needs; is compatible with recycling in local systems; does not lead to hazardous chemical releases or persistent plastic pollution; and does not undermine efforts to reduce reliance on small-format flexibles.
- **Paper-based flexibles come with their own risks** (pg. 17-23), including high water use; varying GHG footprints depending on the design, supply chain, and local energy mix; and global wood demand already exceeding responsible supply.
- Pages 14-15 include an **assessment to help companies identify the most relevant pathways** for reducing small-format flexible plastic waste.
- The following Report Findings include **key breakthroughs needed** in material sourcing, paper production, and packaging technology, and **priority actions for companies** to scale responsibly designed paper-based flexibles.

Objective

- To provide a vision for the role paper-based flexible packaging could play in tackling small-format flexible plastic packaging pollution in markets with high leakage rates (where impacts are greatest).

Background

- The report data is based on insights from over 60 experts across NGOs, companies, paper and plastic packaging manufacturers, and academic institutions; research from the Ellen MacArthur Foundation and the Consumer Goods Forum Plastic Waste Coalition of Action; and a technical review by the Carbon Trust, the Food Packaging Forum, and Normec OWS (methodology on pg. 3-4).

- The report focuses on primary, business-to-consumer flexible packaging sized A5 or smaller, such as wrappers. Markets with formal collection systems are excluded.
- “Paper-based flexibles” refers to flexible packaging primarily made from a cellulosic substrate derived from wood or non-wood fibers.

Report Findings

Pathways for tackling small-format flexible plastic waste in markets with high leakage rates (pg. 12-15):

- **Complementary approaches are needed to tackle small-format flexible plastic waste in markets with high leakage rates:**
    1. **Reducing reliance** on small-format flexible packaging by adopting alternative delivery models and packaging that eliminates the need for it.
    2. **Designing any remaining flexibles** to fit within a circular economy, thereby reducing environmental impacts.
- Pages 14-15 include an **assessment to help companies identify the most relevant pathways** for reducing small-format flexible plastic waste.
    - Assessments should be specific to the product, consumer segment, and market.
    - Considerable research and local stakeholder engagement are required for an accurate assessment.

Risks and limitations of paper-based flexible packaging (pg. 17-23):

- **Risks of paper-based flexibles:**
    - Paper-based flexibles may have a **higher GHG footprint** than plastic-based ones when unmanaged landfill is the primary disposal pathway, and a lower footprint when they weigh less than 1.5x the weight of the plastic they replace.
    - Up to half of all **virgin wood pulp** used for paper may come from **Ancient and Endangered Forests.**
    - The volume of responsibly certified **supply is projected to grow at half the rate** of wood pulp demand through 2040.
- **Limitations of paper-based flexibles:**

- Small-format paper-based flexible packaging still has low collection rates.
- Small format size, contamination, and low material quality can **undermine recycling economics.**
- Fibers and polymers degrade with each recycling cycle, **limiting the number of technically viable recycling loops**.

Six criteria for responsibly designed small-format, paper-based flexible packaging (pg. 25-31):

NOTE: The following pages include detailed criteria.

1. **Ensure sourcing does not degrade forests (pg. 26):**
    - Take a **portfolio-wide approach to fiber sourcing** to reduce virgin fiber use.
    - Avoid sourcing feedstock from areas linked to deforestation and apply robust safeguards to respect the rights of Indigenous Peoples and local communities.
    - Given the global limit on the amount of wood that can be responsibly produced, prioritize reducing overall packaging needs.
2. **Minimize environmental impacts during production (pg. 27):**
    - **Assess, track, and minimize water use and emissions** across all packaging components, particularly in water-scarce regions.
    - Avoid producing or recycling paper in water-scarce areas to minimize impact.
    - Improve **energy efficiency** and transition to renewables across the supply chain.
    - Design packaging with lifecycle emissions in mind, including end-of-life treatment.
    - Invest in closed-loop water systems and align supply chains with water stewardship initiatives.
3. **Meet technical, economic, and consumer needs (pg. 28):**
    - Design packaging to deliver the necessary product protection, **shelf life, consumer usability**, and recyclability while **remaining cost-effective** for businesses and consumers at scale.
    - Define packaging specifications based on the actual product needs, rather than benchmarking against default plastic flexible packaging formats that often exceed what is truly needed.
    - **Engage consumers** to encourage adoption of packaging solutions (e.g., through merchandising toolkits for retailers).

4. **Ensure packaging is recyclable locally (pg. 29):**
    - Design packaging to meet local recyclability guidelines and be practical to handle post-use.
    - Reference international recyclability guidance where local guidelines are absent.
5. **Avoid hazardous chemicals and persistent plastic pollution (pg. 30):**
    - Adhere to widely recognized **restricted chemical lists** (e.g., the EU REACH and POPS regulations).
    - Design packaging to meet robust, recognized **standards for home composting and biodegradability** in soil, freshwater, and marine environments (examples on pages 41-46).
    - Consumers may be more likely to discard packaging in the open environment if they believe it will biodegrade. Do not communicate biodegradability on labels; provide clear, context-specific disposal guidance.
6. **Deploy responsibly designed paper-based flexibles as part of a broader circular economy strategy (pg. 31):**
    - **Assess flexible packaging portfolios** by region, channel, and product to identify the most impactful pathways for each context.
    - Advocate for enabling policies, including harmonizing reuse regulations, setting clear targets for reuse systems, and financial incentives.
    - Ensure circular strategies support a **just transition**: Invest in climate adaptation, ensure fair compensation and safe working environments for waste pickers, and provide low-income consumers with affordable access to essential products.

Innovations needed to scale paper-based flexible packaging (pg. 33-35):

- **Key breakthroughs needed in material sourcing, paper production, and packaging technology:**
    - Non-wood fiber technical performance, recyclability, and responsible supply.
    - Water efficiency and decarbonization of paper production and recycling.
    - Barrier materials (including coating materials) that are recyclable, home-compostable, and biodegradable across environments.
    - Inks, adhesives, and additives that are non-toxic, home-compostable, and biodegradable across environments.
    - Machinability and suitability of machines to process paper-based packaging at competitive run times.

- The pace and feasibility of innovation vary by product type. Page 34 breaks down **technology readiness timelines and cost drivers** for each innovation challenge.
- Page 35 includes **examples of emerging innovations.**

Priority actions for companies to scale responsibly designed paper-based flexibles (pg. 37-38):

- **Accelerate innovation:** Share R&D efforts to reduce costs, risks, and timeframes for bringing material innovations that address all six critical responsible-design criteria to market at scale.
- **Develop sustainable fiber supply chains and protect forests.**
    - Set a **portfolio-wide fiber-sourcing strategy** to reduce overall virgin fiber use.
    - Prioritize environmentally preferable fibers where feasible.
    - Invest in innovation and infrastructure and collaborate with other companies to scale the supply of responsible non-wood fiber across the packaging portfolio.
- **Establish effective and socially inclusive collection and recycling systems.**
    - Jointly fund the **city-wide transformation** of packaging collection and recycling infrastructure. Engage waste pickers, unlock public-private co-investment, and demonstrate a pathway to national system transformation.
    - **Engage** local waste management and paper recycling companies to ensure packaging design aligns with local recyclability guidelines.
- **Advance and prioritize other solution pathways.**
    - Join **multi-company reuse demonstrators** operating at the city or country scale that share reuse infrastructure and packaging. These can support learning, inform policy, reduce costs, and unlock investment to further scale up.
    - Identify opportunities to shift from small-format packaging to larger-volume packaging and to reuse-and-refill models.

CORPORATE SUSTAINABILITY REPORTING

The Air Pollution Reporting Gap

By GRI

View the full report here

Notable Highlights

- 57% of companies use the GRI Standards in their reporting, and only 43% of them use GRI 305-7 (related to air pollutants).
- **Mentions of air pollutants are more common than pollutant disclosures** (with a quantitative emissions value) **across all pollutant categories.** The difference is most apparent for nitrogen oxides, sulfur oxides, and particulate matter, where 30-44% of companies reference them, while only 23-31% provide emissions values.
- **Nitrous oxides** (44.2% mentions, 30.8% disclosures) **and sulfur oxides** (38.7% mentions, 27.9% disclosures) are the two **most-reported pollutants**.
- Many companies **express an intention to reduce air pollution impacts** and frame commitments around general outcomes, such as improving measurement methodologies, expanding pollutant inventories, or strengthening management practices.
- The following Report Findings break down **air pollutant reporting by sector.**

Objective

- To examine how companies report on air pollutants, including nitrogen oxides (NOx), sulfur oxides (SOx), particulate matter (PM), volatile organic compounds (VOC), hazardous air pollutants (HAPs), and persistent organic pollutants (POPs).

Background

- The report data is based on an analysis of 915 sustainability and annual reports from over 1,000 public companies worldwide from the 2023-2024 reporting year. Companies had a median revenue of $3.3 billion (methodology on pg. 2-5).
- Companies were selected from the GRI database, with 125 from each of the following sectors: Agriculture, Transport, Mining, Pharmaceuticals, Construction, Metals Processing, Construction Materials, and Chemicals.

- The analysis distinguishes between mentions of pollutants and pollution disclosures, in which a pollutant was accompanied by a quantitative emissions value.

Report Findings

Corporate air pollutant reporting across sectors (pg. 7, 17-18):

Chart 2. Air pollution mentions and disclosures breakdown for the entire sample

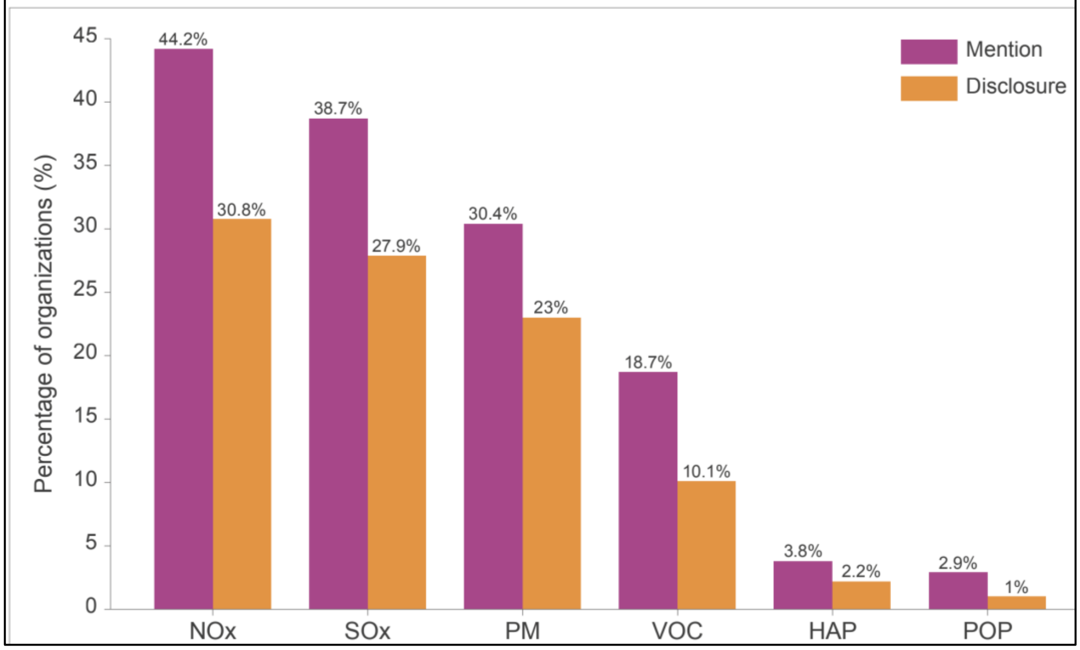

Image taken from pg. 7

Table 3. Heat map of disclosure frequency across pollutants and sectors

Sector	Nox	Sox	PM	VOC	HAP	POP
Agriculture	18%	15%	15%	2%	0%	0%
Chemicals	42%	38%	21%	27%	10%	4%
Construction	24%	18%	17%	6%	0%	0%
Construction materials	53%	42%	40%	7%	2%	2%
Metal processing	30%	27%	23%	7%	2%	0%
Mining	38%	38%	31%	18%	5%	4%
Pharma	24%	21%	15%	10%	0%	0%
Transport	30%	23%	22%	5%	0%	0%

Image taken from pg. 8

- **Mentions of air pollutants are more common than disclosures across all pollutants**. The difference is most apparent for NOx, SOx, and PM, where 30-44% of companies reference these pollutants, while only 23-31% provide emissions values.
    - This is possibly due to **NOx, SOx, and PM** being the most frequently referenced pollutants in reporting frameworks and regulatory air quality inventories, thereby **attracting more stakeholder attention and being monitored more routinely**.
    - VOCs, HAPs, and POPs may require more specialized measurement approaches or be relevant only to certain industrial processes.
- Companies that disclose numerical emissions data **typically present aggregated data for the whole organization for a single year** rather than across years.
- Several company reports note that detailed emissions **data are available elsewhere** (e.g., external data portals), creating a degree of transparency but also **information fragmentation for stakeholders.**

Air pollutant reporting by sector (pg. 9-16):

NOTE: The following pages include detailed sector data.

- **Agriculture (pg. 9):** 26.4% mention NOx, and 22.4% mention SOx. Mention and disclosure rates were around 15% for PM and virtually non-existent for the remaining pollutants.
- **Pharmaceuticals (pg. 10):** About 20% of companies mention VOCs, but only about 10% disclose. This could reflect early-stage reporting practices in which the pollutant is recognized, but disclosure systems aren't consistently in place.
- **Transport (pg. 11):** 50.4% of companies mentioned NOx, and 37.6% SOx. However, fewer than 30% of companies provide disclosures.
- **Construction (pg. 12):** There is a wider gap between PM mentions and disclosures (27.2% vs. 16.8%) than for other pollutants, suggesting that companies have more readily available data for particulate emissions.
- **Metals Processing (pg. 13):** While VOCs are relevant to certain production and energy use processes in the sector, only 11% of companies mention VOCs, and 7% disclose emissions values.
- **Construction Materials (pg. 14):** This sector has the smallest gap between pollutant mentions and disclosures across all pollutants.
- **Chemicals (pg. 15):** The sector has among the highest NOx and SOx mentions (over 50%) and disclosure (~60%) rates. Half of the companies mention VOCs, but only 27% provide disclosures.
- The Chemicals and **Mining (pg. 16)** sectors are the only two with reporting activity related to HAPs and POPs.

PUBLIC-PRIVATE PARTNERSHIPS

Public-Private Partnerships: Financing The Future

By FII Institute

View the full report here

Notable Highlights

- The **financing gap for global infrastructure is estimated to reach $15 trillion** by 2040, including a $3.7 trillion shortfall in the U.S. Meanwhile, **unlisted infrastructure funds** have grown from roughly $20 billion in assets under management in 2009 to **over $1.5 trillion in 2024**.
- **Private sector involvement in public projects helps** de-risk new markets and reduce time and cost overages (by leveraging companies' expertise in delivering projects under conditions like supply chain volatility and inflation). **Strong legal frameworks are essential** to ensure projects benefit the public good.
- **Banks can support public-private partnerships (PPPs) by** funding infrastructure categories that markets have historically ignored (e.g., climate adaptation), structuring deals to attract capital, reducing administrative friction, and translating risks into packages investors are willing to take on.
- While 41% of global leaders think PPPs "equally benefit everyone," only 23% of the public agrees. This **skepticism can trigger project delays** or cancellations.
- The following Report Findings include **PPP challenges and recommendations** to increase investor engagement, build public trust in PPPs, and enhance PPP success.

Objective

- To explore the development of public-private partnerships (PPPs), including key challenges, investor engagement, the role of banks, and public trust, and recommendations for success.

Background

- The report is based on datasets, studies, and reports from various public and private sources (listed on pg. 67).

Report Findings

The case for public-private partnerships (PPPs) (pg. 6-9, 14-27):

- **Global PPP spending across low- and middle-income countries reached $100.7 billion in 2024,** up 16% from 2023 and above the five-year average of $83.7 billion.
    - PPPs account for 10% of global annual investment in physical and social infrastructure.
    - Emerging markets account for about 61% of global PPP activity by GDP share.
- Close to 3.5% of GDP—equivalent to **around $4.2 trillion annually—must be invested over the next decade** to future-proof transport, energy, and digital infrastructure against urbanization, supply chain disruptions, and AI-driven digitalization.
    - Fiscal debt above 6% of GDP is common across many economies, making countries that act as the sole financiers of national infrastructure increasingly unsustainable.
    - Nearly **one-third of infrastructure assets have no net-zero target.**
- For investors, infrastructure-backed PPPs offer **long-duration, inflation-linked cash flows** when public markets are volatile.
- The next phase of **growth in the global digital economy depends on coordinated partnerships** across sectors, not just technology; PPPs align governments, businesses, and investors around shared outcomes. The Framework for Collaborative Investment in the Digital Economy includes a roadmap on digital PPPs.
- Pages 22-25 include **case studies** of successful PPPs.

How the private sector can bolster public projects (pg. 30-33):

- The private sector can help **de-risk new markets**. By both entities using their balance sheets to absorb early uncertainty, private investment can be unlocked at scale.
- Bringing in major contractors and technology firms that specialize in delivering projects under tight timelines, supply chain volatility, inflation, and regulatory shifts can **reduce time and cost overages** and increase visibility into how assets will perform over decades.
- Strong legal frameworks that define roles, responsibilities, and dispute-resolution mechanisms can **keep the public good at the core of projects**.

How banks can help enable public-private partnerships (pg. 36-39):

- The most direct way banks can support projects is by **funding infrastructure categories** that markets have historically ignored, such as climate adaptation.
- Banks can **help design PPP deals to attract deep pools of capital** and avoid stalling in later renegotiations.
- Public projects more often fail due to misallocated risks than impossible engineering. Banks can **translate engineering risks into structures/packages that investors are willing to take on**.
- A significant share of PPP friction is administrative. Banks specializing in blockchain-based settlement and smart-contract-like automation can **reduce administrative friction**, thereby speeding up cash flows and enhancing reporting transparency.

Public-private partnership challenges (pg. 34-35):

- Projects risk **ballooning costs due to "optimism bias,"** where actors underestimate costs and overestimate demand.
- **Contractual limitations:**
    - Contractual terms such as 25-30-year project concessions are no longer effective, given volatile interest rates and political churn. PPPs must be designed with **pre-agreed review points** and clearly defined triggers for adjustment.
    - In digital and AI-enabled infrastructure, a 25-year contract can be **outpaced by technology** innovation cycles, leading to project abandonment.
- A **change of government** can destroy investor confidence overnight. Bipartisan consensus and stand-alone legislation that outlasts individual officials and electoral cycles are critical for PPP success.
- **Aggressive bidding:** Private actors often underprice construction and operating costs simply to win the deal, assuming they can renegotiate later.

Investors are more likely to engage in PPPs that include (pg. 41-43):

- **Explicit ESG/impact data** and reliable, comparable performance data over the life of an asset (e.g., maintenance backlogs and emissions outcomes).
- Systems to **reduce project friction** (i.e., delays, paperwork, and milestone verification).
- Structures that ensure **solid returns** both on local terms and after currency exchange.
- A **standalone legal framework** that outlasts electoral cycles and provides clarity on who holds which risks.

- A degree of **flexibility**, provided through regular updates and renegotiations.
- The **ability to exit** long-term projects when needed.

Recommendations to enhance PPP success (pg. 48-51):

- **Share project risk** and allocate it where it can be actively managed at the lowest cost.
- Major projects often exceed original contract prices and have compressed timelines. **Plan realistically,** use selection criteria that reward quality and resilience rather than just the lowest numbers, and stress-test assumptions.
- **Avoid technological obsolescence** in tech-heavy projects by using modular build-outs, shortening contract durations, and including explicit clauses that allow tech upgrades without full project renegotiations.
- **Create a shared definition of PPP success**, including what the public partner is purchasing (e.g., availability, reliability, decarbonization outcomes) and what the private partner receives for delivering.
- **Develop governance that outlasts** political administrations or CEOs, including clear legal frameworks, repeatable procurement processes, and institutional capabilities.

Recommendations to build public trust in PPPs (pg. 56-59):

- Measure project success beyond metrics like GDP uplift or internal rate of return. **Embed indicators that matter to citizens**, such as opportunity, health, and well-being, into PPP design.
- **Demonstrate the project's benefits** to the local community early and report performance without specialist jargon.
- **Promote transparency** by publishing contracts with limited redactions, disclosing performance data, and using digital tools to bring projects to life in real time.
- **Develop community-centered PPP models** that prioritize local hiring and skills transfer. For example, the FII Institute and its partners developed an AI Inclusive initiative to upskill local populations with inclusive AI training.

MINING & METALS EMISSIONS

Global Mining & Metals Greenhouse Gas Emissions Dataset

By ICMM

View the full report here

Notable Highlights

- **The global Mining and Metals sector accounted for 11% of global GHG emissions in 2024,** including 3% from mining and 8% from metal production.
- 93% of those emissions were Scope 1, and 7% were Scope 2.
- Steel production (55%), coal mining (23%), and aluminum production (15%) were the **largest emitters** on an absolute basis.
- Emissions from mining and metal production **increased by 3% from 2020 to 2024**, driven by higher production and emissions intensity of thermal coal and nickel.
- **80%** of emissions were **generated in Asia** in 2024.
- To help decarbonize the sector, **companies can transition to on-site renewable energy and vehicle electrification** within mining and metals facilities **and form strategic, long-term collaborations** across sectors.
- The following report Findings include **sector decarbonization opportunities**.

Objective

- To analyze Scope 1 and Scope 2 GHG emissions in the global Mining and Metals sector in 2024, including scale, sources, and distribution across commodities and regions.

Background

- The report is based on Scope 1 and Scope 2 emissions data from 1,743 facilities across 14 commodities, which were derived from Wood Mackenzie's Emissions Benchmarking Tool and matched to ICMM's Global Mining Dataset (methodology on pg. 5-6, 18-23).
- The emissions account for about 87% of global production of the 14 commodities. Emission estimates were modeled to account for the remaining 13%.
- While the report focuses on 2024 data, the Global Mining Dataset covers 2020 to 2025.

Report Findings

2024 emissions across 14 mining and metal commodities (pg. 7-8):

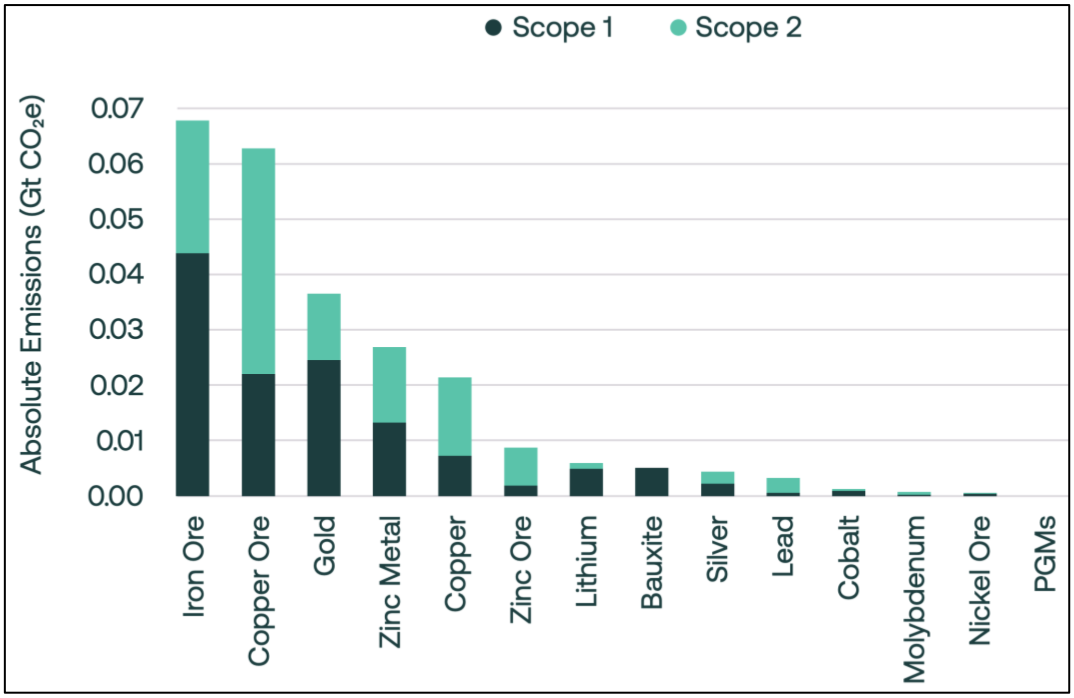

Image taken from pg. 8

- **82% of mining emissions in 2024 were fugitive emissions** (unintentional gas releases) related to coal.

Sector emissions intensity (pg. 9-10):

- **Gold has the highest emissions intensity of all commodities**, followed by silver. However, their contribution to total industry emissions is low because global production is lower than that of aluminum, steel, and coal.
- The emissions **intensity of aluminum decreased by 3%** from 2020 to 2024, driven by a shift toward hydropower and other renewable electricity sources.

The global distribution of sector emissions (pg. 11-12):

- **Steel production accounts for** 93% of mining and metals emissions in Europe, nearly 60% in Central and South America, about 55% in Asia, and **40% in North America**.
- Coal production accounts for 41% of mining and metals emissions in North America.

Sector decarbonization opportunities (pg. 13-14):

- **Within mining and metals facilities, companies can transition to on-site renewable energy and vehicle electrification.**
    - Access to low-carbon fuels, commercially ready technologies, and supporting infrastructure is needed to do so.
    - At a typical mine, diesel combustion in haul trucks and loaders accounts for approximately 50% of direct Scope 1 emissions; on-site power generation accounts for around 30%.
- **Strategic, long-term collaboration across sectors is needed** to develop supportive policy frameworks, unlock financing, and prevent rising mineral demand from driving even higher emissions.
- **Examples of ICMM member action** to decarbonize the sector are available here.
- **Coal-related fugitive emissions can be mitigated by capturing methane** from mine ventilation or by pre-draining it before mining starts and utilizing it as an energy source.
- Steel decarbonization efforts are being driven by a shift away from blast furnace-basic oxygen furnace (BF-BOF) crude steel production toward **lower-emission direct-reduced iron (DRI) and electric arc furnace (EAF) methods.**
    - DRI-EAF production is scaling up, with the main constraint for DRI growth being the availability of high-grade iron ore.
    - Carbon capture, utilization, and storage (**CCUS) is crucial** for mitigating emissions from existing BF-BOF plants that cannot be replaced immediately.
- **Aluminum** smelting is electricity-intensive; **decarbonizing the electricity supply** is the most significant near-term lever.