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Extractive industries: imperatives, opportunities, and dilemmas in the net-zero transition

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Abstract: The extractives industries are highly controversial but remain vitally important in much of the developing world. This paper considers their role in reducing energy poverty and discusses scenarios for the future of the global markets for oil, gas, and metals (emphasizing the increasing importance of Asia). It then provides a snapshot of the increasing dependence of many developing countries on the extractives sector and uses that analysis to provide a perspective on the new opportunities arising from the global net-zero transition. Finally, the paper sets out six dilemmas arising from the role of the extractive industries under the sub-headings of: poverty reduction and nature; mining and environmental risk; demand and supply imbalances; fragile states and supply chains; strategic dependence; and technological backwardness. Overall, the paper seeks to sketch the context, both national and global, in which policy-makers must make often hard choices.

Key words: climate, commodities, extractive industries, mining, natural gas, oil

JEL classification: C81, C82, L72, Q02

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1 Introduction

On 25 January 2019, a dam holding back 'tailings' (mining waste and water) from the Córrego do Feijão iron ore mine[1] collapsed. At least 232 people were killed by the rapidly moving sludge, including workers trapped in a canteen at lunchtime. This followed another tailings disaster in Minas Gerais in 2015 when a dam failure at an iron ore mine, also owned by Vale SA (the world's largest producer of iron ore), destroyed the village of Bento Rodrigues, killing 19 people and dumping toxic sludge into the Doce River which flows into the Atlantic Ocean.

Such disasters reinforce the widely-held view that the extractive industries are a toxic activity bedevilled by continuing abuses: environmental, social and political. The word 'extractive' itself resonates with negative connotations as any brief scan of the media shows.

The extractive industries have rarely had a good image, and while many of the big companies are improving their practices, systemic problems abound. Mining, together with oil and gas extraction, can inflict catastrophic and irreversible damage to natural capital and livelihoods. Small-scale ('artisanal') mining commonly lacks effective regulation, resulting in the pollution of water and soils (as mercury is used to recover gold from sediments), deforestation, child labour and frequent accidents.[2]

The theft of revenues from mining and oil and gas continues, and corruption still bedevils commodity trading. The huge resource wealth of the Democratic Republic of the Congo (DRC), Libya, and Venezuela has failed to secure their prosperity—but has certainly destabilized their societies. Success stories, notably Botswana, remain rare among resource-rich countries.

The sector's standing has sunk even further with the climate crisis. Campaigners from 'Extinction Rebellion' and 'Just End Oil' glue themselves to the doors of Western oil companies and banks demanding 'system change not climate change'. The growth of investment funds with environmental, social and corporate governance (ESG) mandates—a market worth well over US$23 trillion—has accelerated disinvestment from oil and gas extraction as well as coal mining.[3] Companies are vulnerable to the eventual 'stranding' of fossil fuels and there is alarm over the potential impact on financial systems.[4] Miners of metals need to decarbonize if global value chains (GVCs) in agriculture, manufacturing, and services are themselves to fully decarbonize.

Nevertheless, developing countries still look to the extractive industries given their economic importance, and not least to the imperative to end poverty. With over 700 million people living without electricity (and 2.4 billion people using inefficient and polluting cooking systems) it is hard to ignore coal and gas resources (even as solar, wind, geothermal and other renewables increasingly dominate the energy future).[5] The extractive industries are a big source of tax revenue with which to fund development spending, and they can potentially help in diversifying economies. Moreover,

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[1] Near the town of Brumadinho in Brazil's Minas Gerais province.

[2] This paper focuses on industrial mining and oil and gas.

[3] https://www.jpmorgan.com/global/research/esg

[4] This concern led to the creation in 2017 of the Network for Greening the Financial System (NGFS), which now consists of 121 central banks and financial supervisors. Insuring new coal mines and coal-fired power plants is also getting harder.

[5] https://sdgs.un.org/goals/goal7

the sector is often the largest foreign exchange source: oil, gas and coal together account for more than 20 per cent of total exports in 17 low-income countries (LICs) and lower-middle income countries (LMICs), while mining provides foreign exchange for even more countries (especially through the exports of critical minerals needed for the wind turbines, solar panels, electric vehicles (EVs) and other net-zero infrastructure).[6] These are opportunities for poorer nations.

We therefore face a set of dilemmas. The extractive industries remain critically important to many developing economies and their imperative to end poverty. Building the infrastructure and technologies of global net zero requires more metals in amounts far beyond those available from recycling. Yet the sector often causes social and political harm and is a danger to renewable natural capital. Burning fossil fuels will soon exhaust the global carbon budget and is already causing large-scale climate damage in developing countries by drought, flooding, and storms.[7] Pakistan's floods in 2022 alone caused damage and economic losses of over US$30 billion (with reconstruction and recovery requiring a further US$16 billion).[8]

These dilemmas are well understood in the Global South and surface regularly at the UN's climate meetings (UN Conference of the Parties—COPs), especially around the failure of wealthier nations to fulfil their commitments to funding climate adaption and mitigation—including financing clean energy and transport investments—and to take greater responsibility for their own emissions, both current and historic. Many governments are adamant that they must continue producing fossil fuels: prior to COP27 in 2022, Nigeria's President Buhari put it bluntly: '… don't tell Africans they can't use their own resources'.[9]

This paper discusses the imperatives, the opportunities, and the global scenarios in which these play out. It also identifies a number of dilemmas to which this emerging future gives rise. It sets out some of the still unresolved tensions between the imperatives and within the opportunities. These can only worsen in the absence of greater international action on the net-zero transition itself as well as in assisting poorer countries move onto lower carbon energy pathways, adjust their resource sector strategies to net zero, and position themselves to benefit from a new world of greener GVCs.[10]

2 Energy poverty

Poverty, which is an imperative, has many dimensions: insufficient income to provide a decent standard of living; undernutrition and ill-health; illiteracy and a lack of skills.[11] And then there is energy poverty which goes hand-in-hand with income poverty as it limits the achievement of better

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[6] Ericsson and Löf (2020a: Table 1). The United Nations (UN) has developed a classification system for critical minerals and other resources, which is now used by the African Union and the European Commission. See: https://unece.org/climate-change/press/cop28-un-urges-coordinated-action-align-soaring-critical-raw-materials

[7] The impact of climate change on cities is of particular concern: see Bastin et al. (2019.

[8] Government of Pakistan (2022: 23).

[9] Muhammadu Buhari 'How Not to Talk with Africa about Climate Change', Washington Post, 9 November 2022. President Buhari went on to say: 'If Africa were to use all its known reserves of natural gas—the cleanest transitional fossil fuel—its share of global emissions would rise from a mere 3 per cent to 3.5 per cent'.

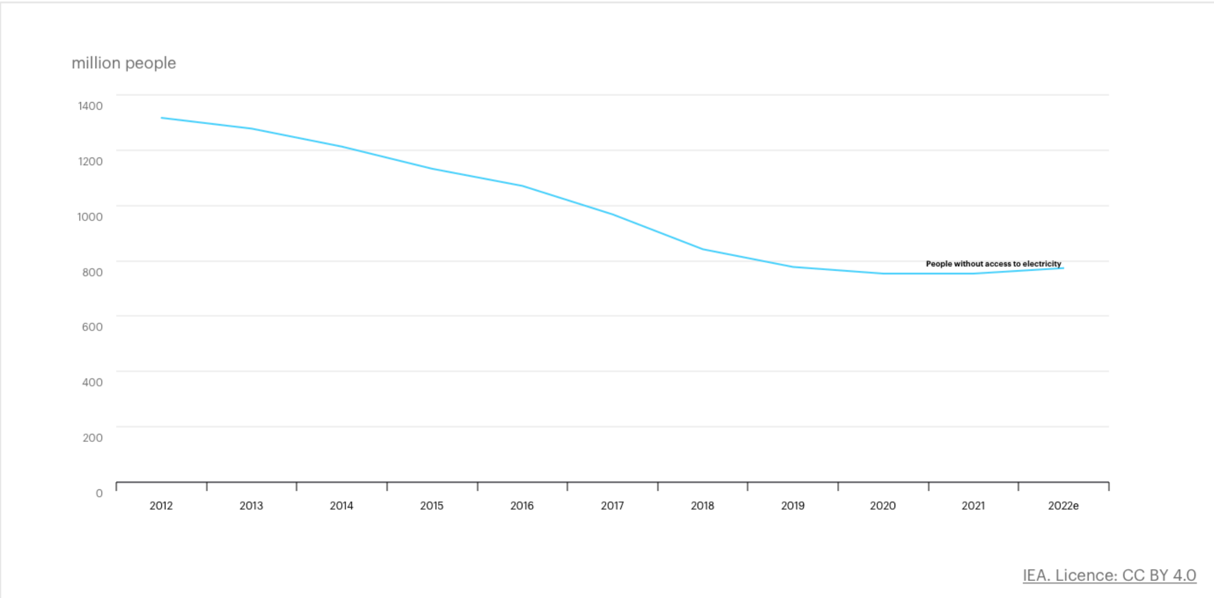
[10] The task of resolving the tension between the imperatives of poverty reduction and climate would be made easier if the wealthier world cut its own fossil-fuel production. Newell and Simms (2019) propose a treaty to this effect.

[11] On poverty see Addison et al. (2009).

livelihoods (via reliable power for irrigation pumps on smallholder farms, agricultural processing to add value to crops; and easy phone recharging to allow farmers and small businesses to check market conditions).[12] Firewood, charcoal, often the main fuels for household cooking, denude forests and add to emissions. Energy poverty is also a big contributor to the ill-health and the illiteracy that accompanies income poverty (as clinics cannot keep essential medicines reliably refrigerated, households cannot cook nutritious food or must use fuels that cause respiratory illness, and children must study by the light of a flickering paraffin lamp or not at all). The UN's first Sustainable Development Goal (SDG), 'No Poverty', cannot be realized unless SDG 7 is also achieved: 'ensure access to affordable, reliable, sustainable and modern energy for all'.[13]

Some 775 million people in the world—roughly equivalent to Europe's total population—lack electricity, (see Figure 1).[14] Around 600 million people without reliable access to electricity live in Africa (and mainly in sub-Saharan Africa—SSA). This is more than 40 per cent of Africa's population (and 970 million Africans lack access to clean cooking fuels) according to the International Energy Agency (IEA).[15] A decade of success in reducing global energy poverty stalled and then worsened as the COVID-19 pandemic hit economies, and later as the cost of imported energy surged with the Ukraine war. Africa accounted for much of that deterioration in global poverty.

Figure 1: People without access to electricity worldwide, 2012–22



Note: 2022e = estimated values for 2022

Source: IEA, https://www.iea.org/data-and-statistics/charts/people-without-access-to-electricity-worldwide-2012-2022. Original published with CC-BY 4.0 licence.

12 González-Eguino (2015) reviews the definition and measurement of energy poverty.

13 https://sdgs.un.org/goals. On the SDGs, see Parra et al. (2021).

14 https://www.statista.com/statistics/1106711/population-of-europe. This figure includes European Union (EU) and non-EU countries.

15 IEA (2022a: 35).

Energy poverty is one reason why today some 40 per cent of people in SSA live below the World Bank's poverty line.[16] In contrast, the East Asia and Pacific region's progress in reducing poverty has been spectacular. The region's average (country) poverty rate fell from 62 per cent in 1990 to 3 per cent in 2015 as China's growth lifted millions out of poverty. South Asia also cut the number of poor from half a billion in 1990 to 216 million by 2015. [17] Asia's rapid advance, combined with Africa's slow progress, means that SSA is likely to account for nearly 90 per cent of the global poor by 2030, according to World Bank simulations.[18]

Energy is therefore a clear imperative for the national development goals of African governments, though many find it tough to deliver improvements due to funding shortages and institutional weakness. Rwanda, however, shows what can be done: the number of households with electricity access rose from 10 per cent in 2010 to around 50 per cent by 2020, with a target of 100 per cent by 2024.[19] This makes Rwanda a global top-performer in improving energy access. It has helped Rwandans become more productive as farmers and in business, thereby raising and sustaining economic growth (annual real gross domestic product (GDP) growth averaged 7–9 per cent before the pandemic), and Rwanda is on course to graduate to MIC status within a decade.[20] Africa can succeed, but the continent needs considerably more help if it is to do so.

2.1 Achieving the necessary investments

Energy investments are expensive. They compete with other spending priorities such as health and education (key drivers of human development) for the limited public revenues that are available. Economic growth helps reduce this trade-off as it increases public revenues and the extractives sector is often the biggest contributor to revenues in resource-rich countries. Governments in those countries can look to revenues from oil, gas and mining to fund their energy investments as well as other spending on poverty and human development. Additionally, some countries intend to use their national gas resources to build out their energy infrastructure in ways that improve energy access (Tanzania is an example). Nigeria's government plans to end the energy poverty of some 100 million Nigerians (nearly half the population) by increasing the use the country's gas reserves (amongst the world's largest) as a 'transition fuel'. Gas will secure Nigeria's base-load electricity generation to support a growing share of renewables, with gas eventually declining as the country's target date (2060) for net zero approaches.[21]

However, for LICs and LMICs, large-scale external funding on a concessional basis (grants or low-interest loans) is also vital to boosting energy access, especially through solar and wind power. This may come via official development aid (ODA), special climate funds or eventually from the loss-and-damage fund that was agreed at COP-27 in 2022. Concessional funding can then also leverage

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[16] https://blogs.worldbank.org/opendata/number-poor-people-continues-rise-sub-saharan-africa-despite-slow-decline-poverty-rate

[17] World Bank (2018: 1). The data are for years preceding the COVID-19 pandemic. For an update see: https://blogs.worldbank.org/eastasiapacific/setting-standards-why-updating-poverty-lines-matters-east-asia

[18] World Bank (2018: 25). The COVID-19 pandemic made matters worse (Addison et. al 2020; IMF 2019). The pandemic increased the numbers in extreme poverty by 20%, including 80 million more Africans (Sumner et al. 2020).

[19] https://www.usaid.gov/powerafrica/rwanda

[20] IMF (2017). https://www.worldbank.org/en/country/rwanda/overview

[21] https://energytransition.gov.ng

in private finance. The IEA reckons that Africa will require funding of US$25 billion per annum to achieve universal access to 'modern' energy by 2030.[22] Yet given the difficulties of mobilizing climate finance to date the funding task should not be underestimated and nor should the practicalities around the investments required to reach the 2030 goal, especially to provide electricity to communities in remoter regions.[23]

3 Scenarios and the global energy future

3.1 Drivers of global energy demand growth

In poorer economies, efforts to end poverty, including energy poverty, should be a major driver of the global energy future. One of the best means to reduce poverty is via *inclusive* economic growth (provided this is also environmentally sustainable).[24] Agricultural growth is acknowledged as especially effective at reducing poverty, since most of the poor make their livelihoods as smallholder farmers, agricultural labourers or in the informal businesses that serve rural communities.[25] In a world where nearly a tenth of the population is hungry, household food security is a crucial basic need (including urban food security).[26] Poverty reduction via agricultural growth calls for higher productivity that in turn requires greater energy intensity in the farming methods used (not least pumps for irrigation). So improving energy access for rural households (and for peri-urban and urban agriculture) will go hand in hand with greater national energy demand and intensity. This poses exceptional challenges for sustainability as the sector's emissions will go even higher: agriculture accounts for up to a third of global emissions (and agriculture is also one of the biggest contributors to biodiversity loss, water stress, and deforestation).[27]

Energy intensity increases as per capita incomes grow, accelerating as LICs graduate into the middle-income stage of development (when economies typically see more manufacturing activities that are much more energy-demanding than the agriculture that dominates LIC economies). Households in middle-income countries (MICs) also use, and can afford to pay for, more electricity and more energy intensive products and services. Energy intensity then tends to flatten out around the upper middle-income per capita level as countries head into the high-income category where services rather than manufacturing account for an increasing share of economic activity.[28]

[22] IEA (2022a: 16). This is but a small part of the amount required to deliver net zero globally: see in particular, the report of the Independent High-Level Expert Group on Climate (Songwe et al. 2022).

[23] Hogarth and Granoff (2015) discuss energy distribution.

[24] The poverty-reducing effects of growth are enhanced when countries also expand social protection and invest more in education and health: see Addison et al. (2009) and Ravallion (2017).

[25] Arndt et al. (2016) and de Janvry and Sadoulet (2009).

[26] Global hunger measured by the prevalence of undernourishment was 9.2% in 2022: about 735 million people, including 282 million Africans (FAO 2023: 28, 30).

[27] Within agriculture, food accounts for 25–30% of global emissions (Ritchie 2021). Food production accounts for half the global biodiversity impacts and 60% of the water impacts (UNEP 2024: 134). Many developing countries are going down the same unsustainable agricultural path as the world's richer countries. The latter have ended up with agricultural sectors characterized by large-scale emissions and environmental damage: see for instance Helm (2019) on the UK.

[28] Deichmann et al. (2018).

The MICs group contains the most dynamic developing economies. Whereas the LICs have the highest *shares* of poor people in their populations, the MICs have the highest *absolute* number: nearly three-quarters of the world's poor currently live in MICs: some five billion of the world's seven billion people).[29] Because the MICs stand a good chance of continuing to both grow and reduce poverty: (the COVID-19 pandemic interrupted but did not fundamentally derail this trend) they are now passing through the stage in their development which typically exhibits the largest increment in a country's energy consumption: India, as the principal example, will be the single largest source of growth in global primary energy demand by 2040.[30]

Population growth is a second big driver of global energy consumption. Again, Africa comes into focus: SSA's population replacement rate (4.8) is substantially above the level of 2.1 that yields an unchanging population. In contrast China is now an increasingly ageing society and its population is already declining.[31] By the end of the century Africa will be home to 40 per cent of humanity. Yet today Africa still only generates 6 per cent of the electricity per person (per year) of the American average.[32] Nigeria, Africa's most populous country with 216 million citizens, will have a population greater than the United States by 2050, yet today, it is remarkable that the entire country consumes about the same amount of electricity as one medium-sized American city (the 100 million Nigerians in energy poverty account for about one-fifth of all energy-poor Africans).[33] Ensuring that all Africans can consume even a modestly increased amount of electricity will add up to a large increase in total energy demand, even if their average energy consumption remains well below that of the rich world.

Interconnecting with population growth is the third driver, namely urbanization, which adds to energy demand: cities and towns have much higher levels of per capita energy consumption than rural villages and account already for 60–80 per cent of global energy consumption.[34] The global urban population is expected to rise from 3.5 billion to 6.5 billion by 2050 (an 86 per cent increase) again mostly in the developing world. Especially striking is the 'megalopolis' now rapidly growing along the West African coast from Cote d'Ivoire to Nigeria, taking in Benin, Ghana and Togo along the way and which demographers predict will become the world's largest zone of continuous dense habitation. Its energy consumption although remaining low in per capita terms could easily come to exceed that of most major European cities.

In short, economic growth, population growth, and urbanization in the developing world will drive the story of global energy consumption over coming decades. Consequently, in the decades up to 2040 nearly 90 per cent of the world's growth in global electricity demand is expected to occur in the Global South.[35]

To summarize our story so far: the governments of the developing world all aspire to achieve inclusive economic growth. But such success will lead to unprecedented energy demand on top of

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[29] https://www.worldbank.org/en/country/mic/overview.

[30] IEA (2018a: 35).

[31] Bricker and Ibbitson (2019); Lutz et al. (2004); and Prskawetz et al. (2008).

[32] EIA (2020:3).

[33] Moss and Devermont (2018).

[34] https://www.undp.org/speeches/smart-and-sustainable-solutions-cities. Urbanization is also putting immense pressure on supplies of building materials, especially sand (Bendixen et al. 2019). The built environment is one of the biggest drivers of materials demand (UNEP 2024: xiv).

[35] IEA (2018a: 35).

the already high energy consumption of the rich world. While striving to increase the share of renewables in the energy mix, most countries will still need base-load energy generation. For many this implies gas, either from their own gas fields or imported via pipelines and (increasingly) shipped in as liquified natural gas (LNG). Whereas the advanced economies together with China and India have nuclear capacity to provide base-load—and are building more—nuclear power is available to only a handful of developing countries such as Argentina, Brazil and Pakistan (with new construction underway in Bangladesh). In Africa there is only one such country namely South Africa, although nuclear plants are under construction in Egypt.[36] Other countries such as Mozambique have hydropower, and there is a large (but controversial) hydropower project underway in Ethiopia.

Hydrogen is also an opportunity for economies like Kenya and Namibia that are blessed with abundant renewables (geothermal and solar respectively) to produce green hydrogen which can be liquified and exported to Asia (and used to develop their own green manufacturing base, perhaps financed by Asian investment).[37] Latin America is also seeking opportunities in green hydrogen with an eye to the regional and Asian markets (discussed later in this paper).

3.2 Energy scenarios

The opportunities and market prospects for countries with resources of oil, gas and metals depend on the key drivers already discussed but also critically on whether climate commitments are realized and how fast.[38] Delivery against those commitments will influence the pace of technological progress in renewable energy infrastructure as well as EVs which in their turn will affect their rates of adoption. These various forces are driven by interacting decisions and outcomes—political, scientific, and commercial—that are shaping the global economy of the 21st century. Scenarios about the next two to three decades for the global economy are critical information tools to help countries, as well as companies, develop coherent strategies for their own investments.

In this context, the scenarios developed by BP and the IEA help us speculate systematically about the future.[39] Although their projections differ in detail, these two authorities agree that the share of renewables in global energy consumption will be substantially higher by 2040, while the share of coal will be much lower. Notwithstanding the retreat from fossil fuels, both agree that there will be a robust demand for gas for several decades more. Although the IEA sees the share of gas declining faster than does BP, both agree that fossil fuels and especially natural gas will remain important in the global energy mix for many more years.

BP's *Energy Outlook 2022* is the most useful for our purposes: it has three scenarios for the period up to 2050, conditioned on assumptions about climate action and emissions.[40] The net zero scenario assumes that climate action targets (broadly Paris-2015 plus later COPs) will be achieved

[36] https://world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx

[37] Hydrogen can also be used to produce ammonia for fertilizer, which will be of great benefit to improving Africa's low yields and increasing the region's food security (IEA 2022a: 18).

[38] On the need for speed in climate action see: Stern (2015), van der Ploeg and Venables (2022), and Wallace-Wells (2019).

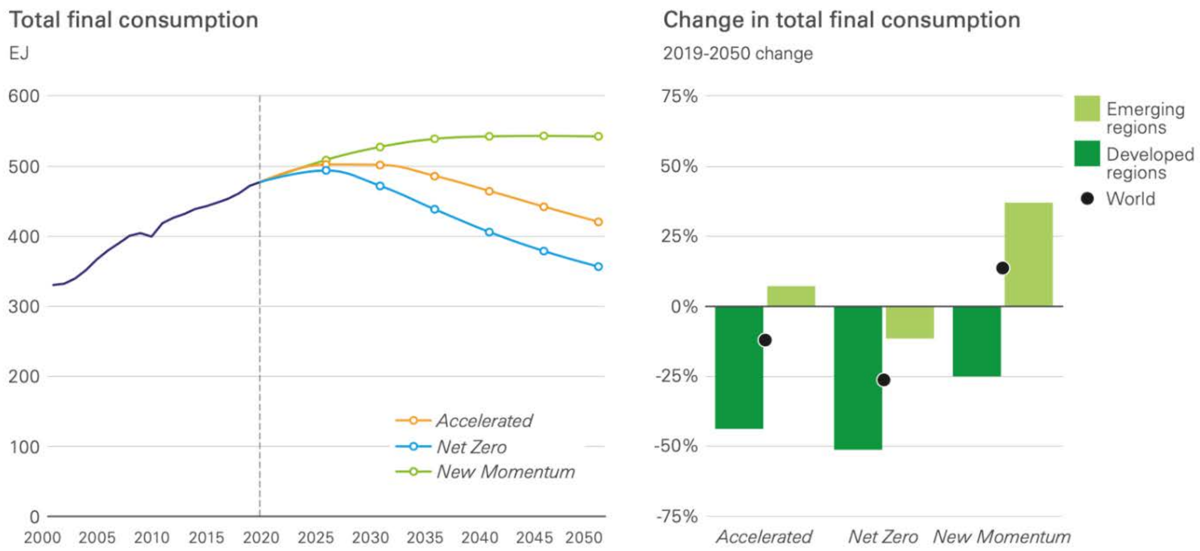
[39] In 2023, BP transferred its annual energy report to the Energy Institute: https://www.energyinst.org/statistical-review. It is noted that the scenario 'projections' are not forecasts—indeed they typically consider a range of different possible futures.

40 BP (2022).

resulting in emissions falling by 95 per cent relative to their 2019 levels by 2050. In BP's accelerated scenario net zero is not reached by 2050, but BP argues that it is nevertheless 'Paris consistent' with emissions falling 75 per cent relative to their 2019 levels (the remaining emissions being in the hardest-to-abate sectors, especially heavy industry). In the new momentum scenario emissions decline by only 20 per cent relative to 2019 as some climate pledges are implemented but are still well off the net zero scenario's target by 2050 (when emissions are only 20 per cent below their 2019 levels). The latter is broadly the world's current trajectory: one in which global warming will rise well above the 1.5C target.

Figure 2 shows total (global) final energy consumption. In the new momentum scenario (the world's current pathway) total energy consumption is higher in 2050 with the emerging regions (the developing world) dominating the rise in energy consumption, consistent with our own analysis earlier. Coal still accounts for 13 per cent of the energy mix in 2050 (compared to 20 per cent in 2019) mainly because of India and other big Asian coal consumers (whereas coal's shares are much lower at 4 per cent and 3 per cent respectively if the net zero or accelerated scenarios materialize).

Figure 2: Total final energy consumption, three BP scenarios



Source: BP (2022: 16).

The share of renewables grows strongly in all three BP scenarios: in the *Net Zero* scenario from 12 per cent of the total in 2019 to 64 per cent by 2050. In the IEA's *Renewables 2022: Analysis and Forecast to 2027* (published in December 2022) the IEA makes the largest ever upward revisions to its forecasts for renewables, factoring in the Russia-Ukraine war (which is leading to greater substitution of renewables for gas due to the disruption in gas markets) and the Biden administration's big push on energy transition (notably the Inflation Reduction Act, IRA). It concludes that renewables will become the biggest source of global electricity generation by 2025, surpassing coal.[41]

[41] IEA (2022b: 10). The IEA also uses three scenarios: the stated policies scenario which is the trajectory implied by today's policy settings; the announced pledges scenario which assumes that all targets announced by

However, gas remains the critical transition fuel with a share that remains over 20 per cent by 2050 in all three BP scenarios. In BP's new momentum scenario even the absolute volumes of gas consumed will be 30 per cent higher in 2050 than in 2019.[42] BP's analysis was, however, completed before the Ukraine war, whereas the more recent IEA analysis lowers its expectations for gas demand (from its 2021 assessment) with demand growth through to 2030 being significantly lower than in the period 2010–19, and then on a flat trajectory from 2030 through to 2050 with the growth in gas consumption in the developing world, especially in Asia, being offset by declines in the advanced economies (the Asian gas market is discussed later in this section).[43]

All scenarios must be hedged with caveats, and they need regular revision (not least to accommodate policy changes, new technologies, energy efficiency progress, and new shocks).[44] But they are useful in stimulating debate—not least over the underlying assumptions—and for informing policies in countries with endowments of the component fuels. Scenario-building also feeds into the investment decisions of companies which must commit billions of dollars in the expectation of profitable production over time horizons that span decades. To avoid nasty macro-economic surprises, governments are also well-advised to make far greater use of scenarios than most currently do, to simulate the fiscal impact of shocks, and to maintain the necessary analytical capacity to do this. This can more than pay-off in negotiating the terms and conditions of investments (and related agreements on taxation and revenue-sharing) with multinational companies (which have far more market knowledge than do small producing countries, especially new producers with limited experience).

3.3 The Asian energy century

It is a cliché to say that we live in the Asian century, but this is certainly true as far as energy, metals and commodities generally are concerned.[45] The Asia-Pacific region is the big energy story, and the big climate story. China and India together already account for about one-third of global emissions from fuel combustion and this share seems certain to rise.[46]

All producing countries therefore need to keep a close eye on how policy is evolving across Asia. What happens in the ministries and boardrooms of Beijing, Delhi, in addition to Seoul, and Tokyo is critical to the market prospects of the DRC's cobalt, Mozambique's gas, and Uganda's oil: perhaps more so than in the capitals of Europe and North America. And aside from being a net importer, the Asian region is itself a big producer and exporter of oil, gas and metals: coal, gas, and iron ore from Australia and Timor Leste; coal, copper and nickel from Indonesia; most rare earths from China; and uranium from Kazakhstan (to give just a few examples).

There are at least five themes to the Asian energy future. The first is the current energy dominance of coal and how fast gas is likely to replace it. The second is the switch from coal and gas to renewables. The third is Asia's growing market for hydrogen. The fourth is how Asia might incentivize producers to supply more net zero (or at least lower emissions) fuels and metals: if

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governments are met on time and in full; and the net zero emissions by 2050 scenario (IEA 2022b; IEA 2022c). On the energy market as a whole, and its possible future, Yergin (2020) is an excellent guide.

[42] See BP (2022: Annex Data Tables).

[43] IEA (2022c: 49 and 365)

[44] See Addison (2018) for further discussion of scenarios.

[45] On Asia's rise see Nayyar (2019a; 2019b). Bridge and Le Billon (2017) discuss oil and the Asian regional market.

[46] https://www.iea.org/geco/data

these countries are going to sustain fossil fuel use, can they at least work to lower emissions? The fifth is the impact on global metals demand from Asia's transition to net zero.

3.4 Energy transition in Asia

For the first and second of our Asian themes—the interplay between coal, gas and renewables—a useful starting point is how Asia's policymakers balance their often-competing energy objectives, all of which are important in their own right. In a study for UNU-WIDER, Kathryn McPhail and Etienne Romsom identify eight key priorities that drive current energy policy in Asia: affordability; energy security; energy access, air quality; climate change impact; continuity of supply (managing intermittency); how to balance the grid; and diversity of use.[47] They assess how natural gas, oil, coal, and renewables rank against each of these eight priorities in China, India and a block of countries in South East Asia (SEA).[48] Table 1 reveals considerable differences across the three blocks, and indicates how Asian policymakers are playing their energy cards.

Table 1: Energy transition priorities across Asia

Energy priorities ranking comparison	China	India	SEA
Affordability	3	8	8
Energy security	7	5	6
Energy access	1	7	5
Air Quality	8	2	2
Climate change impact	2	4	1
Continuity of supply	5	6	7
Grid balancer	4	1	3
Diversity of use	6	3	4

Note: The table shows a comparative ranking; how each of the regions rank their priorities as evidenced in energy decision making (1 = low, 8 = high).

Source: Romson and McPhail (2020a).

The top priority under China's 13th five-year plan (2015–20) was air quality (see Table 1), with the best matching energy sources for this being renewables, gas, hydro and nuclear. The choice of gas versus coal depends on whether concerns about air quality trump energy security (China's second highest priority). The 14th five-year plan (2021–25)—released in 2022 amid the turmoil in global gas markets—not surprisingly gives energy security a very high priority, and China has ramped up coal generation again to help deliver this.[49] China is still easily the world's biggest consumer of coal and its biggest producer: domestic coal output hit a new record in 2022, propelled by energy security worries.[50] Nevertheless, under the 14th plan, coal's share in the primary energy mix is expected to drop to 45 per cent by 2040 (from 60 per cent today), with the gas share rising from 9 to 12 per cent, and with wind, solar, hydro, and nuclear growing strongly alongside gas. The volumes of gas required are huge and so China is becoming an ever-bigger driver of global gas markets: it overtook Japan and South Korea as Asia's largest LNG importer in 2021.[51]

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[47] Romsom and McPhail (2020a). See also Romsom and McPhail (2020b) on the Asian gas market.

[48] SEA's combined population is almost 700 million.

[49] CREA (2020).

[50] Total global coal production is around 8,000 million tonnes per annum, with China producing about 3,500 million tonnes. India produces around 700 million tonnes and Indonesia 500 million tons annually.

[51] Japan took the top spot again in 2022 as China's economy slowed due to the continuation of the COVID-19 lockdown but the trend still favours China to again exceed all other Asian LNG importers.

Significantly, China has become the world's largest investor in renewable energy. Indeed, by 2017, China accounted for almost half of the world's investment in renewables, and today China is also a leader in manufacturing green energy technologies and EVs. Solar is already the cheapest alternative to coal in China (though still constrained by grid connection issues). China's renewables energy sector now accounts for around one-quarter of the world's total capacity, its capacity is more than double that of the US, and China is well ahead of Europe.[52] Significantly, all this investment implies a growing demand for metals.

India and SEA attach the highest priority to affordability, and India gives a high priority to energy access, while China attaches lower priorities to energy access (which is already good) and to affordability (Table 1). For India and Indonesia (the most populous nation in SEA) their high priorities of affordability and energy access have been pursued mainly through coal. India and Indonesia are the world's second and third biggest thermal coal producers respectively, and their output hit new highs in 2022 (coal generated 38 per cent of Indonesia's energy in 2021), and Indonesia is also the world's largest exporter of thermal coal. Both India and Indonesia have politically strong coal lobbies as large fortunes continue to be made in the industry and many poor communities depend on coal mining for work.

India is ambivalent about phasing out coal. Indeed, as recently as 2020 the government put out to tender 86 new coal mines to exploit India's huge, estimated coal reserves of 300,000 million tonnes. While India is targeting an increase in renewables to 40 per cent of energy consumption by 2030, including more off-grid solar power for its large rural populations, fossil fuel subsidies are today at least seven times larger than those for renewables.[53] Although India has set a target of 2070 for net zero, its projected rate of energy demand is so large that the absolute consumption of coal will surely continue to grow. After COP27 in 2022 the power minister Mr R.J. Singh made it clear that: 'The phase-down (of coal) would happen in *percentage* terms, not in *absolute* terms' (our emphasis).[54]

It is clear from all this that Asia's energy transition urgently needs to accelerate, otherwise the region could on current trends fully consume the remaining global carbon budget (for the Paris 2ºC scenario).[55] Will it accelerate? One driver is international action. In 2022 after COP27 the Group of Seven (G7) countries offered Vietnam a US$15.5 billion package to help its transition to renewables, following earlier similar support to Indonesia after COP26. Another driver is commercial, and stems from the application of carbon taxes (which constitute a powerful headwind for coal). In December 2022 the EU agreed a 'carbon border adjustment mechanism' (CBAM) to come into force in 2026 (a transitional phase began in October 2023).[56] CBAM targets carbon-intensive goods such as iron, steel and aluminium. This will penalize emissions-intensive exporters such as India's steel industry that use large amounts of mainly coal-fired power. But it might also encourage them to lobby against the powerful coal incumbents, and push for a faster shift to renewables in India's energy mix. If CBAM does gain traction it will incentivize states elsewhere to move on carbon pricing, which would again accelerate the energy transition. China

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[52] https://www.iea.org/geco/data

[53] https://mnre.gov.in/solar/current-status/and https://www.iisd.org/publications/brief/background-note-fossil-fuel-subsidy-reform

[54] 'Have Energy Needs, No Cut for Coal Phase-Down: Power Minister R.K. Singh'. *The Indian Express*, 27 November 2022.

[55] https://globalenergymonitor.org

[56] https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en. The EU's trade partners claim that CBAM it is not compliant with World Trade Organization (WTO) rules.

could eventually introduce its own carbon border tariffs, and raise the domestic carbon price, in response to the EU's CBAM and the Biden administration's IRA. Competition in decarbonization between the EU, China and the USA may also force the pace of energy transition across Asia, bringing coal to a quicker end.

Hydrogen is our third Asia theme. Asia's market for hydrogen is already growing fast and China is the largest green hydrogen producer and consumer, based on its renewable power capacity. Hydrogen is especially important in reducing the use of coking coal in producing steel. India's competitiveness will be threatened as GVCs turn green unless it closes the gap with China and others in using green hydrogen in industry and, as already noted, it will be vulnerable to CBAM and other carbon border tariffs. As also discussed earlier, Africa and Latin America could find a ready Asian market for liquified hydrogen produced by geothermal, solar, and hydro.

Our fourth Asia theme is the region's potential to encourage emission reductions both in its own continuing use of fossil fuels but also among its suppliers. Since Asia constitutes at least 70 per cent of the global LNG market, it should have the market power to push down scope one and two emissions in the upstream global oil and gas industry and further encourage the use of carbon offsetting (a means to deal with scope three emissions, though an imperfect one).[57] The prospects of low-emissions gas, and perhaps even net-zero gas, then increase (and are given a further push by initiatives now underway for tighter verification of the standards). Again, the impetus for decarbonization arises from reaping the commercial gains from the greening of GVCs (not just in manufacturing, but also in agriculture and services). Japanese and South Korean utilities have already started to pay a price premium for zero-carbon verified LNG cargoes in order to supply carbon-neutral gas to customers. Singapore, which was SEA's first country to introduce a carbon tax, is now positioning itself as a green LNG hub with a carbon trading scheme (building on its role as Asia's largest oil-trading hub).[58]

Such market developments provide incentives to cut emissions across the gas value-chain (especially methane). Tanzania's new (greenfield) LNG project, for example, could potentially have the lowest emissions footprint of any LNG project currently under development in the world.[59] And Tanzania is nicely positioned on the Indian Ocean to ship its LNG to Asia and earn a price premium. New producers have an advantage as it is far easier to build emissions reduction into oil and gas infrastructure at the development stage than to retrofit it later on.

Our fifth theme is that Asia's net-zero transition will significantly increase the demand for metals. China has been the big story in the metals market for nearly two decades, and its consumption took off after acceding to the WTO in 2001. Economic growth then averaged 9 per cent per annum for many years—much to the benefit of African mining.[60] In recent years China has accounted for over 70 per cent of global demand for iron ore, over 50 per cent for aluminium and nickel, and over 40 per cent for copper and lead. As a result, global metals production has grown at almost twice the rate of global GDP since 2000.[61] Countries endowed with the requisite metals can expect continued demand growth in the future from China, albeit at the expense of being tied

[57] On the definition of scope one, two and three emissions see: https://www.epa.gov/climateleadership/scope-1-and-scope-2-inventory-guidance

[58] Romson and McPhail (2022: 20).

[59] Romson and McPhail (2022: 22).

[60] Addison et al. (2016, 2017).

[61] ICMM (2016: Figure 2).

to the Chinese business cycle: a risk that the country's long COVID-19 pandemic lockdown illustrated.[62] China has already secured long-term contracts for the supply of critical metals such as cobalt, lithium and nickel, and Chinese companies have also become big investors in mining in the DRC and elsewhere.[63]

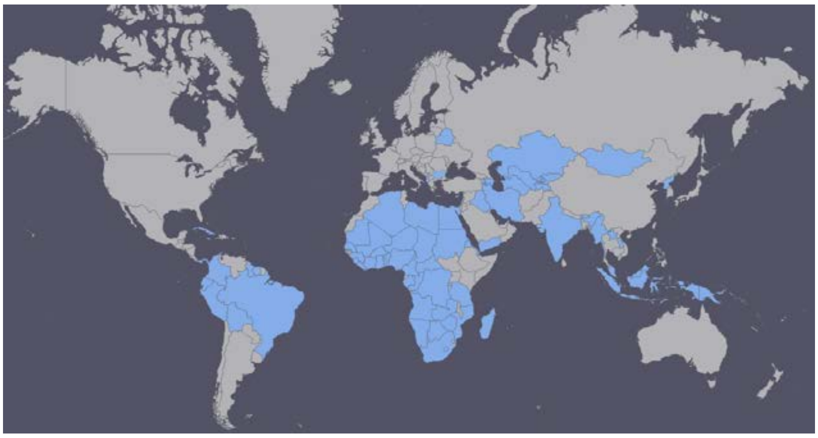
We next take a more detailed look at minerals, and the potential impact on producing countries of market trends.

4 Opportunities for the extractive industries of the developing world

4.1 The current dependence

Encouraging the diversification of developing economies and reducing their dependence on commodity exports is a long-standing goal of development policy. Yet, over the last two decades the dependence of many countries on the extractive industries has *increased* significantly: this is a key finding from a UNU-WIDER study covering the period 1996–2016 as summarized in the map in Figure 3 (Roe and Dodd 2018).

Figure 3: Export dependence on extractive industries



Note: darker shading indicates a country where the extractives sector accounts for 30% or more of total export earnings.

Source: UNU-WIDER blog article, https://www.wider.unu.edu/publication/it-or-not-poor-countries-are-increasingly-dependent-mining-and-oil-gas.

Two further UNU-WIDER studies find that there were 43 LICs and LMICs where the extractive sector's share of total exports was 20 per cent or above in 2018 and in 24 of the 43 country cases extractives exceeded 50 per cent of total exports (Ericsson and Löf, 2018 and 2020a).[64] A third

[62] See for example, McKinsey Global Institute (2013: Exhibit 5) and Addison et al. (2016).

[63] China is home to some of the most advanced cobalt processing companies and has considerable investments in DRC mining, for example the Tenke Fungurume mine. China's Belt and Road Initiative has been a driver. Nevertheless, China's control over African mining is less than often assumed: about 7% of the value of total African mine production in 2018 (Ericsson et al. 2020b). Economy and Levi (2014); Pigato and Tang (2015) and Nedopil (2023). Bräutigam (2009) discusses China's broader engagement with Africa.

[64] Amongst the 24 countries in which extractives account for more than 50 per cent of total exports, there are 15 countries in which minerals dominate, five are mainly oil and gas exporters (Angola, Nigeria, Cameroon, Republic of the Congo, and Yemen), while the other four countries have a balance between mineral exports

UNU-WIDER study finds that for Africa's exports, the level of natural resource content (from all sources) nearly doubled between 1995 and 2015 for almost all countries (Osei-Owusu et al., 2022).

Oil, gas and mining certainly provide useful economic opportunities but a high dependence also exposes economies to the risks inherent in commodity markets (especially price volatility) as well as to the more fundamental market adjustments to the net-zero transition. These risks are especially significant for Africa, where more than half the countries are highly dependent on the extractives industries (30 countries out of 54), compared to 11 Asian countries, and one Latin American (Bolivia).[65]

4.2 Metals: which countries benefit?

In a UNU-WIDER study, Ericsson and Löf (2020a) identify the thirteen critical minerals that are essential to building ten technologies that underpin the net-zero future: wind turbines, solar photovoltaic, carbon-capture, nuclear energy, light-emitting diodes, EVs, energy storage, electric motors, hydrogen vehicles, and electronics. The ten critical minerals are: chromium, cobalt, copper, graphite, lithium, manganese, molybdenum, nickel, niobium, palladium, platina, rare earths, and tantalum.[66] Some 40 developing countries are already producing (or have identified reserves) of these critical minerals.[67] The DRC, Indonesia, and Zambia have the highest production values, while Zimbabwe is also now producing seven out of thirteen of the critical minerals. Overall, copper is the single most important: accounting for 55 per cent of the total critical mineral value for the group of 40 countries.

The next question is: in which countries will mining these critical minerals potentially have the most economic impact? To answer this question Ericsson and Löf (2020a) score each country using five indicators: the number of the thirteen critical minerals for which the country has reserves; the number of these critical minerals already in production; the scale of new exploration activity relative to production; and the existence of a significant mining industry (defined as mine production greater than US$4 billion). Weighting the indicator scores generates a ranking of countries according to greatest *future potential*. At least *eighteen* countries achieve impressively high scores, and Zimbabwe, Papua New Guinea (PNG), the DRC, Tanzania, and Zambia come top.[68] While not definitive, this study does indicate which economies could significantly benefit from the net-zero transition (Box 1 provides further insights).

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and oil and gas exports. Tanzania and Mozambique and others are set to join this group of 24 highly extractives-dependent economies.

[65] Roe and Dodd (2018).

[66] The study by Ericsson and Löf (2020a) builds on work by the World Bank (2017: 75) and Vidal et al. (2013). See also: Gloaguen et al. (2022); Herrington (2021). IEA (2022d) provides an overview of the role of critical minerals in the clean energy transition.

[67] See Ericsson and Löf (2020a) for a full list of these countries and their critical minerals.

[68] The countries with the greatest potential are, in order of their scores: Zimbabwe, Papua New Guinea, DRC, Tanzania, Zambia, Cote d'Ivoire, Philippines, Burkina Faso, Kyrgyzstan, Morocco, Madagascar, India, Mauritania, Uganda, Ghana, Mozambique, Bolivia and Indonesia.

Box 1: Potential beneficiaries from critical minerals

A mineral yields no revenue until it is extracted, processed, and transported to a market. This necessitates considerable investment, which is in its turn determined by investors' perceptions of risk—including country risk (the regulatory and policy environment as well as political stability). A country's potential to benefit therefore consists of much more than favourable geology. Ericsson and Löf (2020a) assess this potential using three indicators, namely: geology (number of critical minerals); investments (measured by announced project costs as a percentage of GDP); and country risk for investors (using the MineHutte index).[69]

Geology: The DRC scores highly because it accounts for 60 % of all global cobalt mined. The DRC is also a large copper producer as are PNG and Zambia, and PNG along with the Philippines and Indonesia produce both copper and nickel (metals which account for more than 70 % of the total production value of production of the thirteen critical minerals). For lithium, Chile is the world's second largest producer after Australia. Bolivia has the world's largest lithium reserves but has failed to attract investment and its production remain negligible.

Investments: There is considerable variation in investment across countries. At the top end, announced projects in PNG are equivalent to 67% of GDP, while in DRC, Madagascar, and Zambia the figure is in the 10–15% range, and at the bottom end, in Tanzania and Morocco, the ratio is 2.2% and 0.1% respectively.

Country risk: Mining operations can span decades and stability is a key variable in determining whether investment occurs or not. Investment in Bolivia's lithium mining stalled as policy flip flopped. Yet geology can sometimes trump a country's fragile politics. The DRC, for example, has a dysfunctional legal system and mining code, and a history of high-level corruption—and scores absolutely worst in the MineHutte comparison. Nevertheless, the country has large and longstanding mining operations and several more projects under development, notably in copper and cobalt.

5 Dilemmas

In sum, the global energy future will certainly be very different from what has gone before. Yet trying to anticipate how exactly this will play out, including in poorer countries potentially able to benefit, reveals many dilemmas over the role of the extractive industries. Here are just six examples.

5.1 Poverty reduction and nature

The first dilemma for resource rich but poorer economies is how to reduce their poverty while protecting nature. This was discussed earlier when we reasserted that *inclusive* growth is essential to reducing poverty.[70] For example, raising the productivity of Africa's farmers by substituting capital equipment and fertilizer and other inputs for their long hours of labour will not only improve household incomes, well-being and food security but will also add to GDP and its growth. Investing a good portion of the tax revenue from the extractives sector into agricultural development will have a high return to poverty reduction *and* growth. At the same time, agricultural

[69] The research consultancy MineHutte has developed an index or rating to estimate the investment risk in each country using indicators including: Legal (Mining Code); Governance (ease of doing business, transparency); Social (political stability, conflict, population density); Fiscal (royalty rates, tax regime, economic growth); and Infrastructure (rails, roads, ports, energy security). See: https://minehutte.com/methodology/.

[70] Arguments for 'de-growth' have become fashionable but stopping growth is neither likely to be economically nor politically feasible in the developing world, not least because population growth itself adds to GDP—unless every new labour force entrant is economically inactive, which is a recipe for starvation.

intensification will raise the sector's energy demands and emissions intensity especially *if* existing carbon-intensive technologies continue. It can also degrade nature unless appropriate conservation techniques are used. Hence the importance of innovation in agricultural technology as a global public good.

5.2 Mining and environmental risk

A second dilemma is that the considerable new mining that is inescapable, will add further to emissions and risks polluting nature unless well-regulated.[71] While building a 'circular economy' to recycle and reuse more of the planet's resources will be a significant contributor to net zero, it is unrealistic to expect this will soon meet all the world's needs for materials. Today, less than one-third of 60 metals have an end-of-life recycling rate above 50 per cent, and for 34 elements recycling is less than 1 per cent.[72] Only about 20 per cent of cobalt and platinum is obtained from recycled sources in the EU.[73] The global recycling rate for lithium is below 1 per cent.[74] For at least the next decade, and probably longer, recycled metals will be insufficient to meet humanity's needs, including efforts to end energy poverty. A comprehensive World Bank study of the implications of the low-carbon transition for materials demand concludes, that: '... the technologies assumed to populate the clean energy shift—wind, solar, hydrogen, and electricity systems—are in fact significantly MORE material intensive in their composition than current traditional fossil-fuel-based energy supply systems'.[75]

As examples of this, the manufacture of wind turbines, batteries, and EVs, together with the construction of low-carbon buildings and low-emissions mass transport systems like trams and railways, require lots of steel produced from iron ore mined in places like Brazil's Minas Gerais. Aluminium smelters will use more bauxite from the mines of Australia, China, and Guinea. More copper will come from Chile and Zambia, nickel from Indonesia (the world's largest producer), manganese from South Africa, and tin from China, Indonesia, and Peru. A myriad of other metals with hard-to-pronounce names (like niobium and molybdenum) will also be needed.

Cobalt and lithium are especially crucial to the digital and net-zero economies. The batteries in EVs and those for the very large ('utility scale') storage of electricity produced by wind farms and solar PV need vastly more lithium and cobalt than smartphones and laptops.[76] The average EV battery uses 14 kilos of cobalt (about the weight of two large bowling balls) whereas the typical laptop battery use 28 grams (smartphones average 8 grams).[77]

The growth of EV adoption is therefore especially challenging for the supply of metals.[78] There were 16.5 million EVs on the world's roads in 2022, triple the 2018 number, and EVs were nearly

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[71] On the environmental dimensions of mining see Bell (2018) and Edwards et al. (2014).

[72] UNEP (2011). See also UNEP (2019).

[73] Babbitt et al. (2021: 354)

[74] Haas et al. (2015: 773).

[75] World Bank (2017: xii). Emphasis in the original. Addison (2018) discusses the issue further.

[76] The growth rate of renewables implies huge investments in energy storage. By the mid-2020s the global energy storage market could be worth US$7–22 billion annually (Deloitte 2018: 3).

[77] Castelvecchi (2021) discusses EVs. See also: 'The Cobalt Pipeline', *The Washington Post*, 30 September 2016.

[78] Jones (2020); Jones et al. (2022).

10 per cent of global car sales—with the largest market, China, accounting for half the growth.[79] Signatories to the Electric Vehicles Initiative are aiming for an EV market share of 30 per cent by 2030 which for China is a massive increase on the 2 per cent share at present.[80] If this target is met, then the demand for the cobalt used in the batteries of EVs will be 25 times greater in 2030 than its 2018 level.[81] Growing demand is stimulating large increases in the production of the materials essential to EVs, notably lithium, cobalt, manganese, nickel, copper, graphite and rare earths: the DRC's production of cobalt rose by 400 per cent between 2009 and 2019, and the production of lithium in Argentina and Chile was up by 290 and 240 per cent respectively over the same period.[82] The infrastructure required to charge and service the EVs also adds substantially to materials demand.

As another example of this dilemma, a team of scientists has warned the UK Climate Change Committee that for EVs to replace the UK's 31.5 million (internal combustion engines) cars by 2050 will require almost twice the current annual *global* production of cobalt, an entire year of neodymium's global output, three-quarters of the world's lithium output, and 12 per cent of annual copper production.[83]

These numbers are staggering. And the rate of demand growth will accelerate as the rest of the developing world follows China in using EVs. EVs in India for example, still have a small share of the market (less than 1 per cent of new car sales) but this will surely grow as the government has ambitious targets.

But these expected trends in metal demands and so production need to be managed against the further increase in emissions and potential damage to nature that could arise. So, another imperative is to shift the global mining sector rapidly towards net zero, minimize its environmental footprint, and maximize its social impact—tough challenges.

5.3 Demand and supply imbalances

The third dilemma is that it is unclear whether the supply of metals can keep up with the growth in demand even if there is a huge increase in investment. It takes at least a decade to bring a major mine into production. And minimizing the environmental footprint adds to the cost and length of time required in the mine's construction and development phase (as well as for related transport and power infrastructure). Refining must also be transformed by replacing emissions-intensive technologies with cleaner power sources and this too takes time, not least because refining itself needs new technical breakthroughs (and therefore considerable new investment). Price spikes during periods of excess demand seem inevitable. Demand pressure may encourage faster progress in finding cheaper substitute materials, which is already happening for batteries. But this too takes

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[79] IEA (2022e: 4).

[80] IEA (2018b: 16).

[81] IEA (2018d: 13).

[82] Jones et al. (2022).

[83] 'Reaching Net-Zero emissions in the UK by 2050', open letter to the UK's Climate Change Committee, by Professor Richard Herrington and eight other scientists, 3 June 2019: https://www.nhm.ac.uk/press-office/press-releases/leading-scientists-set-out-resource-challenge-of-meeting-net-zer.html. They also estimate that the rate of EVs growth in the UK will require a 20 per cent increase in electricity generation and, if provided by wind power then the additional materials required in the construction of wind turbines must also be added in. See also Herrington (2021).

time and considerable investment. Therefore, price volatility and periodic shortages are likely until global metals markets settle into a new steady-state, possibly around mid-century.

5.4 Fragile states and supply chains

The fourth dilemma follows from the third, namely that much mining of critical minerals is undertaken in politically fragile states. These are beset by human rights abuses in supply chains, haphazard regulation, frequent changes in corporate tax regimes, and political instability.[84] Notable examples are the DRC (which has over 60 per cent of the world's cobalt reserves and a turbulent history often centred around fighting for control of the nation's abundant natural resources) and Guinea (which produces a fifth of the world's bauxite, and where a coup in September 2021 jolted the market). Big mining companies increasingly realize that what they call 'tougher jurisdictions' offer some of the few realistic prospects for growing their portfolios of critical minerals. Not only will they have to risk billions of dollars in hard environments with deficient (or often non-existent) infrastructure, but in such environments, they must also apply yet more effort to managing reputational risk. Consumers are increasingly sensitive to the ethics of supply chains, ESG investors are a growing force, and the premier industry body—the International Council on Mining and Metals (ICMM)—sets high standards for membership. All of this is guaranteed to bring numerous headaches to company boardrooms.

Relatedly, oil companies have historically been able to largely insulate themselves from the often-unsavoury politics of petrostates—by taking the public position that the use of revenue once transferred to the state is entirely a matter for the governments of sovereign nations to decide upon.[85] This position has become harder to sustain over the last decade, in part because of the work of the Extractives Industries Transparencies Initiative (EITI), civil society organizations, and others in shedding more light on the revenue flows. Many petrostates do not have functioning democracies (i.e., their governments and leaderships are not truly accountable to their citizens, even if elections are held). Given the world's continued dependence on oil and gas for energy generation and transport until the energy transition takes a firm hold, a good portion of supply will likely continue to flow from regimes that do not serve their citizens well.[86]

5.5 Strategic dependence

The fifth dilemma centres on the geopolitics of accessing mineral resources and refined metals. This is an increasing worry for geo-strategists given the deterioration in China's relations with The West, and the broader 'deglobalization' which may now be upon us. China dominates global refining capacity: 90 per cent of rare earth processing (and 70 per cent of all world rare earths mining) and about half of the world's lithium refining capacity.[87] Neodymium (crucial for magnets) and other rare earths from China, tantalum from Rwanda, and iridium from South Africa, are just

[84] Such states are also more prone to attract rogue investors—most recently Russia's Wagner Group (and their successors) that offer protection and other services to local regimes in return for access to gold and other valuable mineral resources. Mali is an example (see Watling et al. 2024: 23).

[85] See for instance Coll (2013) on the history of ExxonMobil.

[86] See Wenar (2016).

[87] There are 17 rare earths nearly all with unfamiliar names: lanthanum, praseodymium, dysprosium, neodymium, ytterbium etc. They are endowed with unique magnetic and other properties that make them critical to many of today's modern technologies such as smart phones, liquid crystal displays, broadband signalling, hybrid vehicles, laser devices and missile guidance systems: for example the supreme lightness of magnets made using neodymium .

some of the 20 raw materials (later updated to 27) listed as critical to the European economy.[88] Reliable and unhindered access to supplies therefore depends not only on the geology and economics of mining, but on the geopolitics as well.[89]

5.6 Technological backwardness

Sticking with fossil fuels such as coal and gas for energy generation and petrol and diesel for transport can keep the developing world's growth going for a decade or two. However, countries making that choice—or having it imposed upon them by a lack of viable alternatives or finance to build net-zero pathways—will fall behind the rest of the world in technological progress and in their ability to take advantage of increasingly green GVCs. They could be left on a twentieth century technology frontier while the rest of the world pushes forward the twenty-first century frontier. This is the sixth dilemma.

Continued dependency on fossil fuels may facilitate a rise in absolute standards of living in some poorer countries—and some reduction in poverty—but will be insufficient to achieve convergence with the living standards of those countries adopting the 21st century technologies of clean energy and transport. Africa could be left in the paradoxical situation of exporting many of the metals critical to the material needs of the 21st century's net-zero transition, while being stuck with 20th century energy and transport systems, burning the fossil fuels that the rest of the world is giving up on. Africa will then be even further away from the technology frontier to which it rightly aspires, and the continent will be peripheral to green GVCs and the technological possibilities and economic opportunities that they increasingly offer.

We have provided the reader with six dilemmas to reflect upon, and there are more—including the dilemma of managing a resource boom.

6 Conclusions

This paper has highlighted the opportunities for the developing world in the global net-zero transition: LICs and MICs are presently the main source of metals required for decarbonized infrastructure, energy generation and transport (in addition to their use in a whole range of manufactures, not least those of digital infrastructure, a demand source that will continue to grow). Growing and sharing global prosperity will require a huge expansion of mining, as only a fraction of the demand growth can be met from recycling (in spite of efforts to increase recycling rates). Similarly, our analysis of the Asian energy transition highlights the likelihood that the world will require significantly more gas for at least a few more decades. Oil will still find a ready market as a source of transport fuels, even as the share of EVs grows, and petrochemicals will remain a growing market until we have better alternatives to plastics and other materials. A number of LICs and MICs are well-placed to meet a substantial portion of this demand growth, which promises greater revenue to fund their own development strategies, even as those strategies must adapt to climate change itself.

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[88] EC (2014). The Commission's list of critical raw materials is regularly updated: http://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en

[89] See for instance: Global Commission on the Geopolitics of Energy Transformation (2019) and Goldthau et al. (2019).

However, alongside these opportunities are many challenges. Foremost amongst these is the necessity to reduce the environmental footprint and emissions of mining as well as oil and gas. Another is managing the risks and uncertainties which arise from resource wealth.

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