MAPPING CARBON NEUTRALITY IN UNCHARTED TERRITORY
Governance & Policy Implications for the Mining Sector

Miguel Schloss

President Surinvest Ltda.; member of Bretton Woods (World Bank- IMF) Committee, and Trustee of Global Legal International network. Former Director of Corporate Planning of World Bank, and Executive Director of Transparency International

Introduction

If it looks familiar, you've seen it in your dreams

Much of current day spine tingling debates on climate change and the environment are poorly grounded on apocalyptic views of our future, without offering good answers to what needs to be done to reverse past trends.

So is the case of extractive industries, where growing nationalism and pressures to "control" such activities undermine their potential competitiveness and productivity, and with it their contribution of surplus generation for economic development.

While the concerns on these matters are valid, caring and protecting the natural environment must also achieve universal prosperity for all — both objectives are mutually supportive and absolutely indispensable,

and we desperately need to get it right. Getting filled with exaggeration, alarmism, and extremism is just the enemy of a positive, humanistic, and rational environmentalism.

While the concerns on both the environment, as well as the management of extractive industries, are valid, they both are undergirded by broader forces triggered by the pandemic, supply chain disruptions, energy transition, technology revolution that are threatening the fabric of our societies, the way we work and so much else. If anything, we are in one of the most disruptive, challenging and impactful periods in years, manifested in widespread public discontent, protests, and multiple government, and legal reforms in decades.

The challenge is to open a path to policy change that generate sustainable development responding to emerging societal demands, and doing so in uncharted territory. This publication proposes a technical as much as a more people-centered approach, to avoid Governments or private companies "capturing" emerging opportunities for those in power -- thereby overcoming the discontent that has been allowed to threaten our modus vivendi.

Yet as tectonic shifts are taking place around capitals throughout the world, it is at the kitchen table and the tightening purse strings that are the real drivers shaping these new political alignments. It is difficult not to see the glaring gap between goals and achievements in the energy and environment debate at governmental planes, with the more here-and-now concerns on energy security, affordability, and sustainability at household levels.

Luckily, mining (particularly copper), while being both energy and carbon emitting intensive, is as well a key input for renewable power generation. With proper policies outlined in this book, and as debated at the World Copper Conference 2022, in Chile, this sector could be well positioned to become an integral part of the emerging clean tech economy and a source of growth in years to come.

This paper is to summarize the issues, their governance and policy implications, to help the copper and energy sectors engage in the emerging agenda and achieve productive participation under evolving conditions.

The Imperative of Social Acceptance and Economic Contribution

Dead fish go with the flow

It has almost become trite to note that we are living in difficult times. The pandemic, energy transition, climate change, technology revolution that engulfs the world is threatening the fabric of our societies, the way we work and so much else. If anything, we are perhaps in one of the most disruptive, challenging and impactful periods in years, manifested in widespread public discontent, protests, and multiple government, legal reforms in decades.

The challenge is to open a path to policy change that generate sustainable development responding to emerging societal demands, and doing so in uncharted territory. This will require a more people-centered approach, to avoid Governments or private companies "capturing" benefits and emerging opportunities for people in power -- thereby overcoming the discontent that has been allowed to accumulate that threatens our modus vivendi.

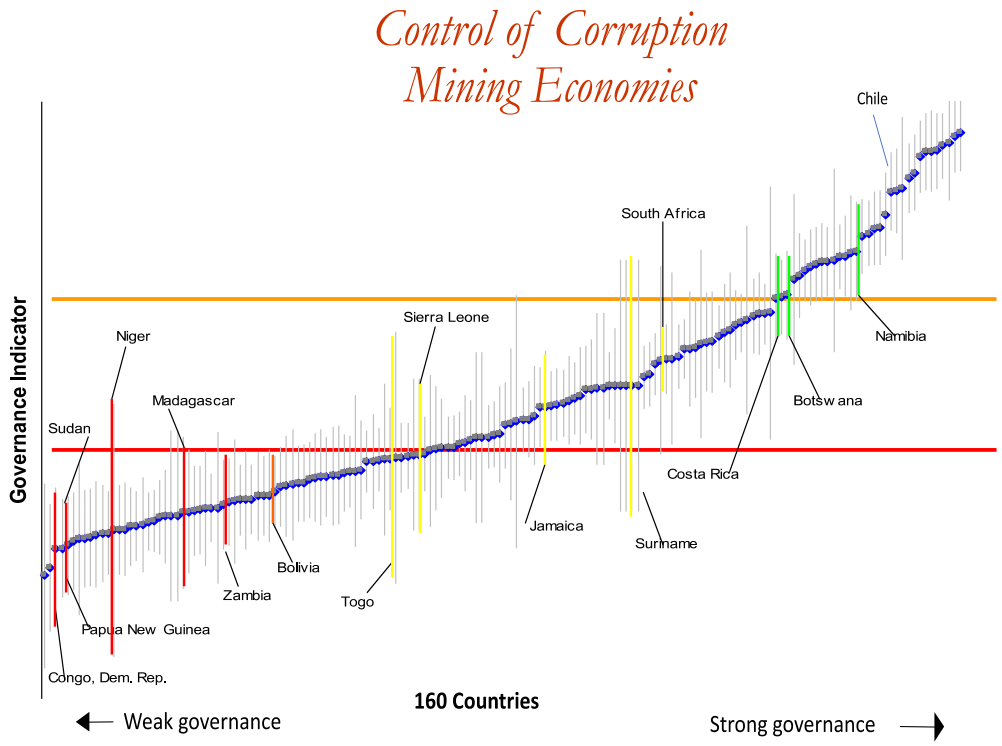
In fact, it is hardly a coincidence that countries with the greatest natural resources in general, and mining in particular, also are seen to have the highest levels of corruption and poor economic performance. There is an imperative of mining companies to achieve increased social acceptance and economic contribution – ultimately enhancing their "license to operate".

It is accordingly becoming increasingly important to address emerging societal demands and associated structural adjustments. Among such imperatives is the need to respond to achieve carbon neutrality by mid-century, as per international agreements, and provide more effective responses to working in environments that test the limits of continuing economic development under existing technological practices.

At present, Transparency International's Bribers Payers Index, which ranks the leading exporting countries and sectors in terms of the degree to which their companies are perceived to be paying bribes abroad, indicates that corruption is widely seen as playing a significant role in international trade.

Particularly disturbing is the high corruption associated with extractive industries – the economic bedrock for many developing countries. It should thus not be too surprising that mining has a poor connotation, and is seen as contributing to this sorry state of affairs. [1]

With the exception of Namibia, Botswana and Chile, all other developing countries whose mining sector exceeds 5% of their GDP are rated in the lower 50% of World Bank Institute governance indexes in such as control of corruption (or for that matter Transparency International's corruption perception index), as can be seen below:



Source for data: http://www.worldbank.org/wbi/governance/govdata2001.htm. This chart shows estimates of control of corruption for 160 countries during 2000/01, with selected countries indicated for illustrative purposes. The vertical bars show the likely range of Governance indicators, and the midpoints of these bars show the most likely value for each country. The length of these ranges varies with the amount of information available for each country. Colors are assigned according to the following criteria: Red, less than 30% of overall countries rank worse; Yellow, between 30% and 70%; Green, over 70% . Countries' relative positions in no way reflect the official views of the World Bank or the International Monetary Fund.

Globalization and transparency are magnifying these societal shifts, going to the heart of long-term profitability, the license to operate, and the social contract for mining enterprises. Most international surveys, when put together, suggest that many international companies, particularly mining enterprises, are seen as having "too much power". The key challenge to the extractive industry in the 21st century is thus to operate in an increasingly globalized, competitive, demanding and integrated world.

The era of enclave projects and sheltered existence has come to an end, and the industry's activities are subject to ever-closer scrutiny. Inevitably, host countries' corruption and poor development performance impairs the industry's reputation, increases shareholder risks, impedes efficient use of resources, and can even lead to social unrest.

A way must be found to ensure that extractive industries benefit societies that host them, while responding to the fiduciary responsibilities to their shareholders, thereby inducing stable business development and growth, lower risk, and sustainability. This can only be achieved if their activities are embedded in the host society and their institutional setup.

To put matters differently, most foreign investment in developing countries takes place in extractive industries such as mining and petroleum. Revenues from such investments make their way to governments in the form of taxes, royalties, fees and other payments. If such revenues were effectively and transparently managed, they could provide a basis for successful growth and poverty reduction.

All too often, the state and other institutions managing these resources are unaccountable to the ordinary citizens and become a vehicle for embezzlement, fraud, misappropriation and corruption.

In more extreme cases, access to such resources intensifies regional conflict and the resulting political, economic and social disorder may be exploited to facilitate large-scale misappropriation of state assets. Inevitably, mining and petroleum companies operating under these conditions are seen to be complicit in the disempowerment of the population in countries to which the natural resources belong.

It would be naïve to believe that the sole awareness of dealing with such issues will be sufficient to overcome the problem. The sheer complexity of the issues, the sparse availability of skills to address such issues, the deep vested interests explaining the current states of affairs are some of the important obstacles to be overcome.

By the same token, it would be foolhardy of executives to regard the governments and people affected by the industry as inconvenient irritants - rather than the ultimate stakeholders and beneficiaries of mining activities. The public increasingly expects business to deliver the goods and services it desires not only at a price it can afford but also in a manner it finds acceptable.

More than most industries, mining relies on a high level of public consent in to be able to sustain its activities since either the States or their citizenry tend to exercise a significant degree of control over access to, and exploitation of mineral resources.

Leading mining companies now accept that the industry's continuing access to resources on viable terms - its "license to operate" - is dependent upon demonstrating that it has the will and capability to operate within transparent and sustainable development principles. To this end, the industry and the countries concerned need better governance structures to help manage resources generated by the sector.[2]

To be effective, however, the go-it-alone practice that has prevailed in the sector will have to give way to developing alliances and the empowering of stakeholders and investment. This will require a shift of traditional technocratic and State-driven approach to a more holistic and empirically anchored approach to problem-solving, and reducing discretionary powers in the public sector that generate conditions for corruption[3], through:

- Solid mining **sector policies and strategies** that provide incentives for investment and generation of a fair share of resources for the host countries concerned, particularly through the adoption of legislation and regulations that are competitive internationally (including the establishment of open, efficient and transparent access to mining properties)

- Establishment of a mining **tax regime** that is reliable, predictable and competitive
- Strengthening of government **oversight institutions** so that they can act on solid technical grounds, and independent vehicles of contestation and adjudication to assure fair treatment of all concerned.
- Buildup of a reliable and wide range system to **technical data** on the resource base of the countries concerned to facilitate generation of interest in further exploration and eventual production investments.

In fact, countries that have adopted such policies (some since the mid 80's) have been rewarded with significant increases in foreign exchange earnings, fiscal revenues, investments and even levels of reserves resulting from increased exploration activities, as noted below, and consequent increased growth.

RESULTS BEFORE AND AFTER MINING SECTOR REFORMS
(MILLIONS OF US$)

Country	Exploration		Production		Exports	
	Before	After	Before	Alter	Before	After
Argentina	<3	150	340	1.310	70	700
Chile	15	250	2.400	7.500	2.300	6.900
Peru	10	200	2.000	3.900	1.900	3.600
Tanzania	<1	35	53	350	53	350
Ghana	<1	N.A.	125	700	125	650
Mali	<1	30	<1	242	<1	230

Climate Change: words or deeds?

Advertising helps, but doesn't resolve issues

Who would have thought that after almost 30 years since the UN Convention on Climate Change, the gap between pledges and delivery on them remains so wide, and that consequently global warming continues unabated?

Except for the decrease in CO2 emissions in 2020, resulting from the recent economic crisis, emissions at present will remain at the same levels that prevailed

before the pandemic, reflecting the practically stagnant levels for more than the previous 20 years. [4]

In this regard, when considering performance in reducing carbon emissions, it is essential to properly characterize and diagnose the effort needed to achieve the agreed goals and implications. The Inter-governmental Panel on Climate Change (IPCC) has been indicating that to limit warming to 1.5 ° C from preindustrial times, carbon emissions needed to decline 45 percent by 2030. They did not say that the world would end, nor that civilization would collapse, if temperatures were to rise above 1.5 ° C. [5]

Moreover, in the fourth assessment report, the IPCC projected that by 2100, the global economy would be three to six times larger than it is today, and that the costs of adapting to a high (4° C) temperature rise would reduce gross domestic product (GDP) just 4.5 percent, which surely does not sound like the end of the world.

In this connection, the IPCC has noted that "there is robust evidence of disasters displacing people worldwide, but limited evidence that climate change or sea level risks is the direct cause". [6]

This is not to say that climate change does not require proper attention and priority, but that there are other drivers, such as low socio-economic development low capabilities of the state, are judged to be just as to be equally if not substantially more influential in current and associated imbalances. [7]

That said, the recent COP meeting, represented for the first time a welcome (albeit timid) dose of realism. Gone are the all-too-frequent rhetorical pronouncements about the dangers heralding the end of humanity and the self-congratulatory declarations celebrating new promises to avert such a disaster.

There was moderate recognition that the world was on the way to a rise of 2.7° C towards global warming, while experts estimate that the outlined plans could produce a trajectory of between 1.8° C and 2.4° C increase.

Consequently, the target in the original agreements of 1.5 ° C is still in force, but barely, and it has therefore been agreed to review the commitments by the end of 2022 to steer plans for a 1.5° C warming.

An effort of this magnitude requires a change of pace of historical proportions for energy policies and an investment of at least $ 16.5 trillion. These magnitudes will require a profound transformation in production and transportation practices, investments in renewable energy and efficiency, as well as carbon capture and storage. [8]

Pushing harder, having good intentions, throwing money or new promises of financing to the problem for increasingly ambitious and distant goals, as has been done to date in COP meetings, will not generate progress. It must be recognized that most of the energy demand (and CO2 emissions) will be generated by economic growth in emerging economies (especially in Asia).

Moreover, early stages of economic development tend to be energy and hydrocarbons intensive, basically to replace human and animal toil by equipment driven by internal combustion engine.

Accordingly, the attention will have to be focused outside the OECD, which will constitute the largest share, both in relative and absolute growth rates of energy growth.

However, the issue cannot be narrowly focused on reducing emissions per se, but must be properly people-focused and integrated in its broader governance framework, aimed at more affordable, secure and sustainable energy. This will require better attention to:

(i) institutional and economic **policy implications**, given the less developed organizational and governance capacities in these regions;

(ii) a sharper focus on **effectiveness,** efficiency, and simplicity, in view of the limited human and financial resources in those countries; and

(iii) mobilization of **skills**, knowledge and inventiveness of the private sector to develop new technologies and more commercial approaches, to respond effectively and with results on the ground.

With the existing technologies and the trajectory driven by public sectors, the agreed objectives will not be achieved. For this reason, the private sector will have to be fully incorporated.

This will help mobilize knowledge, research and development with the necessary discipline, the integration of commercial criteria that ensure economic viability, and flexibility to respond with agility to emerging conditions.

To carry out vigorously, anchoring in non-distorting incentive mechanisms will be required. This should enhance investment environment and provide much-needed energy security in a period of transition and experimentation.

This is especially important when renewable energies, by definition, are dependent on (and vulnerable to) climatic factors, and their costs are still relatively high at current levels of development, particularly when adjusted by load factors.

To "level the playing field" between traditional and renewable energy sources, the cost of emissions will have to be recognized, subsidies to traditional sources discontinued, and the multiplicity of earmarked funds that distort and resource allocation will have to be avoided.

Whatever the formula to establish prices and/or methods of CO2 tax collections, until a free and a functioning carbon market is established, a more forceful and rapid change of the energy matrix can take place. [9]

At the moment, we are still far from such an objective, since in only G20 countries, application of carbon prices reached 48 percent of all polluting sector, and the average price barely reached $ 20 per emitted ton - vs. $ 70 that is estimated to prevent the temperature from rising beyond 1.5° C.

As the low-carbon transition gathers pace, voluntary carbon markets (VCMs) are growing around the world alongside and, in some places, in lieu of compliance

oversight arrangements, at times in the absence of more formalized government-led schemes.

While nascent, the VCMs, where companies purchase credits to offset their emissions, surpassed last year $1 billion, covering almost 640 companies from the S&P 500 and high-emitting sectors, and some 27 percent of U.S. companies now have set net zero targets.

Together with other policies, well-designed VCMs can help reduce costs for emerging climate technologies. This is bound to enhance their chances of adoption at scale, achieve more significant decarbonization and market efficiency across regions.

More importantly, this will further contribute to levelling the playing field between traditional and emerging technologies.

In some cases, such as the European Union, carbon border adjustment mechanisms are starting to take shape as a form of carbon pricing of imported goods and the path to advancing climate action globally in the coming years.

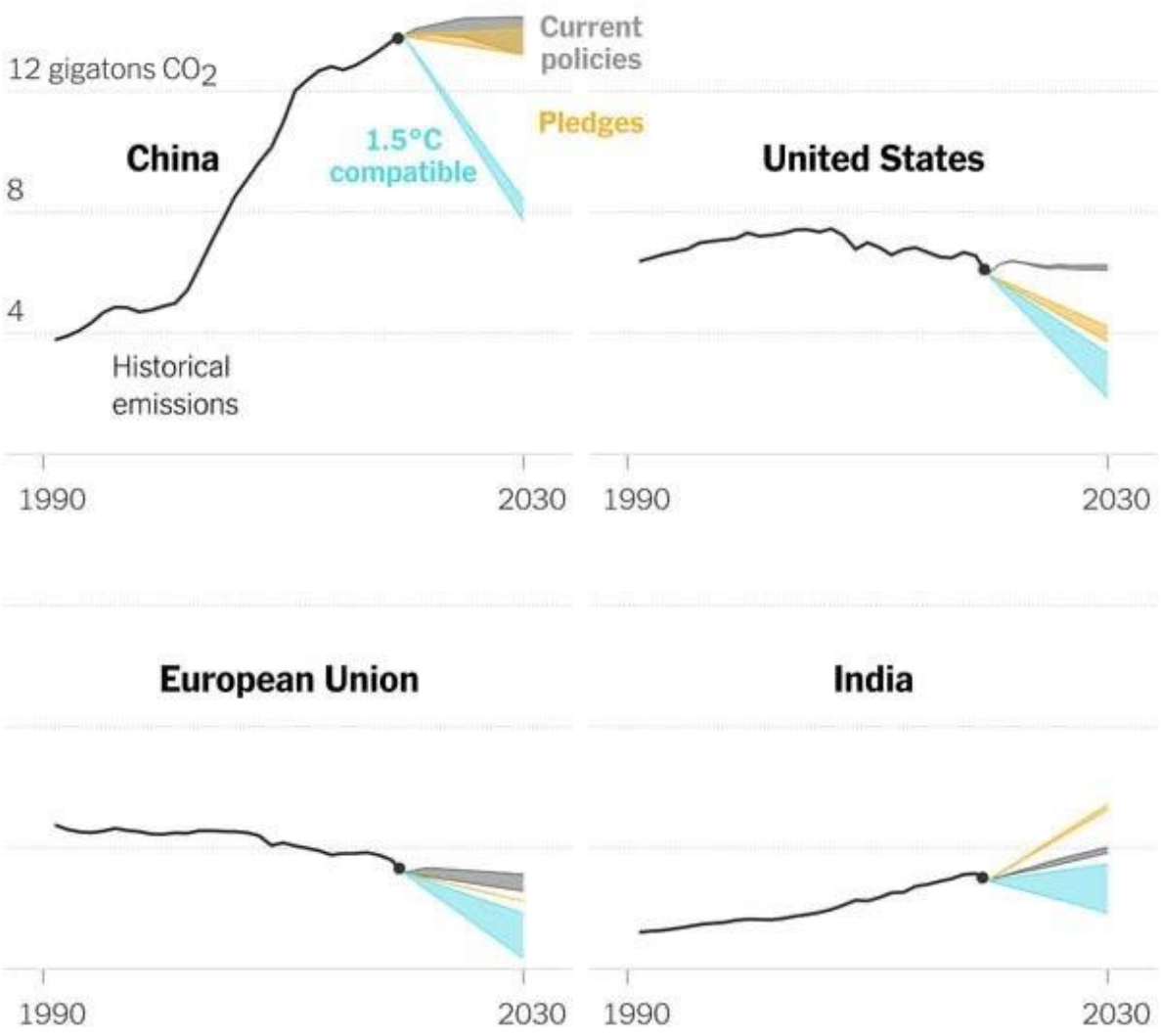
With emerging guardrails and transparency, carbon credits generate a vital source of finance for projects that contribute to climate mitigation, resilience, and sustainable development goals, which avoids “greenwashing” of unsubstantiated claims of emission reductions.

Adding up pledges and programs, recent COP proceedings suggest that more than 100 countries pledged to reduce methane emissions, and another 100 gave committed to ending deforestation.

A few major countries outlined plans to accelerate their shift to renewables, the bottom line is that numerous G20 countries, where volume counts, are not yet on a trajectory to reach their stated net-zero goals.

But in all, major gaps persist in achieving the right trajectory to achieve the international agreed targets.

This can be seen in the depiction below, showing the difference between projected emission trajectories with current policies and those to achieve the 1.5 °C goals:

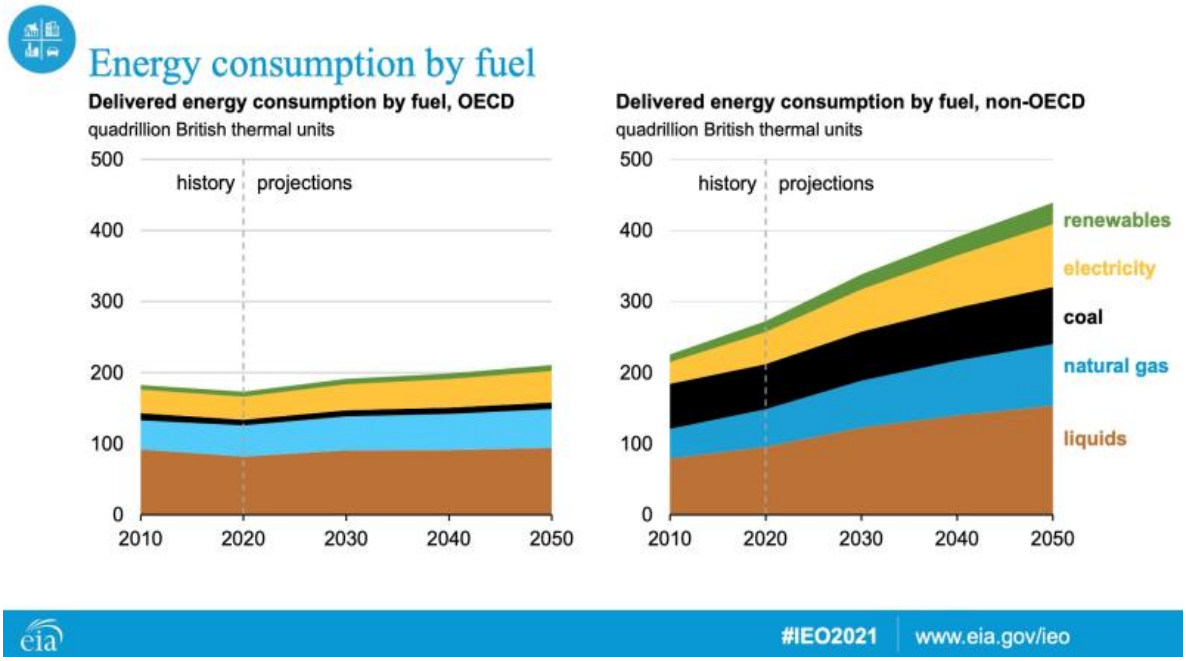


Politically, it will be difficult to move faster, as this will inevitably increase the cost of living and perhaps economic growth. For this reason, as carbon neutrality is a global problem that does not resonate with or respond to daily needs felt at the local level.

Accordingly, transition and adaptation programs should be developed to respond to the needs of evolution towards carbon neutral solutions. In the absence of a broad political consensus to curb emissions, the political system is likely to choose fragmented, imperfect approaches, and probably more costly solutions that may well aim below the targets that have been set, requiring more interventions in the future.

As a result of economic and population growth, global energy consumption is going to increase and, short of major and unforeseen technological breakthrough, so is global energy-related CO2 emissions through 2050.

Most of the energy demand (and CO2 emission) and economic growth will concentrate on emerging economies, as early stages of economic development tend to be hydrocarbons-intensive (to replace human and animal toil for small combustions engine equipment — pumps, motorbikes, and the like)[10], and as noted in the graph below, non-OECD energy consumption will constitute the largest share, in both relative and absolute growth rates:



Accordingly, it is in non-OECD countries where attention needs to be focused -- as it is there where human, technical, organizational resources are also the weakest, and where the greatest support will be required to achieve and effective transition. Therefore, areas meriting special focus are:

Demand and timely feedback, particularly how policies respond to clients (industrial, mining, households) — and the reasons for progress or lack thereof, and ensuing early corrective actions and emerging issues -- such as responses to limited reserve capacity, and weaker energy security stemming from renewable technologies or unexpected cost overruns of newer technologies, as being faced in some of early adopter countries.

Institutional and policy implications, to overcome limitations of top-down planning and execution arrangements, and greater adaptations to emerging conditions.

Economy, efficiency and simplicity, to avoid a tendency of pressing lowering emissions, no matter at what costs — for tracking arrangements, approval and clearance arrangements, complex and difficult to manage,

etc. Greater cost sensitivity, scale requirements and ease of management are key ingredients for viability and ensuing progress. Similarly, the virtues of simplicity, better fit solutions to local capabilities, and tractability, on the one hand, and the requirements for comprehensiveness, on the other, one can expect to set incentives so that investment and operation actions are paid close and continual attention to meet proper efficiency improvements and concentrate attention on effectiveness to achieve lower emissions.

Greater granularity and integration, to avoid aggregate planning to miss specificities and help countries approach specific on-the-ground issues while fostering global synergy to learn from different experiences, particularly those relating to changing technologies. In this way, climate concerns could be mainstreamed in energy sector planning to assure proper balance between energy security, affordability, and societal implications like environmental access to lower income population.

Ultimately, the transition to zero emissions by mid-century must be feasible, fair, efficient and equitable, to be successful and sustainable. In addition to enabling non-OECD countries to cope with the transition, a special effort will be needed (most probably funded and spearheaded in developed countries to further develop existing technologies to reduce costs, and come up with new ones to enable achieve the targets in a more effective manner. To this end, attention will be required on:

- **Developing zero-carbon fuels**. As 80% of global final energy demand is currently served by high-emitting fuels. Zero-carbon substitutes will be key to full decarbonization. Despite critical efforts to expand electrification, some projections suggest that fuels could still serve one quarter of final energy demand by mid-century. Marine shipping, heavy-duty trucking, high-temperature industrial process heating, ironmaking, long-duration energy storage, and aviation are particularly difficult to electrify and will need cost-effective zero-carbon fuels.

- **Enhancing reserve capacity of new technologies** with batteries or other energy storage facilities that are for the time being rather costly. There is still room for significant further improvements in cost-competitive long-term storage systems (advanced batteries, fuel cells, thermal storage, and clean hydrogen systems requiring coordination among many actors for producing, transporting, and having the equipment to use it.); scalable low-carbon firm electricity generating technologies (including possible advanced nuclear). This will be especially important for energy- intensive activities like mining, which is the mainstay of many developing economies, and a wide range of industries, and high-density population centers that require reliable energy supply 24 hours a day throughout the year.

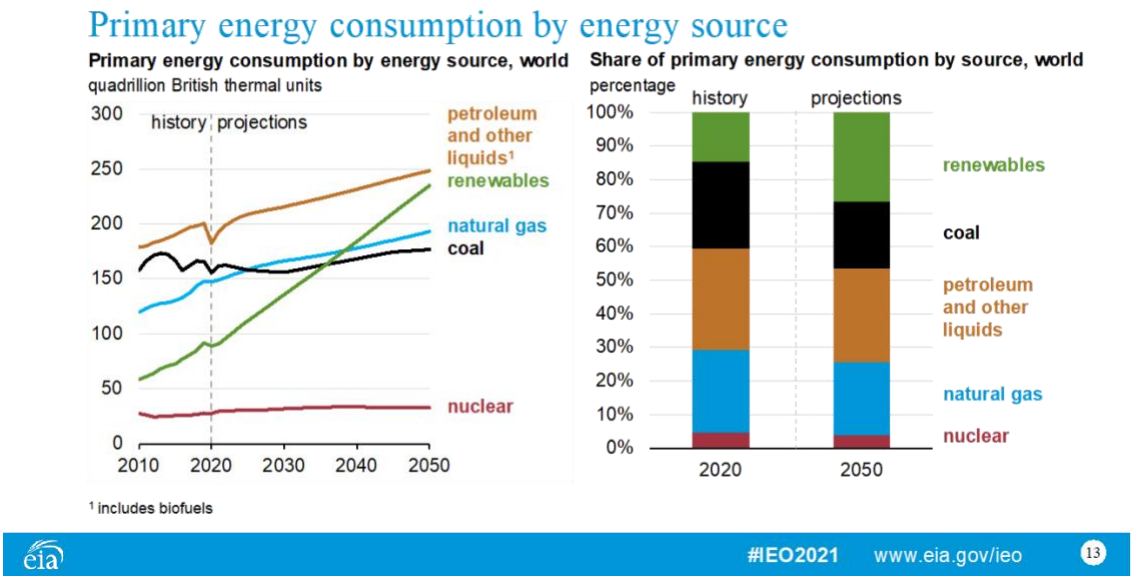
- **Upscaling renewable generating facilities, such as run-of-river plants,** which at present range from 8 to 50 MW capacity to plants over 500MW by connecting various water sources affluents, as currently is being constructed in Chile and Australia. The newness of the engineering and design approaches are generating significant cost and time overruns. In time, with greater experience associated with new design and engineering complexities could costs decrease costs over time.

- **Developing carbon-capture and storage capacity** to remove CO2 "sinks" and facilitate carbon neutrality through removals in the event that new technologies will not be able to produce carbon-free conditions. For the time being, existing technologies are prohibitively expensive, and require considerable energy if capture is to be done from the air directly.
- **Enhancing performance of solar (and other renewable) equipment** with nanotechnologies or similar improvements aimed at reducing costs of solar cells and the carbon footprints of upstream production, thereby bringing photovoltaic applications to competitive levels with traditional generating technologies at grid levels.
- **Developing technologies aimed at lowering temperatures** and improving rain conditions by sowing clouds with silver iodide to induce rain; adding iron to the ocean to increase CO2-consuming phytoplankton; or reducing solar radiation with sulfates.

All these options are at various experimental phases, several of them in confined environments or laboratories. There are other geo-engineering variants being considered with other compounds to scatter sunlight, thereby reducing global warming.

In all, as things stand, aggregate energy consumption may change through rapid increase in renewables. However, short of a major technological breakthrough, the aggregate energy matrix will still have a significant share of traditional sources, such as petroleum and other liquids and natural gas.

These could provide could provide the necessary base loads, and a declining share of coal, as can be seen below (which makes it difficult to believe that it will be possible to have a fully decarbonized economy by 2050, or the interim targets agreed 2030):



To meet global climate targets, the world needs to phase out fossil fuels, particularly coal. This will call for meaningful dialogue on a global coal phaseout, particularly clear explanations on how to transition in that direction.

This may have to include appropriate technical and financial assistance to support the energy security needs of coal-dependent countries like India and South Africa – the two most coal-dependent economies out of the G20 countries with 71 and 86% of their electricity, respectively coming from coal, and what future can be provided to former coal producers

Energy, Mining and Climate Change: Quo Vadis?

If you don't like change, you will like obsolescence a lot less

Mining is both one of the most energy-intensive industry and a major source of raw materials for other industries, including renewable energy technologies. Both factors need to be reconciled to assure a viable long-term future in the mining sector.

The total global energy use by the mining industry comprises about 19% of global coal and coal products and 5% of global gas and 2% of global oil supplied. Total energy demand for mining is anticipated to grow over the near- to mid- term. A low-carbon future will be significantly more mineral intensive than a business-as-usual scenario. Global demand for "strategic minerals" such as lithium, graphite and nickel will skyrocket by 965%, 383% and 108% respectively by 2050.

Copper will also be needed for emerging technologies. While the growing demand for minerals and metals offers an opportunity for mineral-rich developing countries, it also represents a challenge: without climate-smart mining practices, the negative impacts from mining activities will increase, affecting vulnerable communities and environment.

On the energy-intensity side of the equation, the mining industry is responsible for 4-7% of global greenhouse gas emissions – 1% caused directly by mining operations or indirectly through, for example, electricity consumption used to power mines; the remaining 3-6% coming from fugitive methane emissions. Emissions caused by all other indirect usage of the minerals extracted (for example coal used in coal-fueled power stations) are in turn responsible for up to 28% of global greenhouse gas emissions.

At the same time, the mining industry is bound to face increased demand for raw materials, as low-income economies shift to middle-income status, and increasing attention (and requirements) from high- and medium-income countries of emission standards in trade arrangements throughout the value chain, and ensuing increased pressure on the mining industry to reduce emission from their operations.

These tradeoffs will not be easy to manage, because mining operations must remain sensitive to both energy efficiency and security to remain competitive and viable. Continuing lowering costs of wind and solar PV technologies have enabled some inroads of renewable energy in the mining industry. Greater advances and cost reductions in storage facilities will be still necessary to provide a sustainable base load to provide energy security needed by mining companies.

Clean-energy options are accordingly not without challenges and remain mostly unused across the mining sector, as some roadblocks still need to be overcome, particularly:

1. **technical,** including climate-dependent intermittent nature of solar and wind energy sources, which tend to be location-specific, thereby hindering construction of renewable power plants near the mine site, and oftentimes makes remote mining operations dependent on fossil fuels such as diesel, heavy oil fuels, and coal, for on-site generation;

2. **expertise**, which includes limited experience of the mining sector with the construction, operation and procurement of renewable energies;

3. **financing**, given that mining companies prefer not to take on additional capital expenditures on the balance sheet, but also do not like to commit to long-term PPAs, particularly when the life of mine is short or uncertain. Additional complexities are incurred when communities are to benefit from renewable power solutions;

4. **regulatory**, which are primarily composed of fossil fuel subsidies and the lack of laws encouraging investment in renewables, and absence of pricing arrangements of externalities costs of CO2 emissions; and

5. **incentives alignment** between government or the private sector to support of up-front renewable power rollout.

Accordingly, sustainable and responsible strategies and practices across the mineral value chain may have to be instituted to assist governments to build a robust policy, regulatory and legal framework that promotes climate-smart mining and creates an enabling environment for private capital to do its part at the mining industry level. [11] Initiatives of this sort include:

- Underpinning **integration of renewable** energy into mining operations, given the mining sector's significant share of global energy use and that mining operations in remote areas often rely on diesel or coal

- Supporting the **strategic use of geological data** for a better understanding of "strategic mineral" endowments

- Forest-smart mining: preventing deforestation and supporting sustainable **land-use practices**; repurposing mine sites

- **Recycling of minerals**: supporting developing countries to take a circular economy approach and reuse minerals in a way that respects the environment

Mining companies have not ignored the need to become more environmentally responsible. Improvements in exploration and drilling equipment used to locate and extract minerals have created an unprecedented level of precision, reducing the amount of unnecessary excavation.

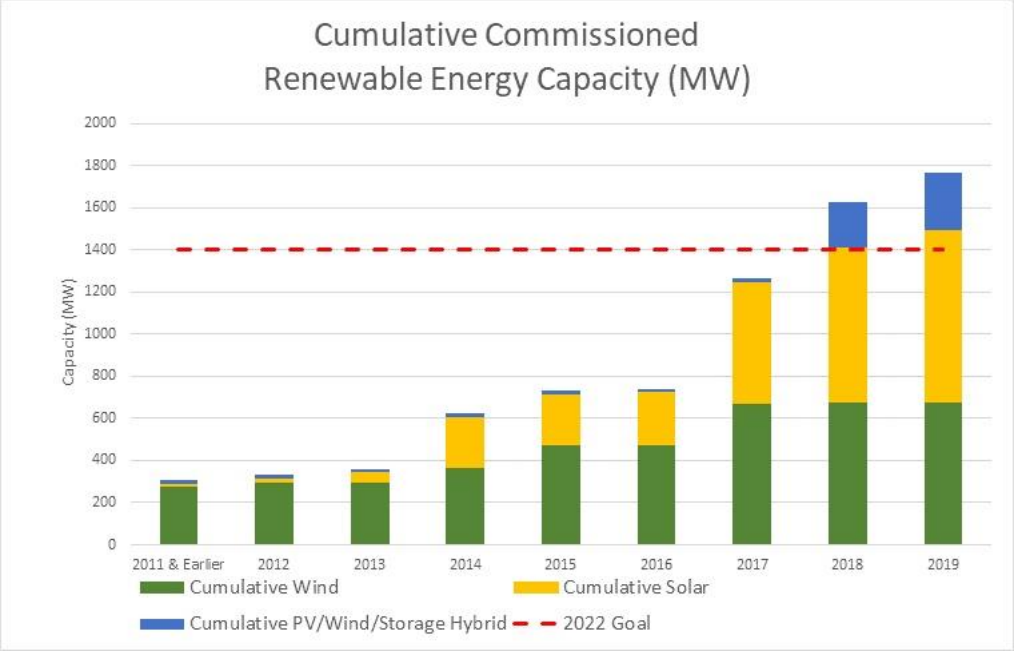
Elsewhere on site, the drive to reduce carbon emissions has impacted the modernization of mine vehicle fleets through hydrogen power. In Chile as well as "dual fuel" systems to power existing combustion engines in Australia, and

truck prototype set to operate this year aimed at cutting carbon emissions by 2,260 tons per year.

Although not intended as a climate-smart investment per se, but as a strictly economic proposition, the El Teniente mine (the largest copper production facility, with some 4,500 km underground corridors) is using gravity as a central source of energy by availing themselves of the major gradient existing between extraction at 2,500 to 3,000+ above sea level, and processing all the way through shipping at sea level in a rather narrow space. Even so, there are potentially additional sources of low-carbon energy sources to generate further environment-friendly solutions.

A low-carbon transition where mining is climate-smart and value chains are sustainable and green will enable emerging economies play a leading role in this transition: developing strategic and associated minerals in a way that respects communities, ecosystems and the environment. Countries with such minerals have an opportunity to benefit from the global shift to clean energy.

The mining sector is already availing itself of more recent opportunities for renewable use in mining operations, outpacing growth compared in many other sectors, though admittedly from a low base, with cumulative commissioned capacity surpassing 1.7 GW:

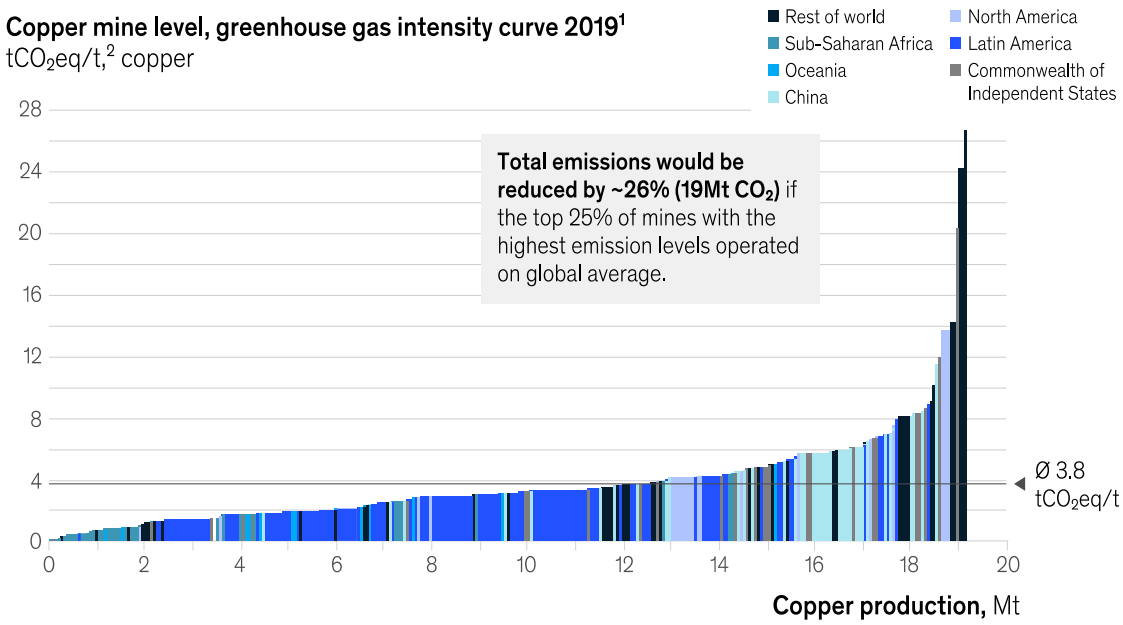


In years past, some mining companies have explored on a technology-driven "push" — advancing low carbon technologies and process design — to drive awareness and adoption of renewables.

But there remains a long road ahead to overcome genuine concerns to move beyond well-established comfort zones in the sector, and generate genuine demand for further low-carbon goods to pull the industries toward the adoption of decarbonization technologies.

Emissions within mining can be broken down into three broad types: Scope 1 (emissions from diesel), Scope 2 (emissions from electricity generation), and Scope 3 (emissions from the supply chain and transport). Today 40 to 50 percent of CO_2 emissions come from diesel used in mobile equipment, with another 30 to 35 percent from nonrenewable electricity.

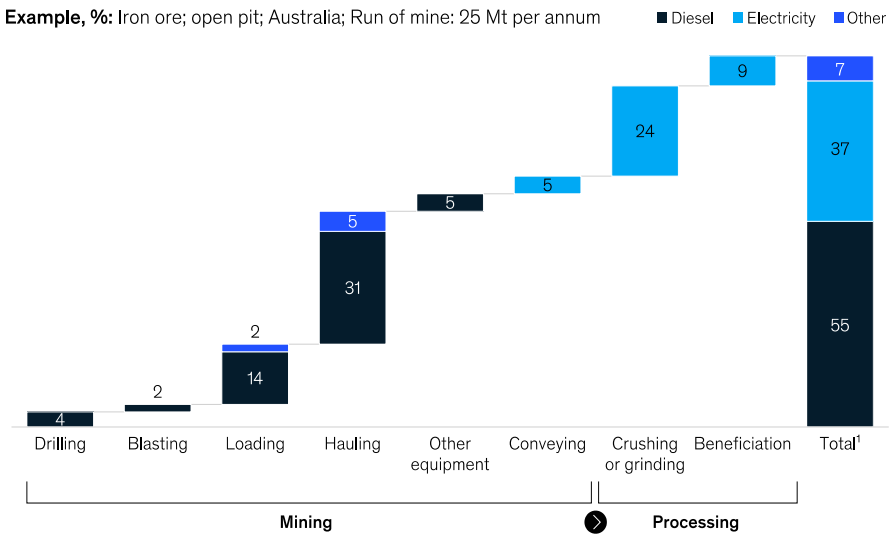
However, the emissions intensity varies widely across mines: for example, within copper, we see a twentyfold spread among the emissions intensity of mines, as can be seen below:



[1]Considers Scope 1 and 2 emissions.
[2]Total CO_2 equivalent per metric ton.

To understand this variation, we have created a comprehensive mine-decarbonization model. This breaks down mining emissions at an equipment level and assesses more than 20 decarbonization options illustrated below, using an iron ore mine in Australia as an example to illustrate what the world's net zero-carbon mine could look like:

Addressing emissions from multiple sources is key to the decarbonization of mining.



[1]Figures may not sum to 100%, because of rounding.
Source: McKinsey Mine Decarbonization Model

Regarding the sector's contribution to renewable technologies, the transition from fossil fuels to low-carbon energy sources will depend on critical minerals. Their consumption could increase sixfold by 2050, according to one scenario [12] by the International Energy Agency. In that world, the trade [13]in energy-related resources will consist largely of critical minerals rather than oil and natural gas. By value, this market could top $400 billion, exceeding the value of all the coal extracted in 2020. Helping this system emerge, and safeguarding it, is a major objective, both to ensure an orderly energy transition and to limit the externalities that often come with extractive industries.

In all, two applications could drive three-fourths of the demand for critical minerals in 2050: electricity networks and batteries. Half of projected demand by then is for copper and a quarter is split between nickel and graphite. Then come lithium, manganese, and cobalt. In terms of value, copper accounts for a third of total in 2050, lithium and nickel each account for almost a quarter each, graphite 10 percent, and cobalt 7 percent.

Copper, lithium, and nickel will account for over 80 percent [14]of the market value in 2050. The production of each mineral is concentrated, but major producers differ by commodity. The largest [15]copper producer is Chile (40 percent of the total), Peru is second (11 percent), and China is third (9 percent). Australia produced half of the world's lithium [16] in 2020, Chile 22 percent, and China 17 percent.

Indications are that many investors are adopting the "Toronto Principle", inducing them to selling all its fossil fuel investments. The Financial Times reported in September 2019 that the number of institutional investors pledged to completely remove fossil fuels from their portfolios by 2030 had jumped from 180 in 2014 to over 1,100, representing around US$11tn in assets. Other signs that the mining industry will face an increasingly hostile investing environment include the European Central Bank's consultation, published on 20 May 2020, to guide banks to price their loan products in correlation to the environmental risks of the borrower/enterprise in question.

So, at the same time as demand for renewable energy continues to grow, enthusiasm for investment in fossil fuels and mining is shrinking, and the mining sector (not only that part mining fossil fuels) risks facing a market that is smaller, pricier and subject to a much greater investor oversight. Accordingly, lenders and investors will require a far more rigorous covenant package in their loan agreements over the coming years when lending into mining activities to manage their exposure to environmental risks and incentivize change towards a more sustainable industry. To make this work will require a detailed – and achievable – ESG performance improvement plan above and beyond mere agreement to principles.

The Challenges of the Way Forward.

Generate enabling conditions, capacity, not dependency

As those who have been in charge of implementing major reforms well know, the distance between design and reality is long.

Three major fault lines will need to be reconciled over the next decade or so. The ***first*** one, in the energy transition, will be the tension between sovereigns and mining companies. Resource-rich countries naturally want to capture the benefits of the resources they hold. This will lead to conflict, visible in places like Serbia, Chile, Peru, and Indonesia. If hydrocarbons are any guide, these conflicts will be intense and transcend the narrow issues of how to divvy up the rents. They go to the core of a country's identity and politics.

Developed economies can help lessen such conflicts by pushing for clear and high standards[17] for extraction. They can help countries negotiate with foreign companies through greater knowledge transfers, offsetting some of the information and expertise asymmetry, such as information to overcome transfer pricing and other mining transactions, to enhance transparency, reduce corruption and build confidence in markets. At company level, a systematic review at the full project cycle and value chain levels may help identify vulnerable areas to address those with higher probability of occurrence and likely outcomes.

The ***second*** source of potential conflict can be triggered by increased environmental, social and governance standards. On the demand side, it should encourage technologies and processes that lessen reliance on the most problematic minerals, helping to grow out of some of the predicaments faced today.

Only a holistic approach can safeguard the critical minerals needed for the energy transition. Climate action without a sensible critical mineral strategy is bound to produce trouble. But the complexities presented by critical minerals cannot be an excuse to delay or shy away from the energy transition that the climate requires.

Companies looking to safeguard the role of some mining activities could follow the experience of gas in the energy transition, which are turning to carbon-neutral liquefied natural gas (LNG). This fast-growing market allows buyers and sellers to counterbalance greenhouse gas emissions from each cargo through carbon offsets. But such trade arrangement still lacks transparency and

consistency, and for the time being is a peripheral solution to emissions from the industry.

The appeal of carbon-neutral arrangements is clear. These deals allow sellers and buyers to offset the emissions of a cargo by financing projects that remove equivalent emissions elsewhere. Projects that qualify for carbon credits range from afforestation and reforestation programs to new wind farms. The cost of carbon offsets can be shared between sellers and buyers, and between cargo buyers and end users, such as utilities and industrial players. The scope of offsets also varies. Some carbon-neutral LNG deals cover full life-cycle emissions [18] from wellhead to combustion by end users, while others cover only "well to tank" emissions in the production to delivery phases – or exploration to end use in the case of mining activities.

A ***third*** challenge is the quality of carbon offsets that underpin this trade. With more companies adopting net-zero emissions targets, the market for fossil fuel carbon offsets (including oil [19] as well as gas) has developed quickly. But there is great skepticism [20]over the consistency and quality [21]of carbon offsets. Problems include the often murky distinction [22]between carbon reductions or avoidance versus actual carbon removal, potential conflicts of interest among third-party verification agencies, and lack of governance [23]of carbon markets to ensure consistency.

Recognizing the role that the mining industry can play in achieving emissions targets, host countries are beginning to require more stringent pollution controls and statutory reporting requirements (e.g., the inclusion of the effects of energy consumption in environmental impact assessments required for obtaining an operating permit). Host governments of leading mineral producers such as Canada, Australia, Chile, and others are creating enabling policies and regulations such as carbon taxes, green certifications, and flexible dispatch to accommodate renewable sources integration.

Renewable energy can be integrated into the extraction, processing, and refining activities of mineral production. These activities include drilling, transportation, digging, loading, and power generation for mine sites without grid connection.

For mines that are grid-connected, working with the utility to expand the use of renewable energy either on the utility or mine side of the utility meter could provide primary benefits of renewable energy (e.g., lower costs and reduced GHG emissions) while potentially sheltering mines from more complicated legal and financial concerns of developing their own renewable energy sources. Renewable energy can also be used to provide process heat, though most current sources are best aligned to provide low or medium value heat (i.e., below 400°C).

The ESG (Environmental, Social and Governance) Sector Risk Atlas produced by S&P Global clearly illustrates the negative perception faced by the metals and mining sector. Each sector's exposure to environmental and social risks is given a rating of 1 to 6, 1 being low risk and 6 being high risk. Mining and metals achieved a full 6 out of 6 on the environmental risk scale and 5 out of 6 on the social scale, placing it on par with oil and gas as the most dangerous industry of those measured in the report.

The annual Responsible Mining Index Report of May 2021 paints a similar picture, showing the mining industry making only piecemeal progress towards the achievement of the Sustainable Development Goals (SDGs). Similarly, institutional investors are adopting the "Toronto Principle", and pledging to remove fossil fuels from their portfolios by 2030. Other signs that the mining industry will face an increasingly hostile investing environment include the European Central Bank's May 2020 consultation, guiding banks to price their loan products in correlation to the environmental risks of the borrower/enterprise in question.

So, demand for renewable energy continues to grow, enthusiasm for investment in fossil fuels and mining is shrinking, and the mining sector facing a challenging market, pricier and subject to a greater investor and regulatory oversight. Accordingly, the mining sector will have to face challenging (though promising) conditions ahead, and with the appropriate policies and rigorous institutional corrections, and be part of the renewable energy push, by managing their exposure to environmental risks, ESG performance, and change towards a more sustainable industry.

Now what? – Bulldozing Barriers and Silos

Critical thinking, learning and innovation, from the bottom up

At the bottom of it all, today the world lacks the solutions that will be needed to achieve global net-zero carbon emissions at reasonable economic and social cost later this century. Nor are the solutions in hand to adapt equitably and efficiently to the climate-related risks that will occur even if mitigation goals can be met. These problems are among the most urgent facing humankind.

Much can and must be achieved with existing technologies and policy approaches, but without game-changing advances in multiple fields of science, technology, and policy the world's efforts to address the climate challenge will not succeed. Before the pandemic, there was no greater priority for the international community than to work towards this goal. Obviously, we must continue to muster our energies to respond to the pandemic. Yet, just as obviously, the climate challenge still looms. We cannot afford to put our efforts to address it on hold.

Seen in this light, after 26 annual COP meetings there is precious little one can point in terms of effective results. Much of the approach has relied on setting targets for reductions of carbon emissions, and pledging resources to achieve such results. A cadre of politicians and ideologues of pure faith, who believe that convictions or sense of justice are enough to justify actions, have mistakenly ex officio: their place is the pulpit of a church, not the public square or a policy-making body.

However, rather than polarizing discussions and deflecting attention from the issue at hand, policy-makers and enterprise managers need to differentiate themselves, among other things, by paying adequate attention to the incentive structures to align interests and attention towards sustainability of sectors and projects, their energy efficiency, their compatibility with the environment, etc. - not as an aggregate, but a way of planning in an integral way from the beginning in such a way that they are economical for clients and users.

The penchant for showing commitment to climate change concerns has led to an increasing flourish of guidelines, norms and standards. To mention just a few recent ones: (i) the U.S. Securities and Exchange Commission draft climate-related financial disclosure rules for public discussion aimed at requiring large, public companies to report on their climate impact, including their emissions and governance of climate risk; [24](ii) the United States and the European Commission joint commitment to Europe's energy security and sustainability aimed at accelerating the global transition to clean energy, and committing to the establishment of a joint Task Force to reduce Europe's dependence on Russian Fossil Fuels, and address the energy security emergency, to ensure energy supply for EU and Ukraine. [25]

While such frameworks have their justification, when put altogether, they could led to an overcrowding set of norms that may be difficult and onerous to implement in tandem. More importantly, the rush of widening norms is generating a partisan environment that is starting to polarize relations between institutions that should be working with, rather than against each other to undertake a better calibrated and effective transition process.

Examples of countervailing pressures are manifesting themselves in efforts to keep coal in the energy mix through 2050, largely triggered by the dearth of plans to deal with the economies and employment prospects in coal producing areas, including the expansion of coal-reliant heavy industry in India, the availability and security of local coal supply in some regions as against still frail reliability of clean energy generating facilities in terms of load factors and weather conditions. Such issues need to be seriously addressed, both in terms of the cost advantage of emerging technologies as much as and the livelihood in coal producing areas if the transition is to take place, particularly in non-OECD Asia to fuel the region's growing economies.

Similarly, growing conflicts of such nature are emerging with the Organization of Petroleum Exporting Countries (OPEC), which has served notice that they will no longer use oil data from the International Energy Agency (IEA) to assess compliance with production quotas amid a deepening rift between the two institutions. This can affect the transparency needed to track OPEC transactions

and the working of the group's Joint Technical Committee -- which represents a broader alliance between OPEC and non-members which may well lead to replacing the IEA's numbers amid concerns that the reliability of the agency's overall data is being undermined by its challenged political neutrality, given its strong and open views on climate change and advocacy against hydrocarbons.

The severe energy crisis that has gripped markets and the growing push to curb carbon emissions has made cooperation more difficult, and has evidenced the conflict that has been allowed to fester, with consequent resistance of OPEC to respond with increased outputs. This has exposed the underlying energy insecurity of existing sector balances that is likely to remain as long as the conflicting approach to the issue continues to prevail among all agencies concerned.

At the end of the day, though, if the incentives are right and the business is profitable, investments will flow, and carbon mitigation is going to take a hold. Efforts cannot rely exclusively on government action – clearance of environmental programs for investments, setting targets, tracking of compliance arrangements, etc. They tend to have their limitations, given institutional constraints, costly and time-consuming processes, at times associated with corruption, and other such constraints. For this reason, having enabling conditions to facilitate investments that can attract enterprises, will be necessary if serious upscaling is to take place.

Going beyond the generation of a capital market for operations of this sort, the way of operating institutions and authorities has tended to be rather linear – in the main oriented towards efficiency and compliance with regulations, in which opportunities for innovation and social benefits may be lost. This is probably insufficient in the context of structural changes that are forcing the growing crises that require more agile approaches to move with the changing societal demands. Cost reduction will remain a priority in a low-growth and uncertain environment, and it's important for companies to target those areas that yield the biggest benefits.

Essentially, this will require visibility across the supply chain to make decisions around how to prioritize products and manage relationships with suppliers, as an

integral part of energy efficiency and environmental implications. This would enable optimize beyond individual company operations, including tier one suppliers, and prevent generating carbon border adjustments of one sort or another, when exporting to ever increasingly integrated markets.

Reflecting on the Future

Sell on the rumor, buy on the fact

History often foretells that in times of necessity, our most precious allusions get dispelled. And this is never so much the case, as in times of crises and unattended demands. Today, with continuing concerns on pandemic, energy transition, technology revolution, we are beginning to wake up to a global paradigm shift. Generational security doctrines and economic orthodoxies that have been rooted in a post-WWII global order are faltering in the face of shifting economic and political weight, including a Sino-Russian alliance flexing its muscles.

Yet as tectonic shifts are taking place around capitals throughout the world, it is at the kitchen table and the tightening purse strings that are the real drivers shaping these new political alignments. It is difficult not to see the glaring gap between goals and achievements in the energy and environment debate at governmental planes, with the more here-and-now concerns on energy security, affordability, and sustainability at household levels.

Nowhere has this become more evident than at the gas pump – 40% of European gas was supplied by Russia. It follows that since this energy flow has stopped, induced by both, policy decisions to curb hydrocarbons production delinked from geopolitical power shifts, triggering price surges to record levels in Europe and the United States.

No technical (solar, wind or other) fixes, or push for certain aggregate goals is going to be effective, unless it provides an adequate response to consumers' real needs, and enterprises have the proper framework and incentives to operate and invest.

Beyond that, no political, social or moral achievement is without formidable obstacles. There are vested interests to be confronted, attitudes to be changed, resistances to be overcome. The problems are immediate, the ultimate goal frustratingly far away. The challenge to address them requires leadership by influence -- not about authority; aligned incentives capable of mobilizing a myriad of strands and people, without the need of deliberate and complicated coordination in the first place; integration and coherence of action, capable to learn from experience and be adaptive for all time.

In today's world, trying to roughshod or press countries into implementing some targets is no longer a viable approach. Each country has its institutional capability and policy framework, particularly in a new and evolving forms of energy generation – no two countries are alike. A viable (and yet unproven) international framework will have to learn and accommodate each country according to their individual character and capability.

Given the urge for effective action, cooperation will be essential – the strong assisting the weak; the creative helping the capable of upscaling – and vice versa. The approach cannot succeed if it seeks uniformity, but honors diversity, to free countries try out and experiment different approaches and technologies, until effective ones are found that can demonstrably address the present energy/environment conundrum.

- [1] El Mercurio (Santiago, Chile) May 16, 2018 - “Política minera para impacto económico"; Capital Business Journal (Santiago, Chile) Feb. 2018 - "Política minera; del subsuelo al desarrollo económico"; Abbreviated version published in Pulso - Feb 14, 2018 (M. Schloss)

- [2] Instituto de Gobierno y Gestión Pública - Universidad de San Martin USMP (Lima, Perú) Dec. 2015 - "Experiencias Internacionales para Fortalecer la Gobernabilidad (International Experiences for Strengthening Governance)" ISSN 2414-4991 (M. Schloss)

  [3] Academic Research and Publishing Group, May 2021: “Recasting Governance for Challenging Times” ; Global Journal of Management and Business Research, August 2021 (M. Schloss)

- [4] El Mercurio (Valpo.) May 23, 2021: "Cambio climático y transformación”.(M. Schloss)

- [5] Keywan Riahi, Arnulf Grubler, and Nebojsa Nakicenovic, “Scenarios of Long-Term, Socio-economic and Environmental Development Under Climate Stabilization, “Technological Forecasting and Social Change 74, no.7; 887-935, https://dol.org/10.1016/.j.techfore.20006.05.026

- [6] Michael Oppenheimer, Bruce C. Glavovic, Jochen Hinkel et al., “Sea Level Riase and Implicatioins for Low-Lying Islands, Coasts and Communities,” in IPCC Special Report on gthe Ocean and Cryosphere in a Changing Climate, IPCC, https://www.ipcc.ch/site/assets/uploads/sites/3/2019/11/08_SROCC_Ch04-FINAL.pdf,321-445

- [7] Katherine J. Mach, Caroline M. Kraan, W. Neil Adger et al., “Climate as a Risk Factor for Armed Conflict,” Nature 571; 193-97, https://doi.org/10.1038/s41586-019-1300-6

- [8] Global Journal of Science Frontier Research: Environment & Earth Science Oct. 2020: "Tackling Climate Change in a Changing World"

- [9] Global Journal of Economics and Commerce (USA) April 2020 "Planning at the Dawn of the XXI Century: The Ambiguous Road to COP26” - ISNN 2249-4588 & 0975-5853

- [10] La Tercera (Etiqueta Voces) Santiago, Chile May 5, 2021: "Cambio climático, en un mundo cambiante"

- [11] Capital Business Journal (Santiago, Chile) Feb. 2018 - "Política minera; del subsuelo al desarrollo económico" . Abbreviated version published in Pulso - Feb 14, 2018

[12] International Energy Agency: World Energy Outlook 2021

[13] https://twitter.com/fbirol/status/1448136581034827787

[14] https://www.iea.org/reports/net-zero-by-2050 International Energy Agency: Net Zero by 2050

[15] https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-copper.pdf

[16] https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-lithium.pdf

[17] https://www.ergi.tools

[18] Columbia Univ. https://www.energypolicy.columbia.edu/sites/default/files/file-uploads/Carbon-neutral%20LNG%20commentary,%20design%20reflow,%207.02.21%20.pdf

[19] S&P Global https://www.spglobal.com/commodity-insights/en/market-insights/blogs/oil/100821-carbon-intensity-crude-oil

[20] Berkley Carbon Trading Project: https://carbon-direct.com/wp-content/uploads/2021/02/Carbon-Direct_Carbon-Plan_Berkeley-Carbon-Trading-Project_TSVCM-Comments-1.pdf

[21] https://www.volts.wtf/p/carbon-offsets-arent-working-and?s=r

[22] The Oxford Principles for Net Zero Aligned Carbon Offsetting (Sep 2020): https://www.smithschool.ox.ac.uk/publications/reports/Oxford-Offsetting-Principles-2020.pdf

[23] Bloomberg Green Finance: https://www.bloomberg.com/news/features/2021-06-02/carbon-offsets-new-100-billion-market-faces-disputes-over-trading-rules?sref=B2BBHw9t

[24] Devex Invested: SEC's climate transparency rules are 'big step forward' https://www.devex.com/news/devex-invested-sec-s-climate-transparency-rules-are-big-step-forward-102899

[25] Joint Statement between the EC and the US on European Energy Security:https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_22_2041 and https://www.whitehouse.gov/briefing-room/statements-releases/2022/03/25/fact-sheet-united-states-and-european-commission-announce-task-force-to-reduce-europes-dependence-on-russian-fossil-fuels/