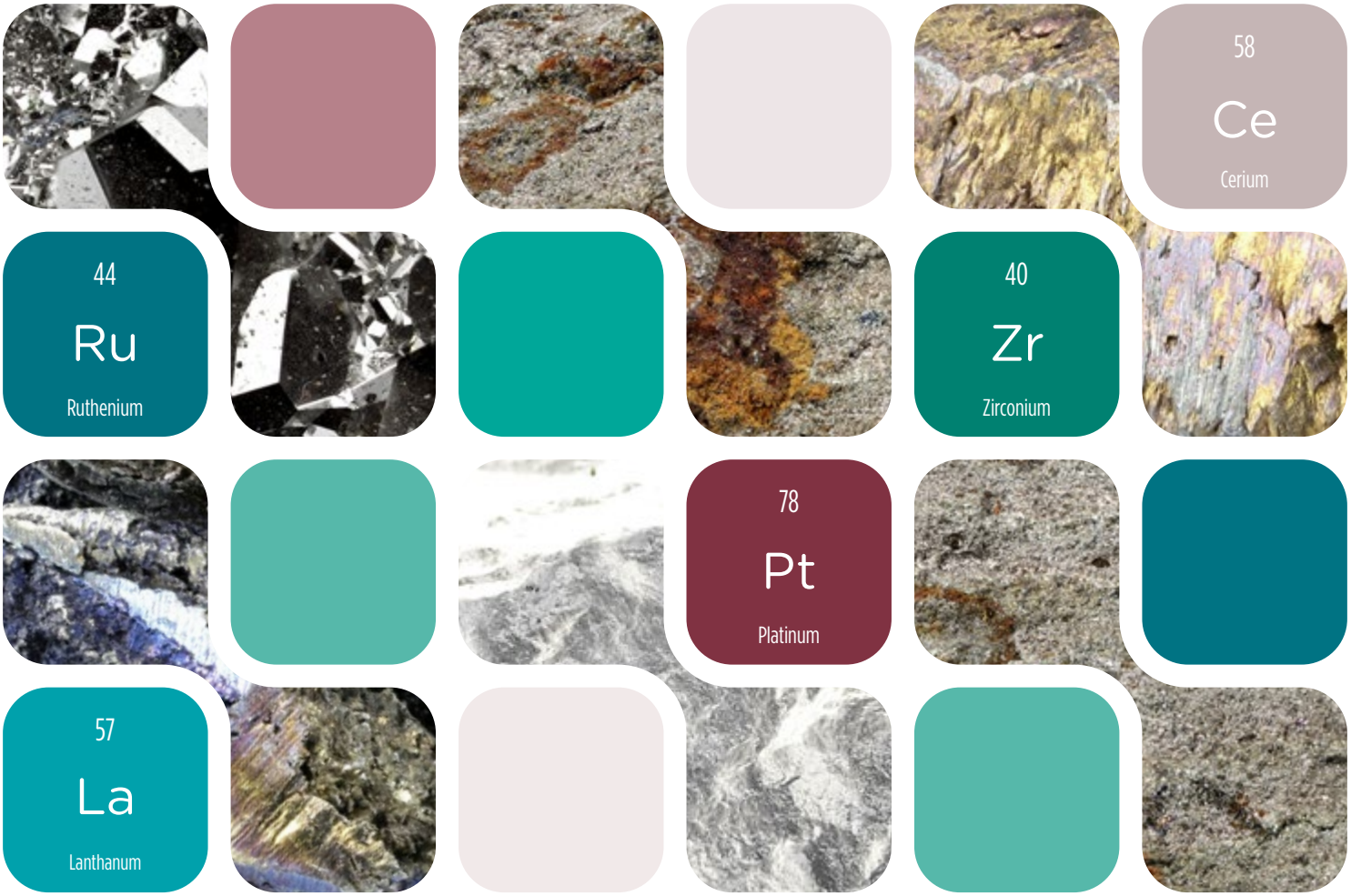
Norwegian Institute of International Affairs

IRENA
International Renewable Energy Agency

Critical materials for renewable energy
Improving data governance



ISBN: 978-92-9260-631-2

Citation: IRENA and NUPI (2024), *Critical materials for renewable energy: Improving data governance*, International Renewable Energy Agency, Abu Dhabi.

Available for download: www.irena.org/publications
For further information or to provide feedback: publications@irena.org

About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

About NUPI

The Norwegian Institute of International Affairs (NUPI) was established by the Norwegian Storting (parliament) in 1959 and is an independent research institution. NUPI carries out research on international issues, including the global energy transition and climate policy.

Acknowledgements

This report was authored by Roman Vakulchuk (NUPI), Dastan Bekmuratov (NUPI), Francisco Boshell (IRENA), Ida Dokk Smith (NUPI), Isaac Elizondo Garcia (IRENA), Benjamin Gibson (ex-IRENA), Luis Janeiro (IRENA), Julia Loginova (University of Queensland), Gavkharkhon Mamadzhanova (NUPI), André Månberger (Lund University), Indra Overland (NUPI), Thiri Shwesin Aung (Harvard University), Tatjana Stankovic (NUPI), Philip Swanson (NUPI) under the direction of Indra Overland (Head of Centre for Energy Research, NUPI) and Roland Roesch (Director, IRENA Innovation and Technology Centre).

Valuable input was also provided by Dora Lopez (University of Oklahoma), Jinlei Feng (IRENA), Michael Taylor (ex-IRENA), Thijs van de Graaf (Ghent University) and Zafar Samadov (IRENA). The report was copy-edited by Justin French-Brooks and a technical review was provided by Paul Komor. Editorial support was provided by Francis Field and Stephanie Clarke. The graphic design was provided by Phoenix Design Aid.

IRENA is grateful for the support received from the Government of Norway for the production of this report.

Contents

FIGURES

TABLES

BOXES

Abbreviations

Al	aluminium
B	boron
Be	beryllium
BGS	British Geological Survey
BOM	bill of materials
Cd	cadmium
Ce	cerium
CM	critical material
Co	cobalt
Cr	chromium
Cu	copper
Dy	dysprosium
EITI	Extractive Industries Transparency Initiative
Eu	europium
EV	electric vehicle
Fe	iron
Ga	gallium
Gd	gadolinium
Ge	germanium
Gr	graphite
In	indium
Ir	iridium
JODI	Joint Organisations Data Initiative
K	potassium
La	lanthanum
Li	lithium
METRIC	Materials for the Energy Transition: Repository & Information Collection
Mg	magnesium
Mn	manganese
Mo	molybdenum
Nb	niobium
Nd	neodymium
Ni	nickel
ODC	Open Data Charter
OECD	Organisation for Economic Co-operation and Development
OLADE	Latin American Energy Organization
P	phosphorus
Pb	lead
Pd	palladium
PGM	platinum group metal
Pr	praseodymium
Pt	platinum
Re	rhenium
REE	rare earth element
Rh	rhodium
Ru	ruthenium
Se	selenium
Si	silicon
Sm	samarium
Sn	tin
Sr	strontium
Ta	tantalum
Tb	terbium
Te	tellurium
Ti	titanium
UN	United Nations
USGS	US Geological Survey
V	vanadium
W	tungsten
WTO	World Trade Organization
Y	yttrium
Zn	zinc
Zr	zirconium

Executive summary

The success of the global energy transition depends on a rapidly growing and uninterrupted supply of critical materials for renewable energy technologies. This requires a unified, open and transparent global repository of data on critical materials, covering extraction, trade and criticality assessment. The lack of such a repository leads to actors taking less-well-informed decisions about critical materials markets. Data opacity delays the supply of critical materials to international markets and interrupts the deployment of renewable energy.

This study reviews the main actors involved in the governance of critical materials supply chain data, including national government institutions, international organisations and foundations, mineral associations, and commercial data providers.

A total of 45 data sources produced by these actors were reviewed in the study, with a focus on data accessibility, transparency and coverage.

Key challenges for the governance of data on critical materials supply chains

- Critical materials markets are opaque, as existing data on critical materials suffer from missing values, low quality, outdated or being limited in coverage, and difficult to compare.
- In many cases, data on critical materials are embedded in larger databases that include other types of commodities. Such general databases often lack the detailed data – on the rapidly growing demand for minerals, technological innovation and upscaling of recycling – needed for governments and private actors in the mining sector to take better informed decisions.
- Critical materials data governance is highly fragmented. It involves at least 37 actors with different agendas and interests. Although detailed data are available for some materials, most are scattered across different sources. Access to the most recent data often requires subscriptions from commercial providers, with some costing tens of thousands of USD per data source.
- The lack of transparency creates risks for the energy transition: it can lead to poor investment decisions, competitive international relations, supply chain disruptions, price spikes, trade disputes, resource nationalism and rising geopolitical tensions.

There is a need to improve data for:

- Reserves, mines and processing: Proven geological reserves; geological accessibility; exploration; mining sites; market concentration; valuable by-products from mining; ore grade; processing facilities; environmental, social and governance factors affecting mining; type of technology/process used by each processing facility to allow assessment of life cycle emissions and water consumption for mining and processing.

- Trade flows: Supply chains; tariff and non-tariff measures; illegal trade; trade restrictions; recycling; real-time and historical benchmark pricing; supply/demand forecasts; patent and trademark information.

- Assessment of criticality: Regularly updated list of critical materials for the energy transition; definition of a criticality threshold value; demand forecasts for technologies, storage and other supporting infrastructure; renewable energy mix forecast; material use; material use for different renewable energy technologies; materials substitution; recycling technologies, recycling facilities, recycling rates and market outlook.

A solution: Materials for the Energy Transition – Repository & Information Collection (METRIC)

- As of October 2024, no global unified critical materials data repository exists. This report proposes to establish the Materials for the Energy Transition – Repository & Information Collection (METRIC), which would enhance the transparency of supply chain data and could have global benefits. It could substantially improve the quality, transparency, timeliness and completeness of data from a variety of sources.

- The design of METRIC draws on good governance theory and lessons learnt from a review of nine international and national initiatives for improving data governance in other sectors.

- METRIC could mitigate critical materials risks, increase predictability, and strengthen international collaboration on renewable energy by providing more unified, comparable and detailed data on all major critical materials data dimensions located in one place. Currently, one has to search across a broad variety of sources for data that are often non-standardised and non-unified and thus non-comparable. This complicates the process of key stakeholders taking well-informed decisions about critical materials markets.

1. Introduction

The success of the global transition to renewable energy depends on a rapidly growing and uninterrupted supply of critical materials for the manufacture of renewable energy technologies, energy storage and electric vehicles (EVs) (see Table 1). A unified, open and transparent data repository for critical materials supply chains can facilitate more effective governance of critical materials. The lack of such a repository leads to actors taking less-informed decisions about critical materials markets. In turn, data opacity may slow down the supply of materials to international markets and interrupt the deployment of renewable energy.

This study examines existing major data sources on critical materials. It reviews the main actors involved in the governance of critical materials supply chain data, including national government institutions, international organisations and foundations, mineral associations and commercial data providers. A total of 45 data sources produced by these actors are reviewed in the study with a focus on data accessibility, transparency and coverage. The list of data actors is not exhaustive, but it includes the major critical materials data providers.

The study has three purposes:

- It reviews existing primary and secondary data sources on critical materials. It evaluates their strengths and weaknesses, focusing on the degree of accessibility, transparency and coverage.
- It reviews existing international and national initiatives to improve data availability in various other sectors that might serve as examples for a critical materials data repository.
- It proposes to establish a Materials for the Energy Transition: Repository & Information Collection (METRIC) initiative to improve data transparency, access and quality for critical materials markets.

Motivation for the study

With the world growing increasingly dependent on critical materials, demands for greater transparency of global supply chains and markets for materials, including availability of data, have been growing at a similar pace. For example, Gielen and Lyons (2022) call for measures to increase the transparency of the lithium market in order to reduce risks for both suppliers and consumers. They note that even such a mature market suffers from opacity and limited data availability.

The limited data on critical materials supply chains create risks for the ongoing effort to accelerate the energy transition in a number of ways:

- It complicates assessment of the criticality of materials.
- It makes supply and demand forecasting more difficult and reduces the accuracy of research results.
- It makes resource governance less transparent.
- It can cause misallocation of capital and limit investment decisions on existing and new mines.
- It can undermine a level playing field and provoke competitive rather than co-operative behaviour among states and other energy transition actors.

In summary, the lack of transparency surrounding critical materials may result in unreliable supply chains, raise costs and exacerbate geopolitical risks. The creation of a unified, open-access and transparent data governance repository can reduce these risks and create an important global public benefit.

TABLE 1 A global ranking of critical materials for renewable energy by criticality score

MOST CRITICAL		MODERATELY CRITICAL		LEAST CRITICAL	
Lithium	**0.81**	Silver	**0.49**	Molybdenum	**0.39**
Cobalt	**0.81**	Strontium	**0.48**	Magnesium	**0.39**
Gallium	**0.73**	Platinum	**0.47**	Yttrium	**0.39**
REEs*	**0.72**	Phosphorus	**0.47**	Cadmium	**0.38**
Neodymium	**0.68**	Chromium	**0.47**	Terbium	**0.38**
Indium	**0.68**	Rhodium	**0.45**	Zinc	**0.36**
PGMs*	**0.67**	Lanthanum	**0.45**	Iridium	**0.36**
Dysprosium	**0.65**	Ruthenium	**0.44**	Zirconium	**0.35**
Nickel	**0.63**	Aluminium	**0.44**	Samarium	**0.35**
Tellurium	**0.61**	Boron/borate	**0.43**	Tungsten	**0.34**
Praseodymium	**0.57**	Selenium	**0.43**	Beryllium	**0.33**
Graphite	**0.57**	Palladium	**0.42**	Tin	**0.32**
Manganese	**0.54**	Cerium	**0.41**	Iron/Steel	**0.32**
Copper	**0.52**	Vanadium	**0.41**	Europium	**0.31**
Germanium	**0.51**	Titanium	**0.40**	Potassium	**0.31**
		Silicon	**0.40**	Niobium	**0.29**
				Tantalum	**0.27**
				Gadolinium	**0.24**
				Lead	**0.24**
				Rhenium	**0.22**

Source: IRENA and NUPI (2024).

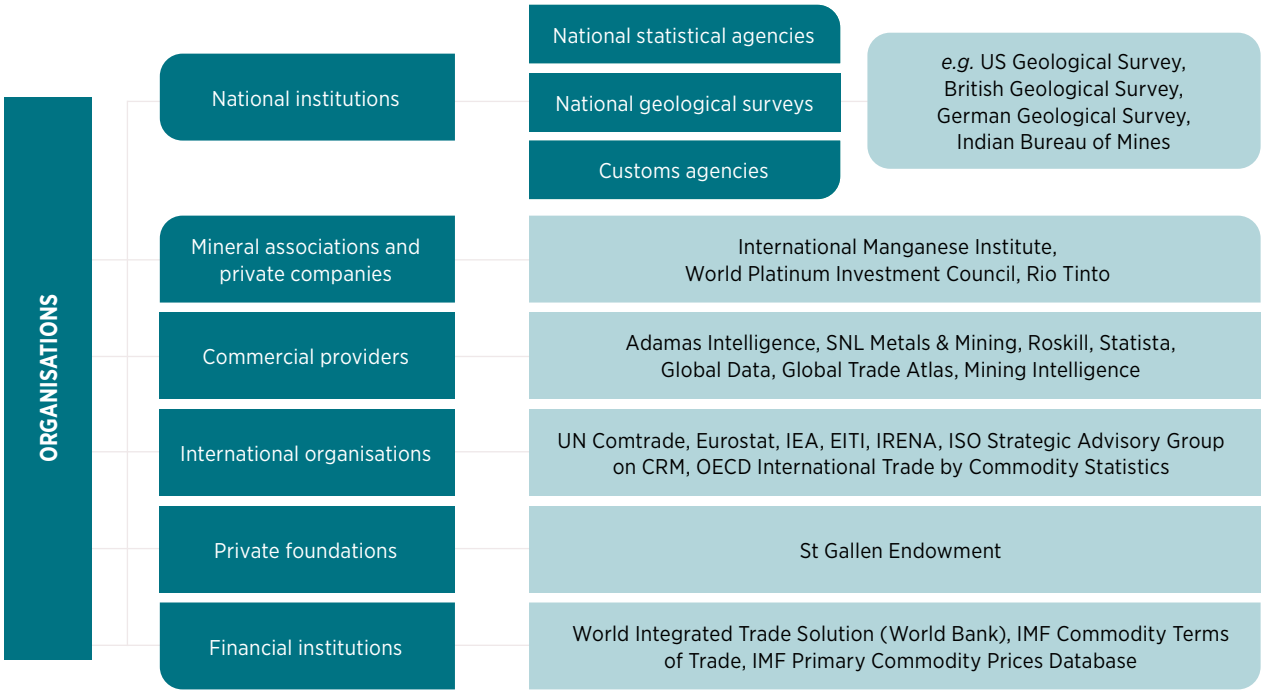
Notes: The mineral groups REEs (rare earth elements) and PGMs (platinum group metals) and the individual minerals that are part of these groups are treated separately. This is because of the scoring system for the clean energy meta-list, which is designed to accommodate the fact that some critical materials lists include only the group names, while others refer to individual minerals that belong to the groups. This also explains why the scores between the groups and their individual minerals diverge. Theoretical range of criticality score 0-1.

2. Review of existing data sources for critical materials supply chains

As of October 2024, there is no single, comprehensive and unified global geological data repository that would include all important data dimensions relevant to the global energy transition. Different aspects of data on critical materials are often part of broader databases that cover many other types of commodities. This is not surprising, as global data gathering on critical materials has never been planned or co-ordinated. The limitation of general-purpose databases is that they often lag behind markets and do not take into account the specific needs of the global energy transition, characterised by rapidly growing demand for materials that currently cannot be easily replaced by other materials, continuous technological innovation and upscaling of recycling infrastructure. Many databases therefore are not updated as frequently as required to meet the needs of fast-developing renewable energy technologies. As a result, such databases are less relevant to the energy transition.

As shown in Figure 1, several types of actors shape the current governance of critical materials data. Some of them collect, manage and provide primary data, while others collect, manage and systematise existing secondary data. The criteria for selecting actors in each category relates to the need to cover most of the major players and for illustrative purposes (see Annex 1 for more detail).

FIGURE 1 Selected organisations that provide data on critical materials



Notes: CRM = critical materials; EITI = Extractive Industries Transparency Initiative; IEA = International Energy Agency; IMF = International Monetary Fund; IRENA = International Renewable Energy Agency; ISO = International Organization for Standardization; OECD = Organisation for Economic Co-operation and Development ; UN = United Nations.

2.1. National institutions

National geological surveys play a primary role in the collection and provision of data on mineral resources and reserves. Geological data include information on the location and estimated volumes of mineral resources, types of reserves and grade of commodities. Some national agencies, such as the US Geological Survey (USGS) and the British Geological Survey (BGS), also collect and provide data on international resources and reserves.

National statistics agencies typically provide data on the production, processing and trade in materials. These data can include information on the quantity and value of produced commodities, domestic consumption, and commodity exports and imports, including volumes, values and destinations. National statistics generally inform company strategies and domestic policy decisions related to mineral exploration, processing needs and trade measures. They also serve as a source of primary data for international statistics organisations, such as the UN Comtrade.

The quality of trade data varies from country to country. Data can be manipulated or withheld from the public by government agencies, which may seek to benefit from the informational advantage or have national security concerns, particularly when state-owned companies are involved. National statistics generally do not cover unreported artisanal and small-scale mining (Sturman *et al.*, 2022). Unreported or misreported flows represent a significant data gap for some minerals, such as cobalt, for which hidden flows may represent over 50% of total trade (Leon *et al.*, 2021). There are also data gaps in information concerning embedded materials in products such as EVs and electrical appliances (McCaffrey *et al.*, 2023).

BOX 1. Data from national institutions

Strengths

- **Credibility:** Many countries have well-established data collection and reporting systems, ensuring accurate information.
- **Accessibility:** Countries usually make statistical data publicly available.
- **Time coverage:** National statistics agencies commonly provide internally consistent data on an annual and sometimes quarterly or monthly basis, making data comparable over time.

Weaknesses

- **Limited comparability:** Low levels of comparability between data from different countries are due to differences in methods of data collection and reporting, units of measurement and levels of data aggregation.
- **Limited granularity:** National statistics agencies often provide data at an aggregate level without details about specific mineral subtypes.
- **Incomplete data:** Some activities along critical minerals value chains may take place outside the formal economy (illegal mining and trade) and may not be captured by official national statistics.
- **Limited capacity and resources:** Many developing countries lack the capacity and financial resources to produce reliable statistics.
- **Lack of reliability and accessibility:** In the case of some countries and minerals, data can be outdated, manipulated or made inaccessible.

National customs data can provide more nuanced information on specific trade flows. For example, the Uljas customs database of Finland, which is a significant importer of cobalt concentrates and exporter of processed cobalt, has been used to analyse details about the trade in semi-processed cobalt, which are not available in international databases such as UN Comtrade or EUROSTAT (Leon *et al.*, 2021). Box 1 summarises the main strengths and weaknesses of critical materials data produced by national institutions.

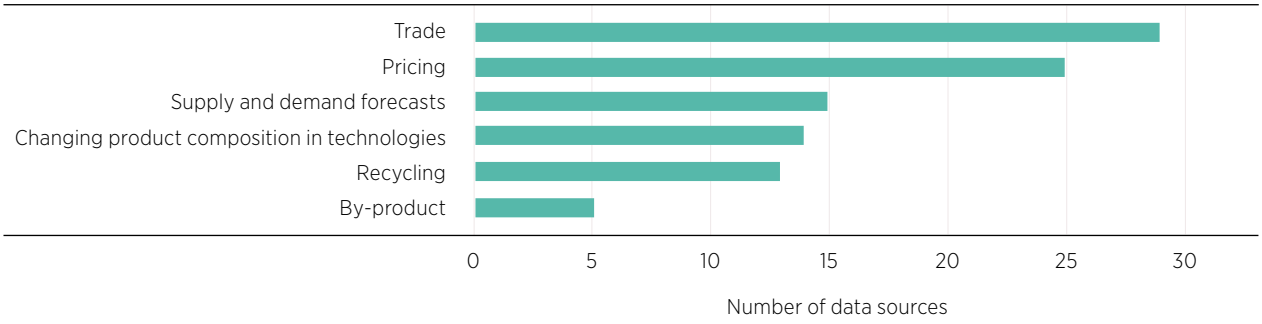
2.2. International and intergovernmental organisations

Figure 2 shows that data about reserves, production and trade are provided by at least 28 international data sources, while the availability of data on supply and demand forecasts (15), changing product composition in technologies (14) and recycling (13) is more limited. Moreover, data on specific by-products are presented in only five sources (see Annex 1 for more detail).

Two widely used sources of international trade data are the UN Comtrade database and the European Union's EUROSTAT. Both provide comprehensive and consistent information about international trade for a wide range of countries and commodities, using standardised methodologies. However, international trade data on critical materials is complex and usually requires expert knowledge and the assessment of additional information in order to fully interpret such data (Jin *et al.*, 2016; Schrijvers *et al.*, 2020).

According to Schrijvers *et al.* (2020), UN Comtrade data have significant gaps and limitations in regard to critical materials trade flows. There are well-known general problems with these trade statistics, such as the substantial average gap between traded goods as reported by exporting and importing countries (Melchior, 2012; Schrijvers *et al.*, 2020). For many critical materials, however, there are additional limitations. The UN Comtrade database does not always distinguish between forms and grades of materials. It also tends to group many minor producers and traders into the "other" category, treating them as one source, thus obscuring potentially important trade flows. For trade in metal concentrates, precise data on metal content and associated elements are almost non-existent. A commodity might pass through one or more intermediate countries before reaching its final destination, or undergo minor, value-adding processing in an intermediate country (Fortier *et al.*, 2021). Such intermediate trade may or may not be reported.

FIGURE 2 Number of international data sources covering various dimensions of critical materials value chains



Note: See Annex 1 for a detailed overview of data sources.

FIGURE 3 Number of data sources covering each critical material

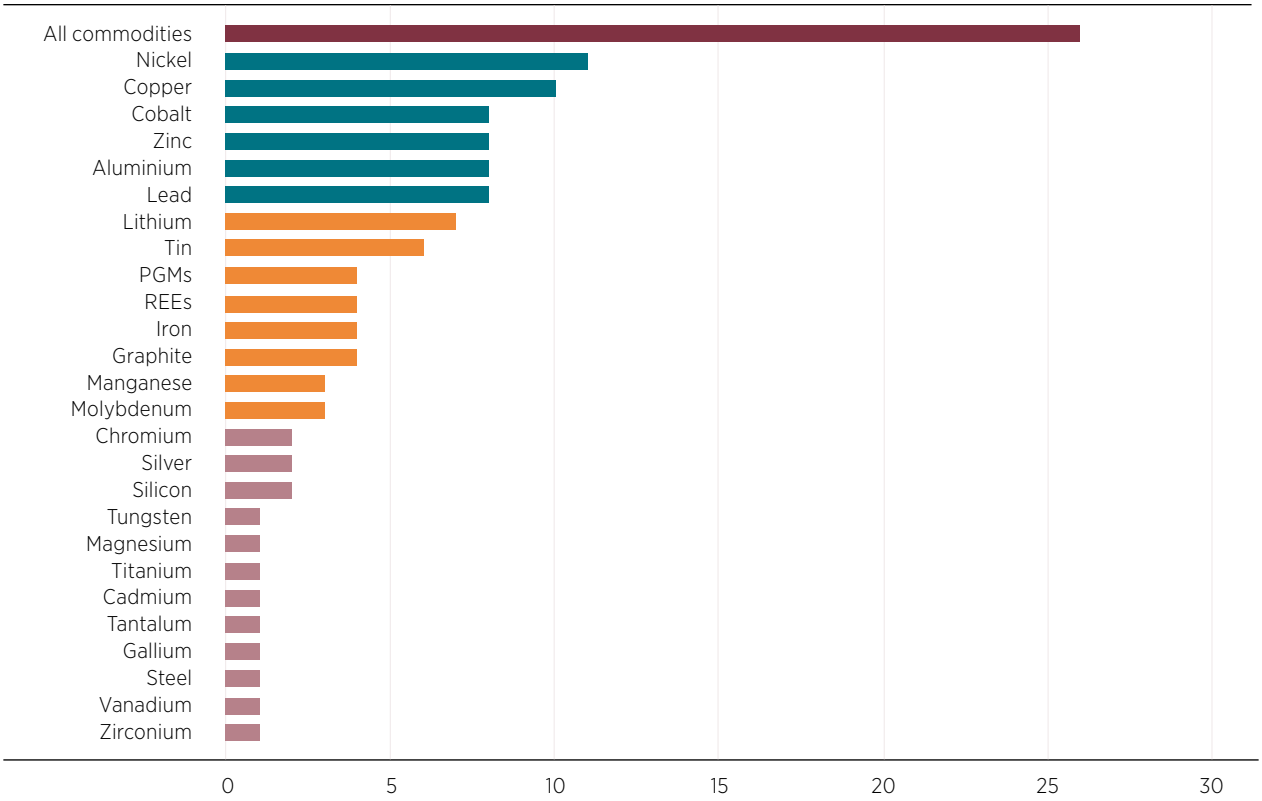


Figure 3 shows the number of international data sources covering selected critical materials. Markets shown as green are more broadly covered (nickel, copper, aluminium and cobalt), compared with those shown as orange (graphite, iron, platinum group metals and rare earth elements are moderately covered) or red (titanium, tungsten, vanadium and zirconium are covered the least).

Due to the complexity of critical materials supply chains, it is difficult to determine which materials are contained in a technology product, let alone upstream information about their sourcing and extraction. For example, some data sources do not specify which type of graphite is referred to and this may complicate data analysis. According to Jin *et al.* (2016), "[t]he various sub-contractors and confidentiality clauses have made or make the supply chain more and more complex". The presence of limited and often incoherent trade data complicates forecasts of future demand and scenario-building exercises for critical materials (Klimenko, Ratner and Tereshin, 2021). For example, EUROSTAT provides limited data on the supply of raw materials for battery value chains in the European Union and therefore needs to be complemented by other sources. Different data sources are generally not harmonised, for example in their use of trade nomenclature, and combining them leads to inconsistencies (Schrijvers *et al.*, 2020).

Similarly, there are inconsistencies in production and trade data on rare earth elements. Sources use different units and cover different time periods and life-cycle stages (Blengini *et al.*, 2020). Another issue that contributes to data inconsistency is that of divergent and often incompatible data aggregation procedures (Schrijvers *et al.*, 2020). Reliable trade data for complex products are difficult to obtain, and in each case additional cross-checking by industry experts will likely be required (Blengini *et al.*, 2020; Grohol, 2023; Jin *et al.*, 2016). Moreover, data on intermediate products are often severely limited, as most datasets include production data mainly at the level of mines (Schrijvers *et al.*, 2020). Significant data gaps also exist for valuable by-product materials recovered during the mining and processing of primary materials, which is also supported by our findings on by-products (see Figure 2).

As regards specific minerals, according to the European Commission (2018), data on minor metals, such as "cobalt or lithium, are either unavailable, scattered, confidential or of low quality, and are often based on 'expert judgement'". Box 2 summarises the main strengths and weaknesses of critical materials data produced by international and intergovernmental organisations.

BOX 2. Data from international and intergovernmental organisations

Strengths

- **Accessibility:** Key data sources are publicly available, although access to more disaggregated and long-term data may be restricted.
- **Coverage:** Access to long-term data comparable across a wide range of countries.
- **Transparency:** International databases commonly use well-established and transparent methodologies.
- **Standardisation:** Global databases use standardised data collection and reporting methodologies and harmonised commodity classification systems.

Weaknesses

- **Incomplete or unreliable data:** Not all countries report trade data to international organisations consistently. Some countries misreport the data, report data of poor quality, or classify data as "confidential trade" or "special category".
- **Data discrepancies:** Gaps in reporting requirements that result in inconsistencies.

2.3. Mineral associations

Some mineral-focused associations collect and provide data on specific minerals. For example, the International Copper Study Group provides yearly and monthly statistics on copper and copper products, including data on copper production, usage and trade by country, drawing on data from country members, metals associations, company direct contacts and reports, national statistical offices and specialised press. Other examples include the International Manganese Institute and the International Nickel Study Group. Box 3 summarises the main strengths and weaknesses of critical materials data produced by mineral associations and private mining companies.

BOX 3. Data from mineral associations and private mining companies

Strengths

- **Detailed data:** The key advantage of mineral associations is in-depth information about specific mineral value chains.
- **Industry connections:** Mineral associations generally have strong linkages to industrial actors, enabling the associations to provide unique data and insights not available from other data sources.
- **Up-to-date data:** Mineral associations tend to maintain up-to-date information about developments in their sector.
- **Capacity to address research gaps:** Mineral associations have resources to fund research in areas where data gaps exist.

Weaknesses

- **Restricted access:** These organisations generally limit public access to their data. Detailed and long-term data often require subscription or purchase.
- **Limited transparency:** The methodologies and primary data sources employed by mineral associations are not always transparent.
- **Low comparability:** Different mineral associations use different data collection and reporting systems, making it difficult to compare data from different associations.
- **Limited access due to high cost of data:** Data provided by industrial associations are often very expensive. As a result, this limits access to data for many stakeholders.
- **Bias:** Mineral associations may have certain strategic interests or perspectives that can produce bias in their data, such as promoting specific minerals or industrial actors.

2.4. Commercial data providers

Some commercial data providers (*e.g.* S&P Global Marketplace or Mining Intelligence) specialise in collecting data on primary commodity markets through active interaction with industry players and mineral commodity associations. They are involved in commercial exchanges with various extractive industry players and typically have access to the most up-to-date data (which are usually also the most valuable). Their data can normally be purchased only via subscription, although some operate with "freemium" models which give partial open

access to the data. Since commercial entities provide limited publicly available data, their methodologies and primary data sources are difficult to evaluate. Box 4 summarises the main strengths and weaknesses of critical materials data produced by commercial entities.

BOX 4. Data from commercial entities

Strengths

- **Detailed data:** The key advantage of commercial providers is that they can collect data on various market aspects on request.
- **Up-to-date forward-looking data:** Commercial providers are closely linked to industrial actors, enabling them to obtain access to the most up-to-date and forward-looking data, which carry a high commercial value among investors, especially with regard to forecast data and trends.

Weaknesses

- **Premium or subscription access only:** These organisations provide limited publicly available data. Detailed and long-term data generally require subscription or purchase.
- **Limited transparency:** Methodologies and primary data sources used by commercial providers are difficult to evaluate.
- **Limited access due to high cost of data:** Data provided by commercial entities are often very expensive, often even more expensive than data offered by mineral associations. This limits access to data for many stakeholders.

2.5. Summary

Existing data on critical materials production and supply chains suffer from multiple weaknesses. Although data on critical materials are rich, they often suffer from missing and incomparable values, as well as low-quality or outdated data points at various levels. The data lacks granularity to support the traceability and governance of critical materials value chains. This results in the general opacity of markets for critical materials.

Existing data governance for critical materials is fragmented, involving more than 30 actors. In many cases, access to data is by subscription only, with prices of up to tens of thousands of dollars per data source. Even though data are rich and detailed for some aspects of some critical materials, much is scattered across different sources and often outdated. Table 2 presents an extract of the review of selected organisations that produce data on critical materials (the full table is shown in Annex 1).

A detailed review of individual data providers (*e.g.* BGS, USGS, World Mining Data) demonstrates that they rely on hundreds of different sources when collecting geological data. For example, for its 2023 geological report (BGS, 2023), the BGS obtained data from the following data providers:

- Publications from six large national and international data sources that focus on specific commodities (African Development Bank Group, BP, Austrian Federal Ministry of Science [WMD], Société de l'Industrie Minérale [Mineral Industry Society], the Interstate Statistical Committee of the Commonwealth of Independent States, World Bureau of Metal Statistics).
- Analysis of 16 websites of different international organisations, such as Extractive Industries Transparency Initiative (EITI), UN agencies, industrial associations, USGS.
- Individual requests for data sent to 126 private companies from all over the world.
- Direct correspondence or website consultation from 205 national institutions and agencies from 132 countries.

TABLE 2 Extract from review of selected data sources on critical materials for renewable energy

Data source	German Geological Survey	The World Trade Statistical Review	INSG - World Nickel Publications	SNL Metals&Mining
Publishing organisation	German Government	WTO	International Nickel Study Group (INSG)	S&P Global Marketplace
Minerals covered	Al, Pb, Cr, Ga, Gr, Cu, Li, Mg, Mn, Ni, Pd, P, Pt, REE, Si, Ta, Ti, W, Zn, Sn, Zr	All commodities	Ni	All commodities
Access to data	Open access	Open access	Subscription	Subscription
Geography covered	Germany	WTO countries	Global	Global
Production volume	Yes	Yes	Yes	Yes
Export data	Yes	Yes	Yes	Yes
Import data	Yes	Yes	Yes	Yes
Trade-restrictive or trade-promoting measures	No	No	Yes	No
Recycling data	No	No	Yes	No
Pricing	Yes	No	Yes	Yes
Supply and demand forecasts	Yes	No	No	Yes
By-products from main mineral	No	No	Yes	No
Changing product composition in technologies	No	No	Yes	No
Linked to UN Comtrade as original source	No	No	No	No

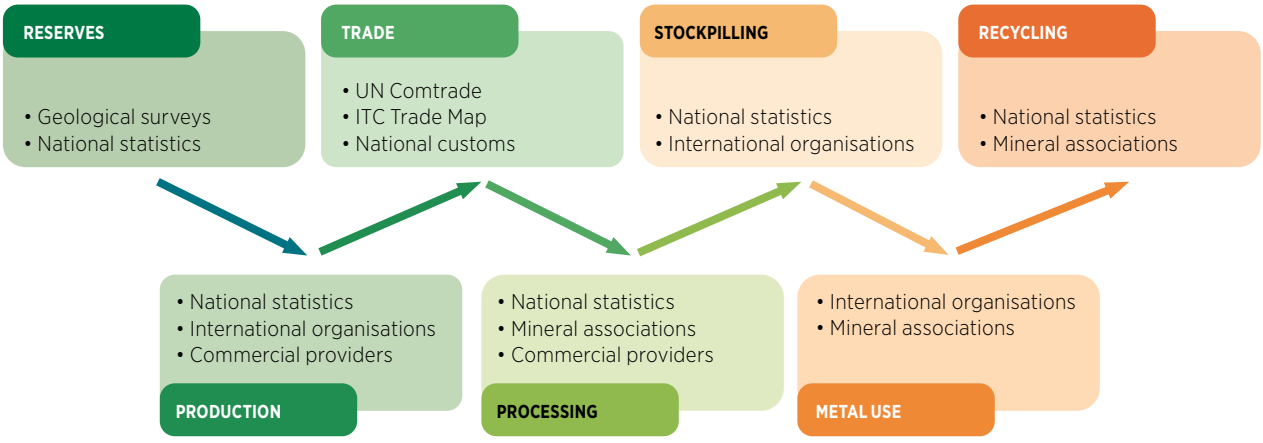
In a similar vein, according to Austria's Federal Ministry of Finance, "Data collection relating to mineral raw materials has been carried out through evaluation of questionnaires sent to the National Committees of member countries of the World Mining Congress as well as to other bodies such as Embassies, Foreign Trade Representatives etc. Other official mining statistics, where publicly available, have also been used; for example, data gathered by the BGS (World Mineral Production) and the USGS have proven very useful for cross-checks. For the present publication the complete data set has been reviewed carefully. Despite a diligent search of all sources, there are some producing areas where data is unavailable. In such instances, careful estimates of production figures have been made" (Federal Ministry of Finance, 2023).

Both the BGS and Austria's Federal Ministry of Finance rely on hundreds of different sources for geological data gathering. However, both of them still only cover a limited number of data categories (see Annex 1). Other organisations cover other data categories; although, there is still no single data provider that would cover all major data categories (see Figure 4) for all (or most) countries in a manner that would satisfy the needs of the growing number of energy transition actors who are interested in such data. As of 2024, these actors need to turn to 45 organisations identified in the study as important data providers for different data categories: some organisations cover mainly trade data, others cover mainly production, and others cover only stockpiling. This leads to data opacity and a high degree of fragmentation of global data governance.

The data opacity is exacerbated by the existence of a large number of actors. They have different capabilities, access to infrastructure, strategic interests, and methodologies for data collection and reporting. As a result, there are significant divergences, sometimes higher than 100%, in data reported by different sources, even when both sources are considered reliable (Leon *et al.*, 2021).

These limitations are more pronounced for downstream stages of the mineral value chains than for upstream. Data about reserves, production and trade are more or less available, but limited data are available on mineral processing, stockpiling, metal use and recycling (see Figure 4).

FIGURE 4 Sources of primary data and degree of data availability along critical materials supply chains



Notes: green = higher availability; orange = lower availability; ITC = International Trade Centre.

3. Existing measures to improve data availability in commodity markets

A total of nine existing data governance initiatives were identified, aimed at enhancing the transparency of various commodity markets. These were reviewed with a particular focus on their data governance models and approaches to improving data availability. Most existing data initiatives were found to originate in the OECD member states or Latin American countries. No similar large-scale initiatives have been established and driven by national and regional stakeholders in Africa, Central Asia, East Asia, South Asia or Southeast Asia, although small initiatives led by non-government organisations are in evidence. This is a drawback as major global mineral producers are low- and middle-income countries located in Africa and Asia.

The purpose of this exercise is to learn lessons from other sectors and see how they have organised their own data governance systems.

- The Latin American Energy Organization (OLADE) was established in 1973. Its data-sharing platform is aimed at better integration, conservation, rational use and commercialisation of Latin America's energy resources, including critical materials (OLADE, 2023). In 2022, OLADE adopted a mandate for developing critical materials.
- The Agricultural Market Information System (AMIS) was launched by the G20 Ministers of Agriculture in 2011 to improve global agricultural market transparency and policy action. It consists of two databases, the Market Database and the Policy Database that integrate UN, WTO and OECD data sources with national reporting and trading actors (AMIS, 2023).
- The commodity trading transparency initiative is being developed by the Extractive Industries Transparency Initiative (EITI), which is headquartered in Oslo, Norway. Established on the initiative of the former UK prime minister Tony Blair, EITI was formally founded by the United Kingdom in 2003. Producer countries report to EITI information about natural resource value chains, from extraction to government revenues. In addition to large-scale extraction activities, the initiative requires countries to estimate production and trade involving artisanal and small-scale mining (EITI, 2023).
- The OECD Open Government Data (OGD) project includes policies that promote "transparency, accountability and value creation by making government data available to all" (OECD, 2023). Through participation in this project, public institutions can become more transparent and accountable to citizens and thus improve good governance and public service delivery. OGD includes an index that assesses government attempts to promote open data in three major areas: openness, usefulness and reusability of government data.
- The World Bank Open Data Initiative, available in multiple languages, is aimed at providing open access to World Bank data in the form of datasets, databases, pre-formatted tables, reports and other resources for agriculture, rural development, economics, energy, security, gender, infrastructure, poverty, the private sector, science and technology, and urban development (World Bank, 2023).

- The Joint Organisations Data Initiative (JODI) was established in 2001 to improve the transparency of oil and gas markets. It was established by six international organisations: the Asia-Pacific Economic Cooperation, the Statistical Office of the European Communities, the International Energy Agency, the Latin American Energy Organization, the Organization of the Petroleum Exporting Countries, and the United Nations Statistics Division. It is co-ordinated by the International Energy Forum based in Riyadh, Saudi Arabia. JODI addresses 90% of the global oil market (JODI, 2024) and the lack of transparent and reliable oil statistics that often causes oil price volatility. Producers and consumers have joined efforts to improve the availability and reliability of oil data. Even though the primary goal was to build a database, an even more important task has been raising awareness among oil market actors about the need for greater transparency on oil supply and demand (JODI, 2024). JODI's slogan is "Better Data, Better Decisions".
- The International Open Data Charter (ODC) has developed the following principles for data governance: (1) open by default; (2) timely and comprehensive; (3) accessible and usable; (4) comparable and interoperable; (5) improved governance and citizen engagement; and (6) inclusive development and innovation. It was launched by 17 signatories at the Open Government Partnership Global Summit in Mexico in October 2015, since then the ODC Principles have been adopted by 95 national and subnational governments (ODC, 2015). As of 2024, it has 96 national and subnational governments as its signatories.
- The Irish Government Open Data Initiative was established to promote transparency through the publication of Irish public sector data in open access, free and reusable formats. In March 2023, the Open Data portal included 14 844 datasets (Government of Ireland, 2023).
- The California Government Open Data Initiative was established to greatly improve the transparency of public services and provide better opportunities for citizen and private sector engagement by means of unlocking government data (California Government, 2023).

Content analysis of the statutes and missions of each of the nine initiatives explored which key principles and practical measures each initiative put forward to address the issue of missing, poorly managed, incomparable, incomplete, inaccessible and opaque data. Then, based on the results obtained from the nine initiatives, the main principles and measures were summarised and classified towards a good governance framework. The selected principles and measures can help improve data management (including data harmonisation and unification) and transparency in global markets for critical materials markets and beyond (see Table 2), which are presented in the next section.

Key principles for good data governance:

- **Transparency**. Data are managed and data access is governed in an open and transparent manner.
- **Accountability**. Data governance is facilitated by an organisation or consortium that takes the work forward and orchestrates the development process. It can be preferable to have a multilateral organisation that other actors perceive to be a neutral partner, giving it the role of interlocutor between different interests.
- **Participation**. All relevant stakeholders commit to and participate in data governance, including data producers, data consumers and public data providers. Major producer and consumer regions are sometimes absent in the current global critical materials governance architecture. This includes under-represented countries of Africa, Asia and South America.

4. Materials for the Energy Transition: Repository & Information Collection (METRIC)

To address the shortcomings in the data available on critical materials, a unified Materials for the Energy Transition: Repository & Information Collection (METRIC) is proposed (see Figure 5 and Table 3). It would draw on existing but separate data sources on critical materials. Its mission would be to improve data management and enhance the transparency of data on the value chains of materials critical to the energy transition. There is an urgent need to improve the governance of such data without sidelining the various actors already involved in their collection. Rather, these actors could be incentivised to join a collaborative data initiative focused on critical materials for renewable energy technologies.

The main value added of METRIC would be methodological coherence, ease of data use, and comprehensiveness of critical materials data. Currently, searches are made across a broad variety of sources for data, which are often non-standardised and non-unified and thus non-comparable.

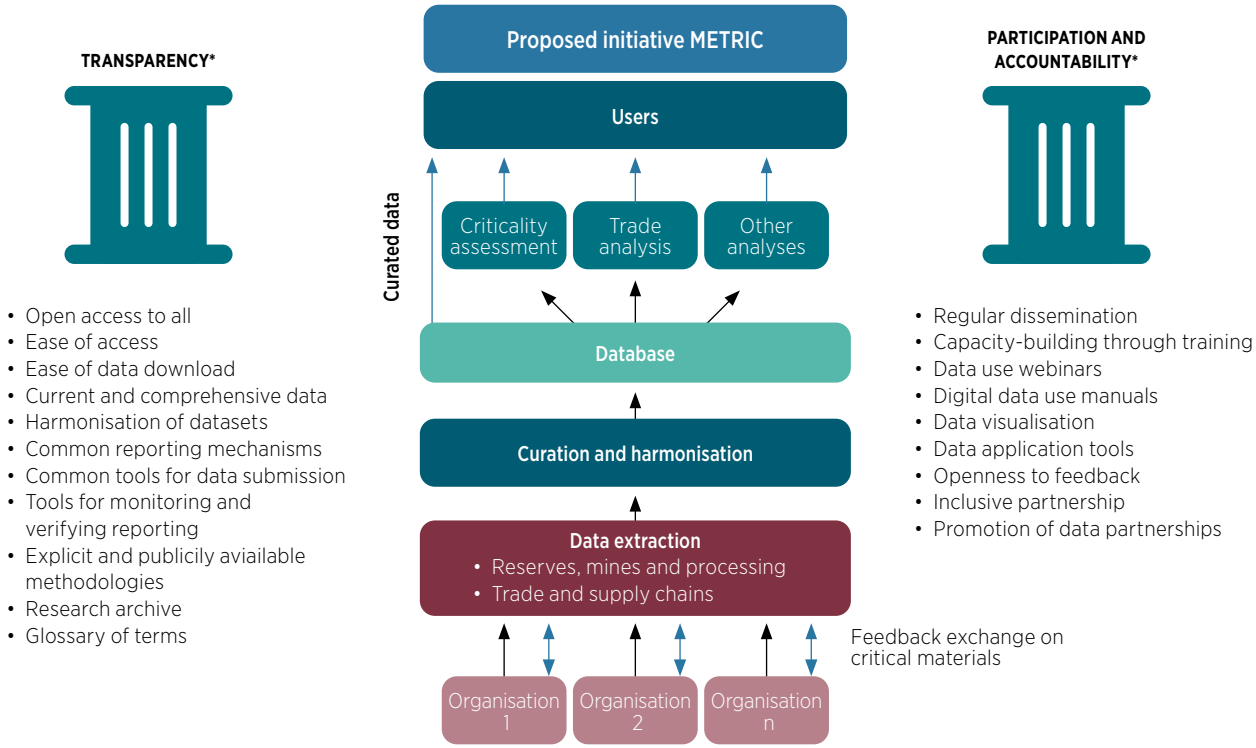
Conceptually, METRIC draws on two variables. The first is the key characteristics of critical materials markets that we identified in our review of the most common data dimensions across the 45 data sources we analysed (see Table 3). The second is the main lessons that we drew from the nine international and national data transparency initiatives. They are presented in Section 3 and take also into account the good governance pillars, such as transparency, participation and accountability (Addink, 2019; Van Doeveren, 2011) (see Figure 5).

METRIC is a model for a unified, open and transparent data architecture and governance framework for critical materials. Its beneficiaries would include governments, civil society, citizens, international organisations, researchers, entrepreneurs and investors. A more unified data governance solution for critical materials markets would improve transparency and information flow, thus helping governments and private actors take better informed decisions on mining, market expansion and supply. In turn, this should help accelerate the deployment of renewable energy technologies globally.

The presence of a streamlined and unified database could improve the quality, timeliness and extent of data submissions by the actors involved in data generation (OECD, 2023; World Bank, 2023). By improving the transparency of supply chains, METRIC would enhance international collaboration on renewable energy and support countries in their transition to sustainable energy.

While such a data system could be highly beneficial, it is important to underline that its creation and maintenance would require significant financial and human resources. For instance, an international organisation or a consortium of organisations could potentially lead and manage this initiative. METRIC would aim to produce data and data analysis according to a concept of material flow diagrams to address the data availability issues illustrated in Figure 4.

FIGURE 5 Principles and content of a unified database on critical materials



* Based on good governance framework and the review of nine data governance initiatives (see Section 3).

TABLE 3 Data dimensions

Reserves, mines and processing
• Proven geological reserves • Geological accessibility • Mining sites • Market concentration (Herfindahl-Hirschman Index) • Valuable by-products from mining • Ore grades • Processing facilities • Exploration investments • Mined production • Secondary production • Processing production • A bill of materials (BOM)* for each critical technology
Trade and supply chains
• Trade flows and supply chains • Tariff and non-tariff barriers • Trade restrictions • Real-time and historical pricing • Benchmark prices • Data on current demand • Data on forecasted demand for raw materials and products • Prices of raw materials • Prices of refined products • Prices of chemicals/precursors/etc. • Use by application • Data on companies that manufacture clean energy hardware and use critical materials
Assessments of criticality
• Regularly updated list of critical materials • Definition of a criticality threshold value • Material composition in renewable energy technologies • Data on material substitution • Recycling technologies, facilities and markets; recycling rates.

* A bill of materials (BOM) is a comprehensive list of components, materials, parts and sub-assemblies required to manufacture or assemble a product. BOMs are commonly used in manufacturing, engineering and product development to document and communicate the exact specifications and quantities of materials needed for the production of a particular item.

Note: This table presents the key characteristics of critical materials markets according to our review of the most common data dimensions in the 45 data sources we analysed (see Annex 1).

5. Conclusions and way forward

Each of the current data governance initiatives has one or several shortcomings that limit their usefulness. For example, they lack wide representation from different geographies and actors or entail subscriptions that are too expensive for many actors. To be successful, a new governance initative needs to meet the abovementioned good governance criteria. The establishment of METRIC could mitigate critical materials risks, increase predictability, and strengthen international collaboration on renewable energy by providing more unified, comparable and detailed data on all major critical materials data dimensions located in one place. Without METRIC, key stakeholders may continue to find it complicated taking well-informed decisions about critical materials markets.

Pursuing collaboration on critical materials between different actors with diverging interests is challenging. It is therefore crucial to be explicit about the benefits of METRIC to different parties and ensure that the organisation leading the work is perceived as legitimate. This could, for example, require a multinational organisation with offices and staff in different regions to take the lead, and the inclusion of both producer and consumer interests (*e.g.* supply security, demand security and justice).

Moving forward, it is recommended that organisations that manage and provide data on critical materials, such as those identified in Annex 1, be convened to establish a platform for dialogue. This engagement could lead to the identification of parties interested in organising and establishing an initiative such as METRIC. Drawing on the insights gained from other successful data governance frameworks, this initiative could similarly benefit from multistakeholder co-operation.

References

Addink, H. (2019), "Good governance: Concept and context", Oxford University Press, https://academic.oup.com/book/35056

AMIS (2023), "About us", *The Agricultural Market Information System*, https://www.amis-outlook.org/amis-about/en/

BGS (2023), "World Mineral Production", *British Geological Survey*, https://www2.bgs.ac.uk/mineralsUK/statistics/worldStatistics.html

Blengini, G., *et al.* (2020), "Study on the EU's list of critical raw materials", Publications Office of the European Union, https://op.europa.eu/en/publication-detail/-/publication/c0d5292a-ee54-11ea-991b-01aa75ed71a1/language-en

California Government (2023), "Open Data Handbook", https://handbook.data.ca.gov/#:~:text=The%20Open%20Data%20Handbook%20provides,and%20metadata%20standards%2C%20and%20governance

EITI (2023), "Commodity Trading Transparency", The Extractive Industries Transparency Initiative (EITI), https://eiti.org/commodity-trading

European Commission (2018), "Report on Raw Materials for Battery Applications", Staff Working Document, https://rmis.jrc.ec.europa.eu/bvc#/

Federal Ministry of Finance (2023), "World Mining Data 2023", Federal Ministry of Finance of the Republic of Austria., https://www.bmf.gv.at/en/topics/mining/mineral-resources-policy/wmd.html

Fortier, S. M., *et al.* (2021), "USGS critical minerals review", *Mining Engineering*, vol. 71 (5), pp. 33–47.

Gielen, D., and Lyons, M. (2022), *Critical materials for the energy transition: Lithium*, 1/2022, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Technical-Papers/Critical-Materials-For-The-Energy-Transition-Lithium

Government of Ireland (2023), "Ireland's Open Data Initiative", Open Data Unit, https://data.gov.ie/

Grohol, M. (2023), *European Commission, Study on the Critical Raw Materials for the EU 2023 – Final Report*, European Commission: Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2873/725585

IRENA and NUPI (2024), *Constructing a ranking of critical materials for the global energy transition*, International Renewable Energy Agency, Abu Dhabi.

Jin, Y., *et al.* (2016), "Review of critical material studies", *Resources, Conservation and Recycling*, vol. 113, pp. 77–87.

JODI (2024), "About JODI. Joint Organisations Data Initiative (JODI). Coordinated by the International Energy Forum", https://www.ief.org/about/jodi

Leon, M. F. G., *et al.* (2021), "Analysis of long-term statistical data of cobalt flows in the EU", *Resources, Conservation and Recycling*, vol. 173, 105690, https://www.sciencedirect.com/science/article/pii/S0921344921002998

McCaffrey, D. M., *et al.* (2023), "Embedded critical material flow: The case of niobium, the United States, and China", *Resources, Conservation and Recycling*, vol. 188, 105690, https://www.sciencedirect.com/science/article/pii/S0921344922005316

Melchior, A. (2012), "World Trade 1970–2010: Globalisation, Regionalisation and Reallocation", Norwegian Institute of International Affairs, http://www.nupi.no/content/download/330908/1137192/version/4/file/WP-805-Melchior.pdf, retrieved 12.02.15

ODC (2015), "International Open Data Charter", https://opendatacharter.org/

OECD (2023), "Open Government Data (OGD) initiative", *Organisation for Economic Co-operation and Development*, https://web-archive.oecd.org/temp/2022-05-20/253891-open-government-data.htm

OLADE (2023), "OLADE - Latin American Energy Organization", https://www.olade.org/en/about-olade/

Schrijvers, D., *et al.* (2020), "A review of methods and data to determine raw material criticality", *Resources, conservation and recycling*, vol. 155, https://www.sciencedirect.com/science/article/pii/S0921344919305233

Sturman, K., *et al.* (2022), "Mission critical: strengthening governance of mineral value chains for the energy transition", Extractive Industries Transparency Initiative (EITI), https://eiti.org/sites/default/files/2022-10/EITI%20Mission%20Critical%20Report%202022.pdf

Van Doeveren, V. (2011), "Rethinking good governance: Identifying common principles", *Public Integrity*, vol. 13 (4), pp. 301–18.

World Bank (2023), "World Bank Open Data", https://data.worldbank.org/

Annex 1

Annex 1: List of data sources on critical materials for renewable energy

Data source (national institutions)	German Geological Survey	British Geological Survey (BGS)	US Geological Survey (USGS)	Indian Mineral Yearbook
Publishing organisation	German government	UK government	US government	Indian government
Minerals covered	Al, Pb, Cr, Ga, Gr, Cu, Li, Mg, Mn, Ni, Pd, P, Pt, REEs, Si, Ta, Ti, W, Zn, Sn, Zr	All commodities	All commodities	All commodities
Access to data	Open access	Open access	Open access	Open access
Geography covered	Germany	Great Britain	United States	India
Production volume	Yes	Yes	Yes	Yes
Export data	Yes	Yes	Yes	Yes
Import data	Yes	Yes	Yes	Yes
Trade-restrictive or trade-promoting measures	No	No	Yes	Yes
Recycling data	No	No	Yes	No
Pricing	Yes	No	Yes	Yes
Supply and demand forecasts	Yes	No	Yes	No
By-products from main mineral	No	No	No	Yes
Changing product composition in technologies	No	No	Yes	No
Linked to UN Comtrade as original source	No	No	No	No

Data source (national institutions)	Critical Materials Assessment
Publishing organisation	US Department of Energy
Minerals covered	Cu, Ge, Ni, U, Zr, Si, Te, Ga, In, Nd, Pr, Dy, Tb, B, Ga, Pt, C, La, Sr, Y, Mn, Li, Co, V, Zn, Fe, Al, Na, S, P, F, Mg, light REEs, Rh, Pd, Ir, Ti
Access to data	Open access
Geography covered	Global
Production volume	Yes
Export data	No
Import data	No
Trade-restrictive or trade-promoting measures	No
Recycling data	Yes
Pricing	Yes
Supply and demand forecasts	Yes
By-products from main mineral	Yes
Changing product composition in technologies	Yes
Linked to UN Comtrade as original source	No

Data source (national institutions)	Comtrade	EUROSTAT	Export Restrictions on Industrial Raw Materials	OECD International Trade by Commodity Statistics
Publishing organisation	UN Statistics Division	Statistical Office of the European Union	OECD	OECD
Minerals covered	All commodities	All commodities	All commodities	All commodities
Access to data	Partially restricted	Open access	Open access	Open access
Geography covered	Global	Global (EU and partner states)	OECD states	OECD states
Production volume	No	No	No	No
Export data	Yes	Yes	No	Yes
Import data	Yes	Yes	No	Yes
Trade-restrictive or trade-promoting measures	No	No	Yes	No
Recycling data	No	Yes	No	No
Pricing	No	No	No	Yes
Supply and demand forecasts	No	No	No	No
By-products from main mineral	No	No	No	No
Changing product composition in technologies	No	No	No	No
Linked to UN Comtrade as original source	Yes	No	No	No

Data source (national institutions)	IMF Commodity Terms of Trade	IMF Commodity Data Portal	IMF Primary Commodity Prices Database	World Mining Data
Publishing organisation	IMF	IMF	IMF	Government of Austria
Minerals covered	Al, Cu, Fe, Pb, Ni, Sn, Zn	Al, Cr, Co, Cu, Pb, Li, Ni, Pd, Pt, REEs, Si, Ag, V, Zn	Al, Co, Cu, Fe, Ni, Zn, Mo, Pb, Sn	All commodities
Access to data	Open access	Open access	Open access	Open access
Geography covered	182 countries	Global	Global	168 countries
Production volume	No	No	No	Yes
Export data	Yes	Yes	No	No
Import data	Yes	Yes	No	No
Trade-restrictive or trade-promoting measures	No	No	No	No
Recycling data	No	No	No	No
Pricing	Yes	Yes	Yes	No
Supply and demand forecasts	No	No	No	No
By-products from main mineral	No	No	No	No
Changing product composition in technologies	No	No	No	No
Linked to UN Comtrade as original source	Yes	Yes	Yes	No

Data source (national institutions)	International Energy Agency (IEA)	Observatory of Economic Complexity (OEC)	BACI: International Trade Database at the Product-Level	Extractive Industries Transparency Initiative (EITI)
Publishing organisation	International Energy Agency (IEA)	Datawheel, MIT's Collective Learning group	Centre d'Études Prospectives et d'Informations Internationales (CEPII)	Extractive Industries Transparency Initiative
Minerals covered	All commodities	All commodities	All commodities	All commodities
Access to data	Open access	Freemium	Open access	Open access
Geography covered	Global	40 countries	Global	EITI countries
Production volume	Yes	No	No	Yes
Export data	Yes	Yes	Yes	Yes
Import data	Yes	Yes	Yes	Yes
Trade-restrictive or trade-promoting measures	Yes	Yes	No	Yes
Recycling data	Yes	No	No	No
Pricing	Yes	No	No	No
Supply and demand forecasts	Yes	No	No	No
By-products from main mineral	No	No	No	Yes
Changing product composition in technologies	No	No	No	No
Linked to UN Comtrade as original source	No	Yes	Yes	Yes

Data source (national institutions)	ITC's Trade Map	ITC's Market Access Conditions	The World Trade Statistical Review	Trade Monitoring
Publishing organisation	ITC	ITC	WTO	WTO
Minerals covered	All commodities	All commodities	All commodities	All commodities
Access to data	Open access	Open access	Open access	Open access
Geography covered	220 countries	202 countries	WTO countries	WTO countries
Production volume	No	No	Yes	No
Export data	Yes	No	Yes	No
Import data	Yes	No	Yes	No
Trade-restrictive or trade-promoting measures	No	Yes	No	Yes
Recycling data	No	No	No	No
Pricing	No	No	No	No
Supply and demand forecasts	No	No	No	No
By-products from main mineral	No	No	No	No
Changing product composition in technologies	No	No	No	No
Linked to UN Comtrade as original source	Yes	No	No	No

Data source (national institutions)	Regional Trade Agreements (RTAs) Database	Database on Preferential Trade Arrangements	The Quantitative Restrictions (QR) Database	World Integrated Trade Solution (WITS)
Publishing organisation	WTO	WTO	WTO	World Bank
Minerals covered	All commodities	All commodities	All commodities	All commodities
Access to data	Open access	Open access	Open access	Open access
Geography covered	WTO countries	WTO countries	WTO countries	Global
Production volume	No	No	No	No
Export data	No	No	No	Yes
Import data	No	No	No	Yes
Trade-restrictive or trade-promoting measures	Yes	Yes	Yes	Yes
Recycling data	No	No	No	No
Pricing	No	No	No	No
Supply and demand forecasts	No	No	No	No
By-products from main mineral	No	No	No	No
Changing product composition in technologies	No	No	No	No
Linked to UN Comtrade as original source	No	No	No	Yes

Data source (national institutions)	LME Reports & Data	Shanghai Metals Market (SMM)	IWCC Statistics and Data Series	ICSG Statistical Database
Publishing organisation	London Metal Exchange (LME)	Shanghai Metals Market (SMM)	International Wrought Copper Council (IWCC)	International Copper Study Group (ICSG)
Minerals covered	Al, Co, Cu, Li, Mo, Zn, Ni, Pb, Sn, PGM	AL, Co, Li, Ni, Cu, Pb, Zn, Sn	Cu	Cu
Access to data	Open access	Open access	Freemium	Subscription
Geography covered	Global	Global	80 major economies	Member countries
Production volume	No	No	Yes	Yes
Export data	Yes	No	Yes	Yes
Import data	Yes	No	Yes	Yes
Trade-restrictive or trade-promoting measures	No	No	No	No
Recycling data	No	No	No	No
Pricing	Yes	Yes	Yes	Yes
Supply and demand forecasts	No	Yes	Yes	Yes
By-products from main mineral	No	No	No	Yes
Changing product composition in technologies	No	No	Yes	No
Linked to UN Comtrade as original source	No	No	No	No

Data source (foundation)	Global Trade Alert
Publishing organisation	St Gallen Endowment/ University of St Gallen/ Max Schmidheiny Foundation
Minerals covered	All commodities
Access to data	Open access
Geography covered	Global
Production volume	No
Export data	No
Import data	No
Trade-restrictive or trade-promoting measures	Yes
Recycling data	No
Pricing	No
Supply and demand forecasts	No
By-products from main mineral	No
Changing product composition in technologies	No
Linked to UN Comtrade as original source	No

Data source (mineral associations)	Platinum Quarterly report	International Manganese Institute	INSG – World Nickel Publications	The Lithium Voice Reports
Publishing organisation	World Platinum Investment Council	International Manganese Institute	International Nickel Study Group (INSG)	International Lithium Association
Minerals covered	PGM	Mn	Ni	Li
Access to data	Open access	Subscription	Subscription	Open access
Geography covered	Global	Top 20 million importers	Global	Global
Production volume	Yes	Yes	Yes	Yes
Export data	No	Yes	Yes	Yes
Import data	No	Yes	Yes	No
Trade-restrictive or trade-promoting measures	No	Yes	Yes	No
Recycling data	Yes	No	Yes	Yes
Pricing	Yes	Yes	Yes	No
Supply and demand forecasts	Yes	Yes	No	Yes
By-products from main mineral	No	No	Yes	Yes
Changing product composition in technologies	Yes	Yes	Yes	No
Linked to UN Comtrade as original source	No	No	No	No

Data source (commercial providers)	Adamas Intelligence	SNL Metals&Mining	Roskill	Global Trade Atlas
Publishing organisation	Adamas Intelligence	S&P Global Marketplace	Wood Mackenzie	S&P Market Intelligence
Minerals covered	REEs, Li, Ni, Co, Mn, Gr	All commodities	Al, Co, Cu, Fe, Pb, Li, Ni, Gr, REEs, Zn	All commodities
Access to data	Subscription	Subscription	Subscription	Subscription
Geography covered	Global	Global	Global	200 countries
Production volume	Yes	Yes	Yes	No
Export data	No	Yes	Yes	Yes
Import data	No	Yes	Yes	Yes
Trade-restrictive or trade-promoting measures	No	No	No	Yes
Recycling data	Yes	No	No	No
Pricing	Yes	Yes	Yes	Yes
Supply and demand forecasts	Yes	Yes	Yes	No
By-products from main mineral	No	No	No	No
Changing product composition in technologies	Yes	No	Yes	No
Linked to UN Comtrade as original source	No	No	No	No

Data source (commercial providers)	Mining Intelligence	Global Data	Global Trade Tracker	Statista
Publishing organisation	Mining Intelligence	Global Data	Global Trade Tracker	Statista
Minerals covered	All commodities	All commodities	All commodities	All commodities
Access to data	Subscription	Subscription	Subscription	Subscription
Geography covered	Global	60 leading mining countries	24 countries	Global
Production volume	Yes	Yes	Yes	Yes
Export data	No	Yes	Yes	Yes
Import data	No	Yes	Yes	Yes
Trade-restrictive or trade-promoting measures	No	Yes	No	No
Recycling data	No	No	No	Yes
Pricing	Yes	Yes	Yes	Yes
Supply and demand forecasts	No	Yes	No	Yes
By-products from main mineral	No	No	No	Yes
Changing product composition in technologies	No	Yes	No	No
Linked to UN Comtrade as original source	No	No	Yes	No

Data source (commercial providers)	World Bureau of Metal Statistics (WBMS)	Benchmark Mineral Intelligence	Bloomberg NEF
Publishing organisation	REFINITIV	Benchmark Mineral Intelligence	Bloomberg
Minerals covered	Al, Cu, Pb, Zn, Ni, Sn, Ag, Cd, Mo, Co, Fe	Li, Co, Ni, Gr	All commodities
Access to data	Subscription	Subscription	Subscription
Geography covered	Global	Global	Global
Production volume	Yes	Yes	Yes
Export data	Yes	No	Yes
Import data	Yes	No	Yes
Trade-restrictive or trade-promoting measures	No	No	Yes
Recycling data	No	Yes	Yes
Pricing	Yes	Yes	Yes
Supply and demand forecasts	Yes	Yes	Yes
By-products from main mineral	No	No	Yes
Changing product composition in technologies	No	Yes	Yes
Linked to UN Comtrade as original source	No	No	No

IRENA
International Renewable Energy Agency

www.irena.org